CLASS I PERMIT APPLICATION
REVISED SUBMITTAL
Hermosa Project

South32 Hermosa Inc.

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Original Submittal: October 2022
Final Submittal: December 2023

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1. EXECUTIVE SUMMARY

South32 Hermosa Inc. (South32) is a mineral exploration and development company focused on the exploration and potential development of the Hermosa Project near Patagonia, Arizona, in Santa Cruz County. The exploration work conducted thus far has shown deposits of zinc (Zn), silver (Ag), manganese (Mn), and lead (Pb), and further exploration work is ongoing. On March 31, 2022, President Biden declared manganese a strategic and critical mineral under the Defense Production Act of 1950, making production of manganese a national priority. In May 2023, the U.S. Federal Permitting Improvement Steering Council (FPISC) confirmed that the Hermosa Project would be the first-ever mining project to be added as a covered project under the FAST-41 program. Inclusion in the FAST-41 program means that the FPISC has found, after rigorous review, that the proposed Hermosa Project would be of national benefit.

Once South32 determines the feasibility of the Hermosa Project and makes a subsequent decision to mine, South32 would proceed with the expeditious construction and operation of an underground mine that would lead to the above-ground shipping or beneficiation of mined ores (zinc, silver, manganese, and lead) into crushed ore or concentrates for further beneficiation off-site. These proposed operations are referred to as "the Hermosa Project" and would be located in an area of Santa Cruz County currently designated as attainment or unclassifiable for all national ambient air quality standards (NAAQS).[1]

The proposed Hermosa Project includes underground mining of two deposits:

- Taylor sulfide deposit (Taylor), a high-grade Zinc-Lead-Silver deposit
- Clark oxide deposit (Clark), a high-grade Manganese-Zinc-Silver deposit

Each deposit will have a dedicated main access (for employees and equipment); Taylor will be accessed via a shaft[2], and Clark will be accessed via a decline[3]. Tailings and rock management will be shared between facilities, while ore will be handled separately. Material beneficiation from the Taylor deposit will involve various ore beneficiation steps including underground crushing and above-ground milling, screening, froth flotation, and regrind, ultimately producing a zinc/lead concentrate. Material from Clark will go through above-ground crushing ultimately producing crushed ore. All products (concentrates and crushed ores) will be shipped off-site for further beneficiation. Tailings from the Taylor facility will be thickened, filtered, and returned underground to backfill voids as cemented paste backfill or dry stacked in either of the tailing storage facilities (TSF1 or TSF2).

South32 is proposing to install sufficient power generation to fully power the Hermosa Project utilizing natural-gas and diesel fired reciprocating engines, although it is proposing an alternate operating scenario that eliminates most power generation should adequate line power become available. There will not be any steam generation associated with these engines.

The proposed Hermosa Project's potential to emit (PTE) regulated air pollutants is estimated based on the maximum expected throughput considering anticipated mining conditions and onsite power generation, and the TSF option that generates the most potential emissions. The potential to emit estimates are summarized in Table 1-1. Based upon those estimates, potential emissions of nitrogen oxides (NO_X) and

[1] Per Arizona Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants, Green Book, Environmental Protection Agency (EPA).

[2] A vertical excavation through which personnel and material can move between the surface and the mine.

[3] A gradually-sloped, sometimes spiraled tunnel providing access to an underground mine.

various single and combined hazardous air pollutants (HAPs) trigger the requirement for a Class I permit. Emissions of non-fugitive regulated air pollutants do not trigger Prevention of Significant Deterioration (PSD) review but do trigger Arizona's minor new source review (NSR) program under A.A.C. R18-2-334. As part of the minor NSR review program, South32 is proposing to perform air dispersion modeling analysis through the EPA-approved AERMOD software to measure impact of NAAQS pollutants, in lieu of a Reasonably Achievable Control Technology (RACT) analysis.[4] Volatile Organic Compound (VOC) emissions resulting from the Project are greater than 20 tpy. The Modeled Emission Rates for Precursors (MERPs) evaluation conducted in Section 7 of Air Dispersion Modeling Report demonstrates that this Project will not cause or contribute to an exceedance of the ozone NAAQS.

Based upon the foregoing regulatory analysis, a Class I application and a minor NSR demonstration meeting the requirements of A.A.C. R18-2-334 are required. The enclosed permit application includes ADEQ's Class I permit standard application form, responds to the filing instructions in section 2-4 of ADEQ's Application Packet for a Class I Permit, demonstrates how the proposed Hermosa Project will comply with all applicable requirements, and includes an air quality modeling report (under separate cover) demonstrating that the proposed Hermosa Project will not interfere with the attainment or maintenance of any NAAQS.

South32 submitted a Class I permit application on October 21st, 2022, and received a determination of completeness from ADEQ on November 23rd, 2022. South32 is providing this final submittal which incorporates all ADEQ comments.

[4] Pursuant to A.A.C. R18-2-334(C).

Table 1-1. Hermosa Project – Potential to Emit

Pollutant	Regulated NSR Pollutant? [2]	Estimated Potential Emissions (tpy) [1,2]		Permit Applicability Evaluation							
		Non-Fugitive [3]	Non-Fugitive & Fugitive [3]	Class I PSD Major Thresholds (tpy)	Less than PSD Thresholds?	Class I Title V Major Source Thresholds (tpy) [2]	Less than Title V Thresholds?	Significant/Class II Thresholds [2]	Less than Class II Thresholds?	Permitting Exemption Thresholds [2]	Less than Registration/Permitting Exemption Thresholds?
PM	Yes	208.04	653.02	250	YES	100	YES	--	--	--	--
PM_{10}	Yes	88.39	222.56	250	YES	100	YES	15	NO	7.5	NO
$PM_{2.5}$	Yes	50.83	69.24	250	YES	100	YES	10	NO	5	NO
NOx	Yes	203.61	203.61	250	YES	100	NO	40	NO	20	NO
SO_2	Yes	6.45	6.45	250	YES	100	YES	40	YES	20	YES
CO	Yes	180.95	180.95	250	YES	100	YES	100	YES	50	NO
VOC	Yes	94.10	95.94	250	YES	100	YES	40	NO	20	NO
Lead compounds	No	0.21	1.21	--	--	10	YES	--	--	--	--
Elemental Lead	Yes	0.21	1.21	250	YES	100	YES	0.6	YES	0.3	YES
Maximum Single HAP - Acetaldehyde	No	39.84	39.84	--	--	10	NO	--	--	--	--
Total HAPs	No	69.40	76.57	--	--	25	NO	--	--	--	--
H_2S	Yes	10.12	10.12	--	--	100	YES	--	--	--	--
CO_2e[4]	-	1,176,929	1,176,929	100,000	--	--	--	--	--	--	--

[1] PM, PM_{10}, and $PM_{2.5}$ include both filterable and condensable fractions, which conservatively overestimates PM emissions from an NSR perspective.

[2] Per Arizona Administrative Code (A.A.C.)
R18-2-101.110 - For "Potential to emit"
R18-2-101.131 - For "Significant"
R18-2-101.75 - For "Major Source"
R18-2-101.101 - For "Permitting Exemption Thresholds"
R18-2-101.124 - For "Regulated NSR Pollutant"

[3] Per A.A.C. R18-2-302.F "The fugitive emissions of a stationary source shall not be considered in determining whether the source requires a Class II permit under subsection (B)(2)(a) or (b) or a registration under subsection (B)(3)(a) or (d), unless the source belongs to a section 302(j) category. If a permit is required for a stationary source, the fugitive emissions of the source shall be subject to all of the requirements of this Article." South32 is not categorized as a Clean Air Act Section 302(j) source. Hence, only non-fugitive emissions are used for permit applicability evaluation.

[4] Sources exceeding 100,000 tons of CO_2e are only subject to PSD if they also trigger PSD for another regulated NSR pollutant. The Hermosa Project does not trigger PSD for any other NSR pollutant. While CO2e is not included under the definition of "regulated NSR pollutant" at A.A.C. R18-2-101.124, GHGs are considered a "regulated NSR pollutant" under the federal Prevention of Significant Deterioration (PSD) program at 40 C.F.R. § 52.21(b)(50). South32 is therefore providing estimates of GHG (i.e., CO2e) emissions for purposes of demonstrating non-applicability of the federal PSD program for GHGs, which ADEQ implements via a delegation agreement with EPA.

2. ADEQ CLASS I APPLICATION FORM

Pursuant to A.A.C R18-2-304.B, to apply for any permit required by A.A.C. Title 18, Chapter 2, applicants must complete the applicable standard application form provided by ADEQ and supply all information required by the form's filing instructions. This section includes a completed ADEQ Standard Permit Application Form and an administrative completeness checklist identifying the location of the information required by the associated filing instructions in ADEQ's Application Packet for a Class I Permit.

SECTION 2.0

CLASS I PERMIT APPLICATION PACKAGE

SECTION 2.1

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Air Quality Division

1110 West Washington • Phoenix, AZ 85007 • Phone: (602) 771-2338

STANDARD CLASS I PERMIT APPLICATION FORM

(As required by A.R.S. § 49-426, and Chapter 2, Article 3, Arizona Administrative Code)

1. Permit to be issued to (Business license name of organization that is to receive permit):
   South32 Hermosa Inc.

2. Mailing Address: 21860 E. River Road, Suite 200
   City: Tuscon State: Arizona ZIP: 85719

3. Name (or names) of Owners/ Principals: Brent Musslewhite
   Phone: 520-485-1300 Fax: Email: brent.musslewhite@south32.net

4. Name of Owner's Agent: Brent Musslewhite
   Phone: 520-485-1300 Fax: Email: brent.musslewhite@south32.net

5. Plant/Site Manager/ Contact Person and Title: Brent Musslewhite
   Phone: 520-485-1300 Fax: Email: brent.musslewhite@south32.net

6. Plant Site Name: Hermosa Project

7. Plant Site Location Address: 749 Harshaw Road
   City: Patagonia County: Santa Cruz Zip Code: 85624
   Indian Reservation (if applicable, which one): N/A
   Latitude/ Longitude, Elevation: 31.466232°/-110.724594°, 5,085 ft
   Section/ Township/ Range: Section 26 Township 22 South, Range 16 East

8. General Nature of Business: Mining

9. Type of Organization:
   ☒ Corporation ☐ Individual Owner ☐ Partnership ☐ Government Entity (Government Facility Code---------------)
   ☐ Other

8. Permit Application Basis: ☒ New Source ☐ Revision ☐ Renewal of Existing Permit
   (Check all that apply.)

   For renewal or modification, include existing permit number (and exp.
   date): Date of Commencement of Construction or Modification: TBD
   Primary Standard Industrial Classification Code: 1031, 1044, 1061

9. I certify that I have knowledge of the facts herein set forth, that the same are true, accurate and complete to the best of my knowledge and belief, and that all information not identified by me as confidential in nature shall be treated by ADEQ as public record. I also attest that I am in compliance with the applicable requirements of the Permit and will continue to comply with such requirements and any future requirements that become effective during the life of the Permit. I will present a certification of compliance to ADEQ no less than annually and more frequently if specified by ADEQ. I further state that I will assume responsibility for the construction, modification,

or operation of the source in accordance with Arizona Administrative Code, Title 18, Chapter 2 and any permit issued thereof.

Signature of Responsible Official: [signature]

Official Title of Signer: Director, Environment and Permitting

Typed or Printed Name of Signer: Brent Musslewhite

Date: June 21, 2022 Telephone Number: 520-485-1300

SECTION 2.2 - EMISSION SOURCES

Estimated "Potential to Emit" per A.A.C. R18-2-101.
Review of applications and issuance of permits will be expedited by supplying all necessary information on this Table.

PAGE_______ OF ______
DATE _______________

REGULATED AIR POLLUTANT DATA					EMISSION POINT DISCHARGE PARAMETERS									
EMISSION POINT [1]		CHEMICAL COMPOSITION OF TOTAL STREAM	AIR POLLUTANT EMISSION RATE		UTM COORDINATES OF EMISSION POINT [5]			STACK SOURCES [6]					NONPOINT	
										EXIT DATA			SOURCES [7]	
NUMBER	NAME	REGULATED AIR POLLUTANT NAME [2]	#/ HR. [3]	TONS/ YEAR [4]	ZONE	EAST (Mtrs)	NORTH (Mtrs)	HEIGHT ABOVE GROUND (feet)	HEIGHT ABOVE STRUC. (feet)	DIA (ft.)	VEL. (fps)	TEMP. (°F)	LENGTH (ft.)	WIDTH (ft.)
	See Appendix A and Modeling Report													

GROUND ELEVATION OF FACILITY ABOVE MEAN SEA LEVEL__________feet
ADEQ STANDARD CONDITIONS ARE 293K AND 101.3 KILOPASCALS (A.A.C. R18-2-101)

****Submit emission calculations spreadsheet with your application****

General Instructions:

1. Identify each emission point with a unique number for this plant site, consistent with emission point identification used on plot plan, previous permits, and Emissions Inventory Questionnaire. Include fugitive emissions. Limit emission point number to eight (8) character spaces. For each emission point use as many lines as necessary to list regulated air pollutant data. Typical emission point names are: heater, vent, boiler, tank, reactor, separator, baghouse, fugitive, etc. Abbreviations are O.K.

2. Components to be listed include regulated air pollutants as defined in A.A.C. R18-2-101. Examples of typical component names are: Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulfur Dioxide (SO_2), Volatile Organic Compounds (VOC), particulate matter (PM), particulate less than 10 microns (PM_{10}), etc. Abbreviations are O.K.

3. Pounds per hour (#/HR) is maximum potential emission rate expected by applicant.

4. Tons per year is annual maximum potential emission expected by applicant, which takes into account process operating schedule.

5. As a minimum applicant shall furnish a facility plot plan as described in the filing instructions. UTM coordinates are required only if the source is a major source or is required to perform refined modeling for the purposes of demonstrating compliance with ambient air quality guidelines.

6. Supply additional information as follows if appropriate:
   (a) Stack exit configuration other than a round vertical stack. Show length and width for a rectangular stack. Indicate if horizontal discharge with a note.
   (b) Stack's height above supporting or adjacent structures if structure is within 3 "stack height above the ground" of stack.

7. Dimensions of nonpoint sources as defined in A.A.C. R18-2-101.

SECTION 2.3 - EQUIPMENT LIST

The following table should include all equipment utilized at the facility, and should be completed with all the requested information. Be sure to notate the units (tons/hour, horsepower, etc.) when recording the Maximum Rated Capacity information, the Serial Number and/or the Equipment ID Number. The date of manufacture must be included in order to determine if portions of the facility are NSPS applicable. Make additional copies of this form if necessary.

Submit photographs of the faceplates for all engines listed below. If an engine is certified, please also include a copy of the engine certification with the application. For any newly added equipment, include a copy of the specification sheet. These documents will be used to verify equipment information and determine applicable regulations.

Type of Equipment	Maximum Rated Capacity [1]	Make	Model	Serial Number	Date of Manufacture	Equipment ID Number
See Appendix A						

[1] For generator sets, enter the maximum rated capacity of the engine rather than the maximum rated capacity of the generator.

SECTION 4.0 - APPLICATION ADMINISTRATIVE COMPLETENESS CHECKLIST

	REQUIREMENT	MEETS REQUIREMENTS			COMMENT
		YES	NO	N/A	
1	Has the standard application form been completed?	X			Section 2.1 of this form
2	Has the responsible official signed the standard application form?	X			Section 2.1 of this form
3	Has a process description been provided?	X			Section 4 of the application
4	Are the facility's emissions documented with all appropriate supporting information?	X			Appendix A of the application
5	Is the facility subject to Minor NSR requirements? If the answer is "YES", answer 6a, 6b and 6c as applicable. If the answer is "NO", skip to 7.	X			Section 9 of the application
6.a	If the facility chooses to implement RACT, is the RACT determination included for the affected pollutants for all affected emission units?			X	Facility will perform modeling in lieu of RACT
6.b	If the facility chooses to demonstrate compliance with NAAQS by screen modeling, is the modeling analysis included?			X	
6.c	If refined modeling has been conducted, is a comprehensive modeling report along with all modeling files included?	X			Provided under separate cover
7	Does the application include an equipment list with the type, name, make, model, serial number, maximum rated capacity, and date of manufacture?	X			Section 2.3/Appendix A
8	Does the application include an identification and description of Pollution Controls? (if applicable)	X			Provided in Section 8
9	For any application component claimed as confidential, are the requirements of AR.S. 49-432 and A.A.C. R18-2-305 addressed?			X	
10	For any current non-compliance issue, is a compliance schedule attached?			X	
11	For minor permit revision that will make a modification upon submittal of application, has a suggested draft permit been attached?			X	
12	For major sources, have all applicable requirements been identified?	X			Section 9 of application
13	For major sources, has a CAM applicability analysis been provided? For CAM applicable units, have CAM plans been provided?	X			Section 9 of application
14	For major sources subject to requirements under Article 4 of the A.A.C., have all necessary New Source Review analyses identified in the application been presented?	X			Section 9 of application

3. APPLICATION ADMINISTRATIVE COMPLETENESS

Table 3-1 provides a list of the permit application items required by Section 2.4 of ADEQ's Application Packet for a Class I Permit along with a reference to where the information is located in this application.

Table 3-1. Application Completeness Summary

Section 2.4 of Class I Application Packet[5]	Information Required	Permit Application Section
1,2	Process/Product Description including Standard Industrial Classification (SIC) code	Section 4
3,4	Description of Alternate Operating Scenarios	Section 4.2
5	Process Flow Diagram	Section 5
6	Material Balance Calculations	N/A[a]
7	Emission Calculations	Section 6 and Appendix A
8	Applicable Requirements	Section 9
9	Proposed Exemptions from Applicable Requirements	N/A[b]
10(a)-(f), (h)	Annual and Hourly Process Rates, Fuel Usage, Raw Material Information	Included in the emission calculations in Section 6 and Appendix A
10(g)	Operating Schedule	Section 4
11	Equipment and Control Device List	Section 8
12	Stack Information	N/A[c]
13	Site Diagram	Section 5
14	Air Pollution Control Information	Section 8
15	Acceptable Documentation for Equipment	N/A[d]
16	Compliance Plan	Section 11
17	Compliance Certification	Section 11

[5] https://static.azdeq.gov/forms/classI_app.pdf

18	Acid Rain Information	N/A[e]
19	Major Source Requirements – BACT and Ambient Impact Analysis	Not applicable
20	Emission Calculations	Section 6 and Appendix A

[a] South32 did not base any emission calculations on a material balance.
[b] South32 is not proposing to be exempt from any otherwise applicable requirements.
[c] Information will be provided with the ambient dispersion modeling analysis which have been submitted under separate cover.
[d] South32 is not using any shop drawings or manufacturer's bulletins in this application.
[e] Acid rain information is required only for facilities subject to federal acid rain regulations. South32 is not subject to acid rain regulations.

4. PROCESS DESCRIPTION

4.1 General Process Description

The proposed Hermosa Project will consist of two deposits:

- Taylor Deposit (Taylor), a high-grade Zinc-Lead-Silver deposit that will be mined primarily for zinc (Zn) and lead (Pb).
- Clark Deposit (Clark), a high-grade Manganese-Zinc-Silver deposit that will be mined for manganese (Mn) as the main constituent.

Each deposit will have a dedicated main access (for employees and equipment); Taylor will have a main production shaft, and Clark will have a decline. The underground operations at the Hermosa Project will be supported by three (3) exhaust ventilation shafts/raises for Clark and two (2) exhaust ventilation shafts/raises for Taylor. Tailings and rock management will be shared between facilities, while ore will be handled separately. Taylor has primary crushing located underground as well as secondary crushing located aboveground. Clark has only aboveground crushing. Furthermore, South32 is proposing two options to install natural-gas and diesel fired reciprocating engines for power generation at the facility:

- Option 1. There will be fifty-eight (58) plus one (1) backup 2.6 MW natural gas engines.
- Option 2. There will be twenty-seven (27) plus one (1) backup 4.4 MW natural gas engines.

Additionally, under both options, there will be:

- Seven (7) engines at Hardshell
  - Six (6) CAT XQ1140 engines, each of 910 ekW
  - One (1) Cummins C200D2RE engine, 198 ekW
- Five (5) ICE at Trench
  - Five (5) CAT C175 engines, each of 3000 ekW
    - These five ICEs shall be subject to a voluntary limit of 500 hours/year to provide backup power for the Hermosa Project. These units would be used intermittently in a fashion similar to traditional emergency engines. They would undergo periodic readiness testing recommended by the manufacturer or South32 Hermosa's insurer no more frequently than once a week for an hour or less and would otherwise be used only when the primary power (either line or prime generated power) to the area protected by the engine is not available or if more power is needed for a discrete, short-term project. Such projects are anticipated to be highly sporadic in nature, likely only one to three times a year for a few days. This intermittent use is not anticipated to significantly affect the emissions distribution from the Hermosa Project as a whole.

Major operations at the Hermosa Project will consist of the following:

- Underground mining (including drilling, blasting, loading, hoisting, and hauling);
- Material transfer;
- Intermediate ore stockpiles;
- Primary and secondary crushing;
- Dust collection from drop points;
- Grinding and screening;
- Froth flotation and regrind;
- Concentrate filtration and thickening;

- Concentrate and crushed ore loading;
- Tailings filtration; and
- Tailings deposition/placement.

In addition to the major operations listed above, South32 will include the following auxiliary operations at the proposed Hermosa Project:

- Laboratory operations;
- Cooling towers (associated with water treatment plant and refrigeration plants);
- Mechanical evaporators;
- Paste backfill system;
- Rock stockpiles;
- Power generation;
- Fuel storage tanks;
- Water and wastewater treatment facilities;
- Reagents storage; and
- Vehicle traffic.

4.2 Alternate Operating Scenario

The proposed Hermosa Project includes sufficient onsite power to meet full development needs for both TSF1 and TSF2. All potentials to emit estimates included full site build-out as the Base Case. The Base Case is not, however, fully representative of initial conditions or South32's preferred development approach. South32 is thus proposing two alternate operating scenarios (AOS) to ensure that its application is fully representative of possible conditions.

4.2.1 Alternate Operating Scenario No. 1 – Line Power Alternative

South32 is committed to reducing greenhouse gas (GHG) emissions from its mining operations to assist in the world-wide effort to minimize global warming. Currently, there is inadequate power available to develop the Hermosa Project. The absence of adequate line power requires installation of substantial generating equipment consisting of Option 1. 59 (58 prime and 1 backup) or Option 2. 28 (27 prime and 1 backup) internal combustion natural gas engines to generate the required power and provide necessary backup power for safety. If line power could be obtained, it would reduce emissions as shown in Tables 4-1 and 4-2 for Option 1 and Option 2, as a much smaller number of diesel engines would be needed only for occasional maintenance and testing use. Under AOS No. 1, all of the 58 generators (and 1 backup) (Option 1) or all of the 27 generators (and 1 backup) (Option 2) would be retired from use, and only 12 diesel fired engines would remain. Consistent with A.A.C. R18-2-306(A)(11), South32 would keep a log of the date that it switches to the alternate operating scenario. No additional applicable requirements are triggered if this Alternate Operating Scenario is implemented.

Unfortunately, it is not known whether or when adequate line power will become available at the Hermosa Project. Given the Presidential Determination and the listing of both manganese and zinc as critical minerals, *see* 2022 Final List of Critical Minerals, 87 Fed. Reg. 10381 (Feb. 24, 2022), and FPISC's FAST-41 determination development of the Hermosa Project must occur expeditiously once the decision to mine is made. Accordingly, South32 is including the use of the onsite power generation as backup power as an AOS in the event line power should become available.

Table 4-1. Sitewide Reductions in Emissions – Base Case (Option 1) and AOS No. 1

Scenario	Number of Natural Gas Generators	Criteria Pollutants Annual Emissions (tpy)								GHG Annual Emissions (tpy)				HAP Emissions (tpy)	
		NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2	CO_2	CH_4	N_2O	CO_2e	Single largest HAP	Total HAPs
Base Case (Option 1)[1 2]	58 (plus 1 backup)	202.35	51.19	69.13	35.50	35.50	35.50	87.26	3.91	1,102,884.29	2,684.59	23.25	1,176,928.89	39.84 (Acetaldehyde)	60.02
Line Power (AOS1)	0	38.47	35.57	39.77	0.99	0.99	0.99	2.93	2.69	42,987.61	1.74	0.35	43,135.13	0.21 (Benzene)	0.44

1. Base Case PTE represents the facility wide PTE from Option 1 (2.6MW) engines only.
2. Safety factor of 30% has been added to the emission factors for 2.6 MW natural gas engines (Option 1).

Table 4-2. Sitewide Reductions in Emissions – Base Case (Option 2) and AOS No. 1

Scenario	Number of Natural Gas Generators	Criteria Pollutants Annual Emissions (tpy)								GHG Annual Emissions (tpy)				HAP Emissions (tpy)	
		NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2	CO_2	CH_4	N_2O	CO_2e	Single largest HAP	Total HAPs
Base Case (Option 2)[1]	27 (plus 1 backup)	82.08	50.83	112.61	39.12	39.12	39.12	78.41	3.39	513,306.86	10.61	1.24	513,940.12	18.24 (Formaldehyde)	29.92
Line Power (AOS1)	0	38.47	35.57	39.77	0.99	0.99	0.99	2.93	2.69	42,987.61	1.74	0.35	43,135.13	0.21 (Benzene)	0.44

1. Base Case PTE represents the facility wide PTE from Option 2 (4.4MW) engines only.

4.2.2 Alternate Operating Scenario No. 2 –Secondary Tailing Storage Facility

The planned development of the Hermosa Project includes development of second TSF on National Forest lands located to the north and east of the proposed Project as a supplement to the existing TSF. Both TSFs would use the same technologies and are subject to the same air quality regulatory requirements. Addition of the second TSF requires approval from the Coronado National Forest through the approval of a mine plan of operations (MPO). Because of the processing time associated with an MPO, it is not likely that the second TSF will be immediately available. Because the ambient air boundary of the facility would change with the addition of TSF2, South32 has submitted a modeling demonstration showing that the Hermosa Project will not interfere with attainment or maintenance of a NAAQS standard either prior to or after addition of the second TSF. The addition of TSF2 does not trigger any additional applicable requirements beyond those discussed as applicable toTSF1.

Similar to AOS No. 1, South32 shall keep a log of the date that it switches from TSF1 only operations to TSF1 and TSF2 operation under A.A.C. R18-2-306(A)(11)(a). This permit application and associated modeling references the Base Case as Plan I and operation of TSF2 as Plan II.

4.3 Underground Mining Drilling, Blasting, Loading, and Unloading

Mining operations begin with drilling and blasting of ore underground. At the anticipated mining location, blast holes are drilled to an appropriate depth using a fleet of mobile drills. The blast holes are filled with an emulsion blasting agent and the blast area is evacuated. Following a blast, the area is sprayed with water to suppress dust, loaders are used to load the blasted material into haul trucks. The ore is then transferred to the underground crusher for Taylor and aboveground crusher for Clark. Emissions from the drilling activities include PM, PM_{10}, $PM_{2.5}$, and Pb. Blasting results in emissions of NO_x, CO, SO_2, PM, PM_{10}, $PM_{2.5}$, and various HAPs. Particulate emissions are produced during the loading and unloading activities.

4.3.1 Underground Ventilation System

Ventilation is used to provide safe working conditions for workers. Note that emissions from underground operations at the Facility will escape through three (3) exhaust ventilation shafts/raises for Clark and two (2) exhaust ventilation shafts/raises for Taylor.

4.4 Primary Crushing System

Extracted material from both deposits will undergo primary crushing, though the crushing process differs for the two deposits. The distinct processes for Taylor and Clark are described below.

4.4.1 Taylor

Ore is fed directly into the crusher through an underground ore pass. This crushed material is then fed onto a conveyor belt. The crushed ore is then conveyed to one of three bins from where it is metered onto conveyers which feed the shaft skips that transport the ore vertically to the surface. Once deposited in an aboveground bin adjacent to the shaft, ore is conveyed to the coarse ore storage silos. During this conveying process, a metal detector and magnet will collect any magnetized metals from the crushed ore and place the collected mass in a bin. A dust suppression system mitigates the dust from the crushing of the run-of-mine (ROM) ore and the conveying of the run. Refer to Section 5 for a detailed Process Flow Diagram on the conveying system as well as the dust collector and suppression system. Primary emissions from the circuit include PM, PM_{10}, $PM_{2.5}$, and Pb.

4.4.2 Clark

Once the ROM ore has been mined, it is transported to the above ground primary crusher via haul truck. The ROM ore is processed through the primary crushing system which includes a rock breaker, a feeder, and the primary crusher.

Material will be unloaded into a dump pocket which feeds to a vibrating grizzly screen. Oversized material is routed first to a hydraulic impact rock breaker to be reduced, and undersize material gravity feeds into the primary jaw crusher. The crushed ore is conveyed to coarse ore silos for storage before being hauled offsite by trucks. Emissions from the primary crusher dump pocket will be controlled by water spray. Emissions from each of the two drop points along the conveyor will be controlled by a collection fan and a baghouse. Refer to Section 5 for a detailed Process Flow Diagram on the conveying system as well as the dust collector and suppression system. Primary emissions from crushing and conveying include PM, PM_{10}, and $PM_{2.5}$.

4.5 Milling and Screening

The crushed ore in the coarse ore silos is conveyed to the milling and screening circuit. Only the Taylor deposit has onsite milling and screening activities; Clark material is hauled offsite.

4.5.1 Taylor

Crushed ore will be transported from the coarse ore silos to the milling circuit using a series of feed conveyors. The grinding circuit comprises of an autogenous mill (AG mill/primary mill), vertical tower mill (VTM/secondary mill), and pebble crusher. Primary mill product will be screened with over-sized material sent to the pebble crusher to be crushed further. This ore will be returned to the primary mill by conveyor. Screen undersized material will be sent to hydro-cyclones. Over-sized material will be sent to the VTM for further size reduction. Cyclone undersized material will be sent to flotation.

Water from the process water tank will combine with the crushed ore coming into the milling circuit resulting in a saturated grinding process which produces negligible, if any, emissions.

4.6 Froth Flotation and Regrind

South32 is proposing to construct a flotation and regrind building near the proposed Taylor mill grinding circuit. Here, the ore will go through a series of rougher, cleaner, and scavenger cells. While some VOC emissions are expected from process tanks and storage tanks for chemicals used for flotation or frothing, there are negligible, if any, emissions of any other pollutants associated with these processes due to the wet nature of these operations.

4.6.1 Taylor (Lead)

After screening at the primary mill, the slurry goes through a trash screen, then flotation and a cleaner. The slurry will continue to the Jameson lead rougher while tailings from the flotation cells will be sent to the tailings thickener. The Jameson lead rougher and subsequent lead rougher scavenger will separate the slurry into lead rougher concentrate and zinc flotation feed.

The lead rougher concentrate will be sent to a cyclone and regrind mill after which it will be separated further by a series of three lead cleaners. The tailings from this process are pumped to the zinc conditioning tanks, while the lead concentrate continues to the lead thickener. The lead thickener will then dewater the lead concentrate and use a filter and concentrate feeder to load containers that will then be sealed and transported via stackers to the container yard. The containerized concentrate is shipped offsite.

4.6.2 Taylor (Zinc)

The zinc flotation feed separated by the lead rougher, and scavenger is pumped to zinc conditioning tanks. From there, the process flow is nearly identical as that for lead. The zinc conditioning tanks discharge to the Jameson zinc rougher and subsequent zinc rougher scavenger. The resultant tailings will be sent to the tailings thickener, while the zinc concentrate will be pumped to a cyclone cluster and regrind mill (cyclone underflow). The cyclone cluster overflow will go to a series of three cleaners that will separate the zinc slurry further into concentrate and tailings. The concentrate will go to the zinc thickener which will dewater the concentrate and then use a filter and feeder to load containers that will then be sealed and transported via stackers to the container yard. The containerized concentrate is shipped offsite.

4.7 Tailings Filtration

There will be a tailings filtration facility for Taylor. The Taylor facility will process tailings from the zinc rougher and cleaner units. Tailings will be dewatered by a thickener first and then tailings filters. The majority of the filter cake will be temporarily stored in silos to be loaded into trucks and hauled to a lined, dry-stack tailings storage facility. The rest will be transported to the tailings paste plant. Flocculants will be mixed in the flocculant skid, outside of the filter building next to the tailings thickener.

4.8 Auxiliary Operations

4.8.1 Tailings Paste Plant

South32 is proposing to construct two separate tailings paste plants, one for Taylor and one for Clark. Through the use of recycled tailings and cement, the paste is able to serve as a fortification to stabilize mine conditions, making the underground environment safer and reducing the risk of subsidence. After the tailings have been mixed properly with cement, they will be pumped to the underground mine. South32 is proposing to include dust collectors at both plants to collect PM, PM_{10}, $PM_{2.5}$ and Pb emissions.

4.8.2 Destruction Tanks (Taylor only)

South32 will use minimal quantities of a cyanide compound (such as zinc cyanide) to depress pyrite from tailings in rougher flotation and the zinc cleaner scavenger flotation as well as sump contents from the flotation areas sump. South32 is proposing to procure solid cyanide pellets, which will be transported via truck to the site, where water will be added to the truck. The solution will be premixed, and then the pre-mixed solution will be offloaded into the storage tanks on-site prior to use in the process. South32 is proposing to install these destruction tanks to remove cyanide from the tailings using sodium metabisulfite (SMBS), a detox catalyzer ($CuSO_4$), compressed air, lime slurry, and a tank agitator. The contents will pass through two destruction tanks in series and are then gravity-fed to the tailings thickener.

4.8.3 Tailings Storage Facility (TSF)

As noted in Section 4.2.2, Plan I is the Base Case which includes use of the existing TSF (TSF1), while Plan II considers use of a second TSF on National Forest System lands (TSF2).

4.8.3.1 Plan I

South32 currently operates a dry stack tailings storage facility that stores legacy tailings and other permitted materials. South32 is proposing to store future production tailings from the Hermosa Project at this facility. The tailings will be filtered at the tailing filtration plant before they are sent to the tailings facility. The external faces of the TSF will be covered with rock armoring to protect against erosion and minimize dust emissions. Dozers/roto-compactors will operate to spread, and compact material. This activity will produce dust emissions.

4.8.3.2 Plan II

The planned development of the Hermosa Project includes development of a second TSF on National Forest lands located to the northeast of the proposed Project area as a supplement to the existing TSF. The external faces of TSF2 will be covered with rock armoring to protect against erosion and minimize dust emissions. It will also produce dust emissions similar to the existing TSF.

4.8.4 Rock and Intermediate Piles

In Plan I, the TSF2 will not be developed so waste rock from both deposits will be transported from the mine to TSF1 and waste rock stockpiles for NAG and PAG. In Plan II, the TSF2 will be constructed so waste rock from both deposits will be transported from the mine to the TSF1 and/or TSF2. Additionally, for Clark, ore will also be stored in intermediate stockpiles. Dust emissions will occur due to wind erosion from these piles. Dozers/roto-compactors will operate to spread, and compact material at the Rock Piles. This will produce emissions of dust as well.

4.8.5 Power Generation (Natural Gas and Diesel Generators)

Natural gas and diesel generators will operate onsite to provide the power needed to operate the facility. As described earlier, there will be: Option 1. 58 2.6 MW natural gas engines or Option 2. 27 4.4 MW natural gas engines located on the Trench claim. If line power is available at the facility, South32 is proposing an alternate operating scenario (AOS 1) where only limited diesel engines may be required. Under AOS No. 1, all of the 58 natural gas generators (Option 1) or all of the 28 natural gas generators (Option 2) would be retired from use. There will be 12 diesel engines throughout the facility.

4.8.6 Fuel Storage Tanks

Storage tanks for diesel and gasoline will be required at the Hermosa Project. The tanks will be located near the aboveground gasoline dispensing facilities and other areas. These will be used to fuel machinery and vehicles that are onsite. There will be two diesel fuel storage tanks of 50,000 gallons capacity each besides other smaller gasoline and diesel tanks. Compressed Natural Gas (CNG)/Liquified Natural Gas (LNG) will also be stored in tanks onsite, but negligible VOC emissions, if any, are expected from these tanks.

4.8.7 Reagents Storage

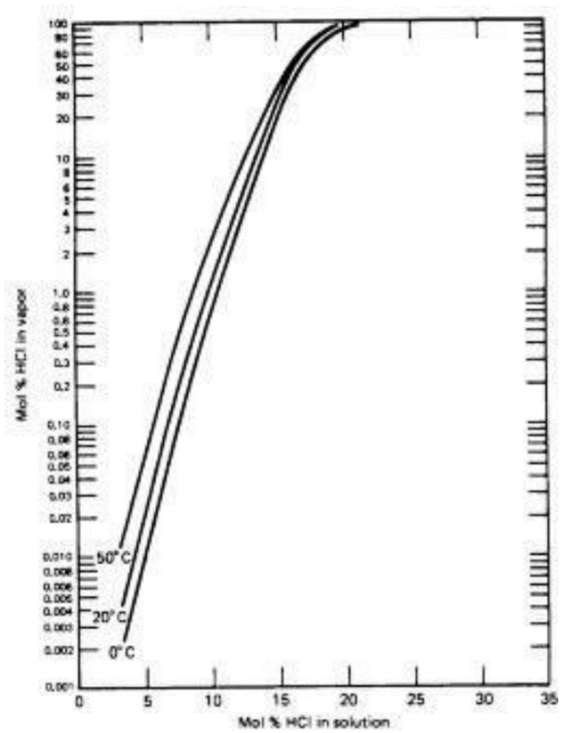
Various organic reagents will be used at the Hermosa Facility. The chemicals including sodium metabisulfite zinc sulphate, copper sulphate, zinc cyanide, lime, frothers (X-133 and MIBC), and collectors (A5100 and 3418A) will be shipped and stored at the Reagents Building. The compounds will be mixed and diluted in the Reagents Building and pumped to various parts of the Facility. Many of these compounds will produce VOC emissions. All materials which can evaporate VOCs shall be stored in closed containers when not in use to minimize VOC evaporation.

4.8.8 Water Treatment Plant and associated Cooling Towers

South32 is proposing to operate two water treatment plants (WTP1 and WTP2). No VOC containing chemicals would be used for water treatment at either. The WTP2 process involves the use of NaHS (sodium hydrosulfide) which will be delivered in totes and dosing will take place directly from the tote. Totes will be closed and equipped with a pressure safety valve to break the vacuum in the tote as NaHS is consumed and maintain tote's integrity. NaHS is stored at a high pH (>11) which ensure H2S will not be released. When NaHS is added to the process, it is dosed into a pipe reactor, allowing for full dissolution of the reagent – creating Na+ and HS- in solution. The feed water is controlled at a pH of 9, at which point sulfide will be predominantly present in the HS- form, with little H2S present. Due to sulfide's affinity for metals in solution, it will instantaneously react and precipitate the dissolved metals from the feed water, as well as the ferric chloride that is added upstream of the NaHS injection, leaving no remaining sulfide under normal operating conditions. Additionally, there are control interlocks in place to prevent conditions where there is not a sufficient metal concentration to consume the H2S (i.e., if there is low flow, or low pH in the feed line, the NaHS addition will stop).

However, HCl is a component of the Ferric Chloride being used to treat the process water. To determine if any emissions are expected, Trinity reviewed the SDS and EPA guidance on HCl emissions and aerosols. Based on the Safety Data Sheet (SDS), the HCl has a weight percentage of less than 0.5% in the Ferric Chloride. According to EPA Guidance in "Hydrochloric Acid Aerosols", "The solubility of HCl in water at atmospheric pressure is 42% by weight at 20°C. It is essentially totally ionized in solution. (. . .) Concentrated hydrochloric acid solutions (~37%) fume readily in moist air." However, the 0.5% weight percentage of HCl present in the Ferric Chloride is significantly below the levels at which HCl mist readily forms, per the EPA's guidelines. Furthermore, the EPA has developed a chart (see below) that compares vapor mole percentage to solution mole percentage. At the chart's lowest value at approximately 3 mol% in solution, the mole percentage in the vapor is around 0.004%. According to the SDS, the Ferric Chloride has an HCl mol% of 0.003%. When comparing this figure with the chart, the mole percentage in the vapor is near zero and should be considered negligible.

Figure 4-1. Mole % of HCl in vapor vs in mole % of HCl in solution[6]



Similarly, the WTP2 process involves use of NaHS which will be delivered in totes and dozing will take place directly from the tote. Totes will be closed and equipped with a pressure safety valve to break the vacuum in the tote as NaHS is consumed and maintain the tote's integrity. NaHS is stored at a high pH (>10) which ensure H_2S will not be released. When NaHS is added to a lower-pH solution (feed water), it will dissociate to Na+ and HS-, the HS- will bind to H+ in the water and form H_2S (about 50% of the NaHS will turn into H_2S at pH 7). However, the H_2S will instantaneously react and precipitate the dissolved metals from the feed water as well as the ferric chloride that is added upstream of the NaHS injection, leaving no remaining H_2S under normal operating conditions. As such, there are no emissions to calculate from the open-top sand ballasted clarifier used at TWP2. There are control interlocks in place to prevent conditions where there is not a sufficient metal concentration to consume the H_2S (i.e., if there is low flow, or low pH in the feed line, the NaHS addition will stop).

The PM, PM_{10}, and $PM_{2.5}$ emissions from material handling drops associated with the reagent chemicals used at WTP2 have been accounted for.

Cooling towers will be used to cool water prior to treatment at the water treatment plant - WTP2. PM, PM_{10}, and $PM_{2.5}$ will be emitted by the cooling towers due to trace amounts of Total Dissolved Solids (TDS) in the water.

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[6] Toxics Release Inventory Guidance for Reporting Hydrochloric Acid (acid aerosols including mists, vapors, gas, fog, and other airborne forms of any particle size). EPA 745-B-19-017. February 2019. Washington, DC 20460: U.S. EPA, OPPT

4.8.9 Refrigeration Plants

Two refrigeration plants will be located aboveground at the mine to provide cooling for the underground mine air. This refrigeration plant is composed of a chiller system (which uses centrifugal chillers, a cooling tower, and tanks) and a bulk air cooler system. PM, PM_{10}, and $PM_{2.5}$ emissions will be emitted by the cooling towers associated with the refrigeration plants due to trace amounts of TDS in the water.

4.8.10 Traffic on Unpaved Roads

Truck traffic associated with the proposed operations is expected to be from the following:

- Delivery vehicles, to transfer the following materials into/out of site:
  - Diesel and gasoline fuel;
  - CNG/LNG fuel for natural gas engines;
  - Blasting agents;
  - Chemical reagents;
  - Zinc, silver, manganese, and lead concentrates/ore;
  - Cement; and
  - Materials and supplies.
- Transport of ore/concentrate within site;
- Transport vehicles for onsite transfer of rock and tailings;
- Bulldozers/Roto-compactors;
- Fuel and maintenance vehicles;
- Watering trucks; and
- Personnel transport vehicles

The unpaved aboveground and underground road traffic will produce PM, PM_{10}, and $PM_{2.5}$ emissions. The unpaved road fugitive emissions will be mitigated by control measures such as watering.

4.8.11 Concrete Batch Plant

There will be two separate concrete batch plants (CBP), one for Taylor and one for Clark. The concrete batch plants will provide cement to be used as a binder, that when mixed with tailings, is used for stabilizing mine conditions to make the underground environment safer and to reduce the risk of subsidence. Particulate matter (PM, PM_{10}, $PM_{2.5}$) is emitted from various material transfer points within the process. Emissions were calculated utilizing emission factors from AP-42, Section 11.12, Table 11.12-2 and the maximum rate capacities of associated equipment. Each CBP will have aggregate and shotcrete stockpiles and associated emissions from wind erosion of these piles.

4.8.12 Evaporators

The water collected from the tailings storage facility is pumped to the water treatment plants for treatment. Prior to treatment, this water is collected in an Underdrain Collection Pond which will have mechanical evaporators installed to maintain the freeboard ratio of the ponds. The evaporators generate PM_{10} and $PM_{2.5}$ emissions. Emissions were calculated using an adapted emission rate based on atomizer evaporator sampling campaigns conducted. Note that only 3 of the planned 4 evaporators would be used at any time and only for 10% of the year.

4.9 Product Description

The primary products from the Project will be zinc concentrate, lead concentrate, silver concentrate and crushed manganese ore.

4.10 SIC Code

The proposed operations fall under the SIC codes 1031 (mining – lead and zinc ore), 1044 (mining – silver ore), and 1061 (mining – ferroalloy ores, except vanadium). The proposed operations fall under NAICS codes 212230 (Copper, nickel, lead and zinc mining) and 212290 (Other metal ore mining).

4.11 Operating Schedule

The proposed mine is seeking authorization to operate 24 hours per day, 7 days a week and 365 days per year for the life of the mine.

4.12 Voluntary Limits

Pursuant to A.A.C. R18-2-304.F.5, South32 may elect to accept voluntary limits in accordance with R18-2-306.01. South32 will include any such voluntary limits in the air dispersion modeling report which have been submitted under separate cover.

5. SITE & PROCESS FLOW DIAGRAMS

5.1 Site Mining History

Mining in the Harshaw District dates from mid-18th century Spanish Colonial times but is poorly documented before the 1870’s. Early unnamed small-scale miners in the Hermosa area developed small tonnages of milling and direct-shipping oxidized ores from a number of small individual mines. Important production of direct-shipping manganese ores was recorded during World Wars I and II and the Korean War. ASARCO operated a mine at the Facility between 1939 and 1949 and produced lead, zinc, silver, and copper from a fissure vein sulfide deposit. ASARCO explored the Hermosa property with intermittent drill programs from 1940 through 1991, supplemented with geological mapping. Exploration has been conducted on the property since 2006.

5.2 Location

The proposed Hermosa Project is located approximately 24 kilometers (~15 miles) east-northeast of Nogales, Arizona in Santa Cruz County. Figure 5-1 and Figure 5-2 provides the general location of the site with respect to southern Arizona as well as surrounding cities and highways. Regionally, the Hermosa Project is located in the northern section of the Patagonia Mountains, a region with a long history of mining and which is characterized by forests and grasslands interspersed with areas of exposed rocks and jutting mountains. The Hermosa Project lies at approximately 1,585 meters above sea level with higher elevations to the north, west, and south. Figure 5-3 through Figure 5-11 include overall site plans during Plan I and Plan II, including property boundaries, as well as zoomed-in maps of the beneficiation areas for Taylor and Clark. Figure 5-12 contains process flow diagrams (PFDs) of the proposed operations at Taylor and Clark.

Figure 5-1. Hermosa Project - Location Map - Plan I

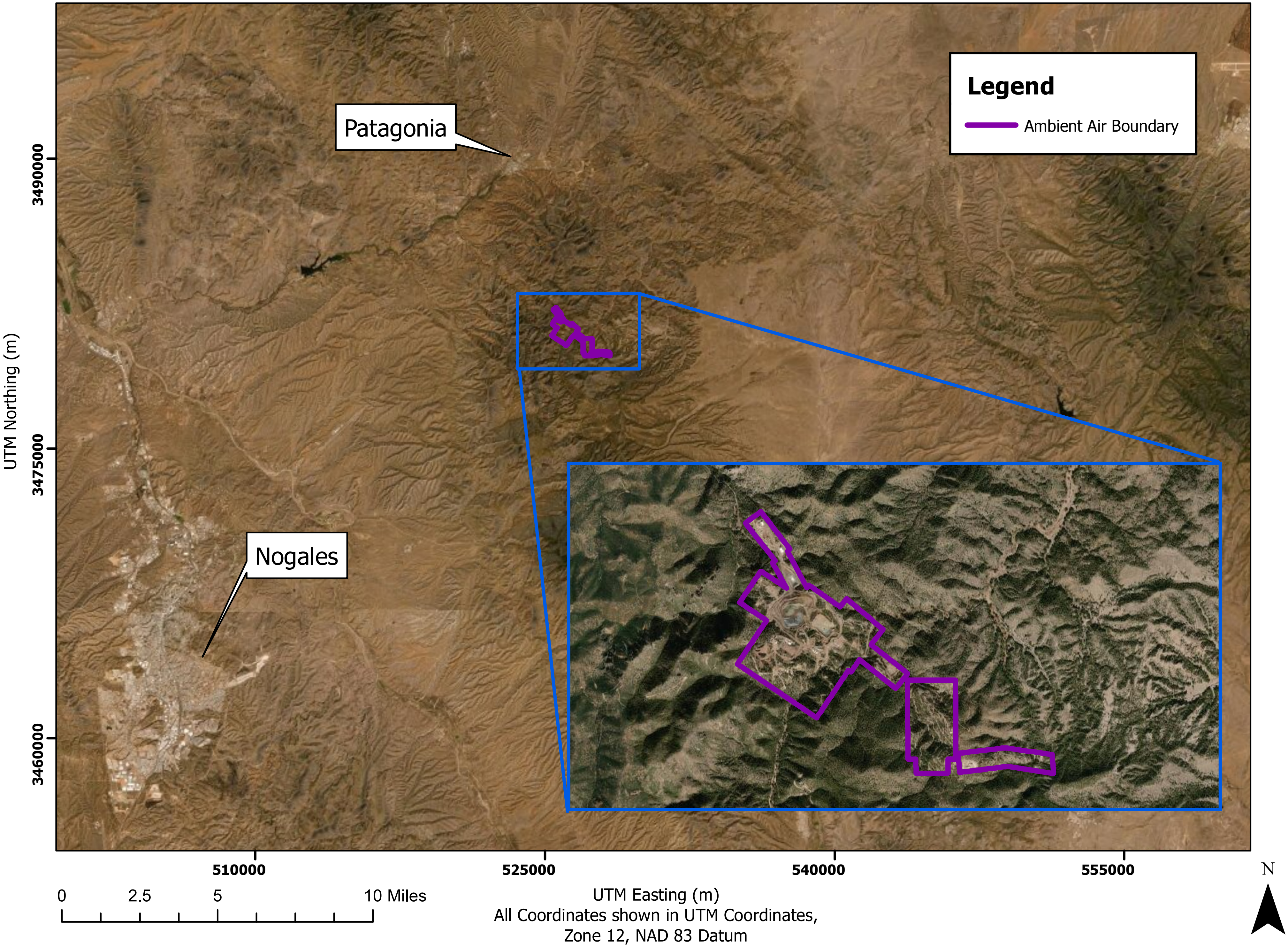


Figure 5-2. Hermosa Project - Location Map - Plan II

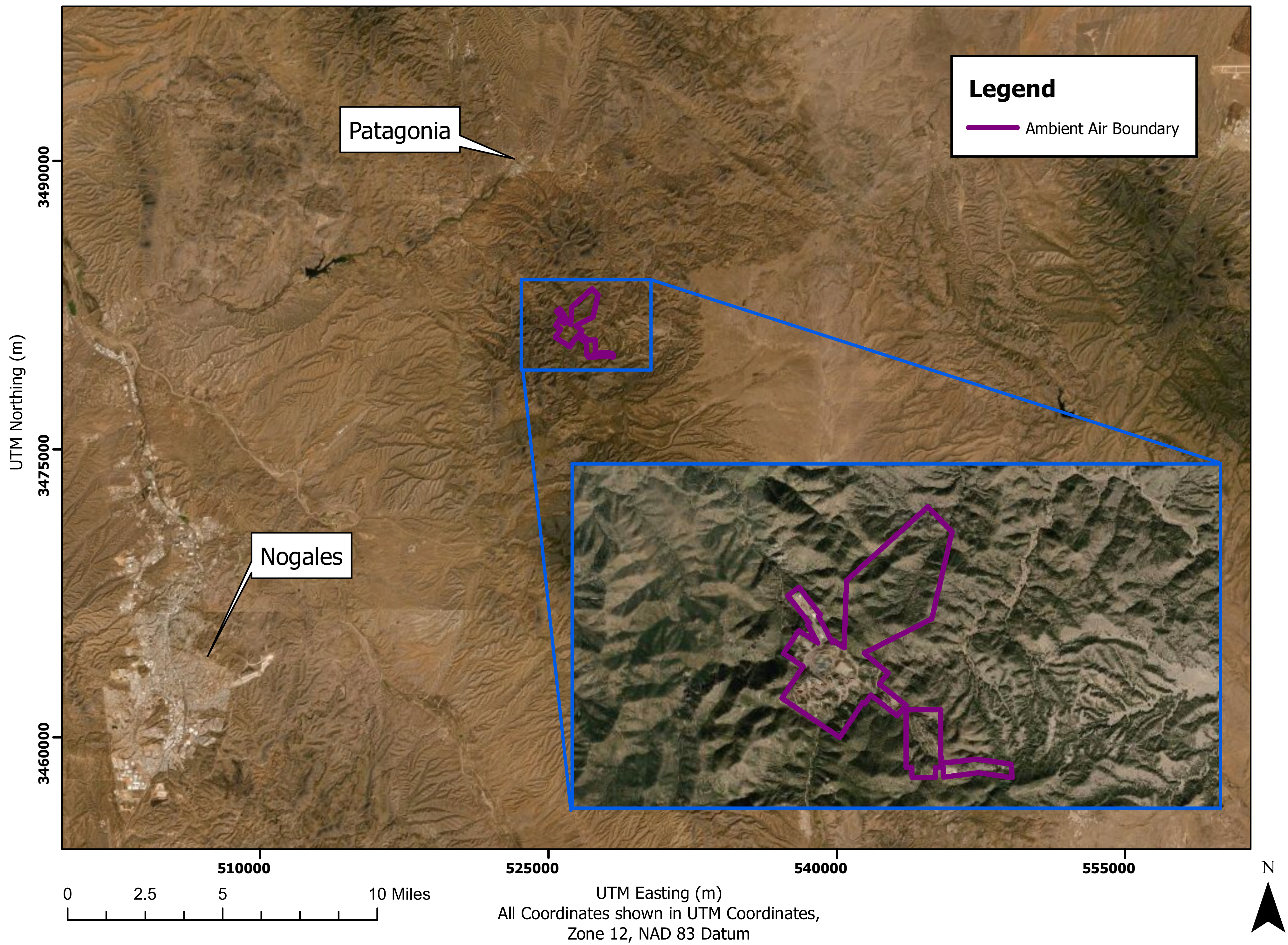
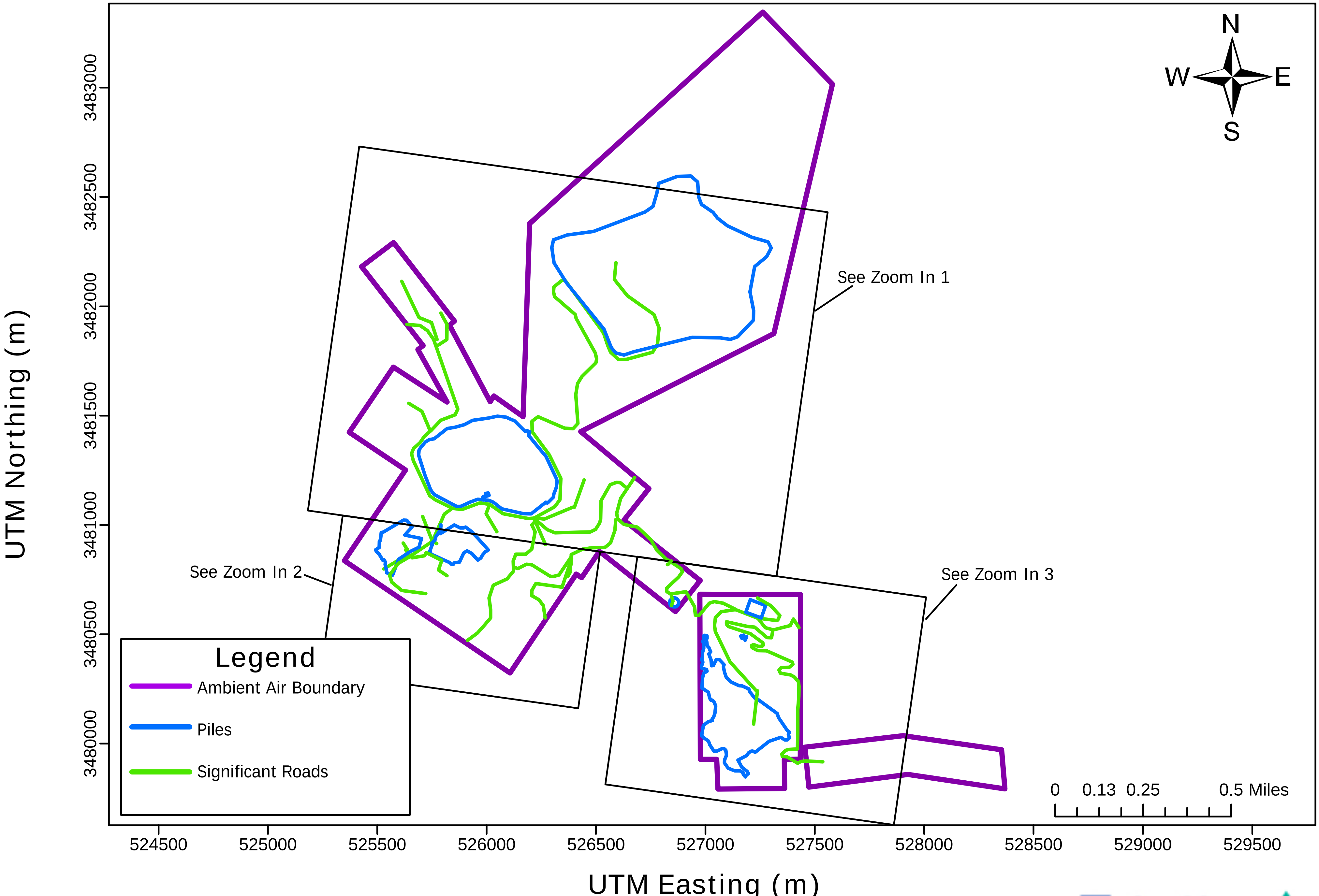


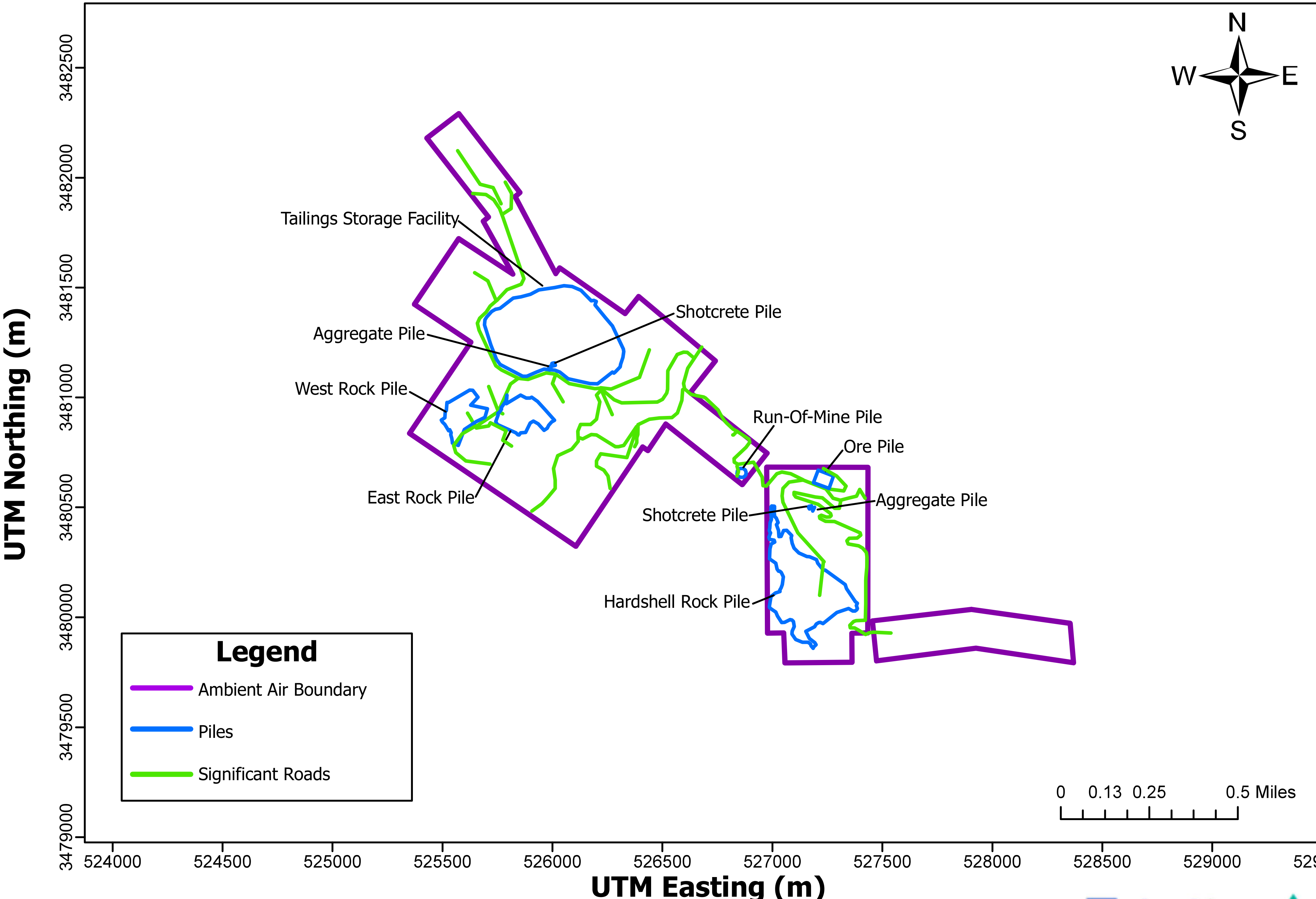
Figure 5-3. Hermosa Project - Zoom In Locations



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

Trinity Consultants

Figure 5-4. Hermosa Project - Piles and Roads - Plan I



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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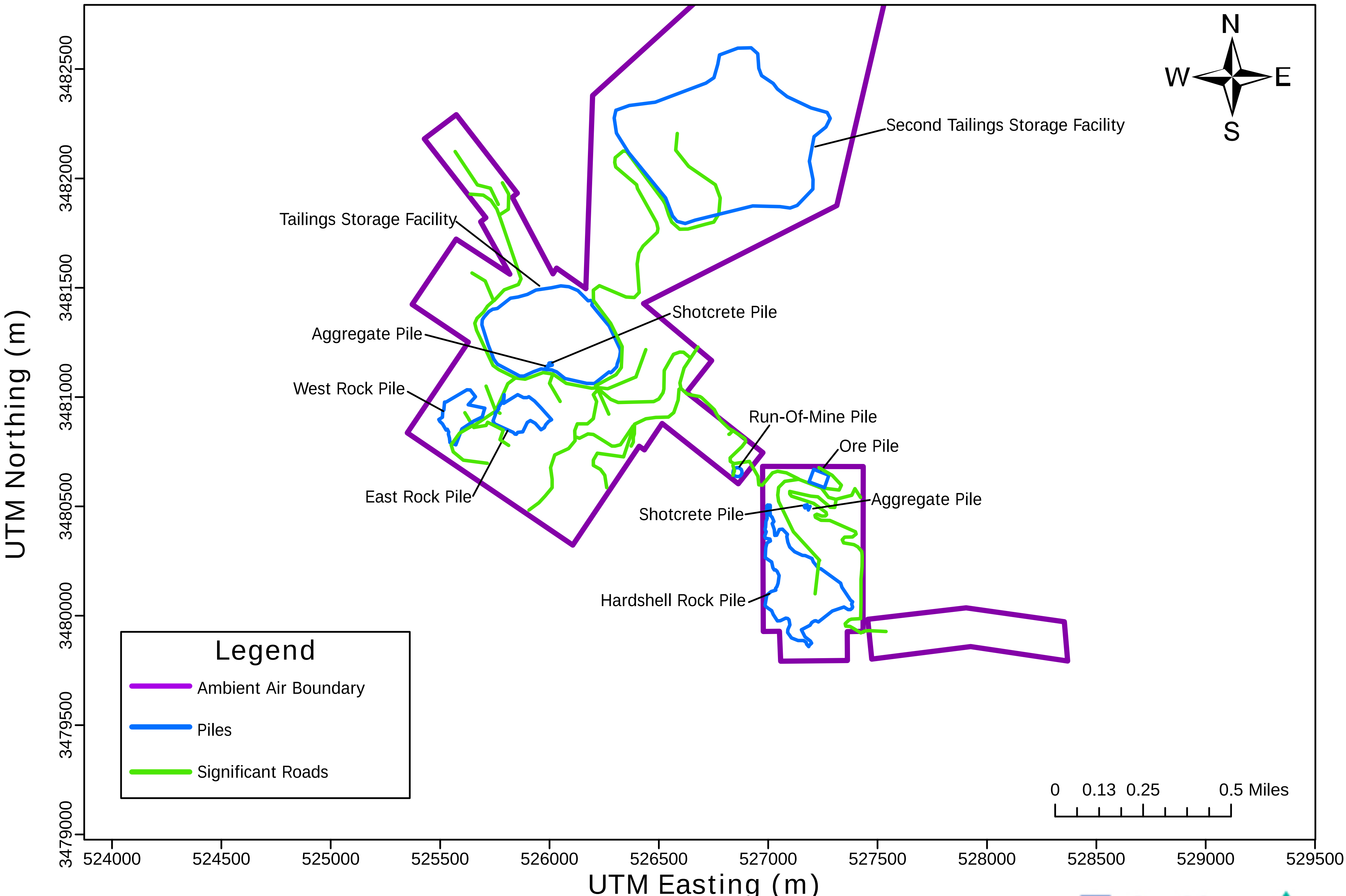
Figure 5-5. Hermosa Project - Piles and Roads - Plan II



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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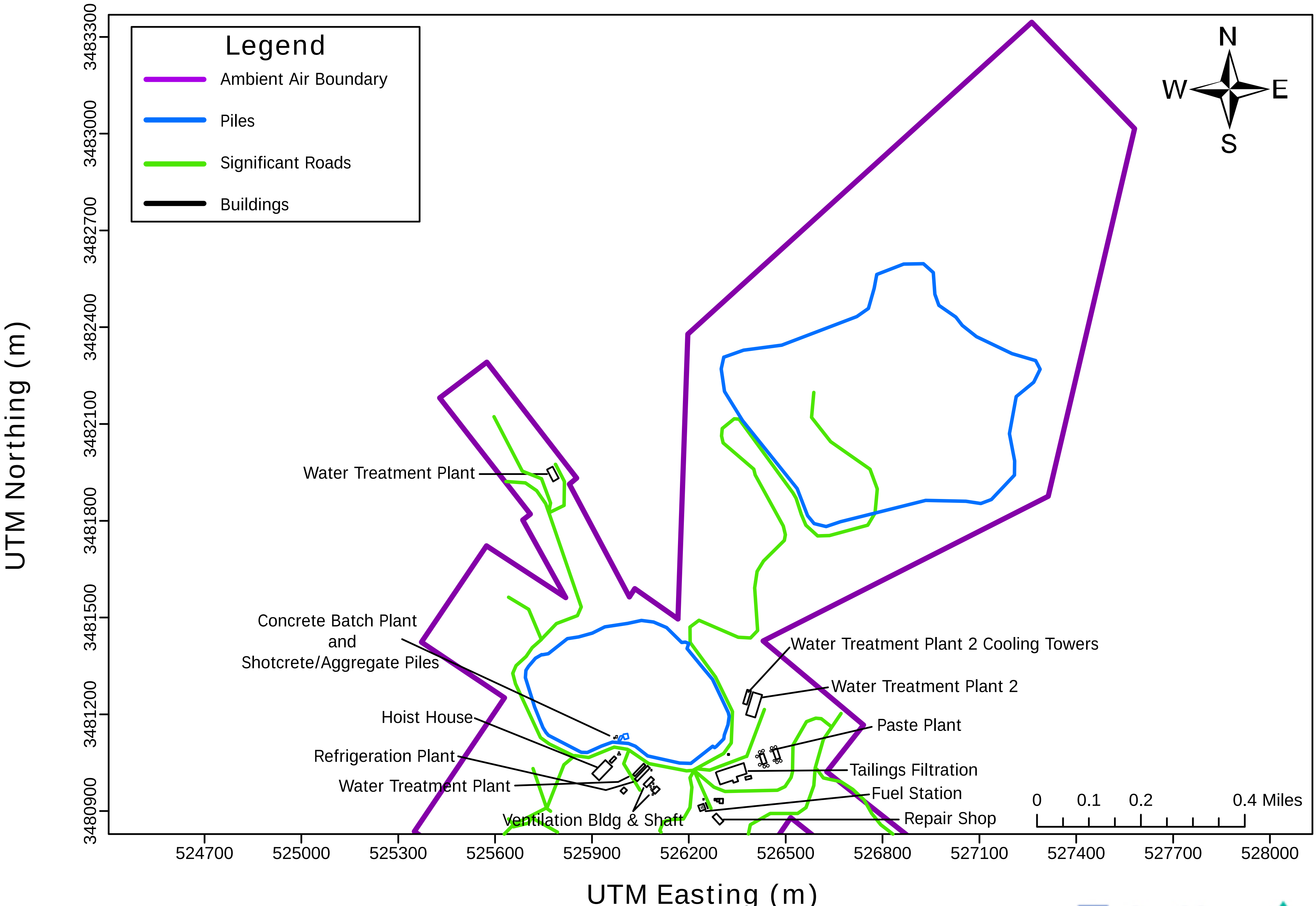
Figure 5-6. Hermosa Project - Building Zoom In 1



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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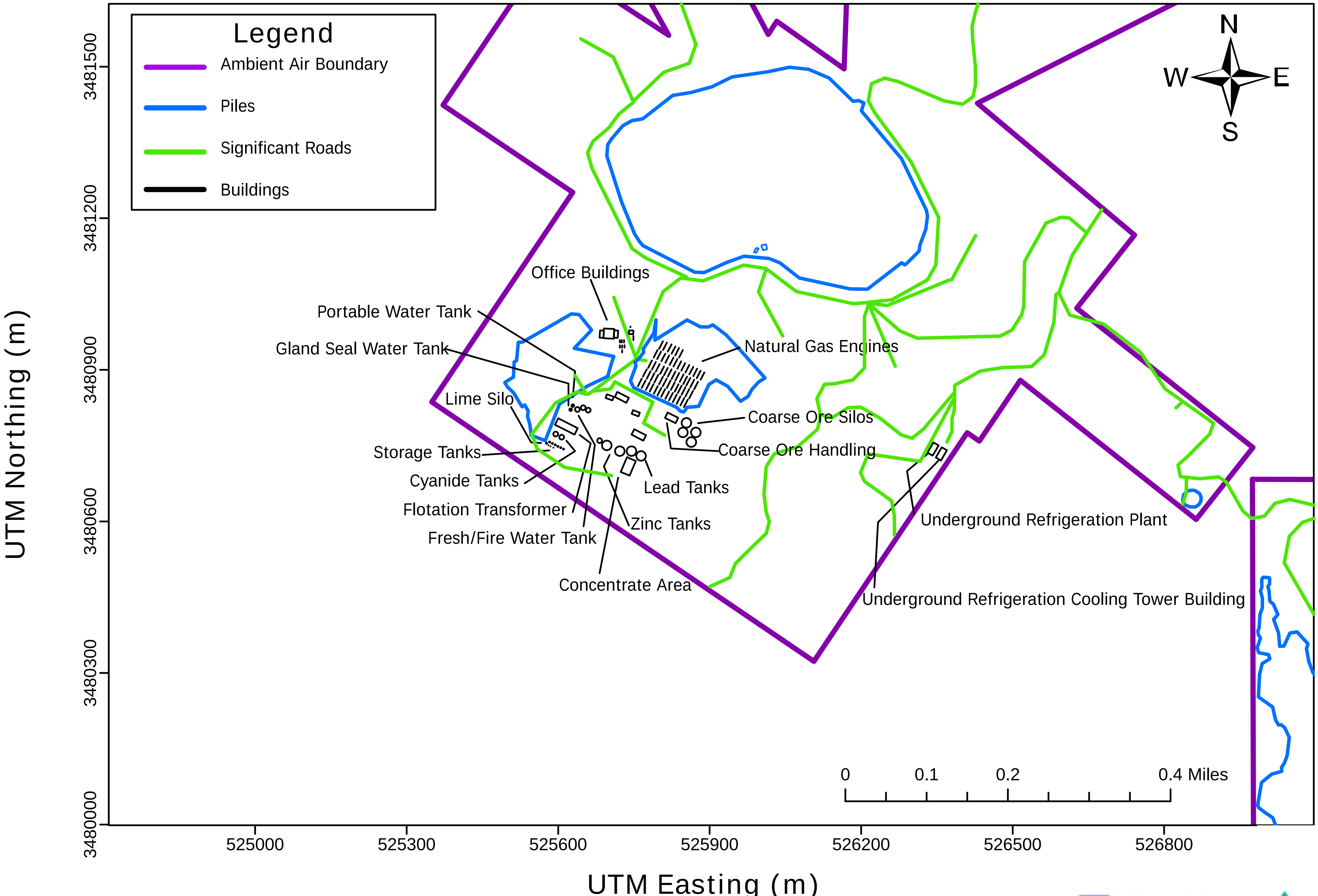
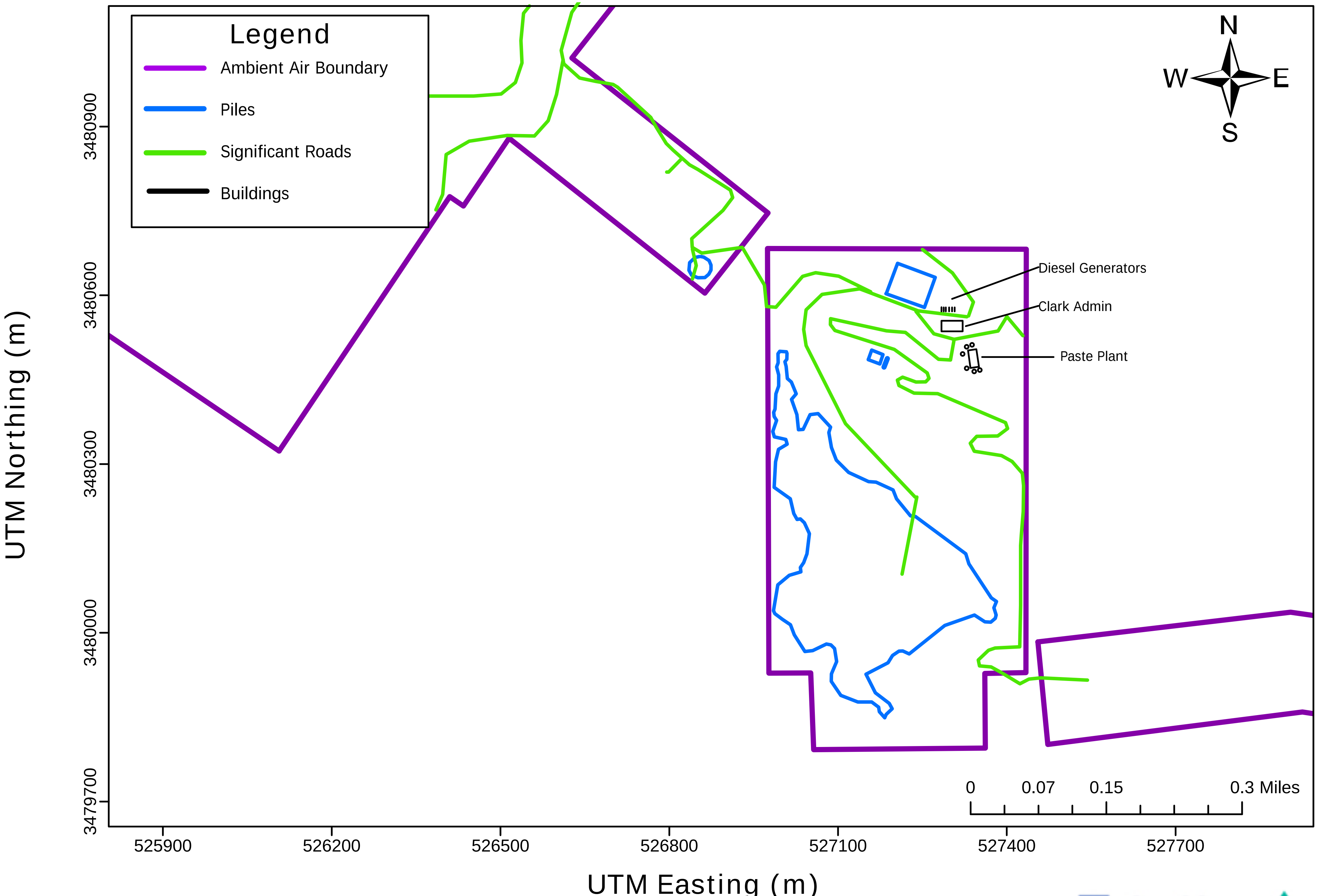
Figure 5-7. Hermosa Project - Building Zoom In 2



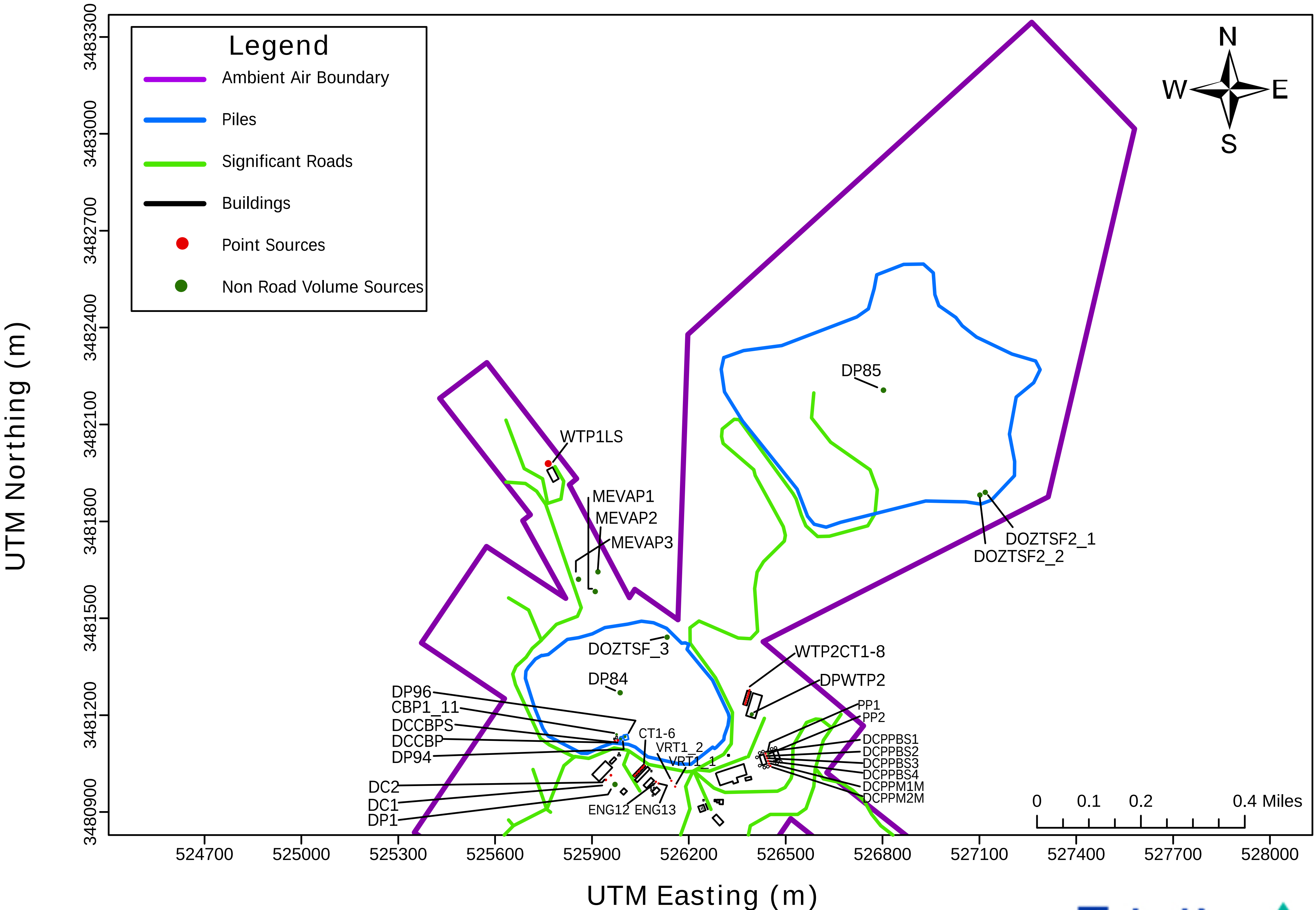
All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

Figure 5-8. Hermosa Project - Building Zoom In 3



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

Figure 5-9. Hermosa Project - Emission Sources Zoom In 1



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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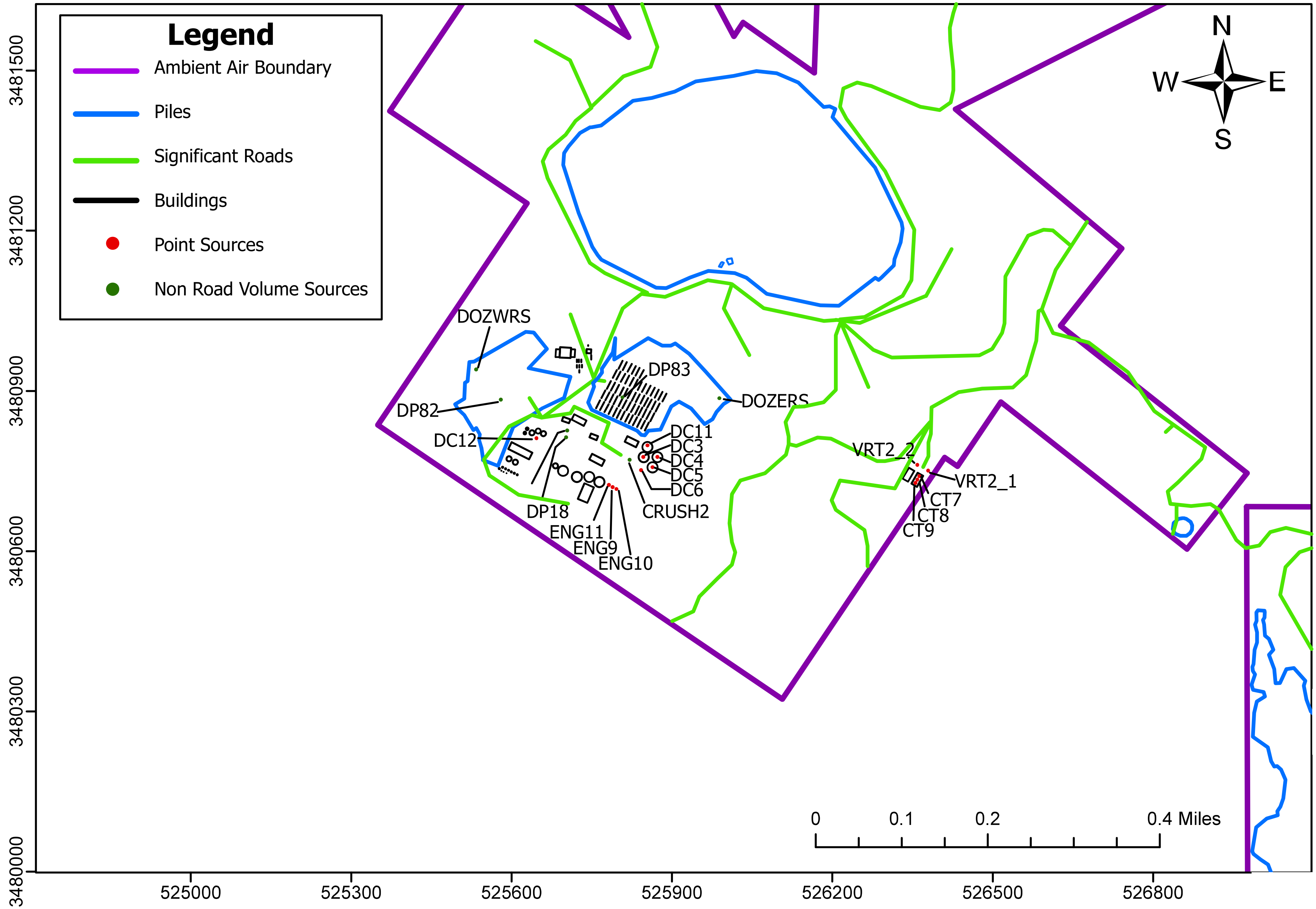
Figure 5-10. Hermosa Project - Emission Sources Zoom In 2



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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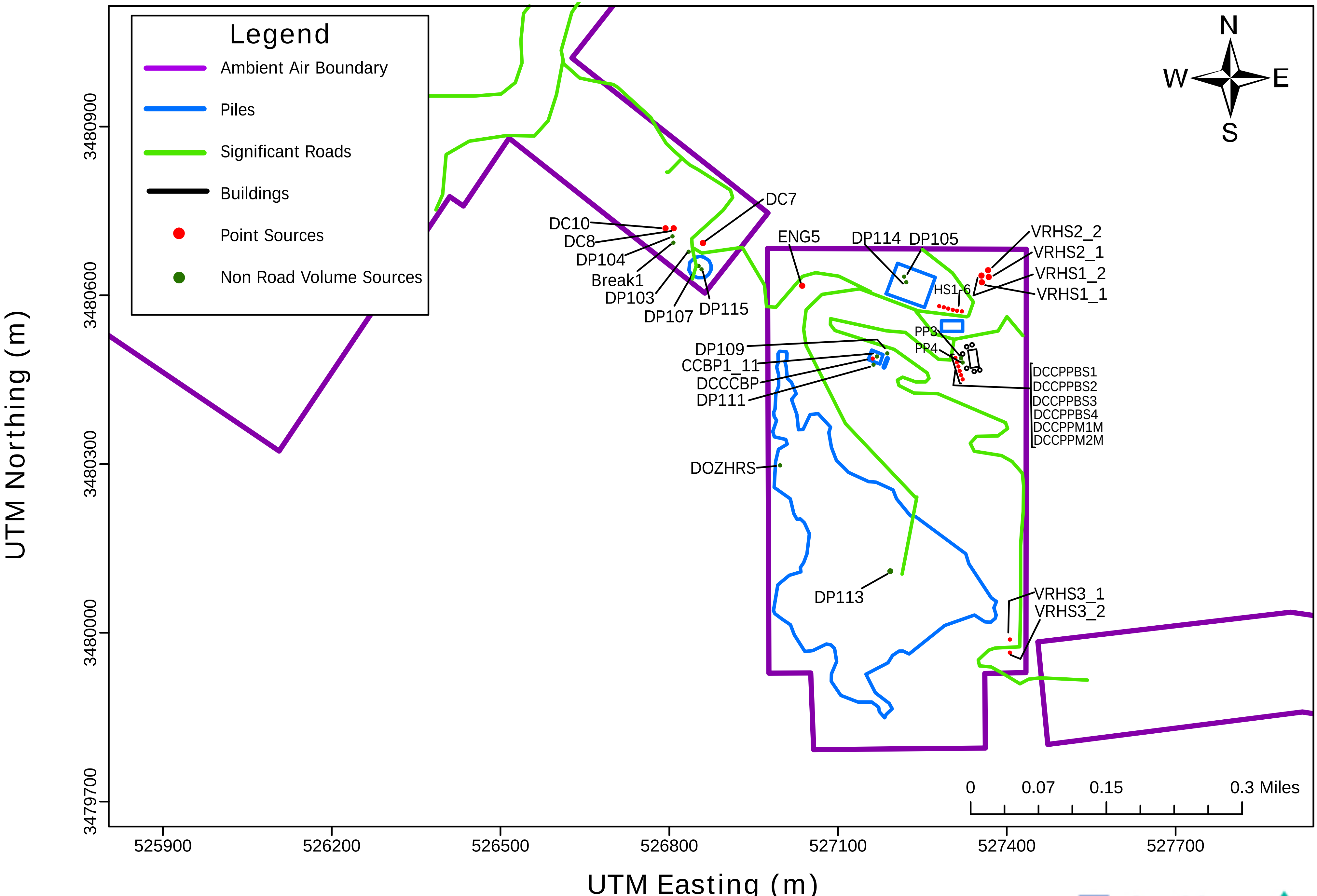
Figure 5-11. Hermosa Project - Emission Sources Zoom In 3



All Coordinates shown in UTM Coordinates,
Zone 12, NAD 1983

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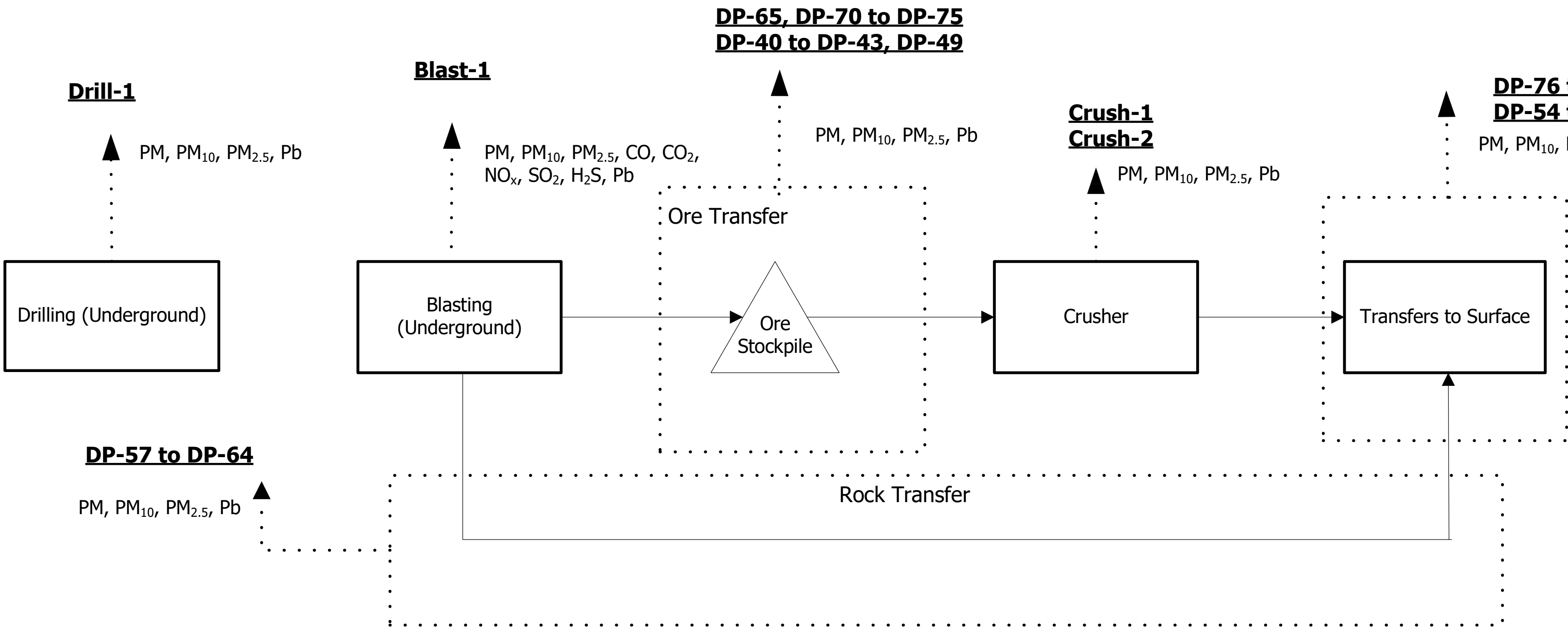
Drilling, Blasting, and Crushing for Taylor Deposit



Legend

Material Flow

Air Emissions

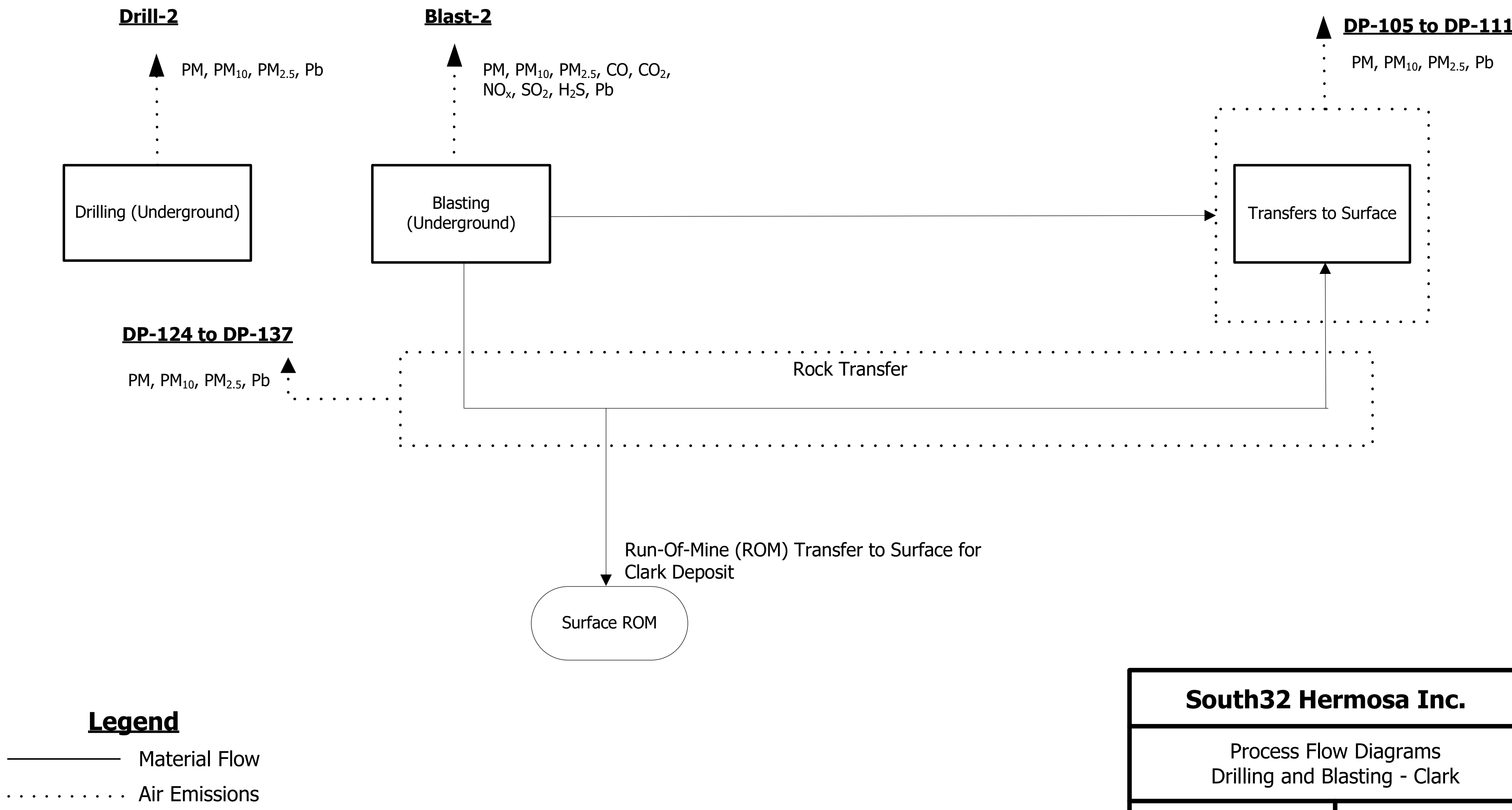
South32 Hermosa Inc.

Process Flow Diagrams
Drilling, Blasting, and Crushing - Taylor

Trinity Consultants

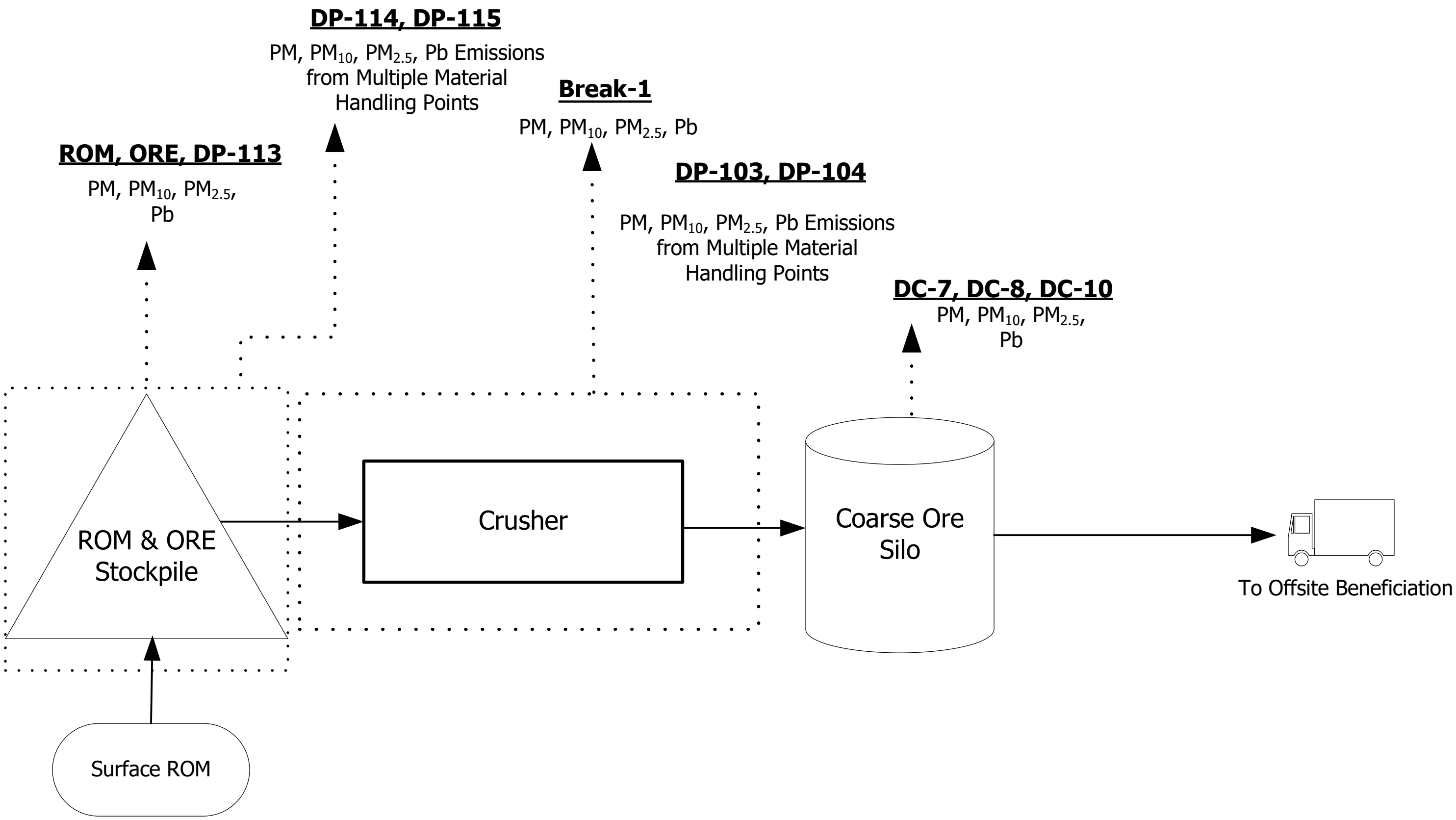
November 2023

Drilling and Blasting for Clark Deposit



South32 Hermosa Inc.
Process Flow Diagrams Drilling and Blasting - Clark
Trinity Consultants — January 2024

Clark Ore Crushing



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Material Flow

Air Emissions

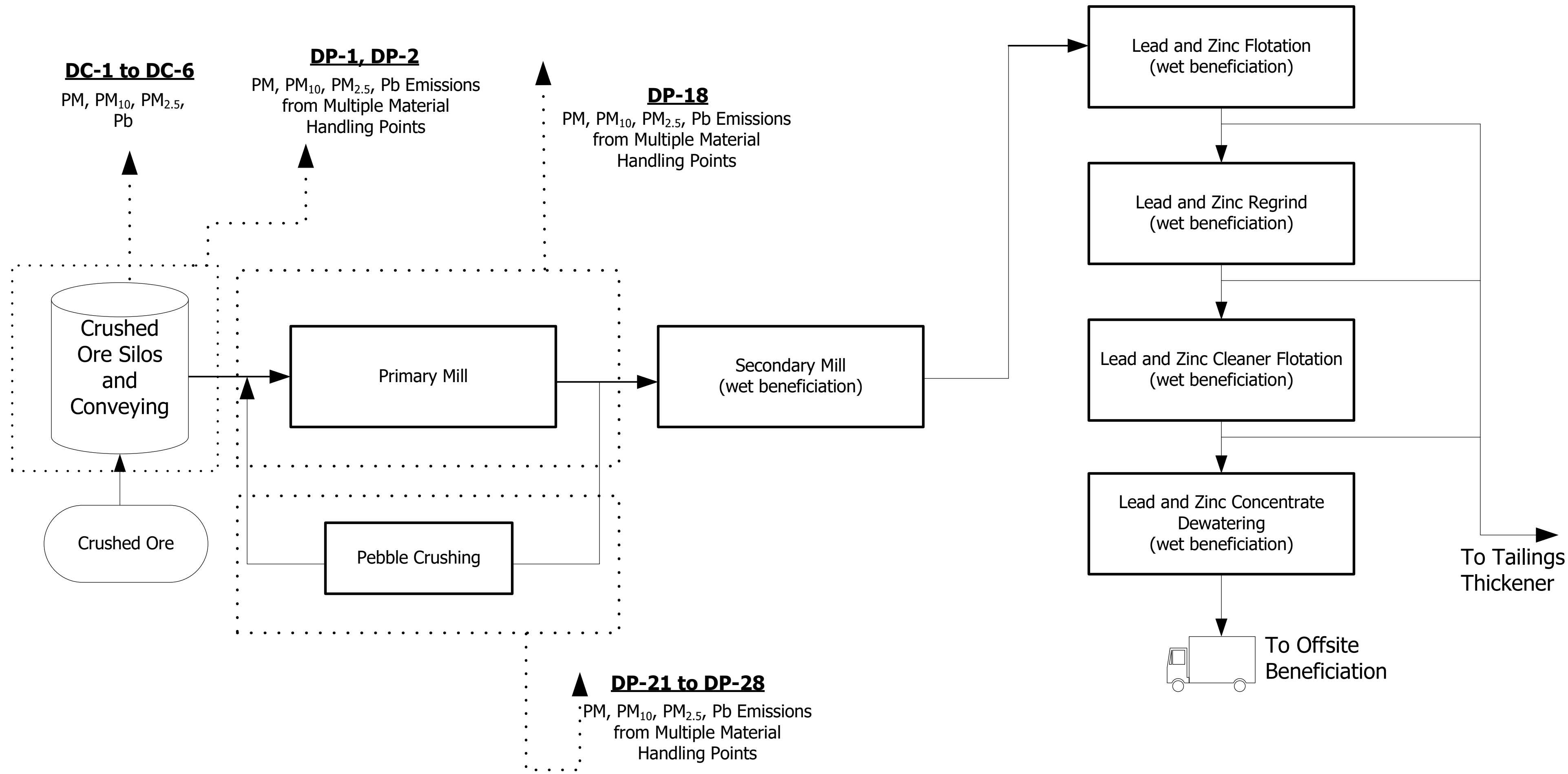
South32 Hermosa Inc.

Process Flow Diagrams
Clark Ore Crushing

Trinity Consultants

January 2024

Ore Beneficiation for Taylor Deposit



Legend

- Material Flow (solid line)
- Air Emissions (dotted line)

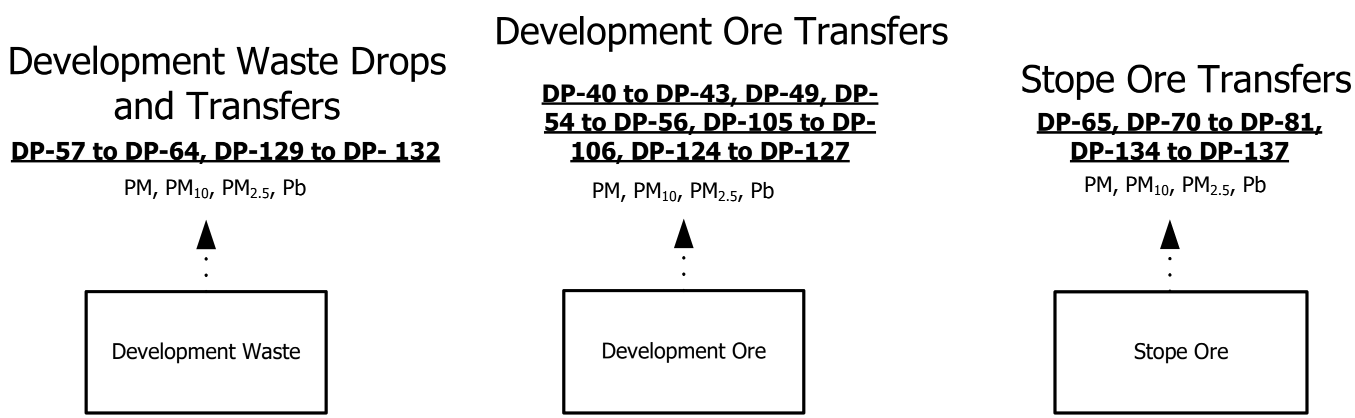
South32 Hermosa Inc.

Process Flow Diagrams
Ore Beneficiation - Taylor

Trinity Consultants

November 2023

Miscellaneous Drops and Transfers



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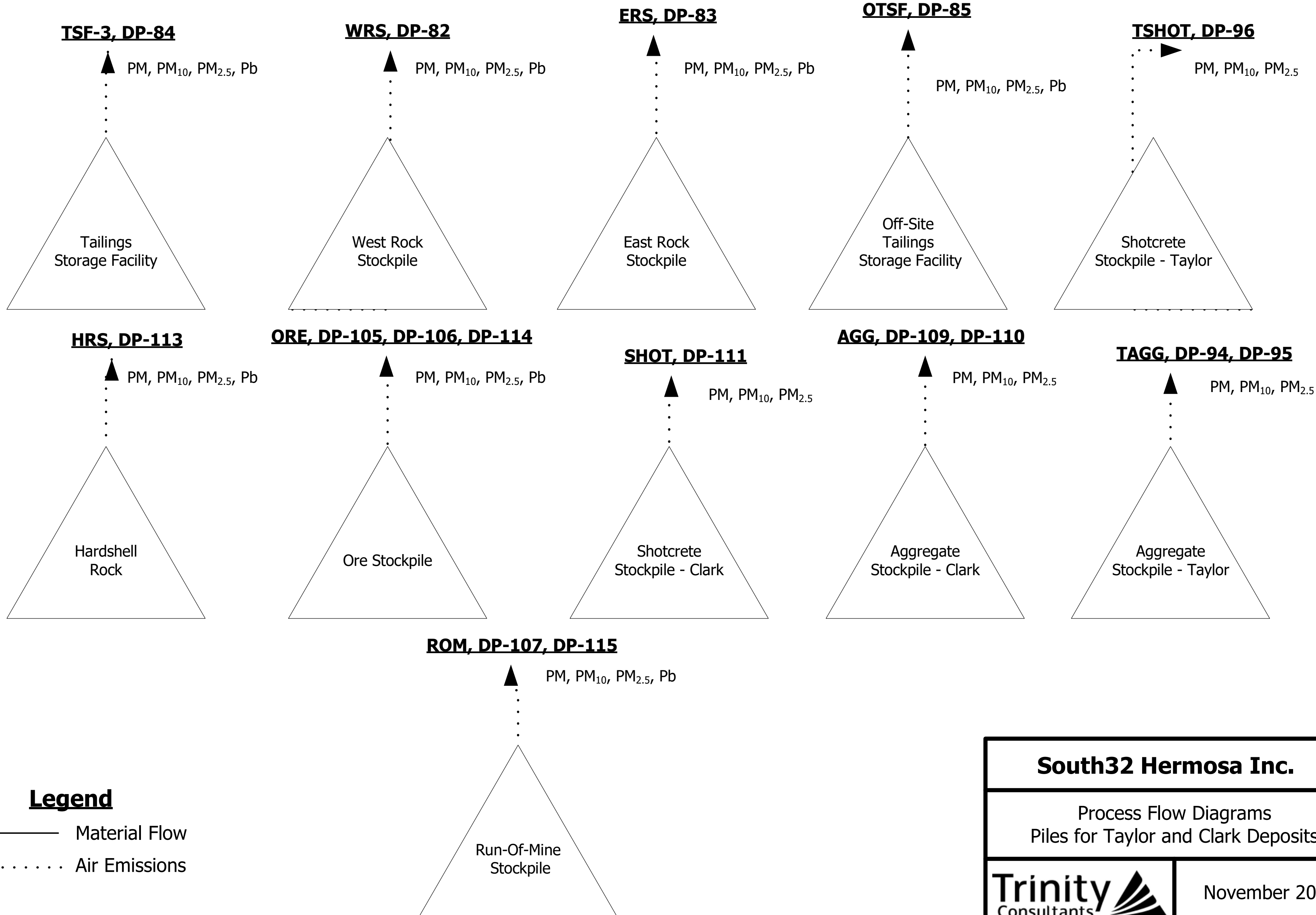
———— Material Flow

. . . . Air Emissions

South32 Hermosa Inc.	
Process Flow Diagrams Miscellaneous Drops and Transfers	
Trinity Consultants	November 2023

Piles for Taylor and Clark Deposits



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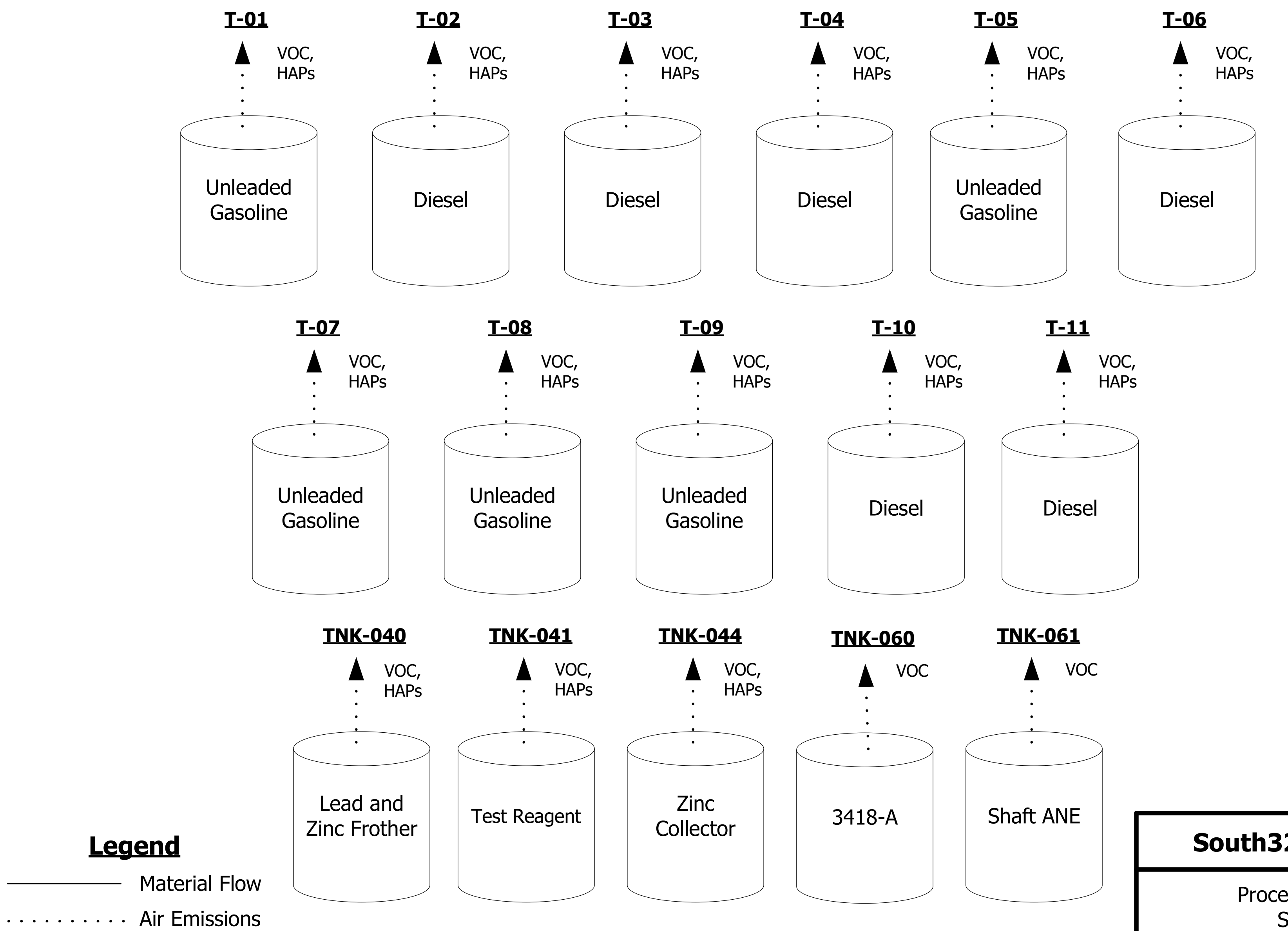
Material Flow (solid line)
Air Emissions (dotted line)

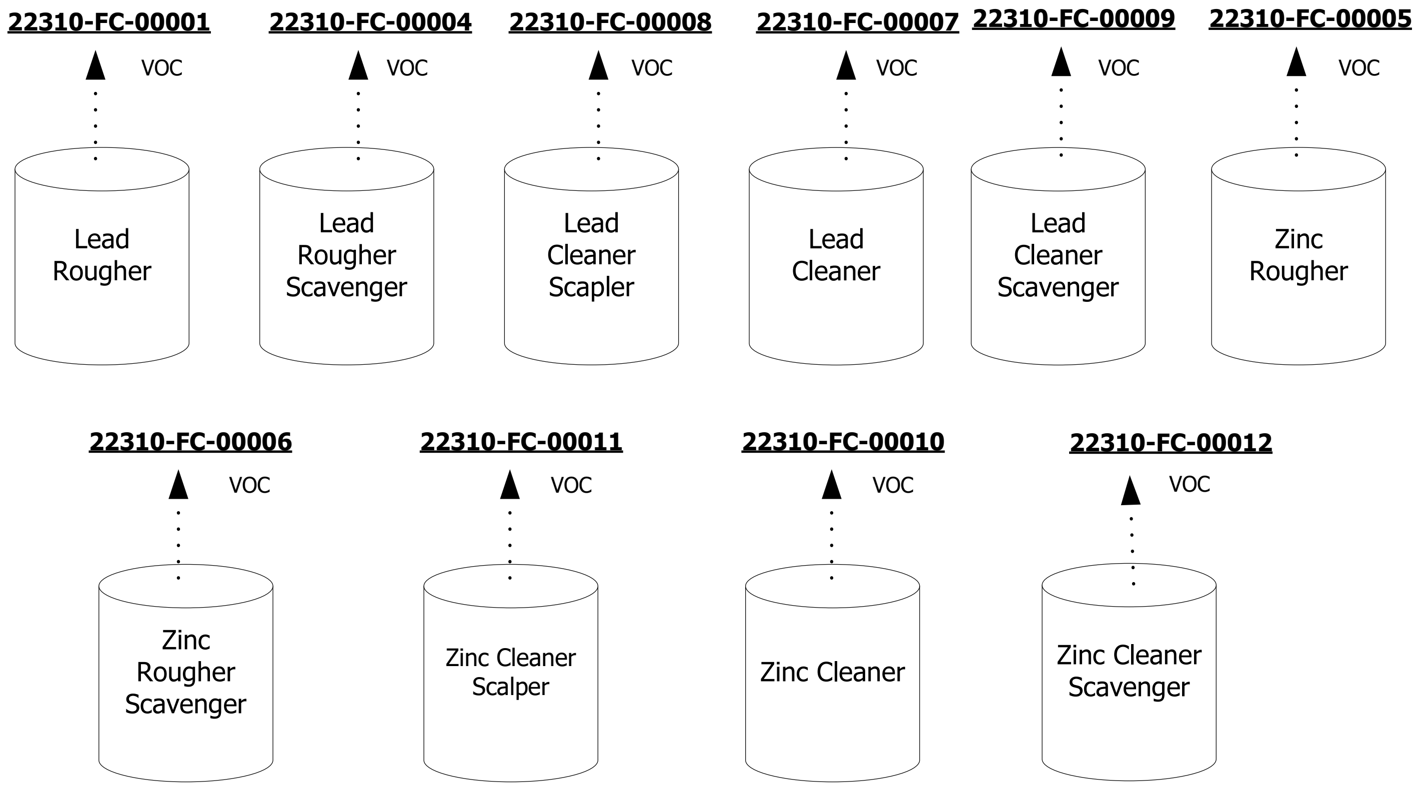
South32 Hermosa Inc.	
Process Flow Diagrams Piles for Taylor and Clark Deposits	
Trinity Consultants	November 2023

Storage Tanks



South32 Hermosa Inc.	
Process Flow Diagrams Storage Tanks	
Trinity Consultants	November 2023

Process Tanks



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———— Material Flow

· · · · · · · · · · Air Emissions

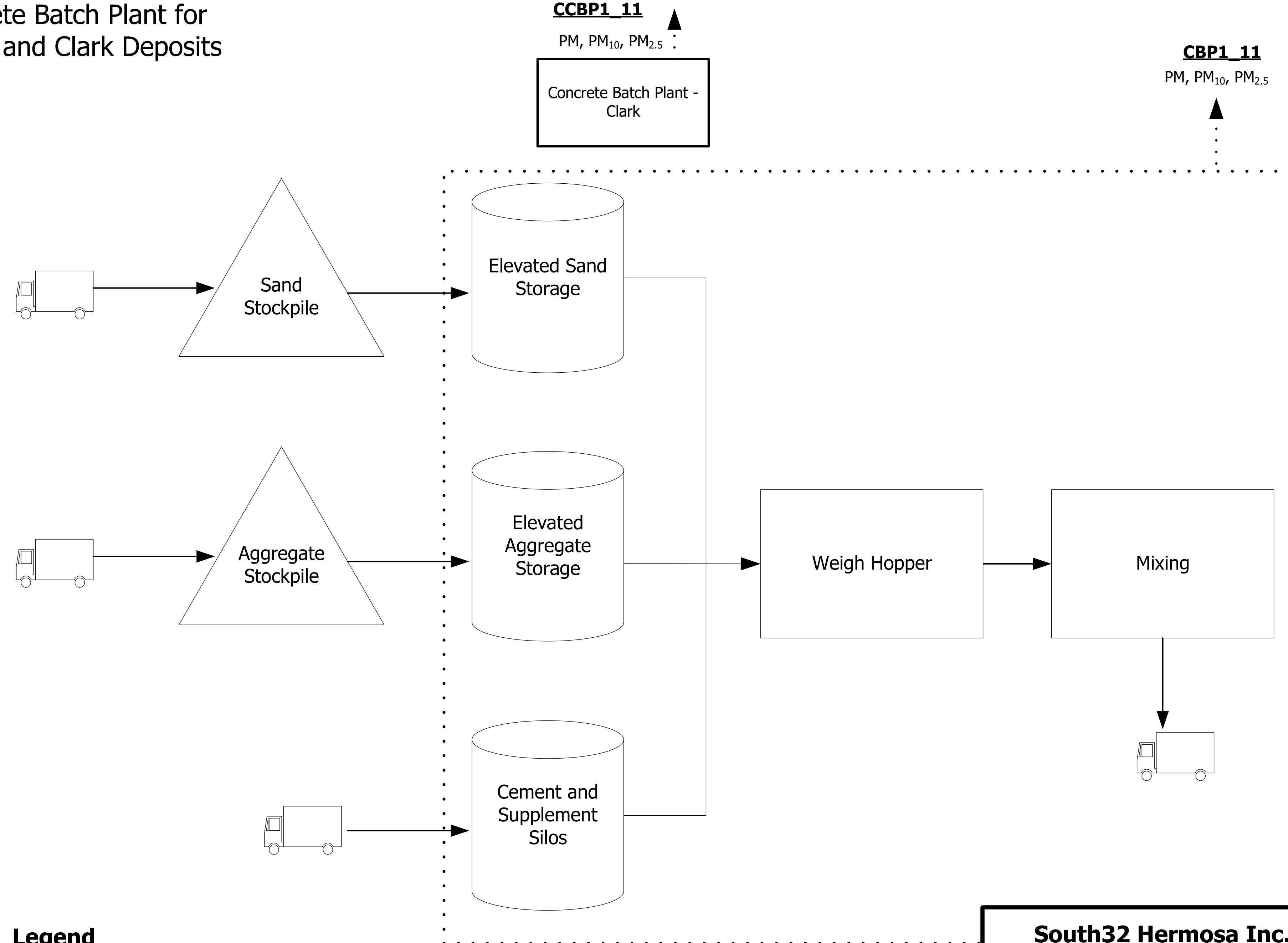
South32 Hermosa Inc.

Process Flow Diagrams
Process Tanks

Trinity Consultants

November 2023

Concrete Batch Plant for
Taylor and Clark Deposits



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Material Flow
Air Emissions

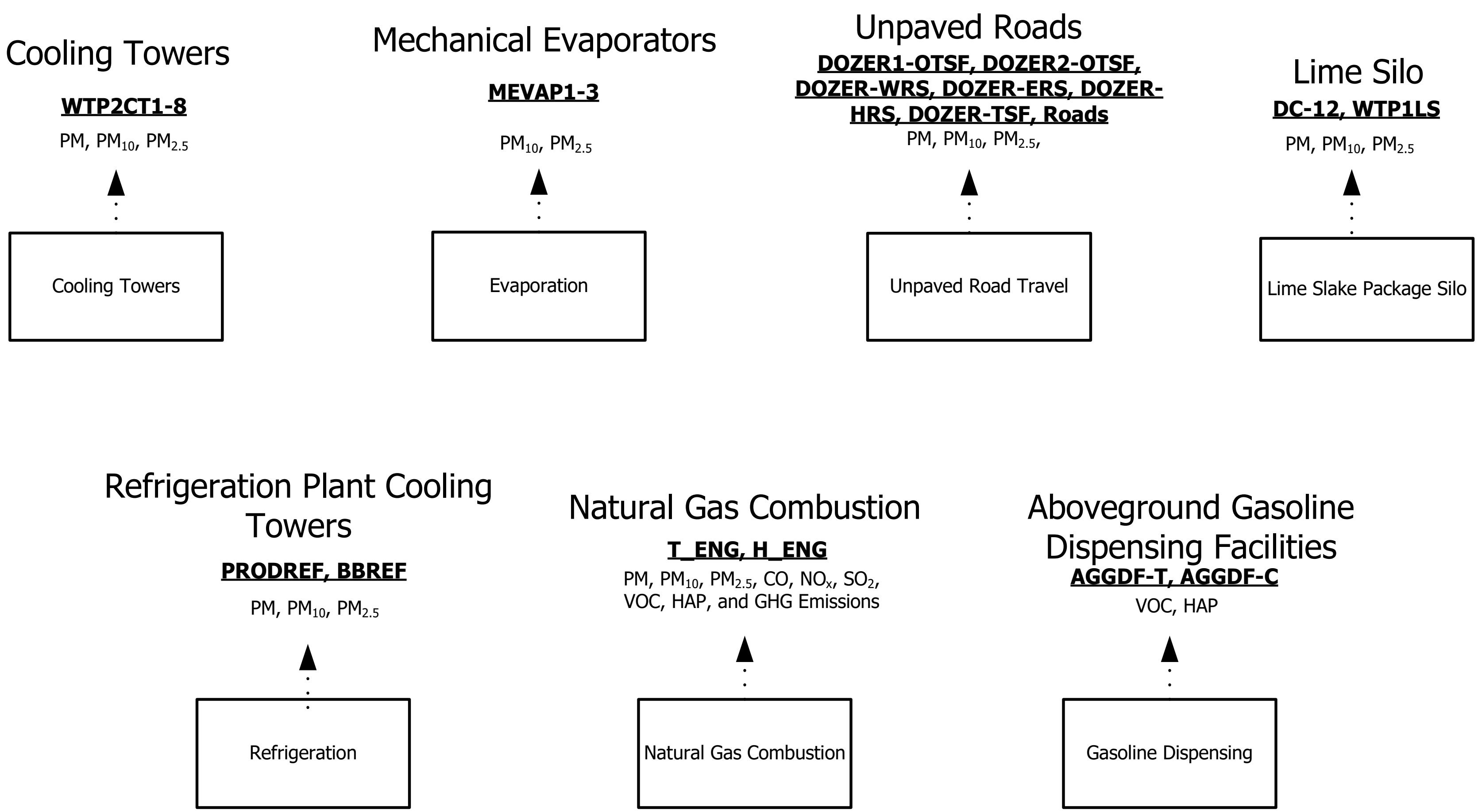
South32 Hermosa Inc.

Process Flow Diagrams
Concrete Batch Plant

Trinity Consultants

November 2023

Auxiliary Operations



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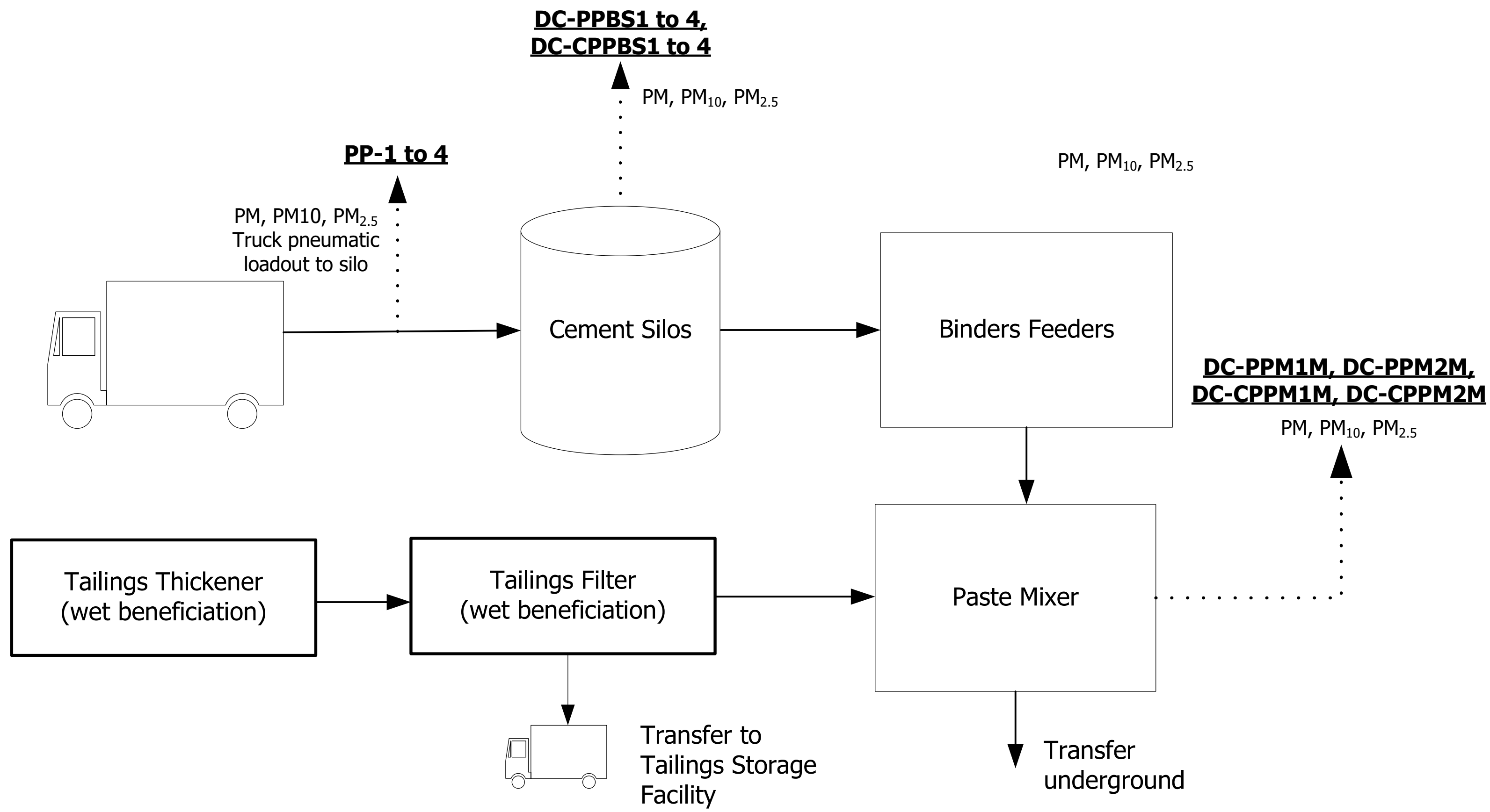
——— Material Flow

· · · · · · · · · · Air Emissions

South32 Hermosa Inc.	
Process Flow Diagrams Auxiliary Operations	
Trinity Consultants	November 2023

Clark and Taylor Paste Plants



Legend

Material Flow (solid line)

Air Emissions (dotted line)

South32 Hermosa Inc.

Process Flow Diagrams
Paste Plant

Trinity Consultants

November 2023

6. EMISSION CALCULATIONS

The proposed operations at the Hermosa Project have the potential to emit PM, PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOC, Lead, HAPs, and GHGs.[7] Hourly, daily, monthly, and annual emissions of these pollutants are calculated using emission unit process rates, emission factors, engineering judgement, and pollution control efficiencies (if applicable). Where available, monthly throughputs were used to calculate the maximum monthly emissions which were used for dispersion modeling for Lead.

Calculations have been developed for years representative of the highest throughput for the life of mine (including Plan I and Plan II) for each emissions unit for both Taylor and Clark deposits. Note that the highest of the two site-wide PTE between Plan I and Plan II represents the highest potential to emit for all regulated air pollutants.

The following sections contain a detailed description of the methodology used to calculate emissions for the proposed operations. Detailed emission calculations are included in Appendix A and select references to supporting documentation for emissions factors and emissions estimating methodologies are included in Appendix B. Individual control efficiencies were used to account for gravity settling of PM_{10} and $PM_{2.5}$ in the underground mine. Control efficiencies for gravity settling used based on a combination of vertical settling and horizontal settling per discussions with ADEQ in May 2023. Details are included in the spreadsheets attached in Appendix A.

6.1 Emissions from Drilling

Particulate matter emissions, including total PM, PM_{10}, $PM_{2.5}$, and Pb emissions, are generated from drilling operations. Drilling emissions were estimated based on material throughput, emission factors, and control efficiencies.

6.1.1 Material Throughput

The material throughput for drilling was based on the proposed tons of material drilled per South32 engineering judgement.

6.1.2 Emission Factor

An uncontrolled PM emission factor for wet drilling was obtained from AP-42, Section 11.19.2 (August 2004), Table 11.19.2-2 Emission Factors for Crushed Stone Processing Operations. The uncontrolled PM and $PM_{2.5}$ emission factors were calculated using particle size multipliers from AP-42, Section 13.2.4 (November 2006).

6.1.3 Control Efficiency

Individual control efficiencies were used to account for gravity settling of PM_{10} and $PM_{2.5}$ in the underground mine. Details are included in the spreadsheets attached in Appendix A.

[7] While GHGs are not included under the definition of "regulated air pollutant" at A.A.C. R18-2-101.122, they are considered a "regulated NSR pollutant" under the federal Prevention of Significant Deterioration (PSD) program at 40 C.F.R. § 52.21(b)(50). South32 is therefore providing estimates of GHG emissions for purposes of demonstrating non-applicability of the federal PSD program for GHGs, which ADEQ implements via a delegation agreement with EPA.

6.1.4 Equations used for Emissions Estimations

$$PM\ Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Material\ Throughput\ \left(\frac{ton\ rock}{hr}\right) \times Emission\ Factor\ \left(\frac{lb}{ton\ rock}\right) x\ (1 - Control\ Efficiency\ (\%))$$

$$PM\ Daily\ Emissions\ \left(\frac{lb}{day}\right) = PM\ Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times 24 \frac{hours}{day}$$

$$PM\ Annual\ Emissions\ (tpy) = Material\ Throughput\ \left(\frac{ton\ rock}{yr}\right) \times Emission\ Factor\ \left(\frac{lb}{ton\ rock}\right) \times (1 - Control\ Efficiency\ (\%)) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right)$$

6.2 Emissions from Blasting

Emissions of PM, PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, HAPs and GHGs are generated from blasting operations. PM, PM_{10}, and $PM_{2.5}$ emissions from blasting were estimated based on blast area, number of blasts, and emission factors. Individual control efficiencies were used to account for gravity settling of particulate in the underground mine. NO_x, CO, H_2S and SO_2 emissions from blasting were estimated based on the usage of blasting products and emission factors. Greenhouse gas emissions from blasting were estimated based on blasting products usage and emission factors. Greenhouse gas emissions were converted to the emissions of carbon dioxide equivalent (CO_2e) based on the global warming potential (GWP) for each greenhouse gas.

6.2.1 Process Rate

Blasting agent usage rates, rate of blasting, and blasting cross-sectional area were estimated based on South32 engineering evaluations.

6.2.2 Emission Factor

South32 proposes to use emulsion-based blasting products, and thus, emissions calculations are based on emission factors for emulsion[8]. Below is a list of references for the emission factors:

- NO_x and CO emission factors based on "Fume Memo WESCO Aug 2021" dated 19 August 2021 provided by Seth Fredrick Dyno Nobel Inc. which is included in Appendix B of this application.
- The SO_2 and H_2S emission factors were obtained from AP-42 Section 13.3 Explosives Detonation (January 1995), Table 13.3-1.

[8] Per "Chemical And Physical Factors That Influence NOx Production During Blasting - Exploratory Study" - Sapko et al., 2002 NIOSH Study, page 5:

Explosives like ANFO contain relatively large grains of ammonium nitrate (AN) which tend to decompose and yield NO_X. In emulsion explosives, the nitrate is mainly found in solution and more intimately in contact with the emulsified fuel droplets. As a result the NO_X produced from the thermal decomposition of AN will tend to react with hydrocarbons to yield nitrogen and water rather than remaining as NO after the detonation. Thus emulsions typically generate less emissions that ANFO.

- PM, PM_{10}, and $PM_{2.5}$ emission factors from blasting were calculated using the following expression from AP-42, Section 11.9, Western Surface Coal Mining (October 1998), Table 11.9-1 for blasting at western surface coal mines:

  $EF = (k)(0.000014)(A)^{1.5}$
  Where:

  EF = emission factor (lb/blast)
  k = scaling factor (1 for PM, 0.52 for PM_{10}, 0.03 for $PM_{2.5}$)
  A = horizontal area of the blast (ft^2), with blasting depth ≤ 70 ft.

- The CO_2 emission factor was based on "Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products" – Iwona Zawadzka-Malota, January 7, 2016 which is included in Appendix B of this application..

6.2.3 Control Efficiency

Good operating practices are the only feasible pollution control methods during blasting. Therefore, no control efficiencies were applied in blasting emission calculations, except for $PM/PM_{10}/PM_{2.5}$, where various control efficiencies for post-blasting gravity settling were used. Details are included in the spreadsheets attached in Appendix A.

6.2.4 Emission Factor

The following equations were used to estimate hourly and annual emissions from all HAPs and criteria pollutants except $PM/PM_{10}/PM_{2.5}$ and Pb:

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Usage\ Rates\ \left(\frac{ton\ Emulsion}{hr}\right) \times EF\ \left(\frac{lb}{ton\ Emulsion}\right)$$

$$Annual\ Emissions\ (tpy) = Usage\ Rates\ \left(\frac{ton}{yr}\right) \times EF\ \left(\frac{lb}{ton\ Emulsion}\right) \times \left(\frac{1}{2000}\right)\left(\frac{tons}{lb}\right)$$

The following equations were used to estimate hourly and annual emissions from $PM/PM_{10}/PM_{2.5}$ and Pb:

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = [1 - Control\ Efficiency] \times Blasting\ Rates\ \left(\frac{blasts}{hr}\right) \times EF\ \left(\frac{Max\ lb}{blast}\right)$$
$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = [1 - Control\ Efficiency] \times Blasting\ Rates\ \left(\frac{blasts}{day}\right) \times EF\ \left(\frac{Max\ lb}{blast}\right)$$

$$Annual\ Emissions\ (tpy) = [1 - Control\ Efficiency] \times Blasting\ Rates\ \left(\frac{blasts}{yr}\right) \times EF\ \left(\frac{Max\ lb}{blast}\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right)$$

6.3 Emissions from Crushing

Particulate matter emissions, including total PM, PM_{10}, $PM_{2.5}$, and Pb emissions, are generated from crushing operations. Crushing emissions were estimated based on material throughput, emission factors, and control efficiencies.

6.3.1 Material Throughput

The material throughput for crushing was based on the proposed tons of material crushed on an hourly, daily, monthly, and annual basis, per South32 engineering judgement. For the rock breaker, it is conservatively assumed that the throughput would be 10% of the total grizzly screen throughput to account for the rock pieces that are too large for the screen and must first be routed to the rock breaker.

6.3.2 Emission Factor

Controlled tertiary wet crushing PM, PM_{10} and $PM_{2.5}$ emission factors obtained from AP-42 19.2.2 were conservatively used for primary, underground crushing as well as the secondary, pebble crusher. Both of these crushing activities are expected to generate lesser emissions than tertiary crushing due to size of materials being crushed. The emission factors for rock breaking are conservatively assumed to be equal to that of drilling, taken from the same source mentioned in the Drilling section above.

6.3.3 Control Efficiency

Various control efficiencies were used to account for gravity settling in the underground crusher. Details are included in the spreadsheets attached in Appendix A. The aboveground pebble crusher has no additional control factors because an inherent wet emission factor is being used.

6.3.4 Equations used for Emissions Estimations

$$Hourly/Monthly\ Emissions\ \left(\frac{lb}{hr}\right) = Material\ Throughput\ \left(\frac{ton\ rock}{hr}\right) \times Emission\ Factor\ \left(\frac{lb}{ton\ rock}\right) \times (1 - Control\ Efficiency\ (\%))$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times 24\frac{hours}{day}$$

$$Annual\ Emissions\ (tpy) = Material\ Throughput\ \left(\frac{ton\ rock}{yr}\right) \times Emission\ Factor\ \left(\frac{lb}{ton\ rock}\right) \times (1 - Control\ Efficiency\ (\%)) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right)$$

6.4 Emissions from Generators

Emissions of PM, PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOC, HAPs, and GHGs will be generated by the generator engines. The following section discusses the detailed methodology used to estimate emissions.

Emissions from the natural gas generator(s) are represented based on the highest emissions when pairing engine rating to emission factors assuming 8,760 hours of operation per year. Engine ratings were adjusted for site elevation using a factor of 3% loss in rating for every 1,000 feet above sea level. The facility sits at approximately 5,000 feet giving a loss of 15%.

6.4.1 Emission Factors

The following emission factors were used for the 2.6 MW natural gas engines:

- NO_x, CO, PM, VOC, Acetaldehyde, Formaldehyde, and GHGs emission factors obtained from stack testing performed in July and September of 2021 on a G3520 Caterpillar engine which is included in Appendix B of this application. A safety factor of 30% was added to the calculations to account for stack test variability.
- SO_2 emission factor was obtained from AP-42 for Natural Gas Engines (maximum emission factor available).
- HAP emission factors for were based on AP-42 Chapter 3.2, Table 3.2-2 (4 Stroke Lean Burn Natural Gas Engines). As these engines are equipped with oxidation catalysts, a calculated control efficiency was applied to select HAPs to account for the emission reductions attributable to this emission control technology. [9] Control efficiencies were determined by comparing stack tested emission factors for VOC and formaldehyde at 75% and 100% loading scenarios. The most conservative among four potential values was chosen and applied to relevant HAPs emission factors affected by oxidation catalysts. HAPs calculated using average brake specific fuel consumption per AP-42 Chapter 3.3 (Oct. 1996) to convert units for use with natural gas generators.

The following emission factors were used for the 4.4 MW natural gas engines:

- NO_x, CO, PM, VOC, Acetaldehyde and Formaldehyde emission factors obtained from emission factors provided by the engine manufacturer.
- GHG emission rates were calculated based on emission factors obtained from 40 CFR Part 98, Subpart C-1, C-2 for natural gas (weighted U.S. average).
- SO_2 emission factor was obtained from AP-42 for Natural Gas Engines (maximum emission factor available).
- HAP emission factors for were based on AP-42 Chapter 3.2, Table 3.2-2 (4 Stroke Lean Burn Natural Gas Engines). As these engines are equipped with oxidation catalysts, a calculated control efficiency was applied to select HAPs to account for the emission reductions attributable to this emission control technology. [10] Control efficiencies were determined by comparing stack tested emission factors for VOC and formaldehyde at 75% and 100% loading scenarios. The most conservative among four potential values was chosen and applied to relevant HAPs emission factors affected by oxidation catalysts. HAPs calculated using average brake specific fuel consumption per AP-42 Chapter 3.3 (Oct. 1996) to convert units for use with natural gas generators.

The following emission factors were used for all other diesel engines:

- NO_x, CO, PM, and VOC emission factors were obtained from the emissions certification provided from the engine manufacturer.

[9] Control efficiencies were applied to select HAPs named in AP-42 Chapter 3.2, Table 3.2-2 (4 Stroke Lean Burn Natural Gas Engines) based on guidance provided by Korby Backen, P.E. on December 15th, 2023.

[10] Ibid.

- ► SO_2 and HAP emission factors were referenced from AP-42 Chapter 3.4 for Large Diesel Engines.

The following emission factors were used for all other diesel engines:

- ► NO_X, CO, PM, and VOC emission factors obtained from "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016). When applicable, NO_X and VOC emissions factors are based on the emission factor for NMHC+NO_X distributed using a ratio of 95% NO_X and 5% VOC. SO_2 and HAP emission factors were referenced from AP-42 Chapter 3.3 for Diesel Engines.

6.4.2 Equations Used for Emission Estimations

The following equations were used to estimate hourly and annual emissions from criteria pollutants, and GHGs:

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Engine\ Rating\ (kW) x\ Emission\ Factor\ \left(\frac{g}{kW-hr}\right) \times \left(\frac{1}{453.592}\right)\left(\frac{lb}{g}\right)$$

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Engine\ Rating\ (kW) \times Emission\ Factor\ \left(\frac{lb}{kW-hr}\right)$$

$$Annual\ Emissions\ (tpy) = Engine\ Rating\ (kW) \times Emission\ Factor\ \left(\frac{g}{kW-hr}\right) \times Operation\ Hours\ \left(\frac{hrs}{yr}\right) \times \left(\frac{1}{453.592}\right)\left(\frac{lb}{g}\right) \times \frac{1}{2000}\left(\frac{tons}{lb}\right)$$

The following equations were used to estimate hourly and annual emissions from criteria pollutants, and GHGs for non-emergency engine only:

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Engine\ Rating\ (kW) x\ Emission\ Factor\ \left(\frac{g}{kW-hr}\right) \times \left(\frac{1}{453.592}\right)\left(\frac{lb}{g}\right) \times \frac{Operationn\ Hours\ (\frac{hrs}{yr})}{8{,}760}$$

$$Annual\ Emissions\ (tpy) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times \frac{1}{2000}\left(\frac{tons}{lb}\right) \times Operation\ Hours\ \left(\frac{hrs}{yr}\right)$$

The following equations were used to estimate annual emissions from HAPs:

$$Annual\ Emissions\ (tpy) = Engine\ Rating\ (kW) \times Emission\ Factor\ \left(\frac{lb}{MMBTU}\right) \times Operation\ Hours\ \left(\frac{hrs}{yr}\right) \times \left(\frac{1}{2000}\right)\left(\frac{tons}{lb}\right) \times 3.41 * 10^{-3} \left(\frac{MMBTU}{kW-hr}\right) \times (1 - CE^{11})$$

6.5 Emissions from Material Loading, Unloading, and Drops

Emissions of PM, PM_{10}, $PM_{2.5}$, and Pb are generated from material loading and unloading operations. Material loading, unloading, and drop emissions were estimated based on material throughput, emission factors, and control efficiencies.

6.5.1 Material Throughput

Material throughput for loading, unloading, and material drop points were based on South32 engineering judgement.

6.5.2 Emission Factor

For all material loading/unloading, the uncontrolled PM, PM_{10}, and $PM_{2.5}$ emission factors were developed using the "drop equation" in AP-42, Section 13.2.4 (November 2006).

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

E= Emission Factor (lb/ton)
k= Particulate Size Multiplier (dimensionless)
U= Mean Wind Speed (miles per hour [mph], per processed onsite meteorological data collected from 2019-2021 for aboveground drops. For underground drops, wind speed was determined based on South32 ventilation design for area where each drop would likely occur; if the wind speed was less than 1.30 mph, a conservative estimate of 1.30 mph was used instead.
M= Material Moisture Content (%), per South32 engineering judgement

6.5.3 Control Efficiency

Various control efficiencies were used for each drop point. Details are included in the spreadsheets attached in Appendix A.

6.5.4 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Material\ Throughput\ \left(\frac{ton}{hr}\right) \times EF\ \left(\frac{lb}{ton}\right) \times (1 - Control\ Factor\ (\%))$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times 24\frac{hours}{day}$$

[11] CE is applied to select HAPs for natural gas engines only, as dicussed in Section 6.4.1

$$Annual\ Emissions\ (tpy) = Material\ Throughput\ \left(\frac{ton}{yr}\right) \times\ EF\ \left(\frac{lb}{ton}\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right) \times (1 - Control\ Factor\ (\%))$$

6.6 Emissions from Unpaved Roads

6.6.1 Emissions From Truck Traffic on Roads (Delivery of Materials /Loader/Ore Transport/Support Vehicles etc.)

PM, PM_{10}, and $PM_{2.5}$ emissions are generated from vehicles traveling on unpaved roads aboveground and underground. Road emissions were calculated based on vehicle miles travelled (VMT), emission factors, and control efficiencies.

6.6.1.1 Vehicle Miles Traveled - Aboveground Roads

The VMT was calculated by multiplying number of trips and round-trip distance traveled by the vehicle. The number of trips was estimated based on material throughput, truck capacities, estimated vehicle miles traveled at the project site, and South32 engineering judgement.

6.6.1.2 Vehicle Miles Traveled - Underground Roads

The VMT was calculated by multiplying the number of vehicles and the maximum round-trip distance traveled by the vehicle. The maximum miles traveled were estimated based on material throughput, truck capacities, estimated vehicle miles traveled at the project site, and South32 engineering judgement.

6.6.1.3 Emission Factor

Uncontrolled PM, PM_{10}, and $PM_{2.5}$ emission factors for vehicles traveling on unpaved roads aboveground and underground were calculated using the following equations from AP-42, Section 13.2.2 (November 2006):

$$E = (k)\left(\frac{s}{12}\right)^a\left(\frac{W}{3}\right)^b$$

$$E_{ext} = E[(365 - P)/365]$$

Where:

E = size-specific hourly and daily emission factor (lb/VMT)
E_{ext} = size-specific annual emission factor (lb/VMT)
k = particle size multiplier, per AP-42 Table 13.2.2-2 (November 2006)
s = surface material silt content (%), per South32 engineering judgement
W = mean vehicle weight (tons)
a, b = constants, per AP-42 Table 13.2.2-2 (November 2006)
P = days per year with at least 0.01 inch precipitation, per processed onsite meteorological data collected in 2019, 2020 and 2021. The most conservative year was used.

6.6.1.4 Control Efficiency

Per the EPA document *Control of Open Fugitive Dust Sources*[12], sufficient watering of unpaved roads can result in a control efficiency up to 95%. For emission estimations purposes, a conservative control efficiency of 90% has been used. In this case, sufficient watering is deemed as watering which meets applicable opacity limitations and other requirements such as to comply with A.A.C. R18-2-605 and R18-2-614.

6.6.1.5 Control Efficiency

$$Hourly\ Emissions\ \left(\frac{lbs}{hr}\right) = EF\ \left(\frac{lb}{VMT}\right) \times Total\ Miles\ Traveled\ \left(\frac{VMT}{hr}\right) \times (1 - Control\ Efficiency\ (\%))$$

$$Annual\ Emissions\ (tpy) = EF\ \left(\frac{lb}{VMT}\right) \times\ Total\ Miles\ Traveled\ \left(\frac{VMT}{yr}\right) \times \left(1 - Control\ Efficiency\ (\%)\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right)$$

6.6.2 Emissions From Bulldozers/Roto-compactors

PM, PM_{10}, and $PM_{2.5}$ emissions will be generated from bulldozers/roto-compactors utilized at the Hermosa Project. Emissions were calculated based on total bulldozer/roto-compactors operational hours and emission factors.

6.6.2.1 Operational Hours

The total operation hours for bulldozers/roto-compactors were calculated by summing the operational hours for each bulldozer/roto-compactor to be utilized at the Hermosa Project.

6.6.2.2 Emission Factor

AP-42, Section 11.9 (October 1998), Table 11.9-1 provides the following equations for calculating emission factors for TSP and particulate matter with an aerodynamic diameter less than 15 microns (PM_{15}) from bulldozing operation:

$$TSP = \frac{5.7(s)^{1.2}}{(M)^{1.3}}$$

$$PM_{10} = \frac{1.0(s)^{1.5}}{(M)^{1.4}}$$

$$PM_{2.5} = \frac{5.7(s)^{1.2}}{(M)^{1.3}}$$

Where:

TSP and PM_{15} = emission factors (lb/hr)
s = material silt content (%), per South32 engineering judgement
M = material moisture content (%), per South32 engineering judgement

AP-42, Section 11.9 (October 1998), Table 11.9-1 also provides scaling factors that can be applied to TSP or PM_{15} emission factors to obtain PM, PM_{10}, and $PM_{2.5}$ emission factors. PM, PM_{10}, and $PM_{2.5}$ emission factors were calculated as follows:

- PM = TSP (conservative assumption)

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[12] EPA, Control of Open Fugitive Dust Sources, EPA-450/3-88/008, September 1988.

- PM_{10} = 0.75 PM_{15} (0.75 is the scaling factor obtained from AP-42, Section 11.9, October 1998, Table 11.9-1)
- $PM_{2.5}$ = 0.105 TSP (0.105 is the scaling factor obtained from AP-42, Section 11.9, October 1998, Table 11.9-1)

6.6.2.3 Control Efficiency

Per the EPA document *Control of Open Fugitive Dust Sources*[13], sufficient watering of unpaved roads can result in a control efficiency up to 95%. For emission estimations purposes, a conservative control efficiency of 70% has been used for dozer emissions at rock stockpiles, while control efficiency of 0% has been used for dozer emissions at tailing storage facilities. In this case, sufficient watering is deemed as watering which meets applicable opacity limitations and other requirements such as to comply with A.A.C. R18-2-605 and R18-2-614.

6.6.2.4 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = EF\ \left(\frac{lb}{hr}\right) \times Operational\ Hours\ \left(\frac{hr}{hr}\right) \times (1 - Control\ Efficiency\ (\%))$$

$$Annual\ Emissions\ (tpy) = EF\ \left(\frac{lb}{hr}\right) \times Operational\ Hours \left(\frac{hr}{yr}\right) \times \left(1 - Control\ Efficiency\ (\%)\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right)$$

6.7 Emissions from Storage Tanks

South32 will utilize storage tanks (~10,000 gallons capacity or less) to store diesel and gasoline needed to support onsite activities. Emissions from these insignificant activities[14] but have been included in the calculations. These tanks will be located near the aboveground fuel dispensing facilities. Furthermore, two 50,000-gallon diesel tanks will be located on-site. Additionally, storage tanks will also be used for all chemical reagents stored onsite. Emissions from all tanks were calculated using the EPA approved TankESP software which is based on AP-42 Chapter 7, Section 7.1 (June 2020).

6.8 Emissions from Wind Erosion

Emissions from wind erosion associated with the stockpiles include PM, PM_{10}, $PM_{2.5}$, and Pb.

6.8.1 Area of Piles and TSF

The area of the various piles and TSF are based on South32 engineering judgement.

6.8.2 Emission Factor

The emission factor for the calculation of the emissions of the different stockpiles are based on methodology found in AP-42 13.2.5 Industrial Wind Erosion (November 2006). PM, PM_{10}, and $PM_{2.5}$ emission factors were calculated using the following equation:

[13] EPA, Control of Open Fugitive Dust Sources, EPA-450/3-88/008, September 1988.

[14] Pursuant to A.A.C. R18-2-304(F)(8), the application need not provide emissions data regarding activities which are insignificant pursuant to the definition of insignificant activities in R18-2-101.

$$E = kNP$$

Where:

E = Emission Factor (ton/acre-yr)
k = Particle size multiplier (1 for PM, .5 for PM_{10}, and .075 for $PM_{2.5}$)
N = Number of disturbances per day
P = Erosion potential corresponding to the observed fastest mile of wind per day (g/m^2)

P is calculated by the following equation:

$$P = 58(u^* - u_t)^2 + 25(u^* - u_t)$$

$$P = 0 \; for \; u^* \leq u_t$$

Where:

u^* = friction velocity (m/s)
u_t = threshold friction velocity (m/s)

The threshold friction velocity is obtained from AP-42 Table 13.2.5-2. The friction velocity, u^*, was calculated based on the following equation:

$$u^* = 0.053 * \; u_{10}^{+}$$

Where:

u_{10}^{+} = fastest mile at the anemometer height for the time period between disturbances (m/s)

A linear regression was performed between the 5-minute average wind speed and the 5-minute max (gust) wind speed. This gave a relationship between average and gust wind speed. The linear regression was used to convert the highest 5-minute average wind speed in the dataset to a 5-minute gust wind speed to be used in lieu of the actual highest 5-minute gust wind speed. This is the value used for the fastest mile (u_{10}^{+}). This method has previously been accepted by ADEQ for calculating wind erosion.

The fastest mile was obtained from the data collected at the meteorological tower located at the Hermosa facility for the years 2019 to 2021.

6.8.3 Control Efficiency

No controls were used for the calculation of emissions from the various piles and TSF as a conservative estimate. However, typically the surface of the tailings hardens, and crust formation occurs. Furthermore, the external faces of the TSF will be covered with rock armoring to protect against erosion and minimize dust emissions.

6.8.4 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Annual\ Emissions \times 2000 \left(\frac{lb}{ton}\right) \times \frac{1}{8760} (hr^{-1})$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times 24\frac{hours}{day}$$

$$Annual\ Emissions\ (tpy) = Average\ Emission\ Factor\ \left(\frac{ton}{acre - yr}\right) \times Tailings\ Surface\ Area\ (acre)$$

6.9 Emissions from Dust Collectors

Dust collectors are used at the Hermosa Project to capture PM emissions caused by transferring, or dropping, material. Dust collectors are located near areas where there are many drops (transfers of material).

6.9.1 Flowrate

Flowrate of the dust collectors was based on South32 engineering judgement.

6.9.2 Emission Factor

Emissions for dust collectors are based on outlet grain loading. The value for outlet grain loading for PM/PM_{10}/$PM_{2.5}$ were based on South32 engineering judgement. Appendix B includes a letter from one of the vendors providing an outlet grain loading guarantee. It was assumed that PM/PM_{10}/$PM_{2.5}$ emissions are equivalent per ADEQ guidance.

6.9.3 Equations Used for Emission Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Annual\ Emissions\ \left(\frac{ton}{yr}\right) \times \frac{1}{8760}\left(\frac{yr}{hr}\right) \times 2000\left(\frac{lb}{ton}\right)$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times 24\frac{hours}{day}$$

$$Annual\ Emissions\ (tpy) = Max\ Outlet\ Grain\ Loading\ \left(\frac{grain}{dscf}\right) \times StackFlow\ Rate\ \left(\frac{dscf}{min}\right) \times 60\ \left(\frac{min}{hr}\right) \times Hours\ of\ Operation\ \left(\frac{hr}{yr}\right) \times \frac{1}{7000}\ \left(\frac{lb}{grain}\right) \times \frac{1}{2000}\left(\frac{ton}{lb}\right)$$

6.10 Emissions from WTP2 Cooling Towers

Emissions from the cooling towers include PM, PM_{10}, $PM_{2.5}$ and trace amounts of TDS.

6.10.1 Flowrate

Flowrate, drift loss and TDS were based on South32 engineering judgement.

6.10.2 Control Efficiency

PM_{10} and $PM_{2.5}$ fractions were determined using the drift rate and TDS. A drift rate of 0.0005% was used.

6.10.3 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = \frac{Daily\ Emissions\ \left(\frac{lb}{day}\right)}{24\,\frac{hours}{day}}$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Annual\ Emissions\ \left(\frac{ton}{year}\right) \times \frac{2000\,\frac{lb}{ton}}{365\,\frac{days}{year}}$$

$$Annual\ Emissions\ (tpy) = Flow\ Rate\ \left(\frac{gal}{min}\right) \times Water\ Density\ \left(\frac{lb}{gal}\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right) \times 60\ \left(\frac{min}{hr}\right) \times 8760\ \left(\frac{hr}{yr}\right) \times Drift\ (\%) \times TDS\ (ppm) \times \left(\frac{1}{1000000}\right) \times PM\ Fraction$$

6.11 Emissions from Refrigeration Plant Cooling Towers

Emissions from the refrigeration plant include PM, PM_{10}, $PM_{2.5}$ and trace amounts of TDS.

6.11.1 Material Throughput

Flowrate, drift loss and TDS were based on South32 engineering judgement.

6.11.2 Control Efficiency

PM_{10} and $PM_{2.5}$ fractions were determined using the drift rate and TDS. Drift percentage of 0.001% was used.

6.11.3 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = \frac{Daily\ Emissions\ \left(\frac{lb}{day}\right)}{24\,\frac{hours}{day}}$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Annual\ Emissions\ \left(\frac{ton}{year}\right) \times \frac{2000\,\frac{lb}{ton}}{365\,\frac{days}{year}}$$

$$Annual\ Emissions\ (tpy) = Flow\ Rate\ \left(\frac{gal}{min}\right) \times Water\ Density\ \left(\frac{lb}{gal}\right) \times \left(\frac{1}{2000}\right)\left(\frac{ton}{lbs}\right) \times 60\ \left(\frac{min}{hr}\right) \times 8760\ \left(\frac{hr}{yr}\right) \times Drift\ (\%) \times TDS\ (ppm) \times \left(\frac{1}{1000000}\right) \times PM\ Fraction$$

6.12 Emissions from Concrete Batch Plants

Emissions from the concrete batch plant include $PM/PM_{10}/PM_{2.5}$.

6.12.1 Material Throughput

Concrete throughput was based on South32 engineering judgement.

6.12.2 Emission Factors

The emission factor for the calculation of the emissions of the concrete batch plant are based AP-42 Section 11.12 (June 2006), Table 11.12-2. If a controlled emission factor was unavailable, an uncontrolled emission factor was used.

6.12.3 Control Efficiency

No control efficiencies were utilized for the concrete batch plant. However, cement drops to the silo were accounted for in the silo's calculations.

6.12.4 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = \frac{Daily\ Emissions\ \left(\frac{lb}{day}\right)}{24\,\frac{hours}{day}}$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Annual\ Emissions\ \left(\frac{ton}{year}\right) \times \frac{2000\,\frac{lb}{ton}}{365\,\frac{days}{year}}$$

$$Annual\ Emissions\ (tpy) = Maximum\ Rated\ Capacity\ (tpy) \times EF\ \left(\frac{lb}{ton}\right)$$

6.13 Emissions from Gasoline Dispensing Facility

South32 will utilize multiple storage tanks to store gasoline needed to support the various on road and non-road vehicles. VOC and HAP emissions are generated from the loading of the tanks.

6.13.1 Material Throughput

Gasoline throughput was based on South32 engineering judgement.

6.13.2 Emission Factors

The emission factor for the calculation of the emissions of the gasoline dispensing facility are based on AP-42 Table 5.2-7 Evaporative Emissions from Gasoline Service Station Operation (7/08). VOC and HAP emission factors were calculated using the following equation:

$$Loading\ Loss\ \left(\frac{lb}{1000}gal\right) = 12.46\ \times \frac{SPM}{T}$$

Where:

S = Saturation Factor (assume 1 for submerged loading)
P = True vapor pressure of liquid loaded (psia, assume 7.4 psia for Gasoline RVP 10 @ 80 °F)
M = molecular weight of vapors (lb/lb-mole)
T= temperature of bulk liquid loaded (°R, 540 °R based upon AP-42 Chapter 7 Tucson average daily maximum ambient temperature)

HAP emissions based on the average percent content of the HAP constituent in gasoline per TankESP Gasoline RVP_X speciation.

6.13.3 Control Efficiency

No control efficiencies were utilized for the gasoline dispensing facility.

6.13.4 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Actual\ Usage\ Rate\ \left(\frac{gals}{hr}\right) \times EF\left(\frac{lbs}{1000\ gal}\right) \times \frac{1}{1000} \times Safety\ Factor\ (\%)$$

$$Annual\ Emissions\ (tpy) = Actual\ Usage\ Rate\ \left(\frac{gals}{yr}\right) \times EF\ \left(\frac{lb}{1000\ gal}\right) \times \frac{1}{1000} \times Safety\ Factor\ (\%)$$

The following equations were used to estimate hourly and annual emissions from HAPSs:

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = VOC\ Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times HAP\ Mass\ Percent(\%)$$

$$Annual\ Emissions\ (tpy) = VOC\ Annual\ Emissions\ \left(\frac{lb}{hr}\right) \times HAP\ Mass\ Percent(\%)$$

6.14 Emissions from Evaporators

Emissions from the mechanical evaporators include PM_{10} and $PM_{2.5}$.

6.14.1 Material Throughput

The throughput is determined by the water being pumped through the mechanical evaporators.

6.14.2 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = TDS\ Concentration\ \left(\frac{mg}{L}\right) \times \frac{Drift\ Loss\ (\%)}{100\%} \times System\ Flow\ Rate\ \left(\frac{gal}{min}\right) \times 3.78\ \left(\frac{L}{gal}\right) \times \frac{2.2}{10^6}\left(\frac{lb}{mg}\right) \times 60\ (\frac{min}{hr})$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times Operation\ Hours\ (\frac{hr}{day})$$

$$Annual\ Emissions\ (tpy)\ = Hourly\ Emissions\ \left(\frac{lb}{hr}\right) \times Operation\ Hours\ \left(\frac{hr}{yr}\right) \times \frac{1}{2000} (\frac{ton}{lb})$$

6.15 Emissions from Process Tanks

Emissions estimated for the open top process tanks at the South32 facility are based on the model "Evaporation from an Open Top Vessel" provided under Section 3.7.1, Eq. 3-24 of the EPA Emissions Inventory Improvement Program (EIIP) Document "Volume II: Chapter 16 – Methods for Estimating Air Emissions from Chemical Manufacturing Facilities, August 2007".[15] Per the prescribed model, the rate of evaporation from the liquid surface open to the atmosphere is directly proportional to the mass transfer coefficient, vapor pressure and liquid surface area, per equation 3-24 below.

$$E_i = \frac{M_i\, K_i A P_i}{R T_L}$$

Compound specific mass transfer coefficients were calculated using Eq. 3-27, using water as the reference compound and adjusting for relative molecule size.

$$K_i = K_0 \left(\frac{M_0}{M_i}\right)^{1/3}$$

Where:
E_i = Hourly emission rate, lb/hr
M_i = Molecular weight, lb/lb-mol
K_i = Mass transfer coefficient, ft/hr
K_0 = Reference mass transfer coefficient of Water, 0.83 ft/hr
M_0 = Molecular weight of Water, 18.02 lb/lb-mol
A = Liquid surface area, ft^2
P_i = Vapor pressure, psi
T_L = Liquid temperature, ^oR
R = Ideal Gas constant, 10.73 psi-ft^3/lb-mole ^oR

The process tanks at South32 consist of solids-liquid mixture, with the liquid containing water and beneficiation additives. For a conservative emissions estimate, liquid phase mole fraction for liquid components was normalized to 100%, ignoring solids content. VOC component weight percentages are very low in the liquid mixture, as seen in Appendix A for emission calculations; therefore, vapor pressure of a component in gas phase was calculated using Henry's law which better represents dilute solutions as solute concentrations approach zero. Henry's law volatility constant (defined via vapor phase partial pressure and liquid-phase mole fraction), H^{px}_v is used to calculate vapor phase partial pressure of the components.

$$P_i = H_v^{px} x_i$$

$$H_v^{px} = H_v^{cc} R T_L d_{solv} / M_{solv}$$

Where:
P_i = Vapor pressure of component in gas phases, psi
H^{px}_v = Henry's law volatility constant, psi/$(mol\%)_{liq}$

[15] https://www.epa.gov/sites/default/files/2015-08/documents/ii16_aug2007final.pdf

x_i = Liquid-phase mole fraction, mol%
H^{cc}_{V} = Henry's law volatility constant, Dimensionless[16]
M_{solv} = Molecular weight of solvent, 18.02 lb/lb-mol (assumed Water)
D_{solv} = Density of solvent, 62.42 lb/ft^3 (assumed Water)

A 100% safety factor is added to conservatively estimate emissions. Annual emissions (tpy) are calculated based on 8,060 hrs/yr of operation.

6.16 Emissions from Paste Plant

Emissions of PM, PM_{10}, and $PM_{2.5}$ are generated from truck pneumatic loadout to the storage silos located at the Paste Plants. Truck pneumatic loadout emissions were estimated based on material throughput and emission factors.

6.16.1 Material Throughput

Material throughput for loading, unloading, and material drop points were based on South32 engineering judgement.

6.16.2 Emission Factor

The emission factors of the truck pneumatic loadout are based on "Cement unloading to elevated storage silo (pneumatic)" sources in AP-42 Section 11.12 (June 2006), Table 11.12-2. If a controlled emission factor was unavailable, the particle size multiplier was used to determine the emission factor.

6.16.3 Equations Used for Emissions Estimations

$$Hourly\ Emissions\ \left(\frac{lb}{hr}\right) = Material\ Throughput\ \left(\frac{ton}{day}\right) \times EF\ \left(\frac{lb}{ton}\right) \times \frac{1\ day}{24\ hours}$$

$$Daily\ Emissions\ \left(\frac{lb}{day}\right) = Material\ Throughput\ \left(\frac{ton}{day}\right) \times EF\ \left(\frac{lb}{ton}\right)$$

$$Annual\ Emissions\ (tpy) = Material\ Throughput\ \left(\frac{ton}{yr}\right) \times\ EF\ \left(\frac{lb}{ton}\right) \times \left(\frac{1}{2000}\right) \left(\frac{ton}{lbs}\right)$$

6.17 Site-Wide Metal HAP Emissions

Metal HAP emissions were calculated based on the mass fraction of Metal HAPs present in PM emissions. Metal HAP emissions emanate from any part of the mining process that includes PM emissions due to the crushing, grinding, handling, conveying, dropping, loading, and unloading of materials. To simplify presentation, Metal HAP emission calculations are not shown; however, Metal HAP emissions are calculated by the following equation.

$$\begin{aligned} &Metal\ HAP\ emissions\ (hourly\ or\ daily\ or\ monthly\ or\ annually) \\ &\qquad = Metal\ HAP\ Percentage\ (\%) \times PM\ emissions\ (hourly\ or\ daily\ or\ monthly\ or\ annualy) \end{aligned}$$

[16] Pure component Henry's law volatility constant (H^{cc}_{V}) data is taken from the Toxchem (version 4.4 Mar-25-2019) chemical library.

7. LIST OF INSIGNIFICANT AND TRIVIAL ACTIVITIES

Activities which are considered "insignificant" pursuant to A.A.C. R18-2-101.68 and associated with the Hermosa Project are presented in this Section. Pursuant to A.A.C. R18-2-304.F.8, insignificant activities shall be listed in a permit application, but the application need not provide emissions data, except as requested by ADEQ following submittal of the application. Therefore, any emissions from these equipment and activities are not considered in this application.

Similarly, proposed activities which are considered "trivial" pursuant to A.A.C. R18-2-101.146 and associated with the Facility are presented in this Section. Although trivial activities can be omitted from permit applications, South32 is identifying them in this application for ADEQ's concurrence and future reference purposes. This list is not intended to be an exhaustive list of all the equipment and activities at the Hermosa Project that meet the trivial activities classification.

7.1 Insignificant Activities

- Liquid Storage and Piping
  - Petroleum product storage tanks containing the following substances, provided South32 lists and identifies the contents of each tank with a volume of 350 gallons or more and provides threshold values for throughput or capacity or both for each such tank: diesel fuels and fuel oil in storage tanks with capacity of 40,000 gallons or less, lubricating oil, transformer oil, and used oil;
    - Tanks details are contained in Appendix A.
  - Gasoline storage tanks with capacity of 10,000 gallons or less.
  - Storage and piping of natural gas, butane, propane, or liquefied petroleum gas, provided that South32 lists and identifies the contents of each stationary storage vessel with a volume of 350 gallons or more and provides threshold values for throughput or capacity or both for each such vessel;
    - South32 will provide tanks details to ADEQ in a supplemental submittal once design is complete.
  - Piping of fuel oils, used oil and transformer oil, provided South32 includes a system description.
  - Storage and handling of drums or other transportable containers where the containers are sealed during storage, and covered during loading and unloading, including containers of waste and used oil regulated under RCRA. South32 must provide a description of material in the containers and the approximate amount stored;
  - Storage tanks of any size containing exclusively soaps, detergents, waxes, greases, aqueous salt solutions, aqueous solutions of acids that are not regulated air pollutants, or aqueous caustic solutions, provided South32 specifies the contents of each storage tank with a volume of 350 gallons or more;
  - Electrical transformer oil pumping, cleaning, filtering, drying and the re-installation of oil back into transformers;
- Internal combustion engine-driven compressors, internal combustion engine-driven electrical generator sets, and internal combustion engine-driven water pumps used for less than 500 hours per calendar year for emergency replacement or standby service, provided South32 keeps records documenting the hours of operation of this equipment;
- Low Emitting Processes
  - Batch mixers with rated capacity of 5 cubic feet or less;
  - Equipment using water, water and soap or detergent, or a suspension of abrasives in water for purposes of cleaning or finishing;

- Blast-cleaning equipment using a suspension of abrasive in water and any exhaust system or collector serving them exclusively;
- Plastic pipe welding;

- Site Maintenance
  - Housekeeping activities and associated products used for cleaning purposes, including collecting spilled and accumulated materials at the including operation of fixed vacuum cleaning systems specifically for such purposes;
  - Sanding of streets and roads to abate traffic hazards caused by ice and snow;
  - Architectural painting and associated surface preparation for maintenance purposes;
- Sampling and Testing
  - Noncommercial (in-house) experimental, analytical laboratory equipment, which is bench scale in nature, including quality control/quality assurance laboratories supporting South32 operations and research and development laboratories;
  - Individual sampling points, analyzers, and process instrumentation, whose operation may result in emissions but that are not regulated as emission units;
- Ancillary Non-Industrial Activities
  - General office activities, such as paper shredding, copying, photographic activities, and blueprinting, but not to include incineration;
  - Use of consumer products, including hazardous substances where the product is used at the Hermosa Facility in the same manner as normal consumer use;
  - Activities directly used in the diagnosis and treatment of disease, injury or other medical condition;
- Miscellaneous Activities
  - Installation and operation of potable, process and wastewater observation wells, including drilling, pumping, filtering apparatus;
  - Transformer vents.

7.2 Trivial Activities

- Low-Emitting Combustion
  - Combustion emissions from propulsion of mobile sources;
  - Portable electrical generators that can be moved by hand from one location to another
- Hand-held or manually operated equipment used for buffing, polishing, carving, cutting, drilling, sawing, grinding, turning, routing or machining of precision parts and metals;
- Brazing, soldering, and welding equipment and cutting torches related to manufacturing and construction activities that do not result in emission of HAP metals;
- Brazing, soldering, and welding equipment and cutting torches directly related to plant maintenance and upkeep and repair or maintenance shop activities that emit HAP metals
- Drop hammers or hydraulic presses for forging or metalworking;
- Air compressors and pneumatically operated equipment, including hand tools;
- Batteries and battery charging stations, except at battery manufacturing plants;
- Process water filtration systems and demineralizers;
- Demineralized water tanks and demineralizer vents;
- Oxygen scavenging or de-aeration of water;
- Steam vents and safety relief valves;
- Use of vacuum trucks and high pressure washer/cleaning equipment within the stationary source boundaries for cleanup and in-source transfer of liquids and slurried solids to wastewater treatment units or conveyances;
- Equipment using water, water and soap or detergent, or a suspension of abrasives in water for purposes of cleaning or finishing;

- Electric motors;
- Repair and maintenance;
  - Janitorial services;
  - Plant and building maintenance and upkeep activities, including grounds-keeping, general repairs, cleaning, painting, welding, plumbing, re-tarring roofs, installing insulation, and paving parking lots;
  - Sanding of streets and roads to abate traffic hazards caused by ice and snow;
- Incidental, Non-Industrial Activities
  - Air-conditioning units used for human comfort that do not have applicable requirements under Title VI of the Act;
  - Ventilating units used for human comfort;
  - General office activities, such as paper shredding, copying, photographic activities, pencil sharpening and blueprinting;
  - Bathroom and toilet vent emissions;
  - Use of consumer products, including hazardous substances as that term is defined in the Federal Hazardous Substances Act (15 U.S.C. 1261 et seq.) where the product is used at a source in the same manner as normal consumer use;
  - Circuit breakers;
- Storage, Piping and Packaging
  - Storage tanks, vessels, and containers holding or storing liquid substances that will not emit any VOC or HAP;
  - Storage cabinets for flammable products;
  - Natural gas pressure regulator vents;
- Sampling and Testing
  - Vents from continuous emissions monitors and other analyzers;
  - Bench-scale laboratory equipment used for physical or chemical analysis, but not laboratory fume hoods or vents;
  - Equipment used for quality control, quality assurance, or inspection purposes, including sampling equipment used to withdraw materials for analysis;
  - Hydraulic and hydrostatic testing equipment;
  - Individual sampling points, analyzers, and process instrumentation, whose operation may result in emissions but that are not regulated as emission units;
- Safety Activities
  - Fire suppression systems;
  - Emergency road flares;
- Filter draining

8. LIST OF EQUIPMENT AND CONTROL DEVICES

A list of equipment has been provided in Section 2 with the associated ADEQ Equipment List form.

Pollution prevention techniques such as unpaved road watering, water sprays, covers, etc. are not considered pollution control devices. South32 has numerous structures, chutes, transfer towers, and enclosures that help prevent the release of particulate matter emissions to the atmosphere.

The facility is expected to have the following control devices that have been included in Section 2 with the associated ADEQ Equipment List form:

- Dust Collectors
- Selective catalytic reduction (SCR) and oxidation catalysts (OxCat) for natural gas engines
  - These engines are interlocked to ensure that the associated SCR and OxCat will operate at all times the engines are above the operating temperature specified for each control device by the engine vendor, including periods of startup, shutdown and malfunction.
  - Furthermore, engines will maintain compliance with NSPS JJJJ or IIII, as applicable, and MACT ZZZZ.

9. REGULATORY APPLICABILITY

The Hermosa Project will be subject to certain federal and state air regulations. This section summarizes the key air quality regulations that will apply under both federal and state programs.

9.1 Permit Applicability Analysis

9.1.1 ADEQ Class I Applicability

Per A.A.C. R18-2-302.B.1, a Class I permit shall be required for a person to begin actual construction of or operate a major source. For purposes of Class I permitting, a "major source" includes a source that directly emits or has the potential to emit, 100 tpy or more of any regulated air pollutant (see A.A.C. R18-2-101.75.c), 10 tons per year (tpy) or more of any hazardous air pollutant or 25 tpy or more of any combination of hazardous air pollutants (see A.A.C. R18-2-101.75.c).

As summarized in Table 1 1, the Hermosa Project's potential site-wide non-fugitive source emissions are greater than 100 tpy for NOx and potential site-wide combined (fugitive and non-fugitive) source emissions for single HAP and combined HAPs are greater than 10 tpy and 25 tpy respectively due primarily to power generation. Site-wide potential to emit regulated air pollutants is based on non-fugitive source emissions only, with the exception of HAP emissions which include both fugitive and non-fugitive emissions. Because the Hermosa Project will have the potential to emit regulated air pollutants in amounts greater than the 100 tpy major source threshold, a Class I permit is required.

9.1.2 New Source Review Applicability

The New Source Review (NSR) permitting program generally requires that a stationary source obtain a permit and undertake other obligations prior to construction of any facility if the proposed project results in the potential to emit air pollution in excess of certain threshold levels.

9.1.2.1 Major NSR Applicability

Two distinct federal NSR permitting programs apply depending on whether the facility is located in an attainment or nonattainment area for a particular pollutant, Prevention of Significant Deterioration (PSD) and Nonattainment Area NSR (NA NSR), respectively. NA NSR permitting applies to new construction or modifications that result in certain emission increases of a particular pollutant for which the area in which the facility is located is classified as "nonattainment". The PSD permitting program applies to projects with certain emissions increases of pollutants for which the area is classified as "attainment" or "unclassifiable."

The Hermosa Project will be located in the area of Santa Cruz County classified in attainment with the National Ambient Air Quality Standards (NAAQS) or unclassified for all regulated pollutants. A section of Santa Cruz County is nonattainment for PM_{10} in the Nogales planning area.[17] However, Hermosa Project operations will be outside the Nogales planning area and are not anticipated to impact the nonattainment area. Accordingly, NA NSR does not apply.

Under PSD permitting rules, the major source threshold is 250 tpy unless the facility is listed as a categorical source in A.A.C. R18-2-101.23, which has a lower 100 tpy threshold under A.A.C. R18-2-401.13.b.

[17] Per 40 CFR §81.303.

Underground mining operations are not categorical sources as defined in R18-2-101.23 and the Hermosa Project will not operate fossil-fuel fired boilers with more than 250 MMBtu/hr heat input (one of the categorical sources with a lower threshold). Therefore, the PSD major source threshold for the Hermosa Project is 250 tpy for any individual regulated NSR pollutant (see A.A.C. R18-2-401.13.b).

Note that because the Hermosa Project is not a categorical source, only non-fugitive emissions are assessed against the 250 tpy major source threshold; fugitive emissions are excluded from the major source applicability determination.[18] As summarized in Table 1-1, all potential site-wide non-fugitive emissions of regulated NSR pollutants will be less than 250 tpy. Therefore, South32 will not be subject to PSD review.

9.1.2.2 Minor New Source Review Applicability

Per A.A.C §R18-2-334.A, minor New Source Review (NSR) requirements shall apply when

- ► *The project involves:*
  - *Construction of any new Class I or Class II source, including the construction of any source requiring a Class II permit under §R18-2-302.01(C)(4); or*
  - *any minor NSR modification to a Class I or Class II source.*

The Hermosa facility will be classified as a new Class I source, therefore minor NSR requirements will apply.

- ► *A regulated minor NSR pollutant emitted by a new stationary source subject to this Section, if the source will have the potential to emit that pollutant at an amount equal to or greater than the permitting exemption threshold.*

The potential to emit of all regulated minor NSR pollutants except for SO_2 are above the permitting exemption threshold, therefore minor NSR requirements will apply to the Hermosa Project for all regulated minor NSR pollutants, except for SO_2. VOC emissions resulting from the Project are greater than 20 tpy. The Modeled Emission Rates for Precursors (MERPs) evaluation conducted in Section 7 of Air Dispersion Modeling Report demonstrates that this Project will not cause or contribute to an exceedance of the ozone NAAQS.

- ► *An increase in emissions of a regulated minor NSR pollutant from a minor NSR modification, if the modification would increase the source's potential to emit that pollutant by an amount equal to or greater than the permitting exemption threshold.*

The proposed project is not a modification to an existing source.

As detailed above, the proposed Hermosa Project will trigger minor NSR requirements under A.A.C R18-2-334. Pursuant to A.A.C. R18-2-334.C, South32 must submit either a RACT demonstration pursuant to R18-2-334.C.1 & D or a modeling demonstration pursuant to R18-2-334.C.2. South32 has elected to submit a modeling demonstration meeting R18-2-334.C.2 requirements that demonstrates the Hermosa Project will not interfere with attainment or maintenance of any NAAQS under separate cover.

[18] A.A.C. R18-2-401.13.e.

9.1.2.3 Part 63 Review Applicability

Per A.A.C §R18-2-1101.B, this application constitutes an application for preconstruction review and approval of a major source of HAPs pursuant to 40 C.F.R. § 63.5. The information required by § 63.5(d) is set forth in this application.

9.2 Federal and State Applicability Analysis

This section provides an applicability analysis of federal and state requirements for the Hermosa Project, including the following:

- New Source Performance Standards
  - 40 CFR 60 Subpart A
  - 40 CFR 60 Subpart Kb
  - 40 CFR 60 Subpart IIII
  - 40 CFR 60 Subpart JJJJ
  - 40 CFR 60 Subpart LL
  - 40 CFR 60 Subpart OOO
- National Emission Standards for Hazardous Air Pollutants
  - 40 CFR 63 Subpart A
  - 40 CFR 63 Subpart ZZZZ
  - 40 CFR 63 Subpart CCCCCC
- Compliance Assurance Monitoring
- Chemical Accident Prevention
- Strategic Ozone Protection
- Arizona Administrative Code

9.2.1 New Source Performance Standards

New Source Performance Standards (NSPS), located in 40 CFR Part 60, set performance standards for new, modified, or reconstructed sources of the regulated pollutant. The following section details the applicability of NSPS regulations to the Hermosa Project's proposed operations.

9.2.1.1 40 CFR 60 Subpart A – General Provisions

Pursuant to the requirements of 40 CFR § 60.1, all affected sources subject to source-specific NSPS are subject to the general provisions of NSPS Subpart A unless specifically excluded by the source-specific NSPS. NSPS Subpart A requires initial notification, performance testing, recordkeeping and monitoring, provides reference methods, and mandates general control device requirements for all other subparts as applicable.

9.2.1.2 40 CFR 60 Subpart Kb – Volatile Organic Liquid Storage Vessels

Pursuant to the requirements of 40 CFR § 60.110b(b), NSPS Subpart Kb, *Standards of Performance for Volatile Organic Liquid Storage Vessels*, regulates storage vessels with a capacity greater than 75 cubic meters (m^3) (19,813 gallons), that are used to store volatile organic liquids for which construction, reconstruction, or modification is commenced after July 23, 1984.

NSPS Subpart Kb provisions in 40 CFR § 60.110b(b) exempt tanks based on vapor pressure of constituent liquid. Specifically, NSPS Subpart Kb states "*This subpart does not apply to storage vessels with a capacity* *greater than or equal to 151 m^3 (39,960 gallons) storing a liquid with a maximum true vapor pressure less than 3.5 kilopascals (kPa) or with a capacity greater than or equal to 75 m^3 but less than 151 m^3 storing a liquid with a maximum true vapor pressure less than 15.0 kPa*."

South32 is proposing to install multiple diesel storage tanks, both aboveground and underground. Since the vapor pressure of diesel is less than 3.5 kPa[19], this subpart does not apply to the diesel tanks.

South32 is also proposing to install multiple gasoline tanks, both aboveground and underground each with capacities under 19,813 gallons. Therefore, this subpart does not apply to the gasoline tanks.

9.2.1.3 40 CFR 60 Subpart IIII – Stationary Compression Ignition Internal Combustion Engines

40 CFR § 60.4200(a)(2), NSPS Subpart IIII, *Standards of Performance for Stationary Compression Ignition Internal Combustion Engines*, provides standards of performance for owners and operators of stationary compression ignition (CI) Internal Combustion Engines (ICE) that were ordered after July 11, 2005, where the stationary CI ICE was manufactured after April 1, 2006, and is not a fire pump engine.

South32 is proposing to install diesel fired stationary CI ICEs at the Hermosa Project, and therefore this subpart does apply. The facility is subject to the following requirements:

- Purchase certified engines per § 60.4205(b), and maintain a copy of the US EPA certificate for the engine;
- Using only ultra-low sulfur diesel per § 60.4207(b);
- Operate, maintain, install, and configure the engines per the manufacturer's instructions;
- Ensure the engine is equipped with a non-resettable hour meter and that run logs noting the reason for operation are maintained per § 60.4209(a).

9.2.1.4 40 CFR 60 Subpart JJJJ – Stationary Spark Ignition Internal Combustion Engines

40 CFR § 60.4230(a)(2), NSPS Subpart JJJJ, *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*, provides standards of performance for owners and operators of stationary spark ignition (SI) Internal Combustion Engines (ICE) that were:

- Ordered after June 12th, 2006, if either:
  - Ordered after July 1st, 2007, with a maximum engine power ≥500 HP (except lean burn engines with a maximum engine power between 500 and 1,350 HP)
  - Ordered after January 1st, 2008, with a maximum engine power between 500 and 1,350 HP
  - Ordered after July 1st, 2008, with a maximum engine power ≤ 500 HP
  - Ordered after January 1st, 2009, for emergency engines with a maximum engine power > 25 HP
- Modified or reconstructed after June 12th, 2006

South32 is proposing to install natural gas-fired stationary SI ICEs at the Hermosa Project, and therefore this subpart does apply.

[19] Per AP-42, Section 7.1, Table 7.1-2.

9.2.1.5 40 CFR 60 Subpart LL – Standards of Performance for Metallic Mineral Processing Plants

Pursuant to the requirements of 40 CFR § 60.380(a), NSPS Subpart LL, Standards of Performance for Metallic Mineral Processing Plants, regulates "… the following affected facilities in metallic mineral processing plants: Each crusher and screen in open-pit mines; each crusher, screen, bucket elevator, conveyor belt transfer point, thermal dryer, product packaging station, storage bin, enclosed storage area, truck loading station, truck unloading station, railcar loading station, and railcar unloading station at the mill or concentrator with the following exceptions. All facilities located in underground mines are exempted from the provisions of this subpart …"

The NSPS Subpart LL provisions in 40 CFR § 60.381 defines "metallic mineral processing plants" as "any combination of equipment that produces metallic mineral concentrates from ore." The current scope of the Hermosa Project includes the production of metallic mineral concentrates from ore, and will include material sizing, transfers, storage and concentration. Therefore, this subpart will apply to affected facilities at the Hermosa Project. Note that the Taylor underground crusher will not be subject to this subpart because all facilities located in underground mines are exempt per 40 CFR § 60.380(a).

9.2.1.6 40 CFR 60 Subpart OOO – Standards of Performance for Nonmetallic Mineral Processing Plants

Pursuant to the requirements of 40 CFR § 60.670(a)(1), NSPS Subpart OOO, Standards of Performance for Nonmetallic Mineral Processing Plants, regulates "… the following affected facilities in fixed or portable nonmetallic mineral processing plants: each crusher, grinding mill, screening operation, bucket elevator, belt conveyor, bagging operation, storage bin, enclosed truck or railcar loading station. Also, crushers and grinding mills at hot mix asphalt facilities that reduce the size of nonmetallic minerals embedded in recycled asphalt pavement and subsequent affected facilities up to, but not including, the first storage silo or bin are subject to the provisions of this subpart."

The NSPS Subpart OOO provisions in 40 CFR § 60.671 defines "Nonmetallic mineral processing plants" as "any combination of equipment that is used to crush or grind any nonmetallic mineral wherever located, including lime plants, power plants, steel mills, asphalt concrete plants, Portland cement plants, or any other facility processing nonmetallic minerals except as provided in §60.670 (b) and (c)." The current scope of the Hermosa Project does not involve the crushing or grinding of nonmetallic minerals. Therefore, this subpart does not apply to the Hermosa Project.

9.2.2 National Emission Standards for Hazardous Air Pollutants for Source Categories

National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Categories, located in 40 CFR Part 63, have been promulgated for source categories that emit hazardous air pollutants (HAP). A facility that is a major source of HAP is defined as having potential emissions greater than 25 tpy of total HAPs and/or 10 tpy of a single HAP. Facilities with a potential to emit HAP at an amount less than the major source thresholds are otherwise considered an "area source." The NESHAP allowable emission limits are most often established on the basis of a maximum achievable control technology (MACT) determination for the particular source. The NESHAP apply to sources in specifically regulated industrial source categories (Clean Air Act [CAA] Section 112(d)) or on a case-by-case basis (CAA Section 112(g)) for facilities not regulated as a specific industrial source type.

The Hermosa Project will be classified as major source of HAP because it will have potential HAP emissions greater than the major source thresholds. The determination of applicability for NESHAP requirements for major sources of HAP are detailed in the following sections. Pursuant to the requirements of 40 CFR § 63.1(a)(2), all affected sources subject to source-specific NESHAP are subject to the general provisions of NESHAP Subpart A unless specifically excluded by the source-specific NESHAP.

9.2.2.1 40 CFR 63 Subpart A – National Emissions Standards for Hazardous Air Pollutants General Provisions

All "affected sources" subject to a NESHAP Subpart are also subject to the applicable General Provisions of NESHAP Subpart A unless specifically excluded by a specific NESHAP Subpart. NESHAP Subpart A includes the following requirements for affected sources subject to a specific NESHAP Subpart:

- Initial construction/reconstruction notification;
- Initial startup notification;
- Performance tests;
- Performance test date initial notification;
- General monitoring requirements;
- General recordkeeping requirements; and
- Semi-annual monitoring system and/or excess emission reports.

Because the proposed Project will include an affected source subject to a specific NESHAP Subpart, the NESHAP Subpart A General Provisions will apply.

9.2.2.2 40 CFR 63 Subpart ZZZZ – National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

Pursuant to the requirements of 40 CFR § 63.6585, NESHAP Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines*, applies to facilities that own or operate a stationary reciprocating internal combustion engine (RICE), except if the stationary RICE is being tested at a stationary RICE test cell/stand. The generators at the Hermosa Project are not being tested at a stationary RICE test cell/stand. Therefore, the generators will be subject to the requirements of NESHAP Subpart ZZZZ.

South32 will demonstrate compliance with NESHAP Subpart ZZZZ by complying with the applicable requirements in NSPS Subpart JJJJ and NSPS Subpart IIII noted above, and all applicable NESHAP Subpart ZZZZ requirements.

9.2.2.3 40 CFR 63 Subpart CCCCCC - National Emission Standards for Hazardous Air Pollutants for Gasoline Dispensing Facilities

Pursuant to the requirements of 40 CFR §63.11111(a), NESHAP Subpart CCCCCC, National Emission Standards for Hazardous Air Pollutants for Gasoline Dispensing Facilities (GDF), applies to owners and operates of gasoline dispensing facilities located at an area source of HAPs. While South32 is a major source of HAPs under Base Case (see Section 4.2), it is possible that it is classified as an area source of HAPs under AOS No. 1 (see Section 4.2). South32 anticipates there will be two GDFs one with a monthly throughput of more than 10,000 gallons, and one with a monthly throughput of less than 10,000 gallons and therefore is subject to this subpart under AOS No. 1.

9.2.3 Compliance Assurance Monitoring

The Compliance Assurance Monitoring (CAM) Rule under 40 CFR Part 64 applies to each pollutant specific emission unit that satisfies all of the following criteria:

- 1. Is subject to an emission limitation or standard for the applicable regulated air pollutant;
- 2. Uses a control device to achieve compliance with any such emission limitation or standard;
- 3. Has potential pre-control emissions of the applicable regulated air pollutant that are equal to or greater than the applicable major source threshold; and
- 4. Is not otherwise exempt.

There are no emission sources whose pre-control emissions individually exceed the major source threshold. Details of uncontrolled emissions are provided in Appendix A. As such, the Hermosa Project is not subject to CAM requirements.

9.2.4 Chemical Accident Prevention

Subpart B of 40 CFR Part 68 outlines requirements for risk management prevention (RMP) plans pursuant to CAA Section 112(r). Applicability of this subpart is determined based whether more than a threshold quantity of a regulated substance is contained in a process at a source. The Hermosa Project will not have a process that contains any regulated substance in quantities greater than the threshold quantities. Therefore, the requirements of 40 CFR Part 68 are not applicable to the Hermosa Project. However, the facility will be subject to the provisions of the CAA General Duty Clause, Section 112, as it pertains to the identification of hazards associated with an accidental release, designing and maintaining a safe facility, and minimizing consequences of any accidental releases that occur.

9.2.5 Stratospheric Ozone Protection Regulations

The requirements originating from Title VI of the Clean Air Act, *Protection of Stratospheric Ozone*, are contained in 40 CFR Part 82. The following Subparts may be potentially application to the Hermosa Project, as it may conduct activities described in those subparts.

40 CFR 82 Subpart B, *Servicing of Motor Vehicle Air Conditioners,* potentially applies if the facility performs service on a motor vehicle involving refrigerant in the motor vehicle air conditioner. Subpart B requires persons conducting this service to do so with proper equipment, training, and certification. An appropriately certified technician will complete all such air conditioner servicing with the proper equipment, training, and certification at the facility.

40 CFR Part 82 Subpart F, *Recycling and Emissions Reduction*, potentially applies if the facility maintains, repairs, services, or disposes of appliances that utilize Class I or Class II ozone depleting substances. Subpart F generally requires persons completing the repairs, service, or disposal to be properly certified. An appropriately certified technician will complete all repairs, service, and disposal of ozone depleting substances from the comfort cooling components at the facility.

40 CFR 82 Subpart H, *Halon Emissions Reduction*, potentially applies if the facility repairs, services, or disposes of any equipment containing halons. Subpart H prohibits the release of halons during testing, maintenance, servicing, repairing, or disposing of equipment containing halons, aside from de minimis releases. Subpart H also requires individuals maintaining, servicing, repairing, or disposing of halons to be trained. South32 will comply with this subpart by minimizing halon releases into the environment as de

minimis releases and having appropriately certified technicians complete all halon equipment servicing, repairs, and disposal.

9.2.6 Arizona Administrative Code (A.A.C.)

The Hermosa Project is subject to regulations contained in A.A.C. R18 Chapter 2 (Air Pollution Control). Table 9-1 through Table 9-4 contain summaries of the applicable ADEQ requirements for the Hermosa Project. Additional details regarding methods used for determining compliance are contained in Table 9-5 through Table 9-7.

Table 9-1. Hermosa Project – State Regulatory Applicability Analysis – Article 3

Applicable Regulation ID	Applicable Regulation Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-302	Applicability; Registration; Classes of Permit	Facility-wide	Site-wide non-fugitive source emissions are expected to be greater that the permitting exemption thresholds and will also be greater than the major source thresholds. As such, South32 will obtain an ADEQ Class I permit prior to actual construction or operation of the Hermosa Project.
A.A.C. R18-2-304	Permit Application Processing Procedures	Facility-wide	South32 will complete the applicable standard application form provided by the Director and supply all information required by the form's filing instructions.
A.A.C R18-2-306.01	Permits Containing Voluntarily Accepted Emission Limitations and Standards	Facility-wide	South32 will comply with the voluntarily accepted limitations in the permit.
A.A.C. R18-2-307.A.1.	Permit Review by the EPA and Affected States	Facility-wide	South32 will submit a copy of the completed application to the Administrator.
A.A.C. R18-2-309	Compliance Plan; Certification	Facility-wide	South32 will submit an annual compliance certification in accordance with the timelines and procedures specified in this section.
A.A.C. R18-2-310.01	Reporting Requirements	Facility-wide	South32 will report to the Director any emissions in excess of the limits established by this Chapter or the applicable permit limits in accordance with the timelines and procedures specified in this section.
A.A.C. R18-2-315	Posting of Permit	Facility-wide	South32 will post the permit or certificate of permit issuance on location at the Hermosa Project.

Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-327	Annual Emissions Inventory Questionnaire	Facility-wide	South32 will complete and submit to the Director an annual emissions inventory questionnaire.
A.A.C R18-2-330.F	Public Participation	Facility-wide	South32 will post a notice containing the information required in R18-2-330.D. at where the Hermosa Project is located.
A.A.C. R18-2-334	Minor New Source Review	Facility-wide	South32 will comply with the requirements of this rule by implementing RACT and/or performing an ambient air quality assessment for each regulated minor NSR pollutant subject to this section.

Table 9-2. Hermosa Project – State Regulatory Applicability Analysis – Article 6

Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-602	Open Burning	Facility-wide	South32 will not engage in any open burning without first obtaining a permit from the appropriate authority, except for those open outdoor fires exempt from a permit.
A.A.C. R18-2-604	Open Areas, Dry Washes, or Riverbeds	▶ Parking areas. ▶ Vacant lots. ▶ Open areas.	South32 will utilize good modern practices (e.g., approved dust suppressant, adhesive soil stabilizer, paving, covering, landscaping, continuous wetting, detouring, barring access, or other acceptable means) to limit excessive amounts of PM from becoming airborne.
A.A.C. R18-2-605	Roadways and Streets	▶ Roadways. ▶ Material transportation.	South32 will utilize good modern practices (e.g., temporary paving, dust suppressants, wetting down, detouring or by other reasonable means) to keep dust and other particulates to a minimum.
A.A.C. R18-2-606	Material Handling	Handling, transporting or conveying of materials.	South32 will prevent excessive amounts of particulate matter from becoming airborne by taking reasonable precautions (e.g., use of spray bars, wetting agents, dust suppressants, covering the load, and hoods).
A.A.C. R18-2-607	Storage Piles	Material stacking, piling, or storing	South32 will prevent excessive amounts of particulate matter from becoming airborne by taking reasonable precautions (e.g., minimizing fall of material, spray bars, chemical stabilization, wetting, or covering).

Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-608	Mineral Tailings	Historic tailings impoundments inherited by South32 as part of land purchase and new tailings storage facilities	As noted in the July 13, 2017, letter to the ADEQ, South32 inherited historic tailings impoundments as part of the land purchase. South32 will take reasonable precautions to prevent excessive amounts of particulate matter from becoming airborne from all tailings at the facility.
A.A.C. R18-2-614	Evaluation of Nonpoint Source Emissions	▶ Roads ▶ Material Transfer ▶ Storage Piles	South32 will comply with the 40% opacity requirement for all non-point sources. South32 will conduct an initial visual assessment, and if any visible emissions are detected, will follow-up with an EPA Method 9 evaluation.

Table 9-3. Hermosa Project – State Regulatory Applicability Analysis – Article 7

Potentially Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-702	General Visible Emissions Standard	▶ Exhaust vent raises/shafts ▶ Dust collectors ▶ Cooling towers	South32 will comply with the 20% opacity requirement for all existing, point sources. South32 will conduct an initial visual assessment, and if any visible emissions are detected, will follow-up with an EPA Method 9 evaluation. Note that engines and tanks are not considered "existing" per definition of "existing emissions unit" pursuant to A.A.C. §R18-2-701(16).
A.A.C. R18-2-703	Standards of Performance for Existing Fossil-fuel Fired Steam Generators and General Fuel-burning Equipment	Engine(s)	Not applicable, as the equipment at the Hermosa Project is not "existing" per definition of "existing emissions unit" pursuant to A.A.C. §R18-2-701(16).
A.A.C. R18-2-710	Standards of Performance for Existing Storage Vessels for Petroleum Liquids	Diesel and Gasoline tanks	Not applicable, since the tanks are subject to R18-2-905 and not "existing" per definition of "existing source" pursuant to A.A.C. §R18-2-701(16).

Potentially Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-719	Standards of Performance for Existing Stationary Rotating Machinery	Generator(s)	Not applicable, since all generators are subject to NSPS JJJJ (R18-2-901), therefore is not "existing" per definition of "existing emissions unit" pursuant to A.A.C. §R18-2-701(16).
A.A.C R-18-2-721	Standards of Performance for Existing Nonferrous Metals Industry Sources	▶ Crushers ▶ Mills ▶ Concentrators	South32 will comply with the requirements of this section for all applicable sources not subject to NSPS Subpart LL.
A.A.C R-18-2-723	Standards of Performance for Existing Concrete Batch Plants	▶ Material Transfer ▶ Storage Piles ▶ Handling, transporting or conveying of materials.	Fugitive dust emitted from concrete batch plants will be controlled in accordance with R18-2-604 through R18-2-607.
A.A.C. R18-2-730 (K)	Standards of Performance for Unclassified Sources	Cyanide Storage	Because solid cyanide pellets are converted to solution form before being handled at the Hermosa Project, there should be no sodium cyanide dust or dust from any other solid cyanide subject to this regulation.

Table 9-4. Hermosa Project – State Regulatory Applicability Analysis – Article 9 and 11

Potentially Applicable Regulation ID	Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-901	Standards of Performance for New Stationary Sources	Various	South32 will comply with the requirements of this section by complying with applicable NSPS described in Section 1.2.2 above, including R18-2-901.1 (A), 46 (LL), 84 (IIII), and 85 (JJJJ).

Potentially Applicable Regulation ID	Potentially Applicable Regulation Title	Equipment Potentially Applicable To	Comments
A.A.C. R18-2-905	Standards of Performance for Storage Vessels for Petroleum Liquids	Diesel and Gasoline Tanks	South32 will comply with the requirements of this section by equipping any petroleum liquid storage tank of less than 40,000 gallons with a submerged filling device or acceptable equivalent for the control of hydrocarbon emissions. All pumps and compressors which handle volatile organic compounds shall be equipped with mechanical seals or other equipment of equal efficiency to prevent the release of organic contaminants into the atmosphere.
A.A.C. R18-2-1101	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	Various	South32 will comply with the requirements of this section by complying with applicable NESHAP described in Section 1.2.1 above, including R18-2-1101.B.1 (A), 81 (ZZZZ), and 105 (CCCCCC).

Table 9-5. Hermosa Project Applicable Regulatory Requirements of A.A.C. R18-2-700 and Methods for Determining Compliance

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used for Determining Compliance
A.A.C. R18-2-702.B.3.	For all sources described in A.A.C. R18-2-702.A (except as otherwise provided in Title 18, Chapter 2 of the A.A.C. relating to specific types of sources): • Opacity ≤ 20% If the presence of uncombined water is the only reason for an exceedance of the opacity limit, the exceedance shall not constitute a violation.	Facility procedure; records of monthly visual surveys; records of Method 9 observations.

Table 9-6. Hermosa Project Applicable Regulatory Requirements of A.A.C. R18-2-900 and Methods for Determining Compliance

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used for Determining Compliance
40 CFR 60.7(a)(1) A.A.C. R18-2-901.1	Provide notification of the date construction (or reconstruction as defined under 40 CFR 60.15) commenced postmarked no later than 30 days after such date. This requirement does not apply in the case of mass-produced facilities which are purchased in completed form.	Facility procedure, submittal of notifications, maintenance of records.
40 CFR 60.7(a)(3) A.A.C. R18-2-901.1	Provide notification of the actual date of initial startup postmarked within 15 days after such date.	Facility procedure, submittal of notifications, maintenance of records.
40 CFR 60.7(a)(4) A.A.C. R18-2-901.1	Submit a notification of any physical or operational change to an existing facility which may increase the emission rate of any air pollutant to which a standard applies, unless that change is specifically exempted under an applicable subpart or in 40 CFR 60.14(e). This notice shall be postmarked 60 days or as soon as practicable before the change is commenced and shall include information describing the precise nature of the change, present and proposed emission control systems, productive capacity of the facility before and after the change, and the expected completion date of the change.	Submittal of notifications, maintenance of records.

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used for Determining Compliance
40 CFR 60.7(a)(6) A.A.C. R18-2-901.1	Submit a notification of the anticipated date for conducting the opacity observations required by 40 CFR 60.11(e)(1). The notification must also include, if appropriate, a request for the Administrator to provide a visible emissions reader during a performance test. The notification must be postmarked not less than 30 days prior to such date.	Submittal of notifications, maintenance of records.
40 CFR 60.7(b) A.A.C. R18-2-901.1	Maintain records of: • The occurrence and duration of any startup, shutdown, or malfunction in the operation of an affected facility; • Any malfunction of the air pollution control equipment; and Any periods during which a continuous monitoring system or monitoring device is inoperative.	Facility procedure; maintenance of records.
40 CFR 60.7(c) A.A.C. R18-2-901.1	Submit excess emissions and monitoring systems performance report and/or summary report form to the Administrator semiannually, except when more frequent reporting is specifically required by an applicable subpart; or the Administrator, on a case-by-case basis, determines that more frequent reporting is necessary to accurately assess the compliance status of the source. All reports shall be postmarked by the 30th day following the end of each six-month period.	Submittal of report, maintenance of records.
40 CFR 60.7(f) A.A.C. R18-2-901.1	Maintain a file of all measurements in a permanent form suitable for inspection. Retain the file for at least two years following the date of such measurements.	Facility procedure; maintenance of records.
40 CFR 60.8(a) A.A.C. R18-2-901.1	Completion of performance test in accordance with 40 CFR 60.8 demonstrating compliance with applicable limits within 60 days after achieving the maximum production rate, but no later than 180 days after initial startup. Submittal of written report of the results of the performance tests to the Director and Administrator.	Performance of EPA Reference Method Tests.
40 CFR 60.11(d) A.A.C. R18-2-901.1	At all times, including periods of startup, shutdown, and malfunction, maintain, and operate, to the extent practicable, any affected facility including associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing emissions.	Facility procedure; maintenance of records.

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used for Determining Compliance
40 CFR 60.11(e) A.A.C. R18-2-901.1	If no performance test under 40 CFR 60.8 is required, completion of opacity observations demonstrating compliance with applicable limits within 60 days after achieving the maximum production rate, but no later than 180 days after initial startup.	Performance of EPA Reference Method 9 Tests.
A.A.C. R18-2-905	Equip petroleum liquid storage tanks of <40,000 gallons with a submerged filling device Equip all facilities for dock loading of petroleum products with a vapor pressure of >2.0 pounds per square inch with submerged filling or other equivalent for the control of hydrocarbon emissions Equip all pumps and compressors which handle volatile organic compounds with mechanical seals or other equipment of equal efficiency to prevent the release of organic contaminants into the atmosphere	Facility procedure; maintenance of records.

Table 9-7. South32 Applicable Regulatory Requirements of NSPS and NESHAP and Methods for Demonstrating Compliance

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used to Demonstrate Compliance
40 CFR 60 Subpart A A.A.C. R18-2-902	Comply with 40 CFR 60 Subpart A requirements of initial notification, performance testing, recordkeeping and monitoring, and mandates general control device requirements for all other subparts as applicable.	Facility procedure; maintenance of records
40 CFR 63 Subpart A A.A.C. R18-2-1102	Comply with 40 CFR 63 Subpart A requirements of initial notification, performance testing, recordkeeping and monitoring, etc.	Facility procedure; maintenance of records
40 CFR 60 Subpart JJJJ A.A.C. R18-2-901.85	Comply with 40 CFR 60 Subpart JJJJ requirements for non-emergency engines ordered after July 1, 2007.	Facility procedure; maintenance of records
40 CFR 60 Subpart LL A.A.C. R18-2-901.46	Comply with 40 CFR 60 Subpart LL requirements for all affected facilities.	Facility procedure; maintenance of records

Regulatory Citation for Applicable Requirements	Description of Requirements	Methods Used to Demonstrate Compliance
40 CFR 63 Subpart CCCCCC A.A.C. R18-2-1101.B.105	Comply with 40 CFR 63 Subpart CCCCCC requirements for Gasoline Dispensing Facilities located at an area source of HAP with a monthly throughput of <10,000 gallons and >10,000 gallons of gasoline.	Facility procedure; maintenance of records
40 CFR 63 Subpart ZZZZ A.A.C. R18-2-1101.B.81	Comply with 40 CFR 63 Subpart ZZZZ requirements for nonemergency stationary reciprocating internal combustion engines located at a major HAP source.	Facility procedure; maintenance of records
40 CFR 60 Subpart IIII A.A.C. R18-2-901.84	Comply with 40 CFR Subpart IIII which provides standards of performance for owners and operators of stationary compression ignition (CI) Internal Combustion Engines (ICE) that were ordered after July 11, 2005, where the stationary CI ICE was manufactured after April 1, 2006, and is not a fire pump engine.	Facility procedure; maintenance of records

9.2.7 Proposed General Conditions

South32 is proposing the following general conditions to address miscellaneous activities that may take place at the Hermosa Project.

1. South32 will not cause or allow sandblasting or other abrasive blasting without minimizing dust emissions to the atmosphere through the use of good modern practices. These practices include wet blasting and/or effective enclosures with necessary dust collecting equipment. South32 will not allow visible emissions from sandblasting or other abrasive blasting operations to exceed the permitted opacity.

2. While performing spray painting operations, South32 will not conduct any spray-painting operation without minimizing organic solvent emissions. Such operations, other than architectural coating and spot painting, will be conducted in an enclosed area equipped with controls. South32 will document each time a spray-painting project is conducted, including the date, duration, type of control measures utilized, and the amount of paint consumed.

10. PERMIT PROCESSING FEE

In accordance with A.A.C R18-2-326, Fees Related to Individual Permits, and the ADEQ Permit Fee Schedule[20] (effective November 1, 2021), no fee is being submitted with this Class I permit application. However, South32 agrees to pay the $173 per hour processing fee required based on the total actual time spent by ADEQ staff on processing this application as well as any fees associated with public notice.

[20] https://static.azdeq.gov/aqd/aqd_class_fees.pdf

11. COMPLIANCE PLAN AND CERTIFICATION

As required by A.A.C. R18-2-304(B)(8)(b) and ADEQ's Instructions in Section 2-4, Item 16 and 17 of ADEQ's Application Packet for a Class I Permit, South32 is committed to maintaining compliance as follows:

- Compliance certification.

  The Hermosa Project is in compliance with all applicable requirements noted as applicable to the Project in Tables 9-1 through 9-7 of this application. South32 determined compliance using the methods described in each of the tables for the applicable requirements identified therein or, for unconstructed units and activities, by knowledge that the affected equipment or activity triggering an applicable requirement is not yet constructed or occurring.

- For applicable requirements with which the source is in compliance at the time of permit issuance.

  The Hermosa Project source will continue to comply with applicable requirements.

- For applicable requirements that will become effective during the permit term.

  The Hermosa Project will meet in a timely manner applicable requirements that become effective during the permit term. South32 is not presently aware of any particular applicable requirements requiring a more specific future schedule. Furthermore, South32 shall submit a compliance certification annually which describes the compliance status of the Hermosa Project with respect to each permit condition.

- A schedule of compliance for sources that are not in compliance with all applicable requirements at the time of permit issuance. Such a schedule shall include a schedule of remedial measures, including an enforceable sequence of actions with milestones, leading to compliance with any applicable requirements for which the source will be in noncompliance at the time of permit issuance. This compliance schedule shall resemble and be at least as stringent as that contained in any judicial consent decree or administrative order to which the source is subject. Any such schedule of compliance shall be supplemental to, and shall not sanction noncompliance with, the applicable requirements on which it is based.

  The Hermosa Project is not out of compliance with any applicable requirements. Therefore, no compliance schedule is required.

- The Hermosa Project includes two proposed Alternative Operating Scenarios described more fully in Section 4.2 of this application.

  The Hermosa Project will meet all applicable requirements for each Alternate Operating Scenario upon implementation of the Alternate Operating Scenario. The time of change from one Alternate Operating Scenario to the other will be logged. If a proposed Alternate Operating Scenario would implicate an applicable requirement that will become effective during the permit term, the Hermosa Project will comply with such requirements on a timely basis. South32 is not presently aware of any applicable requirements would become effective during the permit term.

- A schedule for the submission of certified progress reports no less frequently than every 6 months for sources required to have a schedule of compliance to remedy a violation.

The Hermosa Project is not subject to a compliance schedule and therefore is not subject to a requirement to schedule certified progress reports.

12. ENVIRONMENTAL JUSTICE

For many years, it has been federal policy that environmental actions, including permit issuance, ensure "the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies." In more recent years, the focus has become stronger on identifying underserved and overburdened communities, particularly those that have historically been marginalized, to ensure that they do not suffer from a disproportionate additional impact from a proposed environmental action. South32 shares these concerns and is committed to minimizing adverse impacts on all communities.

South32 has reviewed EPA's EJ Screen 2.1 tool to help it understand the communities in which it is located. At one level, very few individuals of any type live in the immediate vicinity of the proposed Hermosa Project due to its remoteness and generally poor transportation infrastructure. South32 thus undertook a broader review of the area within five miles of the Hermosa Project. This review indicated that the area around the proposed Hermosa Project is fairly representative of the state as a whole. Relevant demographic indicators include:

Demographic Indicator	Value	State Average	State Percentile
People of color	29%	46%	38%
Low-income population	43%	33%	68%
Linguistically isolated population	2%	4%	60%
Population < high school education	5%	12%	40%
Population > 64 years of age	31%	18%	81%
EPA calculated Demographic Index	36%	38%	54%

EPA's "Interim Environmental Justice and Civil Rights in Permitting Frequently Asked Questions" (Aug. 2022), suggests the use of benchmarks at 80, 90 or 95th percentiles (page 9 of Appendix B). The only community that exceeds any of these benchmarks is the population > 64 years of age, which is neither a group of color nor low income that triggers heightened EJ review. This can be seen, additionally, in EPA's provisional demographic index, which is less than 50%.

Although there is a low indication of a potentially underserved community, South32 also evaluated whether the communities around the proposed Hermosa Project may be "overburdened" due to environmental contamination or similar stressors. EPA's EJ Screen 2.1 tool shows that the area around the proposed Hermosa Project are well below the state average (e.g., 50th percentile or less) for particulate matter, ozone, diesel particulate, air toxics, respiratory hazard, Superfund, risk management planning and hazardous waste facilities. The only potential indicators of environmental stress is lead paint (0.2% of housing is pre-1960). The lead paint index likely overstates the issue as it assumes all housing pre-1960 is affected and as noted above, there are few residences within the immediate vicinity of the proposed Hermosa Project. As demonstrated elsewhere in this application, the proposed Hermosa Project would include significant ambient dust controls and modeling suggests that few, if any, residences would fall within an area where any significant impact from particulate matter is expected. More broadly, while the proposed installation of generators will result in increased air pollution risks, including some air toxics exposure, the cumulative impact of particulate matter, ozone and potential air toxics remains very low, as the current burden in the area around the Hermosa Project is very low (< 19th percentile for particulate matter, 21st percentile or lower for the others). As a result, South32 does not believe that the proposed Hermosa Project will impose any significant additional burden on surrounding individuals.

A copy of the initial EJ Screen 2.1 report is included in Appendix C.

The final prong of environmental justice is meaningful community engagement. In addition to the regulatorily-required communications as part of this permitting process, South32 regularly provides informal and formal updates to local officials and has held multiple public open houses in Patagonia, Sonoita and Nogales, the nearest towns, to explain the Hermosa Project and address local resident concerns. In 2021, South32 also proactively established a project advisory panel comprised of community members representing diverse interests from across the county and whose monthly meetings, open to the public, focus on potential impacts and opportunities of the Hermosa Project. These ongoing engagements have helped inform the development of the proposed Hermosa Project, particularly with respect to traffic flows and safety considerations. While no formal consultation has been required with any of the tribes with historic connections to the area, South32 has proactively briefed a number of tribal officials, led talking tours of the site for Tohono O'odham and Ak-Chin officials, conducted voluntary cultural resource surveys across its mining claims in the accompaniment of tribal monitors, and sought informal guidance on cultural resources or other concerns that should be respected. South32 is committed to continuing this effort throughout the permitting process and life of the Hermosa Project.

APPENDIX A. EMISSIONS CALCULATIONS

Section 2.3 Equipment List							
Type of Equipment	**Maximum Rated Capacity**	**Units**	**Make**	**Model**	**Serial Number**	**Date of Manufacture**	**Equipment ID Number**
Crushers - Taylor							
Primary Crusher	1,543	ton/hr	TBD	TBD	TBD	TBD	CRUSH-1
Pebble Crusher	220	ton/hr	TBD	TBD	TBD	TBD	22210-CR-00001
Mills							
Primary Mill	854	ton/hr	TBD	TBD	TBD	TBD	22110-ML-00001
Secondary Mill	2,364	ton/hr	TBD	TBD	TBD	TBD	22120-ML-00001
Lead Regrind Mill	101	ton/hr	TBD	TBD	TBD	TBD	22320-ML-00001
Zinc Regrind Mill	120	ton/hr	TBD	TBD	TBD	TBD	22320-ML-00002
Screens - Taylor							
Primary Mill Discharge Screen	854	ton/hr	TBD	TBD	TBD	TBD	22110-SN-00002
Flotation Trash Screen	712	ton/hr	TBD	TBD	TBD	TBD	22310-SN-00001
Bins/Silos - Taylor							
Pebble Crusher Feed Bin	220	ton/hr	TBD	TBD	TBD	TBD	22210-BN-00001
Mine Shaft Ore Surge Bin	675	ton/hr	TBD	TBD	TBD	TBD	21210-BN-00001
Pebble Crusher Product Surge Bin	220	ton/hr	TBD	TBD	TBD	TBD	22210-BN-00002
Tailings Weigh Bin	615	ton/hr	TBD	TBD	TBD	TBD	22540-BN-00001
Coarse Ore Silo No.1	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00001
Coarse Ore Silo No.2	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00002
Coarse Ore Silo No.3	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00003
Conveyors - Taylor							
Coarse Ore Overland Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21210-CV-00001
Coarse Ore Silo No.1 Feed Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21320-CV-00002
Coarse Ore Silo No.2 Feed Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21320-CV-00003
Primary Mill Feed Conveyor	815	ton/hr	TBD	TBD	TBD	TBD	21710-CV-00001
Primary Screen Discharge Conveyor	220	ton/hr	TBD	TBD	TBD	TBD	22210-CV-00002
Pebble Conveyor	220	ton/hr	TBD	TBD	TBD	TBD	22210-CV-00001
Tailings Transfer Conveyor No.1	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00001
Tailings Transfer Conveyor No.2	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00002
Tailings Silo Feed Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00010
Tailings Paste Plant Feed Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00003
Tailings Truck Loading Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00005
Feeders/Chutes - Taylor							
Pebble Crusher Feeder	220	ton/hr	TBD	TBD	TBD	TBD	22210-FE-00001
Primary Mill Feed Chute	815	ton/hr	TBD	TBD	TBD	TBD	22110-CH-00001
Pebble Crusher Product Feeder	220	ton/hr	TBD	TBD	TBD	TBD	22210-FE-00002
Mine Shaft Ore Discharge Feeder	815	ton/hr	TBD	TBD	TBD	TBD	21210-FE-00001
Coarse Ore Silo Discharge Feeder No.1	675	ton/hr	TBD	TBD	TBD	TBD	21710-FE-00001
Coarse Ore Silo Discharge Feeder No.2	675	ton/hr	TBD	TBD	TBD	TBD	21700-FE-00002
Coarse Ore Silo Discharge Feeder No.3	675	ton/hr	TBD	TBD	TBD	TBD	21700-FE-00003
Concentrate Feeder	70.0	ton/hr	TBD	TBD	TBD	TBD	22440-FE-00001
Tailings Silo Reclaim Feeder	615	ton/hr	TBD	TBD	TBD	TBD	22540-FE-00001
Tailings Filter Discharge Feeder No. 1	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00020
Tailings Filter Discharge Feeder No. 2	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00021
Tailings Filter Discharge Feeder No. 3	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00022
Tailings Filter Discharge Feeder No. 4	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00023
Product Packaging Station							
Container Transport Cart Loading	70	ton/hr	TBD	TBD	TBD	TBD	22440-CB-00001
Dust Collectors - Taylor							
Dust Collector No. 1	3,200	cfm	TBD	TBD	TBD	TBD	DC-1

Section 2.3 Equipment List							
Type of Equipment	Maximum Rated Capacity	Units	Make	Model	Serial Number	Date of Manufacture	Equipment ID Number
Dust Collector No. 2	4,750	cfm	TBD	TBD	TBD	TBD	DC-2
Dust Collector No. 3	3,300	cfm	TBD	TBD	TBD	TBD	DC-3
Dust Collector No. 4	3,300	cfm	TBD	TBD	TBD	TBD	DC-4
Dust Collector No. 5	3,300	cfm	TBD	TBD	TBD	TBD	DC-5
Dust Collector No. 11	3,300	cfm	TBD	TBD	TBD	TBD	DC-11
Dust Collector No. 6	7,500	cfm	TBD	TBD	TBD	TBD	DC-6
Paste Plant - Taylor							
Paste Plant Binder Silo 1	750	cfm	TBD	TBD	TBD	TBD	DC-PPBS1
Paste Plant Binder Silo 2	750	cfm	TBD	TBD	TBD	TBD	DC-PPBS2
Paste Plant Binder Silo 3	1,500	cfm	TBD	TBD	TBD	TBD	DC-PPBS3
Paste Plant Binder Silo 4	1,500	cfm	TBD	TBD	TBD	TBD	DC-PPBS4
Paste Plant Module 1 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-PPM1M
Paste Plant Module 2 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-PPM2M
Storage Tanks - Taylor							
MIBC/F-549 Storage Tank	7,925	gal	TBD	TBD	TBD	TBD	22620-TN-00001
Test Reagent Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00002
Slovay 5100 Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00003
Copper Sulphate Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00005
Copper Sulphate Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00006
Zinc Sulphate Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00007
Zinc Sulphate Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00008
Zinc Cyanide Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00009
Zinc Cyanide Holding Tank	3,963	gal	TBD	TBD	TBD	TBD	22620-TN-00010
SMBS Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00011
SMBS Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00012
Tailings Flocculant Holding Tank	17,171	gal	TBD	TBD	TBD	TBD	22620-TN-00013
Lead Flocculant Holding Tank	1,320	gal	TBD	TBD	TBD	TBD	22620-TN-00014
Zinc Flocculant Holding Tank	1,320	gal	TBD	TBD	TBD	TBD	22620-TN-00015
3418-A Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00004
Shaft ANE Storage Tank	10,293	gal	TBD	TBD	TBD	TBD	TNK-061
Fuel Tanks							
Unleaded Gasoline (S32) T-01	1,000	gal	TBD	TBD	TBD	TBD	T-01
Diesel (Red Dyed S32) T-02	5,000	gal	TBD	TBD	TBD	TBD	T-02
Diesel (Red Dyed S32) T-03	5,000	gal	TBD	TBD	TBD	TBD	T-03
Diesel (Red Dyed Rummel) T-04	12,000	gal	TBD	TBD	TBD	TBD	T-04
Unleaded Gasoline (Rummel) T-05	1,000	gal	TBD	TBD	TBD	TBD	T-05
Diesel (Rummel) T-06	1,000	gal	TBD	TBD	TBD	TBD	T-06
Unleaded Gasoline T-07	10,000	gal	TBD	TBD	TBD	TBD	T-07
Unleaded Gasoline T-08	10,000	gal	TBD	TBD	TBD	TBD	T-08
Unleaded Gasoline T-09	10,000	gal	TBD	TBD	TBD	TBD	T-09
Diesel T-10	50,000	gal	TBD	TBD	TBD	TBD	T-10
Diesel T-11	50,000	gal	TBD	TBD	TBD	TBD	T-11
Concrete Batch Plant -Taylor							
Concrete Batch Plant	40,274	tpy	TBD	TBD	TBD	TBD	CBP
Natural Gas Generators							
CAT 3520 DSL 2600 kW / JGC 624 4481 kW	2,600 / 4,481	kW	Caterpillar / Jenbacher	3520 DSL / J624	TBD	TBD	T_ENG / T_ENG_ALT
Diesel Generators							

Section 2.3 Equipment List							
Type of Equipment	**Maximum Rated Capacity**	**Units**	**Make**	**Model**	**Serial Number**	**Date of Manufacture**	**Equipment ID Number**
CAT XQ1140, 910 kW	910	kW	Caterpillar	3520 DSL	TBD	TBD	HS_1 - HS_6
CAT C175 3000 kW	3000	kW	Caterpillar	C175-16	TBD	TBD	ENG9 - ENG13
C200D2RE	198	kW	Cummins	QSB7-G9	TBD	TBD	ENG5
WTP2 Cooling Towers							
WTP2 CT Cell 1	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT1
WTP2 CT Cell 2	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT2
WTP2 CT Cell 3	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT3
WTP2 CT Cell 4	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT4
WTP2 CT Cell 5	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT5
WTP2 CT Cell 6	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT6
WTP2 CT Cell 7	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT7
WTP2 CT Cell 8	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT8
Surface Refrigeration Plant							
Cooling Tower Cell 1	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 1
Cooling Tower Cell 2	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 2
Cooling Tower Cell 3	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 3
Cooling Tower Cell 4	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 4
UG Refrigeration CT Cell 1	2774	gal/min	TBD	TBD	TBD	TBD	UG Refrigeration CT Cell 1
UG Refrigeration CT Cell 2	2774	gal/min	TBD	TBD	TBD	TBD	UG Refrigeration CT Cell 2
UG Refrigeration CT Cell 3	2774	gal/min	TBD	TBD	TBD	TBD	UG Refrigeration CT Cell 3
UG Refrigeration CT Cell 4	2774	gal/min	TBD	TBD	TBD	TBD	UG Refrigeration CT Cell 4
Gasoline Dispensing Facilities - Taylor							
Aboveground Gasoline Dispensing Facility	150,000	gal/yr	TBD	TBD	TBD	TBD	AGGDF
Evaporators							
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	MEVAP1
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	MEVAP2
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	MEVAP3
Process Tanks							
Lead Rougher	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00001
Lead Rougher Scavenger	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00004
Lead Cleaner Scalper	305	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00008
Lead Cleaner	285	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00007
Lead Cleaner Scavenger	270	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00009
Zinc Rougher	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00005
Zinc Rougher Scavenger	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00006
Zinc Cleaner Scalper	1600	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00011
Zinc Cleaner	1650	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00010
Zinc Cleaner Scavenger	1700	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00012
Zinc Conditioning Tank No. 1	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-002
Zinc Conditioning Tank No. 2	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-003
Feed Stabilization Tank	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-008
Lead Concentrate De-Aeration Tank	200	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-004
Lead Concentrate Thickener Overflow Tank	150	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-005
Lead Concentrate Tank	75	ton/hr	TBD	TBD	TBD	TBD	22430-TNK-011
Zinc Concentrate De-Aeration Tank	225	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-006

Section 2.3 Equipment List							
Type of Equipment	**Maximum Rated Capacity**	**Units**	**Make**	**Model**	**Serial Number**	**Date of Manufacture**	**Equipment ID Number**
Zinc Concentrate Thickener Overflow Tank	150	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-007
Zinc Concentrate Tank	100	ton/hr	TBD	TBD	TBD	TBD	22430-TNK-014
Cyanide Destruction Tank No. 1	2300	ton/hr	TBD	TBD	TBD	TBD	22510-TNK-021
Cyanide Destruction Tank No. 2	2300	ton/hr	TBD	TBD	TBD	TBD	22510-TNK-022
Tailings Stock Tank	1000	ton/hr	TBD	TBD	TBD	TBD	22530-TNK-024
Tailings Filtrate Collection Tank	150	ton/hr	TBD	TBD	TBD	TBD	22530-TNK-025
Scrubber							
Caustic Scrubber	--	ton/hr	TBD	TBD	TBD	TBD	22600-FAN-051
Crushers - Clark							
Primary Crusher	121	ton/hr	Sandvik	QJ241	TBD	TBD	22310-CRU-0001
Feeders/Chutes - Clark							
Primary Crusher Discharge Feed Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0001
Primary Crusher Discharge Head Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0002
Primary Crusher Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0003
Coarse Ore Conveyor Head Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0004
Coarse Ore Discharge Feeder	121	ton/hr	TBD	TBD	TBD	TBD	23100-FDR-0003
Discharge Feeder Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0005
Dust Collectors - Clark							
Dust Collector No. 7	3,200	cfm	TBD	TBD	TBD	TBD	DC-7
Dust Collector No. 8	3,200	cfm	TBD	TBD	TBD	TBD	DC-8
Dust Collector No. 10	3,200	cfm	TBD	TBD	TBD	TBD	DC-10
Bins/Silos - Clark							
Coarse Ore Silo	121	ton/hr	TBD	TBD	TBD	TBD	23100-SLO-0003
Screens - Clark							
Primary Crusher Grizzly Screen	121	ton/hr	TBD	TBD	TBD	TBD	23100-SCN-0001
Conveyors - Clark							
Primary Crusher Discharge Conveyor	121	ton/hr	TBD	TBD	TBD	TBD	23100-CVR-0001
Coarse Ore Conveyor	121	ton/hr	TBD	TBD	TBD	TBD	23100-CVR-0002
Truck Unloading Station							
ROM Truck Unloading	121	ton/hr	TBD	TBD	TBD	TBD	TUD-1
Paste Plant - Clark							
Paste Plant Binder Silo 1	750	cfm	TBD	TBD	TBD	TBD	DC-CPPBS1
Paste Plant Binder Silo 2	750	cfm	TBD	TBD	TBD	TBD	DC-CPPBS2
Paste Plant Binder Silo 3	1,500	cfm	TBD	TBD	TBD	TBD	DC-CPPBS3
Paste Plant Binder Silo 4	1,500	cfm	TBD	TBD	TBD	TBD	DC-CPPBS4
Paste Plant Module 1 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-CPPM1M
Paste Plant Module 2 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-CPPM2M
Concrete Batch Plant - Clark							
Concrete Batch Plant	1,984	tpy	TBD	TBD	TBD	TBD	CBP - C
Gasoline Dispensing Facilities - Clark							
Aboveground Gasoline Dispensing Facility	73,500	gal/yr	TBD	TBD	TBD	TBD	AGGDF-C
General							
Waste Water Treatment Plant #1 Lime Silo	1,001	cfm	TBD	TBD	TBD	TBD	WTP1LS

All relevant equipment utilized at the facility should be included in the equipment list. Please complete all fields.
The date of manufacture must be included in order to determine applicability of regulations.
Indicate the units (tons/hour, horsepower, etc.) when recording the maximum rated capacity.
Make additional copies of this form if necessary.

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DRILL-1	Drilling	PM	1.39E-02	6.07E-02	See Modeling Report									
		PM_{10}	6.55E-03	2.87E-02										
		$PM_{2.5}$	6.56E-03	2.87E-02										
		Lead Compounds	6.87E-04	3.01E-03										
BLAST-1	Blasting	PM	1.25E-01	5.45E-01										
		PM_{10}	6.48E-02	2.84E-01										
		$PM_{2.5}$	2.47E-02	1.08E-01										
		Lead Compounds	6.18E-03	2.71E-02										
CRUSH-1	Primary Crushing	PM	7.99E-02	3.50E-01										
		PM_{10}	3.60E-02	1.57E-01										
		$PM_{2.5}$	4.40E-02	1.93E-01										
		Lead Compounds	3.96E-03	1.74E-02										
CRUSH-2	Pebble Crushing	PM	2.64E-01	1.16E+00										
		PM_{10}	1.19E-01	5.20E-01										
		$PM_{2.5}$	2.20E-02	9.64E-02										
		Lead Compounds	5.74E-03	2.52E-02										
BREAK-1	Clark Rock Breaker	PM	9.10E-04	3.99E-03										
		PM_{10}	4.30E-04	1.89E-03										
		$PM_{2.5}$	6.52E-05	2.85E-04										
		Lead Compounds	1.60E-05	7.01E-05										
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	PM	0.00E+00	0.00E+00										
		PM_{10}	0.00E+00	0.00E+00										
		$PM_{2.5}$	0.00E+00	0.00E+00										
		Lead Compounds	0.00E+00	0.00E+00										
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	PM	0.00E+00	0.00E+00										
		PM_{10}	0.00E+00	0.00E+00										
		$PM_{2.5}$	0.00E+00	0.00E+00										
		Lead Compounds	0.00E+00	0.00E+00										
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-40	Transfer of Development Ore from Face to Loader	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-41	Transfer of Development Ore from Loader to Stockpile	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-42	Transfer of Development Ore from Stockpile to Loader	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-43	Transfer of Development Ore from loader to Haul truck	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	PM	2.74E-03	1.20E-02										
		PM_{10}	1.30E-03	5.68E-03										
		$PM_{2.5}$	1.30E-03	5.68E-03										
		Lead Compounds	5.96E-05	2.61E-04										
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-57	Transfer of Development Waste Mined from Face to Loader	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	8.10E-03	3.55E-02										
		PM_{10}	3.83E-03	1.68E-02										
		$PM_{2.5}$	3.83E-03	1.68E-02										
		Lead Compounds	2.87E-05	1.26E-04										
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-65	Transfer of Stope Ore from Stope to Loader	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-70	Transfer of Stope Ore from Loader to Orepass 1	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
								Height Above Ground (feet)	Height Above Struc. (feet)	Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)			Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	PM	2.16E-02	9.46E-02										
		PM_{10}	1.02E-02	4.47E-02										
		$PM_{2.5}$	1.02E-02	4.48E-02										
		Lead Compounds	1.07E-03	4.69E-03										
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-82	Drop on West Rock Stockpile	PM	1.53E-01	6.68E-01										
		PM_{10}	7.21E-02	3.16E-01										
		$PM_{2.5}$	1.09E-02	4.78E-02										
		Lead Compounds	5.40E-04	2.37E-03										
DP-83	Drop on East Rock Stockpile	PM	1.69E-01	7.40E-01										
		PM_{10}	7.99E-02	3.50E-01										
		$PM_{2.5}$	1.21E-02	5.30E-02										
		Lead Compounds	5.98E-04	2.62E-03										
DP-84	TSF	PM	3.15E-01	1.38E+00										
		PM_{10}	1.49E-01	6.53E-01										
		$PM_{2.5}$	2.26E-02	9.89E-02										
		Lead Compounds	1.34E-03	5.88E-03										
DP-94	Transfer from Agg Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-95	Transfer of Agg Material from Loader to Haul Truck	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	PM	8.16E-06	3.57E-05										
		PM_{10}	3.86E-06	1.69E-05										
		$PM_{2.5}$	5.84E-07	2.56E-06										
		Lead Compounds	0.00E+00	0.00E+00										
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	PM	4.07E-08	1.78E-07										
		PM_{10}	1.93E-08	8.44E-08										
		$PM_{2.5}$	2.92E-09	1.28E-08										
		Lead Compounds	0.00E+00	0.00E+00										
DP-140	Drop of Sodium Sulfate to Bulk Handling System	PM	2.81E-04	1.23E-03										
		PM_{10}	1.33E-04	5.81E-04										
		$PM_{2.5}$	2.01E-05	8.81E-05										
		Lead Compounds	0.00E+00	0.00E+00										
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	PM	5.49E-02	2.40E-01										
		PM_{10}	5.49E-02	2.40E-01										
		$PM_{2.5}$	5.49E-02	2.40E-01										
		Lead Compounds	2.72E-03	1.19E-02										
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	PM	8.14E-02	3.57E-01										
		PM_{10}	8.14E-02	3.57E-01										
		$PM_{2.5}$	8.14E-02	3.57E-01										
		Lead Compounds	4.04E-03	1.77E-02										
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
		Lead Compounds	6.38E-03	2.79E-02										
DC-PPBS1	Paste Plant Binder Silo 1	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-PPBS2	Paste Plant Binder Silo 2	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-PPBS3	Paste Plant Binder Silo 3	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DC-PPBS4	Paste Plant Binder Silo 4	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
DC-PPM1M	Paste Plant Module 1 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
DC-PPM2M	Paste Plant Module 2 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
T-01	Unleaded Gasoline (S32)	VOC	8.56E-02	3.75E-01										
		Total HAPs	1.75E-03	7.67E-03										
T-02	Diesel (Red Dyed S32)	VOC	3.74E-04	1.64E-03										
		Total HAPs	3.44E-05	1.51E-04										
T-03	Diesel (Red Dyed S32)	VOC	3.74E-04	1.64E-03										
		Total HAPs	3.44E-05	1.51E-04										
T-04	Diesel (Red Dyed Rummel)	VOC	4.66E-04	2.04E-03										
		Total HAPs	4.29E-05	1.88E-04										
T-05	Unleaded Gasoline (Rummel)	VOC	7.43E-02	3.25E-01										
		Total HAPs	1.52E-03	6.65E-03										
T-06	Diesel (Rummel)	VOC	1.08E-04	4.74E-04										
		Total HAPs	9.95E-06	4.36E-05										
T-07	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-08	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-09	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-10	Diesel	VOC	8.94E-03	3.92E-02										
		Total HAPs	8.23E-04	3.60E-03										
T-11	Diesel	VOC	8.19E-03	3.59E-02										
		Total HAPs	7.53E-04	3.30E-03										
TNK-040	F549/MIBC	VOC	6.59E-02	2.89E-01										
		Total HAPs	5.99E-02	2.62E-01										
TNK-041	3407-A	VOC	3.38E-04	1.48E-03										
		Total HAPs	2.17E-05	9.52E-05										
TNK-044	Solvay 5100	VOC	3.41E-03	1.49E-02										
		Total HAPs	8.37E-06	3.67E-05										
TNK-045	Copper Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-046	Copper Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-047	Zinc Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-048	Zinc Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-051	Zinc Cyanide	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-052	Zinc Cyanide	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-053	SMBS	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-054	SMBS	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-057	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint Sources	
										Exit Data				
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
TNK-058	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-059	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-060	3418-A	VOC	4.33E-05	1.90E-04										
		Total HAPs	0.00E+00	0.00E+00										
TNK-061	Shaft ANE	VOC	5.44E-05	2.38E-04										
		Total HAPs	0.00E+00	0.00E+00										
TSF_3	Tailing Storage Facility	PM	4.41E+00	1.93E+01										
		PM_{10}	2.20E+00	9.65E+00										
		$PM_{2.5}$	3.30E-01	1.45E+00										
		Lead Compounds	1.88E-02	8.22E-02										
WRS	West Rock Stockpile	PM	1.64E-01	7.17E-01										
		PM_{10}	8.18E-02	3.58E-01										
		$PM_{2.5}$	1.23E-02	5.38E-02										
		Lead Compounds	5.80E-04	2.54E-03										
ERS	East Rock Stockpile	PM	1.81E-01	7.94E-01										
		PM_{10}	9.06E-02	3.97E-01										
		$PM_{2.5}$	1.36E-02	5.95E-02										
		Lead Compounds	5.80E-04	2.54E-03										
TAGG	Taylor Agg Stockpile	PM	1.03E-04	4.53E-04										
		PM_{10}	5.17E-05	2.27E-04										
		$PM_{2.5}$	7.76E-06	3.40E-05										
TSHOT	Taylor Shotcrete Stockpile	PM	1.84E-04	8.06E-04										
		PM_{10}	9.20E-05	4.03E-04										
		$PM_{2.5}$	1.38E-05	6.04E-05										
T_ENG / T_ENG_ALT	CAT 3520 DSL 2600 kW / JGC 624 4481 kW	PM	8.71E+00	3.81E+01										
		PM_{10}	8.71E+00	3.81E+01										
		$PM_{2.5}$	8.71E+00	3.81E+01										
		NO_x	3.74E+01	1.64E+02										
		CO	1.66E+01	7.28E+01										
		SO_2	2.80E-01	1.22E+00										
		VOC	1.93E+01	8.43E+01										
		Total HAPs	1.55E+01	6.80E+01										
		CO_2e	2.59E+05	1.13E+06										
HS_1 - HS_6	CAT XQ1140, 910 kW	PM	1.32E-01	5.80E-01										
		PM_{10}	1.32E-01	5.80E-01										
		$PM_{2.5}$	1.32E-01	5.80E-01										
		NO_x	1.32E+00	5.80E+00										
		CO	1.32E-01	5.80E-01										
		SO_2	1.61E-04	7.04E-04										
		VOC	2.65E-01	1.16E+00										
		Total HAPs	9.09E-02	3.98E-01										
		CO_2e	9.22E+03	4.04E+04										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
ENG9 - ENG13	CAT C175 3000 kW	PM	8.31E-02	3.64E-01										
		PM_{10}	8.31E-02	3.64E-01										
		$PM_{2.5}$	8.31E-02	3.64E-01										
		NO_x	7.27E+00	3.18E+01										
		CO	7.27E+00	3.18E+01										
		SO_2	1.53E-02	6.71E-02										
		VOC	3.94E-01	1.73E+00										
		Total HAPs	2.71E-03	1.19E-02										
		CO_2e	2.89E+02	1.27E+03										
ENG5	C200D2RE	PM	9.60E-03	4.21E-02										
		PM_{10}	9.60E-03	4.21E-02										
		$PM_{2.5}$	9.60E-03	4.21E-02										
		NO_x	1.92E-01	8.41E-01										
		CO	1.68E+00	7.36E+00										
		SO_2	5.99E-01	2.62E+00										
		VOC	9.60E-03	4.21E-02										
		Total HAPs	7.75E-03	3.39E-02										
		CO_2e	3.35E+02	1.47E+03										
WTP2CT	Cooling Towers	PM	5.07E-03	2.22E-02										
		PM_{10}	4.66E-03	2.04E-02										
		$PM_{2.5}$	9.29E-05	4.07E-04										
CBP	Concrete Batch Plant 2	PM	1.62E-01	7.11E-01										
		PM_{10}	6.47E-02	2.83E-01										
		$PM_{2.5}$	6.47E-02	2.83E-01										
ROADS	Road Emissions	PM	4.28E+01	1.87E+02										
		PM_{10}	1.10E+01	4.84E+01										
		$PM_{2.5}$	1.10E+00	4.84E+00										
		Lead Compounds	1.02E-03	4.45E-03										
PRODREF	Refrigeration Plant 3	PM	1.18E-02	5.16E-02										
		PM_{10}	6.13E-03	2.68E-02										
		$PM_{2.5}$	2.14E-03	9.36E-03										
BBREF	Refrigeration Plant 3	PM	1.74E-02	7.60E-02										
		PM_{10}	9.03E-03	3.96E-02										
		$PM_{2.5}$	3.15E-03	1.38E-02										
DOZER-WRS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										
DOZER-ERS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										
DOZER-HRS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										
DOZER-TSF	Dozer Emissions	PM	2.24E+00	9.82E+00										
		PM_{10}	4.77E-01	2.09E+00										
		$PM_{2.5}$	2.35E-01	1.03E+00										
		Lead Compounds	9.55E-03	4.18E-02										
AGGDF	Aboveground Gasoline Dispensing Facility	VOC	1.93E-01	8.45E-01										
		Total HAPs	3.51E-02	1.54E-01										
MEVAP1	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Exit Data: Dia (ft.)	Exit Data: Vel. (fps)	Exit Data: Temp. (F)	Sources: Length (ft)	Sources: Width (ft.)
MEVAP2	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										
MEVAP3	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										
22310-FC-00001	Lead Rougher	VOC	7.03E-03	3.08E-02										
22310-FC-00004	Lead Rougher Scavenger	VOC	7.03E-03	3.08E-02										
22310-FC-00008	Lead Cleaner Scalper	VOC	7.03E-03	3.08E-02										
22310-FC-00007	Lead Cleaner	VOC	7.03E-03	3.08E-02										
22310-FC-00009	Lead Cleaner Scavenger	VOC	7.03E-03	3.08E-02										
22310-FC-00005	Zinc Rougher	VOC	7.03E-03	3.08E-02										
22310-FC-00006	Zinc Rougher Scavenger	VOC	7.03E-03	3.08E-02										
22310-FC-00011	Zinc Cleaner Scalper	VOC	7.03E-03	3.08E-02										
22310-FC-00010	Zinc Cleaner	VOC	7.03E-03	3.08E-02										
22310-FC-00012	Zinc Cleaner Scavenger	VOC	7.03E-03	3.08E-02										
DRILL-2	Drilling-2	PM	4.39E-03	1.92E-02										
		PM_{10}	2.08E-03	9.10E-03										
		$PM_{2.5}$	1.30E-03	5.71E-03										
		Lead Compounds	7.73E-05	3.39E-04										
BLAST-2	Blasting-2	PM	7.01E-02	3.07E-01										
		PM_{10}	3.64E-02	1.60E-01										
		$PM_{2.5}$	8.71E-03	3.81E-02										
		Lead Compounds	1.23E-03	5.40E-03										
DP-103	Dump into Primary Crusher Feed Hopper	PM	6.61E-02	2.89E-01										
		PM_{10}	3.13E-02	1.37E-01										
		$PM_{2.5}$	4.73E-03	2.07E-02										
		Lead Compounds	1.16E-03	5.09E-03										
DP-104	Drop from silo to trucks	PM	2.20E-01	9.65E-01										
		PM_{10}	1.04E-01	4.56E-01										
		$PM_{2.5}$	1.58E-02	6.91E-02										
		Lead Compounds	3.88E-03	1.70E-02										
DP-105	Transfer of Ore from Ore Stockpile to Loader	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-106	Transfer of Ore Mined from Loader to Haul Truck	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-107	Transfer from ROM Stockpile to Loader	PM	3.62E-02	1.59E-01										
		PM_{10}	1.71E-02	7.51E-02										
		$PM_{2.5}$	2.60E-03	1.14E-02										
		Lead Compounds	6.37E-04	2.79E-03										
DP-109	Transfer from Agg Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-110	Transfer of Agg Material from Loader to Haul Truck	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-113	Hardshell Wasterock Storage	PM	5.93E-01	2.60E+00										
		PM_{10}	2.80E-01	1.23E+00										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	0.00E+00	0.00E+00										
DP-114	Ore Stockpile	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-115	ROM Stockpile	PM	3.62E-02	1.59E-01										
		PM_{10}	1.71E-02	7.51E-02										
		$PM_{2.5}$	2.60E-03	1.14E-02										
		Lead Compounds	6.37E-04	2.79E-03										
DP-124	Transfer of Development Ore from Face to Loader	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-125	Transfer of Development Ore from Loader to Stockpile	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-126	Transfer of Development Ore from Stockpile to Loader	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-129	Transfer of Development Waste Mined from Face to Loader	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-134	Transfer of Stope Ore from Stope to Loader	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-135	Transfer of Stope Ore from Loader to Stockpile	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-136	Transfer of Stope Ore from Stockpile to Loader	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-137	Transfer of Stope Ore from Loader to Haul Truck	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
CBP - C	Concrete Batch Plant	PM	8.21E-03	3.59E-02										
		PM_{10}	3.30E-03	1.45E-02										
		$PM_{2.5}$	3.30E-03	1.45E-02										
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
DC-CPPBS1	Paste Plant Binder Silo 1	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-CPPBS2	Paste Plant Binder Silo 2	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-CPPBS3	Paste Plant Binder Silo 3	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
DC-CPPBS4	Paste Plant Binder Silo 4	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
DC-CPPM1M	Paste Plant Module 1 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
DC-CPPM2M	Paste Plant Module 2 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
HRS	Hardshell Rock Stockpile	PM	6.26E-01	2.74E+00										
		PM_{10}	3.13E-01	1.37E+00										
		$PM_{2.5}$	4.70E-02	2.06E-01										
		Lead Compounds	2.22E-03	9.71E-03										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
ORE	Clark Ore Stockpile	PM	2.75E-02	1.20E-01										
		PM_{10}	1.37E-02	6.02E-02										
		$PM_{2.5}$	2.06E-03	9.03E-03										
		Lead Compounds	4.84E-04	2.12E-03										
ROM	Clark ROM Stockpile	PM	8.16E-03	3.57E-02										
		PM_{10}	4.08E-03	1.79E-02										
		$PM_{2.5}$	6.12E-04	2.68E-03										
		Lead Compounds	1.44E-04	6.29E-04										
AGG	Clark Agg Stockpile	PM	1.03E-04	4.53E-04										
		PM_{10}	5.17E-05	2.27E-04										
		$PM_{2.5}$	7.76E-06	3.40E-05										
		Lead Compounds	--	0.00E+00										
SHOT	Clark Shotcrete Stockpile	PM	1.84E-04	8.06E-04										
		PM_{10}	9.20E-05	4.03E-04										
		$PM_{2.5}$	1.38E-05	6.04E-05										
		Lead Compounds	--	0.00E+00										
AGGDF-C	Aboveground Gasoline Dispensing Facility	VOC	9.46E-02	4.14E-01										
		Total HAPs	1.72E-02	7.54E-02										
WTP1LS	Waste Water Treatment Plant #1 Lime Silo	PM	4.29E-02	1.88E-01										
		PM10	4.29E-02	1.88E-01										
		PM2.5	4.29E-02	1.88E-01										
		Lead Compounds	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form

Regulated Air Pollutant Data					Emission Point Discharge Parameters										
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
PP-1	Truck Pneumatic Loadout to Silo 1	PM	9.69E-03	4.24E-02										
		PM_{10}	3.33E-03	1.46E-02										
		$PM_{2.5}$	6.94E-04	3.04E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-2	Truck Pneumatic Loadout to Silo 2	PM	9.69E-03	4.24E-02										
		PM_{10}	3.33E-03	1.46E-02										
		$PM_{2.5}$	6.94E-04	3.04E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-3	Truck Pneumatic Loadout to Silo 1	PM	4.85E-03	2.12E-02										
		PM_{10}	1.66E-03	7.29E-03										
		$PM_{2.5}$	3.47E-04	1.52E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-4	Truck Pneumatic Loadout to Silo 2	PM	4.85E-03	2.12E-02										
		PM_{10}	1.66E-03	7.29E-03										
		$PM_{2.5}$	3.47E-04	1.52E-03										
		Lead Compounds	0.00E+00	0.00E+00										
UGTROADS	Underground Taylor Roads	PM	1.76E+01	7.70E+01										
		PM_{10}	4.54E+00	1.99E+01										
		$PM_{2.5}$	4.54E-01	1.99E+00										
		Lead Compounds	4.31E-04	1.89E-03										
UGCROADS	Underground Clark Roads	PM	1.86E+01	8.14E+01										
		PM_{10}	4.79E+00	2.10E+01										
		$PM_{2.5}$	4.79E-01	2.10E+00										
		Lead Compounds	4.55E-04	1.99E-03										

Table A-1a. Total Site-Wide Emissions

Pollutant	Regulated NSR Pollutant? [2]	Estimated Potential Emissions (tpy) [1,2]		Permit Applicability Evaluation							
		Non-Fugitive [3]	Non-Fugitive & Fugitive [3]	Class I PSD Major Thresholds (tpy)	Less than PSD Thresholds?	Class I Title V Major Source Thresholds (tpy) [2]	Less than Title V Thresholds?	Significant/Class II Thresholds [2]	Less than Class II Thresholds?	Permitting Exemption Thresholds [2]	Less than Registration/ Permitting Exemption Thresholds?
PM	Yes	208.04	457.77	250	YES	100	NO	--	--	--	--
PM_{10}	Yes	88.39	163.31	250	YES	100	YES	15	NO	7.5	NO
$PM_{2.5}$	Yes	50.83	60.66	250	YES	100	YES	10	NO	5	NO
NOx	Yes	203.61	203.61	250	YES	100	NO	40	NO	20	NO
SO_2	Yes	6.45	6.45	250	YES	100	YES	40	YES	20	YES
CO	Yes	180.95	180.95	250	YES	100	NO	100	NO	50	NO
VOC	Yes	94.10	95.94	250	YES	100	YES	40	NO	20	NO
Lead compounds	No	0.21	1.00	--	--	10	YES	--	--	--	--
Elemental Lead	Yes	0.21	1.00	250	YES	100	YES	0.6	YES	0.3	YES
Maximum HAP - Acetaldehyde	No	39.84	39.84	--	--	10	NO	--	--	--	--
Total HAPs	No	69.40	73.63	--	--	25	NO	--	--	--	--
H_2S	Yes	10.12	10.12	--	--	100	YES	--	--	--	--
CO_2e [4]	-	1,176,929	1,176,929	100,000	--	--	--	--	--		--

1. PM, PM_{10}, and $PM_{2.5}$ include both filterable and condensable fractions, which conservatively overestimates PM emissions from an NSR perspective.
2. Per Arizona Administrative Code (A.A.C.)
   R18-2-101.110 - For "Potential to emit"
   R18-2-101.131 - For "Significant"
   R18-2-101.75 - For "Major Source"
   R18-2-101.101 - For "Permitting Exemption Thresholds"
   R18-2-101.124 - For "Regulated NSR Pollutant"
3. Per A.A.C. R18-2-302.F "The fugitive emissions of a stationary source shall not be considered in determining whether the source requires a Class II permit under subsection (B)(2)(a) or (b) or a registration under subsection (B)(3)(a) or (d), unless the source belongs to a section 302(j) category. If a permit is required for a stationary source, the fugitive emissions of the source shall be subject to all of the requirements of this Article." South32 is not categorized as a Clean Air Act Section 302(j) source. Hence, only non-fugitive emissions are used for permit applicability evaluation.
4. Sources exceeding 100,000 tons of CO2e are only subject to PSD if they also trigger PSD for another regulated NSR pollutant. The Hermosa Project does not trigger PSD for any other NSR pollutant. While CO2e is not included under the definition of "regulated NSR pollutant" at A.A.C. R18-2-101.124, GHGs are considered a "regulated NSR pollutant" under the federal Prevention of Significant Deterioration (PSD) program at 40 C.F.R. § 52.21(b)(50). South32 is therefore providing estimates of GHG (i.e., CO2e) emissions for purposes of demonstrating non-applicability of the federal PSD program for GHGs, which ADEQ implements via a delegation agreement with EPA.

Table A-1b. Total Emissions - Source Specific

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
DRILL-1	Drilling	Yes	Non-fugitive	Underground	0.06	0.03	0.03	3.01E-03	--	--	--	--	0.01	--	--
BLAST-1	Blasting	Yes	Non-fugitive	Underground	0.55	0.28	0.11	0.03	1.13	60.75	2.25	--	0.05	9.00	--
CRUSH-1	Primary Crushing	Yes	Non-fugitive	Underground	0.35	0.16	0.19	0.02	--	--	--	--	0.03	--	--
CRUSH-2	Pebble Crushing	Yes	Non-fugitive	Aboveground	1.16	0.52	0.10	0.03	--	--	--	--	0.07	--	--
BREAK-1	Clark Rock Breaker	Yes	Non-fugitive	Aboveground	3.99E-03	1.89E-03	2.85E-04	7.01E-05	--	--	--	--	7.74E-04	--	--
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	Yes	Fugitive	Aboveground	1.98	0.94	0.14	0.10	--	--	--	--	0.19	--	--
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	Yes	Fugitive	Aboveground	1.98	0.94	0.14	0.10	--	--	--	--	0.19	--	--
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	Yes	Fugitive	Aboveground	1.98	0.94	0.14	0.10	--	--	--	--	0.19	--	--
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	Yes	Fugitive	Aboveground	1.29	0.61	0.09	0.03	--	--	--	--	0.08	--	--
DP-40	Transfer of Development Ore from Face to Loader	Yes	Non-fugitive	Underground	1.21E-03	5.71E-04	5.71E-04	2.63E-05	--	--	--	--	7.58E-05	--	--
DP-41	Transfer of Development Ore from Loader to Stockpile	Yes	Non-fugitive	Underground	1.21E-03	5.71E-04	5.71E-04	2.63E-05	--	--	--	--	7.58E-05	--	--
DP-42	Transfer of Development Ore from Stockpile to Loader	Yes	Non-fugitive	Underground	1.21E-03	5.71E-04	5.71E-04	2.63E-05	--	--	--	--	7.58E-05	--	--
DP-43	Transfer of Development Ore from loader to Haul truck	Yes	Non-fugitive	Underground	1.21E-03	5.71E-04	5.71E-04	2.63E-05	--	--	--	--	7.58E-05	--	--
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	Yes	Non-fugitive	Underground	0.01	0.01	0.01	2.61E-04	--	--	--	--	7.53E-04	--	--
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	Non-fugitive	Underground	1.83E-03	8.65E-04	8.66E-04	3.98E-05	--	--	--	--	1.15E-04	--	--
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	Non-fugitive	Underground	1.83E-03	8.65E-04	8.66E-04	3.98E-05	--	--	--	--	1.15E-04	--	--
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	Yes	Non-fugitive	Underground	1.83E-03	8.65E-04	8.66E-04	3.98E-05	--	--	--	--	1.15E-04	--	--
DP-57	Transfer of Development Waste Mined from Face to Loader	Yes	Non-fugitive	Underground	3.57E-03	1.69E-03	1.69E-03	1.26E-05	--	--	--	--	3.40E-05	--	--
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	Yes	Non-fugitive	Underground	3.57E-03	1.69E-03	1.69E-03	1.26E-05	--	--	--	--	3.40E-05	--	--
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	Yes	Non-fugitive	Underground	3.57E-03	1.69E-03	1.69E-03	1.26E-05	--	--	--	--	3.40E-05	--	--
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	Non-fugitive	Underground	3.57E-03	1.69E-03	1.69E-03	1.26E-05	--	--	--	--	3.40E-05	--	--
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	Yes	Non-fugitive	Underground	0.04	0.02	0.02	1.26E-04	--	--	--	--	3.37E-04	--	--
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	Yes	Non-fugitive	Underground	0.01	2.56E-03	2.56E-03	1.92E-05	--	--	--	--	5.14E-05	--	--
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	Non-fugitive	Underground	0.01	2.56E-03	2.56E-03	1.92E-05	--	--	--	--	5.14E-05	--	--
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	Yes	Non-fugitive	Underground	0.01	2.56E-03	2.56E-03	1.92E-05	--	--	--	--	5.14E-05	--	--
DP-65	Transfer of Stope Ore from Stope to Loader	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-70	Transfer of Stope Ore from Loader to Orepass 1	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	Yes	Non-fugitive	Underground	0.01	0.01	0.01	6.69E-04	--	--	--	--	1.28E-03	--	--
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	Yes	Non-fugitive	Underground	0.09	0.04	0.04	4.69E-03	--	--	--	--	0.01	--	--
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	Non-fugitive	Underground	0.02	0.01	0.01	1.01E-03	--	--	--	--	1.94E-03	--	--
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	Yes	Non-fugitive	Underground	0.02	0.01	0.01	1.01E-03	--	--	--	--	1.94E-03	--	--
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	Yes	Non-fugitive	Underground	0.02	0.01	0.01	1.01E-03	--	--	--	--	1.94E-03	--	--
DP-82	Drop on West Rock Stockpile	Yes	Fugitive	Aboveground	0.67	0.32	0.05	2.37E-03	--	--	--	--	0.01	--	--
DP-83	Drop on East Rock Stockpile	Yes	Fugitive	Aboveground	0.74	0.35	0.05	2.62E-03	--	--	--	--	0.01	--	--
DP-84	TSF	Yes	Fugitive	Aboveground	1.38	0.65	0.10	0.01	--	--	--	--	0.07	--	--
DP-94	Transfer from Agg Stockpile to Loader	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	Yes	Fugitive	Aboveground	3.57E-05	1.69E-05	2.56E-06	--	--	--	--	--	--	--	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	Yes	Fugitive	Aboveground	1.78E-07	8.44E-08	1.28E-08	--	--	--	--	--	--	--	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	Yes	Fugitive	Aboveground	1.23E-03	5.81E-04	8.81E-05	--	--	--	--	--	--	--	--
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	Yes	Non-Fugitive	Aboveground	0.24	0.24	0.24	0.01	--	--	--	--	0.02	--	--
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	Yes	Non-Fugitive	Aboveground	0.36	0.36	0.36	0.02	--	--	--	--	0.03	--	--
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	Yes	Non-Fugitive	Aboveground	0.25	0.25	0.25	0.01	--	--	--	--	0.02	--	--
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	Yes	Non-Fugitive	Aboveground	0.25	0.25	0.25	0.01	--	--	--	--	0.02	--	--

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	Yes	Non-Fugitive	Aboveground	0.25	0.25	0.25	0.01	--	--	--	--	0.02	--	--
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	Yes	Non-Fugitive	Aboveground	0.25	0.25	0.25	0.01	--	--	--	--	0.02	--	--
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	Yes	Non-Fugitive	Aboveground	0.56	0.56	0.56	0.03	--	--	--	--	0.05	--	--
DC-PPBS1	Paste Plant Binder Silo 1	Yes	Non-Fugitive	Aboveground	0.14	0.14	0.14	--	--	--	--	--	--	--	--
DC-PPBS2	Paste Plant Binder Silo 2	Yes	Non-Fugitive	Aboveground	0.14	0.14	0.14	--	--	--	--	--	--	--	--
DC-PPBS3	Paste Plant Binder Silo 3	Yes	Non-Fugitive	Aboveground	0.28	0.28	0.28	--	--	--	--	--	--	--	--
DC-PPBS4	Paste Plant Binder Silo 4	Yes	Non-Fugitive	Aboveground	0.28	0.28	0.28	--	--	--	--	--	--	--	--
DC-PPM1M	Paste Plant Module 1 Mixer	Yes	Non-Fugitive	Aboveground	0.56	0.56	0.56	--	--	--	--	--	--	--	--
DC-PPM2M	Paste Plant Module 2 Mixer	Yes	Non-Fugitive	Aboveground	0.56	0.56	0.56	--	--	--	--	--	--	--	--
T-01	Unleaded Gasoline (S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.38	0.01	--	--
T-02	Diesel (Red Dyed S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.64E-03	1.51E-04	--	--
T-03	Diesel (Red Dyed S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.64E-03	1.51E-04	--	--
T-04	Diesel (Red Dyed Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	2.04E-03	1.88E-04	--	--
T-05	Unleaded Gasoline (Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.33	0.01	--	--
T-06	Diesel (Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	4.74E-04	4.36E-05	--	--
T-07	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-08	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-09	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-10	Diesel	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.04	3.60E-03	--	--
T-11	Diesel	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.04	3.30E-03	--	--
TNK-040	F549/MIBC	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.29	0.26	--	--
TNK-041	3407-A	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.48E-03	9.52E-05	--	--
TNK-044	Solvay 5100	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.01	3.67E-05	--	--
TNK-045	Copper Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-046	Copper Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-047	Zinc Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-048	Zinc Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-051	Zinc Cyanide	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-052	Zinc Cyanide	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-053	SMBS	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-054	SMBS	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-057	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-058	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-059	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-060	3418-A	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.90E-04	--	--	--
TNK-061	Shaft ANE	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	2.38E-04	--	--	--
TSF_3	Tailing Storage Facility	Yes	Fugitive	Aboveground	19.29	9.65	1.45	0.08	--	--	--	--	0.95	--	--
WRS	West Rock Stockpile	Yes	Fugitive	Aboveground	0.72	0.36	0.05	2.54E-03	--	--	--	--	0.01	--	--
ERS	East Rock Stockpile	Yes	Fugitive	Aboveground	0.79	0.40	0.06	2.81E-03	--	--	--	--	0.01	--	--
TAGG	Taylor Agg Stockpile	Yes	Fugitive	Aboveground	4.53E-04	2.27E-04	3.40E-05	--	--	--	--	--	--	--	--
TSHOT	Taylor Shotcrete Stockpile	Yes	Fugitive	Aboveground	8.06E-04	4.03E-04	6.04E-05	--	--	--	--	--	--	--	--
T_ENG / T_ENG_ALT	CAT 3520 DSL 2600 kW / JGC 624 4481 kW	Yes	Non-fugitive	Aboveground	38.13	38.13	38.13	--	163.88	72.84	1.22	84.33	68.00	--	1,133,793.76
HS_1 - HS_6	CAT XQ1140, 910 kW	Yes	Non-fugitive	Aboveground	0.58	0.58	0.58	--	5.80	0.58	7.04E-04	1.16	0.40	--	40,402.88
ENG9 - ENG13	CAT C175 3000 kW	Yes	Non-fugitive	Aboveground	0.36	0.36	0.36	--	31.83	31.83	0.07	1.73	0.01	--	1,267.09
ENG5	C200D2RE	Yes	Non-fugitive	Aboveground	0.04	0.04	0.04	--	0.84	7.36	2.62	0.04	0.03	--	1,465.16
WTP2CT	Cooling Towers	Yes	Fugitive	Aboveground	0.02	0.02	4.07E-04	--	--	--	--	--	--	--	--
CBP	Concrete Batch Plant [2]	Yes	Non-fugitive	Aboveground	0.71	0.28	0.28	--	--	--	--	--	--	--	--
ROADS	Road Emissions	Yes	Fugitive	Aboveground	187.43	48.35	4.84	4.45E-03	--	--	--	--	0.02	--	--
PRODREF	Refrigeration Plant [3]	Yes	Non-fugitive	Aboveground	0.05	0.03	0.01	--	--	--	--	--	--	--	--
BBREF	Refrigeration Plant [3]	Yes	Non-fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DOZER-WRS	Dozer Emissions	Yes	Fugitive	Aboveground	1.09	0.14	0.11	3.84E-03	--	--	--	--	0.01	--	--
DOZER-ERS	Dozer Emissions	Yes	Fugitive	Aboveground	1.09	0.14	0.11	3.84E-03	--	--	--	--	0.01	--	--
DOZER-HRS	Dozer Emissions	Yes	Fugitive	Aboveground	1.09	0.14	0.11	3.84E-03	--	--	--	--	0.01	--	--
DOZER-TSF	Dozer Emissions	Yes	Fugitive	Aboveground	9.82	2.09	1.03	0.04	--	--	--	--	0.48	--	--
AGGDF	Aboveground Gasoline Dispensing Facility	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.85	0.15	--	--
MEVAP1	Mechanical Evaporator	Yes	Fugitive	Aboveground	--	0.04	0.01	--	--	--	--	--	--	--	--
MEVAP2	Mechanical Evaporator	Yes	Fugitive	Aboveground	--	0.04	0.01	--	--	--	--	--	--	--	--
MEVAP3	Mechanical Evaporator	Yes	Fugitive	Aboveground	--	0.04	0.01	--	--	--	--	--	--	--	--
22310-FC-00001	Lead Rougher	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.03	--	--	--
22310-FC-00004	Lead Rougher Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.03	--	--	--
22310-FC-00008	Lead Cleaner Scalper	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.10	--	--	--

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
22310-FC-00007	Lead Cleaner	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.08	--	--	--
22310-FC-00009	Lead Cleaner Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.08	--	--	--
22310-FC-00005	Zinc Rougher	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00006	Zinc Rougher Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00011	Zinc Cleaner Scalper	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00010	Zinc Cleaner	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.05	--	--	--
22310-FC-00012	Zinc Cleaner Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.05	--	--	--
DRILL-2	Drilling-2	Yes	Non-fugitive	Underground	0.02	0.01	0.01	3.39E-04	--	--	--	--	3.74E-03	--	--
BLAST-2	Blasting-2	Yes	Non-fugitive	Underground	0.31	0.16	0.04	0.01	0.14	7.59	0.28	--	0.06	1.12	--
DP-103	Dump into Primary Crusher Feed Hopper	Yes	Fugitive	Aboveground	0.29	0.14	0.02	0.01	--	--	--	--	0.06	--	--
DP-104	Drop from silo to trucks	Yes	Fugitive	Aboveground	0.96	0.46	0.07	0.02	--	--	--	--	0.19	--	--
DP-105	Transfer of Ore from Ore Stockpile to Loader	Yes	Fugitive	Aboveground	0.58	0.27	0.04	0.01	--	--	--	--	0.11	--	--
DP-106	Transfer of Ore Mined from Loader to Haul Truck	Yes	Fugitive	Aboveground	0.58	0.27	0.04	0.01	--	--	--	--	0.11	--	--
DP-107	Transfer from ROM Stockpile to Loader	Yes	Fugitive	Aboveground	0.16	0.08	0.01	2.79E-03	--	--	--	--	0.03	--	--
DP-109	Transfer from Agg Stockpile to Loader	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	Yes	Fugitive	Aboveground	0.08	0.04	0.01	--	--	--	--	--	--	--	--
DP-113	Hardshell Wasterock Storage	Yes	Fugitive	Aboveground	2.60	1.23	0.19	0.05	--	--	--	--	0.50	--	--
DP-114	Ore Stockpile	Yes	Fugitive	Aboveground	0.58	0.27	0.04	0.01	--	--	--	--	0.11	--	--
DP-115	ROM Stockpile	Yes	Fugitive	Aboveground	0.16	0.08	0.01	2.79E-03	--	--	--	--	0.03	--	--
DP-124	Transfer of Development Ore from Face to Loader	Yes	Non-fugitive	Underground	9.01E-04	4.26E-04	2.67E-04	1.16E-05	--	--	--	--	9.79E-05	--	--
DP-125	Transfer of Development Ore from Loader to Stockpile	Yes	Non-fugitive	Underground	9.01E-04	4.26E-04	2.67E-04	1.16E-05	--	--	--	--	9.79E-05	--	--
DP-126	Transfer of Development Ore from Stockpile to Loader	Yes	Non-fugitive	Underground	9.01E-04	4.26E-04	2.67E-04	1.16E-05	--	--	--	--	9.79E-05	--	--
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	Yes	Non-fugitive	Underground	9.01E-04	4.26E-04	2.67E-04	1.16E-05	--	--	--	--	9.79E-05	--	--
DP-129	Transfer of Development Waste Mined from Face to Loader	Yes	Non-fugitive	Underground	4.67E-03	2.21E-03	1.38E-03	2.65E-05	--	--	--	--	1.08E-04	--	--
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	Yes	Non-fugitive	Underground	4.67E-03	2.21E-03	1.38E-03	2.65E-05	--	--	--	--	1.08E-04	--	--
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	Yes	Non-fugitive	Underground	4.67E-03	2.21E-03	1.38E-03	2.65E-05	--	--	--	--	1.08E-04	--	--
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	Non-fugitive	Underground	4.67E-03	2.21E-03	1.38E-03	2.65E-05	--	--	--	--	1.08E-04	--	--
DP-134	Transfer of Stope Ore from Stope to Loader	Yes	Non-fugitive	Underground	2.57E-03	1.21E-03	7.62E-04	4.52E-05	--	--	--	--	4.99E-04	--	--
DP-135	Transfer of Stope Ore from Loader to Stockpile	Yes	Non-fugitive	Underground	2.57E-03	1.21E-03	7.62E-04	4.52E-05	--	--	--	--	4.99E-04	--	--
DP-136	Transfer of Stope Ore from Stockpile to Loader	Yes	Non-fugitive	Underground	2.57E-03	1.21E-03	7.62E-04	4.52E-05	--	--	--	--	4.99E-04	--	--
DP-137	Transfer of Stope Ore from Loader to Haul Truck	Yes	Non-fugitive	Underground	2.57E-03	1.21E-03	7.62E-04	4.52E-05	--	--	--	--	4.99E-04	--	--
CBP - C	Concrete Batch Plant	Yes	Non-fugitive	Aboveground	0.04	0.01	0.01	--	--	--	--	--	--	--	--
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	Yes	Non-fugitive	Aboveground	0.12	0.12	0.12	2.11E-03	--	--	--	--	0.02	--	--
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	Yes	Non-fugitive	Aboveground	0.12	0.12	0.12	2.11E-03	--	--	--	--	0.02	--	--
DC-CPPBS1	Paste Plant Binder Silo 1	Yes	Non-fugitive	Aboveground	0.14	0.14	0.14	--	--	--	--	--	--	--	--
DC-CPPBS2	Paste Plant Binder Silo 2	Yes	Non-fugitive	Aboveground	0.14	0.14	0.14	--	--	--	--	--	--	--	--
DC-CPPBS3	Paste Plant Binder Silo 3	Yes	Non-fugitive	Aboveground	0.28	0.28	0.28	--	--	--	--	--	--	--	--
DC-CPPBS4	Paste Plant Binder Silo 4	Yes	Non-fugitive	Aboveground	0.28	0.28	0.28	--	--	--	--	--	--	--	--
DC-CPPM1M	Paste Plant Module 1 Mixer	Yes	Non-fugitive	Aboveground	0.56	0.56	0.56	--	--	--	--	--	--	--	--
DC-CPPM2M	Paste Plant Module 2 Mixer	Yes	Non-fugitive	Aboveground	0.56	0.56	0.56	--	--	--	--	--	--	--	--
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	Yes	Non-fugitive	Aboveground	0.12	0.12	0.12	2.11E-03	--	--	--	--	0.02	--	--
HRS	Hardshell Rock Stockpile	Yes	Fugitive	Aboveground	2.74	1.37	0.21	0.01	--	--	--	--	0.03	--	--
ORE	Clark Ore Stockpile	Yes	Fugitive	Aboveground	0.12	0.06	0.01	2.12E-03	--	--	--	--	0.02	--	--
ROM	Clark ROM Stockpile	Yes	Fugitive	Aboveground	0.04	0.02	2.68E-03	6.29E-04	--	--	--	--	0.01	--	--
AGG	Clark Agg Stockpile	Yes	Fugitive	Aboveground	4.53E-04	2.27E-04	3.40E-05	--	--	--	--	--	--	--	--
SHOT	Clark Shotcrete Stockpile	Yes	Fugitive	Aboveground	8.06E-04	4.03E-04	6.04E-05	--	--	--	--	--	--	--	--
AGGDF-C	Aboveground Gasoline Dispensing Facility	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.41	0.08	--	--
WTP1LS	Waste Water Treatment Plant #1 Lime Silo	Yes	Non-fugitive	Aboveground	0.19	0.19	0.19	--	--	--	--	--	--	--	--
PP-1	Truck Pneumatic Loadout to Silo 1	Yes	Non-fugitive	Aboveground	4.24E-02	1.46E-02	3.04E-03	--	--	--	--	--	--	--	--
PP-2	Truck Pneumatic Loadout to Silo 2	Yes	Non-fugitive	Aboveground	4.24E-02	1.46E-02	3.04E-03	--	--	--	--	--	--	--	--
PP-3	Truck Pneumatic Loadout to Silo 1	Yes	Non-fugitive	Aboveground	2.12E-02	7.29E-03	1.52E-03	--	--	--	--	--	--	--	--
PP-4	Truck Pneumatic Loadout to Silo 2	Yes	Non-fugitive	Aboveground	2.12E-02	7.29E-03	1.52E-03	--	--	--	--	--	--	--	--
UGTROADS	Underground Taylor Roads	Yes	Non-fugitive	Underground	77.04	19.88	1.99	1.89E-03	--	--	--	--	0.01	--	--
UGCROADS	Underground Clark Roads	Yes	Non-fugitive	Underground	81.39	21.00	2.10	1.99E-03	--	--	--	--	0.01	--	--

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/ Aboveground?	Controlled Emissions Summary - Annual (tpy)										
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NOx	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
Total - Non-Fugitive & Fugitive Emissions					457.77	163.31	60.66	1.00	203.61	180.95	6.45	95.94	73.63	10.12	1,176,928.89
Total - Non-Fugitive Emissions					208.04	88.39	50.83	0.21	203.61	180.95	6.45	94.10	69.40	10.12	1,176,928.89

1. Underground emissions conservatively taken as non-fugitive. South32 reserves the right to update this conservative assumption.
2. The concrete batch plant is conservatively assumed to be a non-fugitive source of emissions. South32 reserves the right to update this representation once we have more clarity on the concrete batch plant design per correspondance with ADEQ on Jan 13th 2023.
3. The surface refrigeration plant is considered a non-fugitive source of emissions based on correspondance with ADEQ on Jan 13th 2023.

Table A-2a. Facility HAPs Summary

Pollutant	Emissions (tpy)[1]
Benzene	0.57
Toluene	0.49
Xylene	0.28
1,3-Butadiene	0.20
Formaldehyde	18.24
Acetaldehyde	39.84
Acrolein	3.57
Naphthalene	0.08
1,1,2,2-Tetrachloroethane	0.27
1,1,2-Trichloroethane	0.22
1,3-Dichloropropene	0.18
2-Methylnaphthalene	0.02
2,2,4-Trimethylpentane	0.17
Biphenyl	0.15
Carbon Tetrachloride	0.25
Chlorobenzene	0.21
Chloroform	0.19
Ethylbenzene	0.05
Ethylene Dibromide	0.30
Methanol	1.74
Methylene Chloride	0.14
Hexane	0.79
PAH	0.55
Phenol	0.16
Tetrachloroethane	0.02
Vinyl Chloride	0.10
Cresol	9.52E-05
Ethylene Glycol Dimethyl Ether	0.26
Urethane	3.67E-05
Cumene	4.46E-04
Isooctane	0.04
PAC's	5.84E-05
Antimony Compounds	1.38E-02
Arsenic Compounds	1.99E-02
Beryllium Compounds	7.65E-04
Cadmium Compounds	9.52E-03
Chromium Compounds	1.38E-02
Cobalt Compounds	1.23E-03
Manganese Compounds	3.48
Nickel Compounds	1.02E-02
Selenium Compounds	1.56E-03
Lead Compounds	1.00
Maximum HAP - Acetaldehyde	39.84
Total	73.63

1. PAHs are a subset of PACs which are a subset of POMs. POMs are listed as HAPs. The total HAP emissions are overestimated - as the emissions of some POMs, namely naphthalene and benzo(g,h,i)perylene - are included individually in addition to PAC and PAH emissions.

Table A-2b. Metal HAP in PM - Constituents Summary

Emission Point Number	Emissions Activity	Emissions[1]													
		Include?	PM	Antimony Compounds	Arsenic Compounds	Beryllium Compounds	Cadmium Compounds	Chromium Compounds	Cobalt Compounds	Manganese Compounds	Nickel Compounds	Selenium Compounds	Lead Compounds	Mercury Compounds	Total
DRILL-1	Drilling	Yes	0.06	1.29E-05	9.44E-06	7.28E-08	1.18E-05	2.00E-06	1.58E-06	2.71E-03	6.07E-07	1.58E-06	3.01E-03	--	5.76E-03
BLAST-1	Blasting	Yes	0.55	1.16E-04	8.48E-05	6.55E-07	1.06E-04	1.80E-05	1.42E-05	2.44E-02	5.45E-06	1.42E-05	2.71E-02	--	5.18E-02
CRUSH-1	Primary Crushing	Yes	0.35	7.42E-05	5.44E-05	4.20E-07	6.79E-05	1.15E-05	9.10E-06	1.56E-02	3.50E-06	9.10E-06	1.74E-02	--	3.32E-02
CRUSH-2	Pebble Crushing	Yes	1.16	1.17E-04	1.47E-04	1.27E-06	6.88E-05	4.14E-05	1.51E-05	4.70E-02	1.12E-05	1.56E-05	2.52E-02	--	7.26E-02
BREAK-1	Clark Rock Breaker	Yes	3.99E-03	1.80E-06	2.16E-06	6.70E-09	4.88E-07	1.71E-07	2.39E-08	7.00E-04	3.11E-08	1.99E-08	7.01E-05	--	7.74E-04
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	9.85E-02	--	1.89E-01
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	9.85E-02	--	1.89E-01
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	9.85E-02	--	1.89E-01
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	Yes	0.00	--	--	--	--	--	--	--	--	--	--	--	0.00E+00
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	Yes	0.00	--	--	--	--	--	--	--	--	--	--	--	0.00E+00
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	2.82E-02	--	8.12E-02
DP-40	Transfer of Development Ore from Face to Loader	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-41	Transfer of Development Ore from Loader to Stockpile	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-42	Transfer of Development Ore from Stockpile to Loader	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-43	Transfer of Development Ore from loader to Haul truck	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	Yes	0.01	1.21E-06	1.52E-06	1.32E-08	7.14E-07	4.30E-07	1.57E-07	4.88E-04	1.16E-07	1.62E-07	2.61E-04	--	7.53E-04
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-57	Transfer of Development Waste Mined from Face to Loader	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	Yes	0.04	6.16E-07	1.79E-06	4.98E-08	1.27E-07	9.71E-07	1.35E-07	2.08E-04	2.78E-07	1.15E-07	1.26E-04	--	3.37E-04
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-65	Transfer of Stope Ore from Stope to Loader	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-70	Transfer of Stope Ore from Loader to Orepass 1	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	Yes	0.09	2.01E-05	1.47E-05	1.14E-07	1.84E-05	3.12E-06	2.46E-06	4.23E-03	9.46E-07	2.46E-06	4.69E-03	--	8.98E-03
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-82	Drop on West Rock Stockpile	Yes	0.67	1.16E-05	3.38E-05	9.37E-07	2.38E-06	1.83E-05	2.53E-06	3.91E-03	5.23E-06	2.17E-06	2.37E-03	--	6.35E-03
DP-83	Drop on East Rock Stockpile	Yes	0.74	1.28E-05	3.74E-05	1.04E-06	2.64E-06	2.02E-05	2.81E-06	4.33E-03	5.79E-06	2.40E-06	2.62E-03	--	7.04E-03
DP-84	TSF	Yes	1.38	2.80E-04	2.11E-04	1.64E-06	2.53E-04	4.59E-05	3.44E-05	6.13E-02	1.38E-05	3.45E-05	5.88E-03	--	6.80E-02
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	Yes	0.24	5.09E-05	3.74E-05	2.88E-07	4.66E-05	7.93E-06	6.25E-06	1.07E-02	2.40E-06	6.25E-06	1.19E-02	--	2.28E-02
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	Yes	0.36	7.56E-05	5.55E-05	4.28E-07	6.92E-05	1.18E-05	9.27E-06	1.59E-02	3.57E-06	9.27E-06	1.77E-02	--	3.39E-02
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore Silo Feed Conveyor No. 1	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	1.11E-02	2.48E-06	6.44E-06	1.23E-02	--	2.35E-02
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	1.11E-02	2.48E-06	6.44E-06	1.23E-02	--	2.35E-02
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	1.11E-02	2.48E-06	6.44E-06	1.23E-02	--	2.35E-02
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	1.11E-02	2.48E-06	6.44E-06	1.23E-02	--	2.35E-02
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVB-008 Primary Mill Feed Conveyor	Yes	0.56	1.19E-04	8.76E-05	6.76E-07	1.09E-04	1.86E-05	1.46E-05	2.52E-02	5.63E-06	1.46E-05	2.79E-02	--	5.35E-02
TSF_3	Tailing Storage Facility	Yes	19.29	3.91E-03	2.96E-03	2.30E-05	3.53E-03	6.41E-04	4.81E-04	8.56E-01	1.92E-04	4.82E-04	8.22E-02	--	9.50E-01
WRS	West Rock Stockpile	Yes	0.72	1.24E-05	3.62E-05	1.01E-06	2.56E-06	1.96E-05	2.72E-06	4.19E-03	5.61E-06	2.33E-06	2.54E-03	--	6.82E-03
ERS	East Rock Stockpile	Yes	0.79	1.38E-05	4.01E-05	1.11E-06	2.83E-06	2.17E-05	3.01E-06	4.65E-03	6.21E-06	2.58E-06	2.81E-03	--	7.55E-03
ROADS	Road Emissions	Yes	187.43	6.91E-04	4.36E-03	3.64E-04	3.09E-04	6.18E-03	--	--	5.09E-03	1.82E-04	4.45E-03	4.54E-05	2.17E-02
UGTROADS	Underground Taylor Roads	Yes	77.04	2.93E-04	1.85E-03	1.54E-04	1.31E-04	2.62E-03	--	--	2.16E-03	7.70E-05	1.89E-03	1.93E-05	9.19E-03
UGCROADS	Underground Clark Roads	Yes	81.39	3.09E-04	1.95E-03	1.63E-04	1.38E-04	2.77E-03	--	--	2.28E-03	8.14E-05	1.99E-03	2.03E-05	9.71E-03
DOZER-WRS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-ERS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-MRS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-TSF	Dozer Emissions	Yes	9.82	1.99E-03	1.50E-03	1.17E-05	1.80E-03	3.26E-04	2.45E-04	4.36E-01	9.80E-05	2.45E-04	4.18E-02	--	4.84E-01
DRILL-2	Drilling-2	Yes	0.02	8.68E-06	1.05E-05	3.23E-08	2.36E-06	8.28E-07	1.15E-07	3.38E-03	1.50E-07	9.62E-08	3.39E-04	--	3.74E-03
BLAST-2	Blasting-2	Yes	0.31	1.38E-04	1.67E-04	5.16E-07	3.76E-05	1.32E-05	1.84E-06	5.39E-02	2.39E-06	1.53E-06	5.40E-03	--	5.96E-02
DP-103	Dump into Primary Crusher Feed Hopper	Yes	0.29	1.31E-04	1.57E-04	4.86E-07	3.55E-05	1.24E-05	1.74E-06	5.08E-02	2.26E-06	1.45E-06	5.09E-03	--	5.62E-02
DP-104	Drop from silo to trucks	Yes	0.96	4.35E-04	5.24E-04	1.62E-06	1.18E-04	4.15E-05	5.79E-06	1.69E-01	7.53E-06	4.82E-06	1.70E-02	--	1.87E-01
DP-105	Transfer of Ore from Ore Stockpile to Loader	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	1.02E-01	4.52E-06	2.89E-06	1.02E-02	--	1.12E-01
DP-106	Transfer of Ore Mined from Loader to Haul Truck	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	1.02E-01	4.52E-06	2.89E-06	1.02E-02	--	1.12E-01
DP-107	Transfer from ROM Stockpile to Loader	Yes	0.16	7.16E-05	8.62E-05	2.67E-07	1.94E-05	6.82E-06	9.52E-07	2.79E-02	1.24E-06	7.94E-07	2.79E-03	--	3.08E-02
DP-113	Hardshell Wasterock Storage	Yes	2.60	1.17E-03	1.41E-03	4.36E-06	3.18E-04	1.12E-04	1.56E-05	4.56E-01	2.03E-05	1.30E-05	4.57E-02	--	5.04E-01
DP-114	Ore Stockpile	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	1.02E-01	4.52E-06	2.89E-06	1.02E-02	--	1.12E-01
DP-115	ROM Stockpile	Yes	0.16	7.16E-05	8.62E-05	2.67E-07	1.94E-05	6.82E-06	9.52E-07	2.79E-02	1.24E-06	7.94E-07	2.79E-03	--	3.08E-02
DP-124	Transfer of Development Ore from Face to Loader	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-125	Transfer of Development Ore from Loader to Stockpile	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-126	Transfer of Development Ore from Stockpile to Loader	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-129	Transfer of Development Waste Mined from Face to Loader	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-134	Transfer of Stope Ore from Stope to Loader	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-135	Transfer of Stope Ore from Loader to Stockpile	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-136	Transfer of Stope Ore from Stockpile to Loader	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-137	Transfer of Stope Ore from Loader to Haul Truck	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
HRS	Hardshell Rock Stockpile	Yes	2.74	4.76E-05	1.39E-04	3.85E-06	9.79E-06	7.50E-05	1.04E-05	1.60E-02	2.15E-05	8.91E-06	9.71E-03	--	2.61E-02

ORE	Clark Ore Stockpile	Yes	0.12	5.43E-05	6.54E-05	2.02E-07	1.48E-05	5.18E-06	7.23E-07	2.11E-02	9.39E-07	6.02E-07	2.12E-03	--	2.34E-02
ROM	Clark ROM Stockpile	Yes	0.04	1.61E-05	1.94E-05	6.01E-08	4.38E-06	1.54E-06	2.14E-07	6.27E-03	2.79E-07	1.79E-07	6.29E-04	--	6.94E-03
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	2.11E-02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	2.11E-02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	2.11E-02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
Total			**4.13E+02**	**1.38E-02**	**1.99E-02**	**7.65E-04**	**9.52E-03**	**1.38E-02**	**1.23E-03**	**3.48E+00**	**1.02E-02**	**1.56E-03**	**1.00E+00**	**8.51E-05**	**4.55E+00**

1. Table of HAP Constituents received from South32 in "Copy of Air Permitting Final 0 HAPs"

Table A-2c. Average Constituent Mass Fraction in LOM

HAP	Taylor				Clark		
	Development Ore	Stope Ore	Rock	Tailings[1]	Development Ore	Stope Ore	Rock
Antimony Compounds	0.000100952	0.000212	1.7365E-05	0.000202878	0.000244389	0.000451	4.70138E-05
Arsenic Compounds	0.000127076	0.0001555	5.05638E-05	0.000153165	0.000330447	0.000543	8.47561E-05
Beryllium Compounds	1.09588E-06	0.0000012	1.4024E-06	1.19145E-06	1.1936E-06	0.00000168	1.08653E-06
Cadmium Compounds	5.95151E-05	0.000194	3.56972E-06	0.000182952	6.68071E-05	0.0001225	1.26614E-05
Chromium Compounds	3.58403E-05	0.000033	2.73603E-05	3.32333E-05	5.11672E-05	0.000043	3.08836E-05
Cobalt Compounds	1.30505E-05	0.000026	3.79338E-06	2.49362E-05	4.59693E-06	0.000006	2.23051E-06
Cyanide Compounds	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese Compounds	0.040637342	0.0447	0.005852034	0.044366261	0.094972702	0.1755	0.017263008
Mercury Compounds	N/A	N/A	N/A	N/A	N/A		N/A
Nickel Compounds	9.68749E-06	0.00001	7.82396E-06	9.97433E-06	8.62044E-06	0.0000078	6.47096E-06
Radionuclides	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium Compounds	1.3463E-05	0.000026	3.25003E-06	2.49701E-05	4.33389E-06	0.000005	2.95309E-06
Lead Compounds	0.0217561371071872	0.049605776	0.003541223	0.004258619	0.012895714	0.017592857	0.005668919

[1] For constituents other than lead, mass fractions in the tailings are assumed to be equivalent to the mass fractions in the rocl

Notes on Lead

Material	Notes
Development Ore	Based on average inside domains
Stope Ore	Based on assays within stope design
Rock	Based on average lithology grades minus inside domains

Stope numbers based on evaluation of drillhole data through stope designs
Rock is the evauation of assays within lithological units.

Table A-2d. Metal Content in Surface Soil

Metal	Content (kg/kg)
Antimony	3.80E-06
Arsenic	2.40E-05
Beryllium	2.00E-06
Cadmium	1.70E-06
Chromium	3.40E-05
Nickel	2.80E-05
Selenium	1.00E-06
Mercury	2.50E-07

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples

Table A-2e. Generators HAP Summary

Emission ID	Description	HAP Annual Emissions (tpy)																										
		Benzene	Toluene	Xylene	1,3-Butadiene	Formaldehyde	Acetaldehyde	Acrolein	Naphthalene	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,3-Dichloropropene	2-Methylnaphthalene	2,2,4-Trimethylpentane	Biphenyl	Carbon Tetrachloride	Chlorobenzene	Chloroform	Ethylbenzene	Ethylene Dibromide	Methanol	Methylene Chloride	Hexane	PAH	Phenol	Tetrachloroethane	Vinyl Chloride	Total
T_ENG / T_ENG_ALT	Trench	3.06E-01	2.83E-01	1.28E-01	1.85E-01	1.82E+01	3.98E+01	3.57E+00	5.17E-02	2.72E-01	2.17E-01	1.80E-01	2.31E-02	1.74E-01	1.47E-01	2.50E-01	2.07E-01	1.94E-01	2.76E-02	3.02E-01	1.74E+00	1.36E-01	7.71E-01	5.28E-01	1.63E-01	1.69E-02	1.01E-01	**6.80E+01**
HS_1 - HS_6	Hardshell	1.92E-01	6.94E-02	4.77E-02	9.66E-03	1.95E-02	6.22E-03	1.95E-03	3.21E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.02E-02	--	--	--	**3.98E-01**
ENG9 - ENG13	Diesel	6.01E-03	2.18E-03	1.49E-03	3.03E-04	6.11E-04	1.95E-04	6.10E-05	1.01E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.19E-02**
ENG5	WW1	8.36E-03	3.66E-03	2.55E-03	3.50E-04	1.06E-02	6.87E-03	8.28E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.45E-04	--	--	--	**3.39E-02**
	Total	**5.12E-01**	**3.59E-01**	**1.79E-01**	**1.96E-01**	**1.82E+01**	**3.98E+01**	**3.57E+00**	**8.48E-02**	**2.72E-01**	**2.17E-01**	**1.80E-01**	**2.31E-02**	**1.74E-01**	**1.47E-01**	**2.50E-01**	**2.07E-01**	**1.94E-01**	**2.76E-02**	**3.02E-01**	**1.74E+00**	**1.36E-01**	**7.71E-01**	**5.49E-01**	**1.63E-01**	**1.69E-02**	**1.01E-01**	**6.84E+01**

Table A-2f. Emission Source HAPs Summary

Emission ID	Description	HAP Annual Emissions (tpy)													
		Cresol	Ethylene Glycol Dimethyl Ether	Urethane	Benzene	Hexane	Toluene	Xylene	Ethylbenzene	Benzo(g,h,i)perylene	Cumene	Isooctane	Naphthalene	PAC's	Total
T-01	Unleaded Gasoline (S32)	--	--	--	2.02E-03	1.52E-04	2.32E-03	6.66E-04	1.52E-04	1.49E-19	2.59E-05	2.32E-03	1.18E-06	1.18E-06	**7.7E-03**
T-02	Diesel (Red Dyed S32)	--	--	--	3.20E-06	5.03E-06	3.77E-05	9.81E-05	5.03E-06	1.60E-18	0.00E+00	0.00E+00	7.69E-07	7.69E-07	**1.5E-04**
T-03	Diesel (Red Dyed S32)	--	--	--	3.20E-06	5.03E-06	3.77E-05	9.81E-05	5.03E-06	1.60E-18	0.00E+00	0.00E+00	7.69E-07	7.69E-07	**1.5E-04**
T-04	Diesel (Red Dyed Rummel)	--	--	--	3.98E-06	6.27E-06	4.70E-05	1.22E-04	6.27E-06	2.01E-18	0.00E+00	0.00E+00	9.61E-07	9.61E-07	**1.9E-04**
T-05	Unleaded Gasoline (Rummel)	--	--	--	1.76E-03	1.32E-04	2.01E-03	5.78E-04	1.32E-04	1.29E-19	2.25E-05	2.01E-03	1.02E-06	1.02E-06	**6.6E-03**
T-06	Diesel (Rummel)	--	--	--	9.26E-07	1.46E-06	1.09E-05	2.84E-05	1.46E-06	4.61E-19	0.00E+00	0.00E+00	2.23E-07	2.23E-07	**4.4E-05**
T-07	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-08	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-09	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-10	Diesel	--	--	--	7.64E-05	1.20E-04	9.02E-04	2.35E-03	1.20E-04	3.86E-17	0.00E+00	0.00E+00	1.84E-05	1.84E-05	**3.6E-03**
T-11	Diesel	--	--	--	7.00E-05	1.10E-04	8.26E-04	2.15E-03	1.10E-04	3.54E-17	0.00E+00	0.00E+00	1.69E-05	1.69E-05	**3.3E-03**
TNK-040	F549/MIBC	0.00	2.62E-01	0.00	--	--	--	--	--	--	--	--	--	--	**2.6E-01**
TNK-041	3407-A	9.52E-05	0.00	0.00	--	--	--	--	--	--	--	--	--	--	**9.5E-05**
TNK-044	Solvay 5100	0.00	0.00	3.67E-05	--	--	--	--	--	--	--	--	--	--	**3.7E-05**
AGGDF	Aboveground Gasoline Dispensing Facility	--	--	--	0.02	0.01	0.06	0.06	0.01	--	--	--	--	--	**1.5E-01**
AGGDF-C	Aboveground Gasoline Dispensing Facility	--	--	--	7.45E-03	4.14E-03	2.90E-02	2.90E-02	5.80E-03	--	--	--	--	--	**7.5E-02**
Total		**9.52E-05**	**0.26**	**3.67E-05**	**0.06**	**0.02**	**0.13**	**0.10**	**0.02**	**8.22E-17**	**0.00**	**0.04**	**5.84E-05**	**5.84E-05**	**6.3E-01**

Table A-3a. Taylor Drilling - Parameters and Emission Factors

Emission Point Number	Activity	Throughput [1] (tons/hr)	Throughput [1] (ton/year)	Controlled Emission Factor[3] PM (lb/ton)	PM_{10}[2] (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds [5] (lb/ton)	Control Type	$PM/PM_{10}/Pb$ Efficiency [4] (%)	$PM_{2.5}$ Efficiency [4]
DRILL-1	Drilling	657	5,739,000	1.69E-04	8.00E-05	1.21E-05	8.39E-06	Gravity Settling due to underground drilling (underground only)	87%	17%

1. Per Total tonnes w/ backfill used from "Mined tonnes and Pb grade.xlsx" recd. on 7/12/2021.
2. Per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".
3. Per U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, the particle size multiplier used for calculating emission factors for PM_{10} and $PM_{2.5}$ is as follows:

PM: 0.74
PM_{10}: 0.35
$PM_{2.5}$: 0.053

4. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
5. Lead percentage in stope ore used conservatively for drilling 4.96 %

Table A-3b. Taylor Drilling - Emissions

Emission Point Number	Activity	Controlled Emissions [1] Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Daily Emissions (lb/day) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Hourly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DRILL-1	Drilling	0.06	0.03	0.03	0.00	0.33	0.16	0.16	0.02	1.39E-02	6.57E-03	6.57E-03	6.89E-04

1. Controlled Emissions have been calculated for drilling since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere."
Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-4a. Clark Drilling - Parameters and Emission Factors

Emission Point Number	Activity	Throughput [1]		Controlled Emission Factor[3]				Control		
		(tons/hr)	(ton/year)	PM (lb/ton)	PM_{10}[2] (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds [5] (lb/ton)	Type	PM/PM_{10}/Pb Efficiency [4] (%)	$PM_{2.5}$ Efficiency [4]
DRILL-2	Drilling	128	1,125,000	1.69E-04	8.00E-05	1.21E-05	2.98E-06	Gravity Settling due to underground drilling (underground only)	80%	16%

1. Per email "Clark Updated Inputs for Air Permit" from Cayley Hoffman received on 9/8/2022
2. Per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".
3. Per U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, the particle size multiplier used for calculating emission factors for PM_{10} and $PM_{2.5}$ is as follows:
   PM: 0.74
   PM_{10}: 0.35
   $PM_{2.5}$: 0.053
4. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
5. Lead percentage in stope ore used conservatively for drilling 1.76 %

Table A-4b. Clark Drilling - Emissions

Emission Point Number	Activity	Controlled Emissions [1]											
		Annual Emissions (tpy)				Daily Emissions (lb/day)				Hourly Emissions (lb/hr)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DRILL-2	Drilling	0.02	0.01	0.01	3.39E-04	0.11	0.05	0.03	0.00	4.39E-03	2.08E-03	1.30E-03	7.73E-05

1. Controlled Emissions have been calculated for drilling since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-5a. Taylor Blasting - Parameters

Emission Point No.	Location	Blast Area (ft^2/blast) [1] Maximum	Emulsion Usage Rates [1]		Blasting Rates [1]
			(ton/hr)	(ton/yr)	(blasts/yr)
BLAST-1	Blasting	9,000	17.42	4,500	730

1. Per meeting with Kevin Mccoy on 9/9/2022, 10/14/2022, and 10/17/2022
Maximum Hourly emulsion usage = 17.42 ton/hr

Table A-5b. Taylor Blasting Emissions

Emission Point No.	Location	Pollutant	Emission Factor [1,2,3,4,5,6]	Unit	Controlled Emissions		
					(tpy)	(lb/day)	(lb/hr)
BLAST-1	Blasting	NO_x	0.50	(lb/ton Emulsion)	1.13	--	8.71
		CO	27.00	(lb/ton Emulsion)	60.75	--	470.25
		H_2S	4.00	(lb/ton Emulsion)	9.00	--	69.67
		SO_2	1.00	(lb/ton Emulsion)	2.25	--	17.42
		PM	1.49	(Max lb/Blast)	0.55	2.99	1.49
		PM_{10}	0.78	(Max lb/Blast)	0.28	1.55	0.78
		$PM_{2.5}$	0.30	(Max lb/Blast)	0.11	0.59	0.296
		Lead (from ore)	0.07	(Max lb/Blast)	0.03	0.15	0.074
		CO_2	463.18	(lb/ton)	1,042.15	--	8066.92

1. NO_X and CO emission factors based on "Fume Memo WESCO Aug 2021" pdf dated 19 August 2021 provided by Seth Fredrick Dyno Nobel Inc.
2. H_2S and SO_2 emission factors per AP-42 Section 13.3, Table 13.3-1 for dynamite, gelatin (January 1995).
This emission factor was used by FMI Climax Mine, Colorado (underground mine) per permit application in October 2013 for CDPHE Air Permit No. 95CC899.

3. PM emission factor calculated per AP-42 Section 11.9, Table 11.9-1 for blasting (July 1998)

$0.000014(A)^{1.5}$ where, A = horizontal area (ft^2), with blasting depth ≤ 70 ft

The following scaling factors are applied to PM emission factor to calculate PM_{10} and $PM_{2.5}$ emission factors per AP-42 Table 11.9-1:

PM_{10}:	0.52
$PM_{2.5}$:	0.03

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Gravity Settling (underground only) $PM/PM_{10}/Pb$:	87%
Gravity Settling (underground only) $PM_{2.5}$:	17%

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

4. CO_2 emission factor is based on "Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products" - Iwona Zawadzka-Malota, January 7, 2016.

5. Lead content in ore	4.96 %	
6. Hourly emissions are based on 1 blast/hr (7 Developmental and 1 Stope sub-blasts per blast).	1.00 blast/hr	per meeting with Kevin McCoy on 9/9/2022
	2.00 blasts/day	per meeting with Kevin McCoy on 9/9/2022

Table A-6a. Clark Blasting - Parameters

Emission Point No.	Location	Blast Area (ft^2/blast) [1] Maximum	Emulsion Usage Rates [1]		Blasting Rates [1]
			(ton/hr)	(ton/yr)	(blasts/yr)
BLAST-2	Blasting	4,450	4.60	562	730

1. Per email "Clark Updated Inputs for Air Permit" from Cayley Hoffman received on 9/8/2022 and meetings in 10/2022
Maximum total emulsion usage = 4.60 tons/hr

Table A-6b. Clark Blasting Emissions

Emission Point No.	Location	Pollutant	Emission Factor [1,2,3,4,5,6]	Unit	Controlled Emissions		
					(tpy)	(lb/day)	(lb/hr)
BLAST-2	Blasting	NO_x	0.50	(lb/ton Emulsion)	0.14	--	2.30
		CO	27.00	(lb/ton Emulsion)	7.59	--	124.11
		H_2S	4.00	(lb/ton Emulsion)	1.12	--	18.39
		SO_2	1.00	(lb/ton Emulsion)	0.28	--	4.60
		PM	0.84	(Max lb/Blast)	0.31	1.68	0.84
		PM_{10}	0.44	(Max lb/Blast)	0.16	0.87	0.437
		$PM_{2.5}$	0.1045	(Max lb/Blast)	0.038	0.21	0.1045
		Lead (from ore)	0.015	(Max lb/Blast)	0.0054	0.03	0.0148
		CO_2	463.18	(lb/ton)	130.15	--	2129.05

1. NO_X and CO emission factors based on "Fume Memo WESCO Aug 2021" pdf dated 19 August 2021 provided by Seth Fredrick Dyno Nobel Inc.
2. H_2S and SO_2 emission factors per AP-42 Section 13.3, Table 13.3-1 for dynamite, gelatin (January 1995).
This emission factor was used by FMI Climax Mine, Colorado (underground mine) per permit application in October 2013 for CDPHE Air Permit No. 95CC899.

3. PM emission factor calculated per AP-42 Section 11.9, Table 11.9-1 for blasting (July 1998)

$0.000014(A)^{1.5}$ where, A = horizontal area (ft^2), with blasting depth ≤ 70 ft

The following scaling factors are applied to PM emission factor to calculate PM_{10} and $PM_{2.5}$ emission factors per AP-42 Table 11.9-1:

PM_{10}:	0.52
$PM_{2.5}$:	0.03

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Gravity Settling (underground only) $PM/PM_{10}/Pb$:	80%
Gravity Settling (underground only) $PM_{2.5}$:	16%

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

4. CO2 emission factor is based on "Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products" - Iwona Zawadzka-Malota, January 7, 2016.

5. Lead content in ore	1.76 %	
6. Hourly emissions are based on 1 blast/hr	1.00 blast/hr	per meeting with Cayley Hoffman on 9/9/2022
(4 Developmental and 1 Stope sub-blasts per blast).	2.00 blasts/day	per meeting with Cayley Hoffman on 9/9/2022

Table A-7a. Crushing - Emission Factors

Emission Point Number	Description	Activity	Throughput [1,6]		Controlled Emission Factor [2,3,4,7]				Control		
			(ton ore/hr)	(ton ore/yr)	PM (lb/ton ore)	PM_{10} (lb/ton ore)	$PM_{2.5}$ (lb/ton ore)	Lead Compounds (lb/ton ore)	Type	PM/PM_{10} Efficiency [5] (%)	$PM_{2.5}$ Efficiency [5]
CRUSH-1	Underground Crushing	Primary Crushing	1,543	4,665,131	0.0012	0.00054	0.0001	5.95E-05	Gravity Settling	87%	17%
CRUSH-2	Pebble Crusher	Secondary Crushing	220	1,927,200	0.0012	0.00054	0.0001	2.61E-05	No Control as a Controlled Emission Factor is being used	0%	0%
BREAK-1	Clark Rock Breaker	Rock Breaker	12	47,131	1.69E-04	8.00E-05	1.21E-05	2.98E-06	No Control as a Controlled Emission Factor is being used	0%	0%

1. Throughput per Total tonnes of Ore crushed from "Mined tonnes and Pb grade.xlsx" recd. on 7/12/2021
Hourly throughput based on "thyssenkrupp ERC Product Range Sizes.pdf" recd. on 7/12/2021.
2. Crushing emission factors obtained from AP-42 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing for tertiary crushing
3. Lead conc. 4.96 % for Primary Crushing for Taylor
2.18 % for pebble crusher 4.50E-01 1.85E-01
1.76 % for Rock Breaker for Clark 4.73E-01 1.51E-01
4. Assumed that $PM_{2.5}$ is approximately 30% of PM_{10} per AP-42, as calculated below and described in AP-42 Appendix B.2, Category 3, September 1990.
% cumulative size
$PM_{2.5}$ 15 %
PM_{10} 51 %
Ratio $PM_{2.5}/PM_{10}$ 0.29
5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
For Watering 70%
Gravity Settling (underground only) ($PM/PM_{10}/Pb$) 87%
Gravity Settling (underground only) ($PM_{2.5}$) 17%
6. Rock breakers are hydraulic-type hammers that break down rock pieces that are too large for the Clark Grizzly Screen. As such, the throughput will correspond to a percent (%) of the total grizzly screen throughput. It is conservatively assumed that this value will be 10% for South32.
7. Emission factors per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".

Table A-7b. Crushing - Emissions

Emission Point Number	Activity	Controlled Emissions: Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Daily Emissions (lb/day) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Hourly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
CRUSH-1	Underground Crushing [1]	0.35	0.16	0.19	0.02	5.56	2.50	3.06	0.28	0.23	0.10	0.13	0.01
CRUSH-2	Pebble Crusher	1.16	0.52	0.10	0.03	6.34	2.85	0.53	0.14	0.26	0.12	0.02	0.006
BREAK-1	Clark Rock Breaker	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00	2.04E-03	9.64E-04	1.46E-04	0.000
	Total	**1.51**	**0.68**	**0.29**	**0.04**	**11.94**	**5.37**	**3.59**	**0.41**	**0.50**	**0.22**	**0.15**	**0.02**

1. Controlled Emissions have been calculated for underground crushing since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air

Table A-8a. Crushing - Emission Factors

Emission Point Number	Description	Activity	Throughput [1,6] (ton ore/hr)	Controlled Emission Factor [2,3,4,7] PM (lb/ton ore)	PM_{10} (lb/ton ore)	$PM_{2.5}$ (lb/ton ore)	Lead Compounds (lb/ton ore)	Control Type	PM/PM_{10} Efficiency [5] (%)	$PM_{2.5}$ Efficiency [5]
CRUSH-1	Underground Crushing	Primary Crushing	570	0.0012	0.00054	0.0001	5.95E-05	Gravity Settling	87%	17%
CRUSH-2	Pebble Crusher	Secondary Crushing	130	0.0012	0.00054	0.0001	2.61E-05	No Control as a Controlled Emission Factor is being used	0%	0%
BREAK-1	Clark Rock Breaker	Rock Breaker	9	1.69E-04	8.00E-05	1.21E-05	2.98E-06	No Control as a Controlled Emission Factor is being used	0%	0%

1. Monthly throughput per email from Sarah Richman (South32) dated 5/18/2023
2. Crushing emission factors obtained from AP-42 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing for tertiary crushing
3. Lead conc. 4.96 % for Primary Crushing for Taylor
2.18 % for pebble crusher
1.76 % for Rock Breaker for Clark
4. Assumed that $PM_{2.5}$ is approximately 30% of PM_{10} per AP-42, as calculated below and described in AP-42 Appendix B.2, Category 3, September 1990.

% cumulative size	
$PM_{2.5}$	15 %
PM_{10}	51 %
Ratio $PM_{2.5}/PM_{10}$	0.29

5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

For Watering	70%	
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%	
Gravity Settling (underground only) ($PM_{2.5}$)	17%	1991 Paper

6. Rock breakers are hydraulic-type hammers that break down rock pieces that are too large for the Clark Grizzly Screen. As such, the throughput will correspond to a percent (%) of the total grizzly screen throughput. It is conservatively assumed that this value will be 10% for South32.
7. Emission factors per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".

Table A-8b. Crushing - Emissions

Emission Point Number	Activity	Controlled Emissions Monthly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
CRUSH-1	Underground Crushing [1]	0.09	0.04	0.05	0.00
CRUSH-2	Pebble Crusher	0.16	0.07	0.01	0.003
BREAK-1	Clark Rock Breaker	0.00	0.00	0.00	0.000
Total		**0.24**	**0.11**	**0.06**	**0.01**

1. Controlled Emissions have been calculated for underground crushing since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air

Table A-9a. Taylor Drops - Emissions - Inputs - Hourly/Daily

Emission Point Number	Description	Throughput [1] (ton/hr)	Lead Content [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency	Control Factor [2] $PM_{2.5}$ Efficiency	Windspeed [4]	Uncontrolled Emission Factor [3] PM	Uncontrolled Emission Factor [3] PM_{10}	Uncontrolled Emission Factor [3] $PM_{2.5}$	Uncontrolled Emission Factor [3] Lead Compounds
						(%)	(%)	(mph)	(lb/ton)	(lb/ton)	(lb/ton)	(lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	675	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	675	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-3	Drop from 21200-FOR-001 Mine Shaft Ore Discharge Feeder to 21200-GAT-001 Mine Shaft Diverter Gate	Controlled by Coarse Ore Dust Collection System										
DP-4	Drop from 21200-GAT-001 Mine Shaft Discharge Gate to 21200-CVR-001 Coarse Ore Overland Conveyor											
DP-6	Drop from 21200-CVR-001 Coarse Ore Overland Conveyor to 21300-CHU-001 3-Way Shuttle Chute											
DP-7	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor											
DP-8	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor											
DP-9	Drop from 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor to 21500-SLO-001 Coarse Ore Silo No.1											
DP-10	Drop from 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor to 21500-SLO-002 Coarse Ore Silo No.2											
DP-11	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21500-SLO-003 Coarse Ore Silo No.3											
DP-12	Drop from 21700-FOR-002 Coarse Ore Silo Discharge Feeder No.1 to 21700-SCB-002 Discharge Feeder Belt Scale No.1											
DP-13	Drop from 21700-FOR-004 Coarse Ore Silo Discharge Feeder No.2 to 21700-SCB-004 Discharge Feeder Belt Scale No.2											
DP-14	Drop from 21700-FOR-006 Coarse Ore Silo Discharge Feeder No.3 to 21700-SCB-006 Discharge Feeder Belt Scale No.3											
DP-15	Drop from 21700-SCB-002 Discharge Feeder Belt Scale No.1 to 21700-CVR-008 Primary Mill Feed Conveyor											
DP-16	Drop from 21700-SCB-004 Discharge Feeder Belt Scale No.2 to 21700-CVR-008 Primary Mill Feed Conveyor											
DP-17	Drop from 21700-SCB-006 Discharge Feeder Belt Scale No.3 to 21700-CVR-008 Primary Mill Feed Conveyor											
Primary Milling												
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	854	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	Wet streams, no emissions expected										
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor											
Secondary Crushing												
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
Underground Drops - Development Ore												
DP-40	Transfer of Development Ore from Face to Loader	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	64.10	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	64.10	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
Underground Drops - Development Waste + Paste Remuck												
DP-57	Transfer of Development Waste Mined from Face to Loader	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	138.60	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	138.60	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	5.48E-06

DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
				Underground Drops - Stope Ore								
DP-65	Transfer of Stope Ore from Stope to Loader	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	527.12	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
				Stockpile Drops								
DP-82	Drop on West Rock Stockpile	29.00	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	32.12	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	247.02	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
DP-85	Drops on TSF2					No TSF2 for Plan I						
				From Stockpiles								
DP-94	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
				WTP2								
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	0.001080	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.000005	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	0.037158	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per February 2021 dated Process Flow Diagram, provided by South32 in May 2021.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture Content taken into account in AP-42 Drop Equation)	0%	
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	17%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.05

U = Mean wind speed (miles per hour [mph]), which is equal to:

Based on 2019-2021 On-Site Met Data

1.3 — For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1

0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-9b. Taylor Drops - Hourly Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	**PM_{10}**	**$PM_{2.5}$**	**Lead Compounds**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**Lead Compounds**
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	0.53	0.25	0.04	2.64E-02	12.78	6.04	0.92	0.63
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	0.53	0.25	0.04	2.64E-02	12.78	6.04	0.92	0.63
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	0.67	0.32	0.05	3.34E-02	16.17	7.65	1.16	0.80
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18

DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.60	0.18
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	0.35	0.16	2.49E-02	7.55E-03	8.33	3.94	0.60	0.18
DP-40	Transfer of Development Ore from Face to Loader	5.35E-04	2.53E-04	2.53E-04	1.16E-05	0.01	0.01	0.01	0.00
DP-41	Transfer of Development Ore from Loader to Stockpile	3.74E-04	1.77E-04	1.77E-04	8.15E-06	0.01	0.00	0.00	0.00
DP-42	Transfer of Development Ore from Stockpile to Loader	3.74E-04	1.77E-04	1.77E-04	8.15E-06	0.01	0.00	0.00	0.00
DP-43	Transfer of Development Ore from loader to Haul truck	5.35E-04	2.53E-04	2.53E-04	1.16E-05	0.01	0.01	0.01	0.00
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	5.32E-03	2.52E-03	2.52E-03	1.16E-04	0.13	0.06	0.06	0.00
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00
DP-57	Transfer of Development Waste Mined from Face to Loader	1.16E-03	5.47E-04	5.47E-04	4.09E-06	0.03	0.01	0.01	0.00
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	8.10E-04	3.83E-04	3.83E-04	2.87E-06	0.02	0.01	0.01	0.00
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	8.10E-04	3.83E-04	3.83E-04	2.87E-06	0.02	0.01	0.01	0.00
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	1.16E-03	5.47E-04	5.47E-04	4.09E-06	0.03	0.01	0.01	0.00
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	1.15E-02	5.43E-03	5.44E-03	4.07E-05	0.28	0.13	0.13	0.00
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	1.75E-03	8.28E-04	8.29E-04	6.20E-06	0.04	0.02	0.02	0.00
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	1.75E-03	8.28E-04	8.29E-04	6.20E-06	0.04	0.02	0.02	0.00
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	1.75E-03	8.28E-04	8.29E-04	6.20E-06	0.04	0.02	0.02	0.00
DP-65	Transfer of Stope Ore from Stope to Loader	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-70	Transfer of Stope Ore from Loader to Orepass 1	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	3.08E-03	1.46E-03	1.46E-03	1.53E-04	0.07	0.03	0.03	0.004
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	2.16E-02	1.02E-02	1.02E-02	1.07E-03	0.52	0.25	0.25	0.026
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	4.66E-03	2.21E-03	2.21E-03	2.31E-04	0.11	0.05	0.05	0.006
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	4.66E-03	2.21E-03	2.21E-03	2.31E-04	0.11	0.05	0.05	0.006
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	4.66E-03	2.21E-03	2.21E-03	2.31E-04	0.11	0.05	0.05	0.006
DP-82	Drop on West Rock Stockpile	0.15	0.07	0.01	5.40E-04	3.66	1.73	0.26	0.01
DP-83	Drop on East Rock Stockpile	0.17	0.08	0.01	5.98E-04	4.05	1.92	0.29	0.01
DP-84	TSF	0.32	0.15	0.02	1.26E-03	7.56	3.58	0.54	0.03
DP-94	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	8.16E-06	3.86E-06	5.84E-07	--	1.96E-04	0.00	1.40E-05	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	4.07E-08	1.93E-08	2.92E-09	--	9.78E-07	0.00	7.00E-08	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	2.81E-04	1.33E-04	2.01E-05	--	6.74E-03	0.00	4.82E-04	--
Total		**5.65**	**2.67**	**0.44**	**0.15**	**135.71**	**64.19**	**10.62**	**3.66**

Table A-10a. Taylor Drops - Emissions - Inputs - Monthly

Emission Point Number	Description	Throughput [1] (ton/hr)	Lead Content [1]	Water Content (%) [1]	Control Method	Control Factor [2]		Windspeed [4]	Uncontrolled Emission Factor [3]			
						PM/PM_{10} Efficiency	$PM_{2.5}$ Efficiency		PM	PM_{10}	$PM_{2.5}$	Lead Compounds
						(%)	(%)	(mph)	(lb/ton)	(lb/ton)	(lb/ton)	(lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	588	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	588	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
Primary Milling												
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	720	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
Secondary Crushing												
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
Underground Drops - Development Ore												
DP-40	Transfer of Development Ore from Face to Loader	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	64.10	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	64.10	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	91.60	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
Underground Drops - Development Waste + Paste Remuck												
DP-57	Transfer of Development Waste Mined from Face to Loader	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	138.60	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	138.60	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	5.48E-06
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	197.90	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
Underground Drops - Stope Ore												
DP-65	Transfer of Stope Ore from Stope to Loader	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	258.60	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	258.60	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06

DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	517.20	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
Stockpile Drops												
DP-82	Drop on West Rock Stockpile	29.00	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	32.12	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	247.02	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
DP-85	Drops on TSF2	No TSF2 for Plan I										
From Stockpiles												
DP-94	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
WTP2												
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	0.001080	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.000005	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	0.037158	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per February 2021 dated Process Flow Diagram, provided by South32 in May 2021.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%
Moisture Content (Moisture Content taken into account in AP-42 Drop Equation)	0%
Gravity Settling (underground only) (PM/PM_{10}/Pb)	87%
Gravity Settling (underground only) ($PM_{2.5}$)	17%
For Full Enclosure/Enclosure	80%
For Partial Enclosure	50%
No control	0%

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)
k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is equal to: 19.49 Based on 2019-2021 On-Site Met Data
1.3 For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4
M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-10b. Taylor Drops - Monthly Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	0.46	0.22	0.03	2.30E-02	11.14	5.27	0.80	0.55
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	0.46	0.22	0.03	2.30E-02	11.14	5.27	0.80	0.55
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	0.57	0.27	0.04	2.82E-02	13.63	6.44	0.98	0.68
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	--	--	--	--	--	--	--	--
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	--	--	--	--	--	--	--	--
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.35	0.11
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	0.20	0.10	1.46E-02	4.45E-03	4.91	2.32	0.35	0.11
DP-40	Transfer of Development Ore from Face to Loader	5.35E-04	2.53E-04	2.53E-04	1.16E-05	0.01	0.01	0.01	0.00
DP-41	Transfer of Development Ore from Loader to Stockpile	3.74E-04	1.77E-04	1.77E-04	8.15E-06	0.01	0.00	0.00	0.00
DP-42	Transfer of Development Ore from Stockpile to Loader	3.74E-04	1.77E-04	1.77E-04	8.15E-06	0.01	0.00	0.00	0.00
DP-43	Transfer of Development Ore from loader to Haul truck	5.35E-04	2.53E-04	2.53E-04	1.16E-05	0.01	0.01	0.01	0.00
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	5.32E-03	2.52E-03	2.52E-03	1.16E-04	0.13	0.06	0.06	0.00
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	8.11E-04	3.83E-04	3.84E-04	1.76E-05	0.02	0.01	0.01	0.00

DP-57	Transfer of Development Waste Mined from Face to Loader	1.16E-03	5.47E-04	5.47E-04	4.09E-06	0.03	0.01	0.01	0.00
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	8.10E-04	3.83E-04	3.83E-04	2.87E-06	0.02	0.01	0.01	0.00
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	8.10E-04	3.83E-04	3.83E-04	2.87E-06	0.02	0.01	0.01	0.00
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	1.16E-03	5.47E-04	5.47E-04	4.09E-06	0.03	0.01	0.01	0.00
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	1.15E-02	5.43E-03	5.44E-03	4.07E-05	0.28	0.13	0.13	0.00
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	1.75E-03	8.28E-04	8.29E-04	6.20E-06	0.04	0.02	0.02	0.00
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	1.75E-03	8.28E-04	8.29E-04	6.20E-06	0.04	0.02	0.02	0.00
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	1.75E-03	8.28E-04	5.47E-04	6.20E-06	0.04	0.02	0.01	0.00
DP-65	Transfer of Stope Ore from Stope to Loader	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-70	Transfer of Stope Ore from Loader to Orepass 1	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	1.51E-03	7.14E-04	7.15E-04	7.49E-05	0.04	0.02	0.02	0.002
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	1.51E-03	7.14E-04	7.15E-04	7.49E-05	0.04	0.02	0.02	0.002
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	3.02E-03	1.43E-03	1.43E-03	1.50E-04	0.07	0.03	0.03	0.004
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	2.12E-02	1.00E-02	1.00E-02	1.05E-03	0.51	0.24	0.24	0.025
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	4.58E-03	2.16E-03	2.17E-03	2.27E-04	0.11	0.05	0.05	0.005
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	4.58E-03	2.16E-03	2.17E-03	2.27E-04	0.11	0.05	0.05	0.005
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	4.58E-03	2.16E-03	2.17E-03	2.27E-04	0.11	0.05	0.05	0.005
DP-94	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-82	Drop on West Rock Stockpile	0.15	0.07	0.01	5.40E-04	3.66	1.73	0.26	0.01
DP-83	Drop on East Rock Stockpile	0.17	0.08	0.01	5.98E-04	4.05	1.92	0.29	0.01
DP-84	TSF	0.32	0.15	0.02	1.26E-03	7.56	3.58	0.54	0.03
DP-94	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	8.16E-06	3.86E-06	5.84E-07	--	1.96E-04	9.26E-05	1.40E-05	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	4.07E-08	1.93E-08	2.92E-09	--	9.78E-07	4.63E-07	7.00E-08	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	2.81E-04	1.33E-04	2.01E-05	--	6.74E-03	3.19E-03	4.82E-04	--
Total		**4.42**	**2.09**	**0.35**	**0.12**	**106.02**	**50.14**	**8.45**	**2.77**

Table A-11a. Taylor Drops - Emissions - Inputs - Annual

Emission Point Number	Description	Throughput [1] (tpy)	Lead Content [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	Uncontrolled Emission Factor [3] PM_{10} (lb/ton)	Uncontrolled Emission Factor [3] $PM_{2.5}$ (lb/ton)	Uncontrolled Emission Factor [3] Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
Primary Milling												
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
Secondary Crushing												
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
Underground Drops - Development Ore												
DP-40	Transfer of Development Ore from Face to Loader	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	413,389	2.2%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	5.13E-06
Underground Drops - Development Waste + Paste Remuck												
DP-57	Transfer of Development Waste Mined from Face to Loader	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	7.61	0.0015	0.0007	0.0001	5.48E-06
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	1,222,759	0.35%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	8.36E-07
Underground Drops - Stope Ore												
DP-65	Transfer of Stope Ore from Stope to Loader	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06

DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	4,618,867	4.96%	4.00	Gravity Settling, Watering	96.25%	75.22%	1.79	0.0002	0.0001	0.0000	1.17E-05
Stockpile Drops												
DP-82	Drop on West Rock Stockpile	254,005	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	281,368	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	2,163,873	0.43%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.43E-06
DP-85	Drops on TSF2	No TSF2 for Plan I										
From Stockpiles												
DP-94	Transfer from Agg Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
WTP2												
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	9.46	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.05	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	325.50	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per May 2022 dated Process Flow Diagram, provided by South32 in May 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%
For wet material	0%
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%
Gravity Settling (underground only) ($PM_{2.5}$)	17%
For Full Enclosure/Enclosure	80%
For Partial Enclosure	50%
No control	0%

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

	PM	PM_{10}	$PM_{2.5}$
k = Particle size multiplier (dimensionless)	0.74	0.35	0.053
U = Mean wind speed (miles per hour [mph]), which i	19.49	Based on 2019-2021 On-Site Met Data	
	1.3	For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.	

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-11b. Taylor Drops - Annual Emissions - Controlled

Emission Point Number	Description	Controlled Emissions Annual Emissions (tpy)				Uncontrolled Emissions Annual Emissions (tpy)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.656
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.656
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.66
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	--	--	--	--	--	--	--	--
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	--	--	--	--	--	--	--	--
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crusher Feed/Bypass Chute	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crusher Feed Bin	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-40	Transfer of Development Ore from Face to Loader	1.21E-03	5.71E-04	5.71E-04	2.63E-05	0.03	0.02	0.00	0.00
DP-41	Transfer of Development Ore from Loader to Stockpile	1.21E-03	5.71E-04	5.71E-04	2.63E-05	0.03	0.02	0.00	0.00
DP-42	Transfer of Development Ore from Stockpile to Loader	1.21E-03	5.71E-04	5.71E-04	2.63E-05	0.03	0.02	0.00	0.00
DP-43	Transfer of Development Ore from loader to Haul truck	1.21E-03	5.71E-04	5.71E-04	2.63E-05	0.03	0.02	0.00	0.00
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	1.20E-02	5.68E-03	5.68E-03	2.61E-04	0.32	0.15	0.02	0.01
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	1.83E-03	8.65E-04	8.66E-04	3.98E-05	0.05	0.02	0.00	0.00
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	1.83E-03	8.65E-04	8.66E-04	3.98E-05	0.05	0.02	0.00	0.00
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	1.83E-03	8.65E-04	8.66E-04	3.98E-05	0.05	0.02	0.00	0.00
DP-57	Transfer of Development Waste Mined from Face to Loader	3.57E-03	1.69E-03	1.69E-03	1.26E-05	0.10	0.05	0.01	0.00
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	3.57E-03	1.69E-03	1.69E-03	1.26E-05	0.10	0.05	0.01	0.00
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	3.57E-03	1.69E-03	1.69E-03	1.26E-05	0.10	0.05	0.01	0.00
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	3.57E-03	1.69E-03	1.69E-03	1.26E-05	0.10	0.05	0.01	0.00
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	3.55E-02	1.68E-02	1.68E-02	1.26E-04	0.95	0.45	0.07	0.00
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	5.41E-03	2.56E-03	2.56E-03	1.92E-05	0.14	0.07	0.01	0.00
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	5.41E-03	2.56E-03	2.56E-03	1.92E-05	0.14	0.07	0.01	0.00
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	5.41E-03	2.56E-03	2.56E-03	1.92E-05	0.14	0.07	0.01	0.00
DP-65	Transfer of Stope Ore from Stope to Loader	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-70	Transfer of Stope Ore from Loader to Orepass 1	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	0.01	0.01	6.38E-03	6.69E-04	0.36	0.17	0.03	0.02
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	0.09	0.04	4.48E-02	4.69E-03	2.52	1.19	0.18	0.13
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	0.02	0.01	9.67E-03	1.01E-03	0.54	0.26	0.04	0.03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	0.02	0.01	9.67E-03	1.01E-03	0.54	0.26	0.04	0.03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	0.02	0.01	9.67E-03	1.01E-03	0.54	0.26	0.04	0.03
DP-82	Drop on West Rock Stockpile	0.67	0.32	0.05	2.37E-03	0.67	0.32	0.05	0.00
DP-83	Drop on East Rock Stockpile	0.74	0.35	0.05	2.62E-03	0.74	0.35	0.05	0.00
DP-84	TSF	1.38	0.65	0.10	5.88E-03	1.38	0.65	0.10	0.01
DP-85	Drops on TSF2	--	--	--	--	--	--	--	--
DP-94	Transfer from Agg Stockpile to Loader	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	3.57E-05	1.69E-05	2.56E-06	--	3.57E-05	1.69E-05	2.56E-06	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	1.78E-07	8.44E-08	1.28E-08	--	1.78E-07	8.44E-08	1.28E-08	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	1.23E-03	5.81E-04	8.81E-05	--	1.23E-03	5.81E-04	8.81E-05	--
	Total	**19.71**	**9.32**	**1.56**	**0.55**	**86.99**	**41.14**	**6.23**	**3.12**

Table A-12a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	$PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	PM_{10} (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	129	1.76%	4.00	Watering, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	90	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Ore from Ore Stockpile to Loader	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-106	Transfer of Ore Mined from Loader to Haul Truck	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-107	Transfer from ROM Stockpile to Loader	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-109	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Wasterock Storage Drop	112.71	1.76%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-114	Ore Stockpile Drop	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile Drop	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-125	Transfer of Development Ore from Loader to Stockpile	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-126	Transfer of Development Ore from Stockpile to Loader	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-129	Transfer of Development Waste Mined from Face to Loader	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-134	Transfer of Stope Ore from Stope to Loader	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-135	Transfer of Stope Ore from Loader to Stockpile	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-136	Transfer of Stope Ore from Stockpile to Loader	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-137	Transfer of Stope Ore from Loader to Haul Truck	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture taken into account within drop equation)	0%	
Gravity Settling (underground only) (PM/PM_{10}/Pb)	80%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	16%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is 19.49 — Based on 2020-2021 On-Site Met Data

1.3 — For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1

0.25 %

Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used.

Table A-12b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.10	0.05	0.01	0.00	2.44	1.15	0.17	0.04
DP-104	Drop from silo to trucks	0.24	0.11	0.02	0.00	5.69	2.69	0.41	0.10
DP-105	Transfer of Ore from Ore Stockpile to Loader	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-106	Transfer of Ore Mined from Loader to Haul Truck	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-107	Transfer from ROM Stockpile to Loader	0.04	0.02	0.00	0.00	0.87	0.41	0.06	0.02
DP-109	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-113	Hardshell Wasterock Storage Drop	0.59	0.28	0.042	0.010	14.23	6.73	1.02	0.25
DP-114	Ore Stockpile Drop	0.13	0.06	0.009	0.002	3.17	1.50	0.23	0.06
DP-115	ROM Stockpile Drop	0.04	0.02	0.003	0.001	0.87	0.41	0.06	0.02
DP-124	Transfer of Development Ore from Face to Loader	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.00	0.000
DP-125	Transfer of Development Ore from Loader to Stockpile	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.00	0.000
DP-126	Transfer of Development Ore from Stockpile to Loader	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.00	0.000
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.00	0.000
DP-129	Transfer of Development Waste Mined from Face to Loader	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.01	0.000
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.01	0.000
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.01	0.000
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.01	0.000
DP-134	Transfer of Stope Ore from Stope to Loader	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.00	0.000
DP-135	Transfer of Stope Ore from Loader to Stockpile	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.00	0.000
DP-136	Transfer of Stope Ore from Stockpile to Loader	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.00	0.000
DP-137	Transfer of Stope Ore from Loader to Haul Truck	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.00	0.000
Total		**1.82**	**0.86**	**0.13**	**0.02**	**43.60**	**20.62**	**3.16**	**0.59**

Table A-13a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	Uncontrolled Emission Factor [3] PM_{10} (lb/ton)	Uncontrolled Emission Factor [3] $PM_{2.5}$ (lb/ton)	Uncontrolled Emission Factor [3] Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	86	1.76%	4.00	Watering, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	86	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Ore from Ore Stockpile to Loader	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-106	Transfer of Ore Mined from Loader to Haul Truck	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-107	Transfer from ROM Stockpile to Loader	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-109	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Wasterock Storage Drop	112.71	1.76%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-114	Ore Stockpile Drop	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile Drop	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-125	Transfer of Development Ore from Loader to Stockpile	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-126	Transfer of Development Ore from Stockpile to Loader	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-129	Transfer of Development Waste Mined from Face to Loader	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-134	Transfer of Stope Ore from Stope to Loader	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-135	Transfer of Stope Ore from Loader to Stockpile	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-136	Transfer of Stope Ore from Stockpile to Loader	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-137	Transfer of Stope Ore from Loader to Haul Truck	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A .

For Watering	70%
Moisture Content (Moisture taken into account within drop equation)	0%
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	80%
Gravity Settling (underground only) ($PM_{2.5}$)	16%
For Full Enclosure/Enclosure	80%
For Partial Enclosure	50%
No control	0%

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

	PM	PM_{10}	$PM_{2.5}$
k = Particle size multiplier (dimensionless)	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), whic 19.49 Based on 2020-2021 On-Site Met Data
1.3 For indoor activities, based on minimum value of wind speed per
M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equatioı AP-42 Section 13.2.4.
0.25 %
Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used.

Table A-13b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.07	0.03	0.00	0.00	1.63	0.77	0.12	0.03
DP-104	Drop from silo to trucks	0.23	0.11	0.02	0.00	5.43	2.57	0.39	0.10
DP-105	Transfer of Ore from Ore Stockpile to Loader	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-106	Transfer of Ore Mined from Loader to Haul Truck	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-107	Transfer from ROM Stockpile to Loader	0.04	0.02	0.00	0.00	0.87	0.41	0.06	0.02
DP-109	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-113	Hardshell Wasterock Storage Drop	0.59	0.28	0.042	0.010	14.23	6.73	1.02	0.25
DP-114	Ore Stockpile Drop	0.13	0.06	0.009	0.002	3.17	1.50	0.23	0.06
DP-115	ROM Stockpile Drop	0.04	0.02	0.003	0.001	0.87	0.41	0.06	0.02
DP-124	Transfer of Development Ore from Face to Loader	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.00	0.000
DP-125	Transfer of Development Ore from Loader to Stockpile	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.00	0.000
DP-126	Transfer of Development Ore from Stockpile to Loader	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.00	0.000
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.00	0.000
DP-129	Transfer of Development Waste Mined from Face to Loader	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.00	0.000
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.00	0.000
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.00	0.000
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.00	0.000
DP-134	Transfer of Stope Ore from Stope to Loader	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.01	0.000
DP-135	Transfer of Stope Ore from Loader to Stockpile	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.01	0.000
DP-136	Transfer of Stope Ore from Stockpile to Loader	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.01	0.000
DP-137	Transfer of Stope Ore from Loader to Haul Truck	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.01	0.000
Total		**1.77**	**0.84**	**0.13**	**0.02**	**42.54**	**20.12**	**3.09**	**0.57**

Table A-14a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tpy)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	PM_{10} (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	733,798	1.76%	4.00	Spray Bar, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	733,798	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Ore from Ore Stockpile to Loader	733,794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-106	Transfer of Ore Mined from Loader to Haul Truck	733,794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-107	Transfer from ROM Stockpile to Loader	201,172	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-109	Transfer from Agg Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Wasterock Storage	987,351	1.76%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-114	Ore Stockpile	733,794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile	201,172	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-125	Transfer of Development Ore from Loader to Stockpile	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-126	Transfer of Development Ore from Stockpile to Loader	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.01E-06
DP-129	Transfer of Development Waste Mined from Face to Loader	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	8.83E-07
DP-134	Transfer of Stope Ore from Stope to Loader	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-135	Transfer of Stope Ore from Loader to Stockpile	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-136	Transfer of Stope Ore from Stockpile to Loader	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06
DP-137	Transfer of Stope Ore from Loader to Haul Truck	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.0000	2.74E-06

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%
Moisture Content (Moisture taken into account within drop equation)	0%
Gravity Settling (underground only) (PM/PM_{10}/Pb)	80%
Gravity Settling (underground only) ($PM_{2.5}$)	16%
For Full Enclosure/Enclosure	80%
For Partial Enclosure	50%
No control	0%

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is 19.49 — Based on 2019-2021 On-Site Met Data

1.3 — For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1

0.25 %

Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-14b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions Annual Emissions (tpy)				Uncontrolled Emissions Annual Emissions (tpy)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.29	0.14	0.021	0.005	1.93	0.91	0.14	0.03
DP-104	Drop from silo to trucks	0.96	0.46	0.069	0.017	1.93	0.91	0.14	0.03
DP-105	Transfer of Ore from Ore Stockpile to Loader	0.58	0.27	0.04	0.010	1.93	0.91	0.14	0.03
DP-106	Transfer of Ore Mined from Loader to Haul Truck	0.58	0.27	0.04	0.010	1.93	0.91	0.14	0.03
DP-107	Transfer from ROM Stockpile to Loader	0.16	0.08	0.011	0.003	0.53	0.25	0.04	0.01
DP-109	Transfer from Agg Stockpile to Loader	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-113	Hardshell Wasterock Storage	2.60	1.23	0.186	0.046	2.60	1.23	0.19	0.05
DP-114	Ore Stockpile	0.58	0.27	0.041	0.010	1.93	0.28	0.04	0.01
DP-115	ROM Stockpile	0.16	0.08	0.011	0.003	0.53	0.08	0.01	0.00
DP-124	Transfer of Development Ore from Face to Loader	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-125	Transfer of Development Ore from Loader to Stockpile	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-126	Transfer of Development Ore from Stockpile to Loader	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-129	Transfer of Development Waste Mined from Face to Loader	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-134	Transfer of Stope Ore from Stope to Loader	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-135	Transfer of Stope Ore from Loader to Stockpile	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-136	Transfer of Stope Ore from Stockpile to Loader	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-137	Transfer of Stope Ore from Loader to Haul Truck	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
Total		**6.18**	**2.93**	**0.45**	**0.10**	**14.09**	**5.86**	**0.89**	**0.21**

Table A-15a. Dust Collectors - Emissions

Emission Point Number	Description	Max Outlet Grain Loading [1]	Stack Flow Rate [1,2]	Hours of Operation	Annual Emissions [2,3]				Hourly Emissions [4,5]				Daily Emissions [3,4]			
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds [5]	PM	PM_{10}	$PM_{2.5}$	Lead Compounds [5]	PM	PM_{10}	$PM_{2.5}$	Lead Compounds [5]
		(gr/dscf)	(cfm)	(hr/yr)	(tpy)	(tpy)	(tpy)	(tpy)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/day)	(lb/day)	(lb/day)	(lb/day)
Taylor																
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	0.002	3,200	8,760	0.24	0.24	0.24	0.01	0.05	0.05	0.055	0.003	1.32	1.32	1.32	0.07
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	0.002	4,750	8,760	0.36	0.36	0.36	0.02	0.08	0.08	0.081	0.004	1.95	1.95	1.95	0.10
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.057	0.003	1.36	1.36	1.36	0.07
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.057	0.003	1.36	1.36	1.36	0.07
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.057	0.003	1.36	1.36	1.36	0.07
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.06	0.00	1.36	1.36	1.36	0.07
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	0.002	7,500	8,760	0.56	0.56	0.56	0.03	0.13	0.13	0.129	0.006	3.09	3.09	3.09	0.15
DC-PPBS1	Paste Plant Binder Silo 1 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-PPBS2	Paste Plant Binder Silo 2 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-PPBS3	Paste Plant Binder Silo 3 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-PPBS4	Paste Plant Binder Silo 4 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-PPM1M	Paste Plant Module 1 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
DC-PPM2M	Paste Plant Module 2 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
Clark																
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.027	0.0005	0.66	0.66	0.66	0.01
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.027	0.0005	0.66	0.66	0.66	0.01
DC-CPPBS1	Paste Plant Binder Silo 1 [7]	0.005	750	8,760	0.14	0.14	0.14	0.000	0.03	0.03	0.032	0.0000	0.77	0.77	0.77	0.00
DC-CPPBS2	Paste Plant Binder Silo 2 [7]	0.005	750	8,760	0.14	0.14	0.14	0.000	0.03	0.03	0.032	0.0000	0.77	0.77	0.77	0.00
DC-CPPBS3	Paste Plant Binder Silo 3 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.000	0.06	0.06	0.064	0.0000	1.54	1.54	1.54	0.00
DC-CPPBS4	Paste Plant Binder Silo 4 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.000	0.06	0.06	0.064	0.0000	1.54	1.54	1.54	0.00
DC-CPPM1M	Paste Plant Module 1 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.000	0.13	0.13	0.129	0.0000	3.09	3.09	3.09	0.00
DC-CPPM2M	Paste Plant Module 2 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.000	0.13	0.13	0.129	0.0000	3.09	3.09	3.09	0.00
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.027	0.0005	0.66	0.66	0.66	0.01
General																
WTP1LS	Waste Water Treatment Plant #1 Lime Silo	0.005	1,001	8,760	0.19	0.19	0.19	0.00	0.04	0.04	0.04	0.00	1.03	1.03	1.03	0.00
				Total	**6.64**	**6.64**	**6.64**	**0.11**	**1.52**	**1.52**	**1.52**	**0.03**	**36.39**	**36.39**	**36.39**	**0.62**

1. Per email from Sarah Richman, South32, on 07/06/2021 (Per Fluor Canada Ltd. Engineering).
   Per "Clark Deposit General RFI for Air Permit 030922" RFI received on 3/3/2022
   Per email from Sarah Richman, South32, on 07/21/2023
2. Per "South32 - Mine Development - RFI 201-06-22 Novak" from meeting with South32, dated 06/22/2021, from Grace Huang of Fluor Canada Ltd.
3. Using the conversion factors given below:
   7000 grains/lb
   2000 lb/ton
   60 min/hr
4. Lead Conc.
   4.96 % For Taylor deposit
   1.76 % For Clark deposit
   0.00 % Lead at paste plant assumed to be negligible
5. PM particle size multipler (dimensionless):

PM	PM_{10}	$PM_{2.5}$
0.74	0.35	0.053

6. Per email from Sarah Richman, South32, on 08/24/2022 (Per Fluor Canada Ltd. Engineering)
7. Per email from Sarah Richman, South32, on 08/31/2022 (Per Fluor Canada Ltd. Engineering and Paterson Cooke)

Table A-17a. Wind Erosion Emission Factors

Type of Material	Particulate Matter Emission Factors [3,4,5,6]				Particulate Matter Emission Factor Inputs [1,2]				Notes
	PM/TSP	PM_{10}	$PM_{2.5}$	Units	Max 5-minute wind speed (m/s)	u_{10}^+	u^*	u_t	
Aggregate/shotcrete	0.02	0.01	0.002	ton/acre-yr	16.71	27.9	1.48	1.33	u* = (0.053)(u_{10}^+), where u_{10}^+ = fastest mile for the time period between disturbances (see below for information on fastest mile calculation). The fastest mile was calculated using the linear regression proposed by ADEQ. The maximum 5-minute wind speed is the max 5-minute wind speed collected at the onsite meteorological station.
TSF	0.33	0.17	0.025	ton/acre-yr	16.71	27.9	1.48	0.54	
Rock/Ore/ROM	0.10	0.05	0.008	ton/acre-yr	16.71	27.9	1.48	1.02	

1. k = particle size multiplier, u^* = friction velocity, u_t = threshold friction velocity
2. The fastest mile was calculated using linear regression method historically accepted by ADEQ for other facilities. The maximum 5-minute wind speed is the max 5-minute wind speed collected at the onsite meteorological station.
3. Per AP-42 13.2.5 Equations 6 and 7:
u10+ is calculated as 1.662 * the max 5-minute wind speed + 0.0913. The 1.662 and 0.0913 value was determined from the linear regression analysis.

$$u_s^+ = \frac{(u_s)}{u_r} \quad u_{10}^+$$

where

u_s^+ = surface wind speed distribution
u_s = surface wind speed
u_r = approach wind speed
u_{10}^+ = fastest mile of reference anemometer

$$u^* = \frac{0.4 u_s^+}{\frac{25}{\ln 0.5}} = 0.10 u_s^+$$

where

u* = friction velocity

4. Per AP-42 13.2.5 Equation 3:

$$P = 58\,(u^* - u_t^*)^2 + 25\,(u^* - u_t^*)$$

$$P = 0 \text{ for } u^* \le u_t^*$$

where

u_t = threshold velocity

5. Threshold friction velocity per AP-42 Table 13.2.5-2, using overburden as the material:

1.02	m/s	Overburden can be used to represent Rock/Ore/ROM
1.33	m/s	Roadbed material can be used to represent aggregate/shotcrete
0.54	m/s	Conservatively assumed that fine coal dust on concrete pad can be used to represent TSFs

6. Particle size multiplier for emission factors per AP-42 13.2.5:

PM	1
PM_{10}	0.5
$PM_{2.5}$	0.075

Table A-17b. Wind Erosion Emissions

Emission Point Number	Location	Annual Potential Emissions [1,2,3] (tpy) PM				Daily Potential Emissions [1,2,3] (lb/day) PM				Hourly Potential Emissions [1,2,3] (lb/hr) PM			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
TSF_3	Tailing Storage Facility	19.29	9.65	1.45	0.08	105.72	52.86	7.93	4.50E-01	4.41	2.20	0.33	1.88E-02
WRS	West Rock Stockpile	0.72	0.36	0.05	2.54E-03	3.93	1.96	0.29	1.39E-02	0.16	0.08	0.01	5.80E-04
ERS	East Rock Stockpile	0.79	0.40	0.06	2.81E-03	4.35	2.18	0.33	1.54E-02	0.18	0.09	0.01	6.42E-04
TAGG	Taylor Agg Stockpile	0.0005	0.0002	0.0000	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
TSHOT	Taylor Shotcrete Stockpile	0.0008	0.0004	0.0001	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
HRS	Hardshell Rock Stockpile	2.74	1.37	0.21	9.71E-03	15.03	7.51	1.13	0.05	0.63	0.31	0.05	0.00
ORE	Clark Ore Stockpile	0.12	0.06	0.01	2.12E-03	0.66	0.33	0.05	1.16E-02	0.03	0.01	0.00	0.00
ROM	Clark ROM Stockpile	0.0357	0.0179	0.0027	6.29E-04	0.20	0.10	0.01	3.45E-03	0.01	0.00	0.00	0.00
AGG	Clark Agg Stockpile	0.0005	0.0002	0.0000	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
SHOT	Clark Shotcrete Stockpile	0.0008	0.0004	0.0001	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
	Total:	**23.71**	**11.85**	**1.78**	**0.10**	**129.90**	**64.95**	**9.74**	**0.55**	**5.41**	**2.71**	**0.41**	**0.02**

1. Emissions based on maximum hours 8760 hrs
2. Conversion from grams to pounds 453.6 g/lb
3. Percent of lead in PM emissions and total exposed surface are in table below

Tailings Storage Facility	Lead	0.43	%	Taylor Shotcrete Plant	Lead	0.00	%
	Area	2,535,243	ft^2		Area	1,599.5	ft^2
		58	acre			0.04	acre
East Rock Stockpile	Lead	0.35	%	Taylor Agg Stockpile	Lead	0.00	%
	Area	329,657	ft^2		Area	899.9	ft^2
		8	acre			0.02	acre
West Rock Stockpile	Lead	0.35	%	Hardshell Rock Stockpile	Lead	0.35	%
	Area	297,599	ft^2		Area	1,138,607.5	ft^2
		7	acre			26.1	acre
Clark Shotcrete Plant	Lead	0.00	%	Clark Ore Stockpile	Lead	1.76	%
	Area	1,599.5	ft^2		Area	50,000.5	ft^2
		0.04	acre			1.15	acre
Clark Agg Stockpile	Lead	0.00	%	Clark ROM Stockpile	Lead	1.76	%
	Area	899.9	ft^2		Area	14,842	ft^2
		0.02	acre			0.34	acre

Table A-18a. WTP2 Cooling Tower Parameters

Emission Point Number	Flowrate [1] (gal/min)	Drift [2] (%)	TDS [3] (ppm)
WTP2CT	4,500	0.0005	455

1. Flowrate per July 18th, 2022 email from Sarah Richman
2. Drift % per July 18th, 2022 email from Sarah Richman
3. Influent TDS (455 ppm) concentration per July 18th, 2022 email from Sarah Richman

Drift loss	0.0005%		High Efficiency
Circulating water flow rate	4,500	gpm	
Total dissolved solids	455	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*

Volume of a sphere $V = 4/3*\pi*r^3$

Annual drift 11 lb H_2O/hr

Table A-18b. Water Drop Size Distribution for Low Efficiency Drift Eliminators*

Based on a drift rate of 0.001%

Droplet Dia. (micron)	% mass	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
22	0.43	0.43	5.6E-09	1.0E-12	1.2			
29	1.49	1.92	1.3E-08	2.3E-12	1.6			
44	3.76	5.68	4.5E-08	8.1E-12	2.5			
58	2.09	7.77	1.0E-07	1.9E-11	3.3			7.8%
65	1.86	9.63	1.4E-07	2.6E-11	3.7			
87	1.56	11.19	3.4E-07	6.3E-11	4.9			
108	1.43	12.62	6.6E-07	1.2E-10	6.1			
120	1.26	13.88	9.0E-07	1.6E-10	6.8			
132	1.09	14.97	1.2E-06	2.2E-10	7.5			
144	1.32	16.29	1.6E-06	2.8E-10	8.2			
174	5.81	22.1	2.8E-06	5.0E-10	9.9			
300	5.04	27.14	1.4E-05	2.6E-09	17.0		27.1%	
450**	4.17	31.31	4.8E-05	8.7E-09	25.5	31.3%		
600	4.01	35.32	1.1E-04	2.1E-08	34.0			
750	4.00	39.32	2.2E-04	4.0E-08	42.5			
900	4.03	43.35	3.8E-04	6.9E-08	51.0			
1,050	4.57	47.92	6.1E-04	1.1E-07	59.5			
1,200	5.46	53.38	9.0E-04	1.6E-07	68.0			
1,350	6.80	60.18	1.3E-03	2.3E-07	76.5			
2,250	17.99	78.17	6.0E-03	1.1E-06	127.5			
2,400	21.83	100	7.2E-03	1.3E-06	136.0			

** EPA. 1979. Effects of Pathogenic and Toxic Material Transport Via Cooling Device Drift - Vol. 1 Technical Report. EPA-600/7-79-251a. November 1979.*

*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-18c. Water Drop Size Distribution for High Efficiency Drift Eliminators*

Based on a drift rate of 0.0003%

Droplet Dia. (micron)	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
10	0	5.2E-10	9.5E-14	0.6			
20	0.196	4.2E-09	7.6E-13	1.1			
30	0.226	1.4E-08	2.6E-12	1.7			
40	0.514	3.4E-08	6.1E-12	2.3			
50	1.816	6.5E-08	1.2E-11	2.8			1.8%
60	5.702	1.1E-07	2.1E-11	3.4			
70	21.348	1.8E-07	3.3E-11	4.0			
90	49.812	3.8E-07	6.9E-11	5.1			
110	70.509	7.0E-07	1.3E-10	6.2			
130	82.023	1.2E-06	2.1E-10	7.4			
150	88.012	1.8E-06	3.2E-10	8.5			
180	91.032	3.1E-06	5.6E-10	10.2		91.0%	
210	92.468	4.8E-06	8.8E-10	11.9			
240	94.091	7.2E-06	1.3E-09	13.6			
270	94.689	1.0E-05	1.9E-09	15.3			
300	96.288	1.4E-05	2.6E-09	17.0			
350	97.011	2.2E-05	4.1E-09	19.8			
400	98.34	3.4E-05	6.1E-09	22.7			
450**	99.071	4.8E-05	8.7E-09	25.5	99.1%		
500	99.071	6.5E-05	1.2E-08	28.3			
600	100	1.1E-04	2.1E-08	34.0			

** Reisman, J. and G. Frisbie. 2002. "Calculating Realistic PM10 Emissions from Cooling Towers." Environmental Progress & Sustainable Energy. American Institute of Chemical Engineers. Volume 21, Issue 2, pp. 127-130. July 2002.*

*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-18d. WTP2 Cooling Towers - Emissions

Emission Point Number	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
WTP2CT	2.22E-02	2.04E-02	4.07E-04	1.22E-01	1.12E-01	2.23E-03	5.07E-03	4.66E-03	9.29E-05
TOTAL:	**0.0222**	**0.0204**	**4.07E-04**	**0.122**	**0.112**	**2.23E-03**	**0.0051**	**4.66E-03**	**9.29E-05**

Table A-19a. Surface Refrigeration Plant Parameters

Emission Point Number	Flowrate [1] (gal/min)	Drift [2] (%)	TDS [2] (ppm)
PRODREF	7,529	0.001	1000
BBREF	11,095	0.001	1000

1. Provided by Ross Wilson (BBE Consulting) on 07/06/2023 via email.
2. Per parameters provided by South32 on 09/07/2021.

PRODREF:

Drift loss	0.0010%		Low Efficiency
Circulating water flow rate	7,529	gpm	
Total dissolved solids	1,000	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*
Volume of a sphere	$V = 4/3*\pi*r^3$		
Annual drift	38	lb H_2O/hr	

BBREF:

Drift loss	0.0010%		Low Efficiency
Circulating water flow rate	11,095	gpm	
Total dissolved solids	1,000	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*
Volume of a sphere	$V = 4/3*\pi*r^3$		
Annual drift	55	lb H_2O/hr	

Table A-19b. Water Drop Size Distribution for Low Efficiency Drift Eliminators*

Based on a drift rate of 0.001%

Droplet Dia. (micron)	% mass	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
22	0.43	0.43	5.6E-09	2.2E-12	1.6			
29	1.49	1.92	1.3E-08	5.1E-12	2.1			
44	3.76	5.68	4.5E-08	1.8E-11	3.2			5.7%
58	2.09	7.77	1.0E-07	4.1E-11	4.3			
65	1.86	9.63	1.4E-07	5.8E-11	4.8			
87	1.56	11.19	3.4E-07	1.4E-10	6.4			
108	1.43	12.62	6.6E-07	2.6E-10	8.0			
120	1.26	13.88	9.0E-07	3.6E-10	8.8			
132	1.09	14.97	1.2E-06	4.8E-10	9.7			
144	1.32	16.29	1.6E-06	6.3E-10	10.6		16.3%	
174	5.81	22.1	2.8E-06	1.1E-09	12.8			
300	5.04	27.14	1.4E-05	5.7E-09	22.1			
450**	4.17	31.31	4.8E-05	1.9E-08	33.2	31.3%		
600	4.01	35.32	1.1E-04	4.5E-08	44.2			
750	4.00	39.32	2.2E-04	8.8E-08	55.3			
900	4.03	43.35	3.8E-04	1.5E-07	66.3			
1,050	4.57	47.92	6.1E-04	2.4E-07	77.4			
1,200	5.46	53.38	9.0E-04	3.6E-07	88.4			
1,350	6.80	60.18	1.3E-03	5.2E-07	99.5			
2,250	17.99	78.17	6.0E-03	2.4E-06	165.8			
2,400	21.83	100	7.2E-03	2.9E-06	176.8			

** EPA. 1979. Effects of Pathogenic and Toxic Material Transport Via Cooling Device Drift - Vol. 1 Technical Report. EPA-600/7-79-251a. November 1979.*

*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-19c. Water Drop Size Distribution for High Efficiency Drift Eliminators*

Based on a drift rate of 0.0003%

Droplet Dia. (micron)	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
10	0	5.2E-10	2.1E-13	0.7			
20	0.196	4.2E-09	1.7E-12	1.5			
30	0.226	1.4E-08	5.7E-12	2.2			
40	0.514	3.4E-08	1.3E-11	2.9			0.5%
50	1.816	6.5E-08	2.6E-11	3.7			
60	5.702	1.1E-07	4.5E-11	4.4			
70	21.348	1.8E-07	7.2E-11	5.2			
90	49.812	3.8E-07	1.5E-10	6.6			
110	70.509	7.0E-07	2.8E-10	8.1			
130	82.023	1.2E-06	4.6E-10	9.6			
150	88.012	1.8E-06	7.1E-10	11.1		88.0%	
180	91.032	3.1E-06	1.2E-09	13.3			
210	92.468	4.8E-06	1.9E-09	15.5			
240	94.091	7.2E-06	2.9E-09	17.7			
270	94.689	1.0E-05	4.1E-09	19.9			
300	96.288	1.4E-05	5.7E-09	22.1			
350	97.011	2.2E-05	9.0E-09	25.8			
400	98.34	3.4E-05	1.3E-08	29.5			
450**	99.071	4.8E-05	1.9E-08	33.2	99.1%		
500	99.071	6.5E-05	2.6E-08	36.8			
600	100	1.1E-04	4.5E-08	44.2			

** Reisman, J. and G. Frisbie. 2002. "Calculating Realistic PM10 Emissions from Cooling Towers." Environmental Progress & Sustainable Energy. American Institute of Chemical Engineers. Volume 21, Issue 2, pp. 127-130. July 2002.*

*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-19d. Surface Refrigeration Plant - Emissions

Emission Point Number	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
PRODREF	0.052	0.027	0.009	2.83E-01	1.47E-01	5.13E-02	1.18E-02	6.13E-03	2.14E-03
BBREF	0.076	0.040	0.014	4.17E-01	2.17E-01	7.56E-02	1.74E-02	9.03E-03	3.15E-03
TOTAL:	**0.13**	**0.066**	**0.023**	**0.699**	**0.364**	**0.127**	**0.029**	**0.015**	**0.0053**

Table A-20a. Taylor Concrete Batch Plant Emission Factors and Parameters

Operation	Emission Point Number	Equipment	Activity	Material	Maximum Rates Capacity [1] (tpy)	Emission Factors [2]		
						PM	$PM_{10}/PM_{2.5}$	Units
Concrete Batch Plant	CBP-1	Aggregate delivery to ground storage	Unloading of Aggregate Material	Aggregate	18,666	0.0069	0.0033	lb/ton
	CBP-2	Sand delivery to ground storage	Unloading of Sand	Sand	14,292	0.0021	0.00099	lb/ton
	CBP-3	Aggregate transfer to conveyor	Transferring aggregate material	Aggregate	18,666	0.0069	0.0033	lb/ton
	CBP-4	Sand transfer to conveyor	Transferring Sand	Sand	14,292	0.0021	0.00099	lb/ton
	CBP-5	Aggregate transfer to elevated storage	Transferring aggregate material	Aggregate	18,666	0.0069	0.0033	lb/ton
	CBP-6	Sand transfer to elevated storage	Transferring Sand	Sand	14,292	0.0021	0.00099	lb/ton
	CBP-7	Cement delivery to silo	Unloading of Cement	Cement	4,914	0.00099	0.00034	lb/ton
	CBP-8	Cement supplement delivery to silo	Unloading of Cement Supplement	Cement	731	0.0089	0.0049	lb/ton
	CBP-9	Weigh hopper loading	Loading of Weigh hopper	Concrete	40,274	0.0048	0.0028	lb/ton
	CBP-11	Central mix loading	Loading of Mixer	Concrete	40,274	0.0184	0.0055	lb/ton

1. EPA AP-42 Section 11.12, mixing ratios used:
1
0.46
0.35
0.12
0.02

2. EPA AP-42 Section 11.12, Table 11.12-2. emission factors were utilized. If a controlled emission factor was unavailable, an uncontrolled emission factor was used.

Table A-20b. Taylor Concrete Batch Plant - Emissions

Operation	Emission Point Number	Activity	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
			PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Concrete Batch Plant	CBP-1	Unloading of Aggregate Material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	CBP-2	Unloading of Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	CBP-3	Transferring aggregate material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	CBP-4	Transferring Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	CBP-5	Transferring aggregate material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	CBP-6	Transferring Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	CBP-7	Unloading of Cement	0.002	0.001	0.001	0.01	0.005	0.005	0.001	0.0002	0.0002
	CBP-8	Unloading of Cement Supplement	0.003	0.002	0.002	0.02	0.01	0.01	0.001	0.0004	0.0004
	CBP-9	Loading of Weigh hopper	0.10	0.06	0.06	0.53	0.31	0.31	0.02	0.01	0.01
	CBP-11	Loading of Mixer	0.37	0.11	0.11	2.03	0.61	0.61	0.08	0.03	0.03
		Total:	**0.71**	**0.28**	**0.28**	**3.90**	**1.55**	**1.55**	**0.16**	**0.06**	**0.06**

6/06

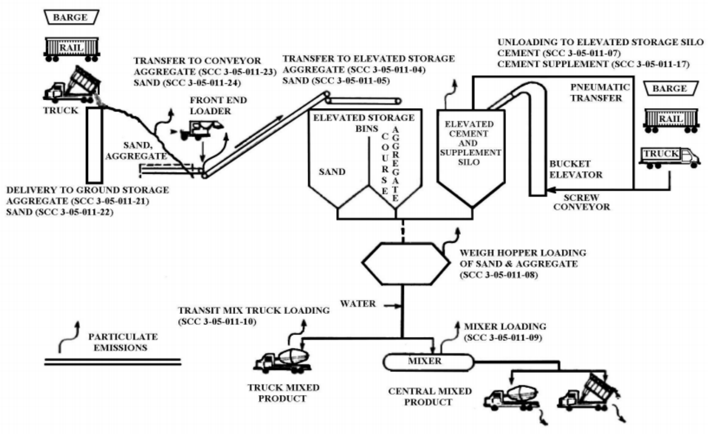

Figure 11.12-1. Typical Concrete Batching Process.

11.12-3

Table A-16a. Engines - Emission Factors

	Pollutant	Value	Unit	Source
JGC 624	NO_x	3.64E-02	g/kW-hr	Not to exceed emission factors for generator 100% load Emissions Performance on JGC 624 K111 engine provided by Thomas Henkenmeier (Innio) on 7/17/2023. PM/PM10/PM2.5 is equal to the provided emission factor + 50% of the condensable PM value from AP-42 (4-stroke, lean burn) as a conservative safety factor. Engines: 33.998 MMbtu/hr
	NO_2	1.27E-02	g/kW-hr	
	CO	6.08E-02	g/kW-hr	
	$PM/PM_{10}/PM_{2.5}$	3.18E-02	g/kW-hr	
	VOC	6.30E-02	g/kW-hr	
	CO_2	-	g/kW-hr	
	CH_4	-	g/kW-hr	
	N_2O	-	g/kW-hr	
	Acetaldehyde	3.00E-03	g/kW-hr	
	Formaldehyde	1.52E-02	g/kW-hr	
	NO_x	3.78E-02	g/kW-hr	Not to exceed generator 75% load Emissions Performance on JGC 624 K111 engine provided by Thomas Henkenmeier (Innio) on 7/17/2023. PM/PM10/PM2.5 is equal to the provided emission factor + 50% of the condensable PM value from AP-42 (4-stroke, lean-burn) as a conservative safety factor. Engines: 33.998 MMbtu/hr.
	NO_2	1.32E-02	g/kW-hr	
	CO	6.08E-02	g/kW-hr	
	$PM/PM_{10}/PM_{2.5}$	3.24E-02	g/kW-hr	
	VOC	6.30E-02	g/kW-hr	
	CO_2	-	g/kW-hr	
	CH_4	-	g/kW-hr	
	N_2O	-	g/kW-hr	
	Acetaldehyde	3.00E-03	g/kW-hr	
	Formaldehyde	1.52E-02	g/kW-hr	
CAT G3520	NO_x	0.0787	g/kW-hr	Per generator 100% load Emissions Performance on G3520 Caterpillar engine provided by Brad Kaufman, VoltaGrid, on 9/22/2021
	NO_2	0.0075	g/kW-hr	
	CO	0.0131	g/kW-hr	
	$PM/PM_{10}/PM_{2.5}$	0.0020	g/kW-hr	
	VOC	1.18E-02	g/kW-hr	
	CO_2	509	g/kW-hr	
	CH_4	1.2884	g/kW-hr	
	N_2O	0.0110	g/kW-hr	
	Acetaldehyde	0.0071	g/kW-hr	
	Formaldehyde	0.0047	g/kW-hr	
	NO_x	0.0526	g/kW-hr	Per generator 75% load Emissions Performance on G3520 Caterpillar engine provided by Brad Kaufman, VoltaGrid, on 9/22/2021
	NO_2	0.0003	g/kW-hr	
	CO	0.0188	g/kW-hr	
	$PM/PM_{10}/PM_{2.5}$	0.0221	g/kW-hr	
	VOC	5.40E-02	g/kW-hr	
	CO_2	530	g/kW-hr	
	CH_4	1.4779	g/kW-hr	
	N_2O	0.0140	g/kW-hr	
	Acetaldehyde	0.0255	g/kW-hr	
	Formaldehyde	0.0000	g/kW-hr	
CAT XQ1140	NOx	0.1000	g/kW-hr	Per Caterpillar engine emissions certification, provided by Kara Haas, South32, on 7/18/2022
	CO	0.0100	g/kW-hr	
	$PM/PM_{10}/PM_{2.5}$	0.0100	g/kW-hr	
	VOC	0.0200	g/kW-hr	
	PM/PM10/PM2.5	0.0400	g/kW-hr	Tier 4 emission factors for diesel engines from Table 1 of §1039.101
	NO_x	3.5000	g/kW-hr	
	CO	3.5000	g/kW-hr	
	VOC	0.19	g/kW-hr	EPA Nonroad Compression-Ignition Engines: Exhaust Emissions Standards, March 2016
	SO_x	1.21E-05	lb/hp-hr	AP-42, Table 3.4-1 (October 1996) based on Ultra Low Sulfur Diesel (15 ppm sulfur or 0.0015%)
	CO_2	73.96	kg/MMBtu	40 CFR Part 98, Subpart C, Table C-1 and C-2 for Distillate Fuel Oil No. 2 (diesel)
	CH_4	3.00E-03	kg/MMBtu	
	N_2O	6.00E-04	kg/MMBtu	
	CO_2	53.06	kg/MMBtu	40 CFR Part 98, Subpart C, Table C-1 and C-2 for Natural Gas (Weighted U.S Average)
	CH_4	1.00E-03	kg/MMBtu	
	N_2O	1.00E-04	kg/MMBtu	
	Benzene	7.76E-04	lb/MMBtu	AP-42 Section 3.4, HAP Emission Factors For Large Uncontrolled Stationary Diesel Engines (>600 HP). The emission factor for PAH (which are HAPs because they are POMs) is the value for 'Total PAH' listed in AP-42 minus the value listed for napthalene, as it is speciated here.
	Toluene	2.81E-04	lb/MMBtu	
	Xylene	1.93E-04	lb/MMBtu	
	1,3-Butadiene	3.91E-05	lb/MMBtu	
	Formaldehyde	7.89E-05	lb/MMBtu	
	Acetaldehyde	2.52E-05	lb/MMBtu	
	Acrolein	7.88E-06	lb/MMBtu	
	Naphthalene	1.30E-04	lb/MMBtu	
	Propylene	2.79E-03	lb/MMBtu	
	Acenaphthylene	9.23E-06	lb/MMBtu	
	Acenaphthene	4.68E-06	lb/MMBtu	
	Fluorene	1.28E-05	lb/MMBtu	
	Phenanthrene	4.08E-05	lb/MMBtu	
	Anthracene	1.23E-06	lb/MMBtu	
	Fluoranthene	4.03E-06	lb/MMBtu	
	Pyrene	3.71E-06	lb/MMBtu	
	Benz(a)anthracene	6.22E-07	lb/MMBtu	
	Chrysene	1.53E-06	lb/MMBtu	
	Benzo(b)fluoranthene	1.11E-06	lb/MMBtu	
	Benzo(k)fluoranthene	2.18E-07	lb/MMBtu	
	Benzo(a)pyrene	2.57E-07	lb/MMBtu	
	Indeno(1,2,3-cd)pyrene	4.14E-07	lb/MMBtu	
	Dibenz(a,h)anthracene	3.46E-07	lb/MMBtu	
	Benzo(g,h,l)perylene	5.56E-07	lb/MMBtu	
	PAH	8.20E-05	lb/MMBtu	
	SO_2	5.88E-04	g/kW-hr	AP-42 for Natural Gas Engines (Maximum Emission Factor Available)
	VOC	1.20E-01	lb/MMBtu	AP-42 for Natural Gas Engines (4 stroke lean burn)
	PM (condensable)	9.91E-03	lb/MMBtu	
	Benzene	4.40E-04	lb/MMBtu	AP-42 Section 3.2, Natural Gas Engines (4 Stroke Lean Burn). The emission factor for PAH (which are HAPs because they are POMs) is the sum of the value listed for 'PAH' in AP-42 and all other PAHs listed in the AP-42 that are not specifically listed HAPs.
	Toluene	4.08E-04	lb/MMBtu	
	Xylene	1.84E-04	lb/MMBtu	
	1,3-Butadiene	2.67E-04	lb/MMBtu	
	Acrolein	5.14E-03	lb/MMBtu	
	Naphthalene	7.44E-05	lb/MMBtu	
	1,1,2,2-Tetrachloroethane	4.00E-05	lb/MMBtu	
	1,1,2-Trichloroethane	3.18E-05	lb/MMBtu	
	1,3-Dichloropropene	2.64E-05	lb/MMBtu	
	2-Methylnaphthalene	3.32E-05	lb/MMBtu	
	2,2,4-Trimethylpentane	2.50E-04	lb/MMBtu	
	Biphenyl	2.12E-04	lb/MMBtu	
	Carbon Tetrachloride	3.67E-05	lb/MMBtu	
	Chlorobenzene	3.04E-05	lb/MMBtu	
	Chloroform	2.85E-05	lb/MMBtu	
	Ethylbenzene	3.97E-05	lb/MMBtu	
	Ethylene Dibromide	4.43E-05	lb/MMBtu	
	Formaldehyde	5.28E-02	lb/MMBtu	
	Fluoranthene	1.11E-06	lb/MMBtu	

Fluorene	5.67E-06	lb/MMBtu	
Methanol	2.50E-03	lb/MMBtu	
Methylene Chloride	2.00E-05	lb/MMBtu	
Hexane	1.11E-03	lb/MMBtu	
PAH	7.75E-05	lb/MMBtu	
Phenol	2.40E-05	lb/MMBtu	
Tetrachloroethane	2.48E-06	lb/MMBtu	
Vinyl Chloride	1.49E-05	lb/MMBtu	
NOx	7.13	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Final engines with 19 ≤ kW < 37 & BAAQMD Guidance - https://www.baaqmd.gov/~/media/Files/Engineering/policy_and_procedures/Engines/EmissionFactorsforDieselEngines.ashx
CO	5.50	g/kW-hr	
PM	0.30	g/kW-hr	
PM10	0.30	g/kW-hr	
PM2.5	0.30	g/kW-hr	
VOC	0.38	g/kW-hr	
SO2	0.00205	lb/hp-hr	AP-42 Section 3.3 for Diesel Engines (<600 HP)
NOx	0.40	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Final engines with 75 ≤ kW < 130.
CO	5.00	g/kW-hr	
PM	0.02	g/kW-hr	
PM10	0.02	g/kW-hr	
PM2.5	0.02	g/kW-hr	
VOC	0.19	g/kW-hr	
NOx	0.40	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Final engines with 130 ≤ kW < 225.
CO	3.50	g/kW-hr	
PM	0.02	g/kW-hr	
PM10	0.02	g/kW-hr	
PM2.5	0.02	g/kW-hr	
VOC	0.19	g/kW-hr	
Benzene	9.33E-04	lb/MMBtu	AP-42 Section 3.3 Table 3.3-2 Speciated Organic Compound Emission Factors For Uncontrolled Diesel Engines (< 600 HP). The emission factor for PAH (which are HAPs because they are POMs) is the value for 'Total PAH' listed in AP-42 minus the value listed for napthalene, as it is speciated here.
Toluene	4.09E-04	lb/MMBtu	
Xylene	2.85E-04	lb/MMBtu	
1,3-Butadiene	3.91E-05	lb/MMBtu	
Formaldehyde	1.18E-03	lb/MMBtu	
Acetaldehyde	7.67E-04	lb/MMBtu	
Acrolein	9.25E-05	lb/MMBtu	
Napthalene	8.48E-05	lb/MMBtu	
PAH	8.32E-05	lb/MMBtu	

Table A-16b. Generator - Criteria Pollutant Emissions (Annual)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW)		Fuel Type	Operation Hours	Criteria Pollutants Annual Emissions (tpy)								GHG Annual Emissions (tpy) [4]			
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2 [1,2]	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2	CO_2	CH_4	N_2O	CO_2e
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	82.15	0.47	29.36	34.51	34.51	34.51	84.33	0.92	827,718.92	2,308.09	21.86	891,936.63
T_ENG (100%)	Trench			150,800	165,880	NG	8,760	163.88	15.62	27.28	4.16	4.16	4.16	24.57	1.22	1,059,896.68	2,682.85	22.91	1,133,793.76
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,725	93,053	NG	8,760	33.96	11.89	54.63	29.12	29.12	29.12	56.61	0.53	365,141.37	6.88	0.69	365,518.49
T_ENG_ALT (100%)	Trench			120,966	124,071	NG	8,760	43.61	15.26	72.84	38.13	38.13	38.13	75.48	0.70	470,319.24	8.86	0.89	470,804.99
HS_1 - HS_6	Hardshell	CAT XQ1140	6	5,460	6,006	Diesel	8,760	5.80	2.90	0.58	0.58	0.58	0.58	1.16	7.04E-04	40,264.71	1.63	0.33	40,402.88
ENG9 - ENG13	Taylor	CAT C175 3000 kW	5	3,000	3,300	Diesel	500	31.83	31.83	31.83	3.64E-01	3.64E-01	3.64E-01	1.73E+00	6.71E-02	1,262.75	0.05	0.01	1,267.09
ENG5	WW1	C200D2RE	1	198	218	Diesel	8,760	0.84	0.84	7.36	0.04	0.04	0.04	0.04	2.62	1,460.15	0.06	0.01	1,465.16
Total Annual Emissions								**202.35**	**51.19**	**112.61**	**39.12**	**39.12**	**39.12**	**87.26**	**3.91**	**1,102,884.29**	**2,684.59**	**23.25**	**1,176,928.89**

1. NO_2 for the 4.4MW engines is calculated using an in stack ratio of 0.35 per engine specs provided by Thomas Henemeier (INNIO) on 7/27/23.
2. VOC emission factors for NG engines assumed to be total of VOC, Acetaldehyde, and Formaldehyde emission factors from performance test.

Table A-16c. Generator - HAP Emissions (Annual)

Emission Point Number	T_ENG (75%)	T_ENG (100%)	T_ENG_ALT (75%)	T_ENG_ALT (100%)	HS_1 - HS_6	ENG9 - ENG13	ENG5	Total Annual Emissions - Max of 2.6/4.4 MW Engines (tpy)
Engine Rating (kW)	**124,410**	**165,880**	**93,053**	**124,071**	**6,006**	**3,300**	**218**	
Fuel Consumption Rate (SCFH)	**1,186,390**	**1,524,124**	**-**	**-**	**-**	**-**	**-**	
Fuel Input (MMBtu/hr)	**1,210.12**	**1,554.61**	**712.67**	**917.95**	**56.38**	**30.98**	**2.04**	
Benzene	2.38E-01	3.06E-01	2.15E-01	2.77E-01	1.92E-01	6.01E-03	8.36E-03	0.512
Toluene	2.21E-01	2.83E-01	1.99E-01	2.57E-01	6.94E-02	2.18E-03	3.66E-03	0.359
Xylene	9.95E-02	1.28E-01	8.99E-02	1.16E-01	4.77E-02	1.49E-03	2.55E-03	0.179
1,3-Butadiene	1.44E-01	1.85E-01	1.30E-01	1.68E-01	9.66E-03	3.03E-04	3.50E-04	0.196
Formaldehyde	0.00E+00	9.79E+00	1.37E+01	1.82E+01	1.95E-02	6.11E-04	1.06E-02	18.241
Acetaldehyde	3.98E+01	1.48E+01	2.70E+00	3.59E+00	6.22E-03	1.95E-04	6.87E-03	39.837
Acrolein	2.78E+00	3.57E+00	2.51E+00	3.23E+00	1.95E-03	6.10E-05	8.28E-04	3.573
Naphthalene	4.02E-02	5.17E-02	3.63E-02	4.68E-02	3.21E-02	1.01E-03	--	0.085
1,1,2,2-Tetrachloroethane	2.12E-01	2.72E-01	1.25E-01	1.61E-01	--	--	--	0.272
1,1,2-Trichloroethane	1.69E-01	2.17E-01	9.93E-02	1.28E-01	--	--	--	0.217
1,3-Dichloropropene	1.40E-01	1.80E-01	8.24E-02	1.06E-01	--	--	--	0.180
2-Methylnaphthalene	1.79E-02	2.31E-02	1.62E-02	2.09E-02	--	--	--	0.023
2,2,4-Trimethylpentane	1.35E-01	1.74E-01	1.22E-01	1.57E-01	--	--	--	0.174
Biphenyl	1.15E-01	1.47E-01	1.04E-01	1.33E-01	--	--	--	0.147
Carbon Tetrachloride	1.95E-01	2.50E-01	1.15E-01	1.48E-01	--	--	--	0.250
Chlorobenzene	1.61E-01	2.07E-01	9.49E-02	1.22E-01	--	--	--	0.207
Chloroform	1.51E-01	1.94E-01	8.90E-02	1.15E-01	--	--	--	0.194
Ethylbenzene	2.15E-02	2.76E-02	1.94E-02	2.50E-02	--	--	--	0.028
Ethylene Dibromide	2.35E-01	3.02E-01	1.38E-01	1.78E-01	--	--	--	0.302
Methanol	1.35E+00	1.74E+00	7.96E-01	1.03E+00	--	--	--	1.736
Methylene Chloride	1.06E-01	1.36E-01	6.24E-02	8.04E-02	--	--	--	0.136
Hexane	6.00E-01	7.71E-01	5.42E-01	6.98E-01	--	--	--	0.771
PAH	4.11E-01	5.28E-01	2.42E-01	3.12E-01	2.02E-02	6.35E-04	7.45E-04	0.549
Phenol	1.27E-01	1.63E-01	7.49E-02	9.65E-02	--	--	--	0.163
Tetrachloroethane	1.31E-02	1.69E-02	7.74E-03	9.97E-03	--	--	--	0.017
Vinyl Chloride	7.90E-02	1.01E-01	4.65E-02	5.99E-02	--	--	--	0.101
							Total Annual HAP Emisions (tpy)	**68.45**

1. The CAT NG engines (EU: T_ENG) are Tier 4 emissions certified and equipped with oxidation catalysts. Oxidation catalysts reduce emissions of organic HAPS. To develop an appropriate control effiency (CE) for the HAP emissions from these engines that could be applied to the AP-42 Ch. 3.2 HAP Emission factors, Formaldehyde and VOC emission factors determined through stack testing were compared with Formaldehyde and VOC emission factors from AP-42 for natural gas engines, and the resulting ratio was applied to all organic HAPs.

100% Load CAT 3520 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *97.9%*
VOC CE = *97.7%*

75% Load CAT 3520 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *100.0%*
VOC CE = *89.8%*

Based on the calcaultions above, a conservative CE of **89.8%** was applied to all AP-42 organic HAP emission factors for these engines.

2. The JGC 624 NG engines (EU: T_ENG_ALT) are Tier 4 emissions certified and equipped with oxidation catalysts. Oxidation catalysts reduce emissions of organic HAPS. To develop an appropriate control effiency (CE) for the HAP emissions from these engines that could be applied to the AP-42 Ch. 3.2 HAP Emission factors, Formaldehyde and VOC emission factors determined through stack testing were compared with Formaldehyde and VOC emission factors from AP-42 for natural gas engines, and the resulting ratio was applied to all organic HAPs.

100% Load JGC 624 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *91.4%*
VOC CE = *84.4%*

75% Load JGC 624 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100

	Fomaldehyde CE =	*91.7%*	
	VOC CE =	*84.9%*	
Based on the calcaultions above, a conservative CE of		**84.4%**	was applied to all AP-42 organic HAP emission factors for these engines.

Table A-16d. Generator - Criteria Pollutant Emissions (Daily)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW) [1,2]		Fuel Type	Operation Hours	Criteria Pollutants Daily Emissions (lb/day) [3,4,5]							
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	450.12	2.57	160.88	189.12	189.12	189.12	462.10	5.03
T_ENG (100%)	Trench	CAT 3520 DSL 2600 kW		150,800	165,880	NG	8,760	897.96	85.57	149.47	22.82	22.82	22.82	134.64	6.71
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,725	93,053	NG	8,760	186.11	65.14	299.35	159.59	159.59	159.59	310.18	2.90
T_ENG_ALT (100%)	Trench	JGC 624 4481 kW		120,966	124,071	NG	8,760	238.95	83.63	399.13	208.95	208.95	208.95	413.58	3.86
HS_1 - HS_6	Hardshell	CAT XQ1140	6	5,460	6,006	Diesel	8,760	31.78	15.89	3.18	3.18	3.18	3.18	6.36	0.00
ENG9 - ENG13	Taylor	CAT C175 3000 kW	5	3,000	3300	Diesel	500	3055.61	3055.61	3055.61	34.92	34.92	34.92	165.88	6.44
ENG5	WW1	C200D2RE	1	198	218	Diesel	8,760	4.61	4.61	40.33	0.23	0.23	0.23	0.23	14.37
Total Daily Emissions								**3,989.96**	**3,161.68**	**3,498.25**	**247.27**	**247.27**	**247.27**	**634.56**	**27.53**

Table A-16e. Generator - Criteria Pollutant Emissions (Hourly)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW) [1,2]		Fuel Type	Operation Hours	Criteria Pollutants Hourly Emissions (lb/hr) [3,4,5]							
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	18.76	0.11	6.70	7.88	7.88	7.88	19.25	0.21
T_ENG (100%)	Trench	CAT 3520 DSL 2600 kW		150,800	165,880	NG	8,760	37.42	3.57	6.23	0.95	0.95	0.95	5.61	0.28
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,725	93,053	NG	8,760	7.75	2.71	12.47	6.65	6.65	6.65	12.92	0.12
T_ENG_ALT (100%)	Trench	JGC 624 4481 kW		120,966	124,071	NG	8,760	9.96	3.48	16.63	8.71	8.71	8.71	17.23	0.16
HS_1 - HS_6	Hardshell	CAT XQ1140	6	5460	6006	Diesel	8760	1.32	0.66	0.13	0.13	0.13	0.13	0.26	0.00
ENG9 - ENG13	Taylor	CAT C175 3000 kW	5	3,000	3300	Diesel	500	127.32	127.32	127.32	1.46	1.46	1.46	6.91	0.27
ENG5	WW1	C200D2RE	1	198	217.8	Diesel	8760	0.19	0.19	1.68	0.01	0.01	0.01	0.01	0.60
Total Hourly Emissions								**166.25**	**131.74**	**145.76**	**10.30**	**10.30**	**10.30**	**26.44**	**1.15**

1. A 10% increase in rating in the 2.6MW engines has been accounted for the change in electrical to mechanical rating. 10.00% Increase
2. Engine rating per Request for Information dated 02/16/2021
3. Average brake specific fuel consumption of 7,000 Btu/hp-hr, Per AP-42 Chapter 3.3, is used to convert from lb/MMBtu to lb/hp-hr for diesel generators and
   1.34 hp/kW
   1,020 Btu/scf, per AP-42 Chapter 1.4 for natural gas engines
4. GHG emissions were converted to CO2e emissions based on the GWP for each GHG.
   GWP of CO_2 1 lbs CO_2e/lb CO_2
   GWP of CH_4 25 lbs CO_2e/lb CH_4
   GWP of N_2O 298 lbs CO_2e/lb N_2O
5. Safety factor of 30% has been added to the emission factors for 2.6MW NG engines. 30.00% Increase

Table A-16f. Number of Generators

Trench 2.6MW Scenario	Power Supplied by CAT 3520 DSL 2600 kW - Sea Lev	2,600	kW
	Power Supplied by CAT 3520 DSL 2600 kW - Site Lev	2,056	kW
	CAT 3520 DSL 2600 kW - Trench	58	Generators
Trench 4.4MW Scenario	Power Supplied by JGC 624 K111, 4481 kW - Site Lev	4,481	ekW
		4,596	mkW
	Power Supplied by JGC 624 K111, 4481 kW - Temp D	4,480	ekW
		4,595	mkW
	JGC 624 K111, 4481 kW - Trench	27	Generators
Hardshell	Power Supplied by CAT XQ1140 - 910kW	910	kW
	CAT 3520 DSL 2600 kW - Hardshell	6	Generators

Note: Rate Gross Capacity is obtained from "South32 - Power Options Emission Calcs - v1.9.xls"

Elevation Derate (applicable to 2.6MW engines)

Site Elevation:	5000	ft
Every 1,000-ft increase in site elevation above sea level is assumed to yield the following % reduction in ISO-rated gas turbine power output, where site elevation (ft) above sea level is assumed to be	3.33	ft
% difference between gross and net MW output is	3	%

Trench/Alta Connected Loa	118.566	MW
Hardshell Connected Load	5.381	MW

Temperature Derate (applicable to 4.4MW units):

At >95 deg F an output deration of 0.67% per degree will occur.
Derate based on met data from 2019-2021.
For days where temperature exceeds 95 deg F, the derate was calculated using the following equation:

Power = (1 - ((T - 95)*0.0067)) * Rated Power

Where: T = Temperature (F)

Total derate for three years was calculated, including all days with 100% power, resulting in a total average derate of 0.017%.

Table A-21a. Clark Concrete Batch Plant Emission Factors and Parameters

Operation	Equipment	Activity	Material	Maximum Rates Capacity [1] (tpy)	Emission Factors [2]		
					PM	$PM_{10}/PM_{2.5}$	Units
Concrete Batch Plant	Aggregate delivery to ground storage	Unloading of Aggregate Material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand delivery to ground storage	Unloading of Sand	Sand	704	0.0021	0.00099	lb/ton
	Aggregate transfer to conveyor	Transferring aggregate material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand transfer to conveyor	Transferring Sand	Sand	704	0.0021	0.00099	lb/ton
	Aggregate transfer to elevated storage	Transferring aggregate material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand transfer to elevated storage	Transferring Sand	Sand	704	0.0021	0.00099	lb/ton
	Cement delivery to silo	Unloading of Cement	Cement	242	0.00099	0.00034	lb/ton
	Cement supplement delivery to silo	Unloading of Cement Supplement	Cement	242	0.0089	0.0049	lb/ton
	Weigh hopper loading	Loading of Weigh hopper	Concrete	1,984	0.0048	0.0028	lb/ton
	Central mix loading	Loading of Mixer	Concrete	1,984	0.0184	0.0055	lb/ton

1. EPA AP-42 Section 11.12, mixing ratios used:

Concrete	1
Aggregate	0.46
Sand	0.35
Cement	0.12
Cement Supplemer	0.02

2. EPA AP-42 Section 11.12, Table 11.12-2. emission factors were utilized. If a controlled emission factor was unavailable, an uncontrolled emission factor was used.

Table A-21b. Clark Concrete Batch Plant - Emissions

Operation	Activity	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
		PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Concrete Batch Plant	Unloading of Aggregate Material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04
	Unloading of Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
	Transferring aggregate material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04
	Transferring Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
	Transferring aggregate material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04

Transferring Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
Unloading of Cement	1.20E-04	4.12E-05	4.12E-05	6.57E-04	2.26E-04	2.26E-04	2.74E-05	9.40E-06	9.40E-06
Unloading of Cement Supplement	1.08E-03	5.93E-04	5.93E-04	5.90E-03	3.25E-03	3.25E-03	2.46E-04	1.35E-04	1.35E-04
Loading of Weigh hopper	4.76E-03	2.78E-03	2.78E-03	2.61E-02	1.52E-02	1.52E-02	1.09E-03	6.34E-04	6.34E-04
Loading of Mixer	1.83E-02	5.46E-03	5.46E-03	1.00E-01	2.99E-02	2.99E-02	4.17E-03	1.25E-03	1.25E-03
Total:	**0.036**	**0.014**	**0.014**	**0.20**	**0.08**	**0.08**	**0.008**	**0.0033**	**0.0033**

6/06

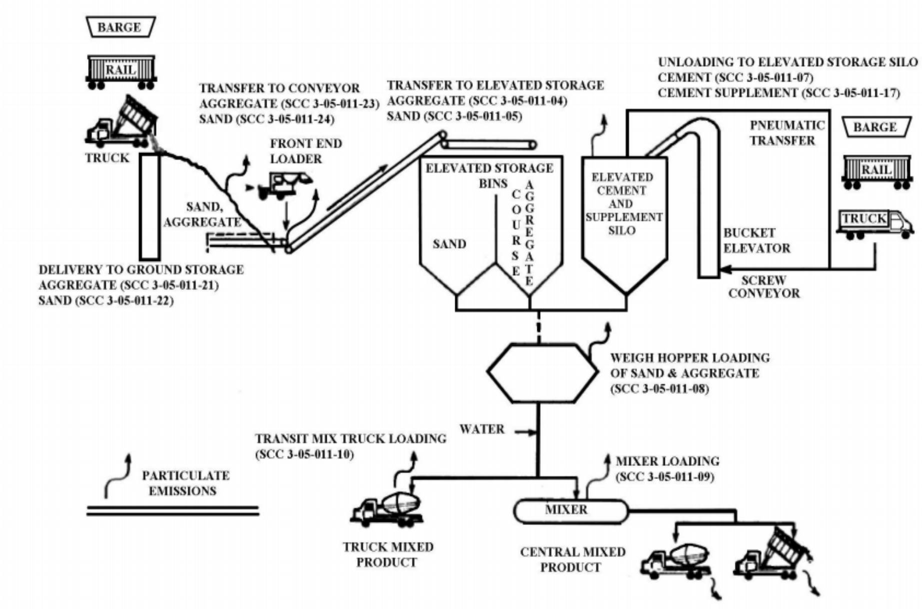

Figure 11.12-1. Typical Concrete Batching Process.

11.12-3

Table A-22. Evaporation Pond Mechanical Evaporators - PM Emissions

Unit	Evaporator Type	TDS Conc. (mg/L)	System Flow Rate [2] (gpm)	Operation Time [3] (hr/yr)	Calculated Emission Rate (lb/hr) [1]		Calculated Emission Rate (lb/day) [1,4]		Calculated Emission Rate (tpy) [1]	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
MEVAP1	Nozzles	2,100	66	876	0.091	0.0136	1.30	0.19	0.0399	0.0059
MEVAP2	Nozzles	2,100	66	876	0.091	0.0136	1.30	0.19	0.0399	0.0059
MEVAP3	Nozzles	2,100	66	876	0.091	0.0136	1.30	0.19	0.0399	0.0059

1. Emission rates are calculated using the following equation and parameters, provided by ADEQ via meeting on 5/30/2023:

$$PM = TDS\left(\frac{mg}{L}\right) \times \frac{Drift(\%)}{100\,\%} \times Q\ Rate\left(\frac{gal}{min}\right) \times 3.78\frac{L}{gal} \times \frac{2.2lb}{10^6 mg} \times \frac{60min}{hr}$$

Where:
Drift loss: 0.327%
PM_{10}: 40.3% of PM
$PM_{2.5}$: 6% of PM

2. Volume (gpm) calculated based on 66 gpm
3. Only 3 our of 4 units operating at once and 10% of the year based on meeting notes from 7/19/2022 with Sarah Richman
4. For daily emissions, evaporators can run during the daylight hours only; conservatively, daylight hour of the summer solstice (14.25 hours) is used

Table A-23a. Aboveground Gasoline Dispensing Facility - Taylor - VOC Emissions

Emission Unit	Maximum Estimated Rate			Emission Factor [2]	VOC Emissions		
	gals/hr	gals/day	gals/yr[1]	(lbs/10^3 gal)	lb/hr	lb/day	ton/yr
AGGDF	17	411	150,000	11.3	0.19	4.63	0.85
				Total	**0.19**	**4.63**	**0.85**

1. Based on aboveground annual gasoline usage provided by South32. All gasoline is treated as being emitted aboveground, despite some being dispensed underground.
2. Emission factor for gasoline is based on petroleum loading loss equation in USEPA publication AP-42, Table 5.2-7, Evaporative Emissions from Gasoline Service Station Operations (7/08). The loading loss equation is :

Loading Loss (lb/1000 gal) = 12.46 x SPM/T

where,

S= saturation factor (assume 1.00 for submerged loading),

P = true vapor pressure of liquid loaded, pounds per square inch absolute (assume 7.4 psia for Gasoline RVP 10 @ 80°F),

M = molecular weight of vapors, pounds per pound-mole (assume 66 lb/lb-mole),
T = temperature of bulk liquid loaded, °R (80°F + 460 = 540°R), based on AP-42 Chapter 7 Tucson average daily maximum ambient temperature

Sample Calculations

VOC emissions (lb/hr) = 17.12 gal/day x 11.3 lb/1,000 gal x 1.0 day/24 hours = 0.19 lb/hr
VOC emissions (ton/yr) = 150000 gal/yr x 11.3 lb/1,000 gal x 1.0 ton/2,000 lbs = 0.85 ton/yr

Table A-23b. Aboveground Gasoline Dispensing Facility - Taylor - HAP Emissions

Emission Unit	Source Description	VOC Emissions [1]		HAP Emissions [2]									
				Benzene		Hexane		Toluene		Xylene		Ethylbenzene	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
AGGDF	Aboveground Gasoline Dispensing Facility	0.19	0.85	0.0035	0.015	0.0019	0.0085	0.014	0.059	0.014	0.059	0.0027	0.012
			Total HAPs (ton/yr)	**0.15**									

1. Based on emission calculations in Table A-23a
2. Mass percent is based on the average percent content of the HAP constituent in gasoline per TankESP Gasoline RVP_X speciation:

Storage Tank Content	HAP Mass Percent				
	Benzene	Hexane	Toluene	Xylene	Ethylbenzene
Gasoline	1.80%	1.00%	7.00%	7.00%	1.40%

Table A-24a. Aboveground Gasoline Dispensing Facility - Clark - VOC Emissions

Emission Unit	Maximum Estimated Rate			Emission Factor [2] (lbs/10^3 gal)	VOC Emissions		
	gals/hr	gals/day	gals/yr [1]		lb/hr	lb/day	ton/yr
AGGDF-C	8	201	73,500	11.3	0.09	2.27	0.41
				Total	**0.09**	**2.27**	**0.41**

1. Based on aboveground annual gasoline usage provided by South32. All gasoline is treated as being emitted aboveground, despite some being dispensed underground.

2. Emission factor for gasoline is based on petroleum loading loss equation in USEPA publication AP-42, Table 5.2-7, Evaporative Emissions from Gasoline Service Station Operations (7/08). The loading loss equation is :

Loading Loss (lb/1000 gal) = 12.46 x SPM/T

where,

S= saturation factor (assume 1.00 for submerged loading),

P = true vapor pressure of liquid loaded, pounds per square inch absolute (assume 7.4 psia for Gasoline RVP 10 @ 80°F),

M = molecular weight of vapors, pounds per pound-mole (assume 66 lb/lb-mole),
T = temperature of bulk liquid loaded, °R (80°F + 460 = 540°R), based on AP-42 Chapter 7 Tucson average daily maximum ambient temperature

Sample Calculations

VOC emissions (lb/hr) = 8.39 gal/day x 11.3 lb/1,000 gal x 1.0 day/24 hours = 0.09 lb/hr
VOC emissions (ton/yr) = 73500 gal/yr x 11.3 lb/1,000 gal x 1.0 ton/2,000 lbs = 0.41 ton/yr

Table A-24b. Aboveground Gasoline Dispensing Facility - Clark - HAP Emissions

Emission Unit	Source Description	VOC Emissions [1]		HAP Emissions [2]									
				Benzene		Hexane		Toluene		Xylene		Ethylbenzene	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
AGGDF-C	Aboveground Gasoline Dispensing Facility	0.09	0.41	0.0017	0.007	0.0009	0.004	0.007	0.03	0.007	0.03	0.0013	0.006
			Total HAPs (ton/yr)	**0.08**									

1. Based on emission calculations in Table A-24a
2. Mass percent is based on the average percent content of the HAP constituent in gasoline per TankESP Gasoline RVP_X speciation:

Storage Tank Content	HAP Mass Percent				
	Benzene	Hexane	Toluene	Xylene	Ethylbenzene
Gasoline	1.80%	1.00%	7.00%	7.00%	1.40%

Table A-25a. Roads - Dozer - Input Parameters

Emission Point No.	Road Surface	Equipment	Total Combined Operation Hour [1]			Emission Factor (lb/hr) [3]						Lead	Control	
			Hourly	Daily	Annual	Short Term			Long Term				Type	Efficiency [2]
			(hr/hr)	(hr/day)	(hr/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	(%)		(%)
DOZER-WRS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-ERS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-HRS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-TSF	Unpaved	Bulldozer	1	12	4,380	4.48	0.95	0.47	4.48	0.95	0.47	0.43	No Control	0%

1. Assumed to operate 12 hours a day and 365 days a year.
2. At South32, watering will be performed to sufficiently to achieve a contr 70%
3. Emission factors for bulldozers per Table 11.9-1, U.S. EPA AP-42, Section 11.9 (Western Surface Coal Mining), October 1998

PM = TSP = k * $\frac{5.7\,(s)^{1.2}}{(M)^{1.3}}$

PM10 = k * PM15 = k * $\frac{1.0\,(s)^{1.5}}{(M)^{1.4}}$

PM2.5 = k * TSP = k * $\frac{5.7\,(s)^{1.2}}{(M)^{1.3}}$

where k = Scaling factor

	PM	PM_{10}	$PM_{2.5}$
k =	1	0.75	0.105

Per AP-42, Table 11.9-1

s = Material silt content (%)

1.6 Rock silt content assumed as to be similar to Crushed limestone in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006)

11 Tailings silt content assumed as to be similar to Taconite mining tailings in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006)

M = Material moisture content (%)

11.00 for Tailings 4 for ore/ rock

	PM	PM_{10}	$PM_{2.5}$
a =	5.7	1	5.7
b =	1.2	1.5	1.2
c =	1.3	1.4	1.3

Table A-25b. Roads -Dozer - Controlled Emissions

Emission Point No.	Road Surface	Equipment	Controlled Emissions [1,2]												Uncontrolled Emissions (tpy)			
			Hourly (lb/hr)				Daily (lb/day)				Annual (tpy)				Annual (tpy)			
			PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
DOZER-WRS	Unpaved	Bulldozer	0.50	0.07	0.052	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-ERS	Unpaved	Bulldozer	0.50	0.07	0.052	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-HRS	Unpaved	Bulldozer	0.50	0.07	0.052	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-TSF	Unpaved	Bulldozer	4.48	0.95	0.471	1.91E-02	53.82	11.44	5.65	0.23	9.82	2.09	1.03	4.18E-02	9.82	2.09	1.03	4.18E-02

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-26a. South32 Hermosa non-fuel Tank Emissions Summary†

Tank ID	Max Capacity (gal)	Stock	Losses (tpy)			Speciated HAP Emissions (tpy)			Total HAP (tpy)
			Standing	Working	Total VOC	Cresol	Ethylene Glycol Dimethyl Ether	Urethane	
TNK-040 [1]	7,925	F549/MIBC	0.166	0.122	0.289	-	0.262	-	0.262
TNK-041 [2]	6,604	3407-A	4.65E-04	1.02E-03	1.48E-03	9.52E-05	-	-	9.52E-05
TNK-044 [3]	6,604	Solvay 5100	6.26E-03	8.67E-03	1.49E-02	-	-	0.00	3.67E-05
TNK-045	2,642	Copper Sulphate	No VOC Emissions			No HAPs Emissions			
TNK-046	5,283	Copper Sulphate							
TNK-047	2,642	Zinc Sulphate							
TNK-048	5,283	Zinc Sulphate							
TNK-051	2,642	Zinc Cyanide							
TNK-052	3,963	Zinc Cyanide							
TNK-053	2,642	SMBS							
TNK-054	5,283	SMBS							
TNK-057	17,171	Tailings Flocculant (SNF AN910-VHM)							
TNK-058	1,320	Tailings Flocculant (SNF AN910-VHM)							
TNK-059	1,320	Tailings Flocculant (SNF AN910-VHM)							
TNK-060	6,604	3418-A	2.14E-05	1.68E-04	1.90E-04				
TNK-061	10,293	Shaft ANE	1.43E-04	9.54E-05	2.38E-04				
Total			**0.17**	**0.13**	**0.31**	**9.52E-05**	**0.262**	**3.67E-05**	**0.263**

† Based on the SDS for tanks TNK-045 through TNK-059, there are no VOC or HAP emissions associated with these tanks. Additionally, there are no HAP emissions associated with tanks TNK-060 and TNK-061.

1. This tank contains a 50/50 mixture of MIBC and F-549. F-549 is comprised of "mixed glycol ethers" according to Section 3 of the SDS. As such, it was conservatively modeled as 100% ethylene glycol dimethyl ether (1,2-dimethoxyethane), the lightest glycol ether.

2. The "test reagent" is not always the same stock, so a representative chemical, 3407-A, was used to estimate tank emissions. "Dithiophosphate" and "modified dithiophosphinate" listed in Section 3 of the SDS are assumed to be sodium diisobutyldithiophosphinate. Due to the unavailablity for Antoine coefficients of this chemical, the A and B coefficients for No. 6 fuel oil are used as a conservative estimate.

3. Due to unavailability of Antoine coefficients for the majority constituent chemical (Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester), the vapor pressure given in the SDS was assumed to be constant to generate usable Antoine coefficients.

Table A-26b. Diesel & Gasoline Storage Tanks - VOC Emissions

Tank ID	Max Capacity (gal)	Stock	VOC Emissions [1]	
			(lb/yr)	(tpy)
T-01	1,000	Unleaded Gasoline (S32)	750.03	0.38
T-02	5,000	Diesel (Red Dyed S32)	3.27	1.64E-03
T-03	5,000	Diesel (Red Dyed S32)	3.27	1.64E-03
T-04	12,000	Diesel (Red Dyed Rummel)	4.08	2.04E-03
T-05	1,000	Unleaded Gasoline (Rummel)	650.59	0.33
T-06	1,000	Diesel (Rummel)	0.95	4.74E-04
T-07	10,000	Unleaded Gasoline	3831.10	1.92
T-08	10,000	Unleaded Gasoline	3831.10	1.92
T-09	10,000	Unleaded Gasoline	3831.10	1.92
T-10	50,000	Diesel	78.34	0.04
T-11	50,000	Diesel	71.75	3.59E-02
Total VOC			**13,055.59**	**6.53**
Max VOC			**3831.10**	**1.92**

1. VOC Emissions per EPA-approved TankESP Software (AP-42 Chapter 7.1, June 2020).

Table A-26c. Diesel & Gasoline Storage Tanks - HAP Weight Percent's

Tank ID	Stock	HAP Liquid Weight Percent's [1]									
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Iso-octane (2,2,4-Trimethylpentane)	Naphthalene	PAC's	Toluene	Xylene
T-01	Unleaded Gasoline (S32)	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-02	Diesel (Red Dyed S32)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-03	Diesel (Red Dyed S32)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-04	Diesel (Red Dyed Rummel)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-05	Unleaded Gasoline (Rummel)	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-06	Diesel (Rummel)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.080%	0.002%	0.030%	0.290%
T-07	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-08	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-09	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-10	Diesel	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-11	Diesel	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%

1. Speciation data for each HAP is based on individual content speciation.

Table A-26d. Diesel and Gasoline Storage Tanks - HAP Emissions (lb/yr)

Tank ID	Stock	HAP Emissions (lb/yr) [1]										
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Isooctane	Naphthalene	PAC's	Toluene	Xylene	Total HAPs
T-01	Unleaded Gasoline (S32)	4.05E+00	2.98E-16	5.19E-02	3.05E-01	3.05E-01	4.64E+00	2.36E-03	2.36E-03	4.64E+00	1.33E+00	15.33
T-02	Diesel (Red Dyed S32)	6.39E-03	3.20E-15	0.00E+00	1.01E-02	1.01E-02	0.00E+00	1.54E-03	1.54E-03	7.54E-02	1.96E-01	0.30
T-03	Diesel (Red Dyed S32)	6.39E-03	3.20E-15	0.00E+00	1.01E-02	1.01E-02	0.00E+00	1.54E-03	1.54E-03	7.54E-02	1.96E-01	0.30
T-04	Diesel (Red Dyed Rummel)	7.96E-03	4.02E-15	0.00E+00	1.25E-02	1.25E-02	0.00E+00	1.92E-03	1.92E-03	9.40E-02	2.45E-01	0.38
T-05	Unleaded Gasoline (Rummel)	3.51E+00	2.59E-16	4.50E-02	2.64E-01	2.64E-01	4.03E+00	2.05E-03	2.05E-03	4.03E+00	1.16E+00	13.30
T-06	Diesel (Rummel)	1.85E-03	9.22E-16	0.00E+00	2.91E-03	2.91E-03	0.00E+00	4.45E-04	4.45E-04	2.18E-02	5.68E-02	0.09
T-07	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-08	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-09	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-10	Diesel	1.53E-01	7.72E-14	0.00E+00	2.41E-01	2.41E-01	0.00E+00	3.69E-02	3.69E-02	1.80E+00	4.69E+00	7.21
T-11	Diesel	1.40E-01	7.07E-14	0.00E+00	2.20E-01	2.20E-01	0.00E+00	3.38E-02	3.38E-02	1.65E+00	4.30E+00	6.60
Total HAPs		**6.99E+01**	**1.64E-13**	**8.92E-01**	**5.74E+00**	**5.74E+00**	**7.98E+01**	**1.17E-01**	**1.17E-01**	**8.35E+01**	**3.26E+01**	**278.42**
Max HAP		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**8.35E+01**	**-**	**-**

1. HAP emissions are calculated based on the HAP weight percent of the content of the tank.

Table A-26e. Diesel and Gasoline Storage Tanks - HAP Emissions (tpy)

Tank ID	Stock	HAP Emissions (tpy)										
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Isooctane	Naphthalene	PAC's	Toluene	Xylene	Total HAPs
T-01	Unleaded Gasoline (S32)	2.02E-03	1.49E-19	2.59E-05	1.52E-04	1.52E-04	2.32E-03	1.18E-06	1.18E-06	2.32E-03	6.66E-04	7.67E-03
T-02	Diesel (Red Dyed S32)	3.20E-06	1.60E-18	0.00E+00	5.03E-06	5.03E-06	0.00E+00	7.69E-07	7.69E-07	3.77E-05	9.81E-05	1.51E-04
T-03	Diesel (Red Dyed S32)	3.20E-06	1.60E-18	0.00E+00	5.03E-06	5.03E-06	0.00E+00	7.69E-07	7.69E-07	3.77E-05	9.81E-05	1.51E-04
T-04	Diesel (Red Dyed Rummel)	3.98E-06	2.01E-18	0.00E+00	6.27E-06	6.27E-06	0.00E+00	9.61E-07	9.61E-07	4.70E-05	1.22E-04	1.88E-04
T-05	Unleaded Gasoline (Rummel)	1.76E-03	1.29E-19	2.25E-05	1.32E-04	1.32E-04	2.01E-03	1.02E-06	1.02E-06	2.01E-03	5.78E-04	6.65E-03
T-06	Diesel (Rummel)	9.26E-07	4.61E-19	0.00E+00	1.46E-06	1.46E-06	0.00E+00	2.23E-07	2.23E-07	1.09E-05	2.84E-05	4.36E-05
T-07	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-08	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-09	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-10	Diesel	7.64E-05	3.86E-17	0.00E+00	1.20E-04	1.20E-04	0.00E+00	1.84E-05	1.84E-05	9.02E-04	2.35E-03	3.60E-03
T-11	Diesel	7.00E-05	3.54E-17	0.00E+00	1.10E-04	1.10E-04	0.00E+00	1.69E-05	1.69E-05	8.26E-04	2.15E-03	3.30E-03
Total HAPs		**3.50E-02**	**8.22E-17**	**4.46E-04**	**2.87E-03**	**2.87E-03**	**3.99E-02**	**5.84E-05**	**5.84E-05**	**4.17E-02**	**1.63E-02**	**1.39E-01**
Max HAP		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**4.17E-02**	**-**	**-**

Table A-27. South32 Hermosa Process Tanks Emission Summary

Tank	Equipment Description	CAS #	Chemical	VOC?	HAP?	Pure Component Molecular Weight M (lb/lbmol)	Pure Component Vapor Pressure P (psia)	Henry's Law Solubility Constant H^{cc}_v Dimensionless	Henry's Law Solubility Constant H^{px}_v (psi/mol% liq)	Liquid Mol% Liq. mol% (mol%liq)	Liquid Temperature T (K)	Liquid Surface Area A (ft2)	Pure Component Mass Transfer Coefficient K (ft/hr)	Vapor Partial Pressure pp (psia)	Hourly Emission Rate [1] E (hourly) (lb/hr)	Annual Emissions [1] E (annual) (lb/yr)	(tpy)
22310-FC-00001	**Lead Rougher**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.31E-06	301.54	207.74	54.97	1.91E-05	0.01	61.59	0.03
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.77E-07	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	207.74	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00004	**Lead Rougher Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.29E-06	301.54	207.74	54.97	1.88E-05	0.01	60.63	0.03
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.68E-07	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	207.74	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00008	**Lead Cleaner Scalper**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.15E-05	301.54	73.19	54.97	1.67E-04	0.02	190.11	0.10
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.06E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00007	**Lead Cleaner**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	9.85E-06	301.54	73.19	54.97	1.43E-04	0.02	162.88	0.08
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	4.33E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00009	**Lead Cleaner Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	9.18E-06	301.54	73.19	54.97	1.33E-04	0.02	151.76	0.08
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	4.04E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00005	**Zinc Rougher**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	2.37E-06	301.54	207.74	54.97	3.44E-05	0.01	111.01	0.06
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	3.68E-06	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.17E-06	301.54	207.74	61.19	2.13E-06	6.89E-04	5.55	2.78E-03
22310-FC-00006	**Zinc Rougher Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	2.31E-06	301.54	207.74	54.97	3.36E-05	0.01	108.49	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	3.60E-06	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.15E-06	301.54	207.74	61.19	2.08E-06	6.74E-04	5.43	2.71E-03
22310-FC-00011	**Zinc Cleaner Scalper**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	4.06E-06	301.54	124.86	54.97	5.89E-05	0.01	114.43	0.06
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	6.32E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	2.01E-06	301.54	124.86	61.19	3.65E-06	7.10E-04	5.73	2.86E-03
22310-FC-00010	**Zinc Cleaner**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	3.44E-06	301.54	124.86	54.97	4.99E-05	0.01	96.94	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	5.35E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.71E-06	301.54	124.86	61.19	3.10E-06	6.02E-04	4.85	2.43E-03
22310-FC-00012	**Zinc Cleaner Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	3.20E-06	301.54	124.86	54.97	4.65E-05	0.01	90.25	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	4.98E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.59E-06	301.54	124.86	61.19	2.88E-06	5.60E-04	4.52	2.26E-03
															0.15	1174.17	0.59

Process Tank Emission Calculation Notes

Emission Factors calculated using:
Ref: Section 3.7.1 - Evaporation from an Open Top Vessel or a Spill
Methods for Estimating Air Emissions from Chemical Manufacturing Facilities, Vol. II Chapter 16
STAPPA/ALAPCO/EPA EIIP, August 2007

E	Hourly or Annual Emission Rate, lb/hr or lb/yr [3]	=(M K A P) / (R T)
M	Molecular Weight, lb/lb-mol	See Table
K	Mass Transfer Coefficient, ft/hr [4]	$= K_0 (M_0/M)^{1/3}$
K_0	Reference Mass Transfer Coefficient of Water, ft/hr	0.83
M_0	Molecular Weight of Water, lb/lb-mol	18.02
A	Liquid Surface Area, ft2	See Table
P	Vapor Pressure, psia	See Table
T	Liquid temperature, ºR [5]	542.77
R	Ideal Gas Constant, Psia-ft^3/lb-mole ºR [6]	10.73159
H	Annual Hours of Operations, hrs/yr [7]	8060
H^{px}_v	Henry's Law Volatility Constant, psi/$(mol\%)_{liq}$ [8]	$= H^{cc}_v$ x R x T x d(solv) / M(solv)
pp^H	Gas Partial Pressure using Henry's Law Constant, psi	= Liq Mol% * H^{xp}_v
H^{cc}_v	Henry's Law Volatility Constant, Dimensionless [9]	See Table
M(solv)	Mol. Wt. of Solvent, lb/lb-mol [10]	18.02
d(solv)	Density of Solvent, lb/ft3 [10]	62.42771972

1. 100% Safety factor added while calculating emission rate to account for any atomization from material movement at the surface, such as spraying
2. Emissions from low volatile compounds (sodium diisobutyldithiophosphinate & Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester) assumed to be negligible.
3. EIIP, Vol. II, Ch. 16, Eq. 3-24
4. EIIP, Vol. II, Ch. 16, Eq. 3-27
5. For conservative estimate - Hourly Average Max. Ambient Temperature for Tucson, AZ. As per AP 42 Section 7.1, Table 7.1-7 (Jun, 2020) is used
6. Table 1-9 Perry's Chemical Engineers' Handbook, 6th ed.
7. Provided by South32
8. Referenced from https://www.degruyter.com/document/doi/10.1515/pac-2020-0302/html?lang=en
9. Referenced from Toxchem 4.4 Mar-25-2019
10. Assume as water

Table A-28. Taylor Emission Factor Inputs

Road Surface	Max Miles Traveled Per Unit			Vehicle Type	Vehicle Model	Max Vehicle Count	Particulate Matter Emission Factor Inputs [1]												
							k			Avg. W		s	P	a			b		
	Day	Month	Year				PM	PM_{10}	$PM_{2.5}$	(kg)	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Unpaved	2	60.83	730	Dev Drill Rig	DD422i	3	4.9	1.5	0.15	26,000	28.66	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Support Drill Rig	DS412i	5	4.9	1.5	0.15	29,000	31.97	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Cable bolter	DS421	2	4.9	1.5	0.15	25,000	27.56	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	LHD (LH517i)	LH517i	2	4.9	1.5	0.15	46,500	51.26	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Truck	TH551i	4	4.9	1.5	0.15	97,870	107.88	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Scissor lift	Utilift MF 540	2	4.9	1.5	0.15	13,100	14.44	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Light vehicle (general usage) Fleet 1	Mahindra Roxor	2	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Charging Rig Fleet 1	Charmec MF 605 D(V)	2	4.9	1.5	0.15	14,600	16.09	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	LH Rigs	DL422i	6	4.9	1.5	0.15	22,000	24.25	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	LH Rig (Ore Passes/Geo)	DL422i	1	4.9	1.5	0.15	22,000	24.25	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	LHD (LH518B)	LH518B	5	4.9	1.5	0.15	70,000	77.16	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Trucks (Haul Loop)	TH663i	3	4.9	1.5	0.15	111,440	122.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Trucks	TH663i	5	4.9	1.5	0.15	111,440	122.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Material transporter	Multimec MF100	2	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	4	121.67	1460	Light vehicle (general usage) Fleet 2	Mahindra Roxor	2	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Charging Rig Fleet 2	Charmec MF 605 D(V)	2	4.9	1.5	0.15	14,600	16.09	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Personnel transporter	Utimec MF 205 PER	3	4.9	1.5	0.15	15,200	16.76	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Shotcreter	Spraymec MF 050 D(V)	2	4.9	1.5	0.15	18,000	19.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.67	5840	Transmixer	Utimec MF 500	4	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Water vehicle	MF 350 Water	2	4.9	1.5	0.15	15,700	17.31	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	0.0027397	0.08	1	Mobile rockbreaker	Maclean RB3	3	4.9	1.5	0.15	17,700	19.51	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Grader	Maclean GR5	2	4.9	1.5	0.15	18,200	20.06	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	Skid Steer	Manitou 4200 V	3	4.9	1.5	0.15	5,291	5.83	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Light vehicle (tech services)	Mahindra Roxor	4	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Material transporter (logistics/Construct)	Multimec MF100	2	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Scissor lift (Construction)	Utilift MF 540	2	4.9	1.5	0.15	13,100	14.44	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Telehandler	GTH - 1056	3	4.9	1.5	0.15	14,470	15.95	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	4	121.67	1460	Maintenance Vehicle	Maclean FL3	3	4.9	1.5	0.15	33,000	36.38	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.33	2920	Fuel/Lube vehicle	Maclean FL3	2	4.9	1.5	0.15	33,000	36.38	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	0.1	3.04	36.5	Mobile Grapple equipment	Brokk 900	3	4.9	1.5	0.15	11,600	12.79	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	Blind Bore Machine	Rhino	2	4.9	1.5	0.15	52,000	57.32	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)
k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%), per AP-42 Table 13.2.2-1, 11/06, Western surface coal mining Plant Road
5.1

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.
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Table A-29. Taylor Underground Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1] k			W	s	P	a			b			Reference
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	
Unpaved	Dev Drill Rig	Hourly/Daily	7.43	1.92	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.66	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Dev Drill Rig	Annual	6.17	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Support Drill Rig	Hourly/Daily	7.81	2.01	0.20	lb/VMT	VMT	4.90	1.50	0.15	31.97	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Support Drill Rig	Annual	6.48	1.67	0.17	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Cable bolter	Hourly/Daily	7.30	1.88	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.56	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Cable bolter	Annual	6.06	1.56	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD (LH517i)	Hourly/Daily	9.66	2.49	0.25	lb/VMT	VMT	4.90	1.50	0.15	51.26	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD (LH517i)	Annual	8.02	2.07	0.21	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Truck	Hourly/Daily	13.50	3.48	0.35	lb/VMT	VMT	4.90	1.50	0.15	107.88	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Truck	Annual	11.20	2.89	0.29	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor lift	Hourly/Daily	5.46	1.41	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.44	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor lift	Annual	4.53	1.17	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (general usage) Fleet 1	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (general usage) Fleet 1	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Charging Rig Fleet 1	Hourly/Daily	5.73	1.48	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.09	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Charging Rig Fleet 1	Annual	4.76	1.23	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LH Rigs	Hourly/Daily	6.89	1.78	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.25	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LH Rigs	Annual	5.72	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LH Rig (Ore Passes/Geo)	Hourly/Daily	6.89	1.78	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.25	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LH Rig (Ore Passes/Geo)	Annual	5.72	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD (LH518B)	Hourly/Daily	11.61	2.99	0.30	lb/VMT	VMT	4.90	1.50	0.15	77.16	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD (LH518B)	Annual	9.63	2.49	0.25	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Trucks (Haul Loop)	Hourly/Daily	14.31	3.69	0.37	lb/VMT	VMT	4.90	1.50	0.15	122.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Trucks (Haul Loop)	Annual	11.88	3.06	0.31	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Trucks	Hourly/Daily	14.31	3.69	0.37	lb/VMT	VMT	4.90	1.50	0.15	122.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Trucks	Annual	11.88	3.06	0.31	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Material transporter	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Material transporter	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (general usage) Fleet 2	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (general usage) Fleet 2	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Charging Rig Fleet 2	Hourly/Daily	5.73	1.48	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.09	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Charging Rig Fleet 2	Annual	4.76	1.23	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Personnel transporter	Hourly/Daily	5.84	1.51	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.76	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Personnel transporter	Annual	4.85	1.25	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Shotcreter	Hourly/Daily	6.30	1.62	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Shotcreter	Annual	5.23	1.35	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Transmixer	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Transmixer	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Water vehicle	Hourly/Daily	5.92	1.53	0.15	lb/VMT	VMT	4.90	1.50	0.15	17.31	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Water vehicle	Annual	4.92	1.27	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Mobile rockbreaker	Hourly/Daily	6.25	1.61	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.51	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Mobile rockbreaker	Annual	5.19	1.34	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Grader	Hourly/Daily	6.33	1.63	0.16	lb/VMT	VMT	4.90	1.50	0.15	20.06	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Grader	Annual	5.26	1.36	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Skid Steer	Hourly/Daily	3.63	0.94	0.09	lb/VMT	VMT	4.90	1.50	0.15	5.83	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Skid Steer	Annual	3.01	0.78	0.08	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (tech services)	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (tech services)	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Material transporter (logistics/Construct)	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Material transporter (logistics/Construct)	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor lift (Construction)	Hourly/Daily	5.46	1.41	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.44	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor lift (Construction)	Annual	4.53	1.17	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Telehandler	Hourly/Daily	5.71	1.47	0.15	lb/VMT	VMT	4.90	1.50	0.15	15.95	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Telehandler	Annual	4.74	1.22	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Maintenance Vehicle	Hourly/Daily	8.27	2.13	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.38	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Maintenance Vehicle	Annual	6.87	1.77	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Fuel/Lube vehicle	Hourly/Daily	8.27	2.13	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.38	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Fuel/Lube vehicle	Annual	6.87	1.77	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Mobile Grapple equipment	Hourly/Daily	5.17	1.33	0.13	lb/VMT	VMT	4.90	1.50	0.15	12.79	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Mobile Grapple equipment	Annual	4.29	1.11	0.11	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Blind Bore Machine	Hourly/Daily	10.15	2.62	0.26	lb/VMT	VMT	4.90	1.50	0.15	57.32	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Blind Bore Machine	Annual	8.43	2.17	0.22	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)
k, a, b = Constants for equation 1a (Per AP-42 Table 13.2.2-2, November 2006)

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

s = 5.1 surface material silt content (%) (Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with AMI, 10/14/22.)
W = Mean vehicle weight (tons)
P = 62 Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021

Table A-30a. Taylor Roads - Vehicles - Input Parameters

Road Surface	Vehicle Type	Trip Type	Number of Vehicles	Trip Distance (miles/vehicle/day)	Vehicle Miles Travelled (VMT)			Uncontrolled Emission Factor (lb/VMT)						Control	
								Short Term			Long Term			Type	Efficiency [1,2]
					(VMT/hr)	(VMT/day)	(VMT/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$		(%)
Unpaved	Dev Drill Rig	Round	3	2	0.250	6.00	2,190	7.43	1.92	0.19	6.17	1.59	0.16	Watering	90%
Unpaved	Support Drill Rig	Round	5	2	0.417	10.00	3,650	7.81	2.01	0.20	6.48	1.67	0.17	Watering	90%
Unpaved	Cable bolter	Round	2	2	0.167	4.00	1,460	7.30	1.88	0.19	6.06	1.56	0.16	Watering	90%
Unpaved	LHD (LH517i)	Round	2	2	0.167	4.00	1,460	9.66	2.49	0.25	8.02	2.07	0.21	Watering	90%
Unpaved	Haul Truck	Round	4	20	3.333	80.00	29,200	13.50	3.48	0.35	11.20	2.89	0.29	Watering	90%
Unpaved	Scissor lift	Round	2	2	0.167	4.00	1,460	5.46	1.41	0.14	4.53	1.17	0.12	Watering	90%
Unpaved	Light vehicle (general usage) Fleet 1	Round	2	2	0.167	4.00	1,460	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Charging Rig Fleet 1	Round	2	2	0.167	4.00	1,460	5.73	1.48	0.15	4.76	1.23	0.12	Watering	90%
Unpaved	LH Rigs	Round	6	1	0.250	6.00	2,190	6.89	1.78	0.18	5.72	1.48	0.15	Watering	90%
Unpaved	LH Rig (Ore Passes/Geo)	Round	1	1	0.042	1.00	365	6.89	1.78	0.18	5.72	1.48	0.15	Watering	90%
Unpaved	LHD (LH518B)	Round	5	2	0.417	10.00	3,650	11.61	2.99	0.30	9.63	2.49	0.25	Watering	90%
Unpaved	Haul Trucks (Haul Loop)	Round	3	20	2.500	60.00	21,900	14.31	3.69	0.37	11.88	3.06	0.31	Watering	90%
Unpaved	Haul Trucks	Round	5	20	4.167	100.00	36,500	14.31	3.69	0.37	11.88	3.06	0.31	Watering	90%
Unpaved	Material transporter	Round	2	6	0.500	12.00	4,380	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Light vehicle (general usage) Fleet 2	Round	2	4	0.333	8.00	2,920	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Charging Rig Fleet 2	Round	2	2	0.167	4.00	1,460	5.73	1.48	0.15	4.76	1.23	0.12	Watering	90%
Unpaved	Personnel transporter	Round	3	6	0.750	18.00	6,570	5.84	1.51	0.15	4.85	1.25	0.13	Watering	90%
Unpaved	Shotcreter	Round	2	2	0.167	4.00	1,460	6.30	1.62	0.16	5.23	1.35	0.13	Watering	90%
Unpaved	Transmixer	Round	4	16	2.667	64.00	23,360	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Water vehicle	Round	2	6	0.500	12.00	4,380	5.92	1.53	0.15	4.92	1.27	0.13	Watering	90%
Unpaved	Mobile rockbreaker	Round	3	0.00274	0.00034	0.01	3	6.25	1.61	0.16	5.19	1.34	0.13	Watering	90%
Unpaved	Grader	Round	2	6	0.500	12.00	4,380	6.33	1.63	0.16	5.26	1.36	0.14	Watering	90%
Unpaved	Skid Steer	Round	3	1	0.125	3.00	1,095	3.63	0.94	0.09	3.01	0.78	0.08	Watering	90%
Unpaved	Light vehicle (tech services)	Round	4	2	0.333	8.00	2,920	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Material transporter (logistics/Construct)	Round	2	6	0.500	12.00	4,380	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Scissor lift (Construction)	Round	2	6	0.500	12.00	4,380	5.46	1.41	0.14	4.53	1.17	0.12	Watering	90%
Unpaved	Telehandler	Round	3	2	0.250	6.00	2,190	5.71	1.47	0.15	4.74	1.22	0.12	Watering	90%
Unpaved	Maintenance Vehicle	Round	3	4	0.500	12.00	4,380	8.27	2.13	0.21	6.87	1.77	0.18	Watering	90%
Unpaved	Fuel/Lube vehicle	Round	2	8	0.667	16.00	5,840	8.27	2.13	0.21	6.87	1.77	0.18	Watering	90%
Unpaved	Mobile Grapple equipment	Round	3	0.1	0.013	0.30	110	5.17	1.33	0.13	4.29	1.11	0.11	Watering	90%
Unpaved	Blind Bore Machine	Round	2	1	0.083	2.00	730	10.15	2.62	0.26	8.43	2.17	0.22	Watering	90%

1. Road Watering is not contemplated every hour, but only as needed to maintain control levels.
2. At South32, the roads will be watered sufficiently to achieve a contrc 90%

Lead Content = 0.0000245 kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples

Table A-30b. Taylor Roads -Vehicles - Emissions

Vehicle Type	Road Surface	Uncontrolled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Dev Drill Rig	Unpaved	1.86	0.48	0.05	4.55E-05	44.60	11.50	1.15	1.09E-03	6.76	1.74	0.17	1.66E-04
Support Drill Rig	Unpaved	3.25	0.84	0.08	7.97E-05	78.07	20.14	2.01	1.91E-03	11.83	3.05	0.31	2.90E-04
Cable bolter	Unpaved	1.22	0.31	0.03	2.98E-05	29.21	7.54	0.75	7.16E-04	4.43	1.14	0.11	1.08E-04
LHD (LH517i)	Unpaved	1.61	0.42	0.04	3.94E-05	38.62	9.96	1.00	9.46E-04	5.85	1.51	0.15	1.43E-04
Haul Truck	Unpaved	44.99	11.60	1.16	1.10E-03	1079.65	278.52	27.85	0.03	163.57	42.20	4.22	4.01E-03
Scissor lift	Unpaved	0.91	0.23	0.02	2.23E-05	21.84	5.63	0.56	5.35E-04	3.31	0.85	0.09	8.11E-05
Light vehicle (general usage) Fleet 1	Unpaved	0.36	0.09	0.01	8.84E-06	8.66	2.23	0.22	2.12E-04	1.31	0.34	0.03	3.22E-05
Charging Rig Fleet 1	Unpaved	0.96	0.25	0.02	2.34E-05	22.93	5.92	0.59	5.62E-04	3.47	0.90	0.09	8.51E-05
LH Rigs	Unpaved	1.72	0.44	0.04	4.22E-05	41.37	10.67	1.07	1.01E-03	6.27	1.62	0.16	1.54E-04
LH Rig (Ore Passes/Geo)	Unpaved	0.29	0.07	0.01	7.04E-06	6.89	1.78	0.18	1.69E-04	1.04	0.27	0.03	2.56E-05
LHD (LH518B)	Unpaved	4.84	1.25	0.12	1.18E-04	116.06	29.94	2.99	2.84E-03	17.58	4.54	0.45	4.31E-04
Haul Trucks (Haul Loop)	Unpaved	35.77	9.23	0.92	8.76E-04	858.46	221.46	22.15	0.02	130.06	33.55	3.36	3.19E-03
Haul Trucks	Unpaved	59.62	15.38	1.54	1.46E-03	1430.77	369.10	36.91	0.04	216.76	55.92	5.59	5.31E-03
Material transporter	Unpaved	3.46	0.89	0.09	8.48E-05	83.07	21.43	2.14	2.04E-03	12.59	3.25	0.32	3.08E-04
Light vehicle (general usage) Fleet 2	Unpaved	0.72	0.19	0.02	1.77E-05	17.33	4.47	0.45	4.24E-04	2.62	0.68	0.07	6.43E-05
Charging Rig Fleet 2	Unpaved	0.96	0.25	0.02	2.34E-05	22.93	5.92	0.59	5.62E-04	3.47	0.90	0.09	8.51E-05
Personnel transporter	Unpaved	4.38	1.13	0.11	1.07E-04	105.08	27.11	2.71	2.57E-03	15.92	4.11	0.41	3.90E-04
Shotcreter	Unpaved	1.05	0.27	0.03	2.57E-05	25.20	6.50	0.65	6.17E-04	3.82	0.98	0.10	9.35E-05
Transmixer	Unpaved	18.46	4.76	0.48	4.52E-04	443.04	114.29	11.43	0.01	67.12	17.32	1.73	1.64E-03
Water vehicle	Unpaved	2.96	0.76	0.08	7.26E-05	71.08	18.34	1.83	1.74E-03	10.77	2.78	0.28	2.64E-04
Mobile rockbreaker	Unpaved	0.00	0.00	0.00	5.25E-08	0.05	0.01	0.00	1.26E-06	0.01	0.00	0.00	1.91E-07
Grader	Unpaved	3.17	0.82	0.08	7.75E-05	75.97	19.60	1.96	1.86E-03	11.51	2.97	0.30	2.82E-04
Skid Steer	Unpaved	0.45	0.12	0.01	1.11E-05	10.89	2.81	0.28	2.67E-04	1.65	0.43	0.04	4.04E-05
Light vehicle (tech services)	Unpaved	0.72	0.19	0.02	1.77E-05	17.33	4.47	0.45	4.24E-04	2.62	0.68	0.07	6.43E-05
Material transporter (logistics/Construct)	Unpaved	3.46	0.89	0.09	8.48E-05	83.07	21.43	2.14	2.04E-03	12.59	3.25	0.32	3.08E-04
Scissor lift (Construction)	Unpaved	2.73	0.70	0.07	6.69E-05	65.52	16.90	1.69	1.61E-03	9.93	2.56	0.26	2.43E-04
Telehandler	Unpaved	1.43	0.37	0.04	3.50E-05	34.26	8.84	0.88	8.39E-04	5.19	1.34	0.13	1.27E-04
Maintenance Vehicle	Unpaved	4.14	1.07	0.11	1.01E-04	99.29	25.61	2.56	2.43E-03	15.04	3.88	0.39	3.69E-04
Fuel/Lube vehicle	Unpaved	5.52	1.42	0.14	1.35E-04	132.39	34.15	3.42	3.24E-03	20.06	5.17	0.52	4.91E-04
Mobile Grapple equipment	Unpaved	0.06	0.02	0.00	1.58E-06	1.55	0.40	0.04	3.80E-05	0.23	0.06	0.01	5.76E-06
Blind Bore Machine	Unpaved	0.85	0.22	0.02	2.07E-05	20.31	5.24	0.52	4.98E-04	3.08	0.79	0.08	7.54E-05
Total Emissions		**211.89**	**54.66**	**5.47**	**0.01**	**5,085.46**	**1,311.91**	**131.19**	**0.12**	**770.45**	**198.75**	**19.88**	**0.02**

Vehicle Type	Road Surface	Controlled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Dev Drill Rig	Unpaved	0.19	0.05	0.00	4.55E-06	4.46	1.15	0.12	1.09E-04	0.68	0.17	0.02	1.66E-05
Support Drill Rig	Unpaved	0.33	0.08	0.01	7.97E-06	7.81	2.01	0.20	1.91E-04	1.18	0.31	0.03	2.90E-05
Cable bolter	Unpaved	0.12	0.03	0.00	2.98E-06	2.92	0.75	0.08	7.16E-05	0.44	0.11	0.01	1.08E-05
LHD (LH517i)	Unpaved	0.16	0.04	0.00	3.94E-06	3.86	1.00	0.10	9.46E-05	0.59	0.15	0.02	1.43E-05
Haul Truck	Unpaved	4.50	1.16	0.12	1.10E-04	107.96	27.85	2.79	2.65E-03	16.36	4.22	0.42	4.01E-04
Scissor lift	Unpaved	0.09	0.02	0.00	2.23E-06	2.18	0.56	0.06	5.35E-05	0.33	0.09	0.01	8.11E-06
Light vehicle (general usage) Fleet 1	Unpaved	0.04	0.01	0.00	8.84E-07	0.87	0.22	0.02	2.12E-05	0.13	0.03	0.00	3.22E-06
Charging Rig Fleet 1	Unpaved	0.10	0.02	0.00	2.34E-06	2.29	0.59	0.06	5.62E-05	0.35	0.09	0.01	8.51E-06
LH Rigs	Unpaved	0.17	0.04	0.00	4.22E-06	4.14	1.07	0.11	1.01E-04	0.63	0.16	0.02	1.54E-05
LH Rig (Ore Passes/Geo)	Unpaved	0.03	0.01	0.00	7.04E-07	0.69	0.18	0.02	1.69E-05	0.10	0.03	0.00	2.56E-06
LHD (LH518B)	Unpaved	0.48	0.12	0.01	1.18E-05	11.61	2.99	0.30	2.84E-04	1.76	0.45	0.05	4.31E-05
Haul Trucks (Haul Loop)	Unpaved	3.58	0.92	0.09	8.76E-05	85.85	22.15	2.21	2.10E-03	13.01	3.36	0.34	3.19E-04
Haul Trucks	Unpaved	5.96	1.54	0.15	1.46E-04	143.08	36.91	3.69	3.51E-03	21.68	5.59	0.56	5.31E-04
Material transporter	Unpaved	0.35	0.09	0.01	8.48E-06	8.31	2.14	0.21	2.04E-04	1.26	0.32	0.03	3.08E-05
Light vehicle (general usage) Fleet 2	Unpaved	0.07	0.02	0.00	1.77E-06	1.73	0.45	0.04	4.24E-05	0.26	0.07	0.01	6.43E-06
Charging Rig Fleet 2	Unpaved	0.10	0.02	0.00	2.34E-06	2.29	0.59	0.06	5.62E-05	0.35	0.09	0.01	8.51E-06
Personnel transporter	Unpaved	0.44	0.11	0.01	1.07E-05	10.51	2.71	0.27	2.57E-04	1.59	0.41	0.04	3.90E-05
Shotcreter	Unpaved	0.10	0.03	0.00	2.57E-06	2.52	0.65	0.06	6.17E-05	0.38	0.10	0.01	9.35E-06
Transmixer	Unpaved	1.85	0.48	0.05	4.52E-05	44.30	11.43	1.14	1.09E-03	6.71	1.73	0.17	1.64E-04
Water vehicle	Unpaved	0.30	0.08	0.01	7.26E-06	7.11	1.83	0.18	1.74E-04	1.08	0.28	0.03	2.64E-05
Mobile rockbreaker	Unpaved	0.00	0.00	0.00	5.25E-09	0.01	0.00	0.00	1.26E-07	0.00	0.00	0.00	1.91E-08
Grader	Unpaved	0.32	0.08	0.01	7.75E-06	7.60	1.96	0.20	1.86E-04	1.15	0.30	0.03	2.82E-05
Skid Steer	Unpaved	0.05	0.01	0.00	1.11E-06	1.09	0.28	0.03	2.67E-05	0.17	0.04	0.00	4.04E-06
Light vehicle (tech services)	Unpaved	0.07	0.02	0.00	1.77E-06	1.73	0.45	0.04	4.24E-05	0.26	0.07	0.01	6.43E-06
Material transporter (logistics/Construct)	Unpaved	0.35	0.09	0.01	8.48E-06	8.31	2.14	0.21	2.04E-04	1.26	0.32	0.03	3.08E-05
Scissor lift (Construction)	Unpaved	0.27	0.07	0.01	6.69E-06	6.55	1.69	0.17	1.61E-04	0.99	0.26	0.03	2.43E-05
Telehandler	Unpaved	0.14	0.04	0.00	3.50E-06	3.43	0.88	0.09	8.39E-05	0.52	0.13	0.01	1.27E-05
Maintenance Vehicle	Unpaved	0.41	0.11	0.01	1.01E-05	9.93	2.56	0.26	2.43E-04	1.50	0.39	0.04	3.69E-05
Fuel/Lube vehicle	Unpaved	0.55	0.14	0.01	1.35E-05	13.24	3.42	0.34	3.24E-04	2.01	0.52	0.05	4.91E-05
Mobile Grapple equipment	Unpaved	0.01	0.00	0.00	1.58E-07	0.16	0.04	0.00	3.80E-06	0.02	0.01	0.00	5.76E-07
Blind Bore Machine	Unpaved	0.08	0.02	0.00	2.07E-06	2.03	0.52	0.05	4.98E-05	0.31	0.08	0.01	7.54E-06
Total Emissions		**21.19**	**5.47**	**0.55**	**5.19E-04**	**508.55**	**131.19**	**13.12**	**1.25E-02**	**77.04**	**19.88**	**1.99**	**1.89E-03**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-31. Clark Emission Factor Inputs

Road Surface	Max Miles Traveled			Vehicle Type	Vehicle Model	Max Vehicle Count	Particulate Matter Emission Factor Inputs [1]												
							k					s	P	a			b		
	Day	Month	Year				PM	PM_{10}	$PM_{2.5}$	Avg (kg)	(ton)	(%)	(days/ yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Unpaved	8	243.3	2920	Jumbo	DD422i	2	4.9	1.5	0.15	26,000	28.7	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Bolter	DD411	3	4.9	1.5	0.15	23,000	25.4	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	60	1825.0	21900	Haul Truck	TH430	5	4.9	1.5	0.15	44,500	49.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	LHD	LH410	4	4.9	1.5	0.15	33,500	36.9	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Production Drill	Simba ME7C	2	4.9	1.5	0.15	29,500	32.5	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Slot-Raise Drill	Easer L	1	4.9	1.5	0.15	37,300	41.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Blockholer	BH3	1	4.9	1.5	0.15	28,000	30.9	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Powder Truck	EC3	2	4.9	1.5	0.15	17,950	19.8	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Grader	120 AWD	1	4.9	1.5	0.15	16,700	18.4	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Lube Truck	FL3	1	4.9	1.5	0.15	13,600	15.0	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Shotcrete Sprayer	SSX & SS3 T4F	1	4.9	1.5	0.15	19,200	21.2	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Transit Mixer	TM3	2	4.9	1.5	0.15	25,050	27.6	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Scissor Deck	SL3	2	4.9	1.5	0.15	15,400	17.0	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Boom Truck	BT3	1	4.9	1.5	0.15	17,300	19.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Light Vehicle	F-250	6	4.9	1.5	0.15	3,750	4.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	24	730.0	8760	Water Vehicle	WS3	1	4.9	1.5	0.15	16,100	17.7	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^{a}(W/3)^{b}$ (1a)

Annual $E_{ext} = E\,[(365-P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%), per AP-42 Table 13.2.2-1, 11/06, Western surface coal mining Plant Road

5.1

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.

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Table A-32. Clark Underground Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1]												Reference
								k			W	s	P	a			b			
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	
Unpaved	Jumbo	Hourly/Daily	7.43	1.92	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.66	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	AP-42, Section 13.2.2, Expression 1a (11/06) AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Jumbo	Annual	6.17	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Bolter	Hourly/Daily	7.03	1.81	0.18	lb/VMT	VMT	4.90	1.50	0.15	25.35	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Bolter	Annual	5.84	1.51	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Truck	Hourly/Daily	9.47	2.44	0.24	lb/VMT	VMT	4.90	1.50	0.15	49.05	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Truck	Annual	7.86	2.03	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD	Hourly/Daily	8.33	2.15	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.93	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD	Annual	6.92	1.78	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Production Drill	Hourly/Daily	7.87	2.03	0.20	lb/VMT	VMT	4.90	1.50	0.15	32.52	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Production Drill	Annual	6.53	1.68	0.17	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Slot-Raise Drill	Hourly/Daily	8.74	2.26	0.23	lb/VMT	VMT	4.90	1.50	0.15	41.12	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Slot-Raise Drill	Annual	7.26	1.87	0.19	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Blockholer	Hourly/Daily	7.68	1.98	0.20	lb/VMT	VMT	4.90	1.50	0.15	30.86	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Blockholer	Annual	6.38	1.65	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Powder Truck	Hourly/Daily	6.29	1.62	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.79	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Powder Truck	Annual	5.22	1.35	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Grader	Hourly/Daily	6.09	1.57	0.16	lb/VMT	VMT	4.90	1.50	0.15	18.41	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Grader	Annual	5.06	1.30	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Lube Truck	Hourly/Daily	5.55	1.43	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.99	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Lube Truck	Annual	4.61	1.19	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Shotcrete Sprayer	Hourly/Daily	6.48	1.67	0.17	lb/VMT	VMT	4.90	1.50	0.15	21.16	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Shotcrete Sprayer	Annual	5.38	1.39	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Transit Mixer	Hourly/Daily	7.31	1.89	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.61	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Transit Mixer	Annual	6.07	1.57	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor Deck	Hourly/Daily	5.87	1.51	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.98	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor Deck	Annual	4.87	1.26	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Boom Truck	Hourly/Daily	6.19	1.60	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.07	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Boom Truck	Annual	5.14	1.33	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light Vehicle	Hourly/Daily	3.11	0.80	0.08	lb/VMT	VMT	4.90	1.50	0.15	4.13	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light Vehicle	Annual	2.58	0.67	0.07	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Water Vehicle	Hourly/Daily	5.99	1.55	0.15	lb/VMT	VMT	4.90	1.50	0.15	17.75	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Water Vehicle	Annual	4.97	1.28	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^{a}(W/3)^{b}$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%)

5.1

Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with AMI, 10/14/22

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021

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Table A-33a. Clark Roads - Vehicles - Input Parameters

Road Surface	Vehicle Type	Trip Type	Losses (tpy)	Trip Distance (miles/vehicle/day)	Vehicle Miles Travelled (VMT)			Uncontrolled Emission Factor (lb/VMT)						Control	
								Short Term			Long Term			Type	Efficiency [1,2] (%)
					(VMT/hr)	(VMT/day)	(VMT/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$		
Unpaved	Jumbo	Round	2	8	0.667	16.00	5,840	7.43	1.92	0.19	6.17	1.59	0.16	Watering	90%
Unpaved	Bolter	Round	3	8	1.000	24.00	8,760	7.03	1.81	0.18	5.84	1.51	0.15	Watering	90%
Unpaved	Haul Truck	Round	5	60	12.500	300.00	109,500	9.47	2.44	0.24	7.86	2.03	0.20	Watering	90%
Unpaved	LHD	Round	4	16	2.667	64.00	23,360	8.33	2.15	0.21	6.92	1.78	0.18	Watering	90%
Unpaved	Production Drill	Round	2	8	0.667	16.00	5,840	7.87	2.03	0.20	6.53	1.68	0.17	Watering	90%
Unpaved	Slot-Raise Drill	Round	1	8	0.333	8.00	2,920	8.74	2.26	0.23	7.26	1.87	0.19	Watering	90%
Unpaved	Blockholer	Round	1	8	0.333	8.00	2,920	7.68	1.98	0.20	6.38	1.65	0.16	Watering	90%
Unpaved	Powder Truck	Round	2	16	1.333	32.00	11,680	6.29	1.62	0.16	5.22	1.35	0.13	Watering	90%
Unpaved	Grader	Round	1	16	0.667	16.00	5,840	6.09	1.57	0.16	5.06	1.30	0.13	Watering	90%
Unpaved	Lube Truck	Round	1	16	0.667	16.00	5,840	5.55	1.43	0.14	4.61	1.19	0.12	Watering	90%
Unpaved	Shotcrete Sprayer	Round	1	16	0.667	16.00	5,840	6.48	1.67	0.17	5.38	1.39	0.14	Watering	90%
Unpaved	Transit Mixer	Round	2	16	1.333	32.00	11,680	7.31	1.89	0.19	6.07	1.57	0.16	Watering	90%
Unpaved	Scissor Deck	Round	2	16	1.333	32.00	11,680	5.87	1.51	0.15	4.87	1.26	0.13	Watering	90%
Unpaved	Boom Truck	Round	1	16	0.667	16.00	5,840	6.19	1.60	0.16	5.14	1.33	0.13	Watering	90%
Unpaved	Light Vehicle	Round	6	16	4.000	96.00	35,040	3.11	0.80	0.08	2.58	0.67	0.07	Watering	90%
Unpaved	Water Vehicle	Round	1	24	1.000	24.00	8,760	5.99	1.55	0.15	4.97	1.28	0.13	Watering	90%

1. Road Watering is not contemplated every hour, but only as needed to maintain control levels.
2. At South32, the roads will be watered sufficiently to achieve a cont 90%

Lead Content = 0.0000245 kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples

Table A-33b. Clark Roads -Vehicles - Emissions

Vehicle Type	Road Surface	Uncontrolled Emissions												Controlled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]				Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Jumbo	Unpaved	4.96	1.28	0.13	1.21E-04	118.92	30.68	3.07	2.91E-03	18.02	4.65	0.46	4.41E-04	0.50	0.13	0.01	1.21E-05	11.89	3.07	0.31	2.91E-04	1.80	0.46	0.05	4.41E-05
Bolter	Unpaved	7.03	1.81	0.18	1.72E-04	168.81	43.55	4.35	4.14E-03	25.57	6.60	0.66	6.27E-04	0.70	0.18	0.02	1.72E-05	16.88	4.35	0.44	4.14E-04	2.56	0.66	0.07	6.27E-05
Haul Truck	Unpaved	118.32	30.52	3.05	2.90E-03	2839.78	732.58	73.26	0.07	430.23	110.99	11.10	0.01	11.83	3.05	0.31	2.90E-04	283.98	73.26	7.33	6.96E-03	43.02	11.10	1.11	1.05E-03
LHD	Unpaved	22.21	5.73	0.57	5.44E-04	533.15	137.54	13.75	0.01	80.77	20.84	2.08	1.98E-03	2.22	0.57	0.06	5.44E-05	53.32	13.75	1.38	1.31E-03	8.08	2.08	0.21	1.98E-04
Production Drill	Unpaved	5.24	1.35	0.14	1.28E-04	125.88	32.47	3.25	3.08E-03	19.07	4.92	0.49	4.67E-04	0.52	0.14	0.01	1.28E-05	12.59	3.25	0.32	3.08E-04	1.91	0.49	0.05	4.67E-05
Slot-Raise Drill	Unpaved	2.91	0.75	0.08	7.14E-05	69.95	18.04	1.80	1.71E-03	10.60	2.73	0.27	2.60E-04	0.29	0.08	0.01	7.14E-06	6.99	1.80	0.18	1.71E-04	1.06	0.27	0.03	2.60E-05
Blockholer	Unpaved	2.56	0.66	0.07	6.28E-05	61.48	15.86	1.59	1.51E-03	9.31	2.40	0.24	2.28E-04	0.26	0.07	0.01	6.28E-06	6.15	1.59	0.16	1.51E-04	0.93	0.24	0.02	2.28E-05
Powder Truck	Unpaved	8.39	2.16	0.22	2.06E-04	201.32	51.93	5.19	4.93E-03	30.50	7.87	0.79	7.47E-04	0.84	0.22	0.02	2.06E-05	20.13	5.19	0.52	4.93E-04	3.05	0.79	0.08	7.47E-05
Grader	Unpaved	4.06	1.05	0.10	9.95E-05	97.44	25.14	2.51	2.39E-03	14.76	3.81	0.38	3.62E-04	0.41	0.10	0.01	9.95E-06	9.74	2.51	0.25	2.39E-04	1.48	0.38	0.04	3.62E-05
Lube Truck	Unpaved	3.70	0.95	0.10	9.07E-05	88.84	22.92	2.29	2.18E-03	13.46	3.47	0.35	3.30E-04	0.37	0.10	0.01	9.07E-06	8.88	2.29	0.23	2.18E-04	1.35	0.35	0.03	3.30E-05
Shotcrete Sprayer	Unpaved	4.32	1.12	0.11	1.06E-04	103.75	26.77	2.68	2.54E-03	15.72	4.06	0.41	3.85E-04	0.43	0.11	0.01	1.06E-05	10.38	2.68	0.27	2.54E-04	1.57	0.41	0.04	3.85E-05
Transit Mixer	Unpaved	9.75	2.51	0.25	2.39E-04	233.89	60.34	6.03	5.73E-03	35.43	9.14	0.91	8.68E-04	0.97	0.25	0.03	2.39E-05	23.39	6.03	0.60	5.73E-04	3.54	0.91	0.09	8.68E-05
Scissor Deck	Unpaved	7.83	2.02	0.20	1.92E-04	187.90	48.47	4.85	4.60E-03	28.47	7.34	0.73	6.97E-04	0.78	0.20	0.02	1.92E-05	18.79	4.85	0.48	4.60E-04	2.85	0.73	0.07	6.97E-05
Boom Truck	Unpaved	4.13	1.06	0.11	1.01E-04	99.00	25.54	2.55	2.43E-03	15.00	3.87	0.39	3.67E-04	0.41	0.11	0.01	1.01E-05	9.90	2.55	0.26	2.43E-04	1.50	0.39	0.04	3.67E-05
Light Vehicle	Unpaved	12.44	3.21	0.32	3.05E-04	298.53	77.01	7.70	7.31E-03	45.23	11.67	1.17	1.11E-03	1.24	0.32	0.03	3.05E-05	29.85	7.70	0.77	7.31E-04	4.52	1.17	0.12	1.11E-04
Water Vehicle	Unpaved	5.99	1.55	0.15	1.47E-04	143.78	37.09	3.71	3.52E-03	21.78	5.62	0.56	5.34E-04	0.60	0.15	0.02	1.47E-05	14.38	3.71	0.37	3.52E-04	2.18	0.56	0.06	5.34E-05
	Total Emissions	**223.85**	**57.75**	**5.77**	**5.48E-03**	**5,372.41**	**1,385.93**	**138.59**	**1.32E-01**	**813.92**	**209.97**	**21.00**	**1.99E-02**	**22.39**	**5.77**	**0.58**	**5.48E-04**	**537.24**	**138.59**	**13.86**	**1.32E-02**	**81.39**	**21.00**	**2.10**	**1.99E-03**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-34. Truck Pneumatic Loadout Emissions

Emission Point Number	Description	Max Daily Throughput (ton/day)	Max Yearly Throughput (ton/yr)	Hourly Emissions PM (lb/hr)	Hourly Emissions PM_{10} (lb/hr)	Hourly Emissions $PM_{2.5}$ (lb/hr)	Daily Emissions PM (lb/day)	Daily Emissions PM_{10} (lb/day)	Daily Emissions $PM_{2.5}$ (lb/day)	Annual Emissions PM (tpy)	Annual Emissions PM_{10} (tpy)	Annual Emissions $PM_{2.5}$ (tpy)
Taylor												
PP-1	Truck Pneumatic Loadout to Silo 1	235	85,746	9.69E-03	3.33E-03	6.94E-04	2.33E-01	7.99E-02	1.67E-02	4.24E-02	1.46E-02	3.04E-03
PP-2	Truck Pneumatic Loadout to Silo 2	235	85,746	9.69E-03	3.33E-03	6.94E-04	2.33E-01	7.99E-02	1.67E-02	4.24E-02	1.46E-02	3.04E-03
Clark												
PP-3	Truck Pneumatic Loadout to Silo 1	117	42,873	4.85E-03	1.66E-03	3.47E-04	1.16E-01	3.99E-02	8.33E-03	2.12E-02	7.29E-03	1.52E-03
PP-4	Truck Pneumatic Loadout to Silo 2	117	42,873	4.85E-03	1.66E-03	3.47E-04	1.16E-01	3.99E-02	8.33E-03	2.12E-02	7.29E-03	1.52E-03

1. Emission factors based on AP-42 Chapter 11 Section 12, Table 11.12-2.
2. Throughput based on email from South32 on June 14, 2023.

PM	PM10	PM2.5	
0.00099	0.00034	7.09E-05	lb of pollutant/ton of material

k = Particle size multiplier (dimensionless)

PM	PM_{10}	$PM_{2.5}$
0.74	0.35	0.053

TABLE 11.12-2 (ENGLISH UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled Total PM	Uncontrolled Emission Factor Rating	Uncontrolled Total PM_{10}	Uncontrolled Emission Factor Rating	Controlled Total PM	Controlled Emission Factor Rating	Controlled Total PM_{10}	Controlled Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0069	D	0.0033	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0021	D	0.00099	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.73	E	0.47	E	0.00099	D	0.00034	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	3.14	E	1.10	E	0.0089	D	0.0049	E
Weigh hopper loading [e] (3-05-011-08)	0.0048	D	0.0028	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.572 or Eqn. 11.12-1	B	0.156 or Eqn. 11.12-1	B	0.0184 or Eqn. 11.12-1	B	0.0055 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	1.118	B	0.310	B	0.098 or Eqn. 11.12-1	B	0.0263 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

[a] All emission factors are in lb of pollutant per ton of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 1865 lbs course aggregate, 1428 lbs sand, 491 lbs cement and 73 lbs cement supplement. Approximately 20 gallons of water was added to this solid material to produce 4024 lbs (one cubic yard) of concrete.

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.
[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

Reference 10:

Tanker trucks are contracted from outside sources to deliver cement to the storage silos of the Johnson and Erie batch plants. The Johnson plant has a single cement storage silo. The Erie plant has two cement storage silos designated east and west. To transport the cement from the tanker to the silo, a 4-inch flexible line is attached to the rear of the tanker truck. The cement is then pneumatically conveyed to the top of the storage silo. It takes approximately 45-minutes to unload one tanker truck.

Each storage silo has its own dust collector attached to its roof. The dust collectors vent to the atmosphere and are not equipped with any fans or blowers. The air flow out of each silo is a result of the air being displaced by the incoming cement.

Reference 11:

TEST RESULTS

During the test, a truck load of cement (44,340 lbs. net) was conveyed into the cement storage silo being tested, by an air compressor mounted on the truck. The air was exhausted through two identical Tiberi Engineering Company dust collectors mounted on top of the bin. Only one of the dust collectors was tested. The test results are as follows:

Table A-35a. Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1]																Reference
								k			W	s	P	a			b			c			M	
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	(%)	
Unpaved	Personnel Transport Vehicles	Hourly/Daily	3.88	1.00	0.10	lb/VMT	VMT	4.90	1.50	0.15	6.75	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Personnel Transport Vehicles	Annual	3.22	0.83	0.08	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (Surface)	Hourly/Daily	10.33	2.66	0.27	lb/VMT	VMT	4.90	1.50	0.15	59.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (Surface)	Annual	8.57	2.21	0.22	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (On-Highway)	Hourly/Daily	8.54	2.20	0.22	lb/VMT	VMT	4.90	1.50	0.15	39.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (On-Highway)	Annual	7.09	1.83	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Water Truck	Hourly/Daily	9.55	2.46	0.25	lb/VMT	VMT	4.90	1.50	0.15	50.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Water Truck	Annual	7.93	2.04	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Dozer	Hourly/Daily	9.00	2.32	0.23	lb/VMT	VMT	4.90	1.50	0.15	43.90	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Dozer	Annual	7.48	1.93	0.19	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Grader	Hourly/Daily	8.22	2.12	0.21	lb/VMT	VMT	4.90	1.50	0.15	35.86	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Grader	Annual	6.83	1.76	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (UG)	Hourly/Daily	9.46	2.44	0.24	lb/VMT	VMT	4.90	1.50	0.15	49.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (UG)	Annual	7.85	2.03	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck Surface	Hourly/Daily	10.01	2.58	0.26	lb/VMT	VMT	4.90	1.50	0.15	55.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck Surface	Annual	8.31	2.14	0.21	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Fuel Delivery Truck	Hourly/Daily	7.41	1.91	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Fuel Delivery Truck	Annual	6.15	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Transit Mixer	Hourly/Daily	7.30	1.88	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Transit Mixer	Annual	6.06	1.56	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Emulsion delivery/powder truck	Hourly/Daily	6.67	1.72	0.17	lb/VMT	VMT	4.90	1.50	0.15	22.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Emulsion delivery/powder truck	Annual	5.53	1.43	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)

1. Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%)

5.1

Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with South32, 10/14/22.

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.

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Table A-35b. Roads - Controlled Emission Factors

Short Term Controlled Emission Factors (lb/VMT)												
Hourly/Daily	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
Personnel Transport Vehicles	3.88E-01	1.00E-01	1.00E-02	9.50E-06	1.47E-06	9.31E-06	7.75E-07	6.59E-07	1.32E-05	1.09E-05	3.88E-07	9.69E-08
Haul Truck (Surface)	1.03E+00	2.66E-01	2.66E-02	2.53E-05	3.92E-06	2.48E-05	2.07E-06	1.76E-06	3.51E-05	2.89E-05	1.03E-06	2.58E-07
Haul Truck (On-Highway)	8.54E-01	2.20E-01	2.20E-02	2.09E-05	3.24E-06	2.05E-05	1.71E-06	1.45E-06	2.90E-05	2.39E-05	8.54E-07	2.13E-07
Water Truck	9.55E-01	2.46E-01	2.46E-02	2.34E-05	3.63E-06	2.29E-05	1.91E-06	1.62E-06	3.25E-05	2.67E-05	9.55E-07	2.39E-07
Dozer	9.00E-01	2.32E-01	2.32E-02	2.21E-05	3.42E-06	2.16E-05	1.80E-06	1.53E-06	3.06E-05	2.52E-05	9.00E-07	2.25E-07
Grader	8.22E-01	2.12E-01	2.12E-02	2.01E-05	3.12E-06	1.97E-05	1.64E-06	1.40E-06	2.80E-05	2.30E-05	8.22E-07	2.06E-07
Haul Truck (UG)	9.46E-01	2.44E-01	2.44E-02	2.32E-05	3.60E-06	2.27E-05	1.89E-06	1.61E-06	3.22E-05	2.65E-05	9.46E-07	2.37E-07
Haul Truck Surface	1.00E+00	2.58E-01	2.58E-02	2.45E-05	3.80E-06	2.40E-05	2.00E-06	1.70E-06	3.40E-05	2.80E-05	1.00E-06	2.50E-07
Fuel Delivery Truck	7.41E-01	1.91E-01	1.91E-02	1.82E-05	2.82E-06	1.78E-05	1.48E-06	1.26E-06	2.52E-05	2.08E-05	7.41E-07	1.85E-07
Transit Mixer	7.30E-01	1.88E-01	1.88E-02	1.79E-05	2.77E-06	1.75E-05	1.46E-06	1.24E-06	2.48E-05	2.04E-05	7.30E-07	1.82E-07
Emulsion delivery/powder truck	6.67E-01	1.72E-01	1.72E-02	1.63E-05	2.53E-06	1.60E-05	1.33E-06	1.13E-06	2.27E-05	1.87E-05	6.67E-07	1.67E-07

Long Term Controlled Emission Factors (lb/VMT)												
Annual	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
Personnel Transport Vehicles	3.22E-01	8.30E-02	8.30E-03	7.89E-06	1.22E-06	7.73E-06	6.44E-07	5.47E-07	1.09E-05	9.01E-06	3.22E-07	8.05E-08
Haul Truck (Surface)	8.57E-01	2.21E-01	2.21E-02	2.10E-05	3.26E-06	2.06E-05	1.71E-06	1.46E-06	2.91E-05	2.40E-05	8.57E-07	2.14E-07
Haul Truck (On-Highway)	7.09E-01	1.83E-01	1.83E-02	1.74E-05	2.69E-06	1.70E-05	1.42E-06	1.20E-06	2.41E-05	1.98E-05	7.09E-07	1.77E-07
Water Truck	7.93E-01	2.04E-01	2.04E-02	1.94E-05	3.01E-06	1.90E-05	1.59E-06	1.35E-06	2.69E-05	2.22E-05	7.93E-07	1.98E-07
Dozer	7.48E-01	1.93E-01	1.93E-02	1.83E-05	2.84E-06	1.79E-05	1.50E-06	1.27E-06	2.54E-05	2.09E-05	7.48E-07	1.87E-07
Grader	6.83E-01	1.76E-01	1.76E-02	1.67E-05	2.59E-06	1.64E-05	1.37E-06	1.16E-06	2.32E-05	1.91E-05	6.83E-07	1.71E-07
Haul Truck (UG)	7.85E-01	2.03E-01	2.03E-02	1.92E-05	2.98E-06	1.89E-05	1.57E-06	1.34E-06	2.67E-05	2.20E-05	7.85E-07	1.96E-07
Haul Truck Surface	8.31E-01	2.14E-01	2.14E-02	2.04E-05	3.16E-06	1.99E-05	1.66E-06	1.41E-06	2.82E-05	2.33E-05	8.31E-07	2.08E-07
Fuel Delivery Truck	6.15E-01	1.59E-01	1.59E-02	1.51E-05	2.34E-06	1.48E-05	1.23E-06	1.05E-06	2.09E-05	1.72E-05	6.15E-07	1.54E-07
Transit Mixer	6.06E-01	1.56E-01	1.56E-02	1.48E-05	2.30E-06	1.45E-05	1.21E-06	1.03E-06	2.06E-05	1.70E-05	6.06E-07	1.51E-07
Emulsion delivery/powder truck	5.53E-01	1.43E-01	1.43E-02	1.36E-05	2.10E-06	1.33E-05	1.11E-06	9.41E-07	1.88E-05	1.55E-05	5.53E-07	1.38E-07

Metal Content in Surface Soil

Lead	2.45E-05	kg/kg
Antimony	3.80E-06	kg/kg
Arsenic	2.40E-05	kg/kg
Beryllium	2.00E-06	kg/kg
Cadmium	1.70E-06	kg/kg
Chromium	3.40E-05	kg/kg
Nickel	2.80E-05	kg/kg
Selenium	1.00E-06	kg/kg
Mercury	2.50E-07	kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples.

Control Efficiency = 90% At South32, the roads will be watered sufficiently to achieve a control efficiency of 90%.

Table A-36. Roads - Controlled Emission Rates

Segment ID	Hourly (lb/hr) [1] PM	PM10	PM2.5	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	4.80	1.24	0.12	1.18E-04	1.82E-05	1.15E-04	9.60E-06	8.16E-06	1.63E-04	1.34E-04	4.80E-06	1.20E-06
RB	34.94	9.01	0.90	8.56E-04	1.33E-04	8.39E-04	6.99E-05	5.94E-05	1.19E-03	9.78E-04	3.49E-05	8.74E-06
BQ	1.60	0.41	0.04	3.91E-05	6.07E-06	3.83E-05	3.19E-06	2.71E-06	5.43E-05	4.47E-05	1.60E-06	3.99E-07
BM	6.58	1.70	0.17	1.61E-04	2.50E-05	1.58E-04	1.32E-05	1.12E-05	2.24E-04	1.84E-04	6.58E-06	1.64E-06
MT	1.68	0.43	0.04	4.11E-05	6.38E-06	4.03E-05	3.36E-06	2.85E-06	5.71E-05	4.70E-05	1.68E-06	4.20E-07
GB	30.01	7.74	0.77	7.35E-04	1.14E-04	7.20E-04	6.00E-05	5.10E-05	1.02E-03	8.40E-04	3.00E-05	7.50E-06
DB	13.13	3.39	0.34	3.22E-04	4.99E-05	3.15E-04	2.63E-05	2.23E-05	4.46E-04	3.68E-04	1.31E-05	3.28E-06
DE	4.39	1.13	0.11	1.08E-04	1.67E-05	1.05E-04	8.78E-06	7.46E-06	1.49E-04	1.23E-04	4.39E-06	1.10E-06
RD	8.50	2.19	0.22	2.08E-04	3.23E-05	2.04E-04	1.70E-05	1.45E-05	2.89E-04	2.38E-04	8.50E-06	2.13E-06
RH	6.32	1.63	0.16	1.55E-04	2.40E-05	1.52E-04	1.26E-05	1.07E-05	2.15E-04	1.77E-04	6.32E-06	1.58E-06
HC	0.37	0.10	0.01	9.17E-06	1.42E-06	8.98E-06	7.49E-07	6.36E-07	1.27E-05	1.05E-05	3.74E-07	9.36E-08
FH	1.89	0.49	0.05	4.64E-05	7.19E-06	4.54E-05	3.79E-06	3.22E-06	6.43E-05	5.30E-05	1.89E-06	4.73E-07
HI	3.09	0.80	0.08	7.56E-05	1.17E-05	7.41E-05	6.17E-06	5.25E-06	1.05E-04	8.64E-05	3.09E-06	7.72E-07
JI	1.00	0.26	0.03	2.46E-05	3.82E-06	2.41E-05	2.01E-06	1.71E-06	3.42E-05	2.81E-05	1.00E-06	2.51E-07
IL	3.84	0.99	0.10	9.40E-05	1.46E-05	9.21E-05	7.67E-06	6.52E-06	1.30E-04	1.07E-04	3.84E-06	9.59E-07
IK	4.44	1.14	0.11	1.09E-04	1.69E-05	1.07E-04	8.88E-06	7.54E-06	1.51E-04	1.24E-04	4.44E-06	1.11E-06
PR	8.30	2.14	0.21	2.03E-04	3.15E-05	1.99E-04	1.66E-05	1.41E-05	2.82E-04	2.32E-04	8.30E-06	2.07E-06
OP	2.38	0.61	0.06	5.83E-05	9.04E-06	5.71E-05	4.76E-06	4.04E-06	8.09E-05	6.66E-05	2.38E-06	5.95E-07
LP	5.86	1.51	0.15	1.43E-04	2.23E-05	1.41E-04	1.17E-05	9.96E-06	1.99E-04	1.64E-04	5.86E-06	1.46E-06
LA	2.10	0.54	0.05	5.15E-05	7.99E-06	5.04E-05	4.20E-06	3.57E-06	7.15E-05	5.89E-05	2.10E-06	5.25E-07
LB	1.46	0.38	0.04	3.58E-05	5.55E-06	3.50E-05	2.92E-06	2.48E-06	4.96E-05	4.09E-05	1.46E-06	3.65E-07
LC	3.37	0.87	0.09	8.25E-05	1.28E-05	8.08E-05	6.73E-06	5.72E-06	1.14E-04	9.42E-05	3.37E-06	8.41E-07
ST	9.61	2.48	0.248	2.35E-04	3.65E-05	2.31E-04	1.92E-05	1.63E-05	3.27E-04	2.69E-04	9.61E-06	2.40E-06
TU	0.83	0.21	0.02	2.02E-05	3.14E-06	1.98E-05	1.65E-06	1.40E-06	2.81E-05	2.31E-05	8.26E-07	2.07E-07
BP	8.82	2.28	0.23	2.16E-04	3.35E-05	2.12E-04	1.76E-05	1.50E-05	3.00E-04	2.47E-04	8.82E-06	2.21E-06
TP	10.26	2.65	0.26	2.51E-04	3.90E-05	2.46E-04	2.05E-05	1.74E-05	3.49E-04	2.87E-04	1.03E-05	2.56E-06
TV	3.16	0.81	0.08	7.74E-05	1.20E-05	7.58E-05	6.32E-06	5.37E-06	1.07E-04	8.84E-05	3.16E-06	7.90E-07
DP	2.89	0.74	0.07	7.07E-05	1.10E-05	6.93E-05	5.77E-06	4.91E-06	9.81E-05	8.08E-05	2.89E-06	7.22E-07
RS	10.44	2.69	0.27	2.56E-04	3.97E-05	2.50E-04	2.09E-05	1.77E-05	3.55E-04	2.92E-04	1.04E-05	2.61E-06
SV	18.71	4.83	0.48	4.58E-04	7.11E-05	4.49E-04	3.74E-05	3.18E-05	6.36E-04	5.24E-04	1.87E-05	4.68E-06
VC	0.15	0.04	0.00	3.69E-06	5.72E-07	3.61E-06	3.01E-07	2.56E-07	5.12E-06	4.22E-06	1.51E-07	3.76E-08
VB	12.39	3.20	0.320	3.03E-04	4.71E-05	2.97E-04	2.48E-05	2.11E-05	4.21E-04	3.47E-04	1.24E-05	3.10E-06
VD	21.02	5.42	0.54	5.15E-04	7.99E-05	5.05E-04	4.20E-05	3.57E-05	7.15E-04	5.89E-04	2.10E-05	5.26E-06
VW	7.17	1.85	0.18	1.76E-04	2.72E-05	1.72E-04	1.43E-05	1.22E-05	2.44E-04	2.01E-04	7.17E-06	1.79E-06
VX	13.81	3.56	0.36	3.38E-04	5.25E-05	3.31E-04	2.76E-05	2.35E-05	4.70E-04	3.87E-04	1.38E-05	3.45E-06
WY	3.81	0.98	0.10	9.33E-05	1.45E-05	9.14E-05	7.61E-06	6.47E-06	1.29E-04	1.07E-04	3.81E-06	9.52E-07
WX	1.68	0.43	0.04	4.10E-05	6.37E-06	4.02E-05	3.35E-06	2.85E-06	5.70E-05	4.69E-05	1.68E-06	4.19E-07
XB	5.07	1.31	0.13	1.24E-04	1.93E-05	1.22E-04	1.01E-05	8.62E-06	1.72E-04	1.42E-04	5.07E-06	1.27E-06
BC	0.30	0.08	0.01	7.33E-06	1.14E-06	7.18E-06	5.99E-07	5.09E-07	1.02E-05	8.38E-06	2.99E-07	7.48E-08
BZ	2.48	0.64	0.064	6.07E-05	9.42E-06	5.95E-05	4.96E-06	4.21E-06	8.43E-05	6.94E-05	2.48E-06	6.20E-07
ZA	0.14	0.04	0.00	3.34E-06	5.18E-07	3.27E-06	2.72E-07	2.32E-07	4.63E-06	3.81E-06	1.36E-07	3.41E-08
ZY	2.40	0.62	0.062	5.88E-05	9.12E-06	5.76E-05	4.80E-06	4.08E-06	8.16E-05	6.72E-05	2.40E-06	6.00E-07
VA	0.31	0.08	0.01	7.63E-06	1.18E-06	7.48E-06	6.23E-07	5.30E-07	1.06E-05	8.72E-06	3.12E-07	7.79E-08
XA	0.94	0.24	0.024	2.31E-05	3.58E-06	2.26E-05	1.89E-06	1.60E-06	3.20E-05	2.64E-05	9.43E-07	2.36E-07
YA	0.97	0.25	0.02	2.37E-05	3.67E-06	2.32E-05	1.93E-06	1.64E-06	3.28E-05	2.70E-05	9.66E-07	2.41E-07
Total Emissions	**287.36**	**74.13**	**7.41**	**7.04E-03**	**1.09E-03**	**6.90E-03**	**5.75E-04**	**4.89E-04**	**9.77E-03**	**8.05E-03**	**2.87E-04**	**7.18E-05**

Segment ID	Daily (lb/day) [1] PM	PM10	PM2.5	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	21.82	5.63	0.56	5.35E-04	8.29E-05	5.24E-04	4.36E-05	3.71E-05	7.42E-04	6.11E-04	2.18E-05	5.46E-06
RB	188.63	48.66	4.87	4.62E-03	7.17E-04	4.53E-03	3.77E-04	3.21E-04	6.41E-03	5.28E-03	1.89E-04	4.72E-05
BQ	4.46	1.15	0.12	1.09E-04	1.69E-05	1.07E-04	8.92E-06	7.58E-06	1.52E-04	1.25E-04	4.46E-06	1.11E-06
BM	61.31	15.82	1.58	1.50E-03	2.33E-04	1.47E-03	1.23E-04	1.04E-04	2.08E-03	1.72E-03	6.13E-05	1.53E-05
MT	5.31	1.37	0.14	1.30E-04	2.02E-05	1.27E-04	1.06E-05	9.02E-06	1.80E-04	1.49E-04	5.31E-06	1.33E-06
GB	312.53	80.62	8.06	7.66E-03	1.19E-03	7.50E-03	6.25E-04	5.31E-04	1.06E-02	8.75E-03	3.13E-04	7.81E-05
DB	90.16	23.26	2.33	2.21E-03	3.43E-04	2.16E-03	1.80E-04	1.53E-04	3.07E-03	2.52E-03	9.02E-05	2.25E-05
DE	33.40	8.62	0.86	8.18E-04	1.27E-04	8.02E-04	6.68E-05	5.68E-05	1.14E-03	9.35E-04	3.34E-05	8.35E-06
RD	74.10	19.12	1.91	1.82E-03	2.82E-04	1.78E-03	1.48E-04	1.26E-04	2.52E-03	2.07E-03	7.41E-05	1.85E-05
RH	69.04	17.81	1.78	1.69E-03	2.62E-04	1.66E-03	1.38E-04	1.17E-04	2.35E-03	1.93E-03	6.90E-05	1.73E-05
HC	3.67	0.95	0.09	8.98E-05	1.39E-05	8.80E-05	7.33E-06	6.23E-06	1.25E-04	1.03E-04	3.67E-06	9.16E-07
FH	7.31	1.89	0.19	1.79E-04	2.78E-05	1.76E-04	1.46E-05	1.24E-05	2.49E-04	2.05E-04	7.31E-06	1.83E-06
HI	38.74	10.00	1.00	9.49E-04	1.47E-04	9.30E-04	7.75E-05	6.59E-05	1.32E-03	1.08E-03	3.87E-05	9.69E-06
JI	8.27	2.13	0.21	2.03E-04	3.14E-05	1.98E-04	1.65E-05	1.41E-05	2.81E-04	2.32E-04	8.27E-06	2.07E-06
IL	38.99	10.06	1.01	9.55E-04	1.48E-04	9.36E-04	7.80E-05	6.63E-05	1.33E-03	1.09E-03	3.90E-05	9.75E-06
IK	40.97	10.57	1.06	1.00E-03	1.56E-04	9.83E-04	8.19E-05	6.96E-05	1.39E-03	1.15E-03	4.10E-05	1.02E-05
PR	19.11	4.93	0.49	4.68E-04	7.26E-05	4.59E-04	3.82E-05	3.25E-05	6.50E-04	5.35E-04	1.91E-05	4.78E-06
OP	6.50	1.68	0.17	1.59E-04	2.47E-05	1.56E-04	1.30E-05	1.11E-05	2.21E-04	1.82E-04	6.50E-06	1.63E-06
LP	17.05	4.40	0.44	4.18E-04	6.48E-05	4.09E-04	3.41E-05	2.90E-05	5.80E-04	4.77E-04	1.70E-05	4.26E-06
LA	6.65	1.71	0.17	1.63E-04	2.53E-05	1.60E-04	1.33E-05	1.13E-05	2.26E-04	1.86E-04	6.65E-06	1.66E-06
LB	5.85	1.51	0.15	1.43E-04	2.22E-05	1.40E-04	1.17E-05	9.95E-06	1.99E-04	1.64E-04	5.85E-06	1.46E-06
LC	11.92	3.08	0.31	2.92E-04	4.53E-05	2.86E-04	2.38E-05	2.03E-05	4.05E-04	3.34E-04	1.19E-05	2.98E-06
ST	31.63	8.16	0.82	7.75E-04	1.20E-04	7.59E-04	6.33E-05	5.38E-05	1.08E-03	8.86E-04	3.16E-05	7.91E-06
TU	3.04	0.78	0.08	7.45E-05	1.16E-05	7.30E-05	6.08E-06	5.17E-06	1.03E-04	8.52E-05	3.04E-06	7.60E-07
BP	28.72	7.41	0.74	7.04E-04	1.09E-04	6.89E-04	5.74E-05	4.88E-05	9.76E-04	8.04E-04	2.87E-05	7.18E-06
TP	33.39	8.61	0.86	8.18E-04	1.27E-04	8.01E-04	6.68E-05	5.68E-05	1.14E-03	9.35E-04	3.34E-05	8.35E-06
TV	15.15	3.91	0.39	3.71E-04	5.76E-05	3.64E-04	3.03E-05	2.58E-05	5.15E-04	4.24E-04	1.52E-05	3.79E-06
DP	13.85	3.57	0.36	3.39E-04	5.26E-05	3.32E-04	2.77E-05	2.35E-05	4.71E-04	3.88E-04	1.38E-05	3.46E-06
RS	35.34	9.12	0.91	8.66E-04	1.34E-04	8.48E-04	7.07E-05	6.01E-05	1.20E-03	9.89E-04	3.53E-05	8.83E-06
SV	63.62	16.41	1.64	1.56E-03	2.42E-04	1.53E-03	1.27E-04	1.08E-04	2.16E-03	1.78E-03	6.36E-05	1.59E-05
VC	0.61	0.16	0.02	1.50E-05	2.33E-06	1.47E-05	1.23E-06	1.04E-06	2.08E-05	1.72E-05	6.13E-07	1.53E-07
VB	42.93	11.07	1.11	1.05E-03	1.63E-04	1.03E-03	8.59E-05	7.30E-05	1.46E-03	1.20E-03	4.29E-05	1.07E-05
VD	76.22	19.66	1.97	1.87E-03	2.90E-04	1.83E-03	1.52E-04	1.30E-04	2.59E-03	2.13E-03	7.62E-05	1.91E-05
VW	30.95	7.98	0.80	7.58E-04	1.18E-04	7.43E-04	6.19E-05	5.26E-05	1.05E-03	8.67E-04	3.09E-05	7.74E-06
VX	102.87	26.54	2.65	2.52E-03	3.91E-04	2.47E-03	2.06E-04	1.75E-04	3.50E-03	2.88E-03	1.03E-04	2.57E-05
WY	16.98	4.38	0.44	4.16E-04	6.45E-05	4.08E-04	3.40E-05	2.89E-05	5.77E-04	4.75E-04	1.70E-05	4.25E-06
WX	5.81	1.50	0.15	1.42E-04	2.21E-05	1.39E-04	1.16E-05	9.87E-06	1.97E-04	1.63E-04	5.81E-06	1.45E-06
XB	18.60	4.80	0.48	4.56E-04	7.07E-05	4.46E-04	3.72E-05	3.16E-05	6.32E-04	5.21E-04	1.86E-05	4.65E-06
BC	1.14	0.29	0.03	2.79E-05	4.33E-06	2.73E-05	2.28E-06	1.94E-06	3.87E-05	3.19E-05	1.14E-06	2.85E-07
BZ	15.59	4.02	0.40	3.82E-04	5.92E-05	3.74E-04	3.12E-05	2.65E-05	5.30E-04	4.36E-04	1.56E-05	3.90E-06
ZA	0.93	0.24	0.02	2.29E-05	3.55E-06	2.24E-05	1.87E-06	1.59E-06	3.18E-05	2.62E-05	9.34E-07	2.34E-07
ZY	15.09	3.89	0.39	3.70E-04	5.73E-05	3.62E-04	3.02E-05	2.56E-05	5.13E-04	4.22E-04	1.51E-05	3.77E-06
VA	1.99	0.51	0.05	4.88E-05	7.57E-06	4.78E-05	3.98E-06	3.39E-06	6.77E-05	5.58E-05	1.99E-06	4.98E-07
XA	6.03	1.55	0.16	1.48E-04	2.29E-05	1.45E-04	1.21E-05	1.02E-05	2.05E-04	1.69E-04	6.03E-06	1.51E-06
YA	6.18	1.59	0.16	1.51E-04	2.35E-05	1.48E-04	1.24E-05	1.05E-05	2.10E-04	1.73E-04	6.18E-06	1.54E-06
Total Emissions	**1,632.42**	**421.12**	**42.11**	**4.00E-02**	**6.20E-03**	**3.92E-02**	**3.26E-03**	**2.78E-03**	**5.55E-02**	**4.57E-02**	**1.63E-03**	**4.08E-04**

Segment ID	Annual (tpy) [2] PM	PM10	PM2.5	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	2.78	0.72	0.07	6.80E-05	1.05E-05	6.66E-05	5.55E-06	4.72E-06	9.44E-05	7.77E-05	2.78E-06	6.94E-07
RB	22.71	5.86	0.59	5.56E-04	8.63E-05	5.45E-04	4.54E-05	3.86E-05	7.72E-04	6.36E-04	2.27E-05	5.68E-06
BQ	0.61	0.16	0.02	1.50E-05	2.32E-06	1.47E-05	1.22E-06	1.04E-06	2.08E-05	1.71E-05	6.11E-07	1.53E-07
BM	5.97	1.54	0.15	1.46E-04	2.27E-05	1.43E-04	1.19E-05	1.02E-05	2.03E-04	1.67E-04	5.97E-06	1.49E-06
MT	0.75	0.19	0.02	1.84E-05	2.85E-06	1.80E-05	1.50E-06	1.27E-06	2.55E-05	2.10E-05	7.49E-07	1.87E-07
GB	31.99	8.25	0.83	7.84E-04	1.22E-04	7.68E-04	6.40E-05	5.44E-05	1.09E-03	8.96E-04	3.20E-05	8.00E-06
DB	9.93	2.56	0.26	2.43E-04	3.77E-05	2.38E-04	1.99E-05	1.69E-05	3.37E-04	2.78E-04	9.93E-06	2.48E-06
DE	2.42	0.62	0.06	5.93E-05	9.19E-06	5.80E-05	4.84E-06	4.11E-06	8.22E-05	6.77E-05	2.42E-06	6.05E-07
RD	5.95	1.53	0.15	1.46E-04	2.26E-05	1.43E-04	1.19E-05	1.01E-05	2.02E-04	1.66E-04	5.95E-06	1.49E-06
RH	5.62	1.45	0.15	1.38E-04	2.14E-05	1.35E-04	1.12E-05	9.56E-06	1.91E-04	1.57E-04	5.62E-06	1.41E-06
HC	0.30	0.08	0.01	7.46E-06	1.16E-06	7.31E-06	6.09E-07	5.18E-07	1.04E-05	8.53E-06	3.05E-07	7.61E-08
FH	1.06	0.27	0.03	2.60E-05	4.04E-06	2.55E-05	2.12E-06	1.81E-06	3.61E-05	2.97E-05	1.06E-06	2.65E-07
HI	2.55	0.66	0.07	6.24E-05	9.68E-06	6.11E-05	5.09E-06	4.33E-06	8.66E-05	7.13E-05	2.55E-06	6.37E-07
JI	0.43	0.11	0.01	1.06E-05	1.65E-06	1.04E-05	8.67E-07	7.37E-07	1.47E-05	1.21E-05	4.33E-07	1.08E-07
IL	1.68	0.43	0.04	4.11E-05	6.38E-06	4.03E-05	3.36E-06	2.85E-06	5.71E-05	4.70E-05	1.68E-06	4.20E-07
IK	6.16	1.59	0.16	1.51E-04	2.34E-05	1.48E-04	1.23E-05	1.05E-05	2.09E-04	1.72E-04	6.16E-06	1.54E-06
PR	2.34	0.60	0.06	5.73E-05	8.88E-06	5.61E-05	4.68E-06	3.97E-06	7.95E-05	6.55E-05	2.34E-06	5.84E-07
OP	0.86	0.22	0.02	2.11E-05	3.28E-06	2.07E-05	1.73E-06	1.47E-06	2.93E-05	2.42E-05	8.63E-07	2.16E-07
LP	2.34	0.60	0.06	5.73E-05	8.89E-06	5.61E-05	4.68E-06	3.98E-06	7.95E-05	6.55E-05	2.34E-06	5.85E-07
LA	0.92	0.24	0.02	2.26E-05	3.50E-06	2.21E-05	1.84E-06	1.57E-06	3.13E-05	2.58E-05	9.22E-07	2.30E-07
LB	0.89	0.23	0.02	2.17E-05	3.37E-06	2.13E-05	1.77E-06	1.51E-06	3.02E-05	2.48E-05	8.87E-07	2.22E-07
LC	1.78	0.46	0.05	4.36E-05	6.77E-06	4.27E-05	3.56E-06	3.03E-06	6.06E-05	4.99E-05	1.78E-06	4.45E-07
ST	3.50	0.90	0.09	8.58E-05	1.33E-05	8.41E-05	7.01E-06	5.96E-06	1.19E-04	9.81E-05	3.50E-06	8.76E-07
TU	0.45	0.12	0.01	1.10E-05	1.70E-06	1.08E-05	8.96E-07	7.62E-07	1.52E-05	1.25E-05	4.48E-07	1.12E-07
BP	3.19	0.82	0.08	7.81E-05	1.21E-05	7.65E-05	6.37E-06	5.42E-06	1.08E-04	8.92E-05	3.19E-06	7.97E-07
TP	3.71	0.96	0.10	9.08E-05	1.41E-05	8.89E-05	7.41E-06	6.30E-06	1.26E-04	1.04E-04	3.71E-06	9.26E-07
TV	2.30	0.59	0.06	5.62E-05	8.72E-06	5.51E-05	4.59E-06	3.90E-06	7.80E-05	6.43E-05	2.30E-06	5.74E-07
DP	2.10	0.54	0.05	5.14E-05	7.97E-06	5.03E-05	4.20E-06	3.57E-06	7.13E-05	5.87E-05	2.10E-06	5.24E-07
RS	4.23	1.09	0.11	1.04E-04	1.61E-05	1.01E-04	8.45E-06	7.18E-06	1.44E-04	1.18E-04	4.23E-06	1.06E-06
SV	7.75	2.00	0.20	1.90E-04	2.95E-05	1.86E-04	1.55E-05	1.32E-05	2.64E-04	2.17E-04	7.75E-06	1.94E-06
VC	0.08	0.02	0.00	2.07E-06	3.22E-07	2.03E-06	1.69E-07	1.44E-07	2.88E-06	2.37E-06	8.47E-08	2.12E-08
VB	5.25	1.36	0.14	1.29E-04	2.00E-05	1.26E-04	1.05E-05	8.93E-06	1.79E-04	1.47E-04	5.25E-06	1.31E-06
VD	9.23	2.38	0.24	2.26E-04	3.51E-05	2.22E-04	1.85E-05	1.57E-05	3.14E-04	2.59E-04	9.23E-06	2.31E-06
VW	4.53	1.17	0.12	1.11E-04	1.72E-05	1.09E-04	9.06E-06	7.70E-06	1.54E-04	1.27E-04	4.53E-06	1.13E-06
VX	12.60	3.25	0.33	3.09E-04	4.79E-05	3.02E-04	2.52E-05	2.14E-05	4.29E-04	3.53E-04	1.26E-05	3.15E-06
WY	2.52	0.65	0.07	6.18E-05	9.58E-06	6.05E-05	5.04E-06	4.29E-06	8.57E-05	7.06E-05	2.52E-06	6.30E-07
WX	0.81	0.21	0.02	1.99E-05	3.09E-06	1.95E-05	1.63E-06	1.38E-06	2.76E-05	2.28E-05	8.13E-07	2.03E-07
XB	2.59	0.67	0.07	6.35E-05	9.86E-06	6.22E-05	5.19E-06	4.41E-06	8.82E-05	7.26E-05	2.59E-06	6.48E-07
BC	0.16	0.04	0.00	3.89E-06	6.03E-07	3.81E-06	3.18E-07	2.70E-07	5.40E-06	4.45E-06	1.59E-07	3.97E-08
BZ	2.28	0.59	0.06	5.59E-05	8.68E-06	5.48E-05	4.57E-06	3.88E-06	7.76E-05	6.39E-05	2.28E-06	5.71E-07
ZA	0.14	0.04	0.00	3.35E-06	5.20E-07	3.28E-06	2.74E-07	2.33E-07	4.65E-06	3.83E-06	1.37E-07	3.42E-08
ZY	2.21	0.57	0.06	5.41E-05	8.40E-06	5.30E-05	4.42E-06	3.76E-06	7.51E-05	6.19E-05	2.21E-06	5.53E-07
VA	0.30	0.08	0.01	7.28E-06	1.13E-06	7.13E-06	5.94E-07	5.05E-07	1.01E-05	8.32E-06	2.97E-07	7.43E-08
XA	0.90	0.23	0.02	2.20E-05	3.42E-06	2.16E-05	1.80E-06	1.53E-06	3.06E-05	2.52E-05	8.99E-07	2.25E-07
YA	0.92	0.24	0.02	2.26E-05	3.50E-06	2.21E-05	1.84E-06	1.57E-06	3.13E-05	2.58E-05	9.21E-07	2.30E-07
Total Emissions	**181.79**	**46.90**	**4.69**	**4.45E-03**	**6.91E-04**	**4.36E-03**	**3.64E-04**	**3.09E-04**	**6.18E-03**	**5.09E-03**	**1.82E-04**	**4.54E-05**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency. Hourly emissions are calculated as the daily emissions divided by 24 hours.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-37. Roads - Segments

Origin	Destination	Material	Vehicle	Annual Trips[1] (trips/yr)	Daily Trips (trips/day)[1]	Hourly Trips (trips/hour)[1]	Surface	Unpaved																																												
							Number of Objects	4	34	7	10	8	45	12	8	10	10	1	7	6	4	13	19	26	14	28	10	15	20	19	9	15	21	25	29	10	22	1	12	26	6	35	5	6	42	3	41	2	41	3	10	11
							Segment Length (mi)	0.04	0.38	0.07	0.11	0.10	0.50	0.14	0.09	0.11	0.11	0.02	0.07	0.08	0.05	0.16	0.21	0.28	0.11	0.29	0.12	0.12	0.22	0.20	0.06	0.18	0.21	0.31	0.29	0.10	0.20	0.01	0.14	0.25	0.08	0.41	0.05	0.05	0.32	0.02	0.31	0.02	0.30	0.04	0.12	0.12
							Segment ID	AR	RB	BQ	BM	MT	GB	DB	DE	RD	RH	HC	FH	HI	JI	IL	IK	PR	OP	LP	LA	LB	LC	ST	TU	BP	TP	TV	DP	RS	SV	VC	VB	VD	VW	VX	WY	WX	XB	BC	BZ	ZA	ZY	VA	XA	YA
Harshaw Option#1	Admin (Taylor) Option#1	Personnel	Personnel Transport Vehicles	876	3	3		X	X					X		X	X		X																																	
Harshaw Option#2	Admin (Taylor) Option#2	Personnel	Personnel Transport Vehicles	219	1	1		X						X		X	X		X											X		X	X			X																
Harshaw Option#1	Vehicle Maintenance Shop (Taylor) Option#1	Personnel	Personnel Transport Vehicles	292	1	1		X	X	X																																										
Harshaw Option#2	Vehicle Maintenance Shop (Taylor) Option#2	Personnel	Personnel Transport Vehicles	73	1	1		X		X																				X		X	X			X																
Harshaw	Admin (Clark)	Personnel	Personnel Transport Vehicles	1095	3	3		X																												X	X		X	X	X		X									
Harshaw	Vehicle Maintenance Shop (Clark)	Personnel	Personnel Transport Vehicles	365	1	1		X																												X	X	X														
Harshaw	Portal	Personnel	Personnel Transport Vehicles	7300	20	10		X																												X	X		X	X	X		X									
Harshaw	Bluff	Personnel	Personnel Transport Vehicles	365	1	1		X																												X	X		X	X	X			X	X		X		X			
Harshaw	Alta	Personnel	Personnel Transport Vehicles	1095	3	3		X																												X	X	X	X													
Harshaw	Portal	Chemicals	Haul Truck (On-Highway)	24	1	1		X																												X	X	X	X	X	X		X									
Harshaw	Clark Truck Shop (Alta)	Tires	Haul Truck (On-Highway)	14	1	1		X																												X	X	X														
Harshaw	Paste Plant	Cement	Haul Truck (On-Highway)	1230	4	4		X																												X	X		X	X	X			X								
Harshaw Option#1	Explosives Magazine (Trench) Option#1	Emulsions	Emulsion delivery/powder truck	24	1	1		X	X					X		X								X	X																											
Harshaw Option#2	Explosives Magazine (Trench) Option#2	Emulsions	Emulsion delivery/powder truck	6	1	1		X						X		X								X	X					X		X	X			X																
Explosives Magazine (Trench) Option#1	Portal Option#1	Emulsions	Emulsion delivery/powder truck	292	1	1			X					X		X								X	X											X	X		X	X	X		X									
Explosives Magazine (Trench) Option#2	Portal Option#2	Emulsions	Emulsion delivery/powder truck	73	1	1								X		X								X	X					X		X	X				X		X	X	X		X									
Filtration Plant Option#1	Paste Plant Option#1	Tailings (Taylor)	Haul Truck Surface	7480	21	4			X		X																									X	X		X	X	X			X								
Filtration Plant Option#2	Paste Plant Option#2	Tailings (Taylor)	Haul Truck Surface	1870	6	1					X																			X		X	X				X		X	X	X			X								
Harshaw	Portal	Misc.	Haul Truck (On-Highway)	730	2	2		X																												X	X		X	X	X		X									
Portal	Crusher	Ore	Haul Truck (UG)	17510	48	4																																		X	X		X									
Crusher	Harshaw	Ore	Haul Truck (On-Highway)	21888	60	8		X																												X	X		X													
Portal	Hardshell Stockpile	NAG	Haul Truck (UG)	29857	82	10																																			X	X	X									
Portal Option#1	onsite TSF Option#1	PAG	Haul Truck (UG)	2388	7	7			X				X																							X	X		X	X	X		X									
Portal Option#2	onsite TSF Option#2	PAG	Haul Truck (UG)	597	2	2							X																	X		X	X				X		X	X	X		X									
Harshaw	Portal	Fuel (Diesel)	Fuel Delivery Truck	598	2	2		X																												X	X		X	X	X		X									
Harshaw	Concrete Batch Plant	Raw materials concrete (sand, aggregate, cement)	Haul Truck (On-Highway)	104	2	2		X																												X	X		X	X	X			X	X	X						
Concrete Batch Plant	Portal	Concrete	Transit Mixer	1095	3	3																																					X	X	X	X						
Harshaw	Alta, Hardshell, Bluff (all areas)	Potable Water Delivery	Haul Truck (On-Highway)	12	1	1		X																												X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Admin (Taylor) Option#1	Clark Wells Option#1	Well Checks	Personnel Transport Vehicles	292	1	1			X					X		X	X		X																	X	X		X	X	X		X	X						X	X	X
Admin (Taylor) Option#2	Clark Wells Option#2	Well Checks	Personnel Transport Vehicles	73	1	1								X		X	X		X											X		X	X				X		X	X	X		X	X						X	X	X
Admin (Clark)	Clark Wells	-	Personnel Transport Vehicles	365	1	1																																		X	X		X	X						X	X	X
Alta, Hardshell, Bluff	Alta, Hardshell, Bluff	-	Grader	365	1	1																														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Alta, Hardshell, Bluff	Alta, Hardshell, Bluff	Road Water	Water Truck	8760	24	2																														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Harshaw Option#1	Shaft Option#1	Personnel	Personnel Transport Vehicles	10357	29	8		X	X					X	X																																					
Harshaw Option#2	Shaft Option#2	Personnel	Personnel Transport Vehicles	2590	8	2		X						X	X															X		X	X			X																
Harshaw Option#1	Vehicle Maintenance Option#1	Personnel	Personnel Transport Vehicles	979	3	1		X	X	X																																										
Harshaw Option#2	Vehicle Maintenance Option#2	Personnel	Personnel Transport Vehicles	245	1	1		X		X																				X		X	X			X																
Harshaw Option#1	Admin Option#1	Personnel	Personnel Transport Vehicles	3414	10	2		X	X					X		X	X		X																																	
Harshaw Option#2	Admin Option#2	Personnel	Personnel Transport Vehicles	854	3	1		X						X		X	X		X											X		X	X			X																
Harshaw Option#1	WTP1 Option#1	Personnel	Personnel Transport Vehicles	58	1	1		X	X					X		X								X		X	X																									
Harshaw Option#2	WTP1 Option#2	Personnel	Personnel Transport Vehicles	15	1	1		X						X		X								X		X	X			X		X	X			X																
Harshaw Option#1	Concentrator Option#1	Personnel	Personnel Transport Vehicles	3299	10	2		X	X					X		X	X			X		X																														
Harshaw Option#2	Concentrator Option#2	Personnel	Personnel Transport Vehicles	825	3	1		X						X		X	X			X		X								X		X	X			X																
Harshaw Option#1	Paste Plant Option#1	Personnel	Personnel Transport Vehicles	135	1	1		X	X		X																																									
Harshaw Option#2	Paste Plant Option#2	Personnel	Personnel Transport Vehicles	34	1	1		X			X																			X		X	X			X																
Harshaw Option#1	Filtration Plant Option#1	Personnel	Personnel Transport Vehicles	135	1	1		X	X		X																																									
Harshaw Option#2	Filtration Plant Option#2	Personnel	Personnel Transport Vehicles	34	1	1		X			X																			X		X	X			X																
Harshaw Option#1	WTP2 Option#1	Personnel	Personnel Transport Vehicles	154	1	1		X	X		X	X																																								
Harshaw Option#2	WTP2 Option#2	Personnel	Personnel Transport Vehicles	39	1	1		X			X	X																		X		X	X			X																
Harshaw Option#1	Vent Raise Option#1	Personnel	Personnel Transport Vehicles	39	1	1		X	X																						X																					
Harshaw Option#2	Vent Raise Option#2	Personnel	Personnel Transport Vehicles	10	1	1		X																						X	X	X	X			X																
Harshaw Option#1	Portal Pad (core facility) Option#1	Personnel	Personnel Transport Vehicles	595	2	2		X	X					X		X								X		X			X																							
Harshaw Option#2	Portal Pad (core facility) Option#2	Personnel	Personnel Transport Vehicles	149	1	1		X						X		X								X		X			X	X		X	X			X																
Harshaw	Trench (all areas)	Potable Water Delivery	Haul Truck (On-Highway)	732	2	2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																			
Harshaw Option#1	Shaft, concentrator, WTP2 Option#1	Chemicals	Haul Truck (On-Highway)	125	1	1		X	X		X	X		X	X	X	X			X		X																														
Harshaw Option#2	Shaft, concentrator, WTP2 Option#2	Chemicals	Haul Truck (On-Highway)	32	1	1		X			X	X		X	X	X	X			X		X								X		X	X			X																
Harshaw Option#1	WTP1 Option#1	Water Treatment Chemicals	Haul Truck (On-Highway)	12	1	1		X	X					X		X								X		X	X																									
Harshaw Option#2	WTP1 Option#2	Water Treatment Chemicals	Haul Truck (On-Highway)	3	1	1		X						X		X								X		X	X			X		X	X			X																
Harshaw Option#1	Vehicle Maintenance Shop Option#1	Tires	Haul Truck (On-Highway)	42	1	1		X	X	X																																										
Harshaw Option#2	Vehicle Maintenance Shop Option#2	Tires	Haul Truck (On-Highway)	11	1	1		X		X																				X		X	X			X																
Harshaw Option#1	Paste Plant Option#1	Cement	Haul Truck (On-Highway)	42	1	1		X	X		X																																									
Harshaw Option#2	Paste Plant Option#2	Cement	Haul Truck (On-Highway)	11	1	1		X			X																			X		X	X			X																
Harshaw Option#1	Explosives Magazine (Trench) Option#1	Emulsions	Emulsion delivery/powder truck	42	1	1		X	X					X		X								X	X																											
Harshaw Option#2	Explosives Magazine (Trench) Option#2	Emulsions	Emulsion delivery/powder truck	11	1	1		X						X		X								X	X					X		X	X			X																
Explosives Magazine (Trench)	Shaft	Emulsions	Emulsion delivery/powder truck	52	1	1									X	X								X	X																											
Concentrator Option#1	Harshaw Option#1	Concentrate	Haul Truck (On-Highway)	24546	68	4		X	X					X		X	X			X			X																													
Concentrator Option#2	Harshaw Option#2	Concentrate	Haul Truck (On-Highway)	6137	17	1		X						X		X	X			X			X							X		X	X			X																
Filtration Plant	onsite TSF	Tailings	Haul Truck Surface	48183	217	11					X		X																																							
Shaft	onsite TSF	PAG	Haul Truck Surface	16081	58	3							X	X	X																																					
Shaft	East/West Stockpile	NAG	Haul Truck Surface	1319	58	3									X	X	X	X		X	X																															
Shaft Option#1	Hardshell Stockpile Option#1	NAG	Haul Truck Surface	452	20	3			X					X	X																					X	X		X	X		X										
Shaft Option#2	Hardshell Stockpile Option#2	NAG	Haul Truck Surface	113	5	1								X	X															X		X	X				X		X	X		X										
Harshaw Option#1	Fuel Station Option#1	Fuel (Diesel)	Fuel Delivery Truck	293	1	1		X	X	X																																										
Harshaw Option#2	Fuel Station Option#2	Fuel (Diesel)	Fuel Delivery Truck	74	1	1		X		X																				X		X	X			X																
Harshaw	VoltaGrid Pad	Fuel CNG (self gen)	Fuel Delivery Truck	18615	51	3		X	X					X		X	X	X																																		
Taylor Stockpile	Taylor Stockpile	Dozer	Dozer	52	1	1							X	X		X	X	X		X	X																															
Harshaw Option#1	Admin Option#1	Misc.	Haul Truck (On-Highway)	5280	15	2		X	X					X		X	X		X																																	
Harshaw Option#2	Admin Option#2	Misc.	Haul Truck (On-Highway)	1320	4	1		X						X		X	X		X											X		X	X			X																
Harshaw Option#1	Concrete Batch Plant Option#1	Raw materials concrete (sand, aggregate, cement)	Haul Truck (On-Highway)	4940	40	3		X	X					X																																						
Harshaw Option#2	Concrete Batch Plant Option#2	Raw materials concrete (sand, aggregate, cement)	Haul Truck (On-Highway)	1235	10	1		X						X																X		X	X			X																
Concrete Batch Plant	Shaft	Concrete	Transit Mixer	1950	15	4									X																																					
Concrete Batch Plant	Concentrator Pad	Concrete	Transit Mixer	2438	125	4										X	X			X		X																														
Concrete Batch Plant	Tailings/Paste Pad	Concrete	Transit Mixer	878	19	4					X			X																																						
Admin	Taylor Wells	-	Personnel Transport Vehicles	365	1	1								X		X	X		X													X	X	X	X																	
Trench	Trench	-	Grader	365	1	1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	
Trench	Trench	Road Water	Water Truck	8760	24	4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	

1. Trip origin, destination, material, vehicle, number of trips/day and trips/yr per RFI received from South32 on 07/12/2023.

Table A-38. Roads - Emission by Segments

Segment ID	Objects per Segment	PM_{10} (lbs/day)		$PM_{2.5}$ (lbs/day)		$PM_{2.5}$ (tons/yr)		Lead (lbs/day)		Weighted Vehicle Height (m)
		Total	Model (g/s/object)	Total	Model (g/s/object)	Total	Model (g/s/object)	Total	Model (g/s/object)	
AR	4	5.63	7.39E-03	0.56	7.39E-04	0.07	5.15E-04	0.0005	7.02E-07	2.45
RB	34	48.66	7.51E-03	4.87	7.51E-04	0.59	4.96E-04	0.0046	7.14E-07	2.74
BQ	7	1.15	8.63E-04	0.12	8.63E-05	0.02	6.48E-05	0.0001	8.19E-08	3.39
BM	10	15.82	8.30E-03	1.58	8.30E-04	0.15	4.43E-04	0.0015	7.89E-07	3.82
MT	8	1.37	8.98E-04	0.14	8.98E-05	0.02	6.95E-05	0.0001	8.53E-08	3.55
GB	45	80.62	9.41E-03	8.06	9.41E-04	0.83	5.28E-04	0.0077	8.93E-07	3.81
DB	12	23.26	1.02E-02	2.33	1.02E-03	0.26	6.14E-04	0.0022	9.66E-07	2.76
DE	8	8.62	5.65E-03	0.86	5.65E-04	0.06	2.24E-04	0.0008	5.37E-07	3.20
RD	10	19.12	1.00E-02	1.91	1.00E-03	0.15	4.41E-04	0.0018	9.53E-07	2.70
RH	10	17.81	9.35E-03	1.78	9.35E-04	0.15	4.17E-04	0.0017	8.88E-07	2.71
HC	1	0.95	4.96E-03	0.09	4.96E-04	0.01	2.26E-04	0.0001	4.72E-07	3.65
FH	7	1.89	1.42E-03	0.19	1.42E-04	0.03	1.13E-04	0.0002	1.34E-07	2.76
HI	6	10.00	8.75E-03	1.00	8.75E-04	0.07	3.15E-04	0.0009	8.31E-07	2.51
JI	4	2.13	2.80E-03	0.21	2.80E-04	0.01	8.04E-05	0.0002	2.66E-07	3.64
IL	13	10.06	4.06E-03	1.01	4.06E-04	0.04	9.58E-05	0.0010	3.86E-07	3.03
IK	19	10.57	2.92E-03	1.06	2.92E-04	0.16	2.40E-04	0.0010	2.77E-07	2.51
PR	26	4.93	9.95E-04	0.49	9.95E-05	0.06	6.67E-05	0.0005	9.45E-08	3.46
OP	14	1.68	6.29E-04	0.17	6.29E-05	0.02	4.57E-05	0.0002	5.98E-08	3.57
LP	28	4.40	8.25E-04	0.44	8.25E-05	0.06	6.20E-05	0.0004	7.83E-08	3.48
LA	10	1.71	9.00E-04	0.17	9.00E-05	0.02	6.84E-05	0.0002	8.55E-08	3.59
LB	15	1.51	5.28E-04	0.15	5.28E-05	0.02	4.39E-05	0.0001	5.02E-08	3.60
LC	20	3.08	8.07E-04	0.31	8.07E-05	0.05	6.61E-05	0.0003	7.67E-08	3.49
ST	19	8.16	2.25E-03	0.82	2.25E-04	0.09	1.37E-04	0.0008	2.14E-07	2.82
TU	9	0.78	4.58E-04	0.08	4.58E-05	0.01	3.70E-05	0.0001	4.35E-08	3.59
BP	15	7.41	2.59E-03	0.74	2.59E-04	0.08	1.58E-04	0.0007	2.46E-07	2.81
TP	21	8.61	2.15E-03	0.86	2.15E-04	0.10	1.31E-04	0.0008	2.05E-07	2.81
TV	25	3.91	8.21E-04	0.39	8.21E-05	0.06	6.81E-05	0.0004	7.79E-08	3.65
DP	29	3.57	6.47E-04	0.36	6.47E-05	0.05	5.37E-05	0.0003	6.14E-08	3.65
RS	10	9.12	4.79E-03	0.91	4.79E-04	0.11	3.14E-04	0.0009	4.54E-07	2.57
SV	22	16.41	3.92E-03	1.64	3.92E-04	0.20	2.62E-04	0.0016	3.72E-07	2.72
VC	1	0.16	8.30E-04	0.02	8.30E-05	0.00	6.28E-05	0.0000	7.88E-08	3.48
VB	12	11.07	4.84E-03	1.11	4.84E-04	0.14	3.25E-04	0.0011	4.60E-07	2.73
VD	26	19.66	3.97E-03	1.97	3.97E-04	0.24	2.64E-04	0.0019	3.77E-07	2.92
VW	6	7.98	6.99E-03	0.80	6.99E-04	0.12	5.60E-04	0.0008	6.63E-07	2.77
VX	35	26.54	3.98E-03	2.65	3.98E-04	0.33	2.67E-04	0.0025	3.78E-07	2.84
WY	5	4.38	4.60E-03	0.44	4.60E-04	0.07	3.74E-04	0.0004	4.37E-07	2.64
WX	6	1.50	1.31E-03	0.15	1.31E-04	0.02	1.01E-04	0.0001	1.24E-07	3.56
XB	42	4.80	6.00E-04	0.48	6.00E-05	0.07	4.58E-05	0.0005	5.69E-08	3.52
BC	3	0.29	5.14E-04	0.03	5.14E-05	0.00	3.93E-05	0.0000	4.89E-08	3.57
BZ	41	4.02	5.15E-04	0.40	5.15E-05	0.06	4.13E-05	0.0004	4.89E-08	3.65
ZA	2	0.24	6.33E-04	0.02	6.33E-05	0.00	5.08E-05	0.0000	6.01E-08	3.72
ZY	41	3.89	4.98E-04	0.39	4.98E-05	0.06	4.00E-05	0.0004	4.73E-08	3.65
VA	3	0.51	8.99E-04	0.05	8.99E-05	0.01	7.35E-05	0.0000	8.54E-08	3.59
XA	10	1.55	8.16E-04	0.16	8.16E-05	0.02	6.67E-05	0.0001	7.75E-08	3.59
YA	11	1.59	7.60E-04	0.16	7.60E-05	0.02	6.21E-05	0.0002	7.22E-08	3.59

Mine Development
Plan II Emission Calculations

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**									
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint**	
										Exit Data			**Sources**	
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
DRILL-1	Drilling	PM	1.39E-02	6.08E-02	See Modeling Report									
		PM_{10}	6.57E-03	2.88E-02										
		$PM_{2.5}$	6.57E-03	2.88E-02										
		Lead Compounds	6.89E-04	3.02E-03										
BLAST-1	Blasting	PM	1.25E-01	5.45E-01										
		PM_{10}	6.48E-02	2.84E-01										
		$PM_{2.5}$	2.47E-02	1.08E-01										
		Lead Compounds	6.18E-03	2.71E-02										
CRUSH-1	Primary Crushing	PM	8.10E-02	3.55E-01										
		PM_{10}	3.65E-02	1.60E-01										
		$PM_{2.5}$	4.46E-02	1.95E-01										
		Lead Compounds	4.02E-03	1.76E-02										
CRUSH-2	Pebble Crushing	PM	2.64E-01	1.16E+00										
		PM_{10}	1.19E-01	5.20E-01										
		$PM_{2.5}$	2.20E-02	9.64E-02										
		Lead Compounds	5.74E-03	2.52E-02										
BREAK-1	Clark Rock Breaker	PM	9.10E-04	3.99E-03										
		PM_{10}	4.30E-04	1.89E-03										
		$PM_{2.5}$	6.52E-05	2.85E-04										
		Lead Compounds	1.60E-05	7.01E-05										
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-18	Drop from 21700-CVR-008 Primary Mill Feed Conveyor to 22100-CHU-002 Primary Mill Feed Chute	PM	4.53E-01	1.98E+00										
		PM_{10}	2.14E-01	9.39E-01										
		$PM_{2.5}$	3.25E-02	1.42E-01										
		Lead Compounds	2.25E-02	9.85E-02										
DP-20	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	PM	0.00E+00	0.00E+00										
		PM_{10}	0.00E+00	0.00E+00										
		$PM_{2.5}$	0.00E+00	0.00E+00										
		Lead Compounds	0.00E+00	0.00E+00										
DP-21	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-22	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-23	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-24	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-25	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-26	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-27	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-28	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	PM	2.95E-01	1.29E+00										
		PM_{10}	1.40E-01	6.12E-01										
		$PM_{2.5}$	2.12E-02	9.27E-02										
		Lead Compounds	6.43E-03	2.82E-02										
DP-40	Transfer of Development Ore from Face to Loader	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-41	Transfer of Development Ore from Loader to Stockpile	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-42	Transfer of Development Ore from Stockpile to Loader	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-43	Transfer of Development Ore from loader to Haul truck	PM	2.76E-04	1.21E-03										
		PM_{10}	1.30E-04	5.71E-04										
		$PM_{2.5}$	1.30E-04	5.71E-04										
		Lead Compounds	6.00E-06	2.63E-05										
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	PM	2.74E-03	1.20E-02										
		PM_{10}	1.30E-03	5.68E-03										
		$PM_{2.5}$	1.30E-03	5.68E-03										
		Lead Compounds	5.96E-05	2.61E-04										
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	PM	4.18E-04	1.83E-03										
		PM_{10}	1.98E-04	8.65E-04										
		$PM_{2.5}$	1.98E-04	8.66E-04										
		Lead Compounds	9.09E-06	3.98E-05										
DP-57	Transfer of Development Waste Mined from Face to Loader	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	PM	8.15E-04	3.57E-03										
		PM_{10}	3.86E-04	1.69E-03										
		$PM_{2.5}$	3.86E-04	1.69E-03										
		Lead Compounds	2.89E-06	1.26E-05										
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	PM	8.10E-03	3.55E-02										
		PM_{10}	3.83E-03	1.68E-02										
		$PM_{2.5}$	3.83E-03	1.68E-02										
		Lead Compounds	2.87E-05	1.26E-04										
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	PM	1.24E-03	5.41E-03										
		PM_{10}	5.84E-04	2.56E-03										
		$PM_{2.5}$	5.85E-04	2.56E-03										
		Lead Compounds	4.37E-06	1.92E-05										
DP-65	Transfer of Stope Ore from Stope to Loader	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-70	Transfer of Stope Ore from Loader to Orepass 1	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										

Section 2.2 Emission Sources Form															
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**										
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint Sources**		
										Exit Data					
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**	
DP-75	Feeder Belt/Hopper	$PM_{2.5}$	1.46E-03	6.38E-03											
		Lead Compounds	1.53E-04	6.69E-04											

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	PM	3.08E-03	1.35E-02										
		PM_{10}	1.46E-03	6.38E-03										
		$PM_{2.5}$	1.46E-03	6.38E-03										
		Lead Compounds	1.53E-04	6.69E-04										
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	PM	2.16E-02	9.46E-02										
		PM_{10}	1.02E-02	4.47E-02										
		$PM_{2.5}$	1.02E-02	4.48E-02										
		Lead Compounds	1.07E-03	4.69E-03										
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	PM	4.67E-03	2.04E-02										
		PM_{10}	2.21E-03	9.67E-03										
		$PM_{2.5}$	2.21E-03	9.67E-03										
		Lead Compounds	2.31E-04	1.01E-03										
DP-82	Drop on West Rock Stockpile	PM	7.27E-02	3.18E-01										
		PM_{10}	3.44E-02	1.51E-01										
		$PM_{2.5}$	5.21E-03	2.28E-02										
		Lead Compounds	2.57E-04	1.13E-03										
DP-83	Drop on East Rock Stockpile	PM	8.05E-02	3.53E-01										
		PM_{10}	3.81E-02	1.67E-01										
		$PM_{2.5}$	5.77E-03	2.53E-02										
		Lead Compounds	2.85E-04	1.25E-03										
DP-84	TSF	PM	1.50E-01	6.58E-01										
		PM_{10}	7.11E-02	3.11E-01										
		$PM_{2.5}$	1.08E-02	4.71E-02										
		Lead Compounds	6.40E-04	2.80E-03										
DP-85	Drops on TSF2	PM	3.15E-01	1.38E+00										
		PM_{10}	1.49E-01	6.53E-01										
		$PM_{2.5}$	2.26E-02	9.89E-02										
		Lead Compounds	1.34E-03	5.88E-03										

Section 2.2 Emission Sources Form															
Regulated Air Pollutant Data					Emission Point Discharge Parameters										
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources						Nonpoint Sources	
										Exit Data					
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-94	Transfer from Agg Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-95	Transfer of Agg Material from Loader to Haul Truck	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	PM	8.16E-06	3.57E-05										
		PM_{10}	3.86E-06	1.69E-05										
		$PM_{2.5}$	5.84E-07	2.56E-06										
		Lead Compounds	0.00E+00	0.00E+00										
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	PM	4.07E-08	1.78E-07										
		PM_{10}	1.93E-08	8.44E-08										
		$PM_{2.5}$	2.92E-09	1.28E-08										
		Lead Compounds	0.00E+00	0.00E+00										
DP-140	Drop of Sodium Sulfate to Bulk Handling System	PM	2.81E-04	1.23E-03										
		PM_{10}	1.33E-04	5.81E-04										
		$PM_{2.5}$	2.01E-05	8.81E-05										
		Lead Compounds	0.00E+00	0.00E+00										
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	PM	5.49E-02	2.40E-01										
		PM_{10}	5.49E-02	2.40E-01										
		$PM_{2.5}$	5.49E-02	2.40E-01										
		Lead Compounds	2.72E-03	1.19E-02										
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	PM	8.14E-02	3.57E-01										
		PM_{10}	8.14E-02	3.57E-01										
		$PM_{2.5}$	8.14E-02	3.57E-01										
		Lead Compounds	4.04E-03	1.77E-02										
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**									
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint**	
										Exit Data			**Sources**	
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	PM	5.66E-02	2.48E-01										
		PM_{10}	5.66E-02	2.48E-01										
		$PM_{2.5}$	5.66E-02	2.48E-01										
		Lead Compounds	2.81E-03	1.23E-02										
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
		Lead Compounds	6.38E-03	2.79E-02										
DC-PPBS1	Paste Plant Binder Silo 1	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-PPBS2	Paste Plant Binder Silo 2	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
DC-PPBS3	Paste Plant Binder Silo 3	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
DC-PPBS4	Paste Plant Binder Silo 4	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
DC-PPM1M	Paste Plant Module 1 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
DC-PPM2M	Paste Plant Module 2 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
T-01	Unleaded Gasoline (S32)	VOC	8.56E-02	3.75E-01										
		Total HAPs	1.75E-03	7.67E-03										
T-02	Diesel (Red Dyed S32)	VOC	3.74E-04	1.64E-03										
		Total HAPs	3.44E-05	1.51E-04										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**									
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint**	
										Exit Data			**Sources**	
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
T-03	Diesel (Red Dyed S32)	VOC	3.74E-04	1.64E-03										
		Total HAPs	3.44E-05	1.51E-04										
T-04	Diesel (Red Dyed Rummel)	VOC	4.66E-04	2.04E-03										
		Total HAPs	4.29E-05	1.88E-04										
T-05	Unleaded Gasoline (Rummel)	VOC	7.43E-02	3.25E-01										
		Total HAPs	1.52E-03	6.65E-03										
T-06	Diesel (Rummel)	VOC	1.08E-04	4.74E-04										
		Total HAPs	9.95E-06	4.36E-05										
T-07	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-08	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-09	Unleaded Gasoline	VOC	4.37E-01	1.92E+00										
		Total HAPs	8.94E-03	3.92E-02										
T-10	Diesel	VOC	8.94E-03	3.92E-02										
		Total HAPs	8.23E-04	3.60E-03										
T-11	Diesel	VOC	8.19E-03	3.59E-02										
		Total HAPs	7.53E-04	3.30E-03										
TNK-040	F549/MIBC	VOC	6.59E-02	2.89E-01										
		Total HAPs	5.99E-02	2.62E-01										
TNK-041	3407-A	VOC	3.38E-04	1.48E-03										
		Total HAPs	2.17E-05	9.52E-05										
TNK-044	Solvay 5100	VOC	3.41E-03	1.49E-02										
		Total HAPs	8.37E-06	3.67E-05										
TNK-045	Copper Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-046	Copper Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-047	Zinc Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-048	Zinc Sulphate	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-051	Zinc Cyanide	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-052	Zinc Cyanide	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-053	SMBS	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-054	SMBS	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-057	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-058	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-059	Tailings Flocculant (SNF AN910-VHM)	VOC	0.00E+00	0.00E+00										
		Total HAPs	0.00E+00	0.00E+00										
TNK-060	3418-A	VOC	4.33E-05	1.90E-04										
		Total HAPs	0.00E+00	0.00E+00										
TNK-061	Shaft ANE	VOC	5.44E-05	2.38E-04										
		Total HAPs	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint Sources	
										Exit Data				
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
TSF2	USFS Tailings Storage Facility	PM	9.24E+00	4.05E+01										
		PM_{10}	4.62E+00	2.02E+01										
		$PM_{2.5}$	6.93E-01	3.04E+00										
		Lead Compounds	3.93E-02	1.72E-01										
TSF_3	Tailing Storage Facility	PM	4.41E+00	1.93E+01										
		PM_{10}	2.20E+00	9.65E+00										
		$PM_{2.5}$	3.30E-01	1.45E+00										
		Lead Compounds	1.88E-02	8.22E-02										
WRS	West Rock Stockpile	PM	1.64E-01	7.17E-01										
		PM_{10}	8.18E-02	3.58E-01										
		$PM_{2.5}$	1.23E-02	5.38E-02										
		Lead Compounds	5.80E-04	2.54E-03										
ERS	East Rock Stockpile	PM	1.81E-01	7.94E-01										
		PM_{10}	9.06E-02	3.97E-01										
		$PM_{2.5}$	1.36E-02	5.95E-02										
		Lead Compounds	6.42E-04	2.81E-03										
TAGG	Taylor Agg Stockpile	PM	1.03E-04	4.53E-04										
		PM_{10}	5.17E-05	2.27E-04										
		$PM_{2.5}$	7.76E-06	3.40E-05										
		Lead Compounds	0.00E+00	0.00E+00										
TSHOT	Taylor Shotcrete Stockpile	PM	1.84E-04	8.06E-04										
		PM_{10}	9.20E-05	4.03E-04										
		$PM_{2.5}$	1.38E-05	6.04E-05										
		Lead Compounds	0.00E+00	0.00E+00										
T_ENG / T_ENG_ALT	CAT 3520 DSL 2600 kW / JGC 624 4481 kW	PM	8.71E+00	3.81E+01										
		PM_{10}	8.71E+00	3.81E+01										
		$PM_{2.5}$	8.71E+00	3.81E+01										
		NO_x	3.74E+01	1.64E+02										
		CO	1.66E+01	7.28E+01										
		SO_2	2.80E-01	1.22E+00										
		VOC	1.93E+01	8.43E+01										
		Total HAPs	1.55E+01	6.80E+01										
		CO_2e	2.59E+05	1.13E+06										
HS_1 - HS_6	CAT XQ1140, 910 kW	PM	1.32E-01	5.80E-01										
		PM_{10}	1.32E-01	5.80E-01										
		$PM_{2.5}$	1.32E-01	5.80E-01										
		NO_x	1.32E+00	5.80E+00										
		CO	1.32E-01	5.80E-01										
		SO_2	1.61E-04	7.04E-04										
		VOC	2.65E-01	1.16E+00										
		Total HAPs	9.09E-02	3.98E-01										
		CO_2e	9.22E+03	4.04E+04										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
ENG9 - ENG13	CAT C175 3000 kW	PM	8.31E-02	3.64E-01										
		PM_{10}	8.31E-02	3.64E-01										
		$PM_{2.5}$	8.31E-02	3.64E-01										
		NO_x	7.27E+00	3.18E+01										
		CO	7.27E+00	3.18E+01										
		SO_2	1.53E-02	6.71E-02										
		VOC	3.94E-01	1.73E+00										
		Total HAPs	2.71E-03	1.19E-02										
		CO_2e	2.89E+02	1.27E+03										
ENG5	C200D2RE	PM	9.60E-03	4.21E-02										
		PM_{10}	9.60E-03	4.21E-02										
		$PM_{2.5}$	9.60E-03	4.21E-02										
		NO_x	1.92E-01	8.41E-01										
		CO	1.68E+00	7.36E+00										
		SO_2	5.99E-01	2.62E+00										
		VOC	9.60E-03	4.21E-02										
		Total HAPs	7.75E-03	3.39E-02										
		CO_2e	3.35E+02	1.47E+03										
WTP2CT	Cooling Towers	PM	5.07E-03	2.22E-02										
		PM_{10}	4.66E-03	2.04E-02										
		$PM_{2.5}$	9.29E-05	4.07E-04										
CBP	Concrete Batch Plant2	PM	1.62E-01	7.11E-01										
		PM_{10}	6.47E-02	2.83E-01										
		$PM_{2.5}$	6.47E-02	2.83E-01										
ROADS	Road Emissions	PM	7.37E+01	3.23E+02										
		PM_{10}	1.90E+01	8.32E+01										
		$PM_{2.5}$	1.90E+00	8.32E+00										
		Lead Compounds	1.77E-03	7.77E-03										
PRODREF	Refrigeration Plant3	PM	1.18E-02	5.16E-02										
		PM_{10}	6.13E-03	2.68E-02										
		$PM_{2.5}$	2.14E-03	9.36E-03										
BBREF	Refrigeration Plant3	PM	1.74E-02	7.60E-02										
		PM_{10}	9.03E-03	3.96E-02										
		$PM_{2.5}$	3.15E-03	1.38E-02										
DOZER1-TSF2	Dozer Emissions	PM	2.24E+00	9.82E+00										
		PM_{10}	4.77E-01	2.09E+00										
		$PM_{2.5}$	2.35E-01	1.03E+00										
		Lead Compounds	9.55E-03	4.18E-02										
DOZER2-TSF2	Dozer Emissions	PM	2.24E+00	9.82E+00										
		PM_{10}	4.77E-01	2.09E+00										
		$PM_{2.5}$	2.35E-01	1.03E+00										
		Lead Compounds	9.55E-03	4.18E-02										
DOZER-WRS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**									
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint**	
										Exit Data			**Sources**	
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
DOZER-ERS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										
DOZER-HRS	Dozer Emissions	PM	2.48E-01	1.09E+00										
		PM_{10}	3.27E-02	1.43E-01										
		$PM_{2.5}$	2.60E-02	1.14E-01										
		Lead Compounds	8.78E-04	3.84E-03										
DOZER-TSF	Dozer Emissions	PM	2.24E+00	9.82E+00										
		PM_{10}	4.77E-01	2.09E+00										
		$PM_{2.5}$	2.35E-01	1.03E+00										
		Lead Compounds	9.55E-03	4.18E-02										
AGGDF	Aboveground Gasoline Dispensing Facility	VOC	1.93E-01	8.45E-01										
		Total HAPs	3.51E-02	1.54E-01										
MEVAP1	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										
MEVAP2	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										
MEVAP3	Mechanical Evaporator	PM_{10}	9.11E-03	3.99E-02										
		$PM_{2.5}$	1.36E-03	5.94E-03										
22310-FC-00001	Lead Rougher	VOC	7.03E-03	3.08E-02										
22310-FC-00004	Lead Rougher Scavenger	VOC	6.92E-03	3.03E-02										
22310-FC-00008	Lead Cleaner Scalper	VOC	2.17E-02	9.51E-02										
22310-FC-00007	Lead Cleaner	VOC	1.86E-02	8.14E-02										
22310-FC-00009	Lead Cleaner Scavenger	VOC	1.73E-02	7.59E-02										
22310-FC-00005	Zinc Rougher	VOC	1.33E-02	5.83E-02										
22310-FC-00006	Zinc Rougher Scavenger	VOC	1.30E-02	5.70E-02										
22310-FC-00011	Zinc Cleaner Scalper	VOC	1.37E-02	6.01E-02										
22310-FC-00010	Zinc Cleaner	VOC	1.16E-02	5.09E-02										
22310-FC-00012	Zinc Cleaner Scavenger	VOC	1.08E-02	4.74E-02										
DRILL-2	Drilling	PM	4.39E-03	1.92E-02										
		PM_{10}	2.08E-03	9.10E-03										
		$PM_{2.5}$	1.30E-03	5.71E-03										
		Lead Compounds	7.73E-05	3.39E-04										
BLAST-2	Blasting	PM	7.01E-02	3.07E-01										
		PM_{10}	3.64E-02	1.60E-01										
		$PM_{2.5}$	8.71E-03	3.81E-02										
		Lead Compounds	1.23E-03	5.40E-03										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**									
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint**	
										Exit Data			**Sources**	
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
DP-103	Dump into Primary Crusher Feed Hopper	PM	6.61E-02	2.89E-01										
		PM_{10}	3.13E-02	1.37E-01										
		$PM_{2.5}$	4.73E-03	2.07E-02										
		Lead Compounds	1.16E-03	5.09E-03										
DP-104	Drop from silo to trucks	PM	2.20E-01	9.65E-01										
		PM_{10}	1.04E-01	4.56E-01										
		$PM_{2.5}$	1.58E-02	6.91E-02										
		Lead Compounds	3.88E-03	1.70E-02										
DP-105	Transfer of Development Ore from Ore Stockpile to Loader	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-106	Transfer of Development Ore Mined from Loader to Haul Truck	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-107	Transfer from ROM Stockpile to Loader	PM	3.62E-02	1.59E-01										
		PM_{10}	1.71E-02	7.51E-02										
		$PM_{2.5}$	2.60E-03	1.14E-02										
		Lead Compounds	6.37E-04	2.79E-03										
DP-109	Transfer from Agg Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-110	Transfer of Agg Material from Loader to Haul Truck	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	PM	1.88E-02	8.23E-02										
		PM_{10}	8.89E-03	3.89E-02										
		$PM_{2.5}$	1.35E-03	5.90E-03										
		Lead Compounds	0.00E+00	0.00E+00										
DP-113	Hardshell Rock Storage	PM	5.93E-01	2.60E+00										
		PM_{10}	2.80E-01	1.23E+00										
		$PM_{2.5}$	4.25E-02	1.86E-01										
		Lead Compounds	3.36E-03	1.47E-02										
DP-114	Ore Stockpile	PM	1.32E-01	5.79E-01										
		PM_{10}	6.25E-02	2.74E-01										
		$PM_{2.5}$	9.47E-03	4.15E-02										
		Lead Compounds	2.33E-03	1.02E-02										
DP-115	ROM Stockpile	PM	3.62E-02	1.59E-01										
		PM_{10}	1.71E-02	7.51E-02										
		$PM_{2.5}$	2.60E-03	1.14E-02										
		Lead Compounds	6.37E-04	2.79E-03										
DP-124	Transfer of Development Ore from Face to Loader	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-125	Transfer of Development Ore from Loader to Stockpile	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
		PM	2.06E-04	9.01E-04										

Section 2.2 Emission Sources Form															
Regulated Air Pollutant Data					**Emission Point Discharge Parameters**										
Emission Point		**Chemical Composition of Total Stream**	**Air Pollutant Emission Rate**		**UTM Coordinates of Emission Point**			**Stack Sources**					**Nonpoint Sources**	
										Exit Data				
Number	**Name**	**Regulated Air Pollutant Name**	**lbs/hr**	**tons/yr**	**Zone**	**East (Mtrs)**	**North (Mtrs)**	**Height Above Ground (feet)**	**Height Above Struc. (feet)**	**Dia (ft.)**	**Vel. (fps)**	**Temp. (F)**	**Length (ft)**	**Width (ft.)**
DP-126	Transfer of Development Ore from Stockpile to Loader	PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint Sources	
										Exit Data				
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	PM	2.06E-04	9.01E-04										
		PM_{10}	9.73E-05	4.26E-04										
		$PM_{2.5}$	6.11E-05	2.67E-04										
		Lead Compounds	2.65E-06	1.16E-05										
DP-129	Transfer of Development Waste Mined from Face to Loader	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	PM	1.07E-03	4.67E-03										
		PM_{10}	5.04E-04	2.21E-03										
		$PM_{2.5}$	3.16E-04	1.38E-03										
		Lead Compounds	6.04E-06	2.65E-05										
DP-134	Transfer of Stope Ore from Stope to Loader	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-135	Transfer of Stope Ore from Loader to Stockpile	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-136	Transfer of Stope Ore from Stockpile to Loader	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
DP-137	Transfer of Stope Ore from Loader to Haul Truck	PM	5.86E-04	2.57E-03										
		PM_{10}	2.77E-04	1.21E-03										
		$PM_{2.5}$	1.74E-04	7.62E-04										
		Lead Compounds	1.03E-05	4.52E-05										
HRS	Hardshell Rock Stockpile	PM	6.26E-01	2.74E+00										
		PM_{10}	3.13E-01	1.37E+00										
		$PM_{2.5}$	4.70E-02	2.06E-01										
		Lead Compounds	2.22E-03	9.71E-03										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
ORE	Clark Ore Stockpile	PM	2.75E-02	1.20E-01										
		PM_{10}	1.37E-02	6.02E-02										
		$PM_{2.5}$	2.06E-03	9.03E-03										
		Lead Compounds	4.84E-04	2.12E-03										
ROM	Clark ROM Stockpile	PM	8.16E-03	3.57E-02										
		PM_{10}	4.08E-03	1.79E-02										
		$PM_{2.5}$	6.12E-04	2.68E-03										
		Lead Compounds	1.44E-04	6.29E-04										
AGG	Clark Agg Stockpile	PM	1.03E-04	4.53E-04										
		PM_{10}	5.17E-05	2.27E-04										
		$PM_{2.5}$	7.76E-06	3.40E-05										
		Lead Compounds	0.00E+00	0.00E+00										
SHOT	Clark Shotcrete Stockpile	PM	1.84E-04	8.06E-04										
		PM_{10}	9.20E-05	4.03E-04										
		$PM_{2.5}$	1.38E-05	6.04E-05										
		Lead Compounds	0.00E+00	0.00E+00										
CBP - C	Concrete Batch Plant	PM	8.21E-03	3.59E-02										
		PM_{10}	3.30E-03	1.45E-02										
		$PM_{2.5}$	3.30E-03	1.45E-02										
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
DC-CPPBS1	Paste Plant Binder Silo 1	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
		Lead Compounds	0.00E+00	0.00E+00										
DC-CPPBS2	Paste Plant Binder Silo 2	PM	3.21E-02	1.41E-01										
		PM_{10}	3.21E-02	1.41E-01										
		$PM_{2.5}$	3.21E-02	1.41E-01										
		Lead Compounds	0.00E+00	0.00E+00										
DC-CPPBS3	Paste Plant Binder Silo 3	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
		Lead Compounds	0.00E+00	0.00E+00										
DC-CPPBS4	Paste Plant Binder Silo 4	PM	6.43E-02	2.82E-01										
		PM_{10}	6.43E-02	2.82E-01										
		$PM_{2.5}$	6.43E-02	2.82E-01										
		Lead Compounds	0.00E+00	0.00E+00										
DC-CPPM1M	Paste Plant Module 1 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
		Lead Compounds	0.00E+00	0.00E+00										

Section 2.2 Emission Sources Form														
Regulated Air Pollutant Data					Emission Point Discharge Parameters									
Emission Point		Chemical Composition of Total Stream	Air Pollutant Emission Rate		UTM Coordinates of Emission Point			Stack Sources					Nonpoint	
										Exit Data			Sources	
Number	Name	Regulated Air Pollutant Name	lbs/hr	tons/yr	Zone	East (Mtrs)	North (Mtrs)	Height Above Ground (feet)	Height Above Struc. (feet)	Dia (ft.)	Vel. (fps)	Temp. (F)	Length (ft)	Width (ft.)
DC-CPPM2M	Paste Plant Module 2 Mixer	PM	1.29E-01	5.63E-01										
		PM_{10}	1.29E-01	5.63E-01										
		$PM_{2.5}$	1.29E-01	5.63E-01										
		Lead Compounds	0.00E+00	0.00E+00										
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	PM	2.74E-02	1.20E-01										
		PM_{10}	2.74E-02	1.20E-01										
		$PM_{2.5}$	2.74E-02	1.20E-01										
		Lead Compounds	4.83E-04	2.11E-03										
AGGDF-C	Gasoline Dispensing Facility	VOC	9.46E-02	4.14E-01										
		Total HAPs	0.00E+00	7.54E-02										
WTP1LS	Waste Water Treatment Plant #1 Lime Silo	PM	4.29E-02	1.88E-01										
		PM_{10}	4.29E-02	1.88E-01										
		$PM_{2.5}$	4.29E-02	1.88E-01										
		Lead Compounds	0.00E+00	0.00E+00										
PP-1	Truck Pneumatic Loadout to Silo 2	PM	9.69E-03	4.24E-02										
		PM_{10}	3.33E-03	1.46E-02										
		$PM_{2.5}$	6.94E-04	3.04E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-2	Truck Pneumatic Loadout to Silo 2	PM	9.69E-03	4.24E-02										
		PM_{10}	3.33E-03	1.46E-02										
		$PM_{2.5}$	6.94E-04	3.04E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-3	Truck Pneumatic Loadout to Silo 1	PM	4.85E-03	2.12E-02										
		PM_{10}	1.66E-03	7.29E-03										
		$PM_{2.5}$	3.47E-04	1.52E-03										
		Lead Compounds	0.00E+00	0.00E+00										
PP-4	Truck Pneumatic Loadout to Silo 2	PM	4.85E-03	2.12E-02										
		PM_{10}	1.66E-03	7.29E-03										
		$PM_{2.5}$	3.47E-04	1.52E-03										
		Lead Compounds	0.00E+00	0.00E+00										
UGTROADS	Underground Taylor Roads	PM	1.76E+01	7.70E+01										
		PM_{10}	4.54E+00	1.99E+01										
		$PM_{2.5}$	4.54E-01	1.99E+00										
		Lead Compounds	4.31E-04	1.89E-03										
UGCROADS	Underground Clark Roads	PM	1.86E+01	8.14E+01										
		PM_{10}	4.79E+00	2.10E+01										
		$PM_{2.5}$	4.79E-01	2.10E+00										
		Lead Compounds	4.55E-04	1.99E-03										

Type of Equipment	Maximum Rated Capacity	Units	Make	Model	Serial Number	Date of Manufacture	Equipment ID Number
Section 2.3 Equipment List							
Crushers - Taylor							
Primary Crusher	1,543	ton/hr	TBD	TBD	TBD	TBD	CRUSH-1
Pebble Crusher	220	ton/hr	TBD	TBD	TBD	TBD	22210-CR-00001
Mills							
Primary Mill	854	ton/hr	TBD	TBD	TBD	TBD	22110-ML-00001
Secondary Mill	2,364	ton/hr	TBD	TBD	TBD	TBD	22120-ML-00001
Lead Regrind Mill	101	ton/hr	TBD	TBD	TBD	TBD	22320-ML-00001
Zinc Regrind Mill	120	ton/hr	TBD	TBD	TBD	TBD	22320-ML-00002
Screens - Taylor							
Primary Mill Discharge Screen	854	ton/hr	TBD	TBD	TBD	TBD	22110-SN-00002
Flotation Trash Screen	712	ton/hr	TBD	TBD	TBD	TBD	22310-SN-00001
Bins/Silos - Taylor							
Pebble Crusher Feed Bin	220	ton/hr	TBD	TBD	TBD	TBD	22210-BN-00001
Mine Shaft Ore Surge Bin	675	ton/hr	TBD	TBD	TBD	TBD	21210-BN-00001
Pebble Crusher Product Surge Bin	220	ton/hr	TBD	TBD	TBD	TBD	22210-BN-00002
Tailings Weigh Bin	615	ton/hr	TBD	TBD	TBD	TBD	22540-BN-00001
Coarse Ore Silo No.1	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00001
Coarse Ore Silo No.2	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00002
Coarse Ore Silo No.3	675	ton/hr	TBD	TBD	TBD	TBD	21510-SI-00003
Conveyors - Taylor							
Coarse Ore Overland Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21210-CV-00001
Coarse Ore Silo No.1 Feed Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21320-CV-00002
Coarse Ore Silo No.2 Feed Conveyor	675	ton/hr	TBD	TBD	TBD	TBD	21320-CV-00003
Primary Mill Feed Conveyor	815	ton/hr	TBD	TBD	TBD	TBD	21710-CV-00001
Primary Screen Discharge Conveyor	220	ton/hr	TBD	TBD	TBD	TBD	22210-CV-00002
Pebble Conveyor	220	ton/hr	TBD	TBD	TBD	TBD	22210-CV-00001
Tailings Transfer Conveyor No.1	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00001
Tailings Transfer Conveyor No.2	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00002
Tailings Silo Feed Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00010
Tailings Paste Plant Feed Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00003
Tailings Truck Loading Conveyor	615	ton/hr	TBD	TBD	TBD	TBD	22540-CV-00005
Feeders/Chutes - Taylor							
Pebble Crusher Feeder	220	ton/hr	TBD	TBD	TBD	TBD	22210-FE-00001
Primary Mill Feed Chute	815	ton/hr	TBD	TBD	TBD	TBD	22110-CH-00001
Pebble Crusher Product Feeder	220	ton/hr	TBD	TBD	TBD	TBD	22210-FE-00002
Mine Shaft Ore Discharge Feeder	815	ton/hr	TBD	TBD	TBD	TBD	21210-FE-00001
Coarse Ore Silo Discharge Feeder No.1	675	ton/hr	TBD	TBD	TBD	TBD	21710-FE-00001
Coarse Ore Silo Discharge Feeder No.2	675	ton/hr	TBD	TBD	TBD	TBD	21700-FE-00002
Coarse Ore Silo Discharge Feeder No.3	675	ton/hr	TBD	TBD	TBD	TBD	21700-FE-00003
Concentrate Feeder	70.0	ton/hr	TBD	TBD	TBD	TBD	22440-FE-00001
Tailings Silo Reclaim Feeder	615	ton/hr	TBD	TBD	TBD	TBD	22540-FE-00001
Tailings Filter Discharge Feeder No. 1	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00020
Tailings Filter Discharge Feeder No. 2	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00021
Tailings Filter Discharge Feeder No. 3	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00022
Tailings Filter Discharge Feeder No. 4	155	ton/hr	TBD	TBD	TBD	TBD	22530-CH-00023
Product Packaging Station							
Container Transport Cart Loading	70	ton/hr	TBD	TBD	TBD	TBD	22440-CB-00001
Dust Collectors - Taylor							
Dust Collector No. 1	3,200	cfm	TBD	TBD	TBD	TBD	DC-1

Section 2.3 Equipment List							
Type of Equipment	**Maximum Rated Capacity**	**Units**	**Make**	**Model**	**Serial Number**	**Date of Manufacture**	**Equipment ID Number**
Dust Collector No. 2	4,750	cfm	TBD	TBD	TBD	TBD	DC-2
Dust Collector No. 3	3,300	cfm	TBD	TBD	TBD	TBD	DC-3
Dust Collector No. 4	3,300	cfm	TBD	TBD	TBD	TBD	DC-4
Dust Collector No. 5	3,300	cfm	TBD	TBD	TBD	TBD	DC-5
Dust Collector No. 11	3,300	cfm	TBD	TBD	TBD	TBD	DC-11
Dust Collector No. 6	7,500	cfm	TBD	TBD	TBD	TBD	DC-6
Paste Plant - Taylor							
Paste Plant Binder Silo 1	750	cfm	TBD	TBD	TBD	TBD	DC-PPBS1
Paste Plant Binder Silo 2	750	cfm	TBD	TBD	TBD	TBD	DC-PPBS2
Paste Plant Binder Silo 3	1,500	cfm	TBD	TBD	TBD	TBD	DC-PPBS3
Paste Plant Binder Silo 4	1,500	cfm	TBD	TBD	TBD	TBD	DC-PPBS4
Paste Plant Module 1 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-PPM1M
Paste Plant Module 2 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-PPM2M
Storage Tanks							
MIBC/F-549 Storage Tank	7,925	gal	TBD	TBD	TBD	TBD	22620-TN-00001
Test Reagent Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00002
Slovay 5100 Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00003
Copper Sulphate Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00005
Copper Sulphate Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00006
Zinc Sulphate Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00007
Zinc Sulphate Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00008
Zinc Cyanide Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00009
Zinc Cyanide Holding Tank	3,963	gal	TBD	TBD	TBD	TBD	22620-TN-00010
SMBS Mix Tank	2,642	gal	TBD	TBD	TBD	TBD	22620-TN-00011
SMBS Holding Tank	5,283	gal	TBD	TBD	TBD	TBD	22620-TN-00012
Tailings Flocculant Holding Tank	17,171	gal	TBD	TBD	TBD	TBD	22620-TN-00013
Lead Flocculant Holding Tank	1,320	gal	TBD	TBD	TBD	TBD	22620-TN-00014
Zinc Flocculant Holding Tank	1,320	gal	TBD	TBD	TBD	TBD	22620-TN-00015
3418-A Storage Tank	6,604	gal	TBD	TBD	TBD	TBD	22620-TN-00004
Shaft ANE Storage Tank	10,293	gal	TBD	TBD	TBD	TBD	TNK-061
Fuel Tanks							
Unleaded Gasoline (S32) T-01	1,000	gal	TBD	TBD	TBD	TBD	T-01
Diesel (Red Dyed S32) T-02	5,000	gal	TBD	TBD	TBD	TBD	T-02
Diesel (Red Dyed S32) T-03	5,000	gal	TBD	TBD	TBD	TBD	T-03
Diesel (Red Dyed Rummel) T-04	12,000	gal	TBD	TBD	TBD	TBD	T-04
Unleaded Gasoline (Rummel) T-05	1,000	gal	TBD	TBD	TBD	TBD	T-05
Diesel (Rummel) T-06	1,000	gal	TBD	TBD	TBD	TBD	T-06
Unleaded Gasoline T-07	10,000	gal	TBD	TBD	TBD	TBD	T-07
Unleaded Gasoline T-08	10,000	gal	TBD	TBD	TBD	TBD	T-08
Unleaded Gasoline T-09	10,000	gal	TBD	TBD	TBD	TBD	T-09
Diesel T-10	50,000	gal	TBD	TBD	TBD	TBD	T-10
Diesel T-11	50,000	gal	TBD	TBD	TBD	TBD	T-11
Concrete Batch Plant -Taylor							
Concrete Batch Plant	40,274	tpy	TBD	TBD	TBD	TBD	CBP
Natural Gas Generators							
CAT 3520 DSL 2600 kW / JGC 624 4481 kW	2,600 / 4,481	kW	Caterpillar / Jenbacher	3520 DSL / J624	TBD	TBD	T_ENG / T_ENG_ALT
Diesel Generators							
CAT XQ1140, 910 kW	910	kW	Caterpillar	3520 DSL	TBD	TBD	HS_1 - HS_6

Section 2.3 Equipment List							
Type of Equipment	Maximum Rated Capacity	Units	Make	Model	Serial Number	Date of Manufacture	Equipment ID Number
CAT C175 3000 kW	3000	kW	Caterpillar	C175-16	TBD	TBD	ENG9 - ENG13
C200D2RE	198	kW	Cummins	QSB7-G9	TBD	TBD	ENG5
WTP2 Cooling Towers							
WTP2 CT Cell 1	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT1
WTP2 CT Cell 2	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT2
WTP2 CT Cell 3	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT3
WTP2 CT Cell 4	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT4
WTP2 CT Cell 5	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT5
WTP2 CT Cell 6	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT6
WTP2 CT Cell 7	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT7
WTP2 CT Cell 8	563	gal/min	TBD	TBD	TBD	TBD	WTP2CT8
Surface Refrigeration Plant							
Cooling Tower Cell 1	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 1
Cooling Tower Cell 2	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 2
Cooling Tower Cell 3	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 3
Cooling Tower Cell 4	1882	gal/min	TBD	TBD	TBD	TBD	Cooling Tower Cell 4
UG Refrigeration CT Cell 1	2774	gal/min	TBD	TBD	TBD	TBD	UG Refridgeration CT Cell 1
UG Refrigeration CT Cell 2	2774	gal/min	TBD	TBD	TBD	TBD	UG Refridgeration CT Cell 2
UG Refrigeration CT Cell 3	2774	gal/min	TBD	TBD	TBD	TBD	UG Refridgeration CT Cell 3
UG Refrigeration CT Cell 4	2774	gal/min	TBD	TBD	TBD	TBD	UG Refridgeration CT Cell 4
Gasoline Dispensing Facilities - Taylor							
Aboveground Gasoline Dispensing Facility	150,000	gal/yr	TBD	TBD	TBD	TBD	AGGDF
Evaporators							
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	EVAP1
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	EVAP2
Mechanical Evaporator	66	gal/min	TBD	TBD	TBD	TBD	EVAP3
Process Tanks							
Lead Rougher	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00001
Lead Rougher Scavenger	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00004
Lead Cleaner Scalper	305	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00008
Lead Cleaner	285	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00007
Lead Cleaner Scavenger	270	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00009
Zinc Rougher	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00005
Zinc Rougher Scavenger	3300	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00006
Zinc Cleaner Scalper	1600	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00011
Zinc Cleaner	1650	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00010
Zinc Cleaner Scavenger	1700	ton/hr	TBD	TBD	TBD	TBD	22310-FC-00012
Zinc Conditioning Tank No. 1	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-002
Zinc Conditioning Tank No. 2	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-003
Feed Stabilization Tank	3300	ton/hr	TBD	TBD	TBD	TBD	22300-TNK-008
Lead Concentrate De-Aeration Tank	200	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-004
Lead Concentrate Thickener Overflow Tank	150	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-005
Lead Concentrate Tank	75	ton/hr	TBD	TBD	TBD	TBD	22430-TNK-011
Zinc Concentrate De-Aeration Tank	225	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-006
Zinc Concentrate Thickener Overflow Tank	150	ton/hr	TBD	TBD	TBD	TBD	22420-TNK-007

Section 2.3 Equipment List							
Type of Equipment	**Maximum Rated Capacity**	**Units**	**Make**	**Model**	**Serial Number**	**Date of Manufacture**	**Equipment ID Number**
Zinc Concentrate Tank	100	ton/hr	TBD	TBD	TBD	TBD	22430-TNK-014
Cyanide Destruction Tank No. 1	2300	ton/hr	TBD	TBD	TBD	TBD	22510-TNK-021
Cyanide Destruction Tank No. 2	2300	ton/hr	TBD	TBD	TBD	TBD	22510-TNK-022
Tailings Stock Tank	1000	ton/hr	TBD	TBD	TBD	TBD	22530-TNK-024
Tailings Filtrate Collection Tank	150	ton/hr	TBD	TBD	TBD	TBD	22530-TNK-025
Scrubber							
Caustic Scrubber	--	--	TBD	TBD	TBD	TBD	22600-FAN-051
Crushers - Clark							
Primary Crusher	121	ton/hr	Sandvik	QJ241	TBD	TBD	22310-CRU-0001
Feeders/Chutes - Clark							
Primary Crusher Discharge Feed Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0001
Primary Crusher Discharge Head Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0002
Primary Crusher Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0003
Coarse Ore Conveyor Head Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0004
Coarse Ore Discharge Feeder	121	ton/hr	TBD	TBD	TBD	TBD	23100-FDR-0003
Discharge Feeder Chute	121	ton/hr	TBD	TBD	TBD	TBD	23100-CHU-0005
Dust Collectors - Clark							
Coarse Ore Dust Collection System,23100-FAN-0001	3,200	cfm	TBD	TBD	TBD	TBD	DC-7
Coarse Ore Dust Collection System,23100-FAN-0002	3,200	cfm	TBD	TBD	TBD	TBD	DC-8
Coarse Ore Dust Collection System,23100-DCD-0005	3,200	cfm	TBD	TBD	TBD	TBD	DC-10
Bins/Silos - Clark							
Coarse Ore Silo	121	ton/hr	TBD	TBD	TBD	TBD	23100-SLO-0003
Screens - Clark							
Primary Crusher Grizzly Screen	121	ton/hr	TBD	TBD	TBD	TBD	23100-SCN-0001
Conveyors - Clark							
Primary Crusher Discharge Conveyor	121	ton/hr	TBD	TBD	TBD	TBD	23100-CVR-0001
Coarse Ore Conveyor	121	ton/hr	TBD	TBD	TBD	TBD	23100-CVR-0002
Truck Unloading Station							
ROM Truck Unloading	121	ton/hr	TBD	TBD	TBD	TBD	TUD-1
Paste Plant							
Paste Plant Binder Silo 1	750	cfm	TBD	TBD	TBD	TBD	DC-CPPBS1
Paste Plant Binder Silo 2	750	cfm	TBD	TBD	TBD	TBD	DC-CPPBS2
Paste Plant Binder Silo 3	1,500	cfm	TBD	TBD	TBD	TBD	DC-CPPBS3
Paste Plant Binder Silo 4	1,500	cfm	TBD	TBD	TBD	TBD	DC-CPPBS4
Paste Plant Module 1 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-CPPM1M
Paste Plant Module 2 Mixer	3,000	cfm	TBD	TBD	TBD	TBD	DC-CPPM2M
Concrete Batch Plant - Clark							
Concrete Batch Plant	1,984	tpy	TBD	TBD	TBD	TBD	CBP - C
Gasoline Dispensing Facilities - Clark							
Aboveground Gasoline Dispensing Facility	73,500	gal/yr	TBD	TBD	TBD	TBD	AGGDF-C
General							
Waste Water Treatment Plant #1 Lime Silo	1,001	cfm	TBD	TBD	TBD	TBD	WTP1LS

All relevant equipment utilized at the facility should be included in the equipment list. Please complete all fields.

The date of manufacture must be included in order to determine applicability of regulations.

Indicate the units (tons/hour, horsepower, etc.) when recording the maximum rated capacity.

Make additional copies of this form if necessary.

Table A-1a. Total Site-Wide Emissions

Pollutant	Regulated NSR Pollutant? [2]	Estimated Potential Emissions (tpy) [1,2]		Permit Applicability Evaluation							
		Non-Fugitive [3]	Non-Fugitive & Fugitive [3]	Class I PSD Major Thresholds (tpy)	Less than PSD Thresholds?	Class I Title V Major Source Thresholds (tpy) [2]	Less than Title V Thresholds?	Significant/Class II Thresholds [2]	Less than Class II Thresholds?	Permitting Exemption Thresholds [2]	Less than Registration/ Permitting Exemption Thresholds?
PM	Yes	208.04	653.02	250	YES	100	NO	--	--	--	--
PM_{10}	Yes	88.39	222.56	250	YES	100	YES	15	NO	7.5	NO
$PM_{2.5}$	Yes	50.83	69.24	250	YES	100	YES	10	NO	5	NO
NO_X	Yes	203.61	203.61	250	YES	100	NO	40	NO	20	NO
SO_2	Yes	6.45	6.45	250	YES	100	YES	40	YES	20	YES
CO	Yes	180.95	180.95	250	YES	100	NO	100	NO	50	NO
VOC	Yes	94.10	95.94	250	YES	100	YES	40	NO	20	NO
Lead compounds	No	0.21	1.23	--	--	10	YES	--	--	--	--
Elemental Lead	Yes	0.21	1.23	250	YES	100	YES	0.6	YES	0.3	YES
Maximum Single HAP - Acetaldehyde	No	39.84	39.84	--	--	10	NO	--	--	--	--
Total HAPs	No	69.40	76.19	--	--	25	NO	--	--	--	--
H_2S	Yes	10.12	10.12	--	--	100	YES	--	--	--	--
CO_2e [4]	-	1,176,929	1,176,929	100,000	--	--	--	--	--	--	--

1. PM, PM_{10}, and $PM_{2.5}$ include both filterable and condensable fractions, which conservatively overestimates PM emissions from an NSR perspective.
2. Per Arizona Administrative Code (A.A.C.)
   R18-2-101.110 - For "Potential to emit"
   R18-2-101.131 - For "Significant"
   R18-2-101.75 - For "Major Source"
   R18-2-101.101 - For "Permitting Exemption Thresholds"
   R18-2-101.124 - For "Regulated NSR Pollutant"
3. Per A.A.C. R18-2-302.F "The fugitive emissions of a stationary source shall not be considered in determining whether the source requires a Class II permit under subsection (B)(2)(a) or (b) or a registration under subsection (B)(3)(a) or (d), unless the source belongs to a section 302(j) category. If a permit is required for a stationary source, the fugitive emissions of the source shall be subject to all of the requirements of this Article." South32 is not categorized as a Clean Air Act Section 302(j) source. Hence, only non-fugitive emissions are used for permit applicability evaluation.
4. Sources exceeding 100,000 tons of CO_2e are only subject to PSD if they also trigger PSD for another regulated NSR pollutant. The Hermosa Project does not trigger PSD for any other NSR pollutant. While CO2e is not included under the definition of "regulated NSR pollutant" at A.A.C. R18-2-101.124, GHGs are considered a "regulated NSR pollutant" under the federal Prevention of Significant Deterioration (PSD) program at 40 C.F.R. § 52.21(b)(50). South32 is therefore providing estimates of GHG (i.e., CO_2e) emissions for purposes of demonstrating non-applicability of the federal PSD program for GHGs, which ADEQ implements via a delegation agreement with EPA.

Table A-1b. Total Emissions - Source Specific

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/Aboveground?	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NO_X	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
T-01	Unleaded Gasoline (S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.38	0.01	--	--
T-02	Diesel (Red Dyed S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.64E-03	1.51E-04	--	--
T-03	Diesel (Red Dyed S32)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.64E-03	1.51E-04	--	--
T-04	Diesel (Red Dyed Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	2.04E-03	1.88E-04	--	--
T-05	Unleaded Gasoline (Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.33	0.01	--	--
T-06	Diesel (Rummel)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	4.74E-04	4.36E-05	--	--
T-07	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-08	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-09	Unleaded Gasoline	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.92	0.04	--	--
T-10	Diesel	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.04	3.60E-03	--	--
T-11	Diesel	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.04	3.30E-03	--	--
TNK-040	F549/MIBC	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.29	0.26	--	--
TNK-041	3407-A	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.48E-03	9.52E-05	--	--
TNK-044	Solvay 5100	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	0.01	3.67E-05	--	--
TNK-045	Copper Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-046	Copper Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-047	Zinc Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-048	Zinc Sulphate	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-051	Zinc Cyanide	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-052	Zinc Cyanide	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-053	SMBS	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-054	SMBS	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-057	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-058	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-059	Tailings Flocculant(SNF AN910-VHM)	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	--	--	--	--
TNK-060	3418-A	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	1.90E-04	--	--	--
TNK-061	Shaft ANE	Yes	Non-fugitive	Aboveground	--	--	--	--	--	--	--	2.38E-04	--	--	--
T_ENG / T_ENG_ALT	CAT 3520 DSL 2600 kW / JGC 624 4481 kW	Yes	Non-fugitive	Aboveground	38.13	38.13	38.13	--	163.88	72.84	1.22	84.33	68.00	--	1,133,793.76
HS_1 - HS_6	CAT XQ1140, 910 kW	Yes	Non-fugitive	Aboveground	0.58	0.58	0.58	--	5.80	0.58	7.04E-04	1.16	0.40	--	40,402.88
ENG9 - ENG13	CAT C175 3000 kW	Yes	Non-fugitive	Aboveground	0.36	0.36	0.36	--	31.83	31.83	0.07	1.73	0.01	--	1,267.09

Emission Point Number	Emissions Activity	Include? Yes/No	Source Type [1]	Underground/Aboveground?	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	NO_x	CO	SO_2	VOC	Total HAPs	H_2S	CO_2e
ENG5	C200D2RE	Yes	Non-fugitive	Aboveground	0.04	0.04	0.04	--	0.84	7.36	2.62	0.04	0.03	--	1,465.16
AGGDF	Aboveground Gasoline Dispensing Facility	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.85	0.15	--	--
22310-FC-00001	Lead Rougher	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.03	--	--	--
22310-FC-00004	Lead Rougher Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.03	--	--	--
22310-FC-00008	Lead Cleaner Scalper	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.10	--	--	--
22310-FC-00007	Lead Cleaner	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.08	--	--	--
22310-FC-00009	Lead Cleaner Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.08	--	--	--
22310-FC-00005	Zinc Rougher	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00006	Zinc Rougher Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00011	Zinc Cleaner Scalper	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.06	--	--	--
22310-FC-00010	Zinc Cleaner	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.05	--	--	--
22310-FC-00012	Zinc Cleaner Scavenger	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.05	--	--	--
AGGDF-C	Gasoline Dispensing Facility	Yes	Fugitive	Aboveground	--	--	--	--	--	--	--	0.41	0.08	--	--
Total - Non-Fugitive & Fugitive Emissions					653.02	222.56	69.24	1.23	203.61	180.95	6.45	95.94	76.19	10.12	1,176,928.89
Total - Non-Fugitive Emissions					208.04	88.39	50.83	0.21	203.61	180.95	6.45	94.10	69.40	10.12	1,176,928.89

2. The concrete batch plant is conservatively assumed to be a non-fugitive source of emissions. South32 reserves the right to update this representation once we have more clarity on the concrete batch plant design per correspondance with ADEQ on Jan 13th 2023.

3. The surface refrigeration plant is considered a non-fugitive source of emissions based on correspondance with ADEQ on Jan 13th 2023.

Table A-2a. Facility HAPs Summary

Pollutant	Emissions (tpy)[1]
Benzene	0.57
Toluene	0.49
Xylene	0.28
1,3-Butadiene	0.20
Formaldehyde	18.24
Acetaldehyde	39.84
Acrolein	3.57
Naphthalene	0.08
1,1,2,2-Tetrachloroethane	0.27
1,1,2-Trichloroethane	0.22
1,3-Dichloropropene	0.18
2-Methylnaphthalene	0.02
2,2,4-Trimethylpentane	0.17
Biphenyl	0.15
Carbon Tetrachloride	0.25
Chlorobenzene	0.21
Chloroform	0.19
Ethylbenzene	0.05
Ethylene Dibromide	0.30
Methanol	1.74
Methylene Chloride	0.14
Hexane	0.79
PAH	0.55
Phenol	0.16
Tetrachloroethane	0.02
Vinyl Chloride	0.10
Cresol	9.52E-05
Ethylene Glycol Dimethyl Ether	0.26
Urethane	3.67E-05
Cumene	4.46E-04
Isooctane	0.04
PAC's	5.84E-05
Antimony Compounds	2.56E-02
Arsenic Compounds	3.12E-02
Beryllium Compounds	1.10E-03
Cadmium Compounds	2.06E-02
Chromium Compounds	2.04E-02
Cobalt Compounds	2.73E-03
Manganese Compounds	5.76
Nickel Compounds	1.45E-02
Selenium Compounds	3.21E-03
Lead Compounds	1.23
Maximum Single HAP Acetaldehyde	39.84
Total	76.19

1. Lead is not included in the HAP Summary, but is included in the Summary tab.

Table A-2b. Metal HAP in PM - Constituents Summary

Emission Point Number	Emissions Activity	Emissions[1]													
		Include? Yes/No	PM	Antimony Compounds	Arsenic Compounds	Beryllium Compounds	Cadmium Compounds	Chromium Compounds	Cobalt Compounds	Manganese Compounds	Nickel Compounds	Selenium Compounds	Lead Compounds	Mercury Compounds	Total
DRILL-1	Drilling	Yes	0.06	1.29E-05	9.46E-06	7.30E-08	1.18E-05	2.01E-06	1.58E-06	2.72E-03	6.08E-07	1.58E-06	3.02E-03	--	5.78E-03
BLAST-1	Blasting	Yes	0.55	1.16E-04	8.48E-05	6.55E-07	1.06E-04	1.80E-05	1.42E-05	2.44E-02	5.45E-06	1.42E-05	0.03	--	5.18E-02
CRUSH-1	Primary Crushing	Yes	0.35	7.52E-05	5.52E-05	4.26E-07	6.89E-05	1.17E-05	9.23E-06	1.59E-02	3.55E-06	9.23E-06	0.02	--	3.37E-02
CRUSH-2	Pebble Crushing	Yes	1.16	1.17E-04	1.47E-04	1.27E-06	6.88E-05	4.14E-05	1.51E-05	4.70E-02	1.12E-05	1.56E-05	0.03	--	7.26E-02
BREAK-1	Clark Rock Breaker	Yes	3.99E-03	1.80E-06	2.16E-06	6.70E-09	4.88E-07	1.71E-07	2.39E-08	7.00E-04	3.11E-08	1.99E-08	7.01E-05	--	7.74E-04
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	0.10	--	1.89E-01
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	0.10	--	1.89E-01
DP-18	Drop from 21700-CVR-008 Primary Mill Feed Conveyor to 22100-CHU-002 Primary Mill Feed Chute	Yes	1.98	4.21E-04	3.09E-04	2.38E-06	3.85E-04	6.55E-05	5.16E-05	8.87E-02	1.98E-05	5.16E-05	0.10	--	1.89E-01
DP-20	Drop from 22100-SCN-001 Primary Mill Discharge Screen to 22200-CVR-010 Primary Screen Discharge Conveyor	Yes	0.00	--	--	--	--	--	--	--	--	--	0.00E+00	--	0.00E+00
DP-21	Drop from 22200-CVR-010 Primary Screen Discharge Conveyor to 22200-CHU-004 Pebble Feed/Bypass Chute	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-22	Drop from 22200-CHU-004 Pebble Feed/Bypass Chute to 22200-BIN-004 Pebble Bin	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-23	Drop from 22200-BIN-004 Pebble Bin to 22200-FDR-010 Pebble Crusher Feeder	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-24	Drop from 22200-FDR-010 Pebble Crusher Feeder to 22200-CRU-002 Pebble Crusher	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-25	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-26	Drop from 22200-BIN-005 Pebble Crusher Product Surge Bin to 22200-FDR-011 Pebble Crusher Product Feeder	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-27	Drop from 22200-FDR-011 Pebble Crusher Product Feeder to 22200-CVR-015 Pebble Return Conveyor	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-28	Drop from 22200-CVR-015 Pebble Return Conveyor to 21700-CVR-008 Primary Mill Feed Conveyor	Yes	1.29	1.31E-04	1.64E-04	1.42E-06	7.70E-05	4.64E-05	1.69E-05	5.26E-02	1.25E-05	1.74E-05	0.03	--	8.12E-02
DP-40	Transfer of Development Ore from Face to Loader	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-41	Transfer of Development Ore from Loader to Stockpile	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-42	Transfer of Development Ore from Stockpile to Loader	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-43	Transfer of Development Ore from loader to Haul truck	Yes	0.00	1.22E-07	1.53E-07	1.32E-09	7.19E-08	4.33E-08	1.58E-08	4.91E-05	1.17E-08	1.63E-08	2.63E-05	--	7.58E-05
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	Yes	0.01	1.21E-06	1.52E-06	1.32E-08	7.14E-07	4.30E-07	1.57E-07	4.88E-04	1.16E-07	1.62E-07	2.61E-04	--	7.53E-04
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	Yes	0.00	1.85E-07	2.32E-07	2.00E-09	1.09E-07	6.56E-08	2.39E-08	7.43E-05	1.77E-08	2.46E-08	3.98E-05	--	1.15E-04
DP-57	Transfer of Development Waste Mined from Face to Loader	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	0.00	6.20E-08	1.81E-07	5.01E-09	1.27E-08	9.77E-08	1.35E-08	2.09E-05	2.79E-08	1.16E-08	1.26E-05	--	3.40E-05
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	Yes	0.04	6.16E-07	1.79E-06	4.98E-08	1.27E-07	9.71E-07	1.35E-07	2.08E-04	2.78E-07	1.15E-07	1.26E-04	--	3.37E-04
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	Yes	0.01	9.40E-08	2.74E-07	7.59E-09	1.93E-08	1.48E-07	2.05E-08	3.17E-05	4.23E-08	1.76E-08	1.92E-05	--	5.14E-05
DP-65	Transfer of Stope Ore from Stope to Loader	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-70	Transfer of Stope Ore from Loader to Orepass 1	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	Yes	0.01	2.86E-06	2.10E-06	1.62E-08	2.62E-06	4.45E-07	3.51E-07	6.03E-04	1.35E-07	3.51E-07	6.69E-04	--	1.28E-03
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	Yes	0.09	2.01E-05	1.47E-05	1.14E-07	1.84E-05	3.12E-06	2.46E-06	4.23E-03	9.46E-07	2.46E-06	4.69E-03	--	8.98E-03
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	Yes	0.02	4.33E-06	3.18E-06	2.45E-08	3.97E-06	6.74E-07	5.31E-07	9.14E-04	2.04E-07	5.31E-07	1.01E-03	--	1.94E-03
DP-82	Drop on West Rock Stockpile	Yes	0.32	5.53E-06	1.61E-05	4.47E-07	1.14E-06	8.71E-06	1.21E-06	1.86E-03	2.49E-06	1.03E-06	1.13E-03	--	3.03E-03
DP-83	Drop on East Rock Stockpile	Yes	0.35	6.13E-06	1.78E-05	4.95E-07	1.26E-06	9.65E-06	1.34E-06	2.06E-03	2.76E-06	1.15E-06	1.25E-03	--	3.35E-03
DP-84	TSF	Yes	0.66	1.34E-04	1.01E-04	7.84E-07	1.20E-04	2.19E-05	1.64E-05	2.92E-02	6.57E-06	1.64E-05	2.80E-03	--	3.24E-02
DP-85	Drops on TSF2	Yes	1.38	2.80E-04	2.11E-04	1.64E-06	2.53E-04	4.59E-05	3.44E-05	6.13E-02	1.38E-05	3.45E-05	5.88E-03	--	6.80E-02

DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	Yes	0.24	5.09E-05	3.74E-05	2.88E-07	4.66E-05	7.93E-06	6.25E-06	0.01	2.40E-06	6.25E-06	0.01	--	2.28E-02
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	Yes	0.36	7.56E-05	5.55E-05	4.28E-07	6.92E-05	1.18E-05	9.27E-06	0.02	3.57E-06	9.27E-06	0.02	--	3.39E-02
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	0.01	2.48E-06	6.44E-06	0.01	--	2.35E-02
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	0.01	2.48E-06	6.44E-06	0.01	--	2.35E-02
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	0.01	2.48E-06	6.44E-06	0.01	--	2.35E-02
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	Yes	0.25	5.25E-05	3.85E-05	2.97E-07	4.81E-05	8.18E-06	6.44E-06	0.01	2.48E-06	6.44E-06	0.01	--	2.35E-02
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	Yes	0.56	1.19E-04	8.76E-05	6.76E-07	1.09E-04	1.86E-05	1.46E-05	0.03	5.63E-06	1.46E-05	0.03	--	5.35E-02
TSF2	USFS Tailings Storage Facility	Yes	40.47	8.21E-03	6.20E-03	4.82E-05	7.40E-03	1.34E-03	1.01E-03	1.80	4.04E-04	1.01E-03	0.17	--	1.99E+00
TSF_3	Tailing Storage Facility	Yes	19.29	3.91E-03	2.96E-03	2.30E-05	3.53E-03	6.41E-04	4.81E-04	0.86	1.92E-04	4.82E-04	0.08	--	9.50E-01
WRS	West Rock Stockpile	Yes	0.72	1.24E-05	3.62E-05	1.01E-06	2.56E-06	1.96E-05	2.72E-06	4.19E-03	5.61E-06	2.33E-06	2.54E-03	--	6.82E-03
ERS	East Rock Stockpile	Yes	0.79	1.38E-05	4.01E-05	1.11E-06	2.83E-06	2.17E-05	3.01E-06	4.65E-03	6.21E-06	2.58E-06	2.81E-03	--	7.55E-03
ROADS	Road Emissions	Yes	322.64	1.20E-03	7.61E-03	6.34E-04	5.39E-04	1.08E-02	--	--	8.88E-03	3.17E-04	7.77E-03	7.92E-05	3.78E-02
UGTROADS	Underground Taylor Roads	Yes	77.04	2.93E-04	1.85E-03	1.54E-04	1.31E-04	2.62E-03	--	--	2.16E-03	7.70E-05	1.89E-03	1.93E-05	9.19E-03
UGCROADS	Underground Clark Roads	Yes	81.39	3.09E-04	1.95E-03	1.63E-04	1.38E-04	2.77E-03	--	--	2.28E-03	8.14E-05	1.99E-03	2.03E-05	9.71E-03
DOZER1-TSF2	Dozer Emissions	Yes	9.82	1.99E-03	1.50E-03	1.17E-05	1.80E-03	3.26E-04	2.45E-04	4.36E-01	9.80E-05	2.45E-04	4.18E-02	--	4.84E-01
DOZER2-TSF2	Dozer Emissions	Yes	9.82	1.99E-03	1.50E-03	1.17E-05	1.80E-03	3.26E-04	2.45E-04	4.36E-01	9.80E-05	2.45E-04	4.18E-02	--	4.84E-01
DOZER-WRS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-ERS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-HRS	Dozer Emissions	Yes	1.09	1.89E-05	5.49E-05	1.52E-06	3.88E-06	2.97E-05	4.12E-06	6.35E-03	8.49E-06	3.53E-06	3.84E-03	--	1.03E-02
DOZER-TSF	Dozer Emissions	Yes	9.82	1.99E-03	1.50E-03	1.17E-05	1.80E-03	3.26E-04	2.45E-04	4.36E-01	9.80E-05	2.45E-04	4.18E-02	--	4.84E-01
DRILL-2	Drilling	Yes	0.02	8.68E-06	1.05E-05	3.23E-08	2.36E-06	8.28E-07	1.15E-07	3.38E-03	1.50E-07	9.62E-08	3.39E-04	--	3.74E-03
BLAST-2	Blasting	Yes	0.31	1.38E-04	1.67E-04	5.16E-07	3.76E-05	1.32E-05	1.84E-06	5.39E-02	2.39E-06	1.53E-06	5.40E-03	--	5.96E-02
DP-103	Dump into Primary Crusher Feed Hopper	Yes	0.29	1.31E-04	1.57E-04	4.86E-07	3.55E-05	1.24E-05	1.74E-06	5.08E-02	2.26E-06	1.45E-06	5.09E-03	--	5.62E-02
DP-104	Drop from silo to trucks	Yes	0.96	4.35E-04	5.24E-04	1.62E-06	1.18E-04	4.15E-05	5.79E-06	0.17	7.53E-06	4.82E-06	0.02	--	1.87E-01
DP-105	Transfer of Development Ore from Ore Stockpile to Loader	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	0.10	4.52E-06	2.89E-06	0.01	--	1.12E-01
DP-106	Transfer of Development Ore Mined from Loader to Haul Truck	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	0.10	4.52E-06	2.89E-06	0.01	--	1.12E-01
DP-107	Transfer from ROM Stockpile to Loader	Yes	0.16	7.16E-05	8.62E-05	2.67E-07	1.94E-05	6.82E-06	9.52E-07	0.03	1.24E-06	7.94E-07	0.00	--	3.08E-02
DP-113	Hardshell Rock Storage	Yes	2.60	1.22E-04	2.20E-04	2.82E-06	3.29E-05	8.02E-05	5.79E-06	0.04	1.68E-05	7.67E-06	0.01	--	6.00E-02
DP-114	Ore Stockpile	Yes	0.58	2.61E-04	3.14E-04	9.73E-07	7.09E-05	2.49E-05	3.47E-06	0.10	4.52E-06	2.89E-06	0.01	--	1.12E-01
DP-115	ROM Stockpile	Yes	0.16	7.16E-05	8.62E-05	2.67E-07	1.94E-05	6.82E-06	9.52E-07	0.03	1.24E-06	7.94E-07	2.79E-03	--	3.08E-02
DP-124	Transfer of Development Ore from Face to Loader	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-125	Transfer of Development Ore from Loader to Stockpile	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-126	Transfer of Development Ore from Stockpile to Loader	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	Yes	0.00	2.20E-07	2.98E-07	1.08E-09	6.02E-08	4.61E-08	4.14E-09	8.56E-05	7.77E-09	3.91E-09	1.16E-05	--	9.79E-05
DP-129	Transfer of Development Waste Mined from Face to Loader	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	Yes	0.00	2.19E-07	3.96E-07	5.07E-09	5.91E-08	1.44E-07	1.04E-08	8.06E-05	3.02E-08	1.38E-08	2.65E-05	--	1.08E-04
DP-134	Transfer of Stope Ore from Stope to Loader	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-135	Transfer of Stope Ore from Loader to Stockpile	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-136	Transfer of Stope Ore from Stockpile to Loader	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
DP-137	Transfer of Stope Ore from Loader to Haul Truck	Yes	0.00	1.16E-06	1.39E-06	4.31E-09	3.14E-07	1.10E-07	1.54E-08	4.50E-04	2.00E-08	1.28E-08	4.52E-05	--	4.99E-04
HRS	Hardshell Rock Stockpile	Yes	2.74	4.76E-05	1.39E-04	3.85E-06	9.79E-06	7.50E-05	1.04E-05	1.60E-02	2.15E-05	8.91E-06	9.71E-03	--	2.61E-02
ORE	Clark Ore Stockpile	Yes	0.12	5.43E-05	6.54E-05	2.02E-07	1.48E-05	5.18E-06	7.23E-07	2.11E-02	9.39E-07	6.02E-07	2.12E-03	--	2.34E-02
ROM	Clark ROM Stockpile	Yes	0.04	1.61E-05	1.94E-05	6.00E-08	4.38E-06	1.54E-06	2.14E-07	6.27E-03	2.79E-07	1.79E-07	6.29E-04	--	6.94E-03
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	0.02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	0.02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	Yes	0.12	5.42E-05	6.52E-05	2.02E-07	1.47E-05	5.17E-06	7.21E-07	0.02	9.37E-07	6.01E-07	2.11E-03	--	2.33E-02
	Total		608.25	2.56E-02	3.12E-02	1.10E-03	2.06E-02	2.04E-02	2.73E-03	5.76	1.45E-02	3.21E-03	1.23	1.19E-04	7.11

1. Table of HAP Constituents received from South32 in "Copy of Air Permitting Final 0 HAPs"

Table A-2c. Constituent Mass Fraction in LOM

HAP	Taylor					Clark		
	Development Ore	Stope Ore	Rock	Tailings[1]		Development Ore	Stope Ore	Rock
Antimony Compounds	0.000100952	0.000212	1.7365E-05	0.000202878		0.000244389	0.000451	4.70138E-05
Arsenic Compounds	0.000127076	0.0001555	5.05638E-05	0.000153165		0.000330447	0.000543	8.47561E-05
Beryllium Compounds	1.09588E-06	0.0000012	1.4024E-06	1.19145E-06		1.1936E-06	0.00000168	1.08653E-06
Cadmium Compounds	5.95151E-05	0.000194	3.56972E-06	0.000182952		6.68071E-05	0.0001225	1.26614E-05
Chromium Compounds	3.58403E-05	0.000033	2.73603E-05	3.32333E-05		5.11672E-05	0.000043	3.08836E-05
Cobalt Compounds	1.30505E-05	0.000026	3.79338E-06	2.49362E-05		4.59693E-06	0.000006	2.23051E-06
Cyanide Compounds	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Manganese Compounds	0.040637342	0.0447	0.005852034	0.044366261		0.094972702	0.1755	0.017263008
Mercury Compounds	N/A	N/A	N/A	N/A		N/A		N/A
Nickel Compounds	9.68749E-06	0.00001	7.82396E-06	9.97433E-06		8.62044E-06	0.0000078	6.47096E-06
Radionuclides	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Selenium Compounds	1.3463E-05	0.000026	3.25003E-06	2.49701E-05		4.33389E-06	0.000005	2.95309E-06
Lead Compounds	0.0217561371071872	0.049605776	0.003541223	0.004		0.012895714	0.017592857	0.005668919

[1] For constituents other than lead, mass fractions in the tailings are assumed to be equivalent to the mass fractions in the rock

Notes on Lead

Material	Notes
Development Ore	Based on average inside domains
Stope Ore	Based on assays within stope design
Rock	Based on average lithology grades minus inside domains

Stope numbers based on evaluation of drillhole data through stope designs
Rock is the evauation of assays within lithological units.

Table A-2d. Metal Content in Surface Soil

Metal	Content (kg/kg)
Antimony	3.80E-06
Arsenic	2.40E-05
Beryllium	2.00E-06
Cadmium	1.70E-06
Chromium	3.40E-05
Nickel	2.80E-05
Selenium	1.00E-06
Mercury	2.50E-07

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Sam

Table A-2e. Generator HAPs Summary

Emission ID	Description	HAP Annual Emissions (tpy)																										
		Benzene	Toluene	Xylene	1,3-Butadiene	Formaldehyde	Acetaldehyde	Acrolein	Naphthalene	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,3-Dichloropropene	2-Methylnaphthalene	2,2,4-Trimethylpentane	Biphenyl	Carbon Tetrachloride	Chlorobenzene	Chloroform	Ethylbenzene	Ethylene Dibromide	Methanol	Methylene Chloride	Hexane	PAH	Phenol	Tetrachloroethane	Vinyl Chloride	Total
T_ENG / T_ENG_ALT	Trench	3.06E-01	2.83E-01	1.28E-01	1.85E-01	1.82E+01	3.98E+01	3.57E+00	5.17E-02	2.72E-01	2.17E-01	1.80E-01	2.31E-02	1.74E-01	1.47E-01	2.50E-01	2.07E-01	1.94E-01	2.76E-02	3.02E-01	1.74E+00	1.36E-01	7.71E-01	5.28E-01	1.63E-01	1.69E-02	1.01E-01	**6.80E+01**
HS_1 - HS_6	Hardshell	1.92E-01	6.94E-02	4.77E-02	9.66E-03	1.95E-02	6.22E-03	1.95E-03	3.21E-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.02E-02	--	--	--	**3.98E-01**
ENG9 - ENG13	Diesel	6.01E-03	2.18E-03	1.49E-03	3.03E-04	6.11E-04	1.95E-04	6.10E-05	1.01E-03	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.19E-02**
ENG5	WW1	8.36E-03	3.66E-03	2.55E-03	3.50E-04	1.06E-02	6.87E-03	8.28E-04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.45E-04	--	--	--	**3.39E-02**
Total		5.12E-01	3.59E-01	1.79E-01	1.96E-01	1.82E+01	3.98E+01	3.57E+00	8.48E-02	2.72E-01	2.17E-01	1.80E-01	2.31E-02	1.74E-01	1.47E-01	2.50E-01	2.07E-01	1.94E-01	2.76E-02	3.02E-01	1.74E+00	1.36E-01	7.71E-01	5.49E-01	1.63E-01	1.69E-02	1.01E-01	**6.84E+01**

Table A-2f. Emission Source - Other HAPs and Lead Compounds Summary

Emission ID	Description	HAP Annual Emissions (tpy)													
		Cresol	Ethylene Glycol Dimethyl Ether	Urethane	Benzene	Hexane	Toluene	Xylene	Ethylbenzene	Benzo(g,h,i)perylene	Cumene	Isooctane	Naphthalene	PAC's	Total
T-01	Unleaded Gasoline (S32)	--	--	--	2.02E-03	1.52E-04	2.32E-03	6.66E-04	1.52E-04	1.49E-19	2.59E-05	2.32E-03	1.18E-06	1.18E-06	**7.7E-03**
T-02	Diesel (Red Dyed S32)	--	--	--	3.20E-06	5.03E-06	3.77E-05	9.81E-05	5.03E-06	1.60E-18	0.00E+00	0.00E+00	7.69E-07	7.69E-07	**1.5E-04**
T-03	Diesel (Red Dyed S32)	--	--	--	3.20E-06	5.03E-06	3.77E-05	9.81E-05	5.03E-06	1.60E-18	0.00E+00	0.00E+00	7.69E-07	7.69E-07	**1.5E-04**
T-04	Diesel (Red Dyed Rummel)	--	--	--	3.98E-06	6.27E-06	4.70E-05	1.22E-04	6.27E-06	2.01E-18	0.00E+00	0.00E+00	9.61E-07	9.61E-07	**1.9E-04**
T-05	Unleaded Gasoline (Rummel)	--	--	--	1.76E-03	1.32E-04	2.01E-03	5.78E-04	1.32E-04	1.29E-19	2.25E-05	2.01E-03	1.02E-06	1.02E-06	**6.6E-03**
T-06	Diesel (Rummel)	--	--	--	9.26E-07	1.46E-06	1.09E-05	2.84E-05	1.46E-06	4.61E-19	0.00E+00	0.00E+00	2.23E-07	2.23E-07	**4.4E-05**
T-07	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-08	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-09	Unleaded Gasoline	--	--	--	1.03E-02	7.78E-04	1.19E-02	3.40E-03	7.78E-04	7.62E-19	1.33E-04	1.19E-02	6.03E-06	6.03E-06	**3.9E-02**
T-10	Diesel	--	--	--	7.64E-05	1.20E-04	9.02E-04	2.35E-03	1.20E-04	3.86E-17	0.00E+00	0.00E+00	1.84E-05	1.84E-05	**3.6E-03**
T-11	Diesel	--	--	--	7.00E-05	1.10E-04	8.26E-04	2.15E-03	1.10E-04	3.54E-17	0.00E+00	0.00E+00	1.69E-05	1.69E-05	**3.3E-03**
TNK-040	F549/MIBC	0.00E+00	2.62E-01	0.00E+00	--	--	--	--	--	--	--	--	--	--	**2.6E-01**
TNK-041	3407-A	9.52E-05	0.00E+00	0.00E+00	--	--	--	--	--	--	--	--	--	--	**9.5E-05**
TNK-044	Solvay 5100	0.00E+00	0.00E+00	3.67E-05	--	--	--	--	--	--	--	--	--	--	**3.7E-05**
AGGDF	Aboveground Gasoline Dispensing Facility	--	--	--	0.02	0.01	0.06	0.06	0.01	--	--	--	--	--	**1.5E-01**
AGGDF-C	Gasoline Dispensing Facility	--	--	--	0.01	4.14E-03	0.03	2.90E-02	0.01	--	--	--	--	--	**7.5E-02**
Total		9.52E-05	2.62E-01	3.67E-05	5.76E-02	1.55E-02	1.30E-01	1.04E-01	2.05E-02	8.22E-17	4.46E-04	3.99E-02	5.84E-05	5.84E-05	**6.3E-01**

Table A-3a. Taylor Drilling - Parameters and Emission Factors

Emission Point Number	Activity	Throughput [1]		Controlled Emission Factor[3]				Control		
				PM	PM_{10}[2]	$PM_{2.5}$	Lead Compounds [5]	Type	$PM/PM_{10}/Pb$ Efficiency [5]	$PM_{2.5}$ Efficiency [5]
		(tons/hr)	(ton/year)	(lb/ton)	(lb/ton)	(lb/ton)	(lb/ton)		(%)	
DRILL-1	Drilling	657	5,755,000	1.69E-04	8.00E-05	1.21E-05	8.39E-06	Gravity Settling due to underground drilling (underground only)	87%	17%

1. Per Total tonnes w/ backfill used from "Mined tonnes and Pb grade.xlsx" recd. on 7/12/2021
2. Per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".
3. Per U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, the particle size multiplier used for calculating emission factors for PM_{10} and $PM_{2.5}$ is as follows:

PM: 0.74
PM_{10}: 0.35
$PM_{2.5}$: 0.053

5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

5. Lead percentage in stope ore used conservatively for drilling 4.96 %

Table A-3b. Taylor Drilling - Emissions

Emission Point Number	Activity	Controlled Emissions [1]											
		Annual Emissions (tpy)				Daily Emissions (lb/day)				Hourly Emissions (lb/hr)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DRILL-1	Drilling	0.06	0.03	2.88E-02	3.02E-03	0.33	0.16	0.16	0.02	1.39E-02	6.57E-03	6.57E-03	6.89E-04

1. Controlled Emissions have been calculated for drilling since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-4a. Clark Drilling - Parameters and Emission Factors

Emission Point Number	Activity	Throughput [1]		Controlled Emission Factor[3]				Control		
				PM	PM_{10}[2]	$PM_{2.5}$	Lead Compounds [5]	Type	$PM/PM_{10}/Pb$ Efficiency [5]	$PM_{2.5}$ Efficiency [5]
		(tons/hr)	(ton/year)	(lb/ton)	(lb/ton)	(lb/ton)	(lb/ton)		(%)	
DRILL-2	Drilling	128	1,125,000	1.69E-04	8.00E-05	1.21E-05	2.98E-06	Gravity Settling due to underground drilling (underground only)	80%	16%

1. Per email "Clark Updated Inputs for Air Permit" from Cayley Hoffman received on 9/8/2022
2. Per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".
3. Per U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, the particle size multiplier used for calculating emission factors for PM_{10} and $PM_{2.5}$ is as follows:

PM: 0.74
PM_{10}: 0.35
$PM_{2.5}$: 0.053

5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

5. Lead percentage in stope ore used conservatively for drilling 1.76 %

Table A-4b. Clark Drilling - Emissions

Emission Point Number	Activity	Controlled Emissions [1]											
		Annual Emissions (tpy)				Daily Emissions (lb/day)				Hourly Emissions (lb/hr)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DRILL-2	Drilling	0.02	0.009	0.0057	0.0003	0.11	0.05	0.031	0.002	0.004	0.002	1.30E-03	7.73E-05

1. Controlled Emissions have been calculated for drilling since gravity settling is a part of an inherent process for underground mines.

Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-5a. Taylor Blasting - Parameters

Emission Point No.	Location	Blast Area (ft^2/blast) [1]	Throughput [1,6]		Blasting Rates [1]
		Maximum	(ton/hr)	(ton/yr)	(blasts/yr)
BLAST-1	Blasting	9,000	17.42	4,500	730

1. Per meeting with Kevin Mccoy on 9/9/2022, 10/14/2022, and 10/17/2022

Maximum Hourly emulsion usage = 17.42 ton/hr

Table A-5b. Taylor Blasting Emissions

Emission Point No.	Location	Pollutant	Emission Factor [1,2,3,4,5,6]	Unit	Controlled Emissions		
					(tpy)	lb/day	lb/hr
BLAST-1	Blasting	NO_x	0.50	(lb/ton Emulsion)	1.13	--	8.71
		CO	27.00	(lb/ton Emulsion)	60.75	--	470.25
		H_2S	4.00	(lb/ton Emulsion)	9.00	--	69.67
		SO_2	1.00	(lb/ton Emulsion)	2.25	--	17.42
		PM	1.49	(Max lb/Blast)	0.55	2.99	1.49
		PM_{10}	0.78	(Max lb/Blast)	0.28	1.55	0.78
		$PM_{2.5}$	0.30	(Max lb/Blast)	0.11	0.59	0.30
		Lead (from ore)	0.07	(Max lb/Blast)	0.03	0.15	0.074
		CO_2	463.18	(lb/ton)	1,042.15	--	8066.92

1. NO_X and CO emission factors based on "Fume Memo WESCO Aug 2021" pdf dated 19 August 2021 provided by Seth Fredrick Dyno Nobel Inc.

2. H_2S and SO_2 emission factors per AP-42 Section 13.3, Table 13.3-1 for dynamite, gelatin (January 1995).
This emission factor was used by FMI Climax Mine, Colorado (underground mine) per permit application in October 2013 for CDPHE Air Permit No. 95CC899.

3. PM emission factor calculated per AP-42 Section 11.9, Table 11.9-1 for blasting (July 1998)

$0.000014(A)^{1.5}$ where, A = horizontal area (ft^2), with blasting depth ≤ 70 ft

The following scaling factors are applied to PM emission factor to calculate PM_{10} and $PM_{2.5}$ emission factors per AP-42 Table 11.9-1:

PM_{10}: 0.52
$PM_{2.5}$: 0.03

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Gravity Settling (underground only) PM/PM_{10}/Pb: 87%
Gravity Settling (underground only) $PM_{2.5}$: 17%

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

4. CO_2 emission factor is based on "Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products" - Iwona Zawadzka-Malota, January 7, 2016.

5. Lead content in ore 4.96 %

6. Hourly emissions are based on 1 blast/hr (7 Developmental and 1 Stope sub-blasts per Blast).
1.00 blast/hr per meeting with Kevin McCoy on 9/9/2022
2.00 blasts/day per meeting with Kevin McCoy on 9/9/2022

Mine Development
Blasting - Clark

Table A-6a. Clark Blasting - Parameters

Emission Point No.	Location	Blast Area (ft^2/blast) [1]	Throughput [1,6]		Blasting Rates [1]
		Maximum	(ton/hr)	(ton/yr)	(blasts/yr)
BLAST-2	Blasting	4,450	4.60	562	730

1. Per email "Clark Updated Inputs for Air Permit" from Cayley Hoffman received on 9/8/2022 and meetings in 10/2022

Maximum total emulsion usage = 4.60 tonnes/hr

Table A-6b. Clark Blasting Emissions

Emission Point No.	Location	Pollutant	Emission Factor [1,2,3,4,5,6]	Unit	Controlled Emissions		
					(tpy)	lb/day	lb/hr
BLAST-2	Blasting	NO_x	0.50	(lb/ton Emulsion)	0.14	--	2.30
		CO	27.00	(lb/ton Emulsion)	7.59	--	124.11
		H_2S	4.00	(lb/ton Emulsion)	1.12	--	18.39
		SO_2	1.00	(lb/ton Emulsion)	0.28	--	4.60
		PM	0.84	(Max lb/Blast)	0.31	1.68	0.84
		PM_{10}	0.44	(Max lb/Blast)	0.16	0.87	0.437
		$PM_{2.5}$	0.10	(Max lb/Blast)	0.038	0.21	0.1045
		Lead (from ore)	0.01	(Max lb/Blast)	0.0054	0.03	0.0148
		CO_2	463.18	(lb/ton)	130.15	--	2129.05

1. NO_X and CO emission factors based on "Fume Memo WESCO Aug 2021" pdf dated 19 August 2021 provided by Seth Fredrick Dyno Nobel Inc.
2. H_2S and SO_2 emission factors per AP-42 Section 13.3, Table 13.3-1 for dynamite, gelatin (January 1995).
   This emission factor was used by FMI Climax Mine, Colorado (underground mine) per permit application in October 2013 for CDPHE Air Permit No. 95CC899.
3. PM emission factor calculated per AP-42 Section 11.9, Table 11.9-1 for blasting (July 1998)

$0.000014(A)^{1.5}$ where, A = horizontal area (ft^2), with blasting depth ≤ 70 ft

The following scaling factors are applied to PM emission factor to calculate PM_{10} and $PM_{2.5}$ emission factors per AP-42 Table 11.9-1:

PM_{10}: 0.52

$PM_{2.5}$: 0.03

Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

Gravity Settling (underground only) PM/PM_{10}/Pb: 80%

Gravity Settling (underground only) $PM_{2.5}$: 16%

Detailed calculations are included in the Gravity Settling Tab of this spreadsheet

4. CO_2 emission factor is based on "Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products" - Iwona Zawadzka-Malota, January 7, 2016.

5. Lead content in ore	1.76 %	
6. Hourly emissions are based on 1 blast/hr (4 Developmental and 1 Stope sub-blasts per Blast).	1.00 blast/hr	per meeting with Cayley Hoffman on 9/9/2022
	2.00 blasts/day	per meeting with Cayley Hoffman on 9/9/2022

Table A-7a. Crushing - Emission Factors

Emission Point Number	Description	Activity	Throughput [1,6]		Controlled Emission Factor [2,3,4,7]				Control		
					PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Type	PM/PM_{10} Efficiency [5]	$PM_{2.5}$ Efficiency [5]
			(ton ore/hr)	(ton ore/yr)	(lb/ton ore)	(lb/ton ore)	(lb/ton ore)	(lb/ton ore)		(%)	
CRUSH-1	Underground Crushing	Primary Crushing	1,543	4,731,314	0.0012	0.00054	0.0001	5.95E-05	Gravity Settling	87%	17%
CRUSH-2	Pebble Crusher	Secondary Crushing	220	1,927,200	0.0012	0.00054	0.0001	2.61E-05	No Control as a Controlled Emission Factor is being used	0%	0%
BREAK-1	Clark Rock Breaker	Rock Breaker	12	47,131	1.69E-04	8.00E-05	1.21E-05	2.98E-06	No Control as a Controlled Emission Factor is being used	0%	0%

1. Throughput per Total tonnes of Ore crushed from "Mined tonnes and Pb grade.xlsx" recd. on 7/12/2021
Hourly throughput based on "thyssenkrupp ERC Product Range Sizes.pdf" recd. on 7/12/2021.
2. Crushing emission factors obtained from AP-42 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing for tertiary crushing
3. Lead conc.
4.96 % for Primary Crushing for Taylor
2.18 % for pebble crusher
1.76 % for Rock Breaker for Clark
4. Assumed that $PM_{2.5}$ is approximately 30% of PM_{10} per AP-42, as calculated below and described in AP-42 Appendix B.2, Category 3, September 1990.

% cumulative size	
$PM_{2.5}$	15 %
PM_{10}	51 %
Ratio $PM_{2.5}/PM_{10}$	0.29

5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

For Watering	70%
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%
Gravity Settling (underground only) ($PM_{2.5}$)	17%

6. Rock breakers are hydraulic-type hammers that break down rock pieces that are too large for the Clark Grizzly Screen. As such, the throughput will correspond to a percent (%) of the total grizzly screen throughput. It is conservatively assumed that this value will be 10%. Emission factor is similar to drilling.
7. Emission factors per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".

Table A-7b. Crushing - Emissions

Emission Point Number	Activity	Controlled Emissions: Annual Emissions (tpy)				Daily Emissions (lb/day)				Hourly Emissions (lb/hr)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
CRUSH-1	Underground Crushing	0.35	0.16	0.20	0.02	5.56	2.50	3.06	0.28	0.23	0.10	0.13	0.01
CRUSH-2	Pebble Crushing	1.16	0.52	0.10	0.03	6.34	2.85	0.53	0.14	0.26	0.12	0.02	0.01
BREAK-1	Clark Rock Breaker	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**1.52**	**0.68**	**0.29**	**0.04**	**11.94**	**5.37**	**3.59**	**0.41**	**0.50**	**0.22**	**0.15**	**0.02**

1. Controlled Emissions have been calculated for underground crushing since gravity settling is a part of an inherent process for underground mines.

Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-8a. Crushing Monthly - Emission Factors

Emission Point Number	Description	Activity	Throughput [1,6] (ton ore/hr)	Controlled Emission Factor [2,3,4,7] PM (lb/ton ore)	PM_{10} (lb/ton ore)	$PM_{2.5}$ (lb/ton ore)	Lead Compounds (lb/ton ore)	Control Type	PM/PM_{10} Efficiency [5] (%)	$PM_{2.5}$ Efficiency [5]
CRUSH-1	Underground Crushing	Primary Crushing	570	0.0012	0.00054	0.0001	5.95E-05	Gravity Settling	87%	17%
CRUSH-2	Pebble Crusher	Secondary Crushing	130	0.0012	0.00054	0.0001	2.61E-05	No Control as a Controlled Emission Factor is being used	0%	0%
BREAK-1	Clark Rock Breaker	Rock Breaker	9	1.69E-04	8.00E-05	1.21E-05	2.98E-06	No Control as a Controlled Emission Factor is being used	0%	0%

1. Monthly throughput per email from Sarah Richman (South32) dated 5/18/2023
2. Crushing emission factors obtained from AP-42 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing for tertiary crushing
3. Lead conc.
   4.96 % for Primary Crushing for Taylor
   2.18 % for pebble crusher
   1.76 % for Rock Breaker for Clark
4. Assumed that $PM_{2.5}$ is approximately 30% of PM_{10} per AP-42, as calculated below and described in AP-42 Appendix B.2, Category 3, September 1990.

% cumulative size	
$PM_{2.5}$	15 %
PM_{10}	51 %
Ratio $PM_{2.5}/PM_{10}$	0.29

5. Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.

For Watering	70%
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%
Gravity Settling (underground only) ($PM_{2.5}$)	17%

6. Rock breakers are hydraulic-type hammers that break down rock pieces that are too large for the Clark Grizzly Screen. As such, the throughput will correspond to a percent (%) of the total grizzly screen throughput. It is conservatively assumed that this value will be 10%. Emission factor is similar to drilling.
7. Emission factors per AP-42 Section 11.19.2, Table 11.19.2-2 (08/2004) for "Wet Drilling - Unfragmented Stone".

Table A-8b. Crushing Monthly - Emissions

Emission Point Number	Activity	Controlled Emissions Monthly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
CRUSH-1	Underground Crushing [1]	0.09	0.04	0.05	0.00
CRUSH-2	Pebble Crushing	0.16	0.07	0.01	0.00
BREAK-1	Clark Rock Breaker	0.00	0.00	0.00	0.0000
Total		**0.24**	**0.11**	**0.06**	**0.01**

1. Controlled Emissions have been calculated for underground crushing since gravity settling is a part of an inherent process for underground mines.
Pursuant to 40 CFR §64.1, "control device" means "equipment, other than inherent process equipment, that is used to destroy or remove air pollutant(s) prior to discharge to the atmosphere." Furthermore, "inherent process equipment" means "equipment that is necessary for the proper or safe functioning of the process, or material recovery equipment that the owner or operator documents is installed and operated primarily for purposes other than compliance with air pollution regulations." The gravity settling is an inherent part of the process.

Table A-9a. Taylor Drops - Emissions - Inputs - Hourly/Daily

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	Uncontrolled Emission Factor [3] PM_{10} (lb/ton)	Uncontrolled Emission Factor [3] $PM_{2.5}$ (lb/ton)	Uncontrolled Emission Factor [3] Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	675	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	675	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-3	Drop from 21200-FOR-001 Mine Shaft Ore Discharge Feeder to 21200-GAT-001 Mine Shaft Diverter Gate	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System							
DP-4	Drop from 21200-GAT-001 Mine Shaft Discharge Gate to 21200-CVR-001 Coarse Ore Overland Conveyor	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System			19.49				
DP-6	Drop from 21200-CVR-001 Coarse Ore Overland Conveyor to 21300-CHU-001 3-Way Shuttle Chute	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System			19.49				
DP-7	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor	--	4.96%	4.00	Controlled by 21300-DCD-004 Coarse Ore Dust Collection System No.5			19.49				
DP-8	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor	--	4.96%	4.00	Controlled by 21300-DCD-005 Coarse Ore Dust Collection System No.6			19.49				
DP-9	Drop from 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor to 21500-SLO-001 Coarse Ore Silo No.1	--	4.96%	4.00	Controlled by 21300-DCD-003 Coarse Ore Dust Collection System No.2			19.49				
DP-10	Drop from 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor to 21500-SLO-002 Coarse Ore Silo No.2	--	4.96%	4.00	Controlled by 21300-DCD-004 Coarse Ore Dust Collection System No.3			19.49				
DP-11	Drop from 21300-CHU-001 3-Way Shuttel Chute to 21500-SLO-003 Coarse Ore Silo No.3	--	4.96%	4.00	Controlled by 21300-DCD-005 Coarse Ore Dust Collection System No.4			19.49				
DP-12	Drop from 21700-FOR-002 Coarse Ore Silo Discharge Feeder No.1 to 21700-SCB-002 Discharge Feeder Belt Scale No.1	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-13	Drop from 21700-FOR-004 Coarse Ore Silo Discharge Feeder No.2 to 21700-SCB-004 Discharge Feeder Belt Scale No.2	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-14	Drop from 21700-FOR-006 Coarse Ore Silo Discharge Feeder No.3 to 21700-SCB-006 Discharge Feeder Belt Scale No.3	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-15	Drop from 21700-SCB-002 Discharge Feeder Belt Scale No.1 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-16	Drop from 21700-SCB-004 Discharge Feeder Belt Scale No.2 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-17	Drop from 21700-SCB-006 Discharge Feeder Belt Scale No.3 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
Primary Milling												
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	854	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	Wet streams, no emissions expected										
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor											
Secondary Crushing												
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crsuher Feed/Bypass Chute	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crsuher Feed Bin	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	220	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
Underground Drops - Development Ore												
DP-40	Transfer of Development Ore from Face to Loader	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	64.10	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	64.10	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
Underground Drops - Development Waste + Paste Remuck												
DP-57	Transfer of Development Waste Mined from Face to Loader	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	138.60	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	138.60	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	5.48E-06
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
Underground Drops - Stope Ore												
DP-65	Transfer of Stope Ore from Stope to Loader	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06

DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	527.12	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
Stockpile Drops												
DP-82	Drop on West Rock Stockpile	13.82	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	15.31	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	117.77	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
DP-85	Drops on TSF2	247.02	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
From Stockpiles												
DP-94	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
WTP2												
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	0.001080	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.000005	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	0.037158	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per February 2021 dated Process Flow Diagram, provided by South32 in May 2021.
Confirmed by RFI provided by South32, Sarah Richman, on 7/12/2021.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture Content taken into account in AP-42 Drop Equation)	0%	
Gravity Settling (underground only) (PM/PM_{10}/Pb)	87%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	17%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)
k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is equal to: 19.49 Based on 2019-2021 On-Site Met Data
1.3 For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-9b. Taylor Drops - Hourly/Daily Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	0.53	0.25	0.04	2.64E-02	12.78	6.04	0.92	6.34E-01
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	0.53	0.25	0.04	2.64E-02	12.78	6.04	0.92	6.34E-01
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	0.67	0.32	0.05	3.34E-02	16.17	7.65	1.158	8.02E-01
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	--	--	--	--	--	--	--	--
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crsuher Feed/Bypass Chute	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crsuher Feed Bin	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	0.35	0.16	0.02	7.55E-03	8.33	3.94	0.597	1.81E-01
DP-40	Transfer of Development Ore from Face to Loader	0.00	0.00	0.000	1.16E-05	0.01	0.01	0.006	2.79E-04
DP-41	Transfer of Development Ore from Loader to Stockpile	0.00	0.00	0.000	8.15E-06	0.01	0.00	0.004	1.96E-04
DP-42	Transfer of Development Ore from Stockpile to Loader	0.00	0.00	0.000	8.15E-06	0.01	0.00	0.004	1.96E-04
DP-43	Transfer of Development Ore from loader to Haul truck	0.00	0.00	0.000	1.16E-05	0.01	0.01	0.006	2.79E-04
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	0.01	0.00	0.003	1.16E-04	0.13	0.06	0.060	2.78E-03
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-57	Transfer of Development Waste Mined from Face to Loader	0.00	0.00	0.001	4.09E-06	0.03	0.01	0.01	9.82E-05
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	0.00	0.00	0.000	2.87E-06	0.02	0.01	0.01	6.88E-05

DP-59	Transfer of Development Waste Mined from Stockpile to Loader	0.00	0.00	0.000	2.87E-06	0.02	0.01	0.01	6.88E-05
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	0.00	0.00	0.001	4.09E-06	0.03	0.01	0.01	9.82E-05
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	0.01	0.01	0.005	4.07E-05	0.28	0.13	0.01	9.76E-04
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.13	1.49E-04
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.02	1.49E-04
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.02	1.49E-04
DP-65	Transfer of Stope Ore from Stope to Loader	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.02	3.67E-03
DP-70	Transfer of Stope Ore from Loader to Orepass 1	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	0.00	0.00	0.001	1.53E-04	0.07	0.03	0.03	3.67E-03
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	0.02	0.01	0.010	1.07E-03	0.52	0.25	0.03	2.57E-02
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	0.00	0.00	0.002	2.31E-04	0.11	0.05	0.03	5.55E-03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.002	2.31E-04	0.11	0.05	0.25	5.55E-03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	0.00	0.00	0.002	2.31E-04	0.11	0.05	0.05	5.55E-03
DP-82	Drop on West Rock Stockpile	0.07	0.03	0.01	2.57E-04	1.74	0.83	0.12	6.18E-03
DP-83	Drop on East Rock Stockpile	0.08	0.04	0.01	2.85E-04	1.93	0.91	0.14	6.84E-03
DP-84	TSF	0.15	0.07	0.01	6.01E-04	3.61	1.71	0.26	1.44E-02
DP-85	Drops on TSF2	0.32	0.15	0.02	1.26E-03	7.56	3.58	0.54	3.03E-02
DP-94	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	8.16E-06	3.86E-06	5.84E-07	--	0.00	0.00	0.00	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	4.07E-08	1.93E-08	2.92E-09	--	0.00	0.00	0.00	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	2.81E-04	1.33E-04	2.01E-05	--	0.01	0.00	0.00	--
	Total	**5.64**	**2.67**	**0.44**	**0.15**	**135.28**	**63.98**	**10.53**	**3.66**

Table A-10a. Taylor Drops - Emissions - Inputs - Hourly/Daily

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	PM_{10} (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds (lb/ton)
	Surface Activities											
	Coarse Ore Delivery and Storage											
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	588	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	588	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
	Primary Milling											
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	720	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-19	Drop from 22110-ML-00001 Primary Mill to 22110-SN-00002 Primary Mill Discharge Screen	Wet streams, no emissions expected										
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor											
	Secondary Crushing											
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crsuher Feed/Bypass Chute	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crsuher Feed Bin	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	130	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
	Underground Drops - Development Ore											
DP-40	Transfer of Development Ore from Face to Loader	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	64.10	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	64.10	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	91.60	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
	Underground Drops - Development Waste + Paste Remuck											
DP-57	Transfer of Development Waste Mined from Face to Loader	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	138.60	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	138.60	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	5.48E-06
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	197.90	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
	Underground Drops - Stope Ore											
DP-65	Transfer of Stope Ore from Stope to Loader	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	258.60	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	258.60	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	517.20	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
	Stockpile Drops											
DP-82	Drop on West Rock Stockpile	13.82	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	15.31	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	117.77	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
DP-85	Drops on TSF2	247.02	0.40%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.10E-06
	From Stockpiles											
DP-94	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
	WTP2											
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	0.001080	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.000005	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	0.037158	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per February 2021 dated Process Flow Diagram, provided by South32 in May 2021.
Confirmed by RFI provided by South32, Sarah Richman, on 7/12/2021.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%
Moisture Content (Moisture Content taken into account in AP-42 Drop Equation)	0%

Gravity Settling (underground only) (PM/PM_{10}/Pb)	87%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	17%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

	PM	PM_{10}	$PM_{2.5}$
k = Particle size multiplier (dimensionless)	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is equal to: 19.49 Based on 2019-2021 On-Site Met Data
1.3 For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-10b. Taylor Drops - Hourly/Daily Emissions - Controlled

Emission Point Number	Description	Controlled Emissions							
		Hourly Emissions (lb/hr)				Daily Emissions (lb/day)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	0.46	0.22	0.03	2.30E-02	11.14	5.27	0.80	5.52E-01
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	0.46	0.22	0.03	2.30E-02	11.14	5.27	0.80	5.52E-01
DP-18	Drop from 21710-CV-00001 Primary Mill Feed Conveyor to 22100-CH-00001 Primary Mill Feed Chute	0.57	0.27	0.04	2.82E-02	13.63	6.44	0.976	6.76E-01
DP-20	Drop from 22110-SN-00002 Primary Mill Discharge Screen to 22210-CV-00002 Primary Screen Discharge Conveyor	--	--	--	--	--	--	--	--
DP-21	Drop from 22210-CV-00002 Primary Screen Discharge Conveyor to 22210-CV-0001 Pebble Crusher Feed Conveyor	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-22	Drop from 22210-CV-00001 Pebble Crusher Feed Conveyor to 22210-CH-00001 Pebble Crsuher Feed/Bypass Chute	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-23	Drop from 22210-CH-00001 Pebble Crusher Feed/Bypass Chute to 22210-BN-00001 Pebble Crsuher Feed Bin	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-24	Drop from 22210-BN-0001 Pebble Crusher Feed Bin to 22210-FE-00001 Pebble Crusher Feeder	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-25	Drop from 22210-FE-00001 Pebble Crusher Feeder to 22210-CR-00001 Pebble Crusher	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-26	Drop from 22210-CR-00001 Pebble Crusher to 22210-BN-00002 Pebble Crusher Product Surge Bin	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-27	Drop from 22210-BN-00002 Pebble Crusher Product Surge Bin to 22210-FE-00002 Pebble Crusher Product Return Feeder	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-28	Drop from 22210-FE-00002 Pebble Crusher Product Return Feeder to 21710-CV-00001 Primary Mill Feed Conveyor	0.20	0.10	0.01	4.45E-03	4.91	2.32	0.351	1.07E-01
DP-40	Transfer of Development Ore from Face to Loader	0.00	0.00	0.000	1.16E-05	0.01	0.01	0.006	2.79E-04
DP-41	Transfer of Development Ore from Loader to Stockpile	0.00	0.00	0.000	8.15E-06	0.01	0.00	0.004	1.96E-04
DP-42	Transfer of Development Ore from Stockpile to Loader	0.00	0.00	0.000	8.15E-06	0.01	0.00	0.004	1.96E-04
DP-43	Transfer of Development Ore from loader to Haul truck	0.00	0.00	0.000	1.16E-05	0.01	0.01	0.006	2.79E-04
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	0.01	0.00	0.003	1.16E-04	0.13	0.06	0.060	2.78E-03
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	0.00	0.00	0.000	1.76E-05	0.02	0.01	0.009	4.23E-04
DP-57	Transfer of Development Waste Mined from Face to Loader	0.00	0.00	0.001	4.09E-06	0.03	0.01	0.01	9.82E-05
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	0.00	0.00	0.000	2.87E-06	0.02	0.01	0.01	6.88E-05
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	0.00	0.00	0.000	2.87E-06	0.02	0.01	0.01	6.88E-05
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	0.00	0.00	0.001	4.09E-06	0.03	0.01	0.01	9.82E-05
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	0.01	0.01	0.005	4.07E-05	0.28	0.13	0.01	9.76E-04
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.13	1.49E-04
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.02	1.49E-04
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	0.00	0.00	0.001	6.20E-06	0.04	0.02	0.02	1.49E-04
DP-65	Transfer of Stope Ore from Stope to Loader	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.02	3.60E-03
DP-70	Transfer of Stope Ore from Loader to Orepass 1	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.03	3.60E-03
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.03	3.60E-03
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	0.00	0.00	0.001	7.49E-05	0.04	0.02	0.03	1.80E-03
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	0.00	0.00	0.001	7.49E-05	0.04	0.02	0.03	1.80E-03
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.02	3.60E-03
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.02	3.60E-03
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.03	3.60E-03
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	0.00	0.00	0.001	1.50E-04	0.07	0.03	0.03	3.60E-03
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	0.02	0.01	0.010	1.05E-03	0.51	0.24	0.03	2.52E-02
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	0.00	0.00	0.002	2.27E-04	0.11	0.05	0.03	5.45E-03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.002	2.27E-04	0.11	0.05	0.24	5.45E-03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	0.00	0.00	0.002	2.27E-04	0.11	0.05	0.05	5.45E-03
DP-82	Drop on West Rock Stockpile	0.07	0.03	0.01	2.57E-04	1.74	0.83	0.12	6.18E-03
DP-83	Drop on East Rock Stockpile	0.08	0.04	0.01	2.85E-04	1.93	0.91	0.14	6.84E-03
DP-84	TSF	0.15	0.07	0.01	6.01E-04	3.61	1.71	0.26	1.44E-02
DP-85	Drops on TSF2	0.32	0.15	0.02	1.26E-03	7.56	3.58	0.54	3.03E-02
DP-94	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--

DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	8.16E-06	3.86E-06	5.84E-07	--	0.00	0.00	0.00	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	4.07E-08	1.93E-08	2.92E-09	--	0.00	0.00	0.00	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	2.81E-04	1.33E-04	2.01E-05	--	0.01	0.00	0.00	--
	Total	**4.25**	**2.01**	**0.34**	**0.12**	**101.96**	**48.22**	**8.11**	**2.77**

Table A-11a. Taylor Drops - Emissions - Inputs - Annual

Emission Point Number	Description	Throughput [1] (tpy)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	$PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	PM_{10} (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-3	Drop from 21200-FOR-001 Mine Shaft Ore Discharge Feeder to 21200-GAT-001 Mine Shaft Diverter Gate	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System			19.49				
DP-4	Drop from 21200-GAT-001 Mine Shaft Discharge Gate to 21200-CVR-001 Coarse Ore Overland Conveyor	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System			19.49				
DP-6	Drop from 21200-CVR-001 Coarse Ore Overland Conveyor to 21300-CHU-001 3-Way Shuttle Chute	--	4.96%	4.00	Controlled by 21200-DCD-001 Coarse Ore Dust Collection System			19.49				
DP-7	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor	--	4.96%	4.00	Controlled by 21300-DCD-004 Coarse Ore Dust Collection System No.5			19.49				
DP-8	Drop from 21300-CHU-001 3-Way Shuttle Chute to 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor	--	4.96%	4.00	Controlled by 21300-DCD-005 Coarse Ore Dust Collection System No.6			19.49				
DP-9	Drop from 21300-CVB-005 Coarse Ore Silo No.1 Feed Conveyor to 21500-SLO-001 Coarse Ore Silo No.1	--	4.96%	4.00	Controlled by 21300-DCD-003 Coarse Ore Dust Collection System No.2			19.49				
DP-10	Drop from 21300-CVB-006 Coarse Ore Silo No.2 Feed Conveyor to 21500-SLO-002 Coarse Ore Silo No.2	--	4.96%	4.00	Controlled by 21300-DCD-004 Coarse Ore Dust Collection System No.3			19.49				
DP-11	Drop from 21300-CHU-001 3-Way Shuttel Chute to 21500-SLO-003 Coarse Ore Silo No.3	--	4.96%	4.00	Controlled by 21300-DCD-005 Coarse Ore Dust Collection System No.4			19.49				
DP-12	Drop from 21700-FOR-002 Coarse Ore Silo Discharge Feeder No.1 to 21700-SCB 002 Discharge Feeder Belt Scale No.1	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-13	Drop from 21700-FOR-004 Coarse Ore Silo Discharge Feeder No.2 to 21700-SCB 004 Discharge Feeder Belt Scale No.2	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-14	Drop from 21700-FOR-006 Coarse Ore Silo Discharge Feeder No.3 to 21700-SCB 006 Discharge Feeder Belt Scale No.3	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-15	Drop from 21700-SCB-002 Discharge Feeder Belt Scale No.1 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-16	Drop from 21700-SCB-004 Discharge Feeder Belt Scale No.2 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
DP-17	Drop from 21700-SCB-006 Discharge Feeder Belt Scale No.3 to 21700-CVR-008 Primary Mill Feed Conveyor	--	4.96%	4.00	Controlled By 21300-DCD-006 Silo Discharge Dust Collection System			19.49				
Primary Milling												
DP-18	Drop from 21700-CVR-008 Primary Mill Feed Conveyor to 22100-CHU-002 Primary Mill Feed Chute	5,032,257	4.96%	4.00	Partial Enclosure, Watering	85%	85%	19.49	0.0053	0.0025	0.0004	0.0003
DP-19	Drop from 22100-MIL-001 Primary Mill to 22200-SCN-001 Primary Mill Discharge Screen	Wet streams, no emissions expected										
DP-20	Drop from 22100-SCN-001 Primary Mill Discharge Screen to 22200-CVR-010 Primary Screen Discharge Conveyor											
Secondary Crushing												
DP-21	Drop from 22200-CVR-010 Primary Screen Discharge Conveyor to 22200-CHU-004 Pebble Feed/Bypass Chute	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-22	Drop from 22200-CHU-004 Pebble Feed/Bypass Chute to 22200-BIN-004 Pebble Bin	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-23	Drop from 22200-BIN-004 Pebble Bin to 22200-FDR-010 Pebble Crusher Feeder	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-24	Drop from 22200-FDR-010 Pebble Crusher Feeder to 22200-CRU-002 Pebble Crusher	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-25	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-26	Drop from 22200-BIN-005 Pebble Crusher Product Surge Bin to 22200-FDR-011 Pebble Crusher Product Feeder	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-27	Drop from 22200-FDR-011 Pebble Crusher Product Feeder to 22200-CVR-015 Pebble Return Conveyor	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-28	Drop from 22200-CVR-015 Pebble Return Conveyor to 21700-CVR-008 Primary Mill Feed Conveyor	1,640,143	2.18%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
Underground Drops - Development Ore												
DP-40	Transfer of Development Ore from Face to Loader	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-41	Transfer of Development Ore from Loader to Stockpile	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-42	Transfer of Development Ore from Stockpile to Loader	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-43	Transfer of Development Ore from loader to Haul truck	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	3.39E-06
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	3.37E-05
DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	413,389	2.2%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	5.13E-06
Underground Drops - Development Waste + Paste Remuck												
DP-57	Transfer of Development Waste Mined from Face to Loader	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	5.52E-07
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	7.61	0.0015	0.0007	0.0001	5.48E-06
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	1,222,759	0.35%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	8.36E-07
Underground Drops - Stope Ore												

DP-65	Transfer of Stope Ore from Stope to Loader	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-70	Transfer of Stope Ore from Loader to Orepass 1	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.30	0.0002	0.0001	0.0000	7.73E-06
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	5.82	0.0011	0.0005	0.0001	5.42E-05
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	4,618,867	4.96%	4.00	Gravity Settling, Watering	96%	75%	1.79	0.0002	0.0001	0.0000	1.17E-05
Stockpile Drops												
DP-82	Drop on West Rock Stockpile	121,097	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-83	Drop on East Rock Stockpile	134,142	0.35%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	1.86E-05
DP-84	TSF	1,031,627	0.43%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.43E-06
DP-85	Drops on TSF2	2,163,873	0.43%	11.00	No Control	0%	0%	19.49	0.0013	0.0006	0.0001	5.43E-06
From Stockpiles												
DP-94	Transfer from Agg Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
WTP2												
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	9.46	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	0.05	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	325.50	0.00%	0.25	No Control	0%	0%	19.49	0.0076	0.0036	0.0005	--

1. Per February 2021 dated Process Flow Diagram, provided by South32 in May 2021.

Confirmed by RFI provided by South32, Sarah Richman, on 7/12/2021.

2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture Content taken into account in AP-42 Drop Equation)	0%	
Gravity Settling (underground only) ($PM/PM_{10}/Pb$)	87%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	17%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

	PM	PM_{10}	$PM_{2.5}$
k = Particle size multiplier (dimensionless)	0.74	0.35	0.053
U = Mean wind speed (miles per hour [mph]), which is equal to:	19.49	Based on 2019-2021 On-Site Met Data	
	1.3	For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.	

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-11b. Taylor Drops - Annual Emissions - Controlled

Emission Point Number	Description	Controlled Emissions Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Uncontrolled Emissions Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-1	Drop of the crushed ore from the mine to the 21200-BIN-001 Mine Shaft Ore Bin	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.66
DP-2	Drop from 21200-BIN-001 Mine Shaft Ore Bin to 21200-FOR-001 Mine Shaft Ore Discharge Feeder	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.656
DP-18	Drop from 21700-CVR-008 Primary Mill Feed Conveyor to 22100-CHU-002 Primary Mill Feed Chute	1.98	0.94	0.14	9.85E-02	13.23	6.26	0.95	0.66
DP-20	Drop from 22100-SCN-001 Primary Mill Discharge Screen to 22200-CVR-010 Primary Screen Discharge Conveyor	--	--	--	--	--	--	--	--
DP-21	Drop from 22200-CVR-010 Primary Screen Discharge Conveyor to 22200-CHU-004 Pebble Feed/Bypass Chute	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-22	Drop from 22200-CHU-004 Pebble Feed/Bypass Chute to 22200-BIN-004 Pebble Bin	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-23	Drop from 22200-BIN-004 Pebble Bin to 22200-FDR-010 Pebble Crusher Feeder	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-24	Drop from 22200-FDR-010 Pebble Crusher Feeder to 22200-CRU-002 Pebble Crusher	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-25	Drop from 22200-CRU-002 Pebble Crusher to 22200-BIN-005 Pebble Crusher Product Surge Bin	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-26	Drop from 22200-BIN-005 Pebble Crusher Product Surge Bin to 22200-FDR-011 Pebble Crusher Product Feeder	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-27	Drop from 22200-FDR-011 Pebble Crusher Product Feeder to 22200-CVR-015 Pebble Return Conveyor	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-28	Drop from 22200-CVR-015 Pebble Return Conveyor to 21700-CVR-008 Primary Mill Feed Conveyor	1.29	0.61	0.09	2.82E-02	4.31	2.04	0.31	0.09
DP-40	Transfer of Development Ore from Face to Loader	0.00	0.00	0.00	2.63E-05	0.03	0.02	0.00	0.00
DP-41	Transfer of Development Ore from Loader to Stockpile	0.00	0.00	0.00	2.63E-05	0.03	0.02	0.00	0.00
DP-42	Transfer of Development Ore from Stockpile to Loader	0.00	0.00	0.00	2.63E-05	0.03	0.02	0.00	0.00
DP-43	Transfer of Development Ore from loader to Haul truck	0.00	0.00	0.00	2.63E-05	0.03	0.02	0.00	0.00
DP-49	Transfer of Development Ore Mined from Haul Truck to Coarse Ore Bin	0.01	0.01	0.01	2.61E-04	0.32	0.15	0.02	0.01

DP-54	Transfer of Development Ore Mined from Crushed Ore Bin to Shaft Loadout Conveyor	0.00	0.00	0.00	3.98E-05	0.05	0.02	0.00	0.00
DP-55	Transfer of Development Ore Mined from Shaft Loadout Conveyor to Measurement Flask	0.00	0.00	0.00	3.98E-05	0.05	0.02	0.00	0.00
DP-56	Transfer of Development Ore Mined from Measurement Flast to Skip	0.00	0.00	0.00	3.98E-05	0.05	0.02	0.00	0.00
DP-57	Transfer of Development Waste Mined from Face to Loader	0.00	0.00	0.00	1.26E-05	0.10	0.05	0.01	0.00
DP-58	Transfer of Development Waste Mined from Loader to Stockpile	0.00	0.00	0.00	1.26E-05	0.10	0.05	0.01	0.00
DP-59	Transfer of Development Waste Mined from Stockpile to Loader	0.00	0.00	0.00	1.26E-05	0.10	0.05	0.01	0.00
DP-60	Transfer of Development Waste Mined from Loader to Haul Truck	0.00	0.00	0.00	1.26E-05	0.10	0.05	0.01	0.00
DP-61	Transfer of Development Waste Mined from Haul Truck to Waste Pass Grizzly	0.04	0.02	0.02	1.26E-04	0.95	0.45	0.01	0.00
DP-62	Transfer of Development Waste Mined from Waste Pass Grizzly to Shaft Loadout Conveyor	0.01	0.00	0.00	1.92E-05	0.14	0.07	0.07	0.00
DP-63	Transfer of Development Waste Mined from Shaft Loadout Conveyor to Measurement Flask	0.01	0.00	0.00	1.92E-05	0.14	0.07	0.01	0.00
DP-64	Transfer of Development Waste Mined from Measurement Flask to Skip	0.01	0.00	0.00	1.92E-05	0.14	0.07	0.01	0.00
DP-65	Transfer of Stope Ore from Stope to Loader	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.01	0.02
DP-70	Transfer of Stope Ore from Loader to Orepass 1	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-71	Transfer of Stope Ore from Orepass 1 to Haul Truck	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-72	Transfer of Stope Ore from Haul Truck to Orepass 2	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-73	Transfer of Stope Ore from Orepass 2 to Haul Truck	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-74	Transfer of Stope Ore from Haul Truck to Coarse Ore Bin	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-75	Transfer of Stope Ore from Coarse Ore Bin to Crusher Feeder Belt/Hopper	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-76	Transfer of Stope Ore from Crusher Feeder Belt/Hopper to Transfer Conveyor	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-77	Transfer of Stope Ore from Transfer Conveyor to Reversing Conveyor	0.01	0.01	0.01	6.69E-04	0.36	0.17	0.03	0.02
DP-78	Transfer of Stope Ore from Reversing Conveyor to Crushed Ore Bin	0.09	0.04	0.04	4.69E-03	2.52	1.19	0.03	0.13
DP-79	Transfer of Stope Ore from Crushed Ore Bin to Shaft Loadout Conveyor	0.02	0.01	0.01	1.01E-03	0.54	0.26	0.03	0.03
DP-80	Transfer of Stope Ore from Shaft Loadout Conveyor to Measurement Flask	0.02	0.01	0.01	1.01E-03	0.54	0.26	0.18	0.03
DP-81	Transfer of Stope Ore from Measuring Flask to Skip	0.02	0.01	0.01	1.01E-03	0.54	0.26	0.04	0.03
DP-82	Drop on West Rock Stockpile	0.32	0.15	0.02	1.13E-03	0.32	0.15	0.02	0.00
DP-83	Drop on East Rock Stockpile	0.35	0.17	0.03	1.25E-03	0.35	0.17	0.03	0.00
DP-84	TSF	0.66	0.31	0.05	2.80E-03	0.66	0.31	0.05	0.00
DP-85	Drops on TSF2	1.38	0.65	0.10	5.88E-03	1.38	0.65	0.10	0.01
DP-94	Transfer from Agg Stockpile to Loader	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-95	Transfer of Agg Material from Loader to Haul Truck	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-96	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.08	0.04	0.01	--	0.08	0.04	0.01	--
DP-138	Drop of 55 lb Dry Anionic Flocculant to Open Top Dump Hopper	3.57E-05	1.69E-05	2.56E-06	--	0.00	0.00	0.00	--
DP-139	Drop of 50 lb Bry Cationic Flocculant via Manual Addition	1.78E-07	8.44E-08	1.28E-08	--	0.00	0.00	0.00	--
DP-140	Drop of Sodium Sulfate to Bulk Handling System	1.23E-03	5.81E-04	8.81E-05	--	0.00	0.00	0.00	--
	Total	**19.63**	**9.28**	**1.55**	**0.55**	**86.91**	**41.11**	**6.18**	**3.12**

Table A-12a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency %	Control Factor [2] $PM_{2.5}$ Efficiency %	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	PM_{10} (lb/ton)	$PM_{2.5}$ (lb/ton)	Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	129	1.76%	4.00	Spray Bar, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	90	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Ore from Ore Stockpile to Loader	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25274E-05
DP-106	Transfer of Ore Mined from Loader to Haul Truck	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-107	Transfer from ROM Stockpile to Loader	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-109	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Rock Storage Drop	112.71	0.57%	4.00	No control	0%	0%	19.49	0.0053	0.0025	0.0004	2.98E-05
DP-114	Ore Stockpile Drop	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile Drop	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-125	Transfer of Development Ore from Loader to Stockpile	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-126	Transfer of Development Ore from Stockpile to Loader	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	22	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-129	Transfer of Development Waste Mined from Face to Loader	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	113	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-134	Transfer of Stope Ore from Stope to Loader	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-135	Transfer of Stope Ore from Loader to Stockpile	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-136	Transfer of Stope Ore from Stockpile to Loader	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-137	Transfer of Stope Ore from Loader to Haul Truck	62	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture taken into account within drop equation)	0%	
Gravity Settling (underground only) (PM/PM_{10}/Pb)	80%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	16%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is equal to: 19.49 Based on 2019-2021 On-Site Met Data

1.3 For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1

0.25 %

Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-12b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions: Hourly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Daily Emissions (lb/day) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.10	0.05	0.007	0.002	2.44	1.15	0.17	0.04
DP-104	Drop from silo to trucks	0.24	0.11	0.02	0.004	5.69	2.69	0.41	0.10
DP-105	Transfer of Ore from Ore Stockpile to Loader	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-106	Transfer of Ore Mined from Loader to Haul Truck	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-107	Transfer from ROM Stockpile to Loader	0.04	0.02	0.00	0.00	0.87	0.41	0.06	0.02

DP-109	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-113	Hardshell Rock Storage Drop	0.59	0.28	0.04	0.003	14.23	6.73	1.02	0.08
DP-114	Ore Stockpile Drop	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-115	ROM Stockpile Drop	0.04	0.02	0.00	0.001	0.87	0.41	0.06	0.02
DP-124	Transfer of Development Ore from Face to Loader	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.001	0.000
DP-125	Transfer of Development Ore from Loader to Stockpile	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.001	0.000
DP-126	Transfer of Development Ore from Stockpile to Loader	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.001	0.000
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	2.06E-04	9.73E-05	6.11E-05	2.65E-06	0.00	0.00	0.001	0.000
DP-129	Transfer of Development Waste Mined from Face to Loader	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.008	0.000
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.008	0.000
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.008	0.000
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	1.07E-03	5.04E-04	3.16E-04	6.04E-06	0.03	0.01	0.008	0.000
DP-134	Transfer of Stope Ore from Stope to Loader	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.004	0.000
DP-135	Transfer of Stope Ore from Loader to Stockpile	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.004	0.000
DP-136	Transfer of Stope Ore from Stockpile to Loader	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.004	0.000
DP-137	Transfer of Stope Ore from Loader to Haul Truck	5.86E-04	2.77E-04	1.74E-04	1.03E-05	0.01	0.01	0.004	0.000
Total		**1.82**	**0.86**	**0.13**	**0.02**	**43.60**	**20.62**	**3.16**	**0.42**

Table A-13a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tph)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency (%)	Control Factor [2] $PM_{2.5}$ Efficiency (%)	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM (lb/ton)	Uncontrolled Emission Factor [3] PM_{10} (lb/ton)	Uncontrolled Emission Factor [3] $PM_{2.5}$ (lb/ton)	Uncontrolled Emission Factor [3] Lead Compounds (lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	86	1.76%	4.00	Spray Bar, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	86	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Ore from Ore Stockpile to Loader	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25274E-05
DP-106	Transfer of Ore Mined from Loader to Haul Truck	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-107	Transfer from ROM Stockpile to Loader	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	0.0001
DP-109	Transfer from Agg Stockpile to Loader	9.19	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	9.19	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	6.43	0.00%	1.77	No control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Rock Storage Drop	112.71	0.57%	4.00	No control	0%	0%	19.49	0.0053	0.0025	0.0004	2.98E-05
DP-114	Ore Stockpile Drop	83.77	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile Drop	22.96	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-125	Transfer of Development Ore from Loader to Stockpile	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-126	Transfer of Development Ore from Stockpile to Loader	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	53	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.01E-06
DP-129	Transfer of Development Waste Mined from Face to Loader	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	74	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	8.83E-07
DP-134	Transfer of Stope Ore from Stope to Loader	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-135	Transfer of Stope Ore from Loader to Stockpile	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-136	Transfer of Stope Ore from Stockpile to Loader	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06
DP-137	Transfer of Stope Ore from Loader to Haul Truck	81	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.0001	0.00001	2.74E-06

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.

2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
Moisture Content (Moisture taken into account within drop equation)	0%	
Gravity Settling (underground only) (PM/PM_{10}/Pb)	80%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	16%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

k = Particle size multiplier (dimensionless)

	PM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

U = Mean wind speed (miles per hour [mph]), which is equal to: 19.49 Based on 2019-2021 On-Site Met Data

1.3 For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1

0.25 %

Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-13b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions: Hourly Emissions (lb/hr) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Controlled Emissions: Daily Emissions (lb/day) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.07	0.03	0.005	0.001	1.63	0.77	0.12	0.03
DP-104	Drop from silo to trucks	0.23	0.11	0.02	0.004	5.43	2.57	0.39	0.10
DP-105	Transfer of Ore from Ore Stockpile to Loader	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-106	Transfer of Ore Mined from Loader to Haul Truck	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-107	Transfer from ROM Stockpile to Loader	0.04	0.02	0.00	0.00	0.87	0.41	0.06	0.02
DP-109	Transfer from Agg Stockpile to Loader	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.15	0.07	0.01	--	3.63	1.72	0.26	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.11	0.05	0.01	--	2.54	1.20	0.18	--
DP-113	Hardshell Rock Storage Drop	0.59	0.28	0.04	0.003	14.23	6.73	1.02	0.08
DP-114	Ore Stockpile Drop	0.13	0.06	0.01	0.00	3.17	1.50	0.23	0.06
DP-115	ROM Stockpile Drop	0.04	0.02	0.00	0.001	0.87	0.41	0.06	0.02

DP-124	Transfer of Development Ore from Face to Loader	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.004	0.000
DP-125	Transfer of Development Ore from Loader to Stockpile	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.004	0.000
DP-126	Transfer of Development Ore from Stockpile to Loader	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.004	0.000
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	5.00E-04	2.36E-04	1.48E-04	6.45E-06	0.01	0.01	0.004	0.000
DP-129	Transfer of Development Waste Mined from Face to Loader	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.005	0.000
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.005	0.000
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.005	0.000
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	6.99E-04	3.31E-04	2.07E-04	3.96E-06	0.02	0.01	0.005	0.000
DP-134	Transfer of Stope Ore from Stope to Loader	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.005	0.000
DP-135	Transfer of Stope Ore from Loader to Stockpile	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.005	0.000
DP-136	Transfer of Stope Ore from Stockpile to Loader	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.005	0.000
DP-137	Transfer of Stope Ore from Loader to Haul Truck	7.63E-04	3.61E-04	2.26E-04	1.34E-05	0.02	0.01	0.005	0.000
Total		**1.77**	**0.84**	**0.13**	**0.02**	**42.54**	**20.12**	**3.09**	**0.41**

Table A-14a. Clark Drops - Emissions - Inputs

Emission Point Number	Description	Throughput [1] (tpy)	Lead Grade [1]	Water Content (%) [1]	Control Method	Control Factor [2] PM/PM_{10} Efficiency	Control Factor [2] $PM_{2.5}$ Efficiency	Windspeed [4] (mph)	Uncontrolled Emission Factor [3] PM	Uncontrolled Emission Factor [3] PM_{10}	Uncontrolled Emission Factor [3] $PM_{2.5}$	Uncontrolled Emission Factor [3] Lead Compounds
						%	%		(lb/ton)	(lb/ton)	(lb/ton)	(lb/ton)
Surface Activities												
Coarse Ore Delivery and Storage												
DP-103	Dump into Primary Crusher Feed Hopper	733,798	1.76%	4.00	Spray Bar, Partial Enclosure	85%	85%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-104	Drop from silo to trucks	733,798	1.76%	4.00	Partial Enclosure, Dust Extractor	50%	50%	19.49	0.0053	0.0025	0.0004	9.25E-05
From Stockpiles												
DP-105	Transfer of Development Ore from Ore Stockpile to Loader	733794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-106	Transfer of Development Ore Mined from Loader to Haul Truck	733794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-107	Transfer from ROM Stockpile to Loader	201172	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-109	Transfer from Agg Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	10,000	0.00%	1.77	No Control	0%	0%	19.49	0.0165	0.0078	0.0012	--
Stockpile Drops												
DP-113	Hardshell Rock Storage	987,351	0.57%	4.00	No Control	0%	0%	19.49	0.0053	0.0025	0.0004	2.98E-05
DP-114	Ore Stockpile	733,794	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
DP-115	ROM Stockpile	201,172	1.76%	4.00	Watering	70%	70%	19.49	0.0053	0.0025	0.0004	9.25E-05
Underground												
DP-124	Transfer of Development Ore from Face to Loader	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000002
DP-125	Transfer of Development Ore from Loader to Stockpile	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000002
DP-126	Transfer of Development Ore from Stockpile to Loader	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000002
DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	190,691	1.29%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000002
DP-129	Transfer of Development Waste Mined from Face to Loader	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000001
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000001
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000001
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	987,351	0.57%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000001
DP-134	Transfer of Stope Ore from Stope to Loader	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000003
DP-135	Transfer of Stope Ore from Loader to Stockpile	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000003
DP-136	Transfer of Stope Ore from Stockpile to Loader	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000003
DP-137	Transfer of Stope Ore from Loader to Haul Truck	543,107	1.76%	4.00	Gravity Settling, Watering	94%	75%	1.30	0.0002	0.00007	0.00001	0.000003

1. Per March 2022 dated Process Flow Diagram, provided by South32 in March 2022.
2. Control Factor based on conservative assumptions using "Nevada DEP - Guidance on Emission Factors for the Mining Industry" and West Virginia DEP Nonmetallic Mineral Processing Plants Application Instructions and Forms for General Permit G40-C - Table A

For Watering	70%	
For Moisture Content	0%	
Gravity Settling (underground only) (PM/PM_{10}/Pb)	80%	Control efficiencies for underground gravity settling are a combination of vertical settling and horizontal settling based on discussions with ADEQ in May 2023. Vertical settling is based on various technical papers and per ADEQ meeting on May 18th 2023. Horizontal settling is based on Stoke's Equation and inputs from South32.
Gravity Settling (underground only) ($PM_{2.5}$)	16%	Detailed calculations are included in the Gravity Settling Tab of this spreadsheet
For Full Enclosure/Enclosure by building	80%	
For Partial Enclosure	50%	
No control	0%	

3. Uncontrolled emission factors using the "drop equation" contained in U.S. EPA AP-42, Section 13.2.4 (Aggregate Handling and Storage Piles), November 2006, as follows:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where E = Emission factor (lb/ton)

	PM	PM_{10}	$PM_{2.5}$
k = Particle size multiplier (dimensionless)	0.74	0.35	0.053
U = Mean wind speed (miles per hour [mph]), which is equal to:	19.49	Based on 2019-2021 On-Site Met Data	
	1.3	For indoor activities, based on minimum value of wind speed per AP-42 Section 13.2.4.	

M = Moisture Content (%) (Assuming 0.25 if water content not specified per EPA AP-42, Section 13.2.4 Equation 1
0.25 %
Moisture Content of Aggregate taken to be 1.7 per AP-42 Section 11.12 Table 11.12-1 Footnote b

4. Underground wind speeds at various drop locations based on ventilation design wind speeds provied in emails from Kevin McCoy (South32) on 05/18/2023 and Cayley Hoffman (South32) on 05/22/2023. For wind speeds under 1.3 miles/hour, a minimum wind speed of 1.3 was conservatively used

Table A-14b. Clark Drops - Emissions - Controlled

Emission Point Number	Description	Controlled Emissions Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds	Uncontrolled Emissions Annual Emissions (tpy) PM	PM_{10}	$PM_{2.5}$	Lead Compounds
DP-103	Dump into Primary Crusher Feed Hopper	0.29	0.14	0.02	0.01	1.93	0.91	0.14	0.03
DP-104	Drop from silo to trucks	0.96	0.46	0.07	0.02	1.93	0.91	0.14	0.03
DP-105	Transfer of Development Ore from Ore Stockpile to Loader	0.58	0.27	0.04	0.01	1.93	0.91	0.14	0.03
DP-106	Transfer of Development Ore Mined from Loader to Haul Truck	0.58	0.27	0.04	0.01	1.93	0.91	0.14	0.03
DP-107	Transfer from ROM Stockpile to Loader	0.16	0.08	0.011	0.003	0.53	0.25	0.04	0.01
DP-109	Transfer from Agg Stockpile to Loader	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-110	Transfer of Agg Material from Loader to Haul Truck	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-111	Transfer of Shotcrete Aggregate from Stockpile to Loader	0.08	0.04	0.006	--	0.08	0.04	0.01	--
DP-113	Hardshell Rock Storage	2.60	1.23	0.186	0.015	2.60	1.23	0.19	0.01
DP-114	Ore Stockpile	0.58	0.27	0.041	0.010	1.93	0.91	0.14	0.03
DP-115	ROM Stockpile	0.16	0.08	0.011	0.003	0.53	0.25	0.04	0.01
DP-124	Transfer of Development Ore from Face to Loader	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-125	Transfer of Development Ore from Loader to Stockpile	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-126	Transfer of Development Ore from Stockpile to Loader	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00

DP-127	Transfer of Development Ore Mined from Loader to Haul Truck	9.01E-04	4.26E-04	2.67E-04	1.16E-05	0.01	0.01	0.00	0.00
DP-129	Transfer of Development Waste Mined from Face to Loader	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-130	Transfer of Development Waste Mined from Loader to Stockpile	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-131	Transfer of Development Waste Mined from Stockpile to Loader	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-132	Transfer of Development Waste Mined from Loader to Haul Truck	4.67E-03	2.21E-03	1.38E-03	2.65E-05	0.08	0.04	0.01	0.00
DP-134	Transfer of Stope Ore from Stope to Loader	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-135	Transfer of Stope Ore from Loader to Stockpile	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-136	Transfer of Stope Ore from Stockpile to Loader	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
DP-137	Transfer of Stope Ore from Loader to Haul Truck	2.57E-03	1.21E-03	7.62E-04	4.52E-05	0.04	0.02	0.00	0.00
Total		**6.18**	**2.93**	**0.45**	**0.07**	**14.09**	**6.66**	**1.01**	**0.21**

Table A-15. Dust Collectors - Emissions

Emission Point Number	Description	Max Outlet Grain Loading [1] (gr/dscf)	Stack Flow Rate [2] (cfm)	Hours of Operation (hr/yr)	Annual Emissions [2,3]				Hourly Emissions [4,5]				Daily Emissions [3,4]			
					PM (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	Lead Compounds [5] (tpy)	PM (lb/hr)	PM_{10} (lb/hr)	$PM_{2.5}$ (lb/hr)	Lead Compounds [5] (lb/hr)	PM (lb/day)	PM_{10} (lb/day)	$PM_{2.5}$ (lb/day)	Lead Compounds [5] (lb/day)
Taylor																
DC-1	21210-CX-00002 Main Shaft Ore Discharge Dust Collector collecting dust from 21210-CV-0003 Main Shaft Outfeed Conveyor	0.002	3,200	8,760	0.24	0.24	0.24	0.01	0.05	0.05	0.05	0.00	1.32	1.32	1.32	0.07
DC-2	21210-CX-00001 Coarse Ore Overland Dust Collector collecting dust from 21210-CV-00001 Coarse Ore Overland Conveyor	0.002	4,750	8,760	0.36	0.36	0.36	0.02	0.08	0.08	0.08	0.00	1.95	1.95	1.95	0.10
DC-3	21210-CX-00004 Silo No. 1 Feed COnveyor Dust Collector collecting dust from 21320-CV-00001 Coarse Ore SIlo Feed Conveyor No. 1	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.06	0.00	1.36	1.36	1.36	0.07
DC-4	21300-DCD-004 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-002 Coarse Ore Silo No. 2	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.06	0.00	1.36	1.36	1.36	0.07
DC-5	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-003 Coarse Ore Silo No. 3	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.06	0.00	1.36	1.36	1.36	0.07
DC-11	21300-DCD-005 Coarse Ore Silo Collection System collecting dust from entrance to 21500-SLO-004 Coarse Ore Silo No. 4	0.002	3,300	8,760	0.25	0.25	0.25	0.01	0.06	0.06	0.06	0.00	1.36	1.36	1.36	0.07
DC-6	21300-DCD-006 Silo Discharge Dust Collection System collecting dust from 21700-SCB-002/004/006 Discharge Feeder Belt Scale No.1 to No.3 and 21700-CVR-008 Primary Mill Feed Conveyor	0.002	7,500	8,760	0.56	0.56	0.56	0.03	0.13	0.13	0.13	0.01	3.09	3.09	3.09	0.15
DC-PPBS1	Paste Plant Binder Silo 1 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-PPBS2	Paste Plant Binder Silo 2 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-PPBS3	Paste Plant Binder Silo 3 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-PPBS4	Paste Plant Binder Silo 4 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-PPM1M	Paste Plant Module 1 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
DC-PPM2M	Paste Plant Module 2 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
Clark																
DC-7	Coarse Ore Dust Collection System,23100-FAN-0001	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.03	0.00	0.66	0.66	0.66	0.01
DC-8	Coarse Ore Dust Collection System,23100-FAN-0002	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.03	0.00	0.66	0.66	0.66	0.01
DC-CPPBS1	Paste Plant Binder Silo 1 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-CPPBS2	Paste Plant Binder Silo 2 [7]	0.005	750	8,760	0.14	0.14	0.14	0.00	0.03	0.03	0.03	0.00	0.77	0.77	0.77	0.00
DC-CPPBS3	Paste Plant Binder Silo 3 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-CPPBS4	Paste Plant Binder Silo 4 [7]	0.005	1,500	8,760	0.28	0.28	0.28	0.00	0.06	0.06	0.06	0.00	1.54	1.54	1.54	0.00
DC-CPPM1M	Paste Plant Module 1 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
DC-CPPM2M	Paste Plant Module 2 Mixer [7]	0.005	3,000	8,760	0.56	0.56	0.56	0.00	0.13	0.13	0.13	0.00	3.09	3.09	3.09	0.00
DC-10	Coarse Ore Dust Collection System,23100-DCD-0005	0.001	3,200	8,760	0.12	0.12	0.12	0.002	0.03	0.03	0.03	0.00	0.66	0.66	0.66	0.01
General																
WTP1LS	Waste Water Treatment Plant #1 Lime Silo	0.005	1,001	8,760	0.19	0.19	0.19	0.00	0.04	0.04	0.04	0.00	1.03	1.03	1.03	0.00
				Total	**6.64**	**6.64**	**6.64**	**0.11**	**1.52**	**1.52**	**1.52**	**0.03**	**36.39**	**36.39**	**36.39**	**0.62**

1. Per email from Sarah Richman, South32, on 07/06/2021 (Per Fluor Canada Ltd. Engineering)
   Per "Clark Deposit General RFI for Air Permit 030922" RFI received on 3/3/2022
2. Per "South32 - Mine Development - RFI 201-06-22 Novak" from meeting with South32, dated 06/22/2021, from Grace Huang of Fluor Canada Ltd.
3. Using the conversion factors given below:
   7000 grains/lb
   2000 lb/ton
   60 min/hr
4. Lead Conc.
   4.96 % For Taylor deposit
   1.76 % For Clark deposit
   0.00 % Lead at paste plant assumed to be negligible
5. PM particle size multipler (dimensionless):

PM	PM_{10}	$PM_{2.5}$
0.74	0.35	0.053

6. Per email from Sarah Richman, South32, on 08/24/2022 (Per Fluor Canada Ltd. Engineering)
7. Per email from Sarah Richman, South32, on 08/31/2022 (Per Fluor Canada Ltd. Engineering and Paterson Cooke)

Table A-16a. Engines - Emission Factors

Pollutant	Value	Unit	Source
NO_x	3.64E-02	g/kW-hr	Not to exceed emission factors for generator 100% load Emissions Performance on JGC 624 K111 engine provided by Thomas Henkenmeier (Innio) on 7/17/2023. PM/PM10/PM2.5 is equal to the provided emission factor + 50% of the condensable PM value from AP-42 (4-stroke, lean burn) as a conservative safety factor. Engines: 33.998 MMbtu/hr
NO_2	-	g/kW-hr	
CO	6.08E-02	g/kW-hr	
$PM/PM_{10}/PM_{2.5}$	3.18E-02	g/kW-hr	
VOC	6.30E-02	g/kW-hr	
CO_2	-	g/kW-hr	
CH_4	-	g/kW-hr	
N_2O	-	g/kW-hr	
Acetaldehyde	3.00E-03	g/kW-hr	
Formaldehyde	1.52E-02	g/kW-hr	
NO_x	3.78E-02	g/kW-hr	Not to exceed generator 75% load Emissions Performance on JGC 624 K111 engine provided by Thomas Henkenmeier (Innio) on 7/17/2023. PM/PM10/PM2.5 is equal to the provided emission factor + 50% of the condensable PM value from AP-42 (4-stroke, lean-burn) as a conservative safety factor. Engines: 33.998 MMbtu/hr.
NO_2	-	g/kW-hr	
CO	6.08E-02	g/kW-hr	
$PM/PM_{10}/PM_{2.5}$	3.24E-02	g/kW-hr	
VOC	6.30E-02	g/kW-hr	
CO_2	-	g/kW-hr	
CH_4	-	g/kW-hr	
N_2O	-	g/kW-hr	
Acetaldehyde	3.00E-03	g/kW-hr	
Formaldehyde	1.52E-02	g/kW-hr	
NO_x	7.87E-02	g/kW-hr	Per Natural Gas Generator 100% load Emissions Performance on G3520 Caterpillar engine provided by Brad Kaufman, VoltaGrid, on 9/22/2021
NO_2	7.50E-03	g/kW-hr	
CO	1.31E-02	g/kW-hr	
$PM/PM_{10}/PM_{2.5}$	2.00E-03	g/kW-hr	
VOC	1.18E-02	g/kW-hr	
CO_2	5.09E+02	g/kW-hr	
CH_4	1.29E+00	g/kW-hr	
N_2O	1.10E-02	g/kW-hr	
Acetaldehyde	7.10E-03	g/kW-hr	
Formaldehyde	4.70E-03	g/kW-hr	
NO_x	5.26E-02	g/kW-hr	Per Natural Gas Generator 75% load Emissions Performance on G3520 Caterpillar engine provided by Brad Kaufman, VoltaGrid, on 9/22/2021
NO_2	3.00E-04	g/kW-hr	
CO	1.88E-02	g/kW-hr	
$PM/PM_{10}/PM_{2.5}$	2.21E-02	g/kW-hr	
VOC	5.40E-02	g/kW-hr	
CO_2	5.30E+02	g/kW-hr	
CH_4	1.48E+00	g/kW-hr	
N_2O	1.40E-02	g/kW-hr	
Acetaldehyde	2.55E-02	g/kW-hr	
Formaldehyde	0.00E+00	g/kW-hr	
NOx	1.00E-01	g/kW-hr	Per Caterpillar engine emissions certification, provided by Kara Haas, South32, on 7/18/2022
CO	1.00E-02	g/kW-hr	
$PM/PM_{10}/PM_{2.5}$	1.00E-02	g/kW-hr	
VOC	2.00E-02	g/kW-hr	
SO_2	5.88E-04	g/kW-hr	AP-42 for Natural Gas Engines (Maximum Emission Factor Available)
VOC	1.20E-01	lb/MMBtu	AP-42 for Natural Gas Engines (4 stroke lean burn)
Benzene	4.40E-04	lb/MMBtu	AP-42 Section 3.2, Natural Gas Engines (4 Stroke Lean Burn). The emission factor for PAH (which are HAPs because they are POMs) is the sum of the value listed for 'PAH' in AP-42 and all other PAHs listed in the AP-42 that are not specifically listed HAPs.
Toluene	4.08E-04	lb/MMBtu	
Xylene	1.84E-04	lb/MMBtu	
1,3-Butadiene	2.67E-04	lb/MMBtu	
Acrolein	5.14E-03	lb/MMBtu	
Naphthalene	7.44E-05	lb/MMBtu	
1,1,2,2-Tetrachloroethane	4.00E-05	lb/MMBtu	
1,1,2-Trichloroethane	3.18E-05	lb/MMBtu	
1,3-Dichloropropene	2.64E-05	lb/MMBtu	
2-Methylnaphthalene	3.32E-05	lb/MMBtu	
2,2,4-Trimethylpentane	2.50E-04	lb/MMBtu	
Biphenyl	2.12E-04	lb/MMBtu	
Carbon Tetrachloride	3.67E-05	lb/MMBtu	
Chlorobenzene	3.04E-05	lb/MMBtu	
Chloroform	2.85E-05	lb/MMBtu	
Ethylbenzene	3.97E-05	lb/MMBtu	
Ethylene Dibromide	4.43E-05	lb/MMBtu	
Formaldehyde	5.28E-02	lb/MMBtu	
Fluoranthene	1.11E-06	lb/MMBtu	
Fluorene	5.67E-06	lb/MMBtu	
Methanol	2.50E-03	lb/MMBtu	
Methylene Chloride	2.00E-05	lb/MMBtu	
Hexane	1.11E-03	lb/MMBtu	
PAH	7.75E-05	lb/MMBtu	
Phenol	2.40E-05	lb/MMBtu	
Tetrachloroethane	2.48E-06	lb/MMBtu	
Vinyl Chloride	1.49E-05	lb/MMBtu	
$PM/PM_{10}/PM_{2.5}$	4.00E-02	g/kW-hr	Tier 4 emission factors for diesel engines from Table 1 of §1039.101
NO_x	3.50E+00	g/kW-hr	
CO	3.50E+00	g/kW-hr	
VOC	1.90E-01	g/kW-hr	EPA Nonroad Compression-Ignition Engines: Exhaust Emissions Standards, March 2016
SO_x	1.21E-05	lb/hp-hr	AP-42, Table 3.4-1 (October 1996) based on Ultra Low Sulfur Diesel (15 ppm sulfur or 0.0015%)
CO_2	7.40E+01	kg/MMBtu	40 CFR Part 98, Subpart C, Table C-1 for Distillate Fuel Oil No. 2 (diesel)
CH_4	3.00E-03	kg/MMBtu	
N_2O	6.00E-04	kg/MMBtu	
PM (condensable)	9.91E-03	lb/MMBtu	AP-42 for Natural Gas Engines (4 stroke lean burn)
CO_2	5.31E+01	kg/MMBtu	40 CFR Part 98, Subpart C, Table C-1 and C-2 for Natural Gas (Weighted U.S Average)
CH_4	1.00E-03	kg/MMBtu	
N_2O	1.00E-04	kg/MMBtu	
Benzene	7.76E-04	lb/MMBtu	AP-42 Section 3.4, HAP Emission Factors For Large Uncontrolled Stationary Diesel Engines (>600 HP). The emission factor for PAH (which are HAPs because they are POMs) is the value for 'Total PAH' listed in AP-42 minus the value listed for napthalene, as it is speciated here.
Toluene	2.81E-04	lb/MMBtu	
Xylene	1.93E-04	lb/MMBtu	
1,3-Butadiene	3.91E-05	lb/MMBtu	
Formaldehyde	7.89E-05	lb/MMBtu	
Acetaldehyde	2.52E-05	lb/MMBtu	
Acrolein	7.88E-06	lb/MMBtu	
Naphthalene	1.30E-04	lb/MMBtu	
PAH	8.20E-05	lb/MMBtu	
NOx	7.13E+00	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Interim engines with 19 ≤ kW < 37 & BAAQMD Guidance - https://www.baaqmd.gov/~/media/Files/Engineering/policy_and_procedures/Engines/EmissionFactorsforDieselEngines.ashx
CO	5.50E+00	g/kW-hr	
PM	3.00E-01	g/kW-hr	
PM10	3.00E-01	g/kW-hr	
PM2.5	3.00E-01	g/kW-hr	
VOC	3.75E-01	g/kW-hr	
SO2	2.05E-03	lb/hp-hr	AP-42 Section 3.3 for Diesel Engines (<600 HP)
NOx	4.00E-01	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Final engines with 75 ≤ kW < 130.
CO	5.00E+00	g/kW-hr	
PM	2.00E-02	g/kW-hr	
PM_{10}	2.00E-02	g/kW-hr	
$PM_{2.5}$	2.00E-02	g/kW-hr	

VOC	1.90E-01	g/kW-hr	
NOx	4.00E-01	g/kW-hr	From "Nonroad Compression-Ignition Engines: Exhaust Emission Standards" (EPA, 2016) for Tier 4 Final engines with 130 ≤ kW < 225.
CO	3.50E+00	g/kW-hr	
PM	2.00E-02	g/kW-hr	
PM_{10}	2.00E-02	g/kW-hr	
$PM_{2.5}$	2.00E-02	g/kW-hr	
VOC	1.90E-01	g/kW-hr	
Benzene	9.33E-04	lb/MMBtu	AP-42 Section 3.3 Table 3.3-2 Speciated Organic Compound Emission Factors For Uncontrolled Diesel Engines (< 600 HP). The emission factor for PAH (which are HAPs because they are POMs) is the value for 'Total PAH' listed in AP-42 minus the value listed for napthalene, as it is speciated here.
Toluene	4.09E-04	lb/MMBtu	
Xylene	2.85E-04	lb/MMBtu	
1,3-Butadiene	3.91E-05	lb/MMBtu	
Formaldehyde	1.18E-03	lb/MMBtu	
Acetaldehyde	7.67E-04	lb/MMBtu	
Acrolein	9.25E-05	lb/MMBtu	
Napthalene	8.48E-05	lb/MMBtu	
PAH	8.32E-05	lb/MMBtu	

Table A-16b. Generator - Criteria Pollutant Emissions (Annual)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW)		Fuel Type	Operation Hours	Criteria Pollutants Annual Emissions (tpy)								GHG Annual Emissions (tpy)			
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2	CO_2	CH_4	N_2O	CO_2e
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	82.15	0.47	29.36	34.51	34.51	34.51	84.33	0.92	827,718.92	2,308.09	21.86	891,936.63
T_ENG (100%)	Trench			150,800	165,880	NG	8,760	163.88	15.62	27.28	4.16	4.16	4.16	24.57	1.22	1,059,896.68	2,682.85	22.91	1,133,793.76
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,740	93,053	NG	8,760	33.96	11.89	54.63	29.12	29.12	29.12	56.61	0.53	365,141.37	6.88	0.69	365,518.49
T_ENG_ALT (100%)	Trench			120,987	124,071	NG	8,760	43.61	15.26	72.84	38.13	38.13	38.13	75.48	0.70	470,319.24	8.86	0.89	470,804.99
HS_1 - HS_6	Hardshell	CAT XQ1140	6	5,460	6,006	Diesel	8,760	5.80	2.90	0.58	0.58	0.58	0.58	1.16	7.04E-04	40,264.71	1.63	0.33	40,402.88
ENG9 - ENG13	Taylor	CAT C175 3000 kW	5	3,000	3,300	Diesel	500	31.83	31.83	31.83	3.64E-01	3.64E-01	3.64E-01	1.73E+00	6.71E-02	1,262.75	0.05	0.01	1,267.09
ENG5	WW1	C200D2RE	1	198	218	Diesel	8,760	0.84	0.84	7.36	0.04	0.04	0.04	0.04	2.62	1,460.15	0.06	0.01	1,465.16
Total Annual Emissions								**202.35**	**51.19**	**112.61**	**39.12**	**39.12**	**39.12**	**87.26**	**3.91**	**1,102,884.29**	**2,684.59**	**23.25**	**1,176,928.89**

1. NO2 for the 4.4MW engines is calculated using an in stack ratio of 0.35 per engine specs provided by Thomas Henemeier (INNIO) on 7/27/23.
2. VOC emission factors for NG engines assumed to be total of VOC, Acetaldehyde, and Formaldehyde emission factors from performance test.

Table A-16c. Generator - HAP Emissions (Annual) [1,2]

Emission Point Number	T_ENG (75%)	T_ENG (100%)	T_ENG_ALT (75%)	T_ENG_ALT (100%)	HS_1 - HS_6	ENG9 - ENG13	ENG5	Total Annual Emissions (tpy)
Engine Rating (kW)	**124,410**	**165,880**	**93,053**	**124,071**	**6,006**	**3,300**	**218**	
Fuel Consumption Rate (SCFH)	**1,186,390**	**1,524,124**	**-**	**-**	**-**	**-**	**-**	
Fuel Input (MMBtu/hr)	**1,210.12**	**1,554.61**	**712.67**	**917.95**	**56.38**	**30.98**	**2.04**	
Benzene	2.38E-01	3.06E-01	2.15E-01	2.77E-01	1.92E-01	6.01E-03	8.36E-03	0.512
Toluene	2.21E-01	2.83E-01	1.99E-01	2.57E-01	6.94E-02	2.18E-03	3.66E-03	0.359
Xylene	9.95E-02	1.28E-01	8.99E-02	1.16E-01	4.77E-02	1.49E-03	2.55E-03	0.179
1,3-Butadiene	1.44E-01	1.85E-01	1.30E-01	1.68E-01	9.66E-03	3.03E-04	3.50E-04	0.196
Formaldehyde	0.00E+00	9.79E+00	1.37E+01	1.82E+01	1.95E-02	6.11E-04	1.06E-02	18.241
Acetaldehyde	3.98E+01	1.48E+01	2.70E+00	3.59E+00	6.22E-03	1.95E-04	6.87E-03	39.837
Acrolein	2.78E+00	3.57E+00	2.51E+00	3.23E+00	1.95E-03	6.10E-05	8.28E-04	3.573
Naphthalene	4.02E-02	5.17E-02	3.63E-02	4.68E-02	3.21E-02	1.01E-03	--	0.085
1,1,2,2-Tetrachloroethane	2.12E-01	2.72E-01	1.25E-01	1.61E-01	--	--	--	0.272
1,1,2-Trichloroethane	1.69E-01	2.17E-01	9.93E-02	1.28E-01	--	--	--	0.217
1,3-Dichloropropene	1.40E-01	1.80E-01	8.24E-02	1.06E-01	--	--	--	0.180
2-Methylnaphthalene	1.79E-02	2.31E-02	1.62E-02	2.09E-02	--	--	--	0.023
2,2,4-Trimethylpentane	1.35E-01	1.74E-01	1.22E-01	1.57E-01	--	--	--	0.174
Biphenyl	1.15E-01	1.47E-01	1.04E-01	1.33E-01	--	--	--	0.147
Carbon Tetrachloride	1.95E-01	2.50E-01	1.15E-01	1.48E-01	--	--	--	0.250
Chlorobenzene	1.61E-01	2.07E-01	9.49E-02	1.22E-01	--	--	--	0.207
Chloroform	1.51E-01	1.94E-01	8.90E-02	1.15E-01	--	--	--	0.194
Ethylbenzene	2.15E-02	2.76E-02	1.94E-02	2.50E-02	--	--	--	0.028
Ethylene Dibromide	2.35E-01	3.02E-01	1.38E-01	1.78E-01	--	--	--	0.302
Methanol	1.35E+00	1.74E+00	7.96E-01	1.03E+00	--	--	--	1.736
Methylene Chloride	1.06E-01	1.36E-01	6.24E-02	8.04E-02	--	--	--	0.136
Hexane	6.00E-01	7.71E-01	5.42E-01	6.98E-01	--	--	--	0.771
PAH	4.11E-01	5.28E-01	2.42E-01	3.12E-01	2.02E-02	6.35E-04	7.45E-04	0.549
Phenol	1.27E-01	1.63E-01	7.49E-02	9.65E-02	--	--	--	0.163
Tetrachloroethane	1.31E-02	1.69E-02	7.74E-03	1.56E-03	--	--	--	0.017
Vinyl Chloride	7.90E-02	1.01E-01	4.65E-02	9.37E-03	--	--	--	0.101
							Total Annual HAP emisions (tpy)	**68.45**

1. The CAT NG engines (EU: T_ENG) are Tier 4 emissions certified and equipped with oxidation catalysts. Oxidation catalysts reduce emissions of organic HAPS. To develop an appropriate control effiency (CE) for the HAP emissions from these engines that could be applied to the AP-42 Ch. 3.2 HAP Emission factors, Formaldehyde and VOC emission factors determined through stack testing were compared with Formaldehyde and VOC emission factors from AP-42 for natural gas engines, and the resulting ratio was applied to all organic HAPs.

100% Load CAT 3520 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *97.9%*
VOC CE = *97.7%*

75% Load CAT 3520 engines CE based on formaldehyde emission factors: CE % = (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor) x 100
Fomaldehyde CE = *100.0%*
VOC CE = *89.8%*

Based on the calcaultions above, a conservative CE of **89.8%** was applied to all AP-42 organic HAP emission factors for these engines.

2. The JGC 624 NG engines (EU: T_ENG_ALT) are Tier 4 emissions certified and equipped with oxidation catalysts. Oxidation catalysts reduce emissions of organic HAPS. To develop an appropriate control effiency (CE) for the HAP emissions from these engines that could be applied to the AP-42 Ch. 3.2 HAP Emission factors, Formaldehyde and VOC emission factors determined through stack testing were compared with Formaldehyde and VOC emission factors from AP-42 for natural gas engines, and the resulting ratio was applied to all organic HAPs.

100% Load JGC 624 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *91.4%*
VOC CE = *84.4%*

75% Load JGC 624 engines CE based on formaldehyde or VOC emission factors: CE % = (1 - (Stack Testing Emission Factor) / (AP-42 Ch. 3.2 Emission Factor)) x 100
Fomaldehyde CE = *91.7%*
VOC CE = *84.9%*

Based on the calcaultions above, a conservative CE of **84.4%** was applied to all AP-42 organic HAP emission factors for these engines.

Table A-16d. Generator - Criteria Pollutant Emissions (Daily)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW) [1,2]		Fuel Type	Operation Hours	Criteria Pollutants Daily Emissions (lb/day) [3,4,5]							
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	450.12	2.57	160.88	189.12	189.12	189.12	462.10	5.03
T_ENG (100%)	Trench	CAT 3520 DSL 2600 kW		150,800	165,880	NG	8,760	897.96	85.57	149.47	22.82	22.82	22.82	134.64	6.71
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,740	93,053	NG	8,760	186.11	65.14	299.35	159.59	159.59	159.59	310.18	2.90
T_ENG_ALT (100%)	Trench	JGC 624 4481 kW		120,987	124,071	NG	8,760	238.95	83.63	399.13	208.95	208.95	208.95	413.58	3.86
HS_1 - HS_6	Hardshell	CAT XQ1140	6	5,460	6,006	Diesel	8,760	31.78	15.89	3.18	3.18	3.18	3.18	6.36	0.00
ENG9 - ENG13	Taylor	CAT C175 3000 kW	5	3,000	3300	Diesel	500	3055.61	3055.61	3055.61	34.92	34.92	34.92	165.88	6.44
ENG5	WW1	C200D2RE	1	198	217.8	Diesel	8,760	4.61	4.61	40.33	0.23	0.23	0.23	0.23	14.37
Total Daily Emissions								**3,989.96**	**3,161.68**	**3,498.25**	**247.27**	**247.27**	**247.27**	**634.56**	**27.53**

Table A-16e. Generator - Criteria Pollutant Emissions (Hourly)

Emission Point Number	Location	Equipment Name	Number of Generators	Engine Rating (kW) [1,2]		Fuel Type	Operation Hours	Criteria Pollutants Hourly Emissions (lb/hr) [3,4,5]							
				(Electrical)	(Mechanical)		(hrs/yr)	NO_x	NO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	SO_2
T_ENG (75%)	Trench	CAT 3520 DSL 2600 kW	58	113,100	124,410	NG	8,760	18.76	0.11	6.70	7.88	7.88	7.88	19.25	0.21
T_ENG (100%)	Trench	CAT 3520 DSL 2600 kW		150,800	165,880	NG	8,760	37.42	3.57	6.23	0.95	0.95	0.95	5.61	0.28
T_ENG_ALT (75%)	Trench	JGC 624 4481 kW	27	90,740	93,053	NG	8,760	7.75	2.71	12.47	6.65	6.65	6.65	12.92	0.12
T_ENG_ALT (100%)	Trench	JGC 624 4481 kW		120,987	124,071	NG	8,760	9.96	3.48	16.63	8.71	8.71	8.71	17.23	0.16
H_ENG	Hardshell	CAT XQ1140	6	5,460	6,006	Diesel	8760	1.32	0.66	0.13	0.13	0.13	0.13	0.26	0.00
EMER_ENG	Taylor	CAT C175 3000 kW	5	3,000	3,300	Diesel	500	127.32	127.32	127.32	1.46	1.46	1.46	6.91	0.27
ENG5	WW1	C200D2RE	1	198	218	Diesel	8760	0.19	0.19	1.68	0.01	0.01	0.01	0.01	0.60
Total Emissions								**166.25**	**131.74**	**145.76**	**10.30**	**10.30**	**10.30**	**26.44**	**1.15**

1. A 10% increase in rating in the 2.6MW engines has been accounted for the change in electrical to mechanical rating. 10.00% Increase
2. Engine rating per Request for Information dated 02/16/2021
3. Average brake specific fuel consumption of 7,000 Btu/hp-hr, Per AP-42 Chapter 3.3, is used to convert from lb/MMBtu to lb/hp-hr for diesel generators and
1.34 hp/kW
1020 Btu/scf, per AP-42 Chapter 1.4 for natural gas engines
4. GHG emissions were converted to CO2e emissions based on the GWP for each GHG
GWP of CO_2 1 lbs CO_2e/lb CO_2
GWP of CH_4 25 lbs CO_2e/lb CH_4
GWP of N_2O 298 lbs CO_2e/lb N_2O
5. Safety factor of 30% has been added to the emission factors for 2.6MW NG engines. 30.00% Increase

Table A-16f. Number of Generators

Power Supplied by CAT 3520 DSL 2600 kW - Sea Level	2,600	kW
Power Supplied by CAT 3520 DSL 2600 kW - Site Level	2,056	kW
CAT 3520 DSL 2600 kW - Trench	58	Generators
Power Supplied by JGC 624 K111, 4481 kW - Site Level	4,481	ekW
	4,596	mkW
Power Supplied by JGC 624 K111, 4481 kW - Temp Derate	4,480	ekW
	4,595	mkW
JGC 624 K111, 4481 kW - Trench	27	Generators
Power Supplied by CAT XQ1140 - 910kW	910	kW
CAT 3520 DSL 2600 kW - Hardshell	6	Generators

Note: Rate Gross Capacity is obtained from "South32 - Power Options Emission Calcs - v1.9.xls"

Elevation Derate (applicable to 2.6MW engines)

Site Elevation:	5000	ft
Every 1,000-ft increase in site elevation above sea level is assumed to yield the following % reduction in ISO-rated gas turbine power output, where site elevation (ft) above sea level is assumed to be	3.33	ft
% difference between gross and net MW output is	3	%

Trench/Alta Connected I	118.566	MW
Hardshell Connected Lo	5.381	MW

Temperature Derate (applicable to 4.4MW units):

At >95 deg F an output deration of 0.67% per degree will occur.

Derate based on met data from 2019-2021.
For days where temperature exceeds 95 deg F, the derate was calculated using the following equation:

Power = (1 - ((T - 95)*0.0067)) * Rated Power
Where: T = Temperature (F)

Total derate for three years was calculated, including all days with 100%

Table A-17a. Wind Erosion Emission Factors

Type of Material	Particulate Matter Emission Factors [3,4,5,6]				Particulate Matter Emission Factor Inputs [1,2]				Notes
	PM/TSP	PM_{10}	$PM_{2.5}$	Units	Max 5-minute wind speed (m/s)	u_{10}^{+}	u^{*}	u_t	
Aggregate/shotcrete	0.02	0.01	0.002	ton/acre-yr	16.71	27.9	1.48	1.33	$u^* = (0.053)(u_{10}^{+})$, where u_{10}^{+} = fastest mile for the time period between disturbances (see below for information on fastest mile calculation). The fastest mile was calculated using the linear regression proposed by ADEQ. The maximum 5-minute wind speed is the max 5-minute wind speed collected at the onsite meteorological station.
TSF	0.33	0.17	0.025	ton/acre-yr	16.71	27.9	1.48	0.54	
Rock/Ore/ROM	0.10	0.05	0.008	ton/acre-yr	16.71	27.9	1.48	1.02	

1. k = particle size multiplier, u^* = friction velocity, u_t = threshold friction velocity
2. The fastest mile was calculated using linear regression method historically accepted by ADEQ for other facilities. The maximum 5-minute wind speed is the max 5-minute wind speed collected at the onsite meteorological station.
3. Per AP-42 13.2.5 Equations 6 and 7:
$u10^{+}$ is calculated as 1.662 * the max 5-minute wind speed + 0.0913. The 1.662 and 0.0913 value was determined from the linear regression analysis.

$$u_s^{+} = \frac{(u_s)}{u_r} \quad u_{10}^{+}$$

where

u_s^{+} = surface wind speed distribution
u_s = surface wind speed
u_r = approach wind speed
u_{10}^{+} = fastest mile of reference anemometer

$$u^* = \frac{0.4 u_s^{+}}{\frac{25}{\ln 0.5}} = 0.10 u_s^{+}$$

where

u^* = friction velocity

4. Per AP-42 13.2.5 Equation 3:

$$P = 58\ (u^* - u_t^*)^2 + 25\ (u^* - u_t^*)$$

$$P = 0 \text{ for } u^* \le u_t^*$$

where

u_t = threshold velocity

5. Threshold friction velocity per AP-42 Table 13.2.5-2:

1.02	m/s	Overburden can be used to represent Rock/Ore/ROM
1.33	m/s	Roadbed material can be used to represent TSFs/aggregate/shotcrete
0.54	m/s	Conservatively assumed that fine coal dust on concrete pad can be used to represent TSFs

6. Particle size multiplier for emission factors per AP-42 13.2.5:

PM	1
PM_{10}	0.5
$PM_{2.5}$	0.075

Table A-17b. Wind Erosion Emissions

Emission Point Number	Location	Annual Potential Emissions [1,2,3] (tpy)				Daily Potential Emissions [1,2,3] (lb/day)				Hourly Potential Emissions [1,2,3] (lb/hr)			
		PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds	PM	PM_{10}	$PM_{2.5}$	Lead Compounds
TSF2	USFS Tailings Storage Facility	40.47	20.24	3.04	0.17	221.75	110.88	16.63	0.94	9.24	4.62	0.69	0.04
TSF_3	Tailing Storage Facility	19.29	9.65	1.45	0.08	105.72	52.86	7.93	4.50E-01	4.41	2.20	0.33	0.02
WRS	West Rock Stockpile	0.72	0.36	0.05	0.00	3.93	1.96	0.29	1.39E-02	0.16	0.08	0.01	0.00
ERS	East Rock Stockpile	0.79	0.40	0.06	0.00	4.35	2.18	0.33	1.54E-02	0.18	0.09	0.01	0.00
TAGG	Taylor Agg Stockpile	0.0005	0.0002	0.0000	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
TSHOT	Taylor Shotcrete Stockpile	0.0008	0.0004	0.0001	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
HRS	Hardshell Rock Stockpile	2.74	1.37	0.21	9.71E-03	15.03	7.51	1.13	0.05	0.63	0.31	0.05	0.00
ORE	Clark Ore Stockpile	0.12	0.06	0.01	2.12E-03	0.66	0.33	0.05	1.16E-02	0.03	0.01	0.00	0.00
ROM	Clark ROM Stockpile	0.0357	0.0179	0.0027	6.29E-04	0.20	0.10	0.01	3.45E-03	0.01	0.00	0.00	0.00

AGG	Clark Agg Stockpile	0.0005	0.0002	0.0000	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
SHOT	Clark Shotcrete Stockpile	0.0008	0.0004	0.0001	--	0.00	0.00	0.00	--	0.00	0.00	0.00	--
	Total:	**64.18**	**32.09**	**4.81**	**0.27**	**351.65**	**175.83**	**26.37**	**1.49**	**14.65**	**7.33**	**1.10**	**0.06**

1. Emissions based on maximum hours 8760 hrs
2. Conversion from grams to pounds 453.6 g/lb
3. Percent of lead in PM emissions and total exposed surface are in table below

USFS Tailings Storage Facility	Lead	0.43	%	Tailings Storage Facility	Lead	0.43	%
	Area	5,317,757	ft²		Area	2,535,243	ft²
		122	acre			58	acre
Taylor Shotcrete Plant	Lead	0.00	%	East Rock Stockpile	Lead	0.35	%
	Area	1,600	ft²		Area	329,657	ft²
		0.04	acre			8	acre
Taylor Agg Stockpile	Lead	0.00	%	West Rock Stockpile	Lead	0.35	%
	Area	900	ft²		Area	297,599	ft²
		0.02	acre			7	acre
Hardshell Rock Stockpile	Lead	0.35	%	Clark Ore Stockpile	Lead	1.76	%
	Area	1,138,608	ft²		Area	50,001	ft²
		26.1	acre			1.15	acre
Clark Shotcrete Plant	Lead	0.00	%	Clark ROM Stockpile	Lead	1.76	%
	Area	1,600	ft²		Area	14,840	ft²
		0.04	acre			0.34	acre
Clark Agg Stockpile	Lead	0.00	%				
	Area	900	ft²				
		0.02	acre				

Table A-18a. WTP2 Cooling Tower Parameters

Emission Point Number	Flowrate [1] (gal/min)	Drift [2] (%)	TDS [3] (ppm)
WTP2CT	4500	0.0005	455

1. Flowrate per July 18th, 2022 email from Sarah Richman
2. Drift % per July 18th, 2022 email from Sarah Richman
3. Influent TDS (455 ppm) concentration per July 18th, 2022 email from Sarah Richman

Drift loss	0.0005%		High Efficiency
Circulating water flow rate	4,500	gpm	
Total dissolved solids	455	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*

Volume of a sphere $V = 4/3*\pi*r^3$

Annual drift 11 lb H_2O/hr

Table A-18b. Water Drop Size Distribution for Low Efficiency Drift Eliminators*

Based on a drift rate of 0.001%

Droplet Dia. (micron)	% mass	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
22	0.43	0.43	5.6E-09	1.0E-12	1.2			
29	1.49	1.92	1.3E-08	2.3E-12	1.6			
44	3.76	5.68	4.5E-08	8.1E-12	2.5			
58	2.09	7.77	1.0E-07	1.9E-11	3.3			7.8%
65	1.86	9.63	1.4E-07	2.6E-11	3.7			
87	1.56	11.19	3.4E-07	6.3E-11	4.9			
108	1.43	12.62	6.6E-07	1.2E-10	6.1			
120	1.26	13.88	9.0E-07	1.6E-10	6.8			
132	1.09	14.97	1.2E-06	2.2E-10	7.5			
144	1.32	16.29	1.6E-06	2.8E-10	8.2			
174	5.81	22.1	2.8E-06	5.0E-10	9.9			
300	5.04	27.14	1.4E-05	2.6E-09	17.0		27.1%	

450**	4.17	31.31	4.8E-05	8.7E-09	25.5	31.3%
600	4.01	35.32	1.1E-04	2.1E-08	34.0	
750	4.00	39.32	2.2E-04	4.0E-08	42.5	
900	4.03	43.35	3.8E-04	6.9E-08	51.0	
1,050	4.57	47.92	6.1E-04	1.1E-07	59.5	
1,200	5.46	53.38	9.0E-04	1.6E-07	68.0	
1,350	6.80	60.18	1.3E-03	2.3E-07	76.5	
2,250	17.99	78.17	6.0E-03	1.1E-06	127.5	
2,400	21.83	100	7.2E-03	1.3E-06	136.0	

** EPA. 1979. Effects of Pathogenic and Toxic Material Transport Via Cooling Device Drift - Vol. 1 Technical Report. EPA-600/7-79-251a. November 1979.*
*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-18c. Water Drop Size Distribution for High Efficiency Drift Eliminators*
Based on a drift rate of 0.0003%

Droplet Dia. (micron)	% mass smaller		H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
10	0		5.2E-10	9.5E-14	0.6			
20	0.196		4.2E-09	7.6E-13	1.1			
30	0.226		1.4E-08	2.6E-12	1.7			
40	0.514		3.4E-08	6.1E-12	2.3			
50	1.816		6.5E-08	1.2E-11	2.8			1.8%
60	5.702		1.1E-07	2.1E-11	3.4			
70	21.348		1.8E-07	3.3E-11	4.0			
90	49.812		3.8E-07	6.9E-11	5.1			
110	70.509		7.0E-07	1.3E-10	6.2			
130	82.023		1.2E-06	2.1E-10	7.4			
150	88.012		1.8E-06	3.2E-10	8.5			
180	91.032		3.1E-06	5.6E-10	10.2		91.0%	
210	92.468		4.8E-06	8.8E-10	11.9			
240	94.091		7.2E-06	1.3E-09	13.6			
270	94.689		1.0E-05	1.9E-09	15.3			

300	96.288	1.4E-05	2.6E-09	17.0	
350	97.011	2.2E-05	4.1E-09	19.8	
400	98.34	3.4E-05	6.1E-09	22.7	
450**	99.071	4.8E-05	8.7E-09	25.5	99.1%
500	99.071	6.5E-05	1.2E-08	28.3	
600	100	1.1E-04	2.1E-08	34.0	

** Reisman, J. and G. Frisbie. 2002. "Calculating Realistic PM10 Emissions from Cooling Towers." Environmental Progress & Sustainable Energy. American Institute of Chemical Engineers. Volume 21, Issue 2, pp. 127-130. July 2002.*

*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-18d. WTP2 Cooling Towers - Emissions

Emission Point Number	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
WTP2CT	2.22E-02	2.04E-02	4.07E-04	1.22E-01	1.12E-01	2.23E-03	5.07E-03	4.66E-03	9.29E-05
TOTAL:	**0.0222**	**0.0204**	**4.07E-04**	**0.122**	**0.112**	**2.23E-03**	**0.0051**	**4.66E-03**	**9.29E-05**

Table A-19a. Surface Refrigeration Plant Parameters

Emission Point Number	Flowrate [1] (gal/min)	Drift [2] (%)	TDS [2] (ppm)
PRODREF	7,529	0.001	1000
BBREF	11,095	0.001	1000

1. Provided by Ross Wilson (BBE Consulting) on 07/06/2023 via email.
2. Per parameters provided by South32 on 09/07/2021.

PRODREF:

Drift loss	0.0010%		Low Efficiency
Circulating water flow rate	7,529	gpm	
Total dissolved solids	1,000	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*

Volume of a sphere $V = 4/3*\pi*r^3$
Annual drift 38 lb H_2O/hr

BBREF:

Drift loss	0.0010%		Low Efficiency
Circulating water flow rate	11,095	gpm	
Total dissolved solids	1,000	ppm	
Density of TDS constituents	2.5	g/cc	*Average density of common salts (CaCO3, CaSO4, CaCl2, NaCl, Na2SO4, Na2CO3)*

Volume of a sphere $V = 4/3*\pi*r^3$
Annual drift 55 lb H_2O/hr

Table A-19b. Water Drop Size Distribution for Low Efficiency Drift Eliminators*
Based on a drift rate of 0.001%

Droplet Dia. (micron)	% mass	% mass smaller	H_2O Droplet Mass (g)	Solids Vol. (cc)	Solids Dia. (micron)	Emissions PM (lb/hr)	Emissions PM_{10} (lb/hr)	Emissions $PM_{2.5}$ (lb/hr)
22	0.43	0.43	5.6E-09	2.2E-12	1.6			
29	1.49	1.92	1.3E-08	5.1E-12	2.1			
44	3.76	5.68	4.5E-08	1.8E-11	3.2			5.7%
58	2.09	7.77	1.0E-07	4.1E-11	4.3			
65	1.86	9.63	1.4E-07	5.8E-11	4.8			

87	1.56	11.19	3.4E-07	1.4E-10	6.4			
108	1.43	12.62	6.6E-07	2.6E-10	8.0			
120	1.26	13.88	9.0E-07	3.6E-10	8.8			
132	1.09	14.97	1.2E-06	4.8E-10	9.7			
144	1.32	16.29	1.6E-06	6.3E-10	10.6		16.3%	
174	5.81	22.1	2.8E-06	1.1E-09	12.8			
300	5.04	27.14	1.4E-05	5.7E-09	22.1			
450**	4.17	31.31	4.8E-05	1.9E-08	33.2	31.3%		
600	4.01	35.32	1.1E-04	4.5E-08	44.2			
750	4.00	39.32	2.2E-04	8.8E-08	55.3			
900	4.03	43.35	3.8E-04	1.5E-07	66.3			
1,050	4.57	47.92	6.1E-04	2.4E-07	77.4			
1,200	5.46	53.38	9.0E-04	3.6E-07	88.4			
1,350	6.80	60.18	1.3E-03	5.2E-07	99.5			
2,250	17.99	78.17	6.0E-03	2.4E-06	165.8			
2,400	21.83	100	7.2E-03	2.9E-06	176.8			

** EPA. 1979. Effects of Pathogenic and Toxic Material Transport Via Cooling Device Drift - Vol. 1 Technical Report. EPA-600/7-79-251a. November 1979.*
*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-19c. Water Drop Size Distribution for High Efficiency Drift Eliminators*
Based on a drift rate of 0.0003%

Droplet Dia. (micron)	% mass smaller		H_2O Droplet Mass (g)	Solids Vol. (cc)	Dia. (micron)	Emissions PM (lb/hr)	PM_{10} (lb/hr)	$PM_{2.5}$ (lb/hr)
10	0		5.2E-10	2.1E-13	0.7			
20	0.196		4.2E-09	1.7E-12	1.5			
30	0.226		1.4E-08	5.7E-12	2.2			
40	0.514		3.4E-08	1.3E-11	2.9			0.5%
50	1.816		6.5E-08	2.6E-11	3.7			
60	5.702		1.1E-07	4.5E-11	4.4			
70	21.348		1.8E-07	7.2E-11	5.2			
90	49.812		3.8E-07	1.5E-10	6.6			
110	70.509		7.0E-07	2.8E-10	8.1			
130	82.023		1.2E-06	4.6E-10	9.6			

150	88.012	1.8E-06	7.1E-10	11.1		88.0%
180	91.032	3.1E-06	1.2E-09	13.3		
210	92.468	4.8E-06	1.9E-09	15.5		
240	94.091	7.2E-06	2.9E-09	17.7		
270	94.689	1.0E-05	4.1E-09	19.9		
300	96.288	1.4E-05	5.7E-09	22.1		
350	97.011	2.2E-05	9.0E-09	25.8		
400	98.34	3.4E-05	1.3E-08	29.5		
450**	99.071	4.8E-05	1.9E-08	33.2	99.1%	
500	99.071	6.5E-05	2.6E-08	36.8		
600	100	1.1E-04	4.5E-08	44.2		

** Reisman, J. and G. Frisbie. 2002. "Calculating Realistic PM10 Emissions from Cooling Towers." Environmental Progress & Sustainable Energy. American Institute of Chemical Engineers. Volume 21, Issue 2, pp. 127-130. July 2002.*
*** Maximum droplet size governed by atmospheric dispersion. Larger droplets fall to the ground before evaporating into a particle (EPA 1979).*

Table A-19d. Surface Refrigeration Plant - Emissions

Emission Point Number	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
PRODREF	0.052	0.027	0.009	2.83E-01	1.47E-01	5.13E-02	1.18E-02	6.13E-03	2.14E-03
BBREF	0.076	0.040	0.014	4.17E-01	2.17E-01	7.56E-02	1.74E-02	9.03E-03	3.15E-03
TOTAL:	**0.13**	**0.066**	**0.023**	**0.699**	**0.364**	**0.127**	**0.029**	**0.015**	**0.0053**

Table A-20a. Taylor Concrete Batch Plant Emission Factors and Parameters

Operation	Equipment	Activity	Material	Maximum Rates Capacity [1] (tpy)	Emission Factors [2]		
					PM	$PM_{10}/PM_{2.5}$	Units
Concrete Batch Plant	Aggregate delivery to ground storage	Unloading of Aggregate Material	Aggregate	18,666	0.0069	0.0033	lb/ton
	Sand delivery to ground storage	Unloading of Sand	Sand	14,292	0.0021	0.00099	lb/ton
	Aggregate transfer to conveyor	Transferring aggregate material	Aggregate	18,666	0.0069	0.0033	lb/ton
	Sand transfer to conveyor	Transferring Sand	Sand	14,292	0.0021	0.00099	lb/ton
	Aggregate transfer to elevated storage	Transferring aggregate material	Aggregate	18,666	0.0069	0.0033	lb/ton
	Sand transfer to elevated storage	Transferring Sand	Sand	14,292	0.0021	0.00099	lb/ton
	Cement delivery to silo	Unloading of Cement	Cement	4,914	0.00099	0.00034	lb/ton
	Cement supplement delivery to silo	Unloading of Cement Supplement	Cement	731	0.0089	0.0049	lb/ton
	Weigh hopper loading	Loading of Weigh hopper	Concrete	40,274	0.0048	0.0028	lb/ton
	Central mix loading	Loading of Mixer	Concrete	40,274	0.0184	0.0055	lb/ton

1. EPA AP-42 Section 11.12, mixing ratios used:
1
0.46
0.35
0.12
0.02

2. EPA AP-42 Section 11.12, Table 11.12-2. emission factors were utilized. If a controlled emission factor was unavailable, an uncontrolled emission factor was used.

Table A-20b. Taylor Concrete Batch Plant - Emissions

Operation	Activity	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
		PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Concrete Batch Plant	Unloading of Aggregate Material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	Unloading of Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	Transferring aggregate material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	Transferring Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	Transferring aggregate material	0.06	0.03	0.03	0.35	0.17	0.17	0.01	0.01	0.01
	Transferring Sand	0.02	0.01	0.01	0.08	0.04	0.04	0.00	0.00	0.00
	Unloading of Cement	0.00	0.00	0.00	0.01	0.00	0.005	0.00	0.00	0.00
	Unloading of Cement Supplement	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00
	Loading of Weigh hopper	0.10	0.06	0.06	0.53	0.31	0.31	0.02	0.01	0.01
	Loading of Mixer	0.37	0.11	0.11	2.03	0.61	0.61	0.08	0.03	0.03
	Total:	**0.71**	**0.28**	**0.28**	**3.90**	**1.55**	**1.55**	**0.16**	**0.06**	**0.06**

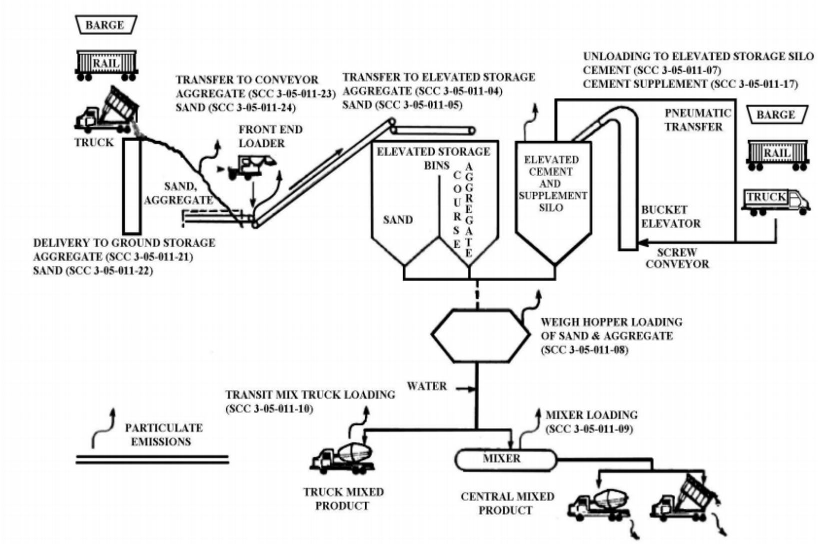

Figure 11.12-1. Typical Concrete Batching Process.

Table A-21a. Clark Concrete Batch Plant Emission Factors and Parameters

Operation	Equipment	Activity	Material	Maximum Rates Capacity [1] (tpy)	Emission Factors [2]		
					PM	$PM_{10}/PM_{2.5}$	Units
Concrete Batch Plant	Aggregate delivery to ground storage	Unloading of Aggregate Material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand delivery to ground storage	Unloading of Sand	Sand	704	0.0021	0.00099	lb/ton
	Aggregate transfer to conveyor	Transferring aggregate material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand transfer to conveyor	Transferring Sand	Sand	704	0.0021	0.00099	lb/ton
	Aggregate transfer to elevated storage	Transferring aggregate material	Aggregate	920	0.0069	0.0033	lb/ton
	Sand transfer to elevated storage	Transferring Sand	Sand	704	0.0021	0.00099	lb/ton
	Cement delivery to silo	Unloading of Cement	Cement	242	0.00099	0.00034	lb/ton
	Cement supplement delivery to silo	Unloading of Cement Supplement	Cement	242	0.0089	0.0049	lb/ton
	Weigh hopper loading	Loading of Weigh hopper	Concrete	1,984	0.0048	0.0028	lb/ton
	Central mix loading	Loading of Mixer	Concrete	1,984	0.0184	0.0055	lb/ton

1. EPA AP-42 Section 11.12, mixing ratios used:
1
0.46
0.35
0.12
0.02

2. EPA AP-42 Section 11.12, Table 11.12-2. emission factors were utilized. If a controlled emission factor was unavailable, an uncontrolled emission factor was used.

Table A-21b. Clark Concrete Batch Plant - Emissions

Operation	Activity	Annual Emissions (tpy)			Daily Emissions (lb/day)			Hourly Emissions (lb/hr)		
		PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Concrete Batch Plant	Unloading of Aggregate Material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04
	Unloading of Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
	Transferring aggregate material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04
	Transferring Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
	Transferring aggregate material	3.17E-03	1.52E-03	1.52E-03	1.74E-02	8.31E-03	8.31E-03	7.24E-04	3.46E-04	3.46E-04
	Transferring Sand	7.39E-04	3.49E-04	3.49E-04	4.05E-03	1.91E-03	1.91E-03	1.69E-04	7.96E-05	7.96E-05
	Unloading of Cement	1.20E-04	4.12E-05	4.12E-05	6.57E-04	2.26E-04	2.26E-04	2.74E-05	9.40E-06	9.40E-06
	Unloading of Cement Supplement	1.08E-03	5.93E-04	5.93E-04	5.90E-03	3.25E-03	3.25E-03	2.46E-04	1.35E-04	1.35E-04
	Loading of Weigh hopper	4.76E-03	2.78E-03	2.78E-03	2.61E-02	1.52E-02	1.52E-02	1.09E-03	6.34E-04	6.34E-04
	Loading of Mixer	1.83E-02	5.46E-03	5.46E-03	1.00E-01	2.99E-02	2.99E-02	4.17E-03	1.25E-03	1.25E-03
	Total:	**0.036**	**0.014**	**0.014**	**0.20**	**0.08**	**0.08**	**0.008**	**0.0033**	**0.0033**

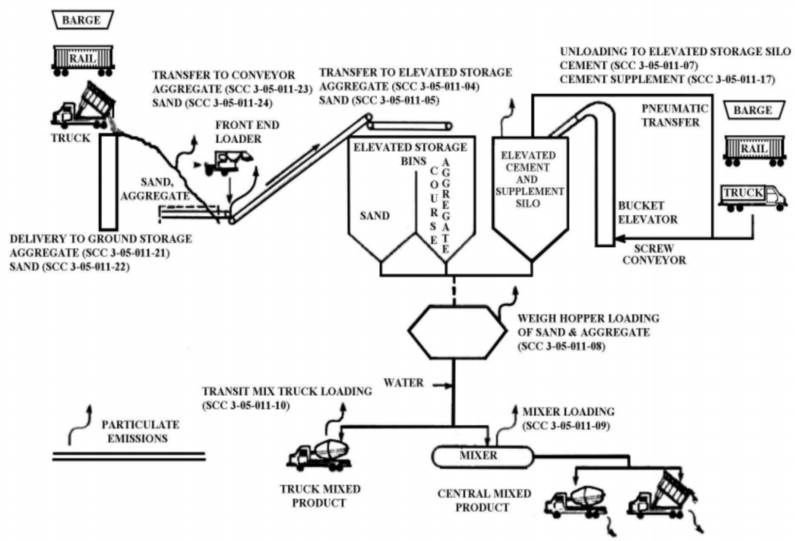

Figure 11.12-1. Typical Concrete Batching Process.

Table A-22. Evaporation Pond Mechanical Evaporators - PM Emissions

Unit	Evaporator Type	TDS Conc. (mg/L)	System Flow Rate [2] (gpm)	Operation Time [3] (hr/yr)	Calculated Emission Rate (lb/hr) [1]		Calculated Emission Rate (lb/day) [1,4]		Calculated Emission Rate (tpy) [1]	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
MEVAP1	Nozzles	2,100	66	876	0.0911	0.014	1.30	0.19	3.99E-02	5.94E-03
MEVAP2	Nozzles	2,100	66	876	0.0911	0.014	1.30	0.19	3.99E-02	5.94E-03
MEVAP3	Nozzles	2,100	66	876	0.0911	0.014	1.30	0.19	3.99E-02	5.94E-03

1. Emission rates are calculated using the following equation and parameters, provided by ADEQ via meeting on 5/30/2023:

$$PM = TDS\left(\frac{mg}{L}\right) \times \frac{Drift(\%)}{100\,\%} \times Q\ Rate\left(\frac{gal}{min}\right) \times 3.78\frac{L}{gal} \times \frac{2.2lb}{10^6 mg} \times \frac{60min}{hr}$$

Where:
Drift loss: 0.327%
PM_{10}: 40.3% of PM
$PM_{2.5}$: 6% of PM

2. Volume (gpm) calculated based on 66 gpm
3. Only 3 our of 4 units operating at once and 10% of the year based on meeting notes from 7/19/2022 with Sarah Richman
4. For daily emissions, evaporators can run during the daylight hours only; conservatively, daylight hour of the summer solstice (14.25 hours) is used.

Table A-23a. Aboveground Gasoline Dispensing Facility - Taylor - VOC Emissions

Emission Unit	Maximum Estimated Rate			Emission Factor [2]	VOC Emissions		
	(gals/hr)	(gals/day)	(gals/yr) [1]	(lbs/10 3 gal)	lb/hr	lb/day	ton/yr
AGGDF-T	17	411	150,000	11.3	0.19	4.63	0.85
				Total	**0.19**	**4.63**	**0.85**

1. Based on aboveground annual gasoline usage provided by South32. All gasoline is treated as being emitted aboveground, despite some being dispensed underground.
2. Emission factor for gasoline is based on petroleum loading loss equation in USEPA publication AP-42, Table 5.2-7, Evaporative Emissions from Gasoline Service Station Operations (7/08). The loading loss equation is :

Loading Loss (lb/1000 gal) = 12.46 x SPM/T

where,

S= saturation factor (assume 1.00 for submerged loading),

P = true vapor pressure of liquid loaded, pounds per square inch absolute (assume 7.4 psia for Gasoline RVP 10 @ 80°F),

M = molecular weight of vapors, pounds per pound-mole (assume 66 lb/lb-mole),
T = temperature of bulk liquid loaded, °R (80°F + 460 = 540°R), based on AP-42 Chapter 7 Tucson average daily maximum ambient temperature

Sample Calculations

VOC emissions (lb/hr) = 17.12 gal/day x 11.3 lb/1,000 gal x 1.0 day/24 hours = 0.19 lb/hr
VOC emissions (ton/yr) = 150000 gal/yr x 11.3 lb/1,000 gal x 1.0 ton/2,000 lbs = 0.85 ton/yr

Table A-23b. Aboveground Gasoline Dispensing Facility - Taylor - HAP Emissions

Emission Unit	Source Description	VOC Emissions [1]		HAP Emissions [2]									
				Benzene		Hexane		Toluene		Xylene		Ethylbenzene	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
AGGDF-T	Aboveground Gasoline Dispensing Facility	0.19	0.85	3.47E-03	0.02	1.93E-03	0.01	1.35E-02	0.06	1.35E-02	0.06	2.70E-03	0.01
			Total HAPs (ton/yr)	**0.15**									

1. Based on emission calculations in Table A-19a
2. Mass percent is based on the average percent content of the HAP constituent in gasoline per TankESP Gasoline RVP_X speciation:

Storage Tank Content	HAP Mass Percent				
	Benzene	Hexane	Toluene	Xylene	Ethylbenzene
Gasoline	1.80%	1.00%	7.00%	7.00%	1.40%

Table A-24a. Aboveground Gasoline Dispensing Facility - Clark - VOC Emissions

Emission Unit	Maximum Estimated Rate			Emission Factor [2] (lbs/10^3 gal)	VOC Emissions		
	gals/hr	gals/day	gals/yr [1]		lb/hr	lb/day	ton/yr
AGGDF-C	8	201	73,500	11.3	0.09	2.27	0.41
				Total	**0.09**	**2.27**	**0.41**

1. Based on aboveground annual gasoline usage provided by South32. All gasoline is treated as being emitted aboveground, despite some being dispensed underground.

2. Emission factor for gasoline is based on petroleum loading loss equation in USEPA publication AP-42, Table 5.2-7, Evaporative Emissions from Gasoline Service Station Operations (7/08). The loading loss equation is :

Loading Loss (lb/1000 gal) = 12.46 x SPM/T

where,

S= saturation factor (assume 1.00 for submerged loading),

P = true vapor pressure of liquid loaded, pounds per square inch absolute (assume 7.4 psia for Gasoline RVP 10 @ 80°F),

M = molecular weight of vapors, pounds per pound-mole (assume 66 lb/lb-mole),

T = temperature of bulk liquid loaded, °R (80°F + 460 = 540°R), based on AP-42 Chapter 7 Tucson average daily maximum ambient temperature

Sample Calculations

VOC emissions (lb/hr) = 8.39 gal/day x 11.3 lb/1,000 gal x 1.0 day/24 hours = 0.09 lb/hr

VOC emissions (ton/yr) = 73500 gal/yr x 11.3 lb/1,000 gal x 1.0 ton/2,000 lbs = 0.41 ton/yr

Table A-24b. Aboveground Gasoline Dispensing Facility - Clark - HAP Emissions

Emission Unit	Source Description	VOC Emissions [1]		HAP Emissions [2]									
				Benzene		Hexane		Toluene		Xylene		Ethylbenzene	
		lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr	lb/hr	ton/yr
AGGDF-C	Aboveground Gasoline Dispensing Facility	0.09	0.41	0.002	0.01	0.001	0.00	0.01	0.03	0.007	0.03	0.001	0.01
			Total HAPs (ton/yr)	**0.08**									

1. Based on emission calculations in Table A-24a

2. Mass percent is based on the average percent content of the HAP constituent in gasoline per TankESP Gasoline RVP_X speciation:

Storage Tank Content	HAP Mass Percent				
	Benzene	Hexane	Toluene	Xylene	Ethylbenzene
Gasoline	1.80%	1.00%	7.00%	7.00%	1.40%

Table A-25a. Roads - Dozer - Input Parameters

Emission Point No.	Road Surface	Equipment	Total Combined Operation Hour [1]			Emission Factor						Lead	Control	
			Hourly	Daily	Annual	Short Term			Long Term				Type	Efficiency [2]
			(hr/hr)	(hr/day)	(hr/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	(%)		(%)
DOZER1-TSF2	Unpaved	Bulldozer	1	12	4,380	4.48	0.95	0.47	4.48	0.95	0.47	0.43	No Control	0%
DOZER2-TSF2	Unpaved	Bulldozer	1	12	4,380	4.48	0.95	0.47	4.48	0.95	0.47	0.43	No Control	0%
DOZER-WRS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-ERS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-HRS	Unpaved	Bulldozer	1	12	4,380	1.65	0.22	0.17	1.65	0.22	0.17	0.35	Watering	70%
DOZER-TSF	Unpaved	Bulldozer	1	12	4,380	4.48	0.95	0.47	4.48	0.95	0.47	0.43	No Control	0%

1. Assumed to operate 12 hours a day and 365 days a year.
2. At South32, watering will be performed to sufficiently to achieve a control efficiency of 70%
3. Emission factors for bulldozers per Table 11.9-1, U.S. EPA AP-42, Section 11.9 (Western Surface Coal Mining), October 1998

$$PM = TSP = k * \frac{5.7\,(s)^{1.2}}{(M)^{1.3}}$$

$$PM10 = k * PM15 = k * \frac{1.0\,(s)^{1.5}}{(M)^{1.4}}$$

$$PM2.5 = k * TSP = k * \frac{5.7\,(s)^{1.2}}{(M)^{1.3}}$$

where k = Scaling factor

	PM	PM_{10}	$PM_{2.5}$
k =	1	0.75	0.105

Per AP-42, Table 11.9-1

s = Material silt content (%)
- 1.6 Rock silt content assumed as to be similar to Crushed limestone in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006)
- 11 Tailings silt content assumed as to be similar to Taconite mining tailings in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006)

M = Material moisture content (%)
- 11.00 for Tailings 4 for ore/rock

	PM	PM_{10}	$PM_{2.5}$
a =	5.7	1	5.7
b =	1.2	1.5	1.2
c =	1.3	1.4	1.3

Table A-25b. Roads -Dozer - Controlled Emissions

Emission Point No.	Road Surface	Equipment	Controlled Emissions [1,2]												Uncontrolled Emissions (tpy)			
			Hourly (lb/hr)				Daily (lb/day)				Annual (tpy)				Annual (tpy)			
			PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
DOZER1-TSF2	Unpaved	Bulldozer	4.48	0.95	0.47	1.91E-02	53.82	11.44	5.65	0.23	9.82	2.09	1.03	4.18E-02	9.82	2.09	1.03	4.18E-02
DOZER2-TSF2	Unpaved	Bulldozer	4.48	0.95	0.47	1.91E-02	53.82	11.44	5.65	0.23	9.82	2.09	1.03	4.18E-02	9.82	2.09	1.03	4.18E-02
DOZER-WRS	Unpaved	Bulldozer	0.50	0.07	0.05	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-ERS	Unpaved	Bulldozer	0.50	0.07	0.052	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-HRS	Unpaved	Bulldozer	0.50	0.07	0.052	1.76E-03	5.95	0.78	0.62	0.02	1.09	0.14	0.11	3.84E-03	3.62	0.48	0.38	1.28E-02
DOZER-TSF	Unpaved	Bulldozer	4.48	0.95	0.471	1.91E-02	53.82	11.44	5.65	0.23	9.82	2.09	1.03	4.18E-02	9.82	2.09	1.03	4.18E-02

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-26a. South32 Hermosa non-fuel Tank Emissions Summary †

Tank ID	Max Capacity (gal)	Stock	Losses (tpy)			Speciated HAP Emissions (tpy)			Total HAP (tpy)
			Standing	Working	Total VOC	Cresol	Ethylene Glycol Dimethyl Ether	Urethane	
TNK-040 [1]	7,925	F549/MIBC	0.166	0.122	0.289	-	0.262	-	0.262
TNK-041 [2]	6,604	3407-A	4.65E-04	1.02E-03	1.48E-03	9.52E-05	-	-	9.52E-05
TNK-044 [3]	6,604	Solvay 5100	6.26E-03	8.67E-03	1.49E-02	-	-	0.00	3.67E-05
TNK-045	2,642	Copper Sulphate	No VOC Emissions			No HAPs Emissions			
TNK-046	5,283	Copper Sulphate							
TNK-047	2,642	Zinc Sulphate							
TNK-048	5,283	Zinc Sulphate							
TNK-051	2,642	Zinc Cyanide							
TNK-052	3,963	Zinc Cyanide							
TNK-053	2,642	SMBS							
TNK-054	5,283	SMBS							
TNK-057	17,171	Tailings Flocculant (SNF AN910-VHM)							
TNK-058	1,320	Tailings Flocculant (SNF AN910-VHM)							
TNK-059	1,320	Tailings Flocculant (SNF AN910-VHM)							
TNK-060	6,604	3418-A	2.14E-05	1.68E-04	1.90E-04				
TNK-061	10,293	Shaft ANE	1.43E-04	9.54E-05	2.38E-04				
Total			**0.17**	**0.13**	**0.31**	**9.52E-05**	**0.262**	**3.67E-05**	**0.263**

† Based on the SDS for tanks TNK-045 through TNK-059, there are no VOC or HAP emissions associated witht these tanks.

1. This tank contains a 50/50 mixture of MIBC and F-549. F-549 is comprised of "mixed glycol ethers" according to Section 3 of the SDS. As such, it was conservatively modeled as 100% ethylene glycol dimethyl ether (1,2-dimethoxyethane), the lightest glycol ether.

2. The "test reagent" is not always the same stock, so a representative chemical, 3407-A, was used to estimate tank emissions. "Dithiophosphate" and "modified dithiophosphinate" listed in Section 3 of the SDS are assumed to be sodium diisobutyldithiophosphinate. Due to the unavailablity for Antoine coefficients of this chemical, the A and B coefficients for No. 6 fuel oil are used as a conservative estimate.

3. Due to unavailability of Antoine coefficients for the majority constituent chemical (Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester), the vapor pressure given in the SDS was assumed to be constant to generate usable Antoine coefficients.

Table A-26b. Diesel & Gasoline Storage Tanks - VOC Emissions

Tank ID	Max Capacity (gal)	Stock	VOC Emissions [1]	
			(lb/yr)	(tpy)
T-01	1,000	Unleaded Gasoline (S32)	750.03	0.38
T-02	5,000	Diesel (Red Dyed S32)	3.27	1.64E-03
T-03	5,000	Diesel (Red Dyed S32)	3.27	1.64E-03
T-04	12,000	Diesel (Red Dyed Rummel)	4.08	2.04E-03
T-05	1,000	Unleaded Gasoline (Rummel)	650.59	0.33
T-06	1,000	Diesel (Rummel)	0.95	4.74E-04
T-07	10,000	Unleaded Gasoline	3831.10	1.92
T-08	10,000	Unleaded Gasoline	3831.10	1.92
T-09	10,000	Unleaded Gasoline	3831.10	1.92
T-10	50,000	Diesel	78.34	0.04
T-11	50,000	Diesel	71.75	3.59E-02
Total VOC			**13,055.59**	**6.53**
Max VOC			**3831.10**	**1.92**

1. VOC Emissions per EPA-approved TankESP Software (AP-42 Chapter 7.1, June 2020).

Table A-26c. Diesel & Gasoline Storage Tanks - HAP Weight Percent's

Tank ID	Stock	HAP Liquid Weight Percent's [1]									
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Iso-octane (2,2,4-Trimethylpentane)	Naphthalene	PAC's	Toluene	Xylene
T-01	Unleaded Gasoline (S32)	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-02	Diesel (Red Dyed S32)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-03	Diesel (Red Dyed S32)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-04	Diesel (Red Dyed Rummel)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-05	Unleaded Gasoline (Rummel)	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-06	Diesel (Rummel)	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.080%	0.002%	0.030%	0.290%
T-07	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-08	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-09	Unleaded Gasoline	1.80%	0.00%	0.50%	1.40%	1.00%	4.00%	0.42%	0.00%	7.00%	7.00%
T-10	Diesel	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%
T-11	Diesel	0.0008%	0.0009%	--	0.01%	0.0001%	--	0.08%	0.002%	0.03%	0.29%

1. Speciation data for each HAP is based on individual content speciation.

Table A-26d. Diesel and Gasoline Storage Tanks - HAP Emissions (lb/yr)

Tank ID	Stock	HAP Emissions (lb/yr) [1]										
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Isooctane	Naphthalene	PAC's	Toluene	Xylene	Total HAPs
T-01	Unleaded Gasoline (S32)	4.05E+00	2.98E-16	5.19E-02	3.05E-01	3.05E-01	4.64E+00	2.36E-03	2.36E-03	4.64E+00	1.33E+00	15.33
T-02	Diesel (Red Dyed S32)	6.39E-03	3.20E-15	0.00E+00	1.01E-02	1.01E-02	0.00E+00	1.54E-03	1.54E-03	7.54E-02	1.96E-01	0.30
T-03	Diesel (Red Dyed S32)	6.39E-03	3.20E-15	0.00E+00	1.01E-02	1.01E-02	0.00E+00	1.54E-03	1.54E-03	7.54E-02	1.96E-01	0.30
T-04	Diesel (Red Dyed Rummel)	7.96E-03	4.02E-15	0.00E+00	1.25E-02	1.25E-02	0.00E+00	1.92E-03	1.92E-03	9.40E-02	2.45E-01	0.38
T-05	Unleaded Gasoline (Rummel)	3.51E+00	2.59E-16	4.50E-02	2.64E-01	2.64E-01	4.03E+00	2.05E-03	2.05E-03	4.03E+00	1.16E+00	13.30
T-06	Diesel (Rummel)	1.85E-03	9.22E-16	0.00E+00	2.91E-03	2.91E-03	0.00E+00	4.45E-04	4.45E-04	2.18E-02	5.68E-02	0.09
T-07	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-08	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-09	Unleaded Gasoline	2.07E+01	1.52E-15	2.65E-01	1.56E+00	1.56E+00	2.37E+01	1.21E-02	1.21E-02	2.37E+01	6.80E+00	78.31
T-10	Diesel	1.53E-01	7.72E-14	0.00E+00	2.41E-01	2.41E-01	0.00E+00	3.69E-02	3.69E-02	1.80E+00	4.69E+00	7.21
T-11	Diesel	1.40E-01	7.07E-14	0.00E+00	2.20E-01	2.20E-01	0.00E+00	3.38E-02	3.38E-02	1.65E+00	4.30E+00	6.60
	Total HAPs	**6.99E+01**	**1.64E-13**	**8.92E-01**	**5.74E+00**	**5.74E+00**	**7.98E+01**	**1.17E-01**	**1.17E-01**	**8.35E+01**	**3.26E+01**	**278.42**
	Max HAP	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**8.35E+01**	**-**	**-**

1. HAP emissions are calculated based on the HAP weight percent of the content of the tank.

Table A-26e. Diesel and Gasoline Storage Tanks - HAP Emissions (tpy)

Tank ID	Stock	HAP Emissions (tpy)										
		Benzene	Benzo(g,h,i)perylene	Cumene	Ethylbenzene	Hexane	Isooctane	Naphthalene	PAC's	Toluene	Xylene	Total HAPs
T-01	Unleaded Gasoline (S32)	2.02E-03	1.49E-19	2.59E-05	1.52E-04	1.52E-04	2.32E-03	1.18E-06	1.18E-06	2.32E-03	6.66E-04	7.67E-03
T-02	Diesel (Red Dyed S32)	3.20E-06	1.60E-18	0.00E+00	5.03E-06	5.03E-06	0.00E+00	7.69E-07	7.69E-07	3.77E-05	9.81E-05	1.51E-04
T-03	Diesel (Red Dyed S32)	3.20E-06	1.60E-18	0.00E+00	5.03E-06	5.03E-06	0.00E+00	7.69E-07	7.69E-07	3.77E-05	9.81E-05	1.51E-04
T-04	Diesel (Red Dyed Rummel)	3.98E-06	2.01E-18	0.00E+00	6.27E-06	6.27E-06	0.00E+00	9.61E-07	9.61E-07	4.70E-05	1.22E-04	1.88E-04
T-05	Unleaded Gasoline (Rummel)	1.76E-03	1.29E-19	2.25E-05	1.32E-04	1.32E-04	2.01E-03	1.02E-06	1.02E-06	2.01E-03	5.78E-04	6.65E-03
T-06	Diesel (Rummel)	9.26E-07	4.61E-19	0.00E+00	1.46E-06	1.46E-06	0.00E+00	2.23E-07	2.23E-07	1.09E-05	2.84E-05	4.36E-05
T-07	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-08	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-09	Unleaded Gasoline	1.03E-02	7.62E-19	1.33E-04	7.78E-04	7.78E-04	1.19E-02	6.03E-06	6.03E-06	1.19E-02	3.40E-03	3.92E-02
T-10	Diesel	7.64E-05	3.86E-17	0.00E+00	1.20E-04	1.20E-04	0.00E+00	1.84E-05	1.84E-05	9.02E-04	2.35E-03	3.60E-03
T-11	Diesel	7.00E-05	3.54E-17	0.00E+00	1.10E-04	1.10E-04	0.00E+00	1.69E-05	1.69E-05	8.26E-04	2.15E-03	3.30E-03
	Total HAPs	**3.50E-02**	**8.22E-17**	**4.46E-04**	**2.87E-03**	**2.87E-03**	**3.99E-02**	**5.84E-05**	**5.84E-05**	**4.17E-02**	**1.63E-02**	**1.39E-01**
	Max HAP	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**4.17E-02**	**-**	**-**

Table A-27. South32 Hermosa Process Tanks Emission Summary

Tank	Equipment Description	CAS #	Chemical	VOC?	HAP?	Pure Component Molecular Weight M (lb/lbmol)	Pure Component Vapor Pressure P (psia)	Henry's Law Solubility Constant H^{cc}_{v} (Dimensionless)	Henry's Law Solubility Constant H^{px}_{v} (psi/mol% liq)	Liquid Mol% Liq. mol% (mol%liq)	Liquid Temperature T (K)	Liquid Surface Area A (ft2)	Pure Component Mass Transfer Coefficient K (ft/hr)	Vapor Partial Pressure pp (psia)	Hourly Emission Rate [1,2] E (hourly) (lb/hr)	Annual Emissions [1,2] E (annual) (lb/yr)	(tpy)
22310-FC-00001	**Lead Rougher**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.31E-06	301.54	207.74	54.97	1.91E-05	0.01	61.59	0.03
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.77E-07	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	207.74	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00004	**Lead Rougher Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.29E-06	301.54	207.74	54.97	1.88E-05	0.01	60.63	0.03
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.68E-07	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	207.74	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00008	**Lead Cleaner Scalper**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	1.15E-05	301.54	73.19	54.97	1.67E-04	0.02	190.11	0.10
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	5.06E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00007	**Lead Cleaner**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	9.85E-06	301.54	73.19	54.97	1.43E-04	0.02	162.88	0.08
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	4.33E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00009	**Lead Cleaner Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	73.19	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	9.18E-06	301.54	73.19	54.97	1.33E-04	0.02	151.76	0.08
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	4.04E-06	301.54	73.19	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	0.00E+00	301.54	73.19	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	0.00E+00	301.54	73.19	61.19	0.00E+00	0.00	0.00	0.00
22310-FC-00005	**Zinc Rougher**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	2.37E-06	301.54	207.74	54.97	3.44E-05	0.01	111.01	0.06
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	3.68E-06	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.17E-06	301.54	207.74	61.19	2.13E-06	6.89E-04	5.55	2.78E-03
22310-FC-00006	**Zinc Rougher Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	207.74	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	2.31E-06	301.54	207.74	54.97	3.36E-05	0.01	108.49	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	207.74	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	3.60E-06	301.54	207.74	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.15E-06	301.54	207.74	61.19	2.08E-06	6.74E-04	5.43	2.71E-03
22310-FC-00011	**Zinc Cleaner Scalper**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	4.06E-06	301.54	124.86	54.97	5.89E-05	0.01	114.43	0.06
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	6.32E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	2.01E-06	301.54	124.86	61.19	3.65E-06	7.10E-04	5.73	2.86E-03
22310-FC-00010	**Zinc Cleaner**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	3.44E-06	301.54	124.86	54.97	4.99E-05	0.01	96.94	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	5.35E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.71E-06	301.54	124.86	61.19	3.10E-06	6.02E-04	4.85	2.43E-03
22310-FC-00012	**Zinc Cleaner Scavenger**	7732-18-5	Water	No	No	18.02	5.66E-01	-	-	1.00E+00	301.54	124.86	98.03	-	N/A	N/A	N/A
		108-11-2	Methyl Isobutyl Carbinol	Yes	No	102.20	6.77E-02	7.20E-04	1.45E+01	3.20E-06	301.54	124.86	54.97	4.65E-05	0.01	90.25	0.05
		13360-78-6	sodium diisobutyldithiophosphinate	Yes	No	232.32	4.37E-01	-	-	0.00E+00	301.54	124.86	41.81	-	N/A	N/A	N/A
		86329-09-1	Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester	Yes	No	173.28	1.07E-03	-	-	4.98E-06	301.54	124.86	46.10	-	N/A	N/A	N/A
		78-83-1	1-Propanol, 2-methyl-	Yes	No	74.12	3.51E-01	8.99E-05	1.81E+00	1.59E-06	301.54	124.86	61.19	2.88E-06	5.60E-04	4.52	2.26E-03
															0.15	1174.17	0.59

Process Tank Emission Calculation Notes

Emission Factors calculated using:
Ref: Section 3.7.1 - Evaporation from an Open Top Vessel or a Spill
Methods for Estimating Air Emissions from Chemical Manufacturing Facilities, Vol. II Chapter 16
STAPPA/ALAPCO/EPA EIIP, August 2007

E	Hourly or Annual Emission Rate, lb/hr or lb/yr [3]	=(M K A P) / (R T)
M	Molecular Weight, lb/lb-mol	See Table
K	Mass Transfer Coefficient, ft/hr [4]	$= K_0 (M_0/M)^{1/3}$
K_0	Reference Mass Transfer Coefficient of Water, ft/hr	0.83
M_0	Molecular Weight of Water, lb/lb-mol	18.02
A	Liquid Surface Area, ft2	See Table
P	Vapor Pressure, psia	See Table
T	Liquid temperature, ºR [5]	542.77
R	Ideal Gas Constant, Psia-ft^3/lb-mole ºR [6]	10.73159
H	Annual Hours of Operations, hrs/yr [7]	8060
H^{px}_{v}	Henry's Law Volatility Constant, psi/$(mol\%)_{liq}$ [8]	$= H^{cc}_{v}$ x R x T x d(solv) / M(solv)
pp^{H}	Gas Partial Pressure using Henry's Law Constant, psi	= Liq Mol% * H^{xp}_{v}
H^{cc}_{v}	Henry's Law Volatility Constant, Dimensionless [9]	See Table
M(solv)	Mol. Wt. of Solvent, lb/lb-mol [10]	18.02
d(solv)	Density of Solvent, lb/ft3 [10]	62.42771972

1. 100% Safety factor added while calculating emission rate to account for any atomization from material movement at the surface, such as spraying
2. Emissions from low volatile compounds (sodium diisobutyldithiophosphinate & Carbamothioic acid, N-2-propen-1-yl-, O-(2-methylpropyl) ester) assumed to be negligible.
3. EIIP, Vol. II, Ch. 16, Eq. 3-24
4. EIIP, Vol. II, Ch. 16, Eq. 3-27
5. For conservative estimate - Hourly Average Max. Ambient Temperature for Tucson, AZ. As per AP 42 Section 7.1, Table 7.1-7 (Jun, 2020) is used
6. Table 1-9 Perry's Chemical Engineers' Handbook, 6th ed.
7. Provided by South32
8. Referenced from https://www.degruyter.com/document/doi/10.1515/pac-2020-0302/html?lang=en
9. Referenced from Toxchem 4.4 Mar-25-2019
10. Assume as water

Table A-28. Taylor Emission Factor Inputs

Road Surface	Max Miles Traveled Per Unit			Vehicle Type	Vehicle Model	Max Vehicle Count	Particulate Matter Emission Factor Inputs [1]												
							k			Avg. W		s	P	a			b		
	Day	Month	Year				PM	PM_{10}	$PM_{2.5}$	(kg)	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Unpaved	2	60.83	730	Dev Drill Rig	DD422i	3	4.9	1.5	0.15	26,000	28.66	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Support Drill Rig	DS412i	5	4.9	1.5	0.15	29,000	31.97	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Cable bolter	DS421	2	4.9	1.5	0.15	25,000	27.56	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	LHD (LH517i)	LH517i	2	4.9	1.5	0.15	46,500	51.26	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Truck	TH551i	4	4.9	1.5	0.15	97,870	107.88	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Scissor lift	Utilift MF 540	2	4.9	1.5	0.15	13,100	14.44	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Light vehicle (general usage) Fleet 1	Mahindra Roxor	2	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Charging Rig Fleet 1	Charmec MF 605 D(V)	2	4.9	1.5	0.15	14,600	16.09	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	LH Rigs	DL422i	6	4.9	1.5	0.15	22,000	24.25	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	LH Rig (Ore Passes/Geo)	DL422i	1	4.9	1.5	0.15	22,000	24.25	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	LHD (LH518B)	LH518B	5	4.9	1.5	0.15	70,000	77.16	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Trucks (Haul Loop)	TH663i	3	4.9	1.5	0.15	111,440	122.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	20	608.33	7300	Haul Trucks	TH663i	5	4.9	1.5	0.15	111,440	122.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Material transporter	Multimec MF100	2	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	4	121.67	1460	Light vehicle (general usage) Fleet 2	Mahindra Roxor	2	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Charging Rig Fleet 2	Charmec MF 605 D(V)	2	4.9	1.5	0.15	14,600	16.09	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Personnel transporter	Utimec MF 205 PER	3	4.9	1.5	0.15	15,200	16.76	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Shotcreter	Spraymec MF 050 D(V)	2	4.9	1.5	0.15	18,000	19.84	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.67	5840	Transmixer	Utimec MF 500	4	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Water vehicle	MF 350 Water	2	4.9	1.5	0.15	15,700	17.31	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	0.0027397	0.08	1	Mobile rockbreaker	Maclean RB3	3	4.9	1.5	0.15	17,700	19.51	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Grader	Maclean GR5	2	4.9	1.5	0.15	18,200	20.06	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	Skid Steer	Manitou 4200 V	3	4.9	1.5	0.15	5,291	5.83	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Light vehicle (tech services)	Mahindra Roxor	4	4.9	1.5	0.15	1,678	1.85	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Material transporter (logistics/Construct)	Multimec MF100	2	4.9	1.5	0.15	22,200	24.47	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	6	182.50	2190	Scissor lift (Construction)	Utilift MF 540	2	4.9	1.5	0.15	13,100	14.44	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	2	60.83	730	Telehandler	GTH - 1056	3	4.9	1.5	0.15	14,470	15.95	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	4	121.67	1460	Maintenance Vehicle	Maclean FL3	3	4.9	1.5	0.15	33,000	36.38	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.33	2920	Fuel/Lube vehicle	Maclean FL3	2	4.9	1.5	0.15	33,000	36.38	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	0.1	3.04	36.5	Mobile Grapple equipment	Brokk 900	3	4.9	1.5	0.15	11,600	12.79	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	1	30.42	365	Blind Bore Machine	Rhino	2	4.9	1.5	0.15	52,000	57.32	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $$E = k\,(s/12)^a (W/3)^b \qquad (1a)$$

Annual $$E_{ext} = E\,[(365 - P)/365] \qquad (2)$$

where E = Size-specific emission factor (lb/VMT)
k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%), per AP-42 Table 13.2.2-1, 11/06, Western surface coal mining Plant Road
5.1

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.
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Table A-29. Taylor Underground Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1]												Reference
								k			W	s	P	a			b			
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	
Unpaved	Dev Drill Rig	Hourly/Daily	7.43	1.92	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.66	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Dev Drill Rig	Annual	6.17	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Support Drill Rig	Hourly/Daily	7.81	2.01	0.20	lb/VMT	VMT	4.90	1.50	0.15	31.97	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Support Drill Rig	Annual	6.48	1.67	0.17	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Cable bolter	Hourly/Daily	7.30	1.88	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.56	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Cable bolter	Annual	6.06	1.56	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD (LH517i)	Hourly/Daily	9.66	2.49	0.25	lb/VMT	VMT	4.90	1.50	0.15	51.26	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD (LH517i)	Annual	8.02	2.07	0.21	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Truck	Hourly/Daily	13.50	3.48	0.35	lb/VMT	VMT	4.90	1.50	0.15	107.88	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Truck	Annual	11.20	2.89	0.29	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor lift	Hourly/Daily	5.46	1.41	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.44	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor lift	Annual	4.53	1.17	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (general usage) Fleet 1	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (general usage) Fleet 1	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Charging Rig Fleet 1	Hourly/Daily	5.73	1.48	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.09	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Charging Rig Fleet 1	Annual	4.76	1.23	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LH Rigs	Hourly/Daily	6.89	1.78	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.25	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LH Rigs	Annual	5.72	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LH Rig (Ore Passes/Geo)	Hourly/Daily	6.89	1.78	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.25	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LH Rig (Ore Passes/Geo)	Annual	5.72	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD (LH518B)	Hourly/Daily	11.61	2.99	0.30	lb/VMT	VMT	4.90	1.50	0.15	77.16	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD (LH518B)	Annual	9.63	2.49	0.25	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Trucks (Haul Loop)	Hourly/Daily	14.31	3.69	0.37	lb/VMT	VMT	4.90	1.50	0.15	122.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Trucks (Haul Loop)	Annual	11.88	3.06	0.31	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Trucks	Hourly/Daily	14.31	3.69	0.37	lb/VMT	VMT	4.90	1.50	0.15	122.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Trucks	Annual	11.88	3.06	0.31	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Material transporter	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Material transporter	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (general usage) Fleet 2	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (general usage) Fleet 2	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Charging Rig Fleet 2	Hourly/Daily	5.73	1.48	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.09	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Charging Rig Fleet 2	Annual	4.76	1.23	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Personnel transporter	Hourly/Daily	5.84	1.51	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.76	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Personnel transporter	Annual	4.85	1.25	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Shotcreter	Hourly/Daily	6.30	1.62	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.84	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Shotcreter	Annual	5.23	1.35	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Transmixer	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Transmixer	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Water vehicle	Hourly/Daily	5.92	1.53	0.15	lb/VMT	VMT	4.90	1.50	0.15	17.31	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Water vehicle	Annual	4.92	1.27	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Mobile rockbreaker	Hourly/Daily	6.25	1.61	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.51	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Mobile rockbreaker	Annual	5.19	1.34	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Grader	Hourly/Daily	6.33	1.63	0.16	lb/VMT	VMT	4.90	1.50	0.15	20.06	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Grader	Annual	5.26	1.36	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Skid Steer	Hourly/Daily	3.63	0.94	0.09	lb/VMT	VMT	4.90	1.50	0.15	5.83	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Skid Steer	Annual	3.01	0.78	0.08	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light vehicle (tech services)	Hourly/Daily	2.17	0.56	0.06	lb/VMT	VMT	4.90	1.50	0.15	1.85	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light vehicle (tech services)	Annual	1.80	0.46	0.05	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Material transporter (logistics/Construct)	Hourly/Daily	6.92	1.79	0.18	lb/VMT	VMT	4.90	1.50	0.15	24.47	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Material transporter (logistics/Construct)	Annual	5.75	1.48	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor lift (Construction)	Hourly/Daily	5.46	1.41	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.44	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor lift (Construction)	Annual	4.53	1.17	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Telehandler	Hourly/Daily	5.71	1.47	0.15	lb/VMT	VMT	4.90	1.50	0.15	15.95	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Telehandler	Annual	4.74	1.22	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Maintenance Vehicle	Hourly/Daily	8.27	2.13	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.38	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Maintenance Vehicle	Annual	6.87	1.77	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Fuel/Lube vehicle	Hourly/Daily	8.27	2.13	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.38	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Fuel/Lube vehicle	Annual	6.87	1.77	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Mobile Grapple equipment	Hourly/Daily	5.17	1.33	0.13	lb/VMT	VMT	4.90	1.50	0.15	12.79	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Mobile Grapple equipment	Annual	4.29	1.11	0.11	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Blind Bore Machine	Hourly/Daily	10.15	2.62	0.26	lb/VMT	VMT	4.90	1.50	0.15	57.32	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Blind Bore Machine	Annual	8.43	2.17	0.22	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT) (Per AP-42 Table 13.2.2-2, November 2006)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

s = surface material silt content (%) 5.1 (Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with AMI, 10/14/22)

W = Mean vehicle weight (tons)

P = 62 Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021

Table A-30a. Taylor Roads - Vehicles - Input Parameters

Road Surface	Vehicle Type	Trip Type	Number of Vehicles	Trip Distance (miles/vehicle/day)	Vehicle Miles Travelled (VMT)			Uncontrolled Emission Factor (lb/VMT)						Control	
								Short Term			Long Term			Type	Efficiency [1,2]
					(VMT/hr)	(VMT/day)	(VMT/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$		(%)
Unpaved	Dev Drill Rig	Round	3	2	0.250	6.00	2,190	7.43	1.92	0.19	6.17	1.59	0.16	Watering	90%
Unpaved	Support Drill Rig	Round	5	2	0.417	10.00	3,650	7.81	2.01	0.20	6.48	1.67	0.17	Watering	90%
Unpaved	Cable bolter	Round	2	2	0.167	4.00	1,460	7.30	1.88	0.19	6.06	1.56	0.16	Watering	90%
Unpaved	LHD (LH517i)	Round	2	2	0.167	4.00	1,460	9.66	2.49	0.25	8.02	2.07	0.21	Watering	90%
Unpaved	Haul Truck	Round	4	20	3.333	80.00	29,200	13.50	3.48	0.35	11.20	2.89	0.29	Watering	90%
Unpaved	Scissor lift	Round	2	2	0.167	4.00	1,460	5.46	1.41	0.14	4.53	1.17	0.12	Watering	90%
Unpaved	Light vehicle (general usage) Fleet 1	Round	2	2	0.167	4.00	1,460	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Charging Rig Fleet 1	Round	2	2	0.167	4.00	1,460	5.73	1.48	0.15	4.76	1.23	0.12	Watering	90%
Unpaved	LH Rigs	Round	6	1	0.250	6.00	2,190	6.89	1.78	0.18	5.72	1.48	0.15	Watering	90%
Unpaved	LH Rig (Ore Passes/Geo)	Round	1	1	0.042	1.00	365	6.89	1.78	0.18	5.72	1.48	0.15	Watering	90%
Unpaved	LHD (LH518B)	Round	5	2	0.417	10.00	3,650	11.61	2.99	0.30	9.63	2.49	0.25	Watering	90%
Unpaved	Haul Trucks (Haul Loop)	Round	3	20	2.500	60.00	21,900	14.31	3.69	0.37	11.88	3.06	0.31	Watering	90%
Unpaved	Haul Trucks	Round	5	20	4.167	100.00	36,500	14.31	3.69	0.37	11.88	3.06	0.31	Watering	90%
Unpaved	Material transporter	Round	2	6	0.500	12.00	4,380	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Light vehicle (general usage) Fleet 2	Round	2	4	0.333	8.00	2,920	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Charging Rig Fleet 2	Round	2	2	0.167	4.00	1,460	5.73	1.48	0.15	4.76	1.23	0.12	Watering	90%
Unpaved	Personnel transporter	Round	3	6	0.750	18.00	6,570	5.84	1.51	0.15	4.85	1.25	0.13	Watering	90%
Unpaved	Shotcreter	Round	2	2	0.167	4.00	1,460	6.30	1.62	0.16	5.23	1.35	0.13	Watering	90%
Unpaved	Transmixer	Round	4	16	2.667	64.00	23,360	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Water vehicle	Round	2	6	0.500	12.00	4,380	5.92	1.53	0.15	4.92	1.27	0.13	Watering	90%
Unpaved	Mobile rockbreaker	Round	3	0.0027	0.00034	0.01	3	6.25	1.61	0.16	5.19	1.34	0.13	Watering	90%
Unpaved	Grader	Round	2	6	0.500	12.00	4,380	6.33	1.63	0.16	5.26	1.36	0.14	Watering	90%
Unpaved	Skid Steer	Round	3	1	0.125	3.00	1,095	3.63	0.94	0.09	3.01	0.78	0.08	Watering	90%
Unpaved	Light vehicle (tech services)	Round	4	2	0.333	8.00	2,920	2.17	0.56	0.06	1.80	0.46	0.05	Watering	90%
Unpaved	Material transporter (logistics/Construct)	Round	2	6	0.500	12.00	4,380	6.92	1.79	0.18	5.75	1.48	0.15	Watering	90%
Unpaved	Scissor lift (Construction)	Round	2	6	0.500	12.00	4,380	5.46	1.41	0.14	4.53	1.17	0.12	Watering	90%
Unpaved	Telehandler	Round	3	2	0.250	6.00	2,190	5.71	1.47	0.15	4.74	1.22	0.12	Watering	90%
Unpaved	Maintenance Vehicle	Round	3	4	0.500	12.00	4,380	8.27	2.13	0.21	6.87	1.77	0.18	Watering	90%
Unpaved	Fuel/Lube vehicle	Round	2	8	0.667	16.00	5,840	8.27	2.13	0.21	6.87	1.77	0.18	Watering	90%
Unpaved	Mobile Grapple equipment	Round	3	0.1	0.013	0.30	110	5.17	1.33	0.13	4.29	1.11	0.11	Watering	90%
Unpaved	Blind Bore Machine	Round	2	1	0.083	2.00	730	10.15	2.62	0.26	8.43	2.17	0.22	Watering	90%

1. Road Watering is not contemplated every hour, but only as needed to maintain control levels
2. At South32, the roads will be watered sufficiently to achieve a control efficien 90%

Lead Content = 0.0000245 kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Sample

Table A-30b. Taylor Roads -Vehicles - Emissions

Vehicle Type	Road Surface	Uncontrolled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Dev Drill Rig	Unpaved	1.86	0.48	0.05	4.55E-05	44.60	11.50	1.15	1.09E-03	6.76	1.74	0.17	1.66E-04
Support Drill Rig	Unpaved	3.25	0.84	0.08	7.97E-05	78.07	20.14	2.01	1.91E-03	11.83	3.05	0.31	2.90E-04
Cable bolter	Unpaved	1.22	0.31	0.03	2.98E-05	29.21	7.54	0.75	7.16E-04	4.43	1.14	0.11	1.08E-04
LHD (LH517i)	Unpaved	1.61	0.42	0.04	3.94E-05	38.62	9.96	1.00	9.46E-04	5.85	1.51	0.15	1.43E-04
Haul Truck	Unpaved	44.99	11.60	1.16	1.10E-03	1079.65	278.52	27.85	0.03	163.57	42.20	4.22	4.01E-03
Scissor lift	Unpaved	0.91	0.23	0.02	2.23E-05	21.84	5.63	0.56	5.35E-04	3.31	0.85	0.09	8.11E-05
Light vehicle (general usage) Fleet 1	Unpaved	0.36	0.09	0.01	8.84E-06	8.66	2.23	0.22	2.12E-04	1.31	0.34	0.03	3.22E-05
Charging Rig Fleet 1	Unpaved	0.96	0.25	0.02	2.34E-05	22.93	5.92	0.59	5.62E-04	3.47	0.90	0.09	8.51E-05
LH Rigs	Unpaved	1.72	0.44	0.04	4.22E-05	41.37	10.67	1.07	1.01E-03	6.27	1.62	0.16	1.54E-04
LH Rig (Ore Passes/Geo)	Unpaved	0.29	0.07	0.01	7.04E-06	6.89	1.78	0.18	1.69E-04	1.04	0.27	0.03	2.56E-05
LHD (LH518B)	Unpaved	4.84	1.25	0.12	1.18E-04	116.06	29.94	2.99	2.84E-03	17.58	4.54	0.45	4.31E-04
Haul Trucks (Haul Loop)	Unpaved	35.77	9.23	0.92	8.76E-04	858.46	221.46	22.15	0.02	130.06	33.55	3.36	3.19E-03
Haul Trucks	Unpaved	59.62	15.38	1.54	1.46E-03	1430.77	369.10	36.91	0.04	216.76	55.92	5.59	5.31E-03
Material transporter	Unpaved	3.46	0.89	0.09	8.48E-05	83.07	21.43	2.14	2.04E-03	12.59	3.25	0.32	3.08E-04
Light vehicle (general usage) Fleet 2	Unpaved	0.72	0.19	0.02	1.77E-05	17.33	4.47	0.45	4.24E-04	2.62	0.68	0.07	6.43E-05
Charging Rig Fleet 2	Unpaved	0.96	0.25	0.02	2.34E-05	22.93	5.92	0.59	5.62E-04	3.47	0.90	0.09	8.51E-05
Personnel transporter	Unpaved	4.38	1.13	0.11	1.07E-04	105.08	27.11	2.71	2.57E-03	15.92	4.11	0.41	3.90E-04
Shotcreter	Unpaved	1.05	0.27	0.03	2.57E-05	25.20	6.50	0.65	6.17E-04	3.82	0.98	0.10	9.35E-05
Transmixer	Unpaved	18.46	4.76	0.48	4.52E-04	443.04	114.29	11.43	0.01	67.12	17.32	1.73	1.64E-03
Water vehicle	Unpaved	2.96	0.76	0.08	7.26E-05	71.08	18.34	1.83	1.74E-03	10.77	2.78	0.28	2.64E-04
Mobile rockbreaker	Unpaved	0.00	0.00	0.00	5.25E-08	0.05	0.01	0.00	1.26E-06	0.01	0.00	0.00	1.91E-07
Grader	Unpaved	3.17	0.82	0.08	7.75E-05	75.97	19.60	1.96	1.86E-03	11.51	2.97	0.30	2.82E-04
Skid Steer	Unpaved	0.45	0.12	0.01	1.11E-05	10.89	2.81	0.28	2.67E-04	1.65	0.43	0.04	4.04E-05
Light vehicle (tech services)	Unpaved	0.72	0.19	0.02	1.77E-05	17.33	4.47	0.45	4.24E-04	2.62	0.68	0.07	6.43E-05
Material transporter (logistics/Construct)	Unpaved	3.46	0.89	0.09	8.48E-05	83.07	21.43	2.14	2.04E-03	12.59	3.25	0.32	3.08E-04
Scissor lift (Construction)	Unpaved	2.73	0.70	0.07	6.69E-05	65.52	16.90	1.69	1.61E-03	9.93	2.56	0.26	2.43E-04
Telehandler	Unpaved	1.43	0.37	0.04	3.50E-05	34.26	8.84	0.88	8.39E-04	5.19	1.34	0.13	1.27E-04
Maintenance Vehicle	Unpaved	4.14	1.07	0.11	1.01E-04	99.29	25.61	2.56	2.43E-03	15.04	3.88	0.39	3.69E-04
Fuel/Lube vehicle	Unpaved	5.52	1.42	0.14	1.35E-04	132.39	34.15	3.42	3.24E-03	20.06	5.17	0.52	4.91E-04
Mobile Grapple equipment	Unpaved	0.06	0.02	0.00	1.58E-06	1.55	0.40	0.04	3.80E-05	0.23	0.06	0.01	5.76E-06
Blind Bore Machine	Unpaved	0.85	0.22	0.02	2.07E-05	20.31	5.24	0.52	4.98E-04	3.08	0.79	0.08	7.54E-05
Total Emissions		**211.89**	**54.66**	**5.47**	**0.01**	**5,085.46**	**1,311.91**	**131.19**	**0.12**	**770.45**	**198.75**	**19.88**	**0.02**

Vehicle Type	Controlled Emissions											
	Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Dev Drill Rig	0.19	0.05	0.00	4.55E-06	4.46	1.15	0.12	1.09E-04	0.68	0.17	0.02	1.66E-05
Support Drill Rig	0.33	0.08	0.01	7.97E-06	7.81	2.01	0.20	1.91E-04	1.18	0.31	0.03	2.90E-05
Cable bolter	0.12	0.03	0.00	2.98E-06	2.92	0.75	0.08	7.16E-05	0.44	0.11	0.01	1.08E-05
LHD (LH517i)	0.16	0.04	0.00	3.94E-06	3.86	1.00	0.10	9.46E-05	0.59	0.15	0.02	1.43E-05
Haul Truck	4.50	1.16	0.12	1.10E-04	107.96	27.85	2.79	2.65E-03	16.36	4.22	0.42	4.01E-04
Scissor lift	0.09	0.02	0.00	2.23E-06	2.18	0.56	0.06	5.35E-05	0.33	0.09	0.01	8.11E-06
Light vehicle (general usage) Fleet 1	0.04	0.01	0.00	8.84E-07	0.87	0.22	0.02	2.12E-05	0.13	0.03	0.00	3.22E-06
Charging Rig Fleet 1	0.10	0.02	0.00	2.34E-06	2.29	0.59	0.06	5.62E-05	0.35	0.09	0.01	8.51E-06
LH Rigs	0.17	0.04	0.00	4.22E-06	4.14	1.07	0.11	1.01E-04	0.63	0.16	0.02	1.54E-05
LH Rig (Ore Passes/Geo)	0.03	0.01	0.00	7.04E-07	0.69	0.18	0.02	1.69E-05	0.10	0.03	0.00	2.56E-06
LHD (LH518B)	0.48	0.12	0.01	1.18E-05	11.61	2.99	0.30	2.84E-04	1.76	0.45	0.05	4.31E-05
Haul Trucks (Haul Loop)	3.58	0.92	0.09	8.76E-05	85.85	22.15	2.21	2.10E-03	13.01	3.36	0.34	3.19E-04
Haul Trucks	5.96	1.54	0.15	1.46E-04	143.08	36.91	3.69	3.51E-03	21.68	5.59	0.56	5.31E-04
Material transporter	0.35	0.09	0.01	8.48E-06	8.31	2.14	0.21	2.04E-04	1.26	0.32	0.03	3.08E-05
Light vehicle (general usage) Fleet 2	0.07	0.02	0.00	1.77E-06	1.73	0.45	0.04	4.24E-05	0.26	0.07	0.01	6.43E-06
Charging Rig Fleet 2	0.10	0.02	0.00	2.34E-06	2.29	0.59	0.06	5.62E-05	0.35	0.09	0.01	8.51E-06
Personnel transporter	0.44	0.11	0.01	1.07E-05	10.51	2.71	0.27	2.57E-04	1.59	0.41	0.04	3.90E-05
Shotcreter	0.10	0.03	0.00	2.57E-06	2.52	0.65	0.06	6.17E-05	0.38	0.10	0.01	9.35E-06
Transmixer	1.85	0.48	0.05	4.52E-05	44.30	11.43	1.14	1.09E-03	6.71	1.73	0.17	1.64E-04
Water vehicle	0.30	0.08	0.01	7.26E-06	7.11	1.83	0.18	1.74E-04	1.08	0.28	0.03	2.64E-05
Mobile rockbreaker	0.00	0.00	0.00	5.25E-09	0.01	0.00	0.00	1.26E-07	0.00	0.00	0.00	1.91E-08
Grader	0.32	0.08	0.01	7.75E-06	7.60	1.96	0.20	1.86E-04	1.15	0.30	0.03	2.82E-05
Skid Steer	0.05	0.01	0.00	1.11E-06	1.09	0.28	0.03	2.67E-05	0.17	0.04	0.00	4.04E-06
Light vehicle (tech services)	0.07	0.02	0.00	1.77E-06	1.73	0.45	0.04	4.24E-05	0.26	0.07	0.01	6.43E-06
Material transporter (logistics/Construct)	0.35	0.09	0.01	8.48E-06	8.31	2.14	0.21	2.04E-04	1.26	0.32	0.03	3.08E-05
Scissor lift (Construction)	0.27	0.07	0.01	6.69E-06	6.55	1.69	0.17	1.61E-04	0.99	0.26	0.03	2.43E-05
Telehandler	0.14	0.04	0.00	3.50E-06	3.43	0.88	0.09	8.39E-05	0.52	0.13	0.01	1.27E-05
Maintenance Vehicle	0.41	0.11	0.01	1.01E-05	9.93	2.56	0.26	2.43E-04	1.50	0.39	0.04	3.69E-05
Fuel/Lube vehicle	0.55	0.14	0.01	1.35E-05	13.24	3.42	0.34	3.24E-04	2.01	0.52	0.05	4.91E-05
Mobile Grapple equipment	0.01	0.00	0.00	1.58E-07	0.16	0.04	0.00	3.80E-06	0.02	0.01	0.00	5.76E-07
Blind Bore Machine	0.08	0.02	0.00	2.07E-06	2.03	0.52	0.05	4.98E-05	0.31	0.08	0.01	7.54E-06
Total Emissions	**21.19**	**5.47**	**0.55**	**5.19E-04**	**508.55**	**131.19**	**13.12**	**1.25E-02**	**77.04**	**19.88**	**1.99**	**1.89E-03**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency
2. Controlled annual emissions calculated based on long term emission factors and control efficiency

Table A-31. Clark Emission Factor Inputs

Road Surface	Max Miles Traveled			Vehicle Type	Vehicle Model	Max Vehicle Count	Particulate Matter Emission Factor Inputs [1]												
							k					s	P	a			b		
	Day	Month	Year				PM	PM_{10}	$PM_{2.5}$	Avg (kg)	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Unpaved	8	243.3	2920	Jumbo	DD422i	2	4.9	1.5	0.15	26,000	28.7	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Bolter	DD411	3	4.9	1.5	0.15	23,000	25.4	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	60	1825.0	21900	Haul Truck	TH430	5	4.9	1.5	0.15	44,500	49.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	LHD	LH410	4	4.9	1.5	0.15	33,500	36.9	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Production Drill	Simba ME7C	2	4.9	1.5	0.15	29,500	32.5	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Slot-Raise Drill	Easer L	1	4.9	1.5	0.15	37,300	41.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	8	243.3	2920	Blockholer	BH3	1	4.9	1.5	0.15	28,000	30.9	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Powder Truck	EC3	2	4.9	1.5	0.15	17,950	19.8	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Grader	120 AWD	1	4.9	1.5	0.15	16,700	18.4	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Lube Truck	FL3	1	4.9	1.5	0.15	13,600	15.0	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Shotcrete Sprayer	SSX & SS3 T4F	1	4.9	1.5	0.15	19,200	21.2	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Transit Mixer	TM3	2	4.9	1.5	0.15	25,050	27.6	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Scissor Deck	SL3	2	4.9	1.5	0.15	15,400	17.0	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Boom Truck	BT3	1	4.9	1.5	0.15	17,300	19.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	16	486.7	5840	Light Vehicle	F-250	6	4.9	1.5	0.15	3,750	4.1	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45
Unpaved	24	730.0	8760	Water Vehicle	WS3	1	4.9	1.5	0.15	16,100	17.7	5.1	62	0.7	0.9	0.9	0.45	0.45	0.45

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)
k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%), per AP-42 Table 13.2.2-1, 11/06, Western surface coal mining Plant Road
5.1

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.
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Table A-32. Clark Underground Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1]												Reference
								k			W	s	P	a			b			
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	
Unpaved	Jumbo	Hourly/Daily	7.43	1.92	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.66	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Jumbo	Annual	6.17	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Bolter	Hourly/Daily	7.03	1.81	0.18	lb/VMT	VMT	4.90	1.50	0.15	25.35	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Bolter	Annual	5.84	1.51	0.15	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Haul Truck	Hourly/Daily	9.47	2.44	0.24	lb/VMT	VMT	4.90	1.50	0.15	49.05	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Haul Truck	Annual	7.86	2.03	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	LHD	Hourly/Daily	8.33	2.15	0.21	lb/VMT	VMT	4.90	1.50	0.15	36.93	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	LHD	Annual	6.92	1.78	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Production Drill	Hourly/Daily	7.87	2.03	0.20	lb/VMT	VMT	4.90	1.50	0.15	32.52	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Production Drill	Annual	6.53	1.68	0.17	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Slot-Raise Drill	Hourly/Daily	8.74	2.26	0.23	lb/VMT	VMT	4.90	1.50	0.15	41.12	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Slot-Raise Drill	Annual	7.26	1.87	0.19	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Blockholer	Hourly/Daily	7.68	1.98	0.20	lb/VMT	VMT	4.90	1.50	0.15	30.86	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Blockholer	Annual	6.38	1.65	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Powder Truck	Hourly/Daily	6.29	1.62	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.79	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Powder Truck	Annual	5.22	1.35	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Grader	Hourly/Daily	6.09	1.57	0.16	lb/VMT	VMT	4.90	1.50	0.15	18.41	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Grader	Annual	5.06	1.30	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Lube Truck	Hourly/Daily	5.55	1.43	0.14	lb/VMT	VMT	4.90	1.50	0.15	14.99	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Lube Truck	Annual	4.61	1.19	0.12	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Shotcrete Sprayer	Hourly/Daily	6.48	1.67	0.17	lb/VMT	VMT	4.90	1.50	0.15	21.16	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Shotcrete Sprayer	Annual	5.38	1.39	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Transit Mixer	Hourly/Daily	7.31	1.89	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.61	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Transit Mixer	Annual	6.07	1.57	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Scissor Deck	Hourly/Daily	5.87	1.51	0.15	lb/VMT	VMT	4.90	1.50	0.15	16.98	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Scissor Deck	Annual	4.87	1.26	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Boom Truck	Hourly/Daily	6.19	1.60	0.16	lb/VMT	VMT	4.90	1.50	0.15	19.07	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Boom Truck	Annual	5.14	1.33	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Light Vehicle	Hourly/Daily	3.11	0.80	0.08	lb/VMT	VMT	4.90	1.50	0.15	4.13	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Light Vehicle	Annual	2.58	0.67	0.07	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	
Unpaved	Water Vehicle	Hourly/Daily	5.99	1.55	0.15	lb/VMT	VMT	4.90	1.50	0.15	17.75	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	
Unpaved	Water Vehicle	Annual	4.97	1.28	0.13	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	

[1] Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%)

5.1

Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with AMI, 10/14/22.

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.

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Table A-33a. Clark Roads - Vehicles - Input Parameters

Road Surface	Vehicle Type	Trip Type	Number of Vehicles	Trip Distance (miles/vehicle/day)	Vehicle Miles Travelled (VMT)			Uncontrolled Emission Factor (lb/VMT)						Control	
								Short Term			Long Term			Type	Efficiency [1,2]
					(VMT/hr)	(VMT/day)	(VMT/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$		(%)
Unpaved	Jumbo	Round	2	8	0.667	16.00	5,840	7.43	1.92	0.19	6.17	1.59	0.16	Watering	90%
Unpaved	Bolter	Round	3	8	1.000	24.00	8,760	7.03	1.81	0.18	5.84	1.51	0.15	Watering	90%
Unpaved	Haul Truck	Round	5	60	12.500	300.00	109,500	9.47	2.44	0.24	7.86	2.03	0.20	Watering	90%
Unpaved	LHD	Round	4	16	2.667	64.00	23,360	8.33	2.15	0.21	6.92	1.78	0.18	Watering	90%
Unpaved	Production Drill	Round	2	8	0.667	16.00	5,840	7.87	2.03	0.20	6.53	1.68	0.17	Watering	90%
Unpaved	Slot-Raise Drill	Round	1	8	0.333	8.00	2,920	8.74	2.26	0.23	7.26	1.87	0.19	Watering	90%
Unpaved	Blockholer	Round	1	8	0.333	8.00	2,920	7.68	1.98	0.20	6.38	1.65	0.16	Watering	90%
Unpaved	Powder Truck	Round	2	16	1.333	32.00	11,680	6.29	1.62	0.16	5.22	1.35	0.13	Watering	90%
Unpaved	Grader	Round	1	16	0.667	16.00	5,840	6.09	1.57	0.16	5.06	1.30	0.13	Watering	90%
Unpaved	Lube Truck	Round	1	16	0.667	16.00	5,840	5.55	1.43	0.14	4.61	1.19	0.12	Watering	90%
Unpaved	Shotcrete Sprayer	Round	1	16	0.667	16.00	5,840	6.48	1.67	0.17	5.38	1.39	0.14	Watering	90%
Unpaved	Transit Mixer	Round	2	16	1.333	32.00	11,680	7.31	1.89	0.19	6.07	1.57	0.16	Watering	90%
Unpaved	Scissor Deck	Round	2	16	1.333	32.00	11,680	5.87	1.51	0.15	4.87	1.26	0.13	Watering	90%
Unpaved	Boom Truck	Round	1	16	0.667	16.00	5,840	6.19	1.60	0.16	5.14	1.33	0.13	Watering	90%
Unpaved	Light Vehicle	Round	6	16	4.000	96.00	35,040	3.11	0.80	0.08	2.58	0.67	0.07	Watering	90%
Unpaved	Water Vehicle	Round	1	24	1.000	24.00	8,760	5.99	1.55	0.15	4.97	1.28	0.13	Watering	90%

1. Road Watering is not contemplated every hour, but only as needed to maintain control levels.
2. At South32, the roads will be watered sufficiently to achieve a cont 90%

Lead Content = 0.0000245 kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples

Table A-33b. Clark Roads -Vehicles - Emissions

Vehicle Type	Road Surface	Uncontrolled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Jumbo	Unpaved	4.96	1.28	0.13	1.21E-04	118.92	30.68	3.07	2.91E-03	18.02	4.65	0.46	4.41E-04
Bolter	Unpaved	7.03	1.81	0.18	1.72E-04	168.81	43.55	4.35	4.14E-03	25.57	6.60	0.66	6.27E-04
Haul Truck	Unpaved	118.32	30.52	3.05	2.90E-03	2839.78	732.58	73.26	0.07	430.23	110.99	11.10	0.01
LHD	Unpaved	22.21	5.73	0.57	5.44E-04	533.15	137.54	13.75	0.01	80.77	20.84	2.08	1.98E-03
Production Drill	Unpaved	5.24	1.35	0.14	1.28E-04	125.88	32.47	3.25	3.08E-03	19.07	4.92	0.49	4.67E-04
Slot-Raise Drill	Unpaved	2.91	0.75	0.08	7.14E-05	69.95	18.04	1.80	1.71E-03	10.60	2.73	0.27	2.60E-04
Blockholer	Unpaved	2.56	0.66	0.07	6.28E-05	61.48	15.86	1.59	1.51E-03	9.31	2.40	0.24	2.28E-04
Powder Truck	Unpaved	8.39	2.16	0.22	2.06E-04	201.32	51.93	5.19	4.93E-03	30.50	7.87	0.79	7.47E-04
Grader	Unpaved	4.06	1.05	0.10	9.95E-05	97.44	25.14	2.51	2.39E-03	14.76	3.81	0.38	3.62E-04
Lube Truck	Unpaved	3.70	0.95	0.10	9.07E-05	88.84	22.92	2.29	2.18E-03	13.46	3.47	0.35	3.30E-04
Shotcrete Sprayer	Unpaved	4.32	1.12	0.11	1.06E-04	103.75	26.77	2.68	2.54E-03	15.72	4.06	0.41	3.85E-04
Transit Mixer	Unpaved	9.75	2.51	0.25	2.39E-04	233.89	60.34	6.03	5.73E-03	35.43	9.14	0.91	8.68E-04
Scissor Deck	Unpaved	7.83	2.02	0.20	1.92E-04	187.90	48.47	4.85	4.60E-03	28.47	7.34	0.73	6.97E-04
Boom Truck	Unpaved	4.13	1.06	0.11	1.01E-04	99.00	25.54	2.55	2.43E-03	15.00	3.87	0.39	3.67E-04
Light Vehicle	Unpaved	12.44	3.21	0.32	3.05E-04	298.53	77.01	7.70	7.31E-03	45.23	11.67	1.17	1.11E-03
Water Vehicle	Unpaved	5.99	1.55	0.15	1.47E-04	143.78	37.09	3.71	3.52E-03	21.78	5.62	0.56	5.34E-04
	Total Emissions	**223.85**	**57.75**	**5.77**	**5.48E-03**	**5,372.41**	**1,385.93**	**138.59**	**1.32E-01**	**813.92**	**209.97**	**21.00**	**1.99E-02**

Vehicle Type	Road Surface	Controlled Emissions											
		Hourly (lb/hr) [1]				Daily (lb/day) [1]				Annual (tpy) [2]			
		PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead	PM	PM_{10}	$PM_{2.5}$	Lead
Jumbo	Unpaved	0.50	0.13	0.01	1.21E-05	11.89	3.07	0.31	2.91E-04	1.80	0.46	0.05	4.41E-05
Bolter	Unpaved	0.70	0.18	0.02	1.72E-05	16.88	4.35	0.44	4.14E-04	2.56	0.66	0.07	6.27E-05
Haul Truck	Unpaved	11.83	3.05	0.31	2.90E-04	283.98	73.26	7.33	6.96E-03	43.02	11.10	1.11	1.05E-03
LHD	Unpaved	2.22	0.57	0.06	5.44E-05	53.32	13.75	1.38	1.31E-03	8.08	2.08	0.21	1.98E-04
Production Drill	Unpaved	0.52	0.14	0.01	1.28E-05	12.59	3.25	0.32	3.08E-04	1.91	0.49	0.05	4.67E-05
Slot-Raise Drill	Unpaved	0.29	0.08	0.01	7.14E-06	6.99	1.80	0.18	1.71E-04	1.06	0.27	0.03	2.60E-05
Blockholer	Unpaved	0.26	0.07	0.01	6.28E-06	6.15	1.59	0.16	1.51E-04	0.93	0.24	0.02	2.28E-05
Powder Truck	Unpaved	0.84	0.22	0.02	2.06E-05	20.13	5.19	0.52	4.93E-04	3.05	0.79	0.08	7.47E-05
Grader	Unpaved	0.41	0.10	0.01	9.95E-06	9.74	2.51	0.25	2.39E-04	1.48	0.38	0.04	3.62E-05
Lube Truck	Unpaved	0.37	0.10	0.01	9.07E-06	8.88	2.29	0.23	2.18E-04	1.35	0.35	0.03	3.30E-05
Shotcrete Sprayer	Unpaved	0.43	0.11	0.01	1.06E-05	10.38	2.68	0.27	2.54E-04	1.57	0.41	0.04	3.85E-05
Transit Mixer	Unpaved	0.97	0.25	0.03	2.39E-05	23.39	6.03	0.60	5.73E-04	3.54	0.91	0.09	8.68E-05
Scissor Deck	Unpaved	0.78	0.20	0.02	1.92E-05	18.79	4.85	0.48	4.60E-04	2.85	0.73	0.07	6.97E-05
Boom Truck	Unpaved	0.41	0.11	0.01	1.01E-05	9.90	2.55	0.26	2.43E-04	1.50	0.39	0.04	3.67E-05
Light Vehicle	Unpaved	1.24	0.32	0.03	3.05E-05	29.85	7.70	0.77	7.31E-04	4.52	1.17	0.12	1.11E-04
Water Vehicle	Unpaved	0.60	0.15	0.02	1.47E-05	14.38	3.71	0.37	3.52E-04	2.18	0.56	0.06	5.34E-05
	Total Emissions	**22.39**	**5.77**	**0.58**	**5.48E-04**	**537.24**	**138.59**	**13.86**	**1.32E-02**	**81.39**	**21.00**	**2.10**	**1.99E-03**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-34. Truck Pneumatic Loadout Emissions

Emission Point Number	Description	Max Daily Throughput (ton/day)	Max Yearly Throughput (ton/yr)	Hourly Emissions PM (lb/hr)	Hourly Emissions PM_{10} (lb/hr)	Hourly Emissions $PM_{2.5}$ (lb/hr)	Daily Emissions PM (lb/day)	Daily Emissions PM_{10} (lb/day)	Daily Emissions $PM_{2.5}$ (lb/day)	Annual Emissions PM (tpy)	Annual Emissions PM_{10} (tpy)	Annual Emissions $PM_{2.5}$ (tpy)
Taylor												
PP-1	Truck Pneumatic Loadout to Silo 1	235	85,746	9.69E-03	3.33E-03	6.94E-04	2.33E-01	7.99E-02	1.67E-02	4.24E-02	1.46E-02	3.04E-03
PP-2	Truck Pneumatic Loadout to Silo 2	235	85,746	9.69E-03	3.33E-03	6.94E-04	2.33E-01	7.99E-02	1.67E-02	4.24E-02	1.46E-02	3.04E-03
Clark												
PP-3	Truck Pneumatic Loadout to Silo 1	117	42,873	4.85E-03	1.66E-03	3.47E-04	1.16E-01	3.99E-02	8.33E-03	2.12E-02	7.29E-03	1.52E-03
PP-4	Truck Pneumatic Loadout to Silo 2	117	42,873	4.85E-03	1.66E-03	3.47E-04	1.16E-01	3.99E-02	8.33E-03	2.12E-02	7.29E-03	1.52E-03

1. Emission factors based on AP-42 Chapter 11 Section 12, Table 11.12-2.
2. Throughput based on email from South32 on June 14, 2023.

PM	PM10	PM2.5	
0.00099	0.00034	7.0905E-05	lb of pollutant/ton of material

k = Particle size multiplier (dimensionless)

PM	PM_{10}	$PM_{2.5}$
0.74	0.35	0.053

TABLE 11.12-2 (ENGLISH UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled Total PM	Uncontrolled Emission Factor Rating	Uncontrolled Total PM_{10}	Uncontrolled Emission Factor Rating	Controlled Total PM	Controlled Emission Factor Rating	Controlled Total PM_{10}	Controlled Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0069	D	0.0033	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0021	D	0.00099	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.73	E	0.47	E	0.00099	D	0.00034	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	3.14	E	1.10	E	0.0089	D	0.0049	E
Weigh hopper loading [e] (3-05-011-08)	0.0048	D	0.0028	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.572 or Eqn. 11.12-1	B	0.156 or Eqn. 11.12-1	B	0.0184 or Eqn. 11.12-1	B	0.0055 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	1.118	B	0.310	B	0.098 or Eqn. 11.12-1	B	0.0263 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.
[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

Reference 10:

Tanker trucks are contracted from outside sources to deliver cement to the storage silos of the Johnson and Erie batch plants. The Johnson plant has a single cement storage silo. The Erie plant has two cement storage silos designated east and west. To transport the cement from the tanker to the silo, a 4-inch flexible line is attached to the rear of the tanker truck. The cement is then pneumatically conveyed to the top of the storage silo. It takes approximately 45-minutes to unload one tanker truck.

Each storage silo has its own dust collector attached to its roof. The dust collectors vent to the atmosphere and are not equipped with any fans or blowers. The air flow out of each silo is a result of the air being displaced by the incoming cement.

Reference 11:

TEST RESULTS

During the test, a truck load of cement (44,340 lbs. net) was conveyed into the cement storage silo being tested, by an air compressor mounted on the truck. The air was exhausted through two identical Tiberi Engineering Company dust collectors mounted on top of the bin. Only one of the dust collectors was tested. The test results are as follows:

Table A-35a. Roads - Emission Factors

Road Surface	Vehicle Type	Averaging Period	Emission Factor [1]				Process Rate Unit	Particulate Matter Emission Factor Inputs [1]																Reference
								k			W	s	P	a			b			c			M	
			PM	PM_{10}	$PM_{2.5}$	Unit		PM	PM_{10}	$PM_{2.5}$	(ton)	(%)	(days/yr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	(%)	
Unpaved	Personnel Transport Vehicles	Hourly/Daily	3.88	1.00	0.10	lb/VMT	VMT	4.90	1.50	0.15	6.75	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Personnel Transport Vehicles	Annual	3.22	0.83	0.08	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (Surface)	Hourly/Daily	10.33	2.66	0.27	lb/VMT	VMT	4.90	1.50	0.15	59.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (Surface)	Annual	8.57	2.21	0.22	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (On-Highway)	Hourly/Daily	8.54	2.20	0.22	lb/VMT	VMT	4.90	1.50	0.15	39.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (On-Highway)	Annual	7.09	1.83	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Water Truck	Hourly/Daily	9.55	2.46	0.25	lb/VMT	VMT	4.90	1.50	0.15	50.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Water Truck	Annual	7.93	2.04	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Dozer	Hourly/Daily	9.00	2.32	0.23	lb/VMT	VMT	4.90	1.50	0.15	43.90	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Dozer	Annual	7.48	1.93	0.19	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Grader	Hourly/Daily	8.22	2.12	0.21	lb/VMT	VMT	4.90	1.50	0.15	35.86	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Grader	Annual	6.83	1.76	0.18	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck (UG)	Hourly/Daily	9.46	2.44	0.24	lb/VMT	VMT	4.90	1.50	0.15	49.00	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck (UG)	Annual	7.85	2.03	0.20	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Haul Truck Surface	Hourly/Daily	10.01	2.58	0.26	lb/VMT	VMT	4.90	1.50	0.15	55.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Haul Truck Surface	Annual	8.31	2.14	0.21	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Fuel Delivery Truck	Hourly/Daily	7.41	1.91	0.19	lb/VMT	VMT	4.90	1.50	0.15	28.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Fuel Delivery Truck	Annual	6.15	1.59	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Transit Mixer	Hourly/Daily	7.30	1.88	0.19	lb/VMT	VMT	4.90	1.50	0.15	27.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Transit Mixer	Annual	6.06	1.56	0.16	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)
Unpaved	Emulsion delivery/powder truck	Hourly/Daily	6.67	1.72	0.17	lb/VMT	VMT	4.90	1.50	0.15	22.50	5.10	62.00	0.70	0.90	0.90	0.45	0.45	0.45	-	-	-	-	AP-42, Section 13.2.2, Expression 1a (11/06)
Unpaved	Emulsion delivery/powder truck	Annual	5.53	1.43	0.14	lb/VMT	VMT	-	-	-		-	62.00	-	-	-	-	-	-	-	-	-	-	AP-42, Section 13.2.2, Expressions 1a and 2 (11/06)

1. Emission factors for vehicular traffic on unpaved roads per U.S. EPA AP-42, Section 13.2.2 (Unpaved Roads), November 2006.

Short-Term $E = k\,(s/12)^a (W/3)^b$ (1a)

Annual $E_{ext} = E\,[(365 - P)/365]$ (2)

where E = Size-specific emission factor (lb/VMT)

k, a, b = Constants for equation 1a

	PM	PM_{10}	$PM_{2.5}$
k =	4.9	1.5	0.15
a =	0.7	0.9	0.9
b =	0.45	0.45	0.45

Per AP-42 Table 13.2.2-2, November 2006

s = surface material silt content (%)

5.1

Silt content assumed as to be similar to Plant Road in Western Surface Coal Mining in AP-42, Section 13.2.4 (11/2006) per conversation with South32, 10/14/22.

W = Mean vehicle weight (tons)

P = Days per year with at least 0.01 inch precipitation, based on precipitation data from 2019-2021 for Hermosa Trench Met Station, using the lowest annual value between 2019-2021.

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Table A-35b. Roads - Controlled Emission Factors

Short Term Controlled Emission Factors (lb/VMT)												
Hourly/Daily	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
Personnel Transport Vehicles	3.88E-01	1.00E-01	1.00E-02	9.50E-06	1.47E-06	9.31E-06	7.75E-07	6.59E-07	1.32E-05	1.09E-05	3.88E-07	9.69E-08
Haul Truck (Surface)	1.03E+00	2.66E-01	2.66E-02	2.53E-05	3.92E-06	2.48E-05	2.07E-06	1.76E-06	3.51E-05	2.89E-05	1.03E-06	2.58E-07
Haul Truck (On-Highway)	8.54E-01	2.20E-01	2.20E-02	2.09E-05	3.24E-06	2.05E-05	1.71E-06	1.45E-06	2.90E-05	2.39E-05	8.54E-07	2.13E-07
Water Truck	9.55E-01	2.46E-01	2.46E-02	2.34E-05	3.63E-06	2.29E-05	1.91E-06	1.62E-06	3.25E-05	2.67E-05	9.55E-07	2.39E-07
Dozer	9.00E-01	2.32E-01	2.32E-02	2.21E-05	3.42E-06	2.16E-05	1.80E-06	1.53E-06	3.06E-05	2.52E-05	9.00E-07	2.25E-07
Grader	8.22E-01	2.12E-01	2.12E-02	2.01E-05	3.12E-06	1.97E-05	1.64E-06	1.40E-06	2.80E-05	2.30E-05	8.22E-07	2.06E-07
Haul Truck (UG)	9.46E-01	2.44E-01	2.44E-02	2.32E-05	3.60E-06	2.27E-05	1.89E-06	1.61E-06	3.22E-05	2.65E-05	9.46E-07	2.37E-07
Haul Truck Surface	1.00E+00	2.58E-01	2.58E-02	2.45E-05	3.80E-06	2.40E-05	2.00E-06	1.70E-06	3.40E-05	2.80E-05	1.00E-06	2.50E-07
Fuel Delivery Truck	7.41E-01	1.91E-01	1.91E-02	1.82E-05	2.82E-06	1.78E-05	1.48E-06	1.26E-06	2.52E-05	2.08E-05	7.41E-07	1.85E-07
Transit Mixer	7.30E-01	1.88E-01	1.88E-02	1.79E-05	2.77E-06	1.75E-05	1.46E-06	1.24E-06	2.48E-05	2.04E-05	7.30E-07	1.82E-07
Emulsion delivery/powder truck	6.67E-01	1.72E-01	1.72E-02	1.63E-05	2.53E-06	1.60E-05	1.33E-06	1.13E-06	2.27E-05	1.87E-05	6.67E-07	1.67E-07

Long Term Controlled Emission Factors (lb/VMT)												
Annual	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
Personnel Transport Vehicles	3.22E-01	8.30E-02	8.30E-03	7.89E-06	1.22E-06	7.73E-06	6.44E-07	5.47E-07	1.09E-05	9.01E-06	3.22E-07	8.05E-08
Haul Truck (Surface)	8.57E-01	2.21E-01	2.21E-02	2.10E-05	3.26E-06	2.06E-05	1.71E-06	1.46E-06	2.91E-05	2.40E-05	8.57E-07	2.14E-07
Haul Truck (On-Highway)	7.09E-01	1.83E-01	1.83E-02	1.74E-05	2.69E-06	1.70E-05	1.42E-06	1.20E-06	2.41E-05	1.98E-05	7.09E-07	1.77E-07
Water Truck	7.93E-01	2.04E-01	2.04E-02	1.94E-05	3.01E-06	1.90E-05	1.59E-06	1.35E-06	2.69E-05	2.22E-05	7.93E-07	1.98E-07
Dozer	7.48E-01	1.93E-01	1.93E-02	1.83E-05	2.84E-06	1.79E-05	1.50E-06	1.27E-06	2.54E-05	2.09E-05	7.48E-07	1.87E-07
Grader	6.83E-01	1.76E-01	1.76E-02	1.67E-05	2.59E-06	1.64E-05	1.37E-06	1.16E-06	2.32E-05	1.91E-05	6.83E-07	1.71E-07
Haul Truck (UG)	7.85E-01	2.03E-01	2.03E-02	1.92E-05	2.98E-06	1.89E-05	1.57E-06	1.34E-06	2.67E-05	2.20E-05	7.85E-07	1.96E-07
Haul Truck Surface	8.31E-01	2.14E-01	2.14E-02	2.04E-05	3.16E-06	1.99E-05	1.66E-06	1.41E-06	2.82E-05	2.33E-05	8.31E-07	2.08E-07
Fuel Delivery Truck	6.15E-01	1.59E-01	1.59E-02	1.51E-05	2.34E-06	1.48E-05	1.23E-06	1.05E-06	2.09E-05	1.72E-05	6.15E-07	1.54E-07
Transit Mixer	6.06E-01	1.56E-01	1.56E-02	1.48E-05	2.30E-06	1.45E-05	1.21E-06	1.03E-06	2.06E-05	1.70E-05	6.06E-07	1.51E-07
Emulsion delivery/powder truck	5.53E-01	1.43E-01	1.43E-02	1.36E-05	2.10E-06	1.33E-05	1.11E-06	9.41E-07	1.88E-05	1.55E-05	5.53E-07	1.38E-07

Metal Content in Surface Soil

Lead	2.45E-05	kg/kg
Antimony	3.80E-06	kg/kg
Arsenic	2.40E-05	kg/kg
Beryllium	2.00E-06	kg/kg
Cadmium	1.70E-06	kg/kg
Chromium	3.40E-05	kg/kg
Nickel	2.80E-05	kg/kg
Selenium	1.00E-06	kg/kg
Mercury	2.50E-07	kg/kg

Per "Evaluation of Background Metals Concentrations in Arizona Soils" June 1991 prepared by The Earth Technology Corporation, Table 3-1, using the maximum value from ADEQ Soil Samples.

Control Efficiency = 90% At South32, the roads will be watered sufficiently to achieve a control efficiency of 90%.

Table A-36. Roads - Controlled Emission Rates

Hourly (lb/hr) [1]

Segment ID	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	0.57	0.15	0.01	1.39E-05	2.16E-06	1.36E-05	1.14E-06	9.65E-07	1.93E-05	1.59E-05	5.68E-07	1.42E-07
RB	36.64	9.45	0.95	8.98E-04	1.39E-04	8.79E-04	7.33E-05	6.23E-05	1.25E-03	1.03E-03	3.66E-05	9.16E-06
BQ	1.10	0.28	0.03	2.70E-05	4.19E-06	2.64E-05	2.20E-06	1.87E-06	3.75E-05	3.09E-05	1.10E-06	2.75E-07
BM	6.00	1.55	0.15	1.47E-04	2.28E-05	1.44E-04	1.20E-05	1.02E-05	2.04E-04	1.68E-04	6.00E-06	1.50E-06
MT	1.10	0.28	0.03	2.69E-05	4.17E-06	2.64E-05	2.20E-06	1.87E-06	3.74E-05	3.08E-05	1.10E-06	2.75E-07
BN	131.26	33.86	3.39	3.22E-03	4.99E-04	3.15E-03	2.63E-04	2.23E-04	4.46E-03	3.68E-03	1.31E-04	3.28E-05
DB	15.20	3.92	0.39	3.73E-04	5.78E-05	3.65E-04	3.04E-05	2.58E-05	5.17E-04	4.26E-04	1.52E-05	3.80E-06
DE	3.24	0.84	0.08	7.94E-05	1.23E-05	7.78E-05	6.48E-06	5.51E-06	1.10E-04	9.08E-05	3.24E-06	8.10E-07
RD	11.61	3.00	0.30	2.84E-04	4.41E-05	2.79E-04	2.32E-05	1.97E-05	3.95E-04	3.25E-04	1.16E-05	2.90E-06
RH	5.35	1.38	0.14	1.31E-04	2.03E-05	1.28E-04	1.07E-05	9.09E-06	1.82E-04	1.50E-04	5.35E-06	1.34E-06
HC	0.34	0.09	0.01	8.39E-06	1.30E-06	8.21E-06	6.84E-07	5.82E-07	1.16E-05	9.58E-06	3.42E-07	8.56E-08
FH	1.62	0.42	0.04	3.98E-05	6.17E-06	3.90E-05	3.25E-06	2.76E-06	5.52E-05	4.55E-05	1.62E-06	4.06E-07
HI	2.30	0.59	0.06	5.63E-05	8.73E-06	5.51E-05	4.60E-06	3.91E-06	7.81E-05	6.43E-05	2.30E-06	5.74E-07
JI	0.83	0.21	0.02	2.03E-05	3.14E-06	1.99E-05	1.65E-06	1.41E-06	2.81E-05	2.32E-05	8.27E-07	2.07E-07
IL	2.19	0.57	0.06	5.38E-05	8.34E-06	5.27E-05	4.39E-06	3.73E-06	7.46E-05	6.14E-05	2.19E-06	5.49E-07
IK	4.69	1.21	0.12	1.15E-04	1.78E-05	1.12E-04	9.37E-06	7.97E-06	1.59E-04	1.31E-04	4.69E-06	1.17E-06
PR	32.60	8.41	0.84	7.99E-04	1.24E-04	7.82E-04	6.52E-05	5.54E-05	1.11E-03	9.13E-04	3.26E-05	8.15E-06
OP	1.70	0.44	0.04	4.17E-05	6.46E-06	4.08E-05	3.40E-06	2.89E-06	5.78E-05	4.76E-05	1.70E-06	4.25E-07
LP	33.36	8.61	0.86	8.17E-04	1.27E-04	8.01E-04	6.67E-05	5.67E-05	1.13E-03	9.34E-04	3.34E-05	8.34E-06
LA	1.38	0.35	0.04	3.37E-05	5.23E-06	3.30E-05	2.75E-06	2.34E-06	4.68E-05	3.85E-05	1.38E-06	3.44E-07
LB	13.47	3.47	0.35	3.30E-04	5.12E-05	3.23E-04	2.69E-05	2.29E-05	4.58E-04	3.77E-04	1.35E-05	3.37E-06
LC	2.21	0.57	0.06	5.41E-05	8.39E-06	5.30E-05	4.42E-06	3.75E-06	7.51E-05	6.18E-05	2.21E-06	5.52E-07
ST	9.02	2.33	0.233	2.21E-04	3.43E-05	2.16E-04	1.80E-05	1.53E-05	3.07E-04	2.53E-04	9.02E-06	2.25E-06
TU	0.62	0.16	0.02	1.51E-05	2.34E-06	1.48E-05	1.23E-06	1.05E-06	2.10E-05	1.73E-05	6.17E-07	1.54E-07
BP	8.29	2.14	0.21	2.03E-04	3.15E-05	1.99E-04	1.66E-05	1.41E-05	2.82E-04	2.32E-04	8.29E-06	2.07E-06
TP	9.64	2.49	0.25	2.36E-04	3.66E-05	2.31E-04	1.93E-05	1.64E-05	3.28E-04	2.70E-04	9.64E-06	2.41E-06
TV	3.09	0.80	0.08	7.58E-05	1.18E-05	7.43E-05	6.19E-06	5.26E-06	1.05E-04	8.67E-05	3.09E-06	7.74E-07
DP	2.83	0.73	0.07	6.93E-05	1.07E-05	6.79E-05	5.66E-06	4.81E-06	9.62E-05	7.92E-05	2.83E-06	7.07E-07
RS	9.02	2.33	0.23	2.21E-04	3.43E-05	2.16E-04	1.80E-05	1.53E-05	3.07E-04	2.53E-04	9.02E-06	2.25E-06
SV	25.36	6.54	0.65	6.21E-04	9.64E-05	6.09E-04	5.07E-05	4.31E-05	8.62E-04	7.10E-04	2.54E-05	6.34E-06
VC	0.14	0.03	0.00	3.31E-06	5.14E-07	3.25E-06	2.70E-07	2.30E-07	4.60E-06	3.79E-06	1.35E-07	3.38E-08
VB	16.55	4.27	0.427	4.06E-04	6.29E-05	3.97E-04	3.31E-05	2.81E-05	5.63E-04	4.63E-04	1.66E-05	4.14E-06
VD	27.69	7.14	0.71	6.78E-04	1.05E-04	6.64E-04	5.54E-05	4.71E-05	9.41E-04	7.75E-04	2.77E-05	6.92E-06
VW	7.57	1.95	0.20	1.85E-04	2.88E-05	1.82E-04	1.51E-05	1.29E-05	2.57E-04	2.12E-04	7.57E-06	1.89E-06
VX	8.46	2.18	0.22	2.07E-04	3.21E-05	2.03E-04	1.69E-05	1.44E-05	2.88E-04	2.37E-04	8.46E-06	2.11E-06
WY	3.82	0.99	0.10	9.36E-05	1.45E-05	9.17E-05	7.64E-06	6.49E-06	1.30E-04	1.07E-04	3.82E-06	9.55E-07
WX	1.84	0.47	0.05	4.51E-05	6.99E-06	4.41E-05	3.68E-06	3.13E-06	6.25E-05	5.15E-05	1.84E-06	4.60E-07
XB	6.12	1.58	0.16	1.50E-04	2.32E-05	1.47E-04	1.22E-05	1.04E-05	2.08E-04	1.71E-04	6.12E-06	1.53E-06
BC	0.33	0.09	0.01	8.17E-06	1.27E-06	8.00E-06	6.67E-07	5.67E-07	1.13E-05	9.34E-06	3.33E-07	8.34E-08
BZ	2.96	0.76	0.076	7.26E-05	1.13E-05	7.11E-05	5.93E-06	5.04E-06	1.01E-04	8.30E-05	2.96E-06	7.41E-07
ZA	0.17	0.04	0.00	4.13E-06	6.41E-07	4.05E-06	3.37E-07	2.87E-07	5.74E-06	4.72E-06	1.69E-07	4.22E-08
ZY	3.38	0.87	0.087	8.29E-05	1.29E-05	8.12E-05	6.77E-06	5.75E-06	1.15E-04	9.47E-05	3.38E-06	8.46E-07
VA	0.25	0.06	0.01	6.11E-06	9.48E-07	5.99E-06	4.99E-07	4.24E-07	8.48E-06	6.99E-06	2.50E-07	6.24E-08
XA	0.75	0.19	0.019	1.85E-05	2.87E-06	1.81E-05	1.51E-06	1.28E-06	2.57E-05	2.11E-05	7.55E-07	1.89E-07
YA	0.77	0.20	0.02	1.90E-05	2.94E-06	1.86E-05	1.55E-06	1.32E-06	2.63E-05	2.17E-05	7.74E-07	1.93E-07
Total Emissions	**457.43**	**118.00**	**11.80**	**1.12E-02**	**1.74E-03**	**1.10E-02**	**9.15E-04**	**7.78E-04**	**1.56E-02**	**1.28E-02**	**4.57E-04**	**1.14E-04**

Daily (lb/day) [1]

Segment ID	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	1.97	0.51	0.05	4.83E-05	7.49E-06	4.73E-05	3.94E-06	3.35E-06	6.70E-05	5.52E-05	1.97E-06	4.93E-07
RB	145.85	37.62	3.76	3.57E-03	5.54E-04	3.50E-03	2.92E-04	2.48E-04	4.96E-03	4.08E-03	1.46E-04	3.65E-05
BQ	3.99	1.03	0.10	9.77E-05	1.52E-05	9.57E-05	7.98E-06	6.78E-06	1.36E-04	1.12E-04	3.99E-06	9.97E-07
BM	58.87	15.19	1.52	1.44E-03	2.24E-04	1.41E-03	1.18E-04	1.00E-04	2.00E-03	1.65E-03	5.89E-05	1.47E-05
MT	4.91	1.27	0.13	1.20E-04	1.87E-05	1.18E-04	9.82E-06	8.34E-06	1.67E-04	1.37E-04	4.91E-06	1.23E-06
BN	1177.60	303.79	30.38	2.89E-02	4.47E-03	2.83E-02	2.36E-03	2.00E-03	4.00E-02	3.30E-02	1.18E-03	2.94E-04
DB	41.37	10.67	1.07	1.01E-03	1.57E-04	9.93E-04	8.27E-05	7.03E-05	1.41E-03	1.16E-03	4.14E-05	1.03E-05
DE	18.54	4.78	0.48	4.54E-04	7.05E-05	4.45E-04	3.71E-05	3.15E-05	6.31E-04	5.19E-04	1.85E-05	4.64E-06
RD	36.32	9.37	0.94	8.90E-04	1.38E-04	8.72E-04	7.26E-05	6.17E-05	1.23E-03	1.02E-03	3.63E-05	9.08E-06
RH	44.55	11.49	1.15	1.09E-03	1.69E-04	1.07E-03	8.91E-05	7.57E-05	1.51E-03	1.25E-03	4.46E-05	1.11E-05
HC	3.10	0.80	0.08	7.59E-05	1.18E-05	7.44E-05	6.20E-06	5.27E-06	1.05E-04	8.68E-05	3.10E-06	7.75E-07
FH	6.74	1.74	0.17	1.65E-04	2.56E-05	1.62E-04	1.35E-05	1.15E-05	2.29E-04	1.89E-04	6.74E-06	1.69E-06
HI	22.13	5.71	0.57	5.42E-04	8.41E-05	5.31E-04	4.43E-05	3.76E-05	7.53E-04	6.20E-04	2.21E-05	5.53E-06
JI	6.42	1.66	0.17	1.57E-04	2.44E-05	1.54E-04	1.28E-05	1.09E-05	2.18E-04	1.80E-04	6.42E-06	1.61E-06
IL	8.53	2.20	0.22	2.09E-04	3.24E-05	2.05E-04	1.71E-05	1.45E-05	2.90E-04	2.39E-04	8.53E-06	2.13E-06
IK	43.76	11.29	1.13	1.07E-03	1.66E-04	1.05E-03	8.75E-05	7.44E-05	1.49E-03	1.23E-03	4.38E-05	1.09E-05
PR	142.48	36.76	3.68	3.49E-03	5.41E-04	3.42E-03	2.85E-04	2.42E-04	4.84E-03	3.99E-03	1.42E-04	3.56E-05
OP	6.03	1.56	0.16	1.48E-04	2.29E-05	1.45E-04	1.21E-05	1.03E-05	2.05E-04	1.69E-04	6.03E-06	1.51E-06
LP	147.12	37.95	3.80	3.60E-03	5.59E-04	3.53E-03	2.94E-04	2.50E-04	5.00E-03	4.12E-03	1.47E-04	3.68E-05
LA	6.15	1.59	0.16	1.51E-04	2.34E-05	1.48E-04	1.23E-05	1.05E-05	2.09E-04	1.72E-04	6.15E-06	1.54E-06
LB	58.12	14.99	1.50	1.42E-03	2.21E-04	1.39E-03	1.16E-04	9.88E-05	1.98E-03	1.63E-03	5.81E-05	1.45E-05
LC	11.19	2.89	0.29	2.74E-04	4.25E-05	2.69E-04	2.24E-05	1.90E-05	3.80E-04	3.13E-04	1.12E-05	2.80E-06
ST	28.23	7.28	0.73	6.92E-04	1.07E-04	6.78E-04	5.65E-05	4.80E-05	9.60E-04	7.90E-04	2.82E-05	7.06E-06
TU	2.94	0.76	0.08	7.21E-05	1.12E-05	7.06E-05	5.88E-06	5.00E-06	1.00E-04	8.24E-05	2.94E-06	7.36E-07
BP	25.65	6.62	0.66	6.28E-04	9.75E-05	6.16E-04	5.13E-05	4.36E-05	8.72E-04	7.18E-04	2.56E-05	6.41E-06
TP	29.82	7.69	0.77	7.31E-04	1.13E-04	7.16E-04	5.96E-05	5.07E-05	1.01E-03	8.35E-04	2.98E-05	7.46E-06
TV	15.69	4.05	0.40	3.84E-04	5.96E-05	3.76E-04	3.14E-05	2.67E-05	5.33E-04	4.39E-04	1.57E-05	3.92E-06
DP	14.34	3.70	0.37	3.51E-04	5.45E-05	3.44E-04	2.87E-05	2.44E-05	4.87E-04	4.01E-04	1.43E-05	3.58E-06
RS	36.36	9.38	0.94	8.91E-04	1.38E-04	8.73E-04	7.27E-05	6.18E-05	1.24E-03	1.02E-03	3.64E-05	9.09E-06
SV	94.41	24.35	2.44	2.31E-03	3.59E-04	2.27E-03	1.89E-04	1.60E-04	3.21E-03	2.64E-03	9.44E-05	2.36E-05
VC	0.60	0.15	0.02	1.46E-05	2.27E-06	1.43E-05	1.19E-06	1.02E-06	2.03E-05	1.67E-05	5.97E-07	1.49E-07
VB	63.50	16.38	1.64	1.56E-03	2.41E-04	1.52E-03	1.27E-04	1.08E-04	2.16E-03	1.78E-03	6.35E-05	1.59E-05
VD	113.70	29.33	2.93	2.79E-03	4.32E-04	2.73E-03	2.27E-04	1.93E-04	3.87E-03	3.18E-03	1.14E-04	2.84E-05
VW	31.68	8.17	0.82	7.76E-04	1.20E-04	7.60E-04	6.34E-05	5.39E-05	1.08E-03	8.87E-04	3.17E-05	7.92E-06
VX	35.20	9.08	0.91	8.62E-04	1.34E-04	8.45E-04	7.04E-05	5.98E-05	1.20E-03	9.86E-04	3.52E-05	8.80E-06
WY	17.29	4.46	0.45	4.24E-04	6.57E-05	4.15E-04	3.46E-05	2.94E-05	5.88E-04	4.84E-04	1.73E-05	4.32E-06
WX	5.89	1.52	0.15	1.44E-04	2.24E-05	1.41E-04	1.18E-05	1.00E-05	2.00E-04	1.65E-04	5.89E-06	1.47E-06
XB	19.64	5.07	0.51	4.81E-04	7.46E-05	4.71E-04	3.93E-05	3.34E-05	6.68E-04	5.50E-04	1.96E-05	4.91E-06
BC	1.17	0.30	0.03	2.88E-05	4.46E-06	2.82E-05	2.35E-06	2.00E-06	3.99E-05	3.29E-05	1.17E-06	2.93E-07
BZ	16.07	4.15	0.41	3.94E-04	6.11E-05	3.86E-04	3.21E-05	2.73E-05	5.46E-04	4.50E-04	1.61E-05	4.02E-06
ZA	0.97	0.25	0.02	2.37E-05	3.67E-06	2.32E-05	1.93E-06	1.64E-06	3.29E-05	2.71E-05	9.67E-07	2.42E-07
ZY	16.07	4.15	0.41	3.94E-04	6.11E-05	3.86E-04	3.21E-05	2.73E-05	5.46E-04	4.50E-04	1.61E-05	4.02E-06
VA	1.93	0.50	0.05	4.73E-05	7.33E-06	4.63E-05	3.86E-06	3.28E-06	6.56E-05	5.40E-05	1.93E-06	4.82E-07
XA	5.84	1.51	0.15	1.43E-04	2.22E-05	1.40E-04	1.17E-05	9.92E-06	1.98E-04	1.63E-04	5.84E-06	1.46E-06
YA	5.98	1.54	0.15	1.47E-04	2.27E-05	1.44E-04	1.20E-05	1.02E-05	2.03E-04	1.68E-04	5.98E-06	1.50E-06
Total Emissions	**2,578.73**	**665.24**	**66.52**	**6.32E-02**	**9.80E-03**	**6.19E-02**	**5.16E-03**	**4.38E-03**	**8.77E-02**	**7.22E-02**	**2.58E-03**	**6.45E-04**

Annual (tpy) [2]

Segment ID	PM	PM_{10}	$PM_{2.5}$	Lead	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Nickel	Selenium	Mercury
AR	0.27	0.07	0.01	6.71E-06	1.04E-06	6.57E-06	5.48E-07	4.66E-07	9.31E-06	7.67E-06	2.74E-07	6.85E-08
RB	19.51	5.03	0.50	4.78E-04	7.41E-05	4.68E-04	3.90E-05	3.32E-05	6.63E-04	5.46E-04	1.95E-05	4.88E-06
BQ	0.57	0.15	0.01	1.40E-05	2.17E-06	1.37E-05	1.14E-06	9.71E-07	1.94E-05	1.60E-05	5.71E-07	1.43E-07
BM	6.63	1.71	0.17	1.63E-04	2.52E-05	1.59E-04	1.33E-05	1.13E-05	2.26E-04	1.86E-04	6.63E-06	1.66E-06
MT	0.71	0.18	0.02	1.73E-05	2.69E-06	1.70E-05	1.42E-06	1.20E-06	2.41E-05	1.98E-05	7.08E-07	1.77E-07
BN	134.49	34.69	3.47	3.29E-03	5.11E-04	3.23E-03	2.69E-04	2.29E-04	4.57E-03	3.77E-03	1.34E-04	3.36E-05
DB	4.13	1.06	0.11	1.01E-04	1.57E-05	9.91E-05	8.26E-06	7.02E-06	1.40E-04	1.16E-04	4.13E-06	1.03E-06
DE	0.89	0.23	0.02	2.18E-05	3.38E-06	2.13E-05	1.78E-06	1.51E-06	3.02E-05	2.49E-05	8.89E-07	2.22E-07
RD	3.56	0.92	0.09	8.72E-05	1.35E-05	8.54E-05	7.11E-06	6.05E-06	1.21E-04	9.96E-05	3.56E-06	8.89E-07
RH	5.43	1.40	0.14	1.33E-04	2.06E-05	1.30E-04	1.09E-05	9.22E-06	1.84E-04	1.52E-04	5.43E-06	1.36E-06
HC	0.29	0.08	0.01	7.16E-06	1.11E-06	7.01E-06	5.84E-07	4.97E-07	9.93E-06	8.18E-06	2.92E-07	7.30E-08
FH	1.00	0.26	0.03	2.45E-05	3.80E-06	2.40E-05	2.00E-06	1.70E-06	3.40E-05	2.80E-05	1.00E-06	2.50E-07
HI	2.44	0.63	0.06	5.98E-05	9.28E-06	5.86E-05	4.88E-06	4.15E-06	8.30E-05	6.84E-05	2.44E-06	6.10E-07
JI	0.39	0.10	0.01	9.63E-06	1.49E-06	9.43E-06	7.86E-07	6.68E-07	1.34E-05	1.10E-05	3.93E-07	9.82E-08
IL	1.24	0.32	0.03	3.04E-05	4.71E-06	2.98E-05	2.48E-06	2.11E-06	4.22E-05	3.47E-05	1.24E-06	3.10E-07
IK	6.57	1.69	0.17	1.61E-04	2.50E-05	1.58E-04	1.31E-05	1.12E-05	2.23E-04	1.84E-04	6.57E-06	1.64E-06
PR	20.09	5.18	0.52	4.92E-04	7.63E-05	4.82E-04	4.02E-05	3.41E-05	6.83E-04	5.62E-04	2.01E-05	5.02E-06
OP	0.82	0.21	0.02	2.01E-05	3.12E-06	1.97E-05	1.64E-06	1.40E-06	2.79E-05	2.30E-05	8.21E-07	2.05E-07
LP	20.74	5.35	0.54	5.08E-04	7.88E-05	4.98E-04	4.15E-05	3.53E-05	7.05E-04	5.81E-04	2.07E-05	5.19E-06
LA	0.87	0.23	0.02	2.14E-05	3.32E-06	2.10E-05	1.75E-06	1.48E-06	2.97E-05	2.45E-05	8.73E-07	2.18E-07
LB	8.15	2.10	0.21	2.00E-04	3.10E-05	1.96E-04	1.63E-05	1.39E-05	2.77E-04	2.28E-04	8.15E-06	2.04E-06
LC	1.66	0.43	0.04	4.06E-05	6.30E-06	3.98E-05	3.31E-06	2.82E-06	5.63E-05	4.64E-05	1.66E-06	4.14E-07
ST	3.60	0.93	0.09	8.82E-05	1.37E-05	8.64E-05	7.20E-06	6.12E-06	1.22E-04	1.01E-04	3.60E-06	9.00E-07
TU	0.42	0.11	0.01	1.04E-05	1.61E-06	1.02E-05	8.50E-07	7.22E-07	1.44E-05	1.19E-05	4.25E-07	1.06E-07
BP	3.27	0.84	0.08	8.02E-05	1.24E-05	7.85E-05	6.55E-06	5.56E-06	1.11E-04	9.16E-05	3.27E-06	8.18E-07
TP	3.81	0.98	0.10	9.32E-05	1.45E-05	9.13E-05	7.61E-06	6.47E-06	1.29E-04	1.07E-04	3.81E-06	9.52E-07
TV	2.34	0.60	0.06	5.72E-05	8.88E-06	5.61E-05	4.67E-06	3.97E-06	7.94E-05	6.54E-05	2.34E-06	5.84E-07
DP	2.14	0.55	0.06	5.23E-05	8.11E-06	5.12E-05	4.27E-06	3.63E-06	7.26E-05	5.98E-05	2.14E-06	5.34E-07
RS	4.83	1.25	0.12	1.18E-04	1.84E-05	1.16E-04	9.66E-06	8.21E-06	1.64E-04	1.35E-04	4.83E-06	1.21E-06
SV	12.32	3.18	0.32	3.02E-04	4.68E-05	2.96E-04	2.46E-05	2.09E-05	4.19E-04	3.45E-04	1.23E-05	3.08E-06
VC	0.08	0.02	0.00	1.95E-06	3.02E-07	1.91E-06	1.59E-07	1.35E-07	2.70E-06	2.22E-06	7.94E-08	1.99E-08
VB	8.36	2.16	0.22	2.05E-04	3.18E-05	2.01E-04	1.67E-05	1.42E-05	2.84E-04	2.34E-04	8.36E-06	2.09E-06
VD	14.98	3.86	0.39	3.67E-04	5.69E-05	3.59E-04	3.00E-05	2.55E-05	5.09E-04	4.19E-04	1.50E-05	3.74E-06
VW	4.51	1.16	0.12	1.10E-04	1.71E-05	1.08E-04	9.01E-06	7.66E-06	1.53E-04	1.26E-04	4.51E-06	1.13E-06
VX	3.08	0.80	0.08	7.55E-05	1.17E-05	7.40E-05	6.17E-06	5.24E-06	1.05E-04	8.63E-05	3.08E-06	7.71E-07
WY	2.50	0.65	0.06	6.14E-05	9.52E-06	6.01E-05	5.01E-06	4.26E-06	8.52E-05	7.01E-05	2.50E-06	6.26E-07
WX	0.81	0.21	0.02	1.98E-05	3.07E-06	1.94E-05	1.61E-06	1.37E-06	2.74E-05	2.26E-05	8.07E-07	2.02E-07
XB	2.59	0.67	0.07	6.36E-05	9.86E-06	6.23E-05	5.19E-06	4.41E-06	8.82E-05	7.26E-05	2.59E-06	6.49E-07
BC	0.16	0.04	0.00	3.89E-06	6.03E-07	3.81E-06	3.18E-07	2.70E-07	5.40E-06	4.45E-06	1.59E-07	3.97E-08
BZ	2.28	0.59	0.06	5.59E-05	8.68E-06	5.48E-05	4.57E-06	3.88E-06	7.76E-05	6.39E-05	2.28E-06	5.71E-07
ZA	0.14	0.04	0.00	3.41E-06	5.29E-07	3.34E-06	2.79E-07	2.37E-07	4.74E-06	3.90E-06	1.39E-07	3.48E-08
ZY	2.25	0.58	0.06	5.51E-05	8.55E-06	5.40E-05	4.50E-06	3.82E-06	7.65E-05	6.30E-05	2.25E-06	5.62E-07
VA	0.29	0.08	0.01	7.16E-06	1.11E-06	7.02E-06	5.85E-07	4.97E-07	9.94E-06	8.19E-06	2.92E-07	7.31E-08
XA	0.88	0.23	0.02	2.17E-05	3.36E-06	2.12E-05	1.77E-06	1.50E-06	3.01E-05	2.48E-05	8.84E-07	2.21E-07
YA	0.91	0.23	0.02	2.22E-05	3.44E-06	2.18E-05	1.81E-06	1.54E-06	3.08E-05	2.54E-05	9.06E-07	2.27E-07
Total Emissions	**316.99**	**81.78**	**8.18**	**7.77E-03**	**1.20E-03**	**7.61E-03**	**6.34E-04**	**5.39E-04**	**1.08E-02**	**8.88E-03**	**3.17E-04**	**7.92E-05**

1. Controlled hourly and daily emissions calculated based on short term emission factors and control efficiency. Hourly emissions are calculated as the daily emissions divided by 24 hours.
2. Controlled annual emissions calculated based on long term emission factors and control efficiency.

Table A-37. Roads - Segments

Origin	Destination	Material	Vehicle	Annual Trips[1] (trips/yr)	Daily Trips (trips/day)[1]	Hourly Trips (trips/hour)[1]	Surface	Unpaved																																												
							Number of Objects	4	34	7	10	8	149	12	8	10	10	1	7	6	4	13	19	26	14	28	10	15	20	19	9	15	21	25	29	10	22	1	12	26	6	35	5	6	42	3	41	2	41	3	10	11
							Segment Length (mi)	0.04	0.38	0.07	0.11	0.10	1.66	0.14	0.09	0.11	0.11	0.02	0.07	0.08	0.05	0.16	0.21	0.28	0.11	0.29	0.12	0.12	0.22	0.20	0.06	0.18	0.21	0.31	0.29	0.10	0.20	0.01	0.14	0.25	0.08	0.41	0.05	0.05	0.32	0.02	0.31	0.02	0.30	0.04	0.12	0.12
							r	AR	RB	BQ	BM	MT	BN	DB	DE	RD	RH	HC	FH	HI	JI	IL	IK	PR	OP	LP	LA	LB	LC	ST	TU	BP	TP	TV	DP	RS	SV	VC	VB	VD	VW	VX	WY	WX	XB	BC	BZ	ZA	ZY	VA	XA	YA
Flux Option#1	Portal Option#1	Personnel	Personnel Transport Vehicles	5782	16	8			X					X		X								X		X		X								X	X		X	X	X		X									
Flux Option#2	Portal Option#2	Personnel	Personnel Transport Vehicles	1446	4	2								X		X								X		X		X		X		X	X				X		X	X	X		X									
Harshaw	Portal	Personnel	Personnel Transport Vehicles	73	1	1		X																												X	X		X	X	X		X									
Flux Option#1	Bluff Option#1	Personnel	Personnel Transport Vehicles	289	1	1			X					X		X								X		X		X								X	X		X	X	X			X	X		X		X			
Flux Option#2	Bluff Option#2	Personnel	Personnel Transport Vehicles	73	1	1								X		X								X		X		X		X		X	X				X		X	X	X			X	X		X		X			
Harshaw	Bluff	Personnel	Personnel Transport Vehicles	4	1	1		X																												X	X		X	X	X			X	X		X		X			
Flux Option#1	Alta Option#1	Personnel	Personnel Transport Vehicles	868	3	3			X					X		X								X		X		X								X	X		X													
Flux Option#2	Alta Option#2	Personnel	Personnel Transport Vehicles	217	1	1								X		X								X		X		X		X		X	X				X		X													
Harshaw	Alta	Personnel	Haul Truck (On-Highway)	11	1	1		X																												X	X	X	X													
Flux Option#1	Portal Option#1	Chemicals	Haul Truck (On-Highway)	20	1	1			X					X		X								X		X		X								X	X		X	X	X		X									
Flux Option#2	Portal Option#2	Chemicals	Haul Truck (On-Highway)	5	1	1								X		X								X		X		X		X		X	X				X		X	X	X		X									
Flux Option#1	Vehicle Maintenance Shop (Clark) Option#1	Tires	Haul Truck (On-Highway)	12	1	1			X					X		X								X		X		X								X	X	X														
Flux Option#2	Vehicle Maintenance Shop (Clark) Option#2	Tires	Haul Truck (On-Highway)	3	1	1								X		X								X		X		X		X		X	X				X	X														
Flux Option#1	Paste Plant Option#1	Cement	Haul Truck (On-Highway)	984	4	4			X					X		X								X		X		X								X	X		X	X	X			X								
Flux Option#2	Paste Plant Option#2	Cement	Haul Truck (On-Highway)	246	1	1								X		X								X		X		X		X		X	X				X		X	X	X			X								
Flux	Explosives Magazine (Trench)	Emulsions	Emulsion delivery/powder truck	30	1	1																			X	X		X																								
Explosives Magazine (Trench) Option #1	Portal Option#1	Emulsions	Emulsion delivery/powder truck	292	1	1			X					X		X								X	X											X	X		X	X	X		X									
Explosives Magazine (Trench) Option #2	Portal Option#2	Emulsions	Emulsion delivery/powder truck	73	1	1								X		X								X	X					X		X	X				X		X	X	X		X									
Filtration Plant Option #1	Paste Plant Option#1	Tailings (Taylor)	Haul Truck Surface	7480	21	4			X		X																									X	X		X	X	X			X								
Filtration Plant Option #2	Paste Plant Option#2	Tailings (Taylor)	Haul Truck Surface	1870	5	1					X																			X		X	X				X		X	X	X			X								
Flux Option#1	Portal Option#1	Misc.	Haul Truck (On-Highway)	584	2	2			X					X		X								X		X		X								X	X		X	X	X		X									
Flux Option#2	Portal Option#2	Misc.	Haul Truck (On-Highway)	146	1	1								X		X								X		X		X		X		X	X				X		X	X	X		X									
Portal	Crusher	Ore	Haul Truck (UG)	17510	48	4																																		X	X		X									
Crusher Option#1	Flux Option#1	Ore	Haul Truck (On-Highway)	17511	48	7			X					X		X								X		X		X								X	X		X													
Crusher Option#2	Flux Option#2	Ore	Haul Truck (On-Highway)	4378	12	2								X		X								X		X		X		X		X	X				X		X													
Portal Option#1	OTSF Option#1	NAG	Haul Truck (UG)	23886	66	8			X				X																							X	X		X	X	X		X									
Portal Option#2	OTSF Option#2	NAG	Haul Truck (UG)	5972	17	2							X																	X		X	X				X		X	X	X		X									
Portal Option#1	OTSF Option#1	PAG	Haul Truck (UG)	2389	7	5			X				X																							X	X		X	X	X		X									
Portal Option#2	OTSF Option#2	PAG	Haul Truck (UG)	598	2	2							X																	X		X	X				X		X	X	X		X									
Flux Option#1	Portal Option#1	Fuel (Diesel)	Fuel Delivery Truck	479	2	2			X					X		X								X		X		X								X	X		X	X	X		X									
Flux Option#2	Portal Option#2	Fuel (Diesel)	Fuel Delivery Truck	120	1	1								X		X								X		X		X		X		X	X				X		X	X	X		X									
Flux Option#1	Concrete Batch Plant Option#1	Raw materials concrete (sand, aggregate, cement)	Haul Truck (On-Highway)	84	2	2			X					X		X								X		X		X								X	X		X	X	X			X	X	X						
Flux Option#2	Concrete Batch Plant Option#2	Raw materials concrete (sand, aggregate, cement)	Haul Truck (On-Highway)	21	1	1								X		X								X		X		X		X		X	X				X		X	X	X			X	X	X						
Concrete Batch Plant	Portal	Concrete	Transit Mixer	1095	3	3																																					X	X	X	X						
Flux	Alta, Hardshell, Bluff (all areas)	Potable Water Delivery	Haul Truck (On-Highway)	12	1	1			X					X		X								X		X		X		X		X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Clark Admin	Clark Wells	Well Checks	Personnel Transport Vehicles	365	1	1																																		X	X		X	X						X	X	X
Alta, Hardshell, Bluff	Alta, Hardshell, Bluff	-	Grader	365	1	1																														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Alta, Hardshell, Bluff	Alta, Hardshell, Bluff	Road Water	Water Truck	8760	24	2																														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flux	Shaft	Personnel	Personnel Transport Vehicles	4041	12	2									X	X								X		X		X																								
Flux	Vehicle Maintenance	Personnel	Personnel Transport Vehicles	382	2	2				X				X		X								X		X		X																								
Flux	Admin	Personnel	Personnel Transport Vehicles	1332	4	4											X		X					X		X		X																								
Flux	WTP1	Personnel	Personnel Transport Vehicles	23	1	1																					X	X																								
Flux	Concentrator	Personnel	Personnel Transport Vehicles	1287	4	4											X			X		X	X	X		X		X																								
Flux	Paste Plant	Personnel	Personnel Transport Vehicles	53	1	1					X			X		X								X		X		X																								
Flux	Filtration Plant	Personnel	Personnel Transport Vehicles	53	1	1					X			X		X								X		X		X																								
Flux	WTP2	Personnel	Personnel Transport Vehicles	60	1	1					X	X		X		X								X		X		X																								
Flux Option#1	Vent Raise Option#1	Personnel	Personnel Transport Vehicles	12	1	1			X					X		X								X		X		X		X	X					X																
Flux Option#2	Vent Raise Option#2	Personnel	Personnel Transport Vehicles	3	1	1								X		X								X		X		X			X	X	X																			
Flux	Portal Pad (core facility)	Personnel	Personnel Transport Vehicles	232	1	1																						X	X																							
Harshaw Option#1	Admin Option#1	Personnel	Personnel Transport Vehicles	1168	4	4		X	X					X		X	X		X																																	
Harshaw Option#2	Admin Option#2	Personnel	Personnel Transport Vehicles	292	1	1		X						X		X	X		X											X		X	X			X																
Flux	Trench (all areas)	Potable Water Delivery	Haul Truck (On-Highway)	183	1	1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X					X	X			
Flux	Shaft, concentrator, WTP2	Chemicals	Haul Truck (On-Highway)	156	1	1					X	X		X	X	X	X			X		X	X	X		X		X																								
Flux	WTP1	Water Treatment Chemicals	Haul Truck (On-Highway)	14	1	1																					X	X																								
Flux	Vehicle Maintenance Shop	Tires	Haul Truck (On-Highway)	52	1	1				X				X		X								X		X		X																								
Flux	Paste Plant	Cement	Haul Truck (On-Highway)	156	2	2					X			X		X								X		X		X																								
Flux	Explosives Magazine (Trench)	Emulsions	Emulsion delivery/powder truck	52	1	1																			X	X		X																								
Explosives Magazine (Trench)	Shaft	Emulsions	Emulsion delivery/powder truck	52	1	1									X	X								X	X																											
Concentrator	Flux	Concentrate	Haul Truck (On-Highway)	33278	91	5											X			X			X	X		X		X																								
Shaft	OTSF	PAG	Haul Truck Surface	763	19	3							X	X	X																																					
Shaft	East/West Stockpile	NAG	Haul Truck Surface	794	40	3									X	X	X	X		X	X																															
Shaft Option#1	Hardshell Stockpile Option#1	NAG	Haul Truck Surface	272	14	3			X					X	X																					X	X		X	X		X										
Shaft Option#2	Hardshell Stockpile Option#2	NAG	Haul Truck Surface	68	4	3								X	X															X		X	X				X		X	X		X										
Flux	Fuel Station	Fuel (Diesel)	Fuel Delivery Truck	732	2	2				X				X		X								X		X		X																								
Flux	VoltaGrid Pad	Fuel CNG (self gen)	Fuel Delivery Truck	18615	51	4											X	X						X		X		X																								
Taylor Stockpile	Taylor Stockpile	Dozer	Dozer	52	1	1							X	X		X	X	X		X	X																															
Flux	Admin	Misc.	Haul Truck (On-Highway)	7300	20	3											X		X					X		X		X																								
Filtration Plant	OTSF	Tailings	Haul Truck Surface	56848	223	15					X		X																																							
Admin	Taylor Wells	Well Checks	Personnel Transport Vehicles	365	1	1								X		X	X		X													X	X	X	X																	
Trench	Trench	-	Grader	365	1	1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	
Trench	Trench	Road Water	Water Truck	8760	24	3		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																	

1. Trip origin, destination, material, vehicle, number of trips/day and trips/yr per RFI received from South32 on 07/12/2023.

Table A-38. Roads - Emission by Segments

Segment ID	Objects per Segment	PM_{10} (lbs/day) Total	PM_{10} (lbs/day) Model (g/s/object)	$PM_{2.5}$ (lbs/day) Total	$PM_{2.5}$ (lbs/day) Model (g/s/object)	$PM_{2.5}$ (tons/yr) Total	$PM_{2.5}$ (tons/yr) Model (g/s/object)	Lead (lbs/day) Total	Lead (lbs/day) Model (g/s/object)	Weighted Vehicle Height (m)
AR	4	0.51	6.67E-04	0.05	6.67E-05	0.01	5.08E-05	0.0000	6.34E-08	3.45
RB	34	37.62	5.81E-03	3.76	5.81E-04	0.50	4.26E-04	0.0036	5.52E-07	2.69
BQ	7	1.03	7.72E-04	0.10	7.72E-05	0.01	6.05E-05	0.0001	7.33E-08	3.62
BM	10	15.19	7.97E-03	1.52	7.97E-04	0.17	4.92E-04	0.0014	7.57E-07	3.86
MT	8	1.27	8.31E-04	0.13	8.31E-05	0.02	6.57E-05	0.0001	7.89E-08	3.65
BN	149	303.79	1.07E-02	30.38	1.07E-03	3.47	6.70E-04	0.0289	1.02E-06	3.44
DB	12	10.67	4.67E-03	1.07	4.67E-04	0.11	2.55E-04	0.0010	4.43E-07	2.52
DE	8	4.78	3.14E-03	0.48	3.14E-04	0.02	8.25E-05	0.0005	2.98E-07	3.26
RD	10	9.37	4.92E-03	0.94	4.92E-04	0.09	2.64E-04	0.0009	4.67E-07	2.47
RH	10	11.49	6.03E-03	1.15	6.03E-04	0.14	4.03E-04	0.0011	5.73E-07	2.74
HC	1	0.80	4.20E-03	0.08	4.20E-04	0.01	2.17E-04	0.0001	3.99E-07	3.67
FH	7	1.74	1.30E-03	0.17	1.30E-04	0.03	1.06E-04	0.0002	1.24E-07	2.86
HI	6	5.71	5.00E-03	0.57	5.00E-04	0.06	3.02E-04	0.0005	4.74E-07	2.50
JI	4	1.66	2.17E-03	0.17	2.17E-04	0.01	7.29E-05	0.0002	2.06E-07	3.70
IL	13	2.20	8.89E-04	0.22	8.89E-05	0.03	7.08E-05	0.0002	8.44E-08	3.47
IK	19	11.29	3.12E-03	1.13	3.12E-04	0.17	2.57E-04	0.0011	2.96E-07	2.48
PR	26	36.76	7.42E-03	3.68	7.42E-04	0.52	5.73E-04	0.0035	7.05E-07	2.54
OP	14	1.56	5.83E-04	0.16	5.83E-05	0.02	4.35E-05	0.0001	5.54E-08	3.65
LP	28	37.95	7.12E-03	3.80	7.12E-04	0.54	5.50E-04	0.0036	6.76E-07	2.54
LA	10	1.59	8.33E-04	0.16	8.33E-05	0.02	6.48E-05	0.0002	7.91E-08	3.68
LB	15	14.99	5.25E-03	1.50	5.25E-04	0.21	4.03E-04	0.0014	4.98E-07	2.54
LC	20	2.89	7.58E-04	0.29	7.58E-05	0.04	6.15E-05	0.0003	7.20E-08	3.65
ST	19	7.28	2.01E-03	0.73	2.01E-04	0.09	1.41E-04	0.0007	1.91E-07	2.97
TU	9	0.76	4.43E-04	0.08	4.43E-05	0.01	3.50E-05	0.0001	4.21E-08	3.68
BP	15	6.62	2.32E-03	0.66	2.32E-04	0.08	1.62E-04	0.0006	2.20E-07	2.96
TP	21	7.69	1.92E-03	0.77	1.92E-04	0.10	1.35E-04	0.0007	1.83E-07	2.96
TV	25	4.05	8.50E-04	0.40	8.50E-05	0.06	6.93E-05	0.0004	8.07E-08	3.62
DP	29	3.70	6.70E-04	0.37	6.70E-05	0.06	5.46E-05	0.0004	6.36E-08	3.62
RS	10	9.38	4.92E-03	0.94	4.92E-04	0.12	3.58E-04	0.0009	4.68E-07	2.70
SV	22	24.35	5.81E-03	2.44	5.81E-04	0.32	4.15E-04	0.0023	5.52E-07	2.67
VC	1	0.15	8.09E-04	0.02	8.09E-05	0.00	5.89E-05	0.0000	7.68E-08	3.71
VB	12	16.38	7.17E-03	1.64	7.17E-04	0.22	5.17E-04	0.0016	6.81E-07	2.67
VD	26	29.33	5.92E-03	2.93	5.92E-04	0.39	4.28E-04	0.0028	5.62E-07	2.79
VW	6	8.17	7.15E-03	0.82	7.15E-04	0.12	5.57E-04	0.0008	6.79E-07	2.79
VX	35	9.08	1.36E-03	0.91	1.36E-04	0.08	6.54E-05	0.0009	1.29E-07	3.69
WY	5	4.46	4.68E-03	0.45	4.68E-04	0.06	3.72E-04	0.0004	4.45E-07	2.65
WX	6	1.52	1.33E-03	0.15	1.33E-04	0.02	9.98E-05	0.0001	1.26E-07	3.58
XB	42	5.07	6.33E-04	0.51	6.33E-05	0.07	4.58E-05	0.0005	6.02E-08	3.52
BC	3	0.30	5.30E-04	0.03	5.30E-05	0.00	3.93E-05	0.0000	5.03E-08	3.57
BZ	41	4.15	5.31E-04	0.41	5.31E-05	0.06	4.13E-05	0.0004	5.04E-08	3.65
ZA	2	0.25	6.55E-04	0.02	6.55E-05	0.00	5.17E-05	0.0000	6.22E-08	3.69
ZY	41	4.15	5.31E-04	0.41	5.31E-05	0.06	4.07E-05	0.0004	5.04E-08	3.62
VA	3	0.50	8.71E-04	0.05	8.71E-05	0.01	7.23E-05	0.0000	8.27E-08	3.65
XA	10	1.51	7.91E-04	0.15	7.91E-05	0.02	6.56E-05	0.0001	7.51E-08	3.65
YA	11	1.54	7.37E-04	0.15	7.37E-05	0.02	6.11E-05	0.0001	7.00E-08	3.65

APPENDIX B. REFERENCES

Disha Gadre

From: Korby Bracken <korby.bracken@voltagrid.com>
Sent: Monday, December 18, 2023 4:57 PM
To: Disha Gadre
Cc: Richman, Sarah; Eric Hiser; MaryAnn Ishak; Gutierrez, Sebastian; Naima Valentin; Tom Pederson
Subject: RE: Catalytic Oxidation on Organic Compounds

Follow Up Flag: Follow up
Flag Status: Flagged

Disha,

As the gas phase methanol passes through the catalyst bed it will also be oxidized.

In addition – the fuel gas utilized in these engines is residue gas – clean and dry methane and ethane. It has been processed by a plant to remove longer chain hydrocarbons via refrigeration or cryogenic processing. Those plants also remove other constituents in the gas so it can be used in homes. Field gas or raw field gas, which is the fuel source for a vast majority of field compression is comprised of many hydrocarbon species which will give the array of combustion byproducts listed in AP-42. In fact, we should see very little VOC in the exhaust gas due to the fuel gas used.

A 95% destruction efficiency is certainly achievable as we have seen 99.6% across the oxidation catalyst from testing.

Korby Bracken, P.E.
Senior Director – Health, Safety & Environment
VoltaGrid LLC

From: Disha Gadre <dgadre@trinityconsultants.com>
Sent: Monday, December 18, 2023 12:04 PM
To: Korby Bracken <korby.bracken@voltagrid.com>
Cc: Richman, Sarah <Sarah.Richman@south32.net>; Eric Hiser <ehiser@hiserjoy.com>; MaryAnn Ishak <MaryAnn.Ishak@trinityconsultants.com>; Gutierrez, Sebastian <Sebastian.Gutierrez@south32.net>; Naima Valentin <Naima.Valentin@trinityconsultants.com>; Tom Pederson <Thomas.Pederson@trinityconsultants.com>
Subject: RE: Catalytic Oxidation on Organic Compounds
Importance: High

Thanks, Korby. Could you please clarify if methanol would also be reduced by the oxidation catayst?

Best Regards,

Disha Gadre, CM
Manager of Consulting Services - Arizona
P 602.274.2900 ext 5301
M 480.740.0204

Trinity Consultants

From: Korby Bracken <korby.bracken@voltagrid.com>
Sent: Friday, December 15, 2023 9:45 AM
To: Disha Gadre <dgadre@trinityconsultants.com>
Cc: Richman, Sarah <Sarah.Richman@south32.net>; Eric Hiser <ehiser@hiserjoy.com>; MaryAnn Ishak <MaryAnn.Ishak@trinityconsultants.com>; Gutierrez, Sebastian <Sebastian.Gutierrez@south32.net>; Naima Valentin <Naima.Valentin@trinityconsultants.com>; Tom Pederson <Thomas.Pederson@trinityconsultants.com>
Subject: RE: Catalytic Oxidation on Organic Compounds

Oxidation catalysts reduce Total Hydrocarbons (THC), anything with a Carbon – Hydrogen bond, including aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylene (BTEX). Some of the elements listed below are hydrocarbons with additional elements/compounds bonded to a carbon making them halogenated, alcohols, chlorinated. Destruction efficiencies on these compounds will vary due to the bond strength and other element, chlorine for example.

The design of the catalyst is to break the Carbon – Hydrogen bond and replace it with Oxygen.

The most basic reaction is the destruction of methane: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ with the $\rightarrow$ being the oxidation reaction across the catalyst with air which provides the O_2. Oxidation of longer chain hydrocarbons (more Cs) will yield more CO_2 and water vapor.

Hope that helps – please let me know if you have any questions.

Korby Bracken, P.E.
Senior Director – Health, Safety & Environment
VoltaGrid LLC

From: Disha Gadre <dgadre@trinityconsultants.com>
Sent: Friday, December 15, 2023 9:09 AM
To: Korby Bracken <korby.bracken@voltagrid.com>
Cc: Richman, Sarah <Sarah.Richman@south32.net>; Eric Hiser <ehiser@hiserjoy.com>; MaryAnn Ishak <MaryAnn.Ishak@trinityconsultants.com>; Gutierrez, Sebastian <Sebastian.Gutierrez@south32.net>; Naima Valentin <Naima.Valentin@trinityconsultants.com>; Tom Pederson <Thomas.Pederson@trinityconsultants.com>
Subject: RE: Catalytic Oxidation on Organic Compounds

Korby,

Thanks for your email. You mention aldehydes specifically in the email below, so I wanted to get your thoughts on these HAPs listed in AP-42 Section 3.2 and whether the OxCat would reduce those as well. You can ignore the aldehydes in this list since you already answered that question.

Benzene	
Toluene	
Xylene	
1,3-Butadiene	
Formaldehyde	
Acetaldehyde	
Acrolein	
Naphthalene	
1,1,2,2-Tetrachloroethan e	
1,1,2-Trichloroethane	
1,3-Dichloropropene	
2-Methylnaphthalene	
2,2,4-Trimethylpentane	
Biphenyl	
Carbon Tetrachloride	
Chlorobenzene	
Chloroform	
Ethylbenzene	
Ethylene Dibromide	
Methanol	
Methylene Chloride	
Hexane	
PAH	
Phenol	
Tetrachloroethane	
Vinyl Chloride	

Best Regards,

Disha Gadre, CM
Manager of Consulting Services - Arizona
P 602.274.2900 ext 5301
M 480.740.0204

Trinity Consultants

From: Richman, Sarah <Sarah.Richman@south32.net>
Sent: Friday, December 15, 2023 9:01 AM
To: Disha Gadre <dgadre@trinityconsultants.com>; MaryAnn Ishak <MaryAnn.Ishak@trinityconsultants.com>; Eric Hiser <ehiser@hiserjoy.com>
Subject: Fwd: Catalytic Oxidation on Organic Compounds

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From: Korby Bracken <korby.bracken@voltagrid.com>
Sent: Friday, December 15, 2023 8:44:55 AM
To: Gutierrez, Sebastian <Sebastian.Gutierrez@south32.net>; Richman, Sarah <Sarah.Richman@south32.net>
Cc: Les Wise <les.wise@voltagrid.com>; Justin Carlisle <justin.carlisle@voltagrid.com>
Subject: Catalytic Oxidation on Organic Compounds

Natural gas fired lean burn engines, such as the Caterpillar G3520 and Jenbacher J620, utilize precious metal coated catalysts to oxidize Total Organic Hydrocarbons (THC) in the exhaust stream to Carbon Dioxide (CO_2) and Water (H_2O). This includes Volatile Organic Compounds (VOC – C_3+) and organic Hazardous Air Pollutants (HAP) such a formaldehyde (CH_2O), acetaldehyde (CH_3CHO), and other aldehydes (R-CHO with R designating the side chain indicating the type of aldehyde).

Korby Bracken, P.E.
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VoltaGrid

Pursuant to the authority vested in California Air Resources Board by Sections 43013, 43018, 43101, 43102, 43104 and 43105 of the Health and Safety Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-19-095;

IT IS ORDERED AND RESOLVED: That the following compression-ignition engines and emission control systems produced by the manufacturer are certified as described below for use in off-road equipment. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	DISPLACEMENT (liters)	FUEL TYPE	USEFUL LIFE (hours)
2022	NCPXL18.1HTH	18.1	Diesel	8000

SPECIAL FEATURES & EMISSION CONTROL SYSTEMS	TYPICAL EQUIPMENT APPLICATION
Electronic Direct Injection, Turbocharger, Charge Air Cooler, Diesel Oxidation Catalyst, Engine Control Module, Exhaust Gas Recirculation, Periodic Trap Oxidizer, Selective Catalytic Reduction-Urea, Ammonia Oxidation Catalyst	Generator

The engine models and codes are attached.

The following are the exhaust certification standards (STD), or family emission limit(s) (FEL) as applicable, and certification levels (CERT) for non-methane hydrocarbon (NMHC), oxides of nitrogen (NOx), or non-methane hydrocarbon plus oxides of nitrogen (NMHC+NOx), carbon monoxide (CO), and particulate matter (PM) in grams per kilowatt-hour (g/kW-hr), and the opacity-of-smoke certification standards and certification levels in percent (%) during acceleration (Accel), lugging (Lug), and the peak value from either mode (Peak) for this engine family (Title 13, California Code of Regulations, (13 CCR) Section 2423):

RATED POWER CLASS	EMISSION STANDARD CATEGORY		EXHAUST (g/kw-hr)					OPACITY (%)		
			NMHC	NOx	NMHC+NOx	CO	PM	ACCEL	LUG	PEAK
560kW≤GEN≤900kW	Tier 4 Final	**STD**	0.19	0.67	N/A	3.5	0.03	N/A	N/A	N/A
		FEL	N/A	N/A	--	N/A	0.01	N/A	N/A	N/A
		CERT	0.02	0.10	--	0.01	0.01	--	--	--

BE IT FURTHER RESOLVED: That the family emission limit(s) (FEL) is an emission level declared by the manufacturer for use in any averaging, banking and trading program and in lieu of an emission standard for certification. It serves as the applicable emission standard for determining compliance of any engine within this engine family under 13 CCR Sections 2423 and 2427.

BE IT FURTHER RESOLVED: That for the listed engine models, the manufacturer has submitted the information and materials to demonstrate certification compliance with 13 CCR Section 2424 (emission control labels), and 13 CCR Sections 2425 and 2426 (emission control system warranty).

Engines certified under this Executive Order must conform to all applicable California emission regulations.

This Executive Order is only granted to the engine family and model-year listed above. Engines in this family that are produced for any other model-year are not covered by this Executive Order.

Executed on this 14th day of December 2021.

Allen Lyons, Chief
Emissions Certification and Compliance Division

Attachment: Engine Models **EO #:** U-R-001-0652 **Family:** NCPXL18.1HTH **Attachment Last Revised:** 11/9/2021

Model	Code	Trim	Config	Displacement	Displacement - Units	Peak Power	Peak Power - Units	Peak Power - Speed (rpm)	Peak Power - Fueling	Peak Power - Fuel Units	Peak Torque	Peak Torque - Units	Peak Torque - Speed (rpm)	Peak Torque - Fuel	Peak Torque - Fuel Units	OBD	GHG	Special	Notes
C18	Cert Test 1	NA	I6	18.13	Liters	778	horsepower	1800	273.3	lb/hr	NA	lb-ft	NA	NA	lb/hr	N/A	N/A	N/A	N/A
C18	1	NA	I6	18.13	Liters	778	horsepower	1800	273.3	lb/hr	NA	lb-ft	NA	NA	lb/hr	N/A	N/A	N/A	N/A
C18	2	NA	I6	18.13	Liters	778	horsepower	1800	273.3	lb/hr	NA	lb-ft	NA	NA	lb/hr	N/A	N/A	N/A	N/A
2806F	3	NA	I6	18.13	Liters	778	horsepower	1800	273.3	lb/hr	NA	lb-ft	NA	NA	lb/hr	N/A	N/A	N/A	N/A

Image shown may not reflect actual configuration

Standby 1000 kW
Prime 910 kW
60 Hz 1800 rpm 480V
60 Hz 1800 rpm 240V
60 Hz 1800 rpm 208V

Specifications

Frequency	Voltage	Standby kW (kVA)	Prime kW (kVA)	Speed rpm
60 Hz	480/277V	1000 (1250)	910 (1136)	1800
60 Hz	240/139V	1000 (1250)	910 (1136)	1800
60 Hz	208/120V	1000 (1250)	910 (1136)	1800

Cat® C18 Diesel Engine	Metric	Imperial (English)
Number of Cylinders	I-6, 4-Stroke-Cycle Water Cooled Diesel	
Bore	145 mm	5.7 in
Stroke	183 mm	7.2 in
Displacement	18.1 L	1106.4 in^3
Aspiration	Turbocharged Aftercooled	
Compression Ratio	14.5:1	
Engine Speed	1800 rpm	
Fuel system	MEUI	
Governor Type	ADEM™ A4 Control System	
Fuel	Requires Ultra Low Sulfur Diesel (ULSD	

Benefits & Features

Fuel/Emissions Strategy

- Meets U.S. EPA Tier 4 Final emission standards and CARB certified for non-road mobile applications at all 60 Hz ratings

Design Criteria

- Meets ISO 8528 transient response

Single-source Supplier

- Package is factory designed and production tested
- Manufactured in ISO 9001:2000 facility

Cat® C18 Diesel Engines

- Uses ACERT™ Technology
- Reliable, rugged, durable design
- Four-stroke diesel engine combines consistent performance and excellent fuel economy with minimum weight
- Electronic ADEM™ A4 engine control

Cat Clean Emissions Modules (CEM)

- Each aftertreatment module consists of Caterpillar Regeneration System (CRS), Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), and Selective Catalytic Reduction (SCR)

Diesel Exhaust Fluid (DEF) Tanks

- 25-gallon DEF tank (each) with on-tank fill and integrated pump, level sensor and heating elements
- Tanks are connected to allow engine access to all DEF.
- Electrically heated DEF lines from tank to CEM

Cat Generator

- Matched to the performance and output characteristics of Cat engines
- Single point access to accessory connections
- UL 1446 Recognized Class H insulation

Cat EMCP 4.4 Control Panel

- Fully featured power metering, protective relaying engine/generator control and monitoring
- Simple user-friendly interface and navigation Automatic set-point adjustment integrated with voltage and frequency selection

Cat Integrated Voltage Regulator (Cat IVR)

- Three-phase sensing
- Adjustable volts-per-hertz regulation
- Provides precise control, excellent block loading, and constant voltage in the normal operating range

Sound Attenuated Container

- Provides ease of transportation and protection
- Sound level is 76 dB(A) at 7 meters per SAE J1074 measured at 75% prime load

Reduced Environmental Impact

- 110% spill containment of onboard engine fluids
- Variable speed cooling fan for reduced fuel consumption and reduced sound at partial loads

Asset Monitoring and Management

- Each genset equipped with Product Link™ Generation (PLG) hardware to provide two-way communication for remote control and equipment monitoring via cellular network
- Customer-defined, equipment-based, real-time status updates and alerts
- Flexible and customer-configurable user interface
- GPS provides asset location and geo-fencing

Factory-installed Standard Equipment

Engine

- **Two (2)** Cat® C18 heavy-duty diesel engines meeting Tier 4 Final emission standards

Generator (per engine)

- Three-phase, random wound, coastal insulation protection, 0.6667 pitch, permanent magnet excited, Class H insulation
- Sized for 105°C temperature rise at 40°C ambient
- Anti-condensation heaters (240V, 1.2 kW)
- 12-lead design, with voltage changeover link board (480V)
- Cat IVR with VAR/PF control

Air Inlet (per engine)

- Heavy-duty air cleaner with precleaner, two-stage cyclonic paper with dust cup and service indicator
- Turbocharger and air-to-air aftercooler

Cat CEM (per engine)

- CEM comes with integrated CRS, DOC, DPF, and SCR and is located in separate compartment

DEF System (per engine)

- 25-gal plastic DEF tank provides capacity to meet or exceed fuel tank runtime @ 75% prime
- DEF tank is equipped with integrated pump, level sensor to display the DEF level in EMCP panel, and electrically heated lines from DEF tank to CEM
- Equipped with low and critically low-level alarms with a critically low shutdown

Charging System (per engine)

- UL Listed 240V, 20 amp battery charger, shock-mounted and enclosed in dust-proof housing
- Charging alternator; 24V-80A, heavy duty with integral regulator and belt guards
- Solar maintainer for batteries

Fuel System (per engine)

- 630-gal (2385 L) double-wall fuel tank, UL 142 and ULC 601 Listed and complies with Transport Canada requirements, 24-hour runtime @ 75% prime, internal and external fuel fill
- Fuel tanks connected by fuel transfer system with filter to allow both engines access to all fuel on-board
- Fuel cooler
- Switch operated, electric priming pump
- Auxiliary connections for customer-supplied fuel transfer system with 2-way fuel transfer valve
- Primary fuel filters (2) with integral water separator and differential pressure gauge
- Engine-mounted secondary fuel filters

Lube System (per engine)

- Pump, integral oil cooler, lube oil, filter, filler and dipstick, and oil sampling valve
- Open crankcase breather with cartridge filter
- Oil drain line with internal brass ball valve routed to connection point accessible from exterior
- 500-hour oil change intervals

Mounting System (per engine)

- Each generator set soft mounted to the heavy duty, fabricated steel base frame
- Steel base frame with tie-down eyes contains integral fuel tank Starting System
- Single electric starting motor, 24V per engine
- Each engine has dual 12V (1400 CCA) maintenance-free batteries with disconnect switch, battery rack, and cables
- UL Listed, 240V single-phase jacket water heater with thermostat and shut-off valves

Cooling

- Provides 47°C ambient capability at Prime rating and 500m
- Vertically mounted radiator with vertical air discharge from the container
- Coolant drain line with internal valve and low-level shutdown switch
- Coolant sight gauge and low-level shutdown switch
- 50/50 Extended Life Coolant

Factory-installed Standard Equipment (continued)

Containerized Module

- 40' ISO high cube container
- Sound attenuated air intake louvers and five lockable personnel doors with panic release
- Interior walls and ceilings insulated with 100 mm of acoustic paneling
- Side bus bar access door, external access load connection bus bars
- Shore power connection via distribution block connections for jacket water heater, battery charger, space heaters, generator condensate heaters, and internal duplex service receptacle
- Customer convenience panel with multiple receptacles
- External Emergency Stop pushbuttons (2)
- Duplex service receptacle (1), 120V, from generator power
- Six internal LED DC lights with one timer
- Corrosion resistant hardware and hinges
- Cat® Rental Power decals
- Painted standard Cat power module white
- External drain access to coolant, oil, and DEF fluids
- Auxiliary connections for customer-supplied fuel transfer system

Shore Power

- 240V shore power connection for jacket water heater, generator space heater, and battery charger
- Includes controls to de-energize jacket water heaters and generator space heater when the engine is running

Generator Set Controls and Protection

- EMCP 4.4 generator set mounted controller per genset
- Automatic start/stop with cooldown timer
- Generator features: 32, 32RV, 46, 50/51, 27/59, 81 O/U
- Utility Multi-function Relay (UMR) protective features: 24, 25, 27, 32, 40, 43, 46, 47, 50, 51, 51N, 59, 67, 79, 81O/U
- Multiple Genset Control Data Link (MGDL) for convenient paralleling connection
- 2000A electrically operated generator circuit breaker per genset
- 3600A feeder (tie) breaker
- Multi-mode operation (island, multi-island and utility parallel)
- Manual and automatic paralleling capability
- Metering display: voltage, current, frequency, power factor, kW, WHM, kVAR, and synchroscope

Trailer

- Two-axle, air-ride chassis with anti-lock brake system

Quality

- Factory testing of standard generator set and complete power module
- UL, NEMA, ISO, and IEEE standards
- O&M manuals
- Full manufacturer's warranty

CAT®

Technical Data

Cat® Generator	
Frame Size	LC6134G
Pitch	0.6667
No. of poles	4
Insulation.	Class H
Excitation	Static regulated brushless PM excited
Constructions	Single bearing, close coupled
Enclosure	Drip proof IP23
Temperature rise	105º C
Alignment	Pilot Shaft
Over speed capability – % of rated	125% of rated
Voltage regulator	3 phase sensing with Volts-per-Hertz
Voltage regulation	Less than ± 0.5% voltage gain
Wave form deviation	3%
Telephone Influence Factor (TIF)	Less than 50
Harmonic Distortion (THD)	Less than 5%

Cat Generator Set			
	Units	**60 Hz — Standby**	**60 Hz — Prime**
Power Rating	kW (kVA)	1000 (1250)	910 (1138)
Performance Specification			
Lubricating System Oil pan capacity	L (gal)	*74 (19.5)	*74 (19.5)
Fuel System Fuel consumption — 100% Load 75% Load 50% Load Fuel tank capacity Running time @ 75% rating	 L/hr (gal/hr) L/hr (gal/hr) L/hr (gal/hr) L (gal) Hr	 272 (71.8) 214 (56.6) 156 (41.0) 4770 (1260) 22	 252 (66.4) 198 (52.4) 144 (38.0) 4770 (1260) 24
Cooling System Ambient capability @ 500m Engine & radiator coolant capacity Engine coolant capacity	 °C (°F) L (gal) L (gal)	 47 (113) 201.4 (53.2) 53.8 (14.2)	 47 (117) 201.4 (53.2) 53.8 (14.2)
Air Requirements Combustion air flow Max dirty air cleaner restriction	 m3/min (cfm) kPa (in H2O)	 70.4 (2486) 12.4 (49.8)	 69.2 (2446) 12.4 (49.8)
Exhaust System Exhaust flow at rated Exhaust temp at rated kW – dry exhaust	 m3/min (cfm) °C (°F)	 180.4 (6370) 490 (914)	 173.4 (6126) 472 (882)
Noise Rating (with enclosure) @ 7 meters (23 feet) @ 75% rating	dB(A)	76	76

*Oil pan capacity for each engine

Technical Data (continued)

Single Unit Operation*

Genset Output	Load Factor	Diesel Consumption & Runtime			DEF Consumption & Runtime		
ekW	%	Gal/Hrs	L /Hrs	Hrs	Gal/Hrs	L /Hrs	Hrs
500	110	37.9	143.5	33	1.3	5.0	38
455	100	33.4	126.4	38	1.2	4.4	43
341	75	25.6	96.9	49	0.9	3.4	56
227	50	18.3	69.3	69	0.6	2.4	78
114	25	11.4	43.2	111	0.4	1.5	125

Dual Unit Operation**

Genset Output	Load Factor	Diesel Consumption & Runtime			DEF Consumption & Runtime		
ekW	%	Gal/Hrs	L /Hrs	Hrs	Gal/Hrs	L /Hrs	Hrs
1000	110	75.8	286.9	17	2.7	10.0	19
910	100	66.8	252.9	19	2.3	8.9	21
682	75	51.2	193.8	25	1.8	6.8	28
454	50	36.6	138.5	34	1.3	4.8	39
228	25	22.8	86.3	55	0.8	3.0	63

* Internal Fluid Transfer System is turned on.

** Load shared equally between two engines.

Dimensions and Weights				
	Length mm (in)	Width mm (in)	Height mm (in)	With Lube Oil & Coolant Kg (lb)
w/o chassis (full fluids)	12192 (480)	2438 (96)	2896 (114)	26,995 (59,513)
w/o chassis (coolant, lube oil, no fuel, no DEF)	12192 (480)	2438 (96)	2896 (114)	22,728 (50,107)
with chassis (full fluids)	12,504 (492)	2488 (98)	4100 (161)	30,349 (66,907)

HMI Exterior Controls

- Start/Stop as single unit or individual genset
- Simultaneously monitor both engines and gensets
- Displays active and logged diagnostics
- Control individual genset breakers and feeder breaker
- Allows for external operation, including start / stop, after EMCP's are placed in Auto

Modes of Operation

- Run as single unit 1140 KVA
  - 2 Generators paralleled / load sharing (2 Generators running continuously, share equal load)
  - 2 Generators paralleled / load sense load demand (1 or 2 generators running depending on size of load)
- Run as 2 separate 570 KVA units at 2 different voltages (480 or 208 VAC)

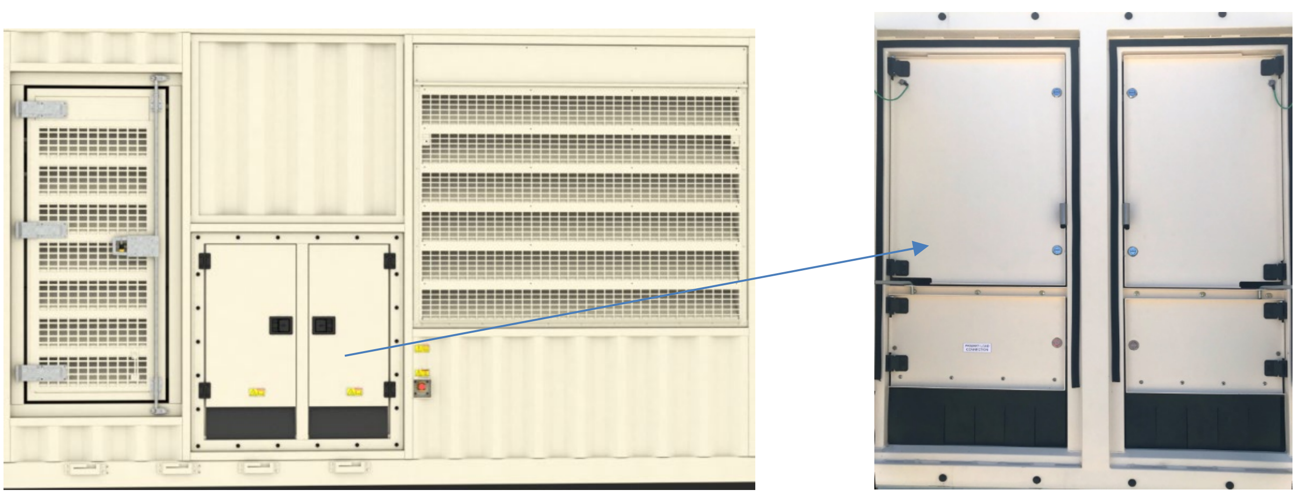
Best Battery

- Provide power to switched common equipment on power module (HMI, Ethernet Switch, Feeder breaker control, Estop circuits, Fuel Equalization system)
- Draw power equally from both genset battery systems

Circuit Breaker

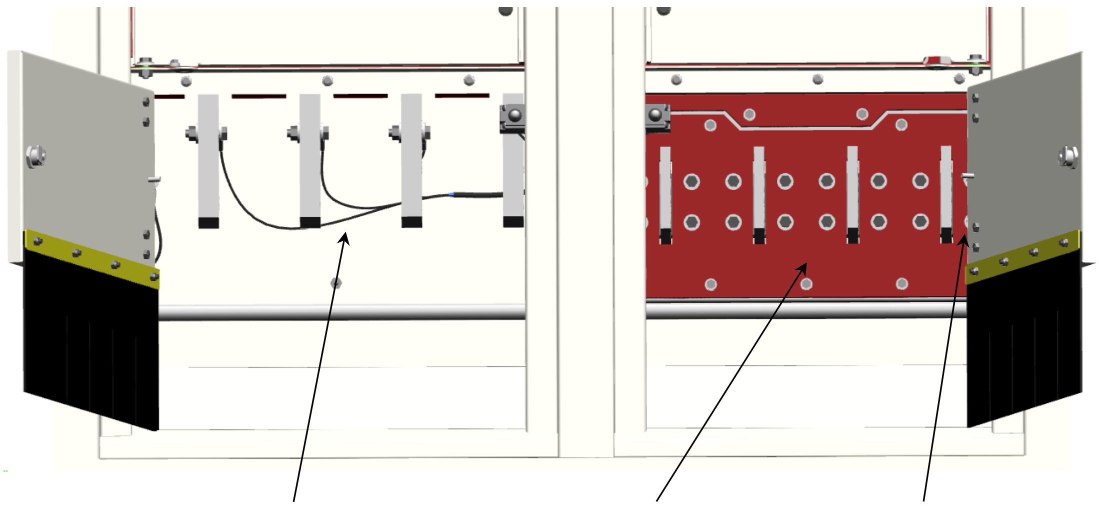
- 2000A electrically operated generator circuit breaker
- 3600A electrically operated (tie) feeder breaker

Distribution / Connection



Distribution / Connection (continued)

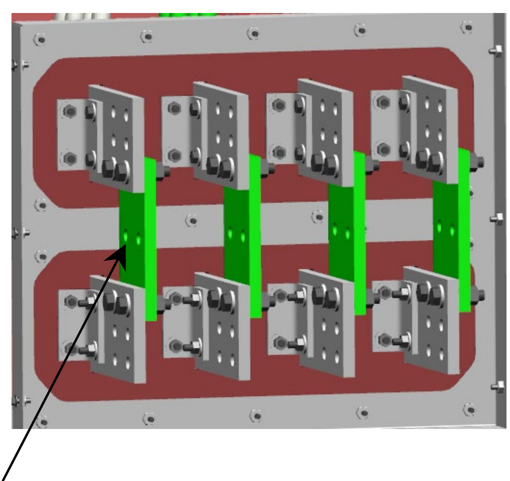
- Dual customer connections:
  - Primary connection when run as single unit 1140 KVA
  - Secondary connection when run as 2 separate 570 KVA units at 2 different voltages (busbar links need removed)

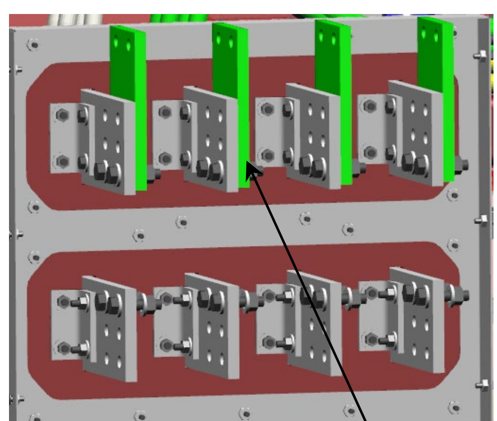


Primary Connection (1) 1140 kVA mode and connection to Front Genset in (2) 570 kVA mode

Secondary Connection to Rear Genset in (2) 570 kVA mode

Shore Power Connections





Removable buss links (1) 1140 kVA configuration

Removable buss links (2) 570 kVA configuration

Ratings Definitions and Conditions

Meets or Exceeds International Specifications: IEC60034-22, ISO3046, ISO8528, NEMA MG1-22, NEMA MG1-16, UL1004B, NEC,CEC, 2006/42/EEC, 2006/95/EC, 2004/108/EC, 2000/EC/14, UL142, Ulc601, IBC CGSB43, API 546, EGSA 101P, IEEE 43, DEFRA, UL1741, NFPA 99/110, OSHA, 97/68/EC, BS4999, BS5000, IEC60034-5.

Fuel Rates are based on fuel oil of 35° API [16°C(60°F)] gravity having an LHV of 42 780 kJ/kg(18,390 Btu/lb) when used at 29°C (85°F) and weighing 838.9 g/liter (7.001 lb/U.S. gal).
Additional ratings may be available for specific customer requirements, contact your Caterpillar representative for details.
For information regarding low sulfur fuel and biodiesel capability, consult your Cat dealer.

Ratings are based on SAE J1349 standard conditions.
These ratings also apply at ISO3046 standard conditions.

Standby – Applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings.
The generator on the generator set is peak prime rated (as defined in ISO8528 at 30°C (86°F).

Prime – Applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power.
There is no limitation on the annual hours of operation and the generator can supply 10% overload power

www.Cat.com/rentalpower

LEHX20182-01 (10/22)

XQ1140 Tier 4 Final

XQ1140 - Diesel

Specifications

UNITS: US METRIC

Generator Set

Rating Prime	910 ekW (1136 kVA)
Frequency	60 Hz
Voltage	120 - 600V
Rating Standby	1000 ekW (1250 kVA)

Engine

Engine	Cat C18
Fuel	Diesel

Dimensions

Height - Without Trailer	114 in
Length - Without Trailer	480 in
Width - Without Trailer	96 in
Weight with Lube Oil and Coolant, Without Trailer	50107 lb

Fuel Consumption

100% Load 60Hz	66.4 gal/hr
75% Load 60Hz	52.4 gal/hr
50% Load 60Hz	38 gal/hr
100% Load 60Hz	71.8 gal/hr
75% Load 60Hz	56.6 gal/hr
50% Load 60Hz	41 gal/hr

Noise rating (with enclosure)

Sound Power @ 7 meters (23 feet) @ All Ratings	76 dB(A)

Specification sheet

Rental Power 200 kW

U.S. EPA Tier IV emissions

Description

This Cummins® rental package is a fully integrated mobile power generation system, providing optimum performance, reliability, and versatility for Standby and Prime Power applications.

Features

Cummins diesel engines

- U.S. Tier IV Final and EU SIIIa certified Cummins QSB7-G9 engines which meet emissions limits without the use of a Diesel Particulate Filter (DPF)
- Dual speed engine for operation at 50 or 60 Hz
- Advanced electronic engine controls with integrated after-treatment system provide superior fuel efficiency while reducing emissions
- High-pressure common rail fuel system reduces engine noise and smoke
- Cummins Direct Flow™ air filtration offering improved air management, longer service life, and easier serviceability
- 2-stage fuel filtration with optimum particle and water separation

Control features

- The most advanced, reliable and capable generator set control system on the market today
- PowerCommand® 3.3 with Masterless Load Demand (MLD) technology enables smartly adapting power to match varying load demand. MLD capable generators allow sharing of information among paralleled generator sets.
- Controls provide precise frequency and voltage regulation, alarm and status message display in one easy to operate customer interface

Engine controls

- Oil pressure and coolant temp gauge
- Fuel level gauge, Diesel Exhaust Fluid (DEF) level gauge and battery voltage gauge
- Hour meter
- Engine control module includes remote start capability

Stamford alternators

- 12-lead reconnectable alternators fitted with voltage selection switch
- Permanent magnet excitation for improved performance in non-linear load applications

Rental package enclosure

- Camlock distribution panel
- Sound attenuated, white powder coated lockable enclosure
- 24 hour fuel tank (75% Prime) with gauge
- Roof mounted, single point lift
- Cooling system rated for 122 °F (50 °C) at 100% Standby ambient
- Complete engine fluid containment reservoir
- 4 position voltage selector switch (277/480 or 139/240 or 120/208 VAC 3 phase or 120/240 VAC 1 phase)
- Shore power (15 A/120 V) – for coolant heater and battery charger
- Conveniently located analog gauges and heated Human Machine Interface (HMI) display

Rental package options

- Optional auxiliary fuel and DEF connections
- DOT approved electric brake trailer with heavy duty center mounted jack, ball or pintle hitch
- DOT approved hydraulic brake trailer with heavy duty center mounted jack, ball or pintle hitch

		Standby rating		Prime rating			
Model	Voltages (V)	60 Hz kW (kVA)	50 Hz kW (kVA)	60 Hz kW (kVA)	50 Hz kW (kVA)	Sound level full load @ 7m	Alternator model
C200D2RE	208/240/480	200 (250)	172 (215)	180 (225)	156 (195)	73 dBA	UCDI274J

Engine specifications

Engine model	QSB7-G9
Alternator data sheet	UCDI274J (208/240/480)
Tier rating	Tier IV
Design	4 cycle, in-line, turbocharged and after-cooled
Bore	107.0 mm (4.21 in.)
Stroke	124.0 mm (4.88 in.)
Displacement	6.69 L (408 in^3)
Cylinder block	Cast iron, In-line 6 cylinder
Battery capacity	2 x 760 cca
Battery charging alternator	70 Amps
Starting voltage	24 Volt, negative ground
Fuel system	Direct injection HPCR system
Fuel filter	Dual Spin on fuel filter with water separator
Air cleaner type	2-stage, dry replaceable element with dust ejector
Lube oil filter type(s)	Single spin-on, full flow
Standard cooling system	122 °F (50 °C) ambient radiator

Alternator specifications

Design	Brushless, 4 pole, drip-proof revolving field
Stator	Double layer concentric, 2/3 winding pitch
Rotor	Singe bearing, flexible disc
Insulation system	Class H per NEMA MG1-1.65 (208/240/480 VAC)
Standard temperature rise	125/40 ºC prime (208/480 VAC)
Exciter type	PMG (Permanent Magnet Generator)
Phase rotation	A (U), B (V), C (W)
Alternator cooling	Direct drive centrifugal blower fan
AC waveform Total Harmonic Distortion	< 1.5% no load, < 5% non-distorting balance linear load
Telephone Influence Factor (TIF)	< 50 per NEMA MG1-22.43
Telephone Harmonic Factor (THF)	< 2%

Power capability specifications **(Assume power factor = 0.80 for 3 phase Amps)**

	Standby rating				
	240 V, 1 phase Amps 60 Hz	**208 V, 3 phase Amps 60 Hz**	**480 V, 3 phase Amps 60 Hz**	**240 V, 3 phase Amps 60 Hz**	**400 V, 3 phase Amps 50 Hz**
C200D2RE	558	694	301	601A	310

Electrical power panel specifications

Model voltage	**120 V duplex receptacles**	**240 V twist**	**Load lug connection (stud diameter)**	**Load lug circuit breakers**
120/480	2 - 20 Amps GFCI	3 - 50 Amps	1/2 inch	800 Amps

PowerCommand 3.3 Control System

An integrated microprocessor based generator set control system providing voltage regulation, engine protection, alternator protection, operator interface and isochronous governing. Refer to document S-1570 for more detailed information on the control.

Simplified display for rental operators – simplified display tailored for rental equipment operations for ease of use.

Masterless Load Demand (MLD) – The controller is capable of smartly managing power from paralleled generators to match varying load patterns.

Power management – Control function provides battery monitoring and testing features and smart starting control system.

Advanced control methodology – Three phase sensing, full wave rectified voltage regulation, with a PWM output for stable operation with all load types.

Regulation compliant – Prototype tested: UL, CSA and CE compliant.

Service – InPower™ PC-based service tool available for detailed diagnostics, setup, data logging and fault simulation.

Easily upgradeable – PowerCommand controls are designed with common control interfaces.

Reliable design – The control system is designed for reliable operation in harsh environment.

Operator panel features

Operator/display functions

- Displays paralleling breaker status
- Provides direct control of the paralleling breaker
- 320 x 240 pixels graphic LED backlight LCD
- Auto, manual, start, stop, fault reset and lamp test/panel lamp switches
- Alpha-numeric display with pushbuttons
- Heated HMI
- LED lamps indicating genset running, remote start, not in auto, common shutdown, common warning, manual run mode, auto mode and stop
- Paralleling control functions
- First Start Sensor System selects first genset to close to bus
- Phase Lock Loop Synchronizer with voltage matching
- Sync check relay
- Isochronous kW and kVar load sharing
- Enhanced safety features for paralleling generators
- Alternator data
- Line-to-Neutral and Line-to-Line AC volts
- 3-phase AC current
- Frequency
- kW, kVar, power factor kVA (three phase and total)
- Engine data
- DC voltage
- Lube oil pressure
- Coolant temperature
- Other data
- Fault history
- Data logging and fault simulation (requires InPower)

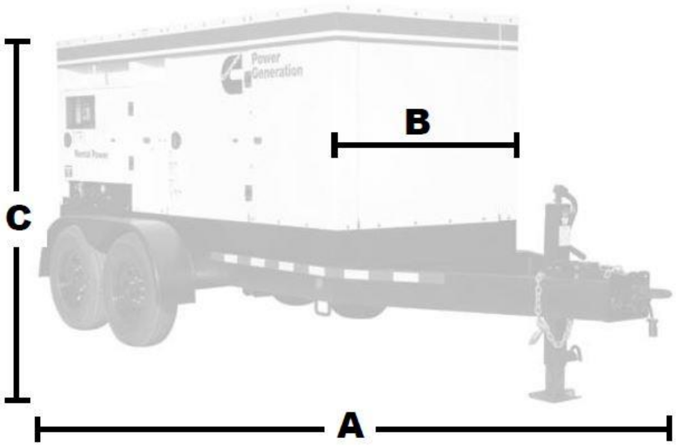
Standard control functions

- Digital governing
- Integrated digital electronic isochronous governor
- Temperature dynamic governing
- Digital voltage regulation
- Integrated digital electronic voltage regulator
- 3-phase, 4-wire Line-to-Line sensing
- Configurable torque matching
- AmpSentry AC protection
- AmpSentry protective relay
- Over current and short circuit shutdown
- Over current warning
- Single and three phase fault regulation
- Over and under voltage shutdown
- Over and under frequency shutdown
- Overload warning with alarm contact
- Reverse power and reverse Var shutdown
- Field overload shutdown
- Engine protection
- Battery voltage monitoring, protection and testing
- Overspeed shutdown
- Low oil pressure warning and shutdown
- High coolant temperature warning and shutdown
- Low coolant level warning or shutdown
- Low coolant temperature warning
- Fail to start (overcrank) shutdown
- Fail to crank shutdown
- Cranking lockout
- Sensor failure indication
- Full authority electronic engine protection
- Control functions
- Time delay start and cool down
- Real time clock for fault and event time stamping
- Cycle cranking
- Load shed
- Remote emergency stop

Ratings definitions

Standby:
Applicable for supplying emergency power for the duration of normal power interruption. No sustained overload capability is available for this rating. (Equivalent to Fuel Stop Power in accordance with ISO3046, AS2789, DIN6271 and BS5514). Nominally rated.

Prime (unlimited running time):
Applicable for supplying power in lieu of commercially purchased power. Prime Power is the maximum power available at a variable load for an unlimited number of hours. A 10% overload capability is available for limited time. (Equivalent to Prime Power in accordance with ISO8528 and Overload Power in accordance with ISO3046, AS2789, DIN6271, and BS5514).



Dimensions

Model	Dim 'A' (mm)	Dim 'B' (mm)	Dim 'C' (mm)	Set weight dry* (kg)	Set weight wet* (kg)	Fuel capacity liters (gal)
C200D2RE	3700 (146)	1450 (57)	1700 (67)	3220 (7100)	3310 (7300)	965 (255)
With trailer	5740 (226)	2140 (84)	2309 (91)	3950 (8710)	4040 (8910)	965 (255)

* Onboard DEF capacity is sized for 24 hours of operation at 15 gallons

Fuel consumption

		Standby				**Prime**				
60 Hz Ratings, kW (kVA)		200 (250)				180 (225)				**Hours of operation**
	Load	**¼**	**½**	**¾**	**Full**	**¼**	**½**	**¾**	**Full**	**75% Load**
	US Gal/hr	5.0	8.1	11.3	14.9	4.8	7.7	10.6	13.7	24
	L/hr	18.9	30.7	42.8	56.4	8.2	29.1	40.1	51.9	24

Note: DEF consumption less than 4% of fuel consumption.

Trailer information

Model	Tire size	Tire type	Load range	Number of tires per trailer	Lug pattern
C200D2RE	ST235/85R16	Radial	2755 lbs – each	4	8 hole

Certifications

These generator sets are certified to following standards:

CAN/CSA STD C22.2 NO. 100
CAN/CSA STD C22.2 NO. 14

For more information contact your local Cummins distributor or visit power.cummins.com

Our energy working for you.™

NAS-5887-EN (08/17)

Cat® C175-16

Diesel Generator Sets

Image shown may not reflect actual configuration

Bore – mm (in)	175 (6.89)
Stroke – mm (in)	220 (8.66)
Displacement – L (in^3)	84.7 (5166.88)
Compression Ratio	16.7:1
Aspiration	TA
Fuel System	EUI
Governor Type	ADEM™ A4

Standby 60 Hz ekW (kVA)	Mission Critical 60 Hz ekW (kVA)	Prime 60 Hz ekW (kVA)	Continuous 60 Hz ekW (kVA)	Emissions Performance
3000 (3750)	3000 (3750)	2725 (3406)	2500 (3125)	U.S. EPA Tier 4 Final

Features

Cat® Diesel Engine

- Meets U.S. EPA Tier 4 Final emission standards
- Reliable performance proven in thousands of applications worldwide

Generator Set Package

- Accepts 100% block load in one step and meets NFPA 110 loading requirements
- Conforms to ISO 8528-5 G3 load acceptance requirements
- Reliability verified through torsional vibration, fuel consumption, oil consumption, transient performance, and endurance testing

Alternators

- Superior motor starting capability minimizes need for oversizing generator
- Designed to match performance and output characteristics of Cat diesel engines

Cooling System

- Cooling systems available to operate in ambient temperatures up to 50°C (122°F)
- Tested to ensure proper generator set cooling

Clean Emissions Module

- Diesel oxidation catalyst for particulate matter (PM) and hydrocarbon (HC) control
- Selective catalytic reduction (SCR) for nitrogen oxides (NOx) control
- Integrated electronics for monitoring, protection, and closed loop NOx control

EMCP 4 Control Panels

- User-friendly interface and navigation
- Scalable system to meet a wide range of installation requirements
- Expansion modules and site specific programming for specific customer requirements

Warranty

- 24 months/1000-hour warranty for standby and mission critical ratings
- 12 months/unlimited hour warranty for prime and continuous ratings
- Extended service protection is available to provide extended coverage options

Worldwide Product Support

- Cat dealers have over 1,800 dealer branch stores operating in 200 countries
- Your local Cat dealer provides extensive post-sale support, including maintenance and repair agreements

Financing

- Caterpillar offers an array of financial products to help you succeed through financial service excellence
- Options include loans, finance lease, operating lease, working capital, and revolving line of credit
- Contact your local Cat dealer for availability in your region

CAT

Standard and Optional Equipment

Engine

Air Cleaner

- ❑ Single element
- ❑ Dual element

Starting

- ❑ Standard batteries
- ❑ Oversized batteries
- ❑ Standard electric starter(s)
- ❑ Dual electric starter(s)
- ❑ Air starter(s)
- ❑ Jacket water heater

Alternator

Output voltage

- ❑ 480V ❑ 6900V
- ❑ 600V ❑ 12470V
- ❑ 4160V ❑ 13200V
- ❑ 6300V ❑ 13800V
- ❑ 6600V

Temperature Rise (over 40°C ambient)

- ❑ 150°C
- ❑ 125°C/130°C
- ❑ 105°C
- ❑ 80°C

Winding type

- ❑ Form wound

Excitation

- ❑ Permanent magnet (PM)

Attachments

- ❑ Anti-condensation heater
- ❑ Stator and bearing temperature monitoring and protection

Power Termination

Type

- ❑ Bus bar
- ❑ Circuit breaker
- ❑ 4000A ❑ 5000A
- ❑ UL ❑ IEC
- ❑ 3-pole
- ❑ Electrically operated

Trip Unit

- ❑ LSI ❑ LSI-G
- ❑ LSIG-P

Control System

Controller

- ❑ EMCP 4.3
- ❑ EMCP 4.4

Attachments

- ❑ Local annunciator module
- ❑ Remote annunciator module
- ❑ Expansion I/O module
- ❑ Remote monitoring software

Charging

- ❑ Battery charger – 20A
- ❑ Battery charger – 35A
- ❑ Battery charger – 50A

Vibration Isolators

- ❑ Rubber
- ❑ Spring
- ❑ Seismic rated

Cat Connect

Connectivity

- ❑ Ethernet
- ❑ Cellular

Extended Service Options

Terms

- ❑ 2 year (prime)
- ❑ 3 year
- ❑ 5 year
- ❑ 10 year

Coverage

- ❑ Silver
- ❑ Gold
- ❑ Platinum
- ❑ Platinum Plus

Ancillary Equipment

- ❑ Automatic transfer switch (ATS)
- ❑ Paralleling switchgear
- ❑ Paralleling controls

Certifications

- ❑ CSA
- ❑ IBC seismic certification
- ❑ OSHPD pre-approval

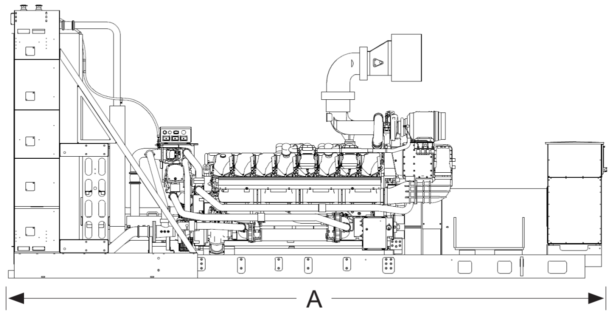
Note: *Some options may not be available on all models. Certifications may not be available with all model configurations. Consult factory for availability.*

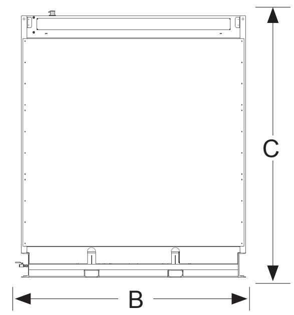
Package Performance

Performance	Standby		Mission Critical		Prime		Continuous	
Frequency	60 Hz		60 Hz		60 Hz		60 Hz	
Gen set power rating with fan	3000 ekW		3000 ekW		2725 ekW		2500 ekW	
Gen set power rating with fan @ 0.8 power factor	3750 kVA		3750 kVA		3406 kVA		3125 kVA	
Emissions	Tier 4 Final		Tier 4 Final		Tier 4 Final		Tier 4 Final	
Performance number	DM8955-05		EM0315-04		DM8956-04		DM8957-05	
Fuel Consumption								
100% load with fan – L/hr (gal/hr)	765.1	(202.1)	765.1	(202.1)	705.0	(186.2)	637.8	(168.5)
75% load with fan – L/hr (gal/hr)	596.7	(157.6)	596.7	(157.6)	558.9	(147.6)	518.0	(136.9)
50% load with fan – L/hr (gal/hr)	451.1	(119.2)	451.1	(119.2)	429.5	(113.5)	396.8	(104.8)
25% load with fan – L/hr (gal/hr)	282.7	(74.7)	282.7	(74.7)	271.2	(71.6)	251.6	(66.5)
Diesel Exhaust Fluid (DEF) Consumption								
100% load with fan – L/hr (gal/hr)	50.7	(13.4)	50.7	(13.4)	45.6	(12.0)	39.2	(10.3)
75% load with fan – L/hr (gal/hr)	30.4	(8.0)	30.4	(8.0)	25.5	(6.7)	22.1	(5.7)
50% load with fan – L/hr (gal/hr)	15.7	(4.1)	15.7	(4.1)	13.8	(3.6)	12.6	(3.2)
25% load with fan – L/hr (gal/hr)	7.4	(2.0)	7.4	(2.0)	6.9	(1.8)	6.5	(1.6)
Cooling System								
Radiator air flow restriction (system) – kPa (in. water)	0.12	(0.48)	0.12	(0.48)	0.12	(0.48)	0.12	(0.48)
Radiator air flow – m³/min (cfm)	3188	(112583)	3188	(112583)	3188	(112583)	3188	(112583)
Engine coolant capacity – L (gal)	303.5	(80.2)	303.5	(80.2)	303.5	(80.2)	303.5	(80.2)
Radiator coolant capacity – L (gal)	685.2	(181.0)	685.2	(181.0)	685.2	(181.0)	685.2	(181.0)
Total coolant capacity – L (gal)	988.7	(261.2)	988.7	(261.2)	988.7	(261.2)	988.7	(261.2)
Inlet Air								
Combustion air inlet flow rate – m³/min (cfm)	259.3	(9155.0)	259.3	(9155.0)	242.7	(8570.0)	230.5	(8138.0)
Exhaust System								
Exhaust stack gas temperature – °C (°F)	472.3	(882.2)	472.3	(882.2)	460.0	(860.0)	452.7	(846.9)
Exhaust gas flow rate – m³/min (cfm)	667.2	(23557.7)	667.2	(23557.7)	610.0	(21540.9)	570.4	(20139.6)
Exhaust system backpressure (maximum allowable) – kPa (in. water)	6.7	(27.0)	6.7	(27.0)	6.7	(27.0)	6.7	(27.0)
CEM outlet temperature – °C (°F)	465.5	(869.9)	465.5	(869.9)	451.1	(844.0)	444.0	(831.2)
Heat Rejection								
Heat rejection to jacket water – kW (Btu/min)	1373	(78075)	1373	(78075)	1229	(69901)	1125	(63972)
Heat rejection to exhaust (total) – kW (Btu/min)	3112	(176964)	3112	(176964)	2796	(159003)	2587	(147112)
Heat rejection to aftercooler – kW (Btu/min)	379	(21574)	379	(21574)	329	(18728)	296	(16810)
Heat rejection to atmosphere from engine – kW (Btu/min)	175	(9978)	175	(9978)	167	(9498)	162	(9237)
Heat rejection to atmosphere from CEM – kW (Btu/min)	53	(3026)	53	(3026)	48	(2756)	45	(2534)
Heat rejection from alternator – kW (Btu/min)	112	(6369)	112	(6369)	99	(5619)	91	(5158)

C175-16 Diesel Generator Sets
Electric Power

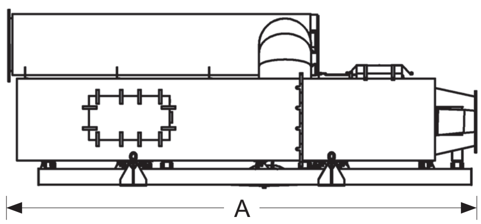
Weights and Dimensions

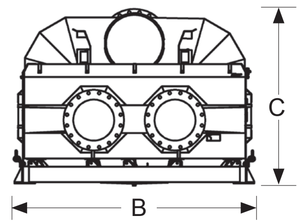




Dim "A" mm (in)	Dim "B" mm (in)	Dim "C" mm (in)	Dry Weight kg (lb)
7908 (311.4)	3118 (122.8)	3614 (142.3)	20 463 (45,114)

Note: *For reference only. Do not use for installation design. Contact your local Cat dealer for precise weights and dimensions.*





Dim "A" mm (in)	Dim "B" mm (in)	Dim "C" mm (in)	Dry Weight kg (lb)
4579 (180.3)	2361 (92.9)	1735 (68.3)	2900 (6393)

Ratings Definitions

Standby
Output available with varying load for the duration of the interruption of the normal source power. Average power output is 70% of the standby rated ekW. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year.

Mission Critical
Output available with varying load for the duration of the interruption of the normal source power. Average power output is 85% of the mission critical rated ekW. Typical peak demand up to 100% of rated ekW for up to 5% of the operating time. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year.

Prime
Output available with varying load for an unlimited time. Average power output is 70% of the prime rated ekW. Typical peak demand is 100% of prime rated ekW with 10% overload capability for emergency use for a maximum of 1 hour in 12. Overload operation cannot exceed 25 hours per year.

Continuous
Output available with non-varying load for an unlimited time. Average power output is 70-100% of the continuous rated ekW. Typical peak demand is 100% of continuous rated ekW for 100% of the operating hours.

Applicable Codes and Standards
AS 1359, CSA C22.2 No. 100-04, UL 142, UL 489, UL 869, UL 2200, IBC, IEC 60034-1, ISO 3046, ISO 8528, NEMA MG1-22, NEMA MG1-33, 2014/35/EU, 2006/42/EC, 2014/30/EU and facilitates compliance to NFPA 37, NFPA 70, NFPA 99, NFPA 110.

Note: Codes may not be available in all model configurations. Please consult your local Cat dealer for availability.

Data Center Applications
- All ratings Tier III/Tier IV compliant per Uptime Institute requirements.
- All ratings ANSI/TIA-942 compliant for Rated-1 through Rated-4 data centers.

Fuel Rates
Fuel consumption reported in accordance with ISO 3046-1, based on fuel oil of 35º API [16°C (60ºF)] gravity having an LHV of 42,780 kJ/kg (18,390 Btu/lb) when used at 15ºC (59ºF) and weighing 850 g/liter (7.0936 lbs/U.S. gal.) All fuel consumption values refer to rated engine power.

www.cat.com/electricpower

Materials and specifications are subject to change without notice.
The International System of Units (SI) is used in this publication.

Disha Gadre

From: Henkemeier, Thomas (INNIO) <thomas.henkemeier1@innio.com>
Sent: Friday, July 7, 2023 9:48 AM
To: Gutierrez, Sebastian
Cc: Richman, Sarah; Disha Gadre; Eric Hiser; Les.Wise; Nathan Ough; Kyle Gessner; Gonzalez, Gregory (INNIO); Perger, Michael (INNIO); Schrick, Carsten (INNIO)
Subject: 230707 Patagonia Jenbacher J624 Engine Post SCR Emissions Data

Follow Up Flag: Follow up
Flag Status: Flagged

Hello Sebastian,

Please find attached the emissions levels in the format requested. I have added unit load level in both KW electric and KW mechanical, and the requested Acetaldehyde values.

Emission values (as half hour average values) *):

Species	Unit	100% Load	75% Load
Load Level	KW (elec)	4481	3348
Load Level	KW (mech)	4596	3447
NOx	g/KW-hr (mech)	0.0364	0.0378
CO	g/KW-hr (mech)	0.0608	0.0608
NMNEHC (VOC)	g/KW-hr (mech)	0.0448	0.0448
CH2O	g/KW-hr (mech)	0.0152	0.0152
PM2.5 / PM10 ***)	g/KW-hr (mech)	0.0152	0.0152
Acetaldehyde	g/KW-hr (mech)	0.0030	0.0030

***) PM10 and PM2.5 are by experience at engine out nearly identical. Values refers to fuel with no impurities and particle free combustion air. Note Condensable Particles are excluded.

If you have any questions, please contact me.

Thomas Henkemeier
Project Development and Applications Engineering

JENBACHER
INNIO

Mobile: +1.346.273.6788
Email: Thomas.henkemeier1@innio.com

camfil
AIR POLLUTION CONTROL

Cartridge Filter Media Emission Statement

Camfil Air Pollution Control offers a wide variety of filtration media to meet our customers' air filtration requirements. The experience used to arrive at these values include in-house lab testing, thirty party testing, and in-field stack tests on a variety of dust types. Air filtration requirements vary by country, state, county, application or company standards. Guaranteed emission levels as discussed here are particles released after passing through a dust collection system's primary filter cartridge. Stack tests on a set of cartridge filters should be conducted after a minimum of 100 hours and prior to a maximum of 2000 hours of normal operation.

Media Grades	Emission Level	
Standard Media -Green, Carbon Impregnated, Flame Retardant	.005 gr/dscf	11.4 mg/m^3
eXtreme Media -Green, Carbon Impregnated, Flame Retardant	.001 gr/dscf	2.3 mg/m^3
Spunbond Media -Standard, Aluminized, Oleophobic	.005 gr/dscf	11.4 mg/m^3
Specialty Media -Flame retardant/PTFE	.00005 gr/dscf	.114 mg/m^3
Spunbond Media -PTFE	.00005 gr/dscf	.114 mg/m^3
Meltblown Media -High Efficiency	.002 gr/dscf	4.6 mg/m^3

Emission level refers to PM10 (10 micron and below) particulate.

To discuss media grade selection, establishing lower emission levels than stated above or adding secondary filtration please contact your Camfil representative.

Randi Huckaby

Product Manager- Dry Filtration APC Global

Camfil
Air Pollution Control
3505 Airport Road
Jonesboro, AR 72401
Tel 870 933-8048
Fax 870 933-8381
www.camfilapc.com

Dyno Nobel

Dyno Nobel Inc.
6440 S Millrock Drive, Suite 150
Salt Lake City, UT 84121
Ph: 800.473.2675
dynonobel.com

Seth Fredrick
WESCO | Western Explosive Systems Co Inc
3135 S Richmond Street
Salt Lake City, UT 84106

19 August 2021

Re: Emission Factors for Dyno Nobel Titan 7000 Emulsions

Dear Seth:

The enclosed data was generated for Dyno Nobel by the U.S. Bureau of Mines many years ago and was originally shared with several customers by Don Cranney, former AN Bulk Products Explosives Technology Manager for Dyno Nobel. The product was tested using two methods, with three shots utilizing the Bichel Gauge and three shots utilizing the Crawshaw – Jones apparatus. The Bichel Gauge technique tests the open (unconfined) detonation of 200g of the product and the Crawshaw – Jones technique tests the detonation of a 300g confined charge which is more indicative of blast hole performance. Both methods detonate the test explosive in a chamber that contains all the gasses generated. The gasses are then analyzed for several species, including CO and NOx.

The data pertinent to your needs are as follows:

DYNO NOBEL TITAN 7000 RU FORMULATION

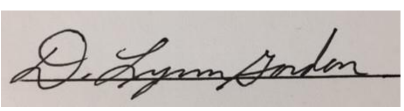
Analyte	Technique	USBM Data (ft^3/lb of explosive detonated)	Emission Factor calculated from data, lb/ton explosive
CO	Bichel Gauge	0.173 ft^3/lb @ STP (average of 3 shots)	27 lb/ton
CO	Crawshaw-Jones	0.153 ft^3/lb @ STP (average of 3 shots)	25 lb/ton
NOx	Bichel Gauge	≈0.002 ft^3/lb @ STP (average of 3 shots)	≈0.5 lb/ton
NOx	Crawshaw-Jones	≈0.00014 ft^3/lb @ STP (average of 3 shots)	<0.05 lb/ton

The data for CO are quite comparable between the two methods, while the data for NOx are more divergent. The values for NOx are so small that it may be difficult to ascribe this to anything more than normal variation in the two methods. However, theoretically it would be expected that the more confined detonation would be more efficient in preventing NOx formation. Thus, it is possible or even likely that the lower level of NOx generation indicated by the confined Crawshaw-Jones test would be more applicable to real-world blasting conditions with larger diameters and/or good confinement.

The formulation for Titan 7000 today is slightly different than it was about twenty years ago, and the Titan 7000 A formulation of interest to you is also a bit different than the standard Titan 7000 product. All current products within the Titan 7000 family (including all variations of Titan 7000, Titan 7000 SX , Titan 7000 A and Titan 7000 G) are formulated to have nearly the same oxygen balance (slightly fuel rich), the property most closely associated with the formation of CO. These products are expected to always be Fume Class 1, which has an upper limit of about 60 lbs. fumes per ton explosive.

For your purposes, a reasonable estimate absent the capability to repeat the tests using the same methodology and equipment from several decades ago is for the CO emission factor to range from about 15 up to 40 lbs. CO per ton of Titan 7000 A. The NOx emission factor for Titan 7000 A is expected to be similar to that of Titan 7000, ranging from <0.05 up to about 0.5 lbs NOx per ton explosive, depending primarily on diameter and confinement or rock conditions.

Regards,



D. Lynn Gordon
R&D Explosives Technology Manager
Ph: 385.351.2105
E: lynn.gordon@am.dynonobel.com

Nonroad Compression-Ignition Engines: Exhaust Emission Standards

	Rated Power (kW)	Tier	Model Year	NMHC (g/kW-hr)	NMHC + NOx (g/kW-hr)	NOx (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)	Smoke [a] (Percentage)	Useful Life (hours /years) [b]	Warranty Period (hours /years) [b]
Federal	kW < 8	1	2000-2004	-	10.5	-	1.0	8.0	20/15/50	3,000/5	1,500/2
		2	2005-2007	-	7.5	-	0.80	8.0			
		4	2008+	-	7.5	-	0.40 [c]	8.0			
	8 ≤ kW < 19	1	2000-2004	-	9.5	-	0.80	6.6		3,000/5	1,500/2
		2	2005-2007	-	7.5	-	0.80	6.6			
		4	2008+	-	7.5	-	0.40	6.6			
	19 ≤ kW < 37	1	1999-2003	-	9.5	-	0.80	5.5		5,000/7 [d]	3,000/5 [e]
		2	2004-2007	-	7.5	-	0.60	5.5			
		4	2008-2012	-	7.5	-	0.30	5.5			
			2013+	-	4.7	-	0.03	5.5			
	37 ≤ kW < 56	1	1998-2003	-	-	9.2	-	-		8,000/10	3,000/5
		2	2004-2007	-	7.5	-	0.40	5.0			
		3 [f]	2008-2011	-	4.7	-	0.40	5.0			
		4 (Option 1) [g]	2008-2012	-	4.7	-	0.30	5.0			
		4 (Option 2) [g]	2012	-	4.7	-	0.03	5.0			
		4	2013+	-	4.7	-	0.03	5.0			
	56 ≤ kW < 75	1	1998-2003	-	-	9.2	-	-			
		2	2004-2007	-	7.5	-	0.40	5.0			
		3	2008-2011	-	4.7	-	0.40	5.0			
		4	2012-2013 [h]	-	4.7	-	0.02	5.0			
			2014+ [i]	0.19	-	0.40	0.02	5.0			
	75 ≤ kW < 130	1	1997-2002	-	-	9.2	-	-			
		2	2003-2006	-	6.6	-	0.30	5.0			
		3	2007-2011	-	4.0	-	0.30	5.0			
		4	2012-2013 [h]	-	4.0	-	0.02	5.0			
			2014+	0.19	-	0.40	0.02	5.0			

Continued

	Rated Power (kW)	Tier	Model Year	NMHC (g/kW-hr)	NMHC + NOx (g/kW-hr	NOx (g/kW-hr	PM (g/kW-hr	CO (g/kW-hr)	Smoke [a] (Percentage)	Useful Life (hours /years) [b]	Warranty Period (hours /years) [b]
Federal	130 ≤ kW < 225	1	1996-2002	1.3 [j]	-	9.2	0.54	11.4	20/15/50	8,000/10	3,000/5
		2	2003-2005	-	6.6	-	0.20	3.5			
		3	2006-2010	-	4.0	-	0.20	3.5			
		4	2011-2013 [h]	-	4.0	-	0.02	3.5			
			2014+ [i]	0.19	-	0.40	0.02	3.5			
	225 ≤ kW < 450	1	1996-2000	1.3 [j]	-	9.2	0.54	11.4			
		2	2001-2005	-	6.4	-	0.20	3.5			
		3	2006-2010	-	4.0	-	0.20	3.5			
		4	2011-2013 [h]	-	4.0	-	0.02	3.5			
			2014+ [i]	0.19	-	0.40	0.02	3.5			
	450 ≤ kW < 560	1	1996-2001	1.3 [j]	-	9.2	0.54	11.4			
		2	2002-2005	-	6.4	-	0.20	3.5			
		3	2006-2010	-	4.0	-	0.20	3.5			
		4	2011-2013 [h]	-	4.0	-	0.02	3.5			
			2014+ [i]	0.19	-	0.40	0.02	3.5			
	560 ≤ kW < 900	1	2000-2005	1.3 [j]	-	9.2	0.54	11.4			
		2	2006-2010	-	6.4	-	0.20	3.5			
		4	2011-2014	0.40	-	3.5	0.10	3.5			
			2015+ [i]	0.19	-	3.5 [k]	0.04 [l]	3.5			
	kW > 900	1	2000-2005	1.3 [j]	-	9.2	0.54	11.4			
		2	2006-2010	-	6.4	-	0.20	3.5			
		4	2011-2014	0.40	-	3.5 [k]	0.10	3.5			
			2015+ [i]	0.19	-	3.5 [k]	0.04 [l]	3.5			

Notes on following page.

Notes:

- For Tier 1, 2, and 3 standards, exhaust emissions of nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and non-methane hydrocarbons (NMHC) are measured using the procedures in 40 Code of Federal Regulations (CFR) Part 89 Subpart E. For Tier 1, 2, and 3 standards, particulate matter (PM) exhaust emissions are measured using the California Regulations for New 1996 and Later Heavy-Duty Off-Road Diesel Cycle Engines.
- For Tier 4 standards, engines are tested for transient and steady-state exhaust emissions using the procedures in 40 CFR Part 1039 Subpart F. Transient standards do not apply to engines below 37 kilowatts (kW) before the 2013 model year, constant-speed engines, engines certified to Option 1, and engines above 560 kW.
- Tier 2 and later model naturally aspirated nonroad engines shall not discharge crankcase emissions into the atmosphere unless these emissions are permanently routed into the exhaust. This prohibition does not apply to engines using turbochargers, pumps, blowers, or superchargers.
- In lieu of the Tier 1, 2, and 3 standards for NOX, NMHC + NOX, and PM, manufacturers may elect to participate in the averaging, banking, and trading (ABT) program described in 40 CFR Part 89 Subpart C.

a Smoke emissions may not exceed 20 percent during the acceleration mode, 15 percent during the lugging mode, and 50 percent during the peaks in either mode. Smoke emission standards do not apply to single-cylinder engines, constant-speed engines, or engines certified to a PM emission standard of 0.07 grams per kilowatt-hour (g/kW-hr) or lower. Smoke emissions are measured using procedures in 40 CFR Part 86 Subpart I.

b Useful life and warranty period are expressed hours and years, whichever comes first.

c Hand-startable air-cooled direct injection engines may optionally meet a PM standard of 0.60 g/kW-hr. These engines may optionally meet Tier 2 standards through the 2009 model years. In 2010 these engines are required to meet a PM standard of 0.60 g/kW-hr.

d Useful life for constant speed engines with rated speed 3,000 revolutions per minute (rpm) or higher is 5 years or 3,000 hours, whichever comes first.

e Warranty period for constant speed engines with rated speed 3,000 rpm or higher is 2 years or 1,500 hours, whichever comes first.

f These Tier 3 standards apply only to manufacturers selecting Tier 4 Option 2. Manufacturers selecting Tier 4 Option 1 will be meeting those standards in lieu of Tier 3 standards.

g A manufacturer may certify all their engines to either Option 1 or Option 2 sets of standards starting in the indicated model year. Manufacturers selecting Option 2 must meet Tier 3 standards in the 2008-2011 model years.

h These standards are phase-out standards. Not more than 50 percent of a manufacturer's engine production is allowed to meet these standards in each model year of the phase out period. Engines not meeting these standards must meet the final Tier 4 standards.

i These standards are phased in during the indicated years. At least 50 percent of a manufacturer's engine production must meet these standards during each year of the phase in. Engines not meeting these standards must meet the applicable phase-out standards.

j For Tier 1 engines the standard is for total hydrocarbons.

k The NOx standard for generator sets is 0.67 g/kW-hr.

l The PM standard for generator sets is 0.03 g/kW-hr.

Citations: Code of Federal Regulations (CFR) citations:

- 40 CFR 89.112 = Exhaust emission standards
- 40 CFR 1039.101 = Exhaust emission standards for after 2014 model year
- 40 CFR 1039.102 = Exhaust emission standards for model year 2014 and earlier
- 40 CFR 1039 Subpart F = Exhaust emissions transient and steady state test procedures
- 40 CFR 86 Subpart I = Smoke emission test procedures
- 40 CFR 1065 = Test equipment and emissions measurement procedures

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Testing of mining explosives with regard to the content of carbon oxides and nitrogen oxides in their detonation products

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ABSTRACT

Blasting operations are a risk to the lives of mining workers. Blasting gases are particularly dangerous factors – these are the products from detonations which come from applying explosives which contain toxic nitrogen oxides and carbon monoxide. The aim of this study was the experimental determination of the composition of the blasting gases from a variety of explosives currently being produced in Poland. On the basis of research results, analysis was carried out. To perform research of the composition of blasting gases, after the detonation of explosives, a laboratory test stand was used. The study involved the determination of gaseous products, i.e. nitrogen oxides and carbon oxides. Research was carried out in accordance with research methodology based on European Directive 93/15/EEC and the harmonized standard PN-EN 13631-16. These studies provided information on the amount of harmful gaseous products from mining explosives after detonation.

1. Introduction

During detonation, explosives used in mining undergo rapid decomposition due to high temperatures and large amounts of constantly evolving gases and heat. The more gases accompanying the decomposition of explosives, the higher the pressure of the gases in the blast hole. Therefore, the results of such blasting operations are greater. Additionally, gases that evolve during the detonation process contain gaseous products which are highly hazardous, such as: carbon monoxide CO, nitrogen monoxide NO and nitrogen dioxide NO_2 (their molecular formulae are marked as NO_x). In addition to these oxides, another significant impact of blasting techniques is the release of the non-toxic gas carbon dioxide CO_2, which is the product of the final explosive transformation of explosives (Mainiero, Harris, & Rowland, 2007).

During explosive transformation, alteration of the chemical structure of the explosive takes place. Decomposition of the initial molecular structure of the explosive leads to the creation of a non-equilibrium chemical system wherein reactions occur between atoms, radicals and products of the partial decomposition of materials. The primary source of energy from explosions, using an explosive that has a typical elemental composition $C_aH_bN_cO_d$, is the energy discharged during the formation of water molecules H_2O and carbon dioxide CO_2 (Maranda, Cudziło, Nowaczewski, & Papliński, 1997; Badgujar, Talawar, Asthana, & Mahulikar, 2008).

Toxic oxides are formed during basic explosive reactions between nitrogen, oxygen and carbon. These transformations

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relate closely to the oxygen balance, which is expressed as a percentage of the difference between the amount of oxygen contained in the explosive and the amount of oxygen that is essential to complete the oxidation of carbon to carbon dioxide and hydrogen to water (Urbański, 1985; Agrawal, 2010). The oxygen balance is indicated as positive, zero or negative when the oxygen content in the explosive is, respectively, bigger than, equal to or smaller than the amount of oxygen required to complete combustion of carbon and hydrogen to carbon dioxide and water.

The chemical reactions which lead to the formation of detonation products, including carbon monoxide CO and nitrogen oxides NO_x, were discussed in literature many years ago (Szepieliev & Kustov, 1974).

Taking into account that detonation products depend both on their chemical composition and the conditions in which detonation occurs, precise information as to the composition of blasting gases can be obtained from experimental tests.

This paper presents the research of selected cartridge explosives intended for use in underground mining. For these explosives there is a requirement to determine the composition of the blasting gases that are formed after their detonation. The explosives tested were produced by a leading Polish industrial explosive company.

Firing of the prepared charges were made for each explosive selected. During the firing of the explosives, the content of nitrogen monoxide NO and nitrogen dioxide NO_2 (referred to as NO_x), carbon monoxide CO (as toxic gases) and carbon dioxide CO_2 was determined. The research results concerning the composition of blasting gases for each explosive were obtained for several different batches of production. Their mean values were compared with the boundary values of the aforementioned oxides on the basis of criteria established in Poland and other European countries.

2. Methods and material

2.1. Explosive characteristics

The research subject matter consisted of materials which belong to two groups:

- Rock explosives (ammonites, dynamites, emulsion explosives) which do not correspond to the requirements concerning mixtures of methane and/or coal dust and air as defined in the Polish standard (PN, 1997) during safety tests, special methane explosives – permitted explosives (methanite) which correspond to the requirements defined in the standard above during safety tests with a mixture of methane and/or coal dust and air.
- Tested explosives i.e. ammonites (Ammonite 1, Ammonite 2) and one methanite (Methanite 1), according to Polish classifications due to their structure and chemical composition, belong to the subgroup of ammonium - nitre powdery explosives. Dynamites (Dynamite 1, Dynamite 2, Dynamite 3, Dynamite 4), on the other hand, belong to the subgroup of nitrate ester plastic explosives. All of the explosives mentioned are varieties of explosives devoid of carcinogenic nitro compounds i.e. dinitrotoluene and trinitrotoluene.

The emulsion explosives are the most recent variety of explosives used in mining. Their basic components include oxidizing agents. The most common of which is ammonium nitrate which is also in a mixture with either sodium nitrate or calcium nitrate. Other components include fuels, water, emulsifiers, allergenic and modifying agents. Tested emulsion explosives (MWE 1, MWE 2, MWE 3) belong to the group of rock explosives. Table 1 shows the summary and characteristic of the tested explosives.

The detonators which contained 0.6 g of penthrite as a secondary charge were used to initiate the detonation of the explosives highlighted.

2.2. The research method

The determination of the composition of blasting gases was carried out in accordance with the requirements of European standard (PN-EN, 2006). The above-mentioned standard is harmonized with the directive (93/15/EEC, 1993) which specifies the blasting gases research method. However, it does not include the requirements with regards to acceptable amounts of toxic carbon monoxide CO and nitrogen oxides NO_x for 1 kg of explosive detonated. Therefore, each country applies its own rules and normative requirements in this field.

In order to carry out the determination of the composition of blasting gases, the charges were made of explosives mentioned in Section 2.1 and initiators. Charges were detonated in a blast chamber as shown in Fig. 1. The chamber consisted of classic steel mortar. The detonation of the charges was carried out on the test bench designed for

Table 1 – The summary and characteristic of the tested explosives.

Explosive	Charges diameter [mm]/mass [g]	Charge shield	Explosive structure	Type of explosive	Oxygen balance
Ammonite 1	32/125	Paper	Powdery	Rock	+1.8
Ammonite 2	32/125	Paper	Powdery	Rock	+2.9
Dynamite 1	36/450	Polyethylene	Plastic	Rock	+4.2
Dynamite 2	32/300	Paper	Plastic	Rock	+3.3
Dynamite 3	40/1000	Polyethylene	Plastic	Rock	+2.6
Dynamite 4	50/500	Polyethylene	Plastic	Rock	+8.44
MWE 1	40/750	Polyethylene	Plastic	Rock	+8.7
MWE 2	32/300	Polyethylene	Plastic	Rock	+8.65
MWE 3	40/750	Polyethylene	Plastic	Rock	−2.38
Methanite 1	32/125	Paper	Powdery	Methanoic special	+4.4

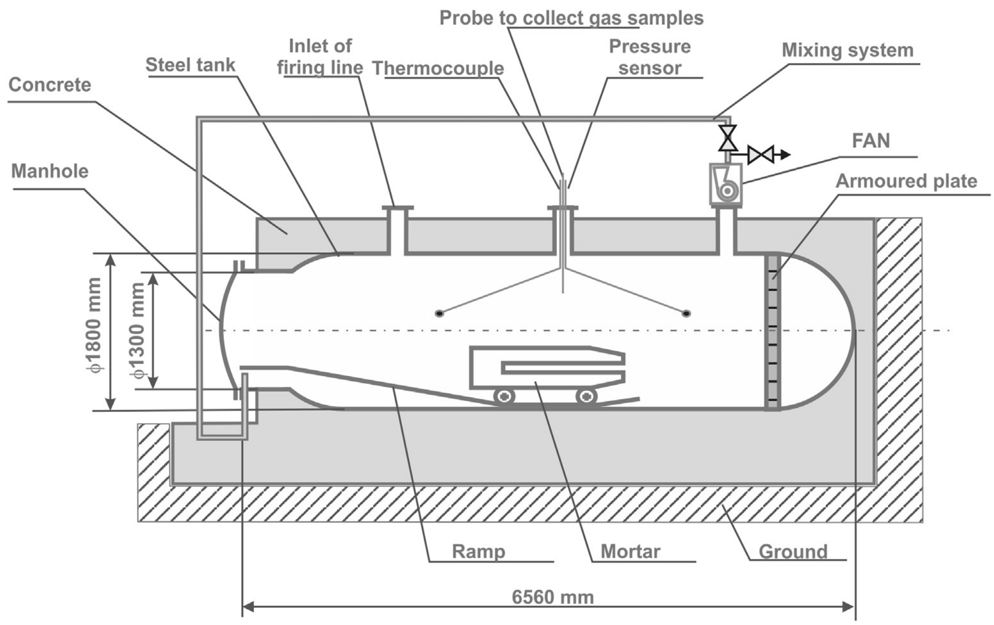


Fig. 1 – The scheme of the 15 m^3 capacity blasting chamber with circulation system.

blasting gas research, which is located in the Explosives and Detonators Research Laboratory, Experimental Mine "Barbara" at the Central Mining Institute.

An essential element of the test bench is the blasting chamber equipped with an integrated mixing and ventilation system used for atmosphere homogenization after the detonation of explosives and for the removal of detonation products after the completion of the research.

Simultaneously, when firing each explosive charge, the registration of nitrogen oxides NO_x, NO, NO_2 and carbon oxides CO, CO_2 concentrations in samples was carried out. However, samples used for analysis were taken from the mixed atmosphere in the blasting chamber, wherein gases underwent cooling and pressure underwent equalization after the explosion.

The content of oxides: NO_x, NO, NO_2, CO and CO_2 in blasting gases was measured for 20 min using two constant measurement analysers. An infrared technique was used to measure CO and CO_2 (IR analyser MIR 25 – Environnement, France) and a chemiluminescent analyser was used for NO and NO_2 (TOPAZE 32 M – Environnement, France).

3. Results and discussion

The mean concentration values of oxides: CO, CO_2, NO, NO_2, NO_x from the measurements of three detonations of each of the explosives was determined. The amount of each oxide was calculated in litres per kilogramme of explosive.

On the basis of the results of the amount of carbon monoxide CO and nitrogen oxides NO_x, relative general toxicity was estimated. This parameter presents the total amount of carbon monoxide CO and nitrogen oxides NO_x multiplied by the general toxicity factor of 6.5 (Szepieliev & Kustov, 1974).

Relative general toxicity (L_{co}) is described using the following equation:

$$L_{co} = CO + 6.5 \times NO_x \quad (1)$$

where:

CO – the amount of carbon monoxide [l/kg].

NO_x – the amount of nitrogen oxides [l/kg].

Relative general toxicity parameter estimations for blasting gases is are required in some European countries (Zawadzka-Małota & Sobala, 2007). The mean values of carbon oxides, nitrogen oxides and general relative toxicity are presented in Table 2.

Fig. 2 and Fig. 3 show the results of explosive decomposition, i.e.: carbon oxides CO, CO_2 and nitrogen oxides NO_x. Fig. 4 shows the amount of the determined toxic nitrogen oxides NO_x and carbon monoxide CO.

Fig. 4 also presents the determined nitrogen oxides NO_x and carbon monoxide CO boundary values in underground usage explosives in accordance with Polish requirements

Table 2 – The results of the determination of the composition of explosives' blasting gases – the amount of carbon oxides, nitrogen oxides and general relative toxicity.

Explosive	The amount of oxides [l/kg]					
	CO_2	CO	NO	NO_2	NO_x	$CO + 6.5 \times NO_x$
Ammonite 1	145.15	5.87	3.58	1.15	4.74	36.65
Ammonite 2	110.22	2.63	0.77	0.56	1.22	10.56
Dynamite 1	167.45	5.93	0.92	0.07	0.99	12.38
Dynamite 2	181.60	4.37	2.61	4.50	0.64	8.53
Dynamite 3	185.12	4.58	1.89	0.11	2.00	17.59
Dynamite 4	171.53	1.56	5.49	0.46	5.96	40.31
MWE 1	109.34	21.85	0.62	0.06	0.68	26.28
MWE 2	123.72	21.43	1.09	0.06	1.15	28.90
MWE 3	105.26	21.43	0.38	0.02	0.40	24.03
Methanite 1	91.85	9.29	3.69	0.16	3.86	34.35

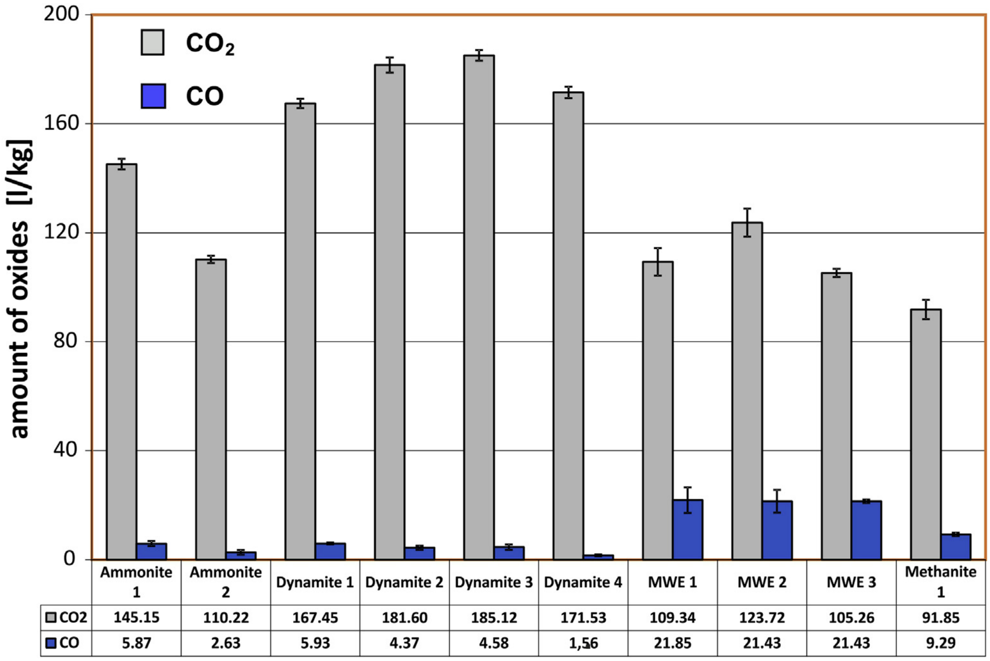


Fig. 2 – Mean values of determinate amounts of carbon oxides CO and CO_2 in explosives' blasting gases.

which amount to: 16 L of NO_x per kilogramme of explosive and 27 L of carbon monoxide CO per kilogramme of explosive (PN, 1997).

In order to assess whether the explosives researched meet the requirements of general relative toxicity parameter, which amounts to a maximum of 50 L of gas per 1 kg of explosive and is adopted in such European countries as Slovakia, the Czech Republic, Belgium and France (Zawadzka-Małota, 2008). Fig. 5 presents an estimation which is relative to the boundary value.

The data in Table 2 and Figs. 2–5 present different amounts of carbon oxides CO, CO_2 and nitrogen oxides NO, NO_2, NO_x in the detonation products of each explosive. The reason for this is different chemical compositions (also oxygen balance), chemical structures, formulation and type of explosive charge shields researched.

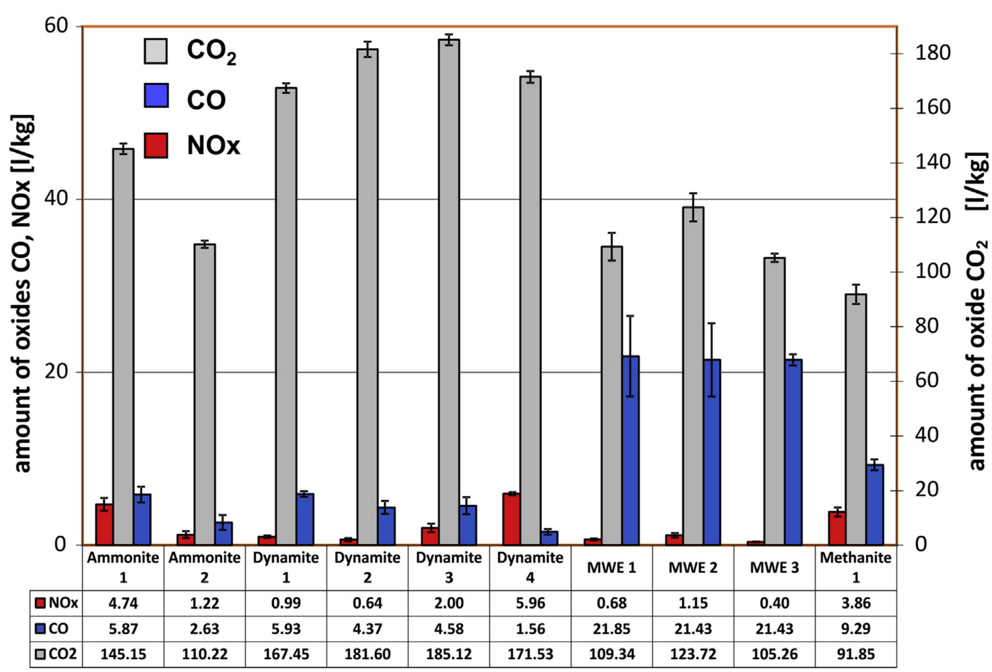
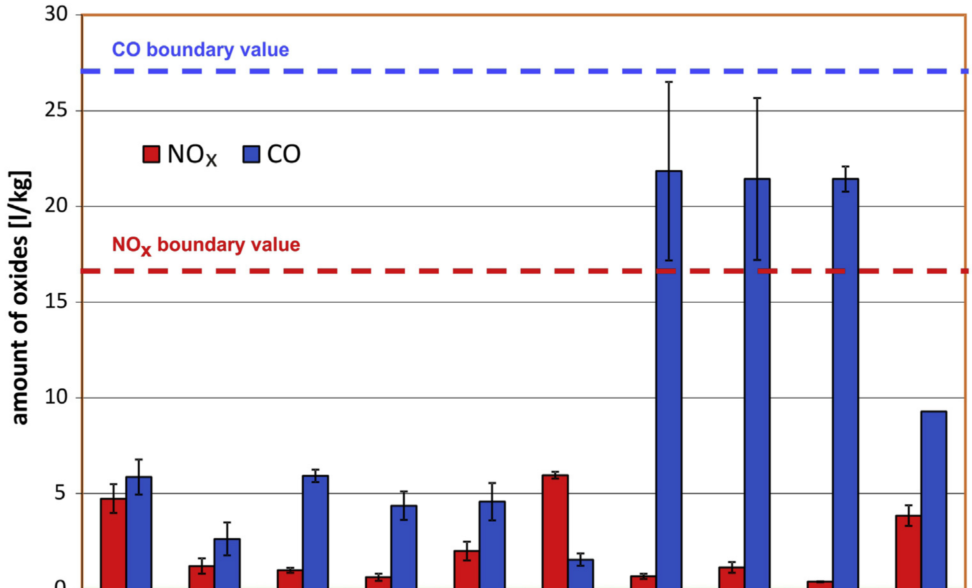


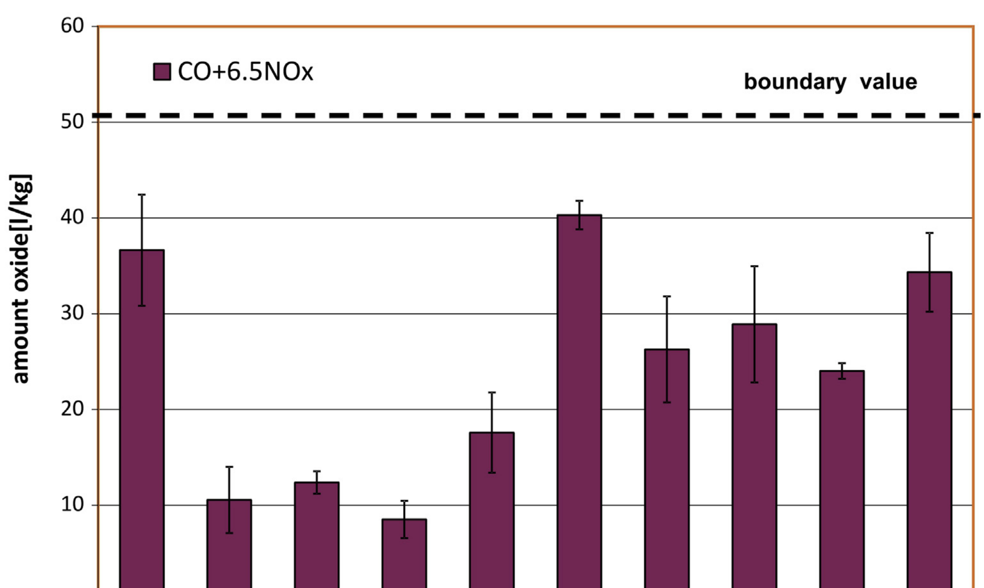
Fig. 3 – Comparison of the results of carbon oxides CO, CO_2 and nitrogen oxides NO_x presented in Table 2.



	Ammonite 1	Ammonite 2	Dynamite 1	Dynamite 2	Dynamite 3	Dynamite 4	MWE 1	MWE 2	MWE 3	Methanite 1
NOx	4.74	1.22	0.99	0.64	2.00	5.96	0.68	1.15	0.40	3.86
CO	5.87	2.63	5.93	4.37	4.58	1.56	21.85	21.43	21.43	9.29

Fig. 4 – Presentation of the mean values of carbon monoxide CO and nitrogen oxides NO_x in explosives blasting gases with regard to the boundary values required in Poland.

If the chemical reaction of a detonation led to the complete decomposition of the explosive, only nitrogen N_2, carbon dioxide CO_2, water vapour H_2O and oxygen O_2 would be present in gas products. Due to the fact that mining explosives are heterogeneous mixtures, diagnosis of the chemical processes that occur during a chemical explosion is a highly complex task. The formation of detonation products occurs under conditions of high pressures and temperatures, as well as in the cooling phase of products capable of further reactions.



	Ammonite 1	Ammonite 2	Dynamite 1	Dynamite 2	Dynamite 3	Dynamite 4	MWE 1	MWE 2	MWE 3	Methanite 1
CO+6,5NOx	36.65	10.56	12.38	8.53	17.59	40.31	26.28	28.90	24.03	34.35

Fig. 5 – General relative toxicity estimated on the basis of determinate amounts of carbon monoxide CO and nitrogen oxides NO_x in explosives' blasting gases.

4. Conclusion

By analysing the test results for the ten explosives used in Polish mining, the following conclusions were made:

Experimental determination of the quantitative and qualitative features of the composition of blasting gases provides an insight in to the course of the explosives' decomposition reaction.

The detonation products of each explosive contain toxic nitrogen oxides NO_x, toxic carbon monoxide CO and carbon dioxide CO_2.

The largest amount of carbon monoxide CO in blasting gases is typically found in emulsion explosives: MWE 1, MWE 2, MWE 3 cartridged in polyethylene. However, small amounts of toxic nitrogen oxides NO_x, occur in the detonation products of these explosives.

A significant amount of carbon dioxide CO_2, i.e. the final detonation process product, occurs in explosives' detonation products (particularly in the case of: Dynamite 1, Dynamite 2, Dynamite 3 and Dynamite 4).

None of the tested explosives exceeded the threshold of the amount of nitrogen oxides NO_x (16 L per kilogramme of explosive) or the threshold of the amount of carbon monoxide CO (27 L per kilogramme of explosive). These boundary amounts are determined by Polish requirements for explosives designed for use in underground mining.

On the basis of the estimated general relative toxicity, it can be stated that the explosives researched meet the requirements in some European countries, i.e. they do not exceed the boundary value of general relative toxicity that amounts to 50 L of gas per kilogramme of explosive.

The results of the research concerning the composition of explosives' blasting gases is highly useful in blasting operations in underground mining and surface mining as well as providing safer working conditions for employees and environmental protection.

Source of funding

The paper presents the exemplary results of laboratory tests carried out as a part of the statutory research of the Central Mining Institute (the number of the statutory research at the Central Mining Institute: 11150211-230). Financing Body: Ministry of Science and Higher Education.

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The Earth Technology Corporation®

EVALUATION OF BACKGROUND METALS CONCENTRATIONS IN ARIZONA SOILS

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June 1991

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AAS — Atomic Absorption Spectroscopy

- CVAAS — Cold Vapor AAS
- FAAS — Flame AAS
- GFAAS — Graphite Furnace AAS

ADEQ — Arizona Department of Environmental Quality

ADHS — Arizona Department of Health Services

AES — Atomic Emission Spectroscopy

- DCAAES — Direct Current Arc Atomic Emission Spectroscopy
- ICP-AES — Inductively Coupled Plasma AES
- ICP-MS — ICP-Mass Spectroscopy
- FAES — Flame AES

EP Tox — Extraction Procedure Toxicity Test

EPA — U.S. Environmental Protection Agency

EREA — Office of Emergency Response and Environmental Analysis of ADEQ, currently known as the Office of Waste Programs

GWPGL — Groundwater Protection Guidance Level

HBGL — Health-Based Guidance Level

INAA — Instrumental Neutron Activation Analysis

MCL — Maximum Contaminant Level

ORAI — Office of Risk Assessment and Investigations of ADHS

OWP — Office of Waste Programs

RCRA — Resource Conservation and Recovery Act

TCLP — Toxicity Characteristic Leaching Procedure

USGS — U.S. Geological Survey

WQARF — Water Quality Assurance Revolving Fund (Arizona)

XRFS — X-Ray Fluorescense Spectroscopy

1.0 INTRODUCTION

1.1 PROJECT SCOPE AND OBJECTIVE

The Arizona Department of Environmental Quality (ADEQ) retained The Earth Technology Corporation (Earth Technology) to a task assignment to develop a database on background metals concentrations in Arizona. "Background metals concentrations" refers to the concentrations of metals that occur naturally in the insite soil and is separate from man-made contamination. This database would then be used as a guideline for evaluating soil cleanup standards at sites where remediation of metals-contaminated soil would be required. ADEQ selected 19 metals to be addressed during this investigation: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc.

To meet the objective of the task assignment, Earth Technology divided the project into four tasks:

- o Task 1 - Initial Data Review and Definition of Sub-areas
- o Task 2 - Literature Review and Records Search
- o Task 3 - Data Evaluation and Database Generation
- o Task 4 - Review of Analytical Techniques and Methods.

A description of the activities performed during each task is provided below.

<u>Task 1 - Initial Data Review and Definition of Sub-areas</u>

During this task, Earth Technology compiled and reviewed geographic, geomorphic, soils, hydrologic, and mineralogic data for Arizona. Because large volumes of data were anticipated for this investigation, Earth Technology proposed to limit the study area to the Phoenix and Tucson urban areas. By concentrating on these areas, a comprehensive database could be developed that would more accurately reflect the range and variation of concentrations of background metals in areas where remedial activities are commonly performed. In addition, Earth Technology planned to define sub-areas within the Phoenix and Tucson areas. These sub-areas were to identify differing metal constituents and/or concentrations resulting from naturally occurring features or phenomena. The subareas identified during

Task 1 were to be further defined or modified based on the data (or lack of data) compiled during subsequent tasks. However, after conducting initial literature reviews, available information on the Phoenix and Tucson areas was found to be insufficient to use as a database, and the study area was enlarged to encompass Arizona as a whole.

Task 2 - Literature Review and Records Search

Earth Technology compiled and reviewed published literature and unpublished data, from the public and private sectors, on the background concentrations of metals in soils. The sources of information consulted during the records searches are identified and discussed in Section 2.0.

Task 3 - Data Evaluation and Database Generation

During Task 3, the compiled data were evaluated based on several criteria including two sample data sets, sample location, concentration, and analytical technique used for analysis of metals. Depth-specific analytical data were available in some locations; however, these data were not extensive enough to characterize vertical zones in the subsurface. Where appropriate, this depth-specific analytical information is reflected in the database.

Task 4 - Review of Analytical Techniques and Methods

The common analytical techniques used to assess the concentration of metals in soil were compiled and reviewed. This evaluation of analytical techniques was conducted concurrently with Task 3 to assist with the screening of data prior to its inclusion in the database. Based on this evaluation, appropriate and reliable analytical techniques for use during remedial investigations have been identified and are discussed in this document.

1.2 BACKGROUND

In 1986, the Office of Emergency Response and Environmental Analysis, currently known as the Office of Waste Programs (OWP), of ADEQ requested a set of "soil cleanup levels for metal contaminants." These data were developed by the Office of Risk Assessment and Investigations (ORAI) of the Arizona

Department of Health Services (ADHS, 1986). The risk assessment approach used to develop soil cleanup levels assumed a daily ingestion of 10 grams of soil during play or gardening. The risk assessment metal concentration was not to exceed a daily dose equivalent to the ingestion of 2-liters of water containing the drinking water maximum contaminant level for each metal (ADHS, 1986).

Using this risk assessment method, ADHS calculated a soil concentration for the 19 metals equivalent to the existing maximum contaminant level (MCL) for drinking water. To establish soil cleanup levels, the equivalent soil concentration was compared to the range of metal concentrations in natural soils as determined by Conner and Shacklette (1975) for the contiguous United States. Because it would be unreasonable to expect the cleanup level to be lower than naturally occurring metals concentrations, the ADEQ's suggested cleanup levels for most of the metals were based on the maximum concentration detected in natural soils (ADHS, 1986). The suggested 1986 soil cleanup levels derived by this process, and the associated range of concentrations reported for soils in the contiguous United States (Conner and Shacklette, 1975) are presented in Table 1-1.

ADHS (1986) emphasized that concentrations developed by the ORAI were suggested cleanup levels and consequently could not be legally enforced. ADHS suggested that situations would arise in which a health risk assessment would justify a higher concentration or require a lower concentration. In general, the suggested soil cleanup levels developed in 1986 did represent the results of a consistent analytical approach based on single risk assessment. The management approach of the cleanup levels, however, was inconsistent (i.e., levels were adjusted for laboratory detection limits and background concentrations).

In 1989, ADEQ and ORAI re-evaluated the 1986 "Suggested Cleanup Levels" for soils in order to develop a new set of guidelines. Two areas of concern were considered in developing these guidelines: (1) if contaminated soil were to be ingested, and (2) if groundwater were threatened due to contaminated soil. They concluded that two types of soil guidance levels were needed: ingestion health-based guidance levels (HBGLs) and groundwater protection guidance levels (GWPGLs). As a result, draft HBGLs (for 230 chemicals including 19 metals) were developed by ORAI and provided to ADEQ in early 1990 (Table 1-1). The HBGLs were developed using a consistent health-risk analysis methodology. These values do not take into account risk management factors such as background levels or laboratory detection limits (as was the case for the 1986 "suggested soil clean-up levels") (ADHS, 1990).

TABLE 1-1. ADHS DRAFT HEALTH-BASED CLEANUP/ GUIDANCE LEVELS FORMETALS IN SOIL

METAL	RANGE OF LEVELS IN NATURAL SOILS(a) (mg/kg)	1986 SUGGESTED SOIL CLAENUP LEVEL(b) (mg/kg)	DRAFT 1990 INGESTION HBGL(d) (mg/kg)	"WORST POSSIBLE CASE INGESTION HBGL(d) (PICA CONDTION) (mg/kg)
ALUMINUM	Not available	15	1,500	15
ANTIMONY	< 150 - 500	500	60	0.6
ARSENIC	<0.2 - 97	100	1,000	10
BARIUM	70 - 5,000	5,000	100,000	1,000
BERYLLIUM	1 - 7	10	0.14	0.0014
CADMIUM	1 - 10	10	100	1
CHROMIUM	3 - 1,500	1,500	2,000	20
COBALT	3 - 50	50	14	0.14
COPPER	2 - 300	300	26,000	260
LEAD	<7 - 700	700	400	4
MERCURY	<0.01 - 4.6	5	40	0.4
MOLYBDENUM	<3 - 7	15	1,400	14
NICKEL	<3 - 700	700	2,000	20
SELENIUM	<0.1 - 4.3	10	900	9
SILVER	<0.5 - 5	10	1,000	10
THALLIUM	Not available	5	10	0.1
URANIUM	Not available	None listed	700	7
VANADIUM	7 - 500	500	140	1.4
ZINC	10 - 2,000	2,000	100,000	1,000

Note:
(a) Source: Conner and Shacklette, 1975. This publication was also used by California regulators to develop cleanup standards
(b) Source: ADHS, 1986
(c) HBGL = Health-based guidance level, Source: ADHS, 1990
(d) Soil ingestion health based guidance level for the "worst possible case" involving an individual prone to eating soil, such as a child with Pica.

The HBGLs represent human ingestion levels that are unlikely to result in deleterious effects during long-term exposure; they are estimated to be preventative of a toxic dose by a systemic toxicant and protective to 1 in 1 million cancer risk level for carcinogenic compounds. The HBGL values for chemical contaminants in soil are expressed in milligrams per kilogram (mg/kg) and were based on an average daily ingestion of soil during a lifetime of 70 years. The average soil ingestion values suggested by the U. S. Environmental Protection Agency (EPA) are 0.2 grams per day for children 1 to 6 years of age and 0.1 grams/day for ages 7 to 70. "Worst possible case" HBGLs (involving an individual prone to eating soil, such as a child with Pica) are 1/100 of the soil ingestion HBGL (Table 1-1). This guidance level may be most useful in areas of possible high physical exposure such as a residential area or areas used for recreational activities like parks, lakes, and playgrounds.

After the HBGL document is released in a final form, a follow-up document will be issued describing how the HBGLs will be utilized as guidance in ADEQ regulatory programs. The GWPGLs are currently being developed by ADEQ. GWPGLs will represent guidance levels in soil that are estimated to be protective of groundwater quality in the underlying aquifer.

Sources for most of the information for risk analysis were EPA data appearing in the Federal Register; EPA Health Advisories, EPA Superfund Public Health Evaluation Manual, EPA Integrated Risk Information System (IRIS), and the National Academy of Science Drinking Water and Health Series (ADHS, 1990).

2.0 REVIEW OF DATA, LITERATURE, AND ANALYTICAL TECHNIQUES

Organizations from both the public and private sectors were contacted during the initial data review and literature search. EPA publications and analytical laboratory techniques were also reviewed to compile data on analytical techniques used for detecting metals in soil. A list of the organizations contacted during this project and a summary of the literature reviewed are presented in Sections 2.1 and 2.2, respectively. Analytical techniques for analysis of metals in soil are discussed in Section 2.3.

2.1 DATA ACQUISITION

A total of 62 people were contacted in 16 public and private organizations to locate data on background concentrations of metals in Arizona soil. Although volumes of data on metals can be obtained for mining areas across Arizona, mining companies were not contacted as part of this project because: (1) the rural location of most mining operations would not be relevant to the Phoenix and Tucson metropolitan areas, and (2) the inherent bias of analytical data generated at mine sites.

The organizations contacted (except for ADEQ) and a brief description of the information obtained are listed in Table 2-1. In addition to these contacts, 9 sets of background soil data (62 samples), which included total metals analyses, were acquired from ADEQ files at the following units:

- o Resource Conservation and Recovery Act (RCRA) Compliance Unit
- o Remedial Projects Unit/Water Quality Assurance Revolving Fund (WQARF)
- o Groundwater Hydrology Section
- o Site Discovery and Hazard Evaluation Unit.

Additional background soil data were available in ADEQ records; however, the majority of these data did not include analysis for total metals concentrations.

TABLE 2-1. ORGANIZATIONS CONTACTED (Excluding ADEQ)

ORGANIZATION	LOCATION	INFORMATION OBTAINED*
Arizona Commission of Agriculture and Horticulture/ State Agricultural Laboratory	Phoenix, AZ	No data available.
Arizona Department of Geology and Mineral Technology	Tempe, AZ	No data available.
Arizona Department of Health Services	Phoenix, AZ	Connor and Shacklette, 1975
Arizona Department of Mines and Mineral Resources	Phoenix, AZ	Keith et al., 1983
Arizona Geological Survey	Tucson, AZ	Pierce, 1984, 1985 Demsey, 1988, 1989 Pearthree, et al., 1988
Arizona State Mine Inspector	Phoenix, AZ	No data available.
Arizona State University	Tempe, AZ	Pewe et al., 1976
U.S. Bureau of Land Management/ Hydrology Unit	Phoenix, AZ	No data available.
U.S. Department of Agriculture/Soil Conservation Service	Phoenix, AZ	No data available.
U.S. Forest Service/ Agriculture Department	Tucson, AZ	No data available.
U.S. Geological Survey/Geology Division	Flagstaff, AZ	No data available.
U.S. Geological Survey/ Water Resources Division	Tempe and Tucson, AZ	USGS, 1974
U.S. Soil Conservation Commission Office	Phoenix, AZ	No data available.
Northern Arizona University	Flagstaff, AZ	No data available.
University of Arizona, Soil and Water Science Department	Tucson, AZ	Soils data not made available for this report. Unknown if data contain metals concentrations for background samples.

Note: * See Section 5.0 for full citation and Section 2.2 for discussion of material.

2.2 LITERATURE REVIEW

Twenty-one documents were identified through the organizations contacted (Table 2-1), that contained data of significance to this project. Of these 21 documents, 7 were professional papers, 11 were published maps, and 3 were published books. Approximately 10 other published books were reviewed but were found not to contain clearly applicable data. A brief review of the publications used in this study follows:

Arizona Department of Health Services

Publication: "Background Geochemistry of Some Rocks, Soils, Plants, and Vegetables in the Conterminous United States" (Connor and Shacklette, 1975).

Background metals concentrations in soil for the contiguous United States. However, this publication did not contain any soils data for Arizona.

Arizona Department of Mines and Mineral Resources

Publication: "Metallic Mineral Districts and Production in Arizona" (Keith et al., 1983).

Contains a map and descriptions of the mineral districts in Arizona. Tonnage data and concentrations (in percent) of the 19 metals were compiled for each mineral district within the surface-water drainage basins of Phoenix and Tucson. These data are discussed in Section 3.0.

Arizona Geological Survey

Publication: "The Mogollon Escarpment" and "Arizona's Backbone: The Transition Zone" (Pierce, 1984, 1985).

Describes the three geomorphic (physiographic) provinces in Arizona. Both Phoenix and Tucson are within the Basin and Range Physiographic Province which includes the southern and western portions of the state.

Publications:

"Geologic Map of Pima and Santa Cruz Counties" (Wilson et al., 1960);

"Geologic Map of Maricopa County" (Wilson et al., 1957);

"Geologic Map of Quaternary and Upper Tertiary Alluvium in the Phoenix North 30' x 60' Quadrangle, Arizona" (Dempsey, 1988);

"Geologic Map of Quaternary and Upper Tertiary Deposits, Tucson, 1' x 2' Quadrangle", (Pearthree, 1988);

"Geologic Map of Quaternary and Upper Tertiary Alluvium in the Phoenix South 30' x 60' Quadrangle" (Depsey, 1989);

Publication: "Environmental Geology of the Tempe Quadrangle, Maricopa County" (Pewe et al, 1976). Geologic and geomorphic data used to define the limits of geomorphic provinces within the Phoenix and Tucson areas.

Publication: "A Geochemical Study of Alluvium Copper Deposits in Pima County, Arizona" (Huff et al., 1970).

Provides analytical results of several hundred stream sediment and soil samples over a known copper deposit.

Arizona State University Library

Publication: "Chemical Analysis of Soils and Other Surficial Materials of the Contiguous United States" (Boerngen and Shacklette, 1981).

Contains site-specific data summarized in U. S. Geological Survey (USGS) Professional Paper 1270 (Boerngen and Shacklette, 1984). The locations of the 47 samples in Arizona as well as the actual analytical data for each location are presented. The data from this publication are summarized in Section 3.1.1 and plotted on Plate 1.

Publication: "Element Concentrations in Soils and Other Surficial Materials of the Contiguous United States" (Boerngen and Shacklette, 1984).

Contains a larger sampling database than Connor and Shacklette (1975), including general analytical data for the western and eastern United States (including 47 soil samples collected in Arizona). The soil samples were analyzed for the metals specified in the task assignment except cadmium, silver, and thallium. Measured element concentrations for each specific data point were not presented in this report but are presented in USGS Open-file Report 81-197 (Boerngen and Shacklette, 1981).

Publication: "Heavy Metals in Soils" (Alloway, 1990).

Describes the analytical techniques used to identify the concentration of metals in soil, as well as key soil properties affecting the accumulation of metals in soils. This publication also contains a detailed description of the origin of each metal in soil and its chemical behavior. The discussion of analytical techniques (presented in Section 2.3) was derived from the information presented in this publication.

Publication: "Landscapes of Arizona - The Geological Story" (Smiley et al., 1984).

Describes the physiographic provinces and geomorphology of Arizona.

Publication: "The Geomorphic and Paleoclimatic Significance of Alluvial Deposits in Southern Arizona" (Melton, 1965).

Describes alluvial fan deposits within the surface-water drainage basin surrounding Tucson, Arizona.

U.S. Department of Agriculture - Soil Conservation Service

Publications:

"General Soils Maps of Pima County" (U.S. Dept. of Agriculture, 1974);

"General Soils Map of Maricopa County" (Hartman, 1973);

"Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties"; (Camp, 1986);

"Soil Survey Eastern Maricopa and Northern Pinal Counties Area" (Adams, 1974);

Maps of soils for the Phoenix and Tucson areas.

U.S. Geological Survey, Water Resources Division

Publication: "Hydrologic Unit Map - 1974, State of Arizona" (USGS, 1974).

Identifies the surface-water drainage basins in Arizona.

U.S. Environmental Protection Agency

Publication: "Test Methods for Evaluating Solid Waste" (EPA, 1986).

Provides detailed descriptions of the analytical methods recommended by EPA to assess the concentration of metals in solid waste.

2.3 SOLUTION-SAMPLE ANALYTICAL TECHNIQUES FOR ANALYSIS OF METALS IN SOILS

Atomic spectroscopic methods are the most commonly employed methods in the waste management field. These techniques use an acid dissolution of soil for total metals analysis. Two types of dissolution procedures can be performed: (1) total analysis involving dissolution of the soil sample with hydrofluoric acid (an extremely aggressive acid); or (2) pseudo-total analysis using mineral acids such as hydrochloric (HCl), nitric (HNO_3), or sulfuric acid (H_2SO_4).

Decomposition of soil samples is conducted in vessels made of polypropylene or polyethylene because hydrofluoric acid cannot be stored or used in glass vessels. The need to use pure hydrofluoric acid can be avoided by using acid vapor in an apparatus designed for this purpose. Analytical laboratories typically do not use this dissolution procedure due to the strength of the acid and procedure requirements.

The procedure most commonly used in the waste management field is pseudo-total analysis (strong acid digestion). Several mineral acids and their mixtures are used for the dissolution and extraction of elements from soils. Although the acids do not dissolve silicates or silica completely, they are vigorous enough to dissolve the heavy metals not bound to silicate phases. Most heavy metal pollutants fall into this category.

There are several atomic spectroscopic methods that involve analysis of acid-solution samples. Two main techniques, Atomic Absorption Spectroscopy (AAS) and Atomic Emission Spectroscopy (AES), are widely used for the determination of most metals. For both AAS and AES, these methods and the metals for which these analyses can be performed are briefly described below and are compared in Table 2-2. Uranium cannot be analyzed for by these techniques as it emits gama-radiation induced by neutron irradiation and is commonly detected by use of a geiger counter.

Atomic Absorption Spectroscopy (AAS)

Atomic absorption spectroscopy is based on the free atom of an element absorbing light at wave-lengths characteristic of that element and determined by its outer electronic structure. The extent of that absorption is a measure of the number of atoms in the light path. This technique provides a moderate to high degree of element specificity and is the method most widely used for assaying of ores. There are three types of AAS: Flame (FAAS), Graphite Furnace (GFAAS), and Cold Vapor (CVAAS). Conventional FAAS detection limits are in the range 1 to 200 mg/kg for total metals in soils. The technique is rapid, and sample handling, measurement, computation and printout are available in automated form.

The limitations of FAAS in sensitivity and the large dilution introduced by the expanding flame gases of the premised air/acetylene flame have been overcome by the use of graphite furnace atomic absorption (GFASS). This technique generally takes the form of a cylinder of graphite heated by the passage of an electric current through it. Because the whole sample is atomized, and because the atomic vapor produced is partly confined within the graphite tube, the sensitivity of GFAAS is 10- to 100-fold greater than that of FAAS (Alloway, 1990).

Cold vapor atomic absorption spectroscopy (CVAAS) is typically performed on a flame or graphite furnace AAS system but uses a mercury analyzer attachment in place of the flame or furnace attachments. This technique is used solely for analysis of mercury in unpolluted or polluted soils (normal graphite furnace methods are not sensitive enough for determinations of mercury in soil.) An oxidative acid digestion procedure is required to destroy organic matter and is followed by reduction of mercury compounds to elemental mercury for analysis in the vapor phase. Because mercury vapor is monatomic, an atomic absorption measurement can be made in the cold mercury vapor released from the reduced solution. The detection limit for CVAAS analysis of mercury is listed in Table 2-2 under both flame and furnace techniques because the same AAS system is used.

Table 2-2 indicates the metals for which FAAS and GFAAS analyses can be performed in accordance with the EPA (1986) SW-846 laboratory manual for analysis of solid wastes. The detection limits listed are examples of what may be attainable for each metal using these methods.

Atomic Emission Spectroscopy (AES)

With this technique, a sample solution is nebulized by an energy source such as a flame, an inductively coupled plasma, or a graphite furnace. The source acts not only to atomize the sample but also to excite the atoms to emit their characteristic spectral lines. The intensities of the emitted lines are a function of the concentration of the atoms in the exciting source and hence of the solution content. Atomic Emission Spectroscopy differs from AAS in that AES can readily provide simultaneous, very rapid, sequential, multi-element analysis of a single sample solution.

Two types of AES methods, Flame Atomic Emission Spectroscopy (FAES) and Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), are discussed below. ICP-Mass Spectroscopy (ICP-MS) is a highly precise but expensive analytical technique that is still in research stages and is not accepted as a viable analytical technique by the EPA. Therefore, this technique is not addressed in this report.

Historically, flame emission spectroscopy (FES) preceded FAES. In the 1950's and 1960's, under the name of flame photometry, FES was used to determine alkali and alkaline earth metals and a few minor elements. The use of FES has largely been replaced by AAS techniques because of better element specificity and freedom from spectral interference effects using AAS. Therefore, this method is not presented in Table 2-2.

Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) uses the emission from the flame-like plasma formed on a quartz torch by coupling a radio frequency electromagnetic field to the electrons in an ionized argon plasma. Plasma is heated by use of electrical current through the plasma. As a result of the heating and torch parameters, the plasma is shaped into a thyroidal or "donut" form. Sample aerosol is directed into the central hole of the plasma donut. Temperatures in the plasma are typically 6,500°K in the analytical measuring zone. At these high temperatures, atomization is virtually complete for most elements, and strong atomic and ionic line emissions can occur. Typical detection limits are shown on Table 2-2.

Analysis by ICP-AES is the preferred technique for most metals due to rapid multi-element analysis. However, AAS techniques are usually preferred over ICP-AES for analysis of arsenic, copper, lead, mercury, selenium, and thallium due to the lower detection limits of AAS. Detection limits for ICP-AES are generally higher than GFAAS but lower than FAAS. This is due to the fact that ICP-AES is susceptible to spectral interference caused from multi-element analysis, which results in higher detection limits than GFAAS. Higher precision of the ICP-AES gives higher detection limits than FAAS. AAS techniques involve single element analysis with longer sample preparation, handling and analysis time than with ICP-AES techniques. Thus, there is a trade-off between speed and detection limits. Unless specifically requested, most laboratories will run metals analysis by ICP-AES for most metals.

3.0 EVALUATION AND CONCLUSIONS

3.1 BACKGROUND CONCENTRATIONS OF METALS IN ARIZONA SOILS

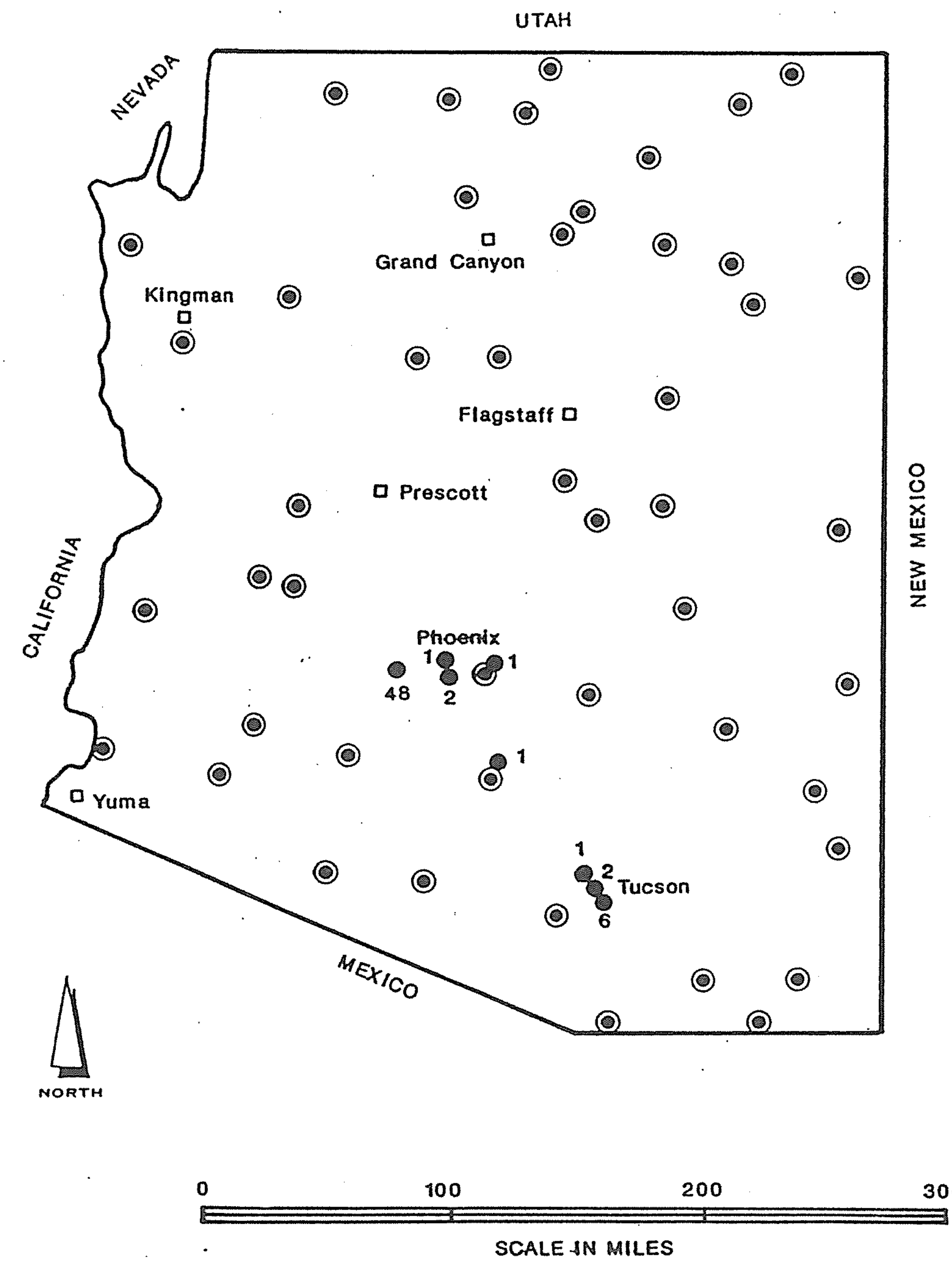
A set of statewide data containing background concentrations of metals in Arizona soil was found during the initial literature review. Other site-specific soil data were obtained during a search of available records maintained by the ADEQ. These site-specific and statewide data, however, were not extensive enough to develop a comprehensive database. Therefore, the database discussed here does not reflect the range and variation of background concentrations of metals in the Phoenix and Tucson urban areas. The database does, however, provide a broad scope of background concentrations of metals in soils that may be used as a guide for site-specific studies.

In this section, the data obtained during the initial data review and records search was evaluated. This evaluation is based on the concentration of selected metals in relation to ADHS guidance levels for metals in soil, and the sample location in relation to physiographic area. Two main sources that provided background concentrations of selected metals in Arizona soil were identified during this project: (1) a set of 47 soil samples collected and analyzed by the U.S. Geological Survey (USGS); and (2) 62 soil samples collected during various site investigations and obtained from records maintained by ADEQ.

3.1.1 USGS Data

The approximate locations of the 47 USGS soil sampling sites are shown in Figure 3-1 and on Plate 1 and are listed in Appendix A (Borengen and Shacklette, 1981). The samples were collected by USGS personnel at approximate 50-mile intervals along routes of travel from one field area to another. Borengen and Shacklette noted that, if possible, the sampling sites were selected to represent surficial materials that were minimally altered from their natural condition. The authors noted that, in practice, this site selection procedure necessitated the collection of samples away from roadcuts and fills. The materials sampled included soil, beach and dune sands, and stone lithosols. Most samples were collected at a depth of about 8 inches to avoid the effects of surface contamination.

The 47 soil samples collected by the USGS were obtained and analysed sometime during a 14-year period from 1961 to 1975. The methods of analysis used by the USGS to determine the concentration of selected metals in the soil samples were as follows:



EXPLANATION:

◎ Approximate Locations of USGS Soil samples (One sample collected per site)

● 48 Approximate Locations of ADEQ Soil Samples, Showing Number of Samples Taken at Each Location

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APPROXIMATE LOCATION OF USGS AND ADEQ SOIL SAMPLES

Figure 3-1

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- o FAAS: mercury and zinc
- o GFAAS: mercury
- o X-Ray Fluorescence Spectroscopy (XRFS): selenium and silver
- o Direct-current Arc Atomic Emission Spectroscopy (DCAAES): aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, thallium, and vanadium.

Unlike the solution-sample analytical techniques of FAAS and GFAAS, XRFS and DCAAES use a solid-sample and differ in the method used to prepare samples and quantify elements. XRFS and DCAAES are not used in the wastemanagement field because of poor resolution and sensitivity and are only suitable as a qualitative technique rather than a quantitative technique. The methods of analysis used for some elements were changed to FAAS and GFAAS during the course of the USGS study.

The analytical results for these samples are provided in Appendix A. From these data, the average, standard deviation, maximum, and minimum concentrations of metals were calculated and are shown in Table 3-1. The USGS soil samples represent a broad coverage for the state and may be representative of what metals concentrations might be for the state as a whole.

3.1.2 ADEQ Data

The approximate locations of the 62 ADEQ soil samples are shown on Figure 3-1 and are identified on Plate 1 as 48a through 48f, 49 through 55, 56a through 61h, and 62. These samples were specifically noted as background samples in the investigations and were obtained from 10 sites removed from known site contamination. The depth of sample acquisition ranged from 0.25 feet to 9 feet below ground surface. The location of, and analytical results for, these samples are provided in Appendix B. The average, standard deviation, maximum, and minimum concentrations of metals for the ADEQ samples are also shown on Table 3-1. In general, the metals concentrations for ADEQ samples are below those of the USGS samples. The ADEQ samples are from the greater Phoenix and Tucson areas and may be representative of what metals concentrations might be for these areas. These data sets represent the best available sources of background data without conducting a state-wide soil sampling and analysis program.

TABLE 3-1. CONCENTRATIONS OF SELECTED METALS DETECTED IN USGS AND ADEQ SOIL SAMPLES FROM ARIZONA3.33

METAL	ADEQ GUIDANCE LEVELS(a)		USGS SOIL SAMPLES(c) CONCENTRATIONS OF METALS				ADEQ SOIL SAMPLES CONCENTRATIONS OF METAL			
	DRAFT 1990 INGESTION HBGL(mg/kg)	"WORST POSS-IBLE CASE INGESTION HBGL(b)(mg/kg)	AVERAGE (mg/kg)	STANDARD DEVIATION (mg/kg)	MAXIMUM (mg/kg)	MINIMUM (mg/kg)	AVERAGE (mg/kg)	STANDARD DEVIATION (mg/kg)	MAXIMUM (mg/kg)	MINIMUM (mg/kg)
ALUMINUM	1,500	15	55,213	28,246	100,000	30,000	10.654	2,859	16,817	6,200
ANTIMONY	60	0.6	<1	0	<1	<1	1.7	1.81	3.8	<0.4
ARSENIC	1,000	10	9.8	17.2	97	1.4	9.4	3.8	24	3.1
BARIUM	100,000	1,000	565	269.7	1,500	200	161.3	30.5	230	72.6
BERYLLIUM	0.14	0.0014	0.52	1.01	5	ND	1.1	0.9	2.0	0.3
CADMIUM	100	1	–	–	–	–	0.4	0.4	1.7	ND
CHROMIUM	2,000	20	61.3	66	300	5	17.5	7.0	34	5.4
COBALT	14	0.14	9.7	6.3	30	ND	–	–	–	–
COPPER	26,000	260	30	30.5	200	5	16.6	5.9	27	6.0
LEAD	400	4	23.4	20.7	100	ND	7.7	4.8	24.5	ND
MERCURY	40	0.4	0.10	0.13	0.57	0.01	0.05	0.2	0.25	ND
MOLYBDENUM	1,400	14	3.0	2.8	3.0	ND	–	–	–	–
NICKEL	2,000	20	27.5	30.5	150	ND	18.2	5.3	28	9.2
SELENIUM	900	9	0.30	0.26	1.6	<0.1	0.6	0.3	1.0	<0.4
SILVER	1,000	10	–	–	–	–	0.5	0.4	0.8	<0.05
THALLIUM	10	0.1	–	–	–	–	0.7	0.4	<1.0	0.5
URANIUM	700	7	2.1	1.0	3.4	1.1	–	–	–	–
VANADIUM	140	1.4	71.3	46.4	300	10	12	16.7	23.8	<0.2
ZINC	100,000	1,000	62.1	34	150	12	38.9	16.4	81	15

Notes:

(a) ADHS, 1990
(b) HBGL = Health-based guidance level (ADHS, 1990)
(c) Borengen and Shacklette, 1991
ND = None detected
– = No data available.

3.1.3 ADEQ Guidance Levels

The USGS and ADEQ analytical data were compared with the ADEQ soil ingestion HBGLs to evaluate the differences between the two sets of analytical data and the HBGLs. For instance, the average and maximum concentrations of aluminum and beryllium in these two data sets (USGS and ADEQ) exceed the ADEQ ingestion HBGLs. The USGS maximum for cobalt and vanadium also exceeds the ingestion HBGLs. The following sections evaluate the USGS and ADEQ analytical results with respect to the draft soil ingestion HBGLs.

Soil Ingestion-Health Based Guidance Levels

As shown on Table 3-1, the draft ADEQ soil ingestion HBGL for aluminum (1,500 mg/kg) is 36 times less than the USGS average of 55,213 mg/kg and is 7 times less the average value for ADEQ samples. Based on these data, soil background levels for aluminum may exceed the draft HBGL throughout most, if not all of the state. The USGS average concentrations for beryllium and USGS maximum concentrations for cobalt and vanadium also exceed the ADEQ ingestion HBGLs. The ADEQ will need to be especially cognizant of these situations during their development of guidelines and will need to evaluate how the HBGLs will be used in ADEQ programs.

Concentrations for the remaining metals (Table 3-1) are below the ingestion HBGLs proposed by ADEQ. If the background metals concentrations are compared with HBGLs that are appropriate for the Pica condition ("worst possible case"), many other metals are found to exceed the HBGL. HBGLs represent concentrations of total metals in soil that are protective of human health. Therefore, in order to evaluate how metals concentrations in a soil compare to the HBGLs, a total metals analysis must be conducted. This should be done on both background samples as well as cleanup verification samples. The most appropriate total metals test that should be used for this comparison is discussed in Section 4.2.

Development of Groundwater Protection Guidance Levels

In addition to the HBGLs, ADEQ intends to develop a separate set of values for soil to protect groundwater quality in the underlying aquifer (ADHS, 1990). These Groundwater Protection Guidance Levels (GWPGLs) will take into account the leachability of metals from soil to groundwater. Therefore, a leachability test must be adopted to standardize comparisons with the GWPGLs. Several standard leach tests have been developed, such as the Toxicity Characteristic Leaching Procedure (TCLP), California Waste Extraction Procedure, Equilibrium Leach Test, and Synthetic Precipitation Leach Test for soils. The Extraction Procedure Toxicity Test (EP Tox) is being replaced by the TCLP and should not be considered as the standard. The results of the leachability test must always be compared to the GWPGLs to ensure that the test is appropriate for the specific geologic and hydrologic site conditions. In order to properly develop the site-specific data for comparison to the GWPGLs, background samples as well as clean-up-verification samples should be analyzed.

3.2 CORRELATING BACKGROUND METALS CONCENTRATIONS WITH PHYSIOGRAPHIC, GEOLOGIC, AND HYDROLOGIC FEATURES

One objective of this study was to evaluate whether background metals concentrations in soils correlate with physiographic province, geomorphology, surface water basins, and/or geochemistry. The hypothesis is that if once a landform, such as an alluvial fan, is delineated and the origin of the parent material identified, then the geochemistry of the soil should resemble that of the parent material. In undisturbed soils, this correlation could be conceivably performed for any size landform. This correlation will be most accurate when dealing with in-situ soils that have gone through minimal weathering and transport (i.e., soil on a mountain slope). Based on the existing statewide USGS database, an attempt was made to correlate metals concentrations to physiographic province. The results of this correlation are discussed below. Plate 1 shows the relationship of both USGS and ADEQ samples to the three physiographic provinces (Basin and Range, Transition Zone, Colorado Plateau) in Arizona.

The available physiographic and geomorphic landform data were sufficient for Tucson, but data for major sections of east Phoenix were not available. Data sources mainly consisted of maps identifying geologic features related to stream sediments, river terraces, alluvial fans, and exposed bedrock. (These maps are identified in Section 2.2 of this report). Background data (on metals concentrations in these soils) that are needed to define these finite subareas are simply not available. However, some correlations between metals concentrations in USGS soil samples and selected mineral districts can be made on a local basis. This correlation is discussed below.

USGS samples 1 through 4, 8 through 11, 13 through 18, and 32 through 36 are all located within the limits of the Colorado Plateau (Plate 1). Colorado Plateau mineral deposits identified from the Metallic/Mineral Districts Map (Keith et al., 1983) are mostly uranium deposits. Samples 1, 4, 8, 17, and 34, were taken in areas close to known uranium deposits (Plate 1). Of these five samples, only sample 8 was tested for uranium (Appendix A). The uranium concentration for this sample was 3.4 mg/kg, which is 1.3 mg/kg above the USGS average, but is below the draft soil ingestion HBGL of 700 mg/kg or the Pica condition HBGL of 7 mg/kg.

Ten other USGS samples were taken close to known mineral deposits within the Transition Zone and Basin and Range Provinces. Samples 16, 29, 38, and 43 were obtained near copper deposits (Plate 1). Of these, sample 29 was found to contain zinc at 100 mg/kg, which is 37.9 mg/kg above USGS average, although far below the draft soil HBGL of 100,000 mg/kg. Sample 38 contained concentrations of 70 mg/kg for both copper and lead, which is 40 mg/kg and 46.6 mg/kg greater than USGS averages for these metals, respectively. The HBGLs for copper and lead are 26,000 mg/kg and 400 mg/kg, respectively. Sample 7, which was taken near a lead-zinc deposit (Plate 1), contained 70 mg/kg of lead and 90 mg/kg of zinc, which is 46.6 mg/kg above the USGS average for lead and 27.9 mg/kg above the USGS average for zinc. These data indicate that soil samples taken in close proximity to mineral deposits may be influenced by the natural concentrations in the ore body.

A comparison of selected average metals concentrations of USGS soil samples from Arizona by physiographic province (Table 3-2) indicates that the metals concentrations are approximately twice as high for the Transition Zone and the Basin and Range provinces than those for the Colorado Plateau. The fact that the majority of the known metallic mineral deposits are located in the southwestern two-thirds of the state supports this finding (based on a limited data set of which not every sample was tested for the metals of concern). Another explanation may be that sampling close to a metallic mineral deposit has caused this correlation. While this is the case in a few instances, the large majority of the samples were taken several miles from known metallic mineral deposits. A more intensive study would need to be conducted in order to confirm this observation.

A second factor that may influence the concentration of metals in soils and alluvial deposits (materials deposited by water) throughout the state is the location of mineral deposits within surface-water drainage basins. Plate 1 delineates the surface-water drainage basins that converge in Phoenix and Tucson. These drainage basins have been superimposed over the known metallic mineral districts within the limits of the basins in order to identify sources of metallic minerals that may contribute to the metals concentrations in soils and alluvium of these basins (Plate 1). Surface water flowing across mineral deposits and associated weathered material dissolves, weathers, and transports grains of metals downstream where they are deposited in soils and alluvial sediments along river banks and flood plains.

TABLE 3-2. COMPARISON OF SELECTED AVERAGE METAL CONCENTRATIONS IN SOIL FROM USGS SAMPLES BY PHYSIOGRAPHIC PROVINCES IN ARIZONA

METAL	AVERAGE CONCENTRATIONS(a) (miligram per kilogram (mg/kg))		
	"WORST POSSIBLE CASE" INGESTION HBGL (b) (mg/kg)	COLORADO PLATEAU	TRANSITION ZONE AND BASIN AND RANGE
ALUMINUM	15	39,118	66,667
ANTIMONY	0.6	1	1
ARSENIC	10	4.4	12.7
BARIUM	1,000	441	617
BERYLLIUM	0.0014	ND	2.5
CADMIUM	1	--	--
CHROMIUM	20	36.7	85.2
COBALT	0.14	5.4	12.8
COPPER	260	14.1	34.4
LEAD	4	13.8	30
MERCURY	0.4	0.05	0.12
MOLYBDENUM	14	ND	0.75
NICKEL	20	12.8	40.5
SELENIUM	9	0.2	0.3
SILVER	10	--	--
THALLIUM	0.1	--	--
URANIUM	7	1.9	2.37
VANADIUM	1.4	39.4	93.8
ZINC	1,000	35.6	72.8

Notes:
(a) = Average concentrations calculated from values in Table A-2 in Appendix A
(b) = HBGL - Health-based guidance level (ADHS, 1990)
ND = None detected
-- = No data available.

The upper reaches of the Santa Cruz River and its tributaries drain a portion of the southern part of the state within the Basin and Range physiographic province (Plate 1). Metallic mineral deposits in this area are mainly copper, lead, and zinc ores. The Salt and Verde Rivers and their tributaries drain a significant area of the state in the mountainous physiographic province known as the Transition Zone (Plate 1). Metallic mineral deposits in this area include copper, lead, zinc, manganese, mercury, tungsten, uranium, and iron. These metals continue to be deposited in these basins due to erosion and transport.

Appendix C contains tables that identify each mineral district within the Phoenix and Tucson areas by county, latitude, and longitude, and provides a description of the mineral deposit. A list of the percentage of precious metals extracted from mined materials for selected mineral districts is also provided. These tables may be useful for determining qualitatively what metals may exist downstream of mineral districts but should not be used for quantitative analysis.

The closer weathered material is to its parent material, the more alike the geochemistry of each material will be. This situation is evident in mineral districts where the concentrations of metals in weathered bedrock material are higher than, concentrations in near-surface material (Melton, 1955).

3.3 EVALUATION OF ANALYTICAL TECHNIQUES

According to most analytical laboratories, and based on the detection limits of the methods for the metals studied, the most precise and effective techniques for metals analysis in environmental remediation projects are GFAAS and ICP-AES. In general, lower detection limits can be obtained by GFAAS, and ICP-AES is the most cost-effective method for most metals. The desired detection limit is the factor that generally dictates whether GFAAS or ICP-AES is performed. If detection limits are not a concern, most laboratories will perform analysis by ICP-AES.

Both GFAAS and ICP-AES have detection limits well below the ADEQ draft 1990 soil ingestion HBGLs for all metals except beryllium and thallium. The HGBLs for beryllium and thallium are 0.14 mg/kg and 10 mg/kg respectively. The detection limits of the ICP-AES are above or equal to the HGBLs for these metals (0.5 mg/kg for beryllium and 10 mg/kg for thallium). The detection limits of GFAAS is one of two orders of magnitude below the HGBLs for these metals (0.01 mg/kg for beryllium and 0.5 mg/kg for thallium).

4.0 RECOMMENDATIONS

4.1 RECOMMENDATION FOR STANDARD METALS BACKGROUND SAMPLING PROCEDURES

In order to maintain consistency and validity for background sampling procedures, a few standard sampling protocols should be followed for establishing background conditions at a given site. First, background soil samples must be taken at locations known or at least judged to be free of contamination. Second, if metals contamination at depth is of concern, background soil samples should be taken at the same depth of contamination for comparison. Third, artificial fill soil samples need to be evaluated separately from native in-situ soil samples. Metals concentrations in tilled agricultural soils and fills may be dramatically different from those in native in-situ soils. Fourth, the soil profile needs to be carefully identified and correlated to the samples as soil changes may result in differing concentrations. Fifth, using the arithmetic average of analytical data for a given soil horizon would be more accurate than performing a composite analysis for a soil horizon. The required number of background soil samples must be justified prior to initiation of the investigation.

4.2 RECOMMENDATION FOR ANALYSIS OF TOTAL METALS CONCENTRATIONS IN SOIL

GFAAS should be used when analyzing soil for concentrations of beryllium and thallium, as the detection limits for these metals are well below the draft HBGLs for them. Analysis of mercury is best performed by CVAAS on a graphite furnace. Analysis of the 16 remaining metals can be performed by GFAAS or ICP-AES depending on the desired detection limits, costs, and analysis time.

4.3 RECOMMENDATION FOR GUIDANCE LEVELS

Analytical results of total metals in background soil samples can be compared to a state average (USGS sample data) and ingestion HGBLs to establish site-specific guidance levels for soils. Because HGBLs are based only on a health risk, a site-specific guidance level could be developed by modifying the HGBLs when background metals concentrations exceed the HGBLs. The extent to which guidance levels are modified will depend on the magnitude of the differences between HGBLs and the background averages for the metals.

In order to establish a basis for the groundwater protection guidance level (GWPGL), a standard leach test needs to be adopted and performed for background metals and contaminated soil samples at each site. Since the TCLP procedure approximates natural leaching conditions, it is the most suitable leach procedure to adopt. After GWPGLs are developed, they should be compared with the results of a risk analysis performed to establish the GWPGL for each site.

4.4 RECOMMENDATION FOR DATA COLLECTION AND DATABASE GENERATION

The 109 background metals soil samples collected from 57 sites across the state were not subject to the standard soil sampling protocol performed today in the environmental field. Nevertheless, these samples probably represent background conditions at these locations. Once a standard protocol for background sampling is established, data can be collected from each site and entered into a database. The database should include: 1) if total metals analysis was performed for comparison to the ingestion HBGLs or if TCLP metals analysis was performed for comparison to the GWPGLs; 2) only sampling that is conducted according to an established soil sampling protocol; 3) latitude and longitude; 4) depth of sample; 5) USCS soil classification; 6) sample designations; 7) analytical results using recognized standard analytical methods; and 8) reference as to facility and ADEQ file or literature source. The existing database would be continually updated, and statistical analyses could be performed to assess metal concentration variations throughout the state for use in modifying HBGLs or GWPGLs.

4.5 RECOMMENDATION FOR SAMPLING PLAN

A sampling plan for the metropolitan areas of the state should be developed in order to obtain a more statistical representation for these areas. A statistical study needs to be conducted to determine the number of samples necessary to establish a representative base for these areas. As a possibility for accumulating additional data, soil samples could be collected by ADEQ field personnel as they perform other inspections or investigations.

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5.1 LITERATURE REFERENCES

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6.0 LIMITATIONS

The conclusions, recommendations and professional opinions presented in this report were developed by The Earth Technology Corporation in accordance with generally accepted geological, hydro-geological, and laboratory analytical principles and practices. This warranty is in lieu of all other warranties either expressed or implied.

This report has been prepared for use by ADEQ in developing Ingestion HBGLs and GWPGL for metals in soil. It may not contain sufficient information for the purposes of other parties or other uses. The data, interpretations, conclusions, and recommendations contained herein should be considered to relate only to the specific project and location discussed herein. The Earth Technology Corporation is not responsible for any future conclusions or recommendations that may be made by others, unless we have been given an opportunity to review such conclusions or recommendations and concur in writing.

APPENDIX A

USGS SOIL SAMPLE ANALYTICAL RESULTS, LOCATIONS, AND DESCRIPTIONS

APPENDIX A. USGS SOIL SAMPLE ANALYTICAL RESULTS, LOCATIONS, AND DESCRIPTIONS

Appendix A consists of available USGS background data on metal concentrations in soil samples from across Arizona. This database is comprised of two tables that are a compilation of data extracted from USGS Open-File Report 81-197 (Boerngen and Shacklette, 1981). Table A-1 and A-2 contain the following information:

- Table A-1 lists the location and gives a brief description of each sample
- Table A-2 lists the concentrations in milligrams per kilogram (mg/kg) for each metal for each soil sample.

TABLE A-1. LOCATION AND DESCRIPTION OF USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH (Feet)	SITE AND SOIL DESCRIPTION
1	APACHE	35° 34'	110° 0'	0.75	COUNTY RD. AT SUNRISE SPRINGS; sandy clay alluvium
2	APACHE	35° 34'	109° 15'	0.1-0.5	ROUTE 264, 2 MILES NORTH ON SAWMILL ROAD; soil not described
3	APACHE	34° 18'	109° 22'	0.75	U.S. 666-180, 15 MILES NORTH OF SPRINGERVILLE; soil over mudstone
4	APACHE	36° 55'	109° 45'	0.75	U.S. 164, CHINLE WASH CROSSING 40 MILES NORTHEAST OF KAYENTA; red sand
5	COCHISE	31° 40'	110° 16'	0.75	ROUTE 82, 2 MILES EAST OF JUNCTION WITH ROUTE 90, WEST OF AIRBANK; soil not described
6	COCHISE	31° 25'	109° 51'	0.75	U.S. 80, 3 MILES EAST OF LOWELL; soil not described
7	COCHISE	31° 40'	109° 37'	0.75	U.S. 666, 1 MILE SOUTH OF ELFRIDA; soil not described
8	COCONINO	35° 56'	111° 23'	0.75	U.S. 89, 7 MILES SOUTH OF JUNCTION WITH U.S. 164; dune sand
9	COCONINO	36° 25'	110° 48'	0.75	U.S. 164-160, 3.5 MILES SOUTH OF COW SPRINGS; red sand
10	COCONINO	34° 33'	111° 18'	0.75	ROUTE 87, AT CLINTS WELL; dark forest soil
11	COCONINO	35° 14'	111° 47'	0.75	INTERSTATE 40, 5 MILES EAST OF FLAGSTAFF; B horizon dark forest soil
12	COCONINO	35° 32'	113° 20'	0.75	U.S. 66, 32 MILES NORTHWEST OF SELIGMAN; arid light B horizon
13	COCONINO	36° 6'	111° 15'	0.1-0.5	ROUTE 264, 1 MILE EAST OF MOENKOPI; soil not described
14	COCONINO	36° 55'	112° 30'	0.1-0.5	U.S. 89, AT GLEN CANYON DAM AT PAGE; sand
15	COCONINO	36° 10'	112° 4'	0.1-0.5	AT NORTH RIM BY GRAND CANYON LODGE; loamy soil
16	COCONINO	36° 43'	112° 14'	0.75	U.S. 89A, 1 MILE SOUTH OF JACOB LAKE LODGE; black rocky loam
17	COCONINO	36° 40'	111° 40'	0.1-0.5	U.S. 89, JUNCTION WITH U.S. 89A AT BITTER SPRINGS; sandy
18	COCONINO	35° 13'	112° 23'	0.75	U.S. 66-89, 5 MILES EAST OF ASH FORK; lithosol from volcanic extrusive lava

Source: Boerngen and Shacklette, 1981.

TABLE A-1. LOCATION AND DESCRIPTION OF USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA
(Page 2 of 3)

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH (Feet)	SITE AND SOIL DESCRIPTION
19	GILA	34° 20'	111° 5'	0.75	ROUTE 160, AT KOHLS RANCH; dark forest soil
20	GILA	33° 49'	110° 27'	0.75	ROUTE 77, 6 MILES NORTH OF SALT RIVER CROSSING, NORTHEAST OF GLOBE; dark forest soil
21	GRAHAM	32° 26'	109° 21'	0.75	8 MILES, NORTHWEST OF BOWIE; alluvial soil
22	GRAHAM	32° 45'	109° 30'	0.75	8 MILES, SOUTHEAST OF SOLOMON; alluvial soil
23	GRAHAM	33° 8'	110° 8'	0.75	U.S. 70, AT BYLAS; arid light soil
24	GREENLEE	33° 22'	109° 17'	0.75	U.S. 666, 54 MILES NORTH OF CLIFTON IN WHITE MOUNTAINS; lithosol from basalt lava
25	MARICOPA	33° 52'	113° 11'	0.75	COUNTY RD. AT SUNRISE SPRINGS; sandy clay alluvium
26	MARICOPA	33° 25'	111° 50'	0.75	3200 EAST MAIL IN MESA; irrigated - alluvium
27	MARICOPA	32° 54'	112° 44'	0.75	ROUTE 85, 2 MILES SOUTH OF GILA BEND; soil not described
28	MOHAVE	36° 43'	113° 3'	0.75	10 MILES WEST OF KAIBAB; alluvial soil
29	MOHAVE	35° 12'	114° 5'	0.75	U.S. 93-466, 2 MILES WEST OF KINGMAN; light arid soil
30	MOHAVE	35° 47'	114° 31'	0.75	U.S. 93, 45 MILES NORTHWEST OF KINGMAN; arid light soil
31	MOHAVE	34° 20'	113° 10'	0.75	U.S. 93, 90 MILES SOUTHEAST OF KINGMAN; near Santa Maria R; soil not described
32	NAVAJO	36° 44'	110° 8'	0.75	U.S. 164-160, 6 MILES NORTHEAST OF KAYENTA; red drifting sand
33	NAVAJO	34° 25'	110° 37'	0.75	ROUTE 160, AT HEBER; arid light soil
34	NAVAJO	35° 2'	110° 37'	0.75	ROUTE 66-180, 5 MILES EAST OF WINSLOW; sandy soil
35	NAVAJO	35° 50'	110° 10'	0.1-0.5	ROUTE 364, 1 MILE WEST OF JEDDITO WASH; 1-6 in. depth; soil not described

Source: Boerngen and Shacklette, 1981.

TABLE A-1. LOCATION AND DESCRIPTION OF USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA
(Page 3 of 3)

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH (Feet)	SITE AND SOIL DESCRIPTION
36	NAVAJO	35° 55'	110° 40'	0.1-0.5	ROUTE 264, 0.5 MILES WEST OF HOTEVILLA; 1-6 in. depth; soil not described
37	PIMA	32° 12'	112° 50'	0.75	ROUTE 85, AT ROWOOD, 1 MILE EAST OF AJO; soil not described
38	PIMA	32° 10'	112° 10'	0.75	ROUTE 86, 2 MILES WEST OF QUIJOTOA; soil not described
39	PIMA	32° 0'	111° 15'	0.75	ROUTE 86, 286 JUNCTION, ROBLES JUNCTION; soil not described
40	PINAL	32° 48'	111° 45'	0.75	1-10 and 108, 6 MILES SOUTH OF CASA GRANDE; sandy colluvium
41	PINAL	33° 18'	111° 5'	0.75	U.S. 60-70, WEST EDGE OF SUPERIOR; stony rough soil
42	SANTA CRUZ	31° 22'	110° 53'	0.75	ROUTE 82, 1 MILE NORTHEAST OF NOGALES; soil not described
43	YUMA	33° 55'	113° 25'	0.75	8 MILES NORTHEAST OF WENDEN; alluvial soil
44	YUMA	33° 3'	113° 24'	0.75	LOS PALOMAS RANCH NEAR HYDER, 25 MILES NORTH OF SENTINEL & INTERSTATE-8; sandy alluvium
45	YUMA	33° 40'	114° 14'	0.75	U.S. 95, 1 MILE SOUTH OF JUNCTION WITH INTERSTATE-10, NEAR QUARTZSITE; soil not described
46	YUMA	32° 53'	114° 30'	0.75	ROUTE 95, 24 MILES NORTH OF YUMA; soil not described
47	YUMA	32° 45'	113° 37'	0.75	INTERSTATE-8 AT MOHAWK PASS; soil not described

Source: Boerngen and Shacklette, 1981.

TABLE A-2. CONCENTRATIONS OF SELECTED METALS DETECTED IN USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA
(Page 1 of 3)

Sample No.	CONCENTRATION in mg/kg																		
	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Ca)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Molybdenium (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Vanadium (V)	Zinc (Zn)
1	70,000	–	5.3	500	ND	–	20.0	10	20.0	15	0.09	ND	30	0.2	–	–	–	70	25
2	30,000	–	–	500	ND	–	30.0	7	10.0	15	–	ND	15	–	–	–	–	30	–
3	30,000	–	6.2	500	ND	–	30.0	7	30.0	15	0.06	ND	15	0.1	–	–	–	70	42
4	15,000	–	1.6	300	ND	–	7.0	<3	7.0	10	0.10	ND	7	0.1	–	–	–	15	25
5	30,000	–	8.5	500	ND	–	30.0	7	30.0	20	0.16	ND	15	0.1	–	–	–	70	50
6	50,000	–	4.3	700	ND	–	15.0	7	15.0	30	0.02	ND	7	0.1	–	–	–	70	50
7	30,000	–	7.1	300	ND	–	15.0	7	70.0	70	0.10	3	15	1.1	–	–	–	30	90
8	100,000	<1	2.3	1,500	ND	–	5.0	5	10.0	20	0.03	ND	ND	0.1	–	–	3.40	70	31
9	30,000	<1	2.0	500	ND	–	7.0	ND	10.0	10	0.02	ND	5	0.1	–	–	1.11	15	18
10	30,000	–	16.0	200	ND	–	30.0	7	30.0	20	0.14	ND	20	1.6	–	–	–	50	50
11	>100,000	–	65.0	700	ND	–	100.0	30	30.0	20	0.08	ND	50	0.3	–	–	–	100	100
12	>100,000	–	1.4	700	3.0	–	70.0	15	30.0	20	0.08	ND	70	0.3	–	–	–	70	100
13	20,000	–	–	200	ND	–	10.0	ND	7.0	15	–	ND	15	–	–	–	–	20	50
14	20,000	–	–	300	ND	–	100.0	5	10.0	20	–	ND	15	–	–	–	–	30	–
15	30,000	–	–	200	ND	–	50.0	7	10.0	15	–	ND	15	–	–	–	–	20	25
16	50,000	–	–	300	ND	–	150.0	10	20.0	20	–	ND	15	–	–	–	–	70	75
17	30,000	–	–	200	ND	–	20.0	ND	10.0	15	–	ND	10	–	–	–	–	20	–

Notes:

ND = Not detected
– = No data available.

Source: Boerngen and Shacklette, 1981.

TABLE A-2. CONCENTRATIONS OF SELECTED METALS DETECTED IN USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA

Sample No.	CONCENTRATION in mg/kg																		
	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Vanadium (V)	Zinc (Zn)
18	30,000	--	9.8	500	ND	--	150.0	15	30.0	20	0.06	ND	50	0.5	--	--	--	150	95
19	30,000	--	6.2	200	ND	--	70.0	7	20.0	10	0.10	ND	30	0.2	--	--	--	50	50
20	30,000	--	8.3	200	1.5	--	100.0	10	20.0	15	0.05	ND	30	0.4	--	--	--	70	25
21	>100,000	--	7.6	700	ND	--	300.0	10	50.0	20	0.05	ND	30	0.1	--	--	--	70	60
22	70,000	--	4.7	500	ND	--	100.0	10	30.0	15	0.02	ND	20	0.2	--	--	--	100	60
23	70,000	--	7.4	700	ND	--	50.0	15	20.0	50	0.05	ND	30	0.4	--	--	--	100	50
24	70,000	--	5.2	1,000	ND	--	300.0	30	70.0	20	0.42	3	150	0.2	--	--	--	300	81
25	70,000	--	8.2	500	ND	--	100.0	10	50.0	15	0.05	ND	30	0.1	--	--	--	70	75
26	>100,000	--	6.5	700	ND	--	70.0	15	30.0	20	0.06	3	50	0.1	--	--	--	100	100
27	70,000	--	2.0	700	1.5	--	30.0	10	30.0	30	0.05	ND	15	0.1	--	--	--	70	60
28	70,000	--	7.5	300	ND	--	50.0	10	30.0	ND	0.04	ND	15	0.2	--	--	--	70	70
29	>100,000	--	5.7	1,000	3.0	--	200.0	20	30.0	20	0.06	3	150	0.2	--	--	--	150	100
30	70,000	<-1	8.6	700	3.0	--	70.0	15	30.0	30	0.03	ND	50	0.1	--	--	--	70	150
31	>100,000	<-1	6.9	500	5.0	--	50.0	15	30.0	50	0.57	ND	70	0.4	--	--	--	100	100
32	10,000	--	1.6	200	ND	--	10.0	ND	5.0	ND	0.01	ND	<5	0.2	--	--	1.13	10	12
33	30,000	--	7.0	300	ND	--	30.0	5	20.0	10	0.03	ND	15	0.8	--	--	--	30	25
34	50,000	--	6.3	700	ND	--	70.0	10	20.0	20	0.06	ND	20	0.2	--	--	--	70	25

Notes:

ND = Not detected

-- = No data available.

Source: Boerngen and Shacklette, 1981.

TABLE A-2. CONCENTRATIONS OF SELECTED METALS DETECTED IN USGS SAMPLES OF SURFICIAL SOILS FROM ARIZONA
(Page 3 of 3)

Sample No.	CONCENTRATION in mg/kg																		
	Aluminum (Al)	Anti-mony (Sb)	Arsenic (As)	Barium (Ba)	Beryl-lium (Be)	Cad-mium (Ca)	Chro-mium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mer-cury (Hg)	Molyb-denum (Mo)	Nickel (Ni)	Sele-nium (Se)	Sil-ver (Ag)	Thal-lium (Tl)	Ura-nium (U)	Vana-dium (V)	Zinc (Zn)
35	30,000	--	--	500	ND	--	20.0	7	10.0	15	--	ND	10	--	--	--	--	30	25
36	50,000	--	--	500	ND	--	15.0	5	10.0	20	--	ND	10	--	--	--	--	30	50
37	30,000	--	4.9	700	ND	--	30.0	10	30.0	20	0.04	3	15	0.1	--	--	--	70	60
38	70,000	--	5.9	1,000	ND	--	30.0	15	70.0	70	0.06	3	15	0.1	--	--	--	70	70
39	50,000	<1	2.9	700	1.5	--	15.0	7	20.0	15	0.04	ND	10	0.1	--	--	--	70	50
40	100,000	<1	4.0	700	1.5	--	70.0	10	30.0	20	0.01	ND	30	0.1	--	--	2.37	150	68
41	>100,000	--	97.0	700	ND	--	50.0	10	30.0	100	0.48	ND	20	0.8	--	--	--	100	50
42	50,000	--	9.1	700	1.5	--	15.0	7	20.0	30	0.05	ND	15	0.1	--	--	--	70	80
43	>100,000	--	2.9	700	ND	--	70.0	20	30.0	15	0.03	ND	30	0.4	--	--	--	100	30
44	70,000	<1	2.7	1,000	1.5	--	50.0	7	7.0	20	0.03	ND	20	0.1	--	--	2.64	70	70
45	30,000	--	7.0	500	ND	--	15.0	7	30.0	20	0.16	ND	7	0.2	--	--	--	50	70
46	50,000	--	6.7	700	1.5	--	30.0	10	15.0	30	0.03	ND	15	0.1	--	--	--	70	70
47	30,000	--	9.2	700	ND	--	30.0	10	70.0	30	0.36	ND	15	0.2	--	--	--	70	70
Maximum	100,000	<1	97	1,500	5	--	300	30	200	100	0.57	3.0	150	1.6	--	--	3.4	300	150
Minimum	30,000	<1	1.4	200	ND	--	5	ND	5	ND	0.01	ND	ND	<0.1	--	--	1.1	10	12
Average	55,213	<1	9.8	565	0.52	--	61.3	9.7	30	23.4	0.10	3.0	27.5	0.30	--	--	2.1	71.3	62.1
Standard Deviation	28,246	0	17.2	269.7	1.01	--	66	6.3	30.5	20.7	0.13	2.8	30.5	0.26	--	--	1.0	46.4	34

Notes:

ND = Not detected

-- = No data available.

Source: Boerngen and Shacklette, 1981.

APPENDIX B

ADEQ SOIL SAMPLE ANALYTICAL RESULTS AND LOCATIONS

APPENDIX B. ADEQ SOIL SAMPLE ANALYTICAL RESULTS AND LOCATIONS

Appendix B consists of available background data on metals concentrations in soil samples. Information in this appendix was obtained from the ADEQ sources listed in Section 2.0. This database is comprised of two tables that are a compilation of data from several reports provided to the ADEQ. Table B-1 and B-2 contain the following information:

- Table B-1 lists the location and source of each sample.
- Table B-2 lists the concentrations in milligrams per kilogram (mg/kg) for each metal for each soil sample.

TABLE B-1. LOCATION AND SOURCE OF SOIL SAMPLING DATA OBTAINED FROM ADEQ RECORDS
(Page 1 of 3)

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH	ADEQ GROUP	FACILITY/ SITE	FACILITY SITE SAMPLE ID NO.
48a	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1A
48b	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1B
48c	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1C
48d	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1D
48e	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1E
48f	Pima	32° 10'	110° 50'	0.75	RCRA Compliance Unit	Olive Grove/Tucson	GB-1F
49	Pima	32° 16'	110° 55'	Surface	RCRA Compliance Unit	Arizona Gear/Tucson	B-3
50	Pima	32° 15'	110° 57'	0.25	Remedial Projects Unit	Chrome Co./Tucson	HS-4
51	Pima	32° 12'	110° 56'	1	Groundwater Hydrology Section	Pacific Fruit Express/Tucson	Background
52	Maricopa	33° 25'	111° 51'	3	Site Discovery and Hazard Evaluation unit	Metal Refinishers/ Mesa	Background
53	Maricopa	33° 27'	112° 02'	5	Remedial Projects Unit	Frazee/Deer-O Paint & Wallcoverings/Phoenix	S-1
54	Maricopa	33° 29'	111° 58'	65-70	Site Discovery and Hazard Evaluation Unit	Motorola/Phoenix	Background
55	Maricopa	33° 25'	111° 59'	Surface	Remedial Projects Unit	ABS Metallurgical Processors, Inc./Phoenix	11
56a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
56h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0110
57a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120
57h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0120

TABLE B-1. LOCATION AND SOURCE OF SOIL SAMPLING DATA OBTAINED FROM ADEQ RECORDS

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH	ADEQ GROUP	FACILITY/ SITE	FACILITY SITE SAMPLE ID NO.
58a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
58h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0210
59a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
59h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0220
60a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230
60h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0230

TABLE B-1. LOCATION AND SOURCE OF SOIL SAMPLING DATA OBTAINED FROM ADEQ RECORDS

SAMPLE NO.	COUNTY	LATITUDE (Degree, Minute)	LONGITUDE (Degree, Minute)	DEPTH	ADEQ GROUP	FACILITY/ SITE	FACILITY SITE SAMPLE ID NO.
61a	Maricopa	33° 25'	112° 22'	0.3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61b	Maricopa	33° 25'	112° 22'	0.75	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61c	Maricopa	33° 25'	112° 22'	1	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61d	Maricopa	33° 25'	112° 22'	2.0	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61e	Maricopa	33° 25'	112° 22'	3	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61f	Maricopa	33° 25'	112° 22'	4.5	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61g	Maricopa	33° 25'	112° 22'	6	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
61h	Maricopa	33° 25'	112° 22'	9	Site Discovery and Hazard Evaluation Unit	Phoenix-Goodyear Airport RI/FS	0320
62	Pinal	32° 56'	110° 5'	Surface	RCRA Compliance Unit	Hexcel Disposal/Casa Grande	Background

TABLE B-2. CONCENTRATIONS OF SELECTED METALS
DETECTED IN ADEQ SAMPLES
(Page 1 of 3)

Sample No.	CONCENTRATION in mg/kg																			
	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Vanadium (V)	Zinc (Zn)
48a	7,400	--	--	--	--	ND	7.2	--	10	TR	--	--	--	--	--	--	--	--	21
48b	8,800	--	--	--	--	ND	7.7	--	10	ND	--	--	--	--	--	--	--	--	21
48c	7,100	--	--	--	--	ND	6.9	--	9.0	TR	--	--	--	--	--	--	--	--	18
48d	12,000	--	--	--	--	ND	8.8	--	11	ND	--	--	--	--	--	--	--	--	23
48e	9,400	--	--	--	--	ND	2.3	--	9.7	ND	--	--	--	--	--	--	--	--	23
48f	6,200	--	--	--	--	ND	6.0	--	8.7	TR	--	--	--	--	--	--	--	--	21
49	--	--	24	230	--	<0.5	14	--	--	9.4	0.25	--	--	<0.5	--	--	--	--	--
50	--	--	--	--	--	<0.5	5.45	--	--	8.91	--	--	19.3	--	--	--	--	--	--
51	15,800	3.8	3.1	72.6	0.96	0.81	11.3	--	17.1	24.5	0.13	--	9.2	0.96	0.70	0.47	--	23.8	--
52	--	--	--	--	--	--	--	--	9.6	--	--	--	--	--	--	--	--	--	--
53	--	<1	6	--	0.30	1.9	19	--	15	5	<1	--	21	<1	0.8	<1	--	--	27
54	--	<0.4	--	--	<2.0	<0.5	9.0	--	6.0	5.3	<0.01	--	14	<0.4	<0.05	--	--	<0.2	15
55	--	--	--	--	--	--	29	--	--	--	--	--	--	--	--	--	--	--	--
56a	8,822	--	8.6	130	--	0.4	15	--	13	9.5	ND	--	12	--	--	--	--	--	32
56b	8,401	--	9.5	158	--	0.3	16	--	11	9.3	ND	--	12	--	--	--	--	--	30
56c	8,056	--	8.6	158	--	0.6	16	--	11	8.0	ND	--	12	--	--	--	--	--	33
56d	8,236	--	8.7	218	--	0.5	14	--	10	5.7	ND	--	10	--	--	--	--	--	25
56e	--	--	--	--	--	--	12	--	--	--	--	--	--	--	--	--	--	--	--
56f	--	--	--	--	--	--	14	--	--	--	--	--	--	--	--	--	--	--	--
56g	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--
56h	--	--	--	--	--	--	12	--	--	--	--	--	--	--	--	--	--	--	--
57a	15,447	--	6.1	168	--	1.2	34	--	24	11.5	ND	--	19	--	--	--	--	--	63
57b	13,832	--	6.0	164	--	1.0	36	--	23	8.7	ND	--	17	--	--	--	--	--	60
57c	16,067	--	6.5	169	--	1.7	34	--	25	11.2	ND	--	20	--	--	--	--	--	81
57d	16,817	--	6.5	169	--	0.6	24	--	23	10.4	ND	--	20	--	--	--	--	--	54
57e	--	--	--	--	--	--	25	--	--	--	--	--	--	--	--	--	--	--	--
57f	--	--	--	--	--	--	22	--	--	--	--	--	--	--	--	--	--	--	--
57g	--	--	--	--	--	--	14	--	--	--	--	--	--	--	--	--	--	--	--
57h	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
ND = Not detected
-- = No data available.
Source: Boerngen and Shacklette, 1981.

TABLE B-2. CONCENTRATIONS OF SELECTED METALS DETECTED IN ADEQ SAMPLES

(Page 2 of 3)

Sample No.	CONCENTRATION in mg/kg																		
	Aluminum (Al)	Anti-mony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Vanadium (V)	Zinc (Zn)
58a	9,381	--	9.5	152	--	--	16	--	15	8.2	ND	--	15	--	--	--	--	--	37
58b	7,963	--	9.2	154	--	--	14	--	14	6.6	ND	--	14	--	--	--	--	--	34
58c	13,147	--	8.7	176	--	--	17	--	16	6.8	ND	--	13	--	--	--	--	--	36
58d	9,748	--	10.7	178	--	--	17	--	15	5.5	ND	--	15	--	--	--	--	--	34
58e	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--	--	--	--	--
58f	--	--	--	--	--	--	18	--	--	--	--	--	--	--	--	--	--	--	--
58g	--	--	--	--	--	--	22	--	--	--	--	--	--	--	--	--	--	--	--
58h	--	--	--	--	--	--	30	--	--	--	--	--	--	--	--	--	--	--	--
59a	9,375	--	10.1	151	--	0.4	16	--	20	11.1	ND	--	19	--	--	--	--	--	43
59b	10,192	--	9.9	172	--	ND	16	--	19	6.6	ND	--	19	--	--	--	--	--	40
59c	11,315	--	9.8	173	--	0.4	16	--	20	6.9	ND	--	20	--	--	--	--	--	42
59d	9,420	--	8.1	163	--	0.4	15	--	19	6.2	ND	--	18	--	--	--	--	--	41
59e	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--
59f	--	--	--	--	--	--	18	--	--	--	--	--	--	--	--	--	--	--	--
59g	--	--	--	--	--	--	15	--	--	--	--	--	--	--	--	--	--	--	--
59h	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--	--	--	--	--
60a	8,558	--	16.1	151	0.96	0.3	28	--	18	9.5	ND	--	18	--	--	--	--	--	39
60b	9,130	--	12.1	121	--	0.2	19	--	18	6.9	ND	--	18	--	--	--	--	--	35
60c	15,328	--	9.4	156	--	0.4	29	--	27	8.9	ND	--	26	--	--	--	--	--	62
60d	12,685	--	9.6	116	0.30	0.4	22	--	23	--	ND	--	23	--	--	--	--	--	51
60e	--	--	--	--	--	--	22	--	--	--	--	--	--	--	--	--	--	--	--
60f	--	--	--	--	--	--	23	--	--	--	--	--	--	--	--	--	--	--	--
60g	--	--	--	--	--	--	21	--	--	--	--	--	--	--	--	--	--	--	--
60h	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--
61a	13,679	--	10.4	197	<2.0	0.6	21	--	27	17.6	ND	--	27	--	--	--	--	--	54
61b	11,452	--	9.2	174	--	0.6	18	--	20	9.0	ND	--	25	--	--	--	--	--	47
61c	11,423	--	8.4	166	--	0.2	21	--	24	9.8	ND	--	28	--	--	--	--	--	51
61d	12,895	--	8.4	158	--	0.2	20	--	24	11.6	ND	--	27	--	--	--	--	--	52
61e	--	--	--	--	--	--	18	--	--	--	--	--	--	--	--	--	--	--	--
61f	--	--	--	--	--	--	21	--	--	--	--	--	--	--	--	--	--	--	--
61g	--	--	--	--	--	--	18	--	--	--	--	--	--	--	--	--	--	--	--
61h	--	--	--	--	--	--	11	--	--	--	--	--	--	--	--	--	--	--	--
62	--	--	--	--	--	--	6.0	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

ND = Not detected

-- = No data available.

TABLE B-2. CONCENTRATIONS OF SELECTED METALS DETECTED IN ADEQ SAMPLES
(Page 3 of 3)

Sample No.	CONCENTRATION in mg/kg																		
	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Ca)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Vanadium (V)	Zinc (Zn)
Maximum	16,827	3.8	24	230	2.0	1.7	34	–	27	24.5	0.25	–	28	1.0	0.8	<1.0	–	23.8	81
Minimum	6,200	<0.4	3.1	72.6	0.3	ND	5.4	–	6.0	ND	ND	–	9.2	<0.4	<0.05	0.5	–	<0.2	15
Average	10,654	1.7	9.4	161.3	1.1	0.4	17.5	–	16.6	7.7	0.05	–	18.2	0.6	0.5	0.7	–	12	38.9
Standard Deviaiton	2,859	1.8	3.8	30.5	0.9	0.4	7.0	–	5.9	4.8	0.2	–	5.3	0.3	0.4	0.4	–	16.7	16.4

Notes:
ND = Not detected
– = No data available.

Source: Boerngen and Shacklette, 1981.

APPENDIX C

SELECTED METALLIC MINERAL DISTRICTS IN ARIZONA

APPENDIX C. SELECTED METALLIC MINERAL DISTRICTS IN ARIZONA

Appendix C contains a compilation of data from selected metallic mineral districts in Arizona. These districts are within the surface-water drainage basins that converge in the Phoenix and Tucson areas. The source for this material comes from the Arizona Bureau of Geology and Mineral Technology (Keith, et al., 1983).

Tables C-1 and C-2 contain the following information:

- o Table C-1 lists the mineral districts within the surface-water drainage basins for Phoenix and Tucson giving location, description, and District No. as shown on Plate 1.

- o Table C-2 gives the percentages of metals within each district.

TABLE C-1. LOCATION AND DESCRIPTION OF SELECTED METALLIC MINERAL DISTRICTS IN ARIZONA
(Page 1 of 2)

District No. (Plate 1)	Mineral District	County	Latitude (Degree, Minute)	Longitude (Degree, Minute)	Deposit Description
D1	Amole	Pima	32° 15′	111° 07′	lead, zinc, silver
L1	Apache Iron	Navajo	34° 09′	110° 40′	iron
H1	Bickle	Maricopa	33° 49′	111° 47′	tungsten
B1	Bloody Basin	Yavapai	34° 09′	111° 52′	copper, w/o gold
F1	Blue Bird	Santa Cruz	31° 26′	110° 32′	manganese
A1	Bradford	Santa Cruz	31° 28′	110° 50′	copper porphyry
J1	Bronco Creek	Maricopa	33° 51′	111° 51′	copper, gold, silver
H2	Camp Verde	Yavapai	34° 28′	111° 53′	tungsten
K9	Cardinal Avenue	Pima	32° 06′	111° 02′	uranium
A2	Catalina	Pima	32° 18′	110° 52′	copper porphyry
C1	Cave Creek	Maricopa	33° 49′	111° 52′	gold, w/o copper
H3	Cave Creek	Santa Cruz	31° 49′	110° 47′	copper porphyry
C2	Cherry Creek	Yavapai	34° 33′	112° 03′	gold, w/o copper
K1	Ciebcue	Navajo	34° 02′	110° 28′	uranium
A4	Copper Basin	Yavapai	34° 29′	112° 35′	copper porphyry
A21	Cuprite	Pima	31° 54′	110° 39′	copper porphyry
K8	Duranium	Santa Cruz	31° 36′	110° 56′	uranium
D2	Empire	Pima	31° 60′	110° 36′	lead, zinc, silver
K2	Fossil Creek	Yavapai	34° 27′	111° 35′	uranium
H4	Four Peaks	Gila-Maricopa	33° 44′	111° 21′	tungsten
F5	Giant Cactus	Gila	33° 30′	110° 31′	manganese
A5	Globe Hills	Gila	35° 23′	110° 45′	copper porphyry
C3	Goldfield	Pinal-Maricopa	33° 36′	111° 28′	gold, w/o copper
J2	Grays Gluch	Maricopa	33° 57′	111° 54′	copper, gold, silver
D3	Greaterville	Pima	31° 52′	110° 44′	lead, zinc, silver
B3	Green Valley	Gila	34° 15′	111° 20′	copper, w/o gold
A6	Harshaw	Santa Cruz	31° 36′	110° 43′	copper porphyry
D4	Hartford	Cochise	31° 27′	110° 44′	lead, zinc, silver, veins
A7	Helvetia-Rosemont	Pima	31° 23′	110° 21′	copper porphyry
D5	Ivanhoe	Santa Cruz	31° 40′	110° 47′	lead, zinc, silver
A20	Jackson	Pima	31° 31′	110° 48′	lead, zinc, silver, veins
D7	Johnson & Hayden	Coconino	35° 39′	115° 0′	lead, silver, zinc
C4	Keystone	Pima	31° 50′	111° 13′	gold, w/o copper
F2	La McKoy	Yavapai	34° 05′	111° 37′	manganese
K3	Lime Creek	Maricopa	33° 57′	111° 44′	uranium
F3	Long Valley	Coconino	34° 33′	111° 19′	manganese
E1	Magazine	Maricopa	33° 58′	111° 49′	silver, w/o lead
D15	Mansfield	Santa cruz	33° 58′	111° 49′	lead, zinc, silver
G2	Mazatzal Mountains	Maricopa-Gila	33° 54′	111° 24′	mercury
B5	McDowell	Maricopa	33° 36′	111° 45′	copper, w/o gold
A7	Miami-Inspiration	Gila	33° 22′	110° 52′	copper porphyry
C5	Mineral Point	Yavapai	34° 38′	112° 16′	gold, w/o copper
C6	Nogales	Santa Cruz	31° 30′	110° 54′	gold, w/o copper

Source: Keith, Gest, DeWitt, Toll and Everson, 1983.

TABLE C-1. LOCATION AND DESCRIPTION OF SELECTED METALLIC MINERAL DISTRICTS IN ARIZONA

(Page 2 of 2)

ict No. e 1)	Mineral District	County	Latitude (Degree, Minute)	Longitude (Degree, Minute)	Deposit Description
	Old Baldy	Pima-Santa Cruz	31° 38′	110° 52′	lead,zinc, silver
5	Pajarito	Santa Cruz	31° 18′	110° 54′	lead, zinc, silver
8	Palmetto	Santa Cruz	31° 24′	110° 45′	copper porphyry
6	Parker Canyon	Santa Cruz	31° 22′	110° 28′	lead, zinc, silver
	Patagonia	Santa Cruz	31° 21′	110° 45′	copper porphyry
	Phoenix Mountains	Maricopa	35° 31′	112° 00′	mercury
A10	Pima	Pima	31° 56′	111° 04′	copper porphyry
A11	Pinal Mountains	Gila	33° 15′	110° 48′	copper porphyry
12	Pioneer	Pinal	33° 17′	110° 05′	copper porphyry
	Pittsburg-Tonto	Gila	33° 58′	111° 17′	copper, gold, silver
B6	Polk	Gila	34° 08′	111° 31′	copper, w/o gold
I4	Pranty's Cabin	Gila	34° 02′	111° 13′	copper, gold, silver
7	Prescott	Yavapai	34° 30′	112° 23′	copper, w/o gold
4	Promontory Butte	Gila	33° 49′	111° 15′	uranium
K5	Pumpkin Center	Gila	31° 17′	110° 42′	uranium
A13	Querces	Santa Cruz	31° 17′	110° 42′	copper porphyry
A14	Quien Sabe	Pima	32° 08′	111° 02′	copper porphyry
F6	Ramsdell	Gila	33° 45′	110° 41′	manganese
D10	Red Rock	Santa Cruz	31° 28′	110° 35′	lead, zinc, silver
A15	Richmond Basin	Gila	33° 29′	110° 45′	copper porphyry
B7	Rincon	Pima	32° 01′	110° 37′	copper, w/o gold
C8	Roosevelt	Gila	33° 42′	111° 10′	gold, w/o copper
F4	Rye Creek	Gila	34° 05′	111° 18′	manganese
D11	San Cayetano	Santa Cruz	31° 28′	110° 57′	lead, zinc, silver
A16	Saginaw Hill	Pima	32° 06′	111° 02′	copper porphyry
D12	Salero	Santa Cruz	31° 33′	110° 50′	lead, zinc, silver
C9	Salt River Mountain	Maricopa	33° 17′	112° 03′	gold, w/o copper
K6	Salt River	Gila	33° 47′	110° 33′	uranium
L2	Seligman Iron	Yavapai	35° 06′	112° 52′	iron
E2	Shea	Yavapai	34° 38′	112° 05′	silver, w/o lead
K7	Sierra Ancha	Gila	33° 49′	110° 59′	uranium
C10	Spring Creek	Gila	34° 03′	111° 04′	gold, w/o lead
A17	Squaw Peak	Yavapai	34° 29′	111° 50′	copper porphyry
A18	Summit	Gila-Pinal	33° 18′	111° 00′	copper porphyry
F7	Sunset	Gila	33° 49′	111° 01′	manganese
C11	Thumb Butte	Yavapai	34° 33′	112° 32′	gold, w/o copper
D13	Tyndall	Santa Cruz	31° 38′	110° 54′	lead, zinc, silver
J5	Verde	Yavapai	34° 33′	112° 06′	copper, cold, silver
H5	Wagner	Gila	33° 32′	110° 59′	tungsten
A19	Washington Camp	Santa Cruz	31° 20′	110° 40′	copper porphyry
C12	Winifred	Maricopa	33° 37′	112° 02′	gold, w/o copper
D14	Wrightson	Santa Cruz	31° 37′	110° 49′	lead, zinc, silver

Source: Keith, Gest, DeWitt, Toll and Everson, 1983.

TABLE C-2. PERCENTAGES OF PRECIOUS METALS EXTRACTED FROM MINED MATERIALS FOR SELECTED MINERAL DISTRICTS IN ARIZONA

(Page 1 of 4)

District No. (Plate 1)	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Molybdenum (Mo)	Silver (Ag)	Uranium (U)	Vanadium (V)	Other Metals
D1	35.6%	58.8%	1.75%	4.2%	<1%	–	–	Gold (Ag) <½%
L1	–	–	–	–	–	–	–	Iron (Fe) 100%
H1	–	–	–	–	–	0.2%	–	Tungsten (W) 99.8%
B1	99.8%	–	–	–	0.2%	–	–	–
F1	–	–	–	–	–	–	–	Manganese (Mn) 100%
A1	91.6%	8.3%	–	–	.1%	–	–	–
J1	99.9%	–	–	–	0.03%			Gold (Ag) <0.5%
H2	–	–	–	–	–	–	–	Tungsten (W) 100%
K9	–	–	–	–	–	100%	–	–
A2	99.9%	<½%	–	–	–	–	–	–
C1	24.5%	<½%	–	–	<1%	–	–	Tungsten (W) 75%, gold (Ag) <½%
H3	97.62%	<1%	–	–	1.6%	–	–	Gold (Ag) <½%
C2	97.06%	<1%	–	–	1.5%	–	–	Gold (Ag) <½%
A4	91.1%	2.4%	6.5%	Reserves	<½%	–	–	Gold (Ag) <½%
K1	–	–	–	–	–	100%	–	Gold (Ag) <1%
A21	99.6%	–	–	–	–	–	–	–
K8					–	100%	–	Tungsten (W) 3.4%
D2	2.3%	94.2%	2.1%	0.3%	1%	–	–	Gold (Ag) <½%, other <1%
K2	–	–	–	–	–	–	–	–
H4	–	–	–	–	–	–	–	Tungsten 100%
F5	–	–	–	–	–	–	–	Manganese 8.5%
A5	99.6%	0.3%	<½%	–	0.5%	–	–	Gold (Ag) <½%
C3	96.3%	–	–	–	1.7%	–	–	Gold (Ag) 2%
J2	<½%	–	<½%	–	<½%	–	–	Gold (Ag) <½%
D3	1%	97%	1.7%	–	<½%	–	–	Gold (Ag) <½%
B3	99.5%	–	–	–	<½%	–	–	Gold (Ag) <½%
A6	1.3%	34.4%	43.8%	–	<½%	–	–	Manganese 20.4%, Gold <½%
D4	8.3%	54.7%	34.2%	–	<½%	–	–	Manganese 1.3%
A7	96%	<½%	2.9%	<½%	<½%	–	–	–

Source: Keith, et al., 1983.

TABLE C-2. PERCENTAGES OF PRECIOUS METALS EXTRACTED FROM MINED MATERIALS FOR SELECTED MINERAL DISTRICTS IN ARIZONA
(Page 2 of 4)

District No. (Plate 1)	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Molyb-denum (Mo)	Silver (Ag)	Uranium (U)	Vanadium (V)	Other Metals
D5	12.8%	54.3%	–	–	<1%	–	–	Gold Aol <½%, Manganese (Mn) 32.4%
A20	97%	–	–	–	2.6%	–	–	–
D7	–	–	–	–	–	–	–	Manganese 100%
C4	10%	82%	7%	–	<1%	–	–	Gold <½%
F2	–	–	–	–	–	–	–	Manganese 100%
K3	–	–	–	–	–	100%	–	–
F3	–	–	–	–	–	–	–	Manganese 100%
E1	99.2%	–	–	–	<1%	–	–	–
D15	12.6%	87.1%	–	–	<½%	–	–	Gold <½%
G2	16.8%	82.4%	–	–	<1%	–	–	Gold <½%, Mercury (Hg)
B5	98.3%	–	–	–	1.6%	–	–	Gold <½%
A7	97.9%	<½%	<½%	1.9%	<½%	–	–	Gold <½%
C5	96%	–	–	–	2.3%	–	–	Gold 1.7%
C6	19.1%	–	–	–	<½%	–	–	Gold <½%, Tungsten 80.5%
D8	<½%	<½%	<½%	–	<½%	–	–	Gold
D16	2.2%	76.8%	<½%	–	1%	<½%	<½%	Gold <½%, Other 20%
A8	11.2%	57%	31.5%	–	<½%	–	–	Gold <½%
D9	28.1%	70.2%	–	–	1%	–	–	Gold <1%
A9	66.5%	33.1%	<½%	–	<½%	–	–	Gold <½%
G1	89.8%	–	–	–	–	–	–	Gold 10.2%, Mercury (Hg)
A10	94.2%	<1%	1.5%	3.3%	<½%	Reserves	–	Gold <½%, Tungsten <½%
A11	55.6%	42.4%	–	–	2.0%	–	–	Gold <½%
A12	92.0%	<½%	3.0%	–	<½%	–	–	Manganese 4.8%
J3	83.3%	16.7%	–	–	–	–	–	–
B6	100%	–	–	–	–	–	–	–
J4	<½%	–	–	–	<½%	–	–	Gold <½%
B7	99.9%	–	–	–	<½%	<½%	–	Gold <½%
K4	–	–	–	–	–	<½%	–	–
K5	–	–	–	–	–	–	–	–

Source: Keith, et al., 1983.

TABLE C-2. PERCENTAGES OF PRECIOUS METALS EXTRACTED FROM MINED MATERIALS FOR SELECTED MINERAL DISTRICTS IN ARIZONA

District No. (Plate 1)	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Molybdenum (Mo)	Silver (Ag)	Uranium (U)	Vanadium (V)	Other Metals
A13	99.9%	–	–	–	<½%	–	–	Gold <½%
A14	96.5%	3.4%	–	–	<½%	–	–	Gold <½%
F6	–	–	–	–	–	–	–	Manganese 100%
D10	44.2%	48.7%	6.6%	–	<½%	–	–	Gold <½%
A15	16.7%	11.1%	–	–	5.6%	–	–	Gold <½%, 66% Manganese
B7	92.7%	7.1%	–	–	<½%	–	–	Gold <½%
C8	–	–	–	–	–	–	–	Gold <½%
F4	–	–	–	–	–	–	–	Gold 100%
D11	<½%	<½%	<½%	–	<½%	–	–	Gold 1.7%
A16	31.0%	20.9%	46.7%	–	1.4%	–	–	Gold <½%
D12	11.1%	85.6%	2.9%	–	<½%	–	–	Gold <½%
C9	97.1%	–	–	–	1.2%	–	–	Gold 1.7%
K6	–	–	–	–	–	100%	–	–
L2	–	–	–	–	–	–	–	Iron (Fe)
E2	94.2%	–	–	–	5.7%	–	–	Gold <½%
K7	–	–	–	–	–	100%	–	–
C10	14.9%	44.8%	–	–	<½%	–	–	Gold <½%, Tungsten 40%
A17	24.6%	66.8%	<½%	7.8	<1%	–	–	Gold <½%
A18	99.9%	<½%	–	–	<½%	–	–	Gold <½%, Tungsten <½%
F7	–	–	–	–	–	–	–	Manganese 100%
C11	97.3%	–	–	–	<1%	–	–	Gold 2.0%
D13	<1%	67.9%	31.3%	–	<½%			Gold <½%

Source: Keith, et al., 1983.

TABLE C-2. PERCENTAGES OF PRECIOUS METALS EXTRACTED FROM MINED MATERIALS FOR SELECTED MINERAL DISTRICTS IN ARIZONA

District No. (Plate 1)	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Molyb-denum (Mo)	Silver (Ag)	Uranium (U)	Vanadium (V)	Other Metals
J5	97.3%	<½%	2.6%	--	<1%	--	--	Gold <½%
H5	--	--	--	--	--	--	--	Tungsten 100%
A19	22.6%	26.2%	51.0%	--	<½%	--	--	Gold <½%
C12	94.7%	<1%	--	--	1.3%	--	--	Gold 3.2%
D14	41%	36.5%	22.3%	--	<½%	--	--	Gold <½%

Source: Keith, et al., 1983.

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AT THE
STEWART & STEVENSON INTEGRATION CENTER
HOUSTON, TEXAS
JULY 29-30 AND SEPTEMBER 1, 2021

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certify that this testing was conducted and this report was created in conformance with the requirements of ASTM D7036

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APPENDICES

Stack Emissions Study
Caterpillar, G3520 TALE
Catalytic Combustion Corporation
Stewart & Stevenson Integration Center
Houston, Texas
July 29-30 and September 1, 2021

1.0 INTRODUCTION

Air Hygiene International, Inc. (Air Hygiene) has completed the Stack Emissions Study for nitrogen oxides (NOx), carbon monoxide (CO), total hydrocarbons/volatile organic compounds (THC/VOC), ammonia (NH_3), particulate matter (PM), acetaldehyde (C_2H_4O), formaldehyde (HCHO), methane (CH_4), ethane (C_2H_6), nitrous oxide (N_2O), and carbon dioxide (CO_2) from the exhaust of the Caterpillar, G3520 TALE for Catalytic Combustion Corporation at the Stewart & Stevenson Integration Center in Houston, Texas. This report details the background, results, process description, and the sampling/analysis methodology of the stack sampling survey conducted on July 29-30 and September 1, 2021.

1.1 TEST PURPOSE AND OBJECTIVES

The purpose of the test was to conduct an emission test to document levels of selected pollutants at three test loads (50, 75, and 100 percent). The information will be used to confirm the emissions controls meet certain emission levels. The specific objective was to determine the emission concentration of NOx, CO, THC/VOC, NH_3, PM, C_2H_4O, HCHO, CH_4, C_2H_6, N_2O, and CO_2 from the exhaust of Catalytic Combustion Corporation's Caterpillar, G3520 TALE.

1.2 SUMMARY OF TEST PROGRAM

The following list details pertinent information related to this specific project:

1.2.1 Participating Organizations
- Catalytic Combustion Corporation
- Air Hygiene

1.2.2 Industry
- Catalyst Manufacturing

1.2.3 Plant Location
- Stewart & Stevenson Integration Center in Houston, Texas
  - GPS Coordinates [Latitude 29.93248, Longitude -95.64816]
  - Physical Address: 10750 Telge Road, Houston, Texas

1.2.4 Equipment Tested
- Caterpillar, G3520 TALE

1.2.5 Emission Points
- Exhaust from the Caterpillar, G3520 TALE
- For all gases, three sample points in the exhaust stack from the Caterpillar, G3520 TALE, at 16.7, 50.0, and 83.3 percent of the diameter
- For all PM testing, 24 sampling points in the exhaust stack from the Caterpillar, G3520 TALE

1.2.6 Emission Parameters Measured

- NOx
- CO
- THC/VOC
- NH_3
- PM
- C_2H_4O
- HCHO
- CH_4
- C_2H_6
- N_2O
- Flow
- H_2O
- CO_2
- O_2

1.2.7 Dates of Emission Test

- July 29-30 and September 1, 2021

1.2.8 Federal and State Certifications

- Stack Testing Accreditation Council AETB Certificate No. 3796.02
- International Standard ISO/IEC 17025:2005 Certificate No. 3796.01
- Texas NELAP Accreditation No. T104704523; Mobile Lab No. 1M104704523

1.3 KEY PERSONNEL

Catalytic Combustion Corporation:	Randy Sadler (rsadler@catalyticcombustion.com)	678-691-7214
Catalytic Combustion Corporation:	Kati Sedlacek (ksedlacek@catalyticcombustion.com)	678-691-7214
Air Hygiene:	Pat McGovern, Jr. (pmcgovern@airhygiene.com)	918-307-8865
Air Hygiene:	Matt McBride (mmcbride@airhygiene.com)	918-307-8865
Air Hygiene:	Chandler King	918-307-8865
Air Hygiene:	Pat McGovern, Sr.	918-307-8865
Air Hygiene:	Wade Nesom	918-307-8865
Air Hygiene:	Jeff Wollrab	918-307-8865

2.0 SUMMARY OF TEST RESULTS

Results from the sampling conducted on Catalytic Combustion Corporation’s Caterpillar, G3520 TALE located at the Stewart & Stevenson Integration Center on July 29-30 and September 1, 2021 are summarized in the following table and relate only to the items tested.

All testing was performed without any real or apparent errors. All testing was conducted according to the approved testing protocol with the exception of a second mobilization to conduct the 100 percent load testing.

TABLE 2.1
SUMMARY OF CATERPILLAR, G3520 TALE RESULTS

Parameter	50% Load	75% Load	100% Load
Date (mm/dd/yy)	07/29/21	07/30/21	09/01/21
Engine Fuel Flow (SCFH)	14,559	20,455	26,278
Power Output (horsepower)	1,811.2	2,668.6	3,598.0
NOx (as NO_2) (ppmvd)	7.24	6.26	9.81
NOx (as NO_2) (ppm@15%O_2)	3.51	3.09	4.86
NOx (as NO_2) (g/kW*hr)	0.0627	0.0526	0.0787
NO (ppmvd)	7.24	6.23	8.87
NO (ppm@15%O_2)	3.51	3.08	4.19
NO (g/kW*hr)	0.0408	0.0341	0.0465
NO (as NO_2) (g/kW*hr)	0.0626	0.0523	0.0713
NO_2 (ppmvd)	0.00	0.03	0.94
NO_2 (ppm@15%O_2)	0.00	0.02	0.68
NO_2 (g/kW*hr)	0.0000	0.0003	0.0075
CO (ppmvd)	6.14	3.68	2.71
CO (ppm@15%O_2)	2.98	1.81	1.33
CO (g/kW*hr)	0.0323	0.0188	0.0131
THC (as C_3H_8) (ppmvd)	190.48	188.10	110.21
THC (as C_3H_8) (ppm@15%O_2)	79.07	80.06	47.36
THC (as C_3H_8) (g/kW*hr)	1.35	1.30	0.73
VOC (as C_3H_8) (ppmvd)	5.38	4.11	0.00
VOC (as C_3H_8) (ppm@15%O_2)	2.23	1.75	0.00
VOC (as C_3H_8) (g/kW*hr)	0.0381	0.0285	0.0000
CH_4 (as C_3H_8) (ppmvd)	184.80	183.55	167.60
CH_4 (as C_3H_8) (ppm@15%O_2)	89.63	90.62	82.95
CH_4 (as C_3H_8) (g/kW*hr)	1.5320	1.4779	1.2884
C_2H_6 (as C_3H_8) (ppmvd)	0.31	0.43	0.24
C_2H_6 (as C_3H_8) (ppm@15%O_2)	0.15	0.21	0.12
C_2H_6 (as C_3H_8) (g/kW*hr)	0.0025	0.0035	0.0019
Total PM (mg)	14.10	6.27	3.48
Total PM (gr/dscf)	6.18E-03	1.91E-03	9.15E-04
Total PM (lb/hr)	0.22	0.10	0.06
Total PM (g/kW*hr)	0.0730	0.0221	0.0020
N_2O (ppmvd)	1.87	1.75	1.45
N_2O (ppm@15%O_2)	0.91	0.86	0.71
N_2O (g/kW*hr)	0.0155	0.0140	0.0110
C_2H_4O (ppmvd)	1.74	3.16	0.94
C_2H_4O (ppm@15%O_2)	0.85	1.56	0.46
C_2H_4O (g/kW*hr)	0.0145	0.0255	0.0071
HCHO (ppmvd)	0.07	0.00	0.91
HCHO (ppm@15%O_2)	0.04	0.00	0.45
HCHO (g/kW*hr)	0.0004	0.0000	0.0047
NH_3 (ppmvd)	0.47	16.79	5.56
NH_3 (ppm@15%O_2)	0.23	8.29	2.80
NH_3 (g/kW*hr)	0.0015	0.0522	0.0168
CO_2 (%)	6.72	6.59	6.64
CO_2 (g/kW*hr)	556	530	509

catc-21-houston.tx-start#1-rpt-v2

3.0 SOURCE OPERATION

3.1 PROCESS DESCRIPTION

Catalytic Combustion Corporation is a provider of catalyst, air correction devices, and exhausts with products used to reduce the output of volatile organic compounds (VOCs). The interest of this test report is one caterpillar natural gas fired internal combustion engine located at the Stewart & Stevenson Integration Center in Houston, Texas.

3.2 SAMPLING LOCATION

The engine exhausts to the atmosphere through an independent stack. A stack extension was fabricated on-site and added prior to the test, the extension and installed test ports met the required EPA Method 1 criteria of at least 0.5 duct diameters (dd) upstream and 2.0 dd downstream from the nearest disturbances. The sampling ports are approximately 27 feet above ground level. A fuel flow meter is located on the unit. Catalytic Combustion Corporation provided an aerial lift to access the stack ports.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

The emission test on the Caterpillar, G3520 TALE at the Stewart & Stevenson Integration Center was performed following United States Environmental Protection Agency (EPA) methods described by the Code of Federal Regulations (CFR). Table 4.1 outlines the specific methods performed on July 29-30 and September 1, 2021.

TABLE 4.1
SUMMARY OF SAMPLING METHODS

Pollutant or Parameter	Sampling Method	Analysis Method
Sample Point Location	EPA Method 1	Equal Area Method
Stack Flow Rate	EPA Method 2	S-Type Pitot Tube
Oxygen	EPA Method 3A	Paramagnetic Cell
Stack Moisture Content	EPA Method 4	Gravimetric Analysis
Particulate Matter	EPA Method 5	Front Half Filterables
Stack Flow Rate	EPA Method 19	Dry Oxygen F Factor
Total Hydrocarbons	EPA Method 25A	Flame Ionization Detector
Particulate Matter	EPA Method 202	Back Half Condensables

Pollutant or Parameter	Sampling Method	Analysis Method
Nitrogen Oxides, Carbon Monoxide, Ammonia, Acetaldehyge, Formaldehyde, Methane, Ethane, Nitrous Oxide, Carbon Dioxide, and Moisture	EPA Method 320	Fourier Transform Infrared

4.2 INSTRUMENT CONFIGURATION AND OPERATIONS FOR GAS ANALYSIS

The sampling and analysis procedures used during these tests conform with the methods outlined in the Code of Federal Regulations (CFR), Title 40, Part 60, Appendix A, Methods 1, 2, 3A, 4, 5, 19, 25A; 40 CFR 51, Appendix M, Method 202; and 40 CFR 63, Appendix A, Method 320.

Figure 4.1 depicts the sample system used for the real-time gas analyzer tests. The gas sample was continuously pulled through the probe and transported, via heat-traced Teflon® tubing, to a heated head pump and into the FTIR then to a stainless-steel minimum-contact condenser designed to dry the sample. Transportation of the sample, through Teflon® tubing, continued into the sample manifold within the mobile laboratory via a stainless steel/Teflon® diaphragm pump. From the manifold, the sample was partitioned to the real-time analyzers through rotameters that controlled the flow rate of the sample. Exhaust samples were routed to the wet based analyzer prior to gas conditioning.

Figure 4.1 shows that the sample system was also equipped with a separate path through which a calibration gas could be delivered to the probe and back through the entire sampling system. This allowed for convenient performance of system bias checks as required by the testing methods.

All instruments were housed in a climate controlled, trailer-mounted mobile laboratory. Gaseous calibration standards were provided in aluminum cylinders with the concentrations certified by the vendor. EPA Protocol No. 1 was used to determine the cylinder concentrations where applicable (i.e., C_3H_8 calibration gases).

Table 4.2 provides a description of the analyzers used for the instrument portion of the tests. All data from the continuous monitoring instruments were recorded on a Logic Beach Portable Data Logging System which retrieves calibrated electronic data from each instrument every one second and reports an average of the collected data every 30 seconds. For target compounds measured with the Fourier transform infrared (FTIR) spectrometer, interferograms consisting of 30 co-added scans were recorded continuously during the test periods, and provided approximately 30-second average concentrations. Spectral data was analyzed by the MKS MG2000 software.

Figure 4.2 represents the sample system used for the PM tests. A heated stainless-steel probe with a glass liner and stainless-steel nozzle was inserted into the sample ports of the stack to extract gas measurements from the emission stream through a filter and glass impinger train. Flow rates are monitored with oil filled manometers and total sample volumes are measured with a dry gas meter. Glassware that is used to collect and analyze Method 202 condensable particulate samples is cleaned prior to the test with soap and water, and rinsed using tap water, deionized water, acetone, and finally, hexane. After cleaning, Air Hygiene incorporates a glassware bake at 300^{o}C for six hours rather than the alternative of collecting a field train proof blank.

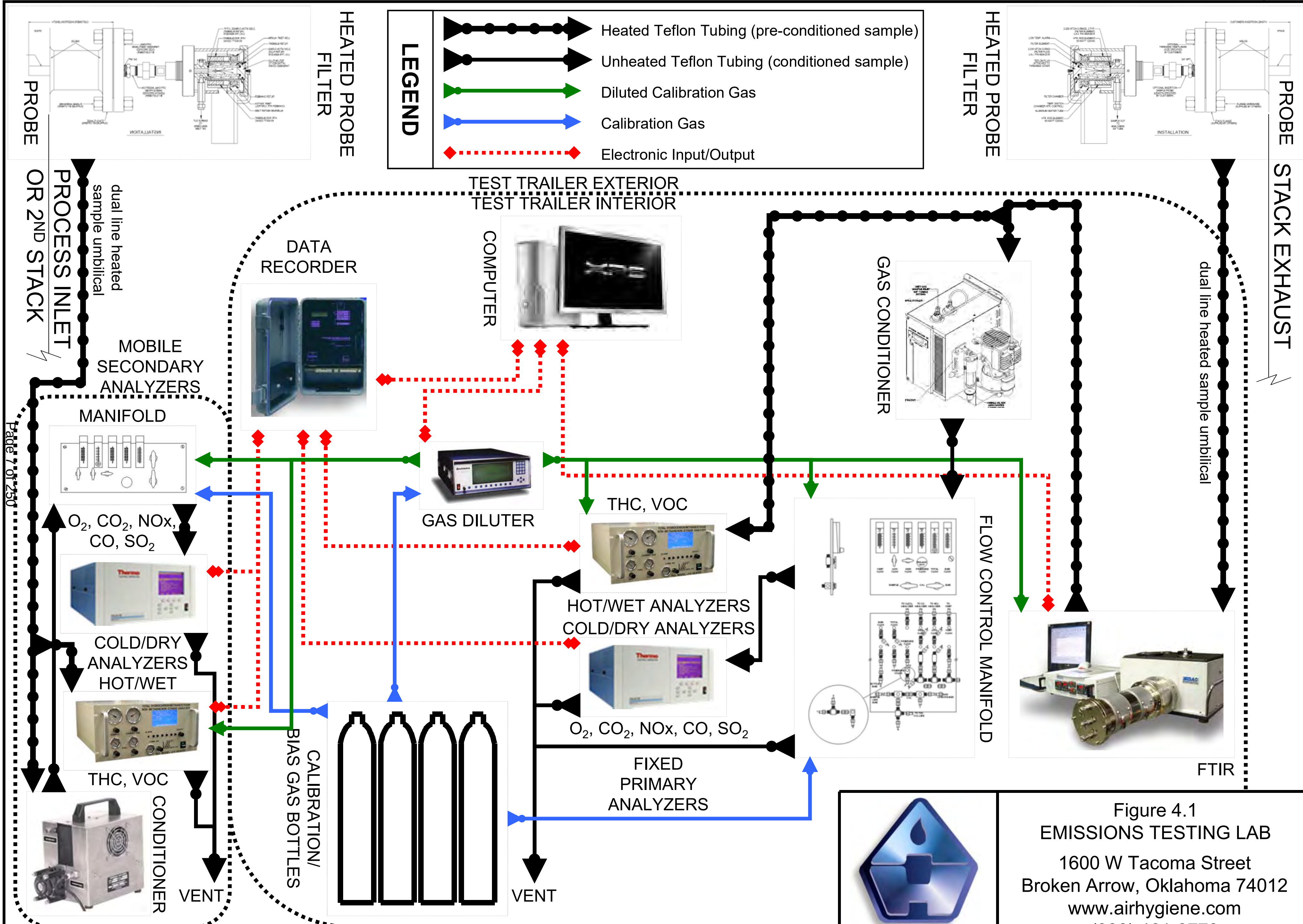
The stack gas analysis for O_2 concentrations was performed in accordance with procedures set forth in EPA Method 3A. The O_2 analyzer uses a paramagnetic cell detector.

THC emission concentrations were quantified in accordance with procedures set forth in EPA Method 25A. A continuous flame ionization (FID) analyzer was used for this purpose. VOC emission concentrations were quantified in conjunction with procedures outlined in EPA Method 320 for FTIR sampling and analysis of methane and ethane content. These results were then subtracted from the THC concentrations to determine VOC concentrations.

An MKS Instruments - MultiGas™ Fourier Transform Infrared (FTIR) spectrometer was used for NOx, CO, NH_3, C_2H_4O, HCHO, CH_4, C_2H_6, N_2O, CO_2 and H_2O analysis per EPA Method 320. The FTIR spectrometer spectral resolution was 0.5 cm^{-1}. The system employed a silicon carbide infrared source at 1200ºC, a helium neon reference laser, beam splitters, potassium bromide (KBr) cell window, front-surface optical transfer mirrors, and multi-pass absorption cells. MCT detectors were used and cooled with liquid nitrogen in order to maintain a constant temperature of 77 Kelvin. The approximately 5.11-meter multi-pass path cells incorporated aspheric, aberration-correcting mirrors to increase the optical throughput and the detection sensitivity. Transducers and thermocouples were connected directly to the insulated sample cells that provide the pressure and temperatures of the sample streams. During testing, the temperature of the absorption cells was set at 191ºC. Elevated temperature prevented gas condensation within the cell and minimized compound adhesion to the cell walls and mirrors. The volume of the absorption cell was 0.5 liters, so at a sample gas flow rate of 4.0 liters per minute, the sample gas in the cell is refreshed approximately four times each minute. Interferograms consisting of 30 co-added scans were recorded continuously during the test periods, and provided approximately 30-second average concentrations.

TABLE 4.2
ANALYTICAL INSTRUMENTATION

Parameter	Manufacturer and Model	Range	Sensitivity	Detection Principle
NOx, CO, NH_3, C_2H_4O, HCHO, CH_4, C_2H_6, N_2O, CO_2, H_2O	MKS 2030	User may select from multiple ranges	0.1 ppm	Fourier Transform Infrared – FTIR
THC	VIG 210	User may select up to 10,000 ppm	0.1 ppm	Flame Ionization Detector
O_2	SERVOMEX 1440	0-25%	0.1%	Paramagnetic cell, inherently linear.

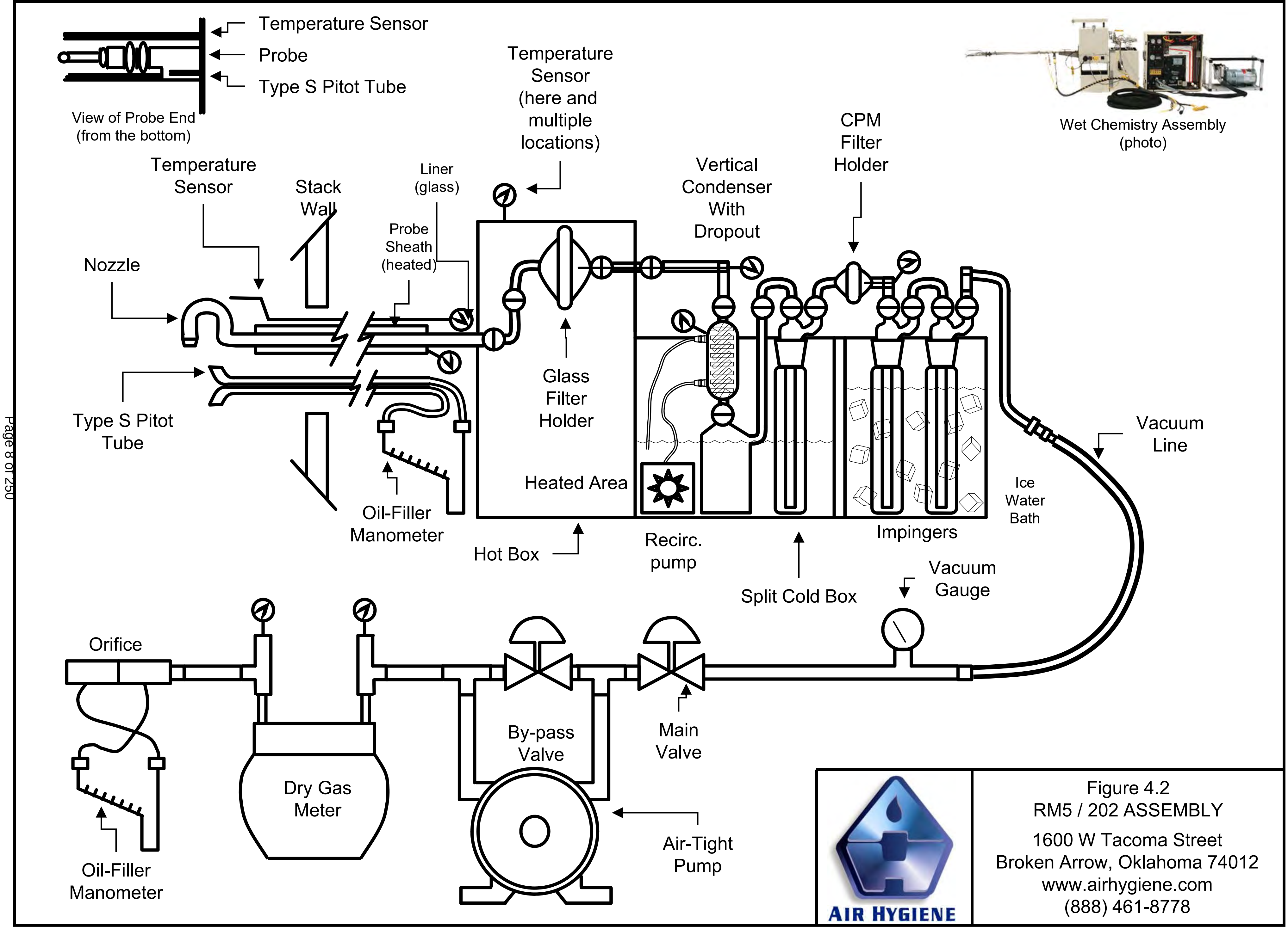


Shown fully equipped. Some labs may not contain these features and others may contain additional features specific to certain scopes.

AIR HYGIENE

Figure 4.1
EMISSIONS TESTING LAB

1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
www.airhygiene.com
(888) 461-8778



Temperature Sensor
Probe
Type S Pitot Tube
View of Probe End (from the bottom)
Temperature Sensor (here and multiple locations)
Wet Chemistry Assembly (photo)
Temperature Sensor
Stack Wall
Liner (glass)
Probe Sheath (heated)
Nozzle
Type S Pitot Tube
Oil-Filler Manometer
Vertical Condenser With Dropout
CPM Filter Holder
Glass Filter Holder
Heated Area
Hot Box
Recirc. pump
Split Cold Box
Impingers
Ice Water Bath
Vacuum Line
Vacuum Gauge
Orifice
Dry Gas Meter
By-pass Valve
Main Valve
Air-Tight Pump
Oil-Filler Manometer
AIR HYGIENE
Figure 4.2
RM5 / 202 ASSEMBLY
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
www.airhygiene.com
(888) 461-8778

APPENDIX A

TEST RESULTS AND CALCULATIONS

TABLE A.1: EMISSIONS TESTING SCHEDULE

Unit	Load	Component	Run	Date	Start	Stop	Time Sync	Duration
G3520 TALE	50%	Stratification Test	1	07/29/21	11:00	12:10	DAHS	01:10
G3520 TALE	50%	NOx, CO, THC, etc.	1-1	07/29/21	09:34	10:33	DAHS	01:00
G3520 TALE	50%	NOx, CO, THC, etc.	1-2	07/29/21	12:05	13:04	DAHS	01:00
G3520 TALE	50%	NOx, CO, THC, etc.	1-3	07/29/21	14:23	15:22	DAHS	01:00
							DAHS	
G3520 TALE	50%	Cyc. Flow Chk.	R-1 50%-V1	07/28/21	08:46	08:59	DAHS	00:13
G3520 TALE	50%	PM	R-1 50%-1	07/29/21	09:34	11:24	DAHS	01:50
G3520 TALE	50%	PM	R-1 50%-2	07/29/21	12:05	13:59	DAHS	01:54
G3520 TALE	50%	PM	R-1 50%-3	07/29/21	14:23	15:58	DAHS	01:35
							DAHS	
G3520 TALE	75%	NOx, CO, THC, etc.	2-1	07/30/21	13:45	14:44	DAHS	01:00
G3520 TALE	75%	NOx, CO, THC, etc.	2-2	07/30/21	15:00	15:59	DAHS	01:00
G3520 TALE	75%	NOx, CO, THC, etc.	2-3	07/30/21	16:27	17:26	DAHS	01:00
							DAHS	
G3520 TALE	75%	PM	R-1 75%-1	07/30/21	08:08	09:42	DAHS	01:34
G3520 TALE	75%	PM	R-1 75%-2	07/30/21	13:17	14:56	DAHS	01:39
G3520 TALE	75%	PM	R-1 75%-3	07/30/21	15:25	17:01	DAHS	01:36
G3520 TALE	100%	NOx, CO, THC, etc.	3-1	09/01/21	09:23	10:25	DAHS	01:02
G3520 TALE	100%	NOx, CO, THC, etc.	3-2	09/01/21	10:26	12:02	DAHS	01:37
G3520 TALE	100%	NOx, CO, THC, etc.	3-3	09/02/21	12:03	13:06	DAHS	01:03
G3520 TALE	100%	Cyc. Flow Chk.	R-1 100%-V1	08/31/21	07:14	07:38	DAHS	00:24
G3520 TALE	100%	PM	R-1 100%-1	08/31/21	09:36	11:17	DAHS	01:41
G3520 TALE	100%	PM	R-1 100%-2	08/31/21	12:05	13:44	DAHS	01:39
G3520 TALE	100%	PM	R-1 100%-3	08/31/21	14:24	16:05	DAHS	01:41

TEST RESULTS AND CALCULATIONS

50% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O Emissions Data

CATERPILLAR, G3520 TALE 50% LOAD DATA SUMMARY

Parameter	50% Load, Run - 1-1	50% Load, Run - 1-2	50% Load, Run - 1-3	Average
Date (mm/dd/yy)	07/29/21	07/29/21	07/29/21	07/29/21
Start Time (hh:mm:ss)	9:34:23	12:05:23	14:23:23	9:34:23
End Time (hh:mm:ss)	10:33:53	13:04:53	15:22:53	15:22:53
Run Duration (min / run)	60	60	60	60
Bar. Pressure (in. Hg)	29.90	29.90	29.84	29.88
Amb. Temp. (°F)	98	99	96	98
Rel. Humidity (%)	53	49	49	50
Spec. Humidity (lb water / lb air)	0.020978	0.019455	0.018009	0.019481
Engine Fuel Flow (SCFH)	14,625	14,511	14,541	14,559
Stack Flow (RM19) (SCFH)	215,406	215,084	216,383	215,625
Stack Moisture (% Method 320)	14.4	14.4	14.4	14.4
Power Output (horsepower)	1,810.4	1,813.0	1,810.4	1,811.2
Engine Timing (BTDC)	23.0	23.0	23.0	23.00
Actual Power (kW)	1,350.0	1,352.0	1,350.0	1,350.67
Amperes (A)	56.0	57.0	56.0	56.33
Air Manifold Temp. (F)	122.0	122.0	124.0	122.67
Engine Speed (rpm)	1,799.0	1,799.0	1,800.0	1,799.33
NOx (as NO_2) (ppmvd)	8.15	6.92	6.67	7.24
NOx (as NO_2) (ppm@15%O_2)	3.93	3.36	3.25	3.51
NOx (as NO_2) (g/kW*hr)	0.0704	0.0596	0.0579	0.06
NO (ppmvd)	8.15	6.91	6.67	7.24
NO (ppm@15%O_2)	3.93	3.35	3.25	3.51
NO (g/kW*hr)	0.0459	0.0388	0.0378	0.0408
NO_2 (ppmvd)	0.00	0.01	0.00	0.00
NO_2 (ppm@15%O_2)	0.00	0.00	0.00	0.00
NO_2 (g/kW*hr)	0.0000	0.0001	0.0000	0.0000
CO (ppmvd)	6.03	5.97	6.40	6.14
CO (ppm@15%O_2)	2.91	2.90	3.12	2.98
CO (g/kW*hr)	0.03	0.03	0.03	0.03
THC (as C_3H_8) (ppmvd)	183.85	190.60	197.00	190.48
THC (as C_3H_8) (ppm@15%O_2)	75.89	79.16	82.17	79.07
THC (as C_3H_8) (g/kW*hr)	1.30	1.34	1.40	1.35
VOC (as C_3H_8) (ppmvd)	4.67	4.59	6.87	5.38
VOC (as C_3H_8) (ppm@15%O_2)	1.93	1.91	2.86	2.23
VOC (as C_3H_8) (g/kW*hr)	0.03	0.03	0.05	0.04
CH_4 (as C_3H_8) (ppmvd)	178.78	185.57	190.04	184.80
CH_4 (as C_3H_8) (ppm@15%O_2)	86.22	90.07	92.60	89.63
CH_4 (as C_3H_8) (g/kW*hr)	1.4813	1.5330	1.5817	1.5320
C_2H_6 (as C_3H_8) (ppmvd)	0.40	0.44	0.09	0.31
C_2H_6 (as C_3H_8) (ppm@15%O_2)	0.19	0.21	0.04	0.15
C_2H_6 (as C_3H_8) (g/kW*hr)	0.0033	0.0036	0.0007	0.0025
N_2O (ppmvd)	1.59	1.97	2.05	1.87
N_2O (ppm@15%O_2)	0.77	0.95	1.00	0.907
N_2O (g/kW*hr)	0.0132	0.0162	0.0170	0.0155
C_2H_4O (ppmvd)	0.52	0.68	4.04	1.74
C_2H_4O (ppm@15%O_2)	0.25	0.33	1.97	0.848
C_2H_4O (g/kW*hr)	0.0043	0.0056	0.0336	0.0145
HCHO (ppmvd)	0.11	0.07	0.05	7.48E-02
HCHO (ppm@15%O_2)	0.05	0.03	0.02	3.62E-02
HCHO (g/kW*hr)	0.0006	0.0004	0.0003	0.0004
NH_3 (ppmvd)	0.54	0.29	0.57	0.47
NH_3 (ppm@15%O_2)	0.26	0.14	0.28	0.23
NH_3 (g/kW*hr)	0.0017	0.0009	0.0018	0.0015
CO_2 (%)	6.71	6.69	6.75	6.72
CO_2 (lb/hr)	1,651.80	1,643.88	1,669.41	1,655.03
CO_2 (lb/kW*hr)	1,223.58	1,215.91	1,236.62	1,225.37
CO_2 (ton/year) at 8760 hr/year	7,234.89	7,200.20	7,312.00	7,249.03
CO_2 (lb/MMBtu)	115.56	115.56	115.56	115.56
CO_2 (g/kW*hr)	555.01	551.53	560.92	555.82
O_2 (%)	8.67	8.74	8.79	8.73

Calculations, Formulas, and Constants

The following information supports the spreadsheets for this testing project.

Given Data:

Ideal Gas Conversion Factor = 385.23 SCF/lb-mol at 68 deg F & 14.696 psia

Fuel Heating Value is based upon Air Hygiene's fuel gas calculation sheet. All calculations are based upon a correction to 68 deg F & 14.696 psia

High Heating Values (HHV) are used for the Fuel Heating Value, F-Factor, and Fuel Flow Data per EPA requirements.

ASTM D 3588		40CFR60, App. A., RM 19, Table 19-1	
Molecular Weight of NOx (lb/lb-mole) =	46.01	Conversion Constant for NOx =	0.0000001194351
Molecular Weight of CO (lb/lb-mole) =	28.00	Conversion Constant for CO =	0.0000000726839
Molecular Weight of N2O (lb/lb-mole) =	64.00	Conversion Constant for N2O =	0.0000001661345
Molecular Weight of THC (propane) (lb/lb-mole) =	44.00	Conversion Constant for THC =	0.0000001142175
Molecular Weight of VOC (methane) (lb/lb-mole) =	16.00	Conversion Constant for VOC (methane) =	0.0000000415336
Molecular Weight of NH_3 (lb/lb-mole) =	17.03	Conversion Constant for NH_3 =	0.0000000442074
Molecular Weight of HCHO (lb/lb-mole) =	30.03	Conversion Constant for HCHO =	0.0000000779534
Molecular Weight of CO_2 (lb/lb-mole) =	44.01	Conversion Constant for CO_2 =	0.0000001142434

NOTE: units are lb/ppm*ft^3

Formulas:

1. Corrected Raw Average (C_{Gas}), 40CFR60, App. A, RM 7E, Eq. 7E-5 (08/15/06)

$$C_{Gas} = (C_{Avg} - C_O) \times \left(\frac{C_{MA}}{C_M - C_O} \right)$$

2. Correction to % O_2, 40CFR60, App. A, RM 20, Eq. 20-5 (11/26/02)

$$C_{adj} = C_{Gas(Target)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}} \right)$$

3. Correction to % O_2 and ISO Conditions

$$C_{ISO} = C_{Adj} \times \sqrt{\frac{P_r}{P_o}} \times e^{(19 \times (H_O - 0.00633))} \times \left(\frac{288}{T_a} \right)^{1.53}$$

4. Method 19 stack exhaust flow (scfh) [ref. EPA EMC FAQ Method 19]

$$Q_S = \left(\frac{FFactor \times Q_f \times HHV}{1{,}000{,}000} \right) \times \left(\frac{20.9\%}{20.9\% - C_{Gas(O2)}} \right)$$

5. Emission Rate in lb/hr

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

6. Emission Rate in tons per year

$$E_{ton/yr} = \frac{E_{lb/hr} \times hr_{year}}{2000}$$

7. Emission Concentration in lb/MMBtu (O_2 based)

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 20.9\%}{20.9\% - C_{Gas(O2)}}$$

8. Emission Concentration in g/hp*hr

$$E_{g/hp\text{-}hr} = \frac{E_{lb/hr} \times 453.6}{mw \times 1341.022} \; or \; \frac{E_{lb/hr} \times 453.6}{hp}$$

RM 7E, (08-15-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

ACE = Analyzer calibration error, percent of calibration span.
B_{WS} = Moisture content of sample gas as measured by Method 4 or other approved method, percent/100.
C_{Avg} = Average unadjusted gas concentration indicated by data recorder for the test run.
C_D = Pollutant concentration adjusted to dry conditions.
C_{Dir} = Measured concentration of a calibration gas (low, mid, or high) when introduced in direct calibration mode.
C_{Gas} = Average effluent gas concentration adjusted for bias.
C_M = Average of initial and final system calibration bias (or 2-point system calibration error) check responses for the upscale calibration gas.
C_{MA} = Actual concentration of the upscale calibration gas, ppmv.
C_O = Average of the initial and final system calibration bias (or 2-point system calibration error) check responses from the low-level (or zero) calibration gas.
C_S = Measured concentration of a calibration gas (low, mid, or high) when introduced in system calibration mode.
C_{SS} = Concentration of NOx measured in the spiked sample.
C_{Spike} = Concentration of NOx in the undiluted spike gas.
C_{Calc} = Calculated concentration of NOx in the spike gas diluted in the sample.
C_V = Manufacturer certified concentration of a calibration gas (low, mid, or high).
C_W = Pollutant concentration measured under moist sample conditions, wet basis.
CS = Calibration span.
D = Drift assessment, percent of calibration span.
E_p = The predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level response.
Eff_{NO2} = NO_2 to NO converter efficiency, percent.
H = High calibration gas, designator.
L = Low calibration gas, designator.
M = Mid calibration gas, designator.
NOFinal = The average NO concentration observed with the analyzer in the NO mode during the converter efficiency test in Section 16.2.2.
NOxCorr = The NOx concentration corrected for the converter efficiency.
NOxFinal = The final NOx concentration observed during the converter efficiency test in Section 16.2.2.
NOxPeak = The highest NOx concentration observed during the converter efficiency test in Section 16.2.2.
Q_{Spike} = Flow rate of spike gas introduced in system calibration mode, L/min.
Q_{Total} = Total sample flow rate during the spike test, L/min.
R = Spike recovery, percent.
SB = System bias, percent of calibration span.
SB_i = Pre-run system bias, percent of calibration span.
SB_f = Post-run system bias, percent of calibration span.
SB / D_{Alt} = Alternative absolute difference criteria to pass bias and/or drift checks.
SCE = System calibration error, percent of calibration span.
SCE_i = Pre-run system calibration error, percent of calibration span.
SCE_{final} = Post-run system calibration error, percent of calibration span.
Z = Zero calibration gas, designator.

40CFR60.355(b)(1), (09-20-06), Nomenclature. The terms used in the equations are defined as follows:

P_r = reference combustor inlet absolute pressure at 101.3 kilopascals ambient pressure, mm Hg
P_o = observed combustor inlet absolute pressure at test, mm Hg
H_o = observed humidity of ambient air, g H_2O/g air
e = transcendental constant, 2.718
T_a = ambient temperature, K

Small Engine and FTIR Nomenclature. The terms used in the equations are defined as follows:

bhp = brake horsepower
hp = horsepower
Q_{sys} = system flow (lpm)
Q_m = matrix spike flow (lpm)

RM 19, (07-29-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

AdjFactor = Percent oxygen or carbon dioxide adjustment applied to a target pollutant
B_{wa} = Moisture fraction of ambient air, percent.
Btu = British thermal unit
$\%_C$ = Concentration of carbon from an ultimate analysis of fuel, weight percent.
$\%_{CO2d}$,$\%_{CO2w}$ = Concentration of carbon dioxide on a dry and wet basis, respectively, percent.
CIP / CDP = Combustor inlet pressure / compressor discharge pressure (mm Hg); note, some manufactures reference as PCD.
E = Pollutant emission rate, ng/J (lb/million Btu).
E_a = Average pollutant rate for the specified performance test period, ng/J (lb/million Btu).
E_{ao}, E_{ai} = Average pollutant rate of the control device, outlet and inlet, respectively, for the performance test period, ng/J (lb/million Btu).
E_{bi} = Pollutant rate from the steam generating unit, ng/J (lb/million Btu).
E_{bo} = Pollutant emission rate from the steam generating unit, ng/J (lb/million Btu).
E_{ci} = Pollutant rate in combined effluent, ng/J (lb/million Btu).
E_{co} = Pollutant emission rate in combined effluent, ng/J (lb/million Btu).
E_d = Average pollutant rate for each sampling period (e.g.,24-hr Method 6B sample or 24-hr fuel sample) or for each fuel lot (e.g., amount of fuel bunkered), ng/J (lb/million E
E_{di} = Average inlet SO_2 rate for each sampling period d, ng/J (lb/million Btu).
E_g = Pollutant rate from gas turbine, ng/J (lb/million Btu).
E_{ga} = Daily geometric average pollutant rate, ng/J (lbs/million Btu) or ppm corrected to 7 percent O_2.
E_{jo},E_{ji} = Matched pair hourly arithmetic average pollutant rate, outlet and inlet, respectively, ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
E_h = Hourly average pollutant, ng/J (lb/million Btu).
E_{hj} = Hourly arithmetic average pollutant rate for hour "j," ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
EXP = Natural logarithmic base (2.718) raised to the value enclosed by brackets.
Fc = Ratio of the volume of carbon dioxide produced to the gross calorific value of the fuel from Method 19
F_d, F_w, F_c = Volumes of combustion components per unit of heat content, scm/J (scf/million Btu).
ft^3 = cubic feet
G = ideal gas conversion factor
(385.23 SCF/lb-mol at 68 deg F & 14.696 psia)
GCM = gross Btu per SCF (constant, compound based)
GCV = Gross calorific value of the fuel consistent with the ultimate analysis, kJ/kg (Btu/lb).
GCV_p, GCV_r = Gross calorific value for the product and raw fuel lots, respectively, dry basis, kJ/kg (Btu/lb).
$\%_H$ = Concentration of hydrogen from an ultimate analysis of fuel, weight percent.
H_b = Heat input rate to the steam generating unit from fuels fired in the steam generating unit, J/hr (million Btu/hr).
H_g = Heat input rate to gas turbine from all fuels fired in the gas turbine, J/hr (million Btu/hr).
$\%_{H2O}$ = Concentration of water from an ultimate analysis of fuel, weight percent.
H_r = Total numbers of hours in the performance test period (e.g., 720 hours for 30-day performance test period).
K = volume of combustion component per pound of component (constant)
K = Conversion factor, 10^{-5} (kJ/J)/(%) [10^6 Btu/million Btu].
K_c = (9.57 scm/kg)/% [(1.53 scf/lb)/%].
K_{cc} = (2.0 scm/kg)/% [(0.321 scf/lb)/%].
K_{hd} = (22.7 scm/kg)/% [(3.64 scf/lb)/%].
K_{hw} = (34.74 scm/kg)/% [(5.57 scf/lb)/%].
K_n = (0.86 scm/kg)/% [(0.14 scf/lb)/%].
K_o = (2.85 scm/kg)/% [(0.46 scf/lb)/%].
K_s = (3.54 scm/kg)/% [(0.57 scf/lb)/%].
K_{sulfur} = $2x10^4$ Btu/wt%-MMBtu
K_w = (1.30 scm/kg)/% [(0.21 scf/lb)/%].
lb = pound
ln = Natural log of indicated value.
L_p,L_r = Weight of the product and raw fuel lots, respectively, metric ton (ton).
$\%_N$ = Concentration of nitrogen from an ultimate analysis of fuel, weight percent.
$M_{\%}$ = mole percent
mol = mole
MW = molecular weight (lb/lb-mol)
MW_{AIR} = molecular weight of air (28.9625 lb/lb-mole)[1]
NCM = net Btu per SCF (constant based on compound)
$\%_O$ = Concentration of oxygen from an ultimate analysis of fuel, weight percent.
$\%_{O2d}$, $\%_{O2w}$ = Concentration of oxygen on a dry and wet basis, respectively, percent.
P_B = barometric pressure, in Hg
P_s = Potential SO2 emissions, percent.
$\%_S$ = Sulfur content of as-fired fuel lot, dry basis, weight percent.
S_e = Standard deviation of the hourly average pollutant rates for each performance test period, ng/J (lb/million Btu).
$\%_{Sf}$ = Concentration of sulfur from an ultimate analysis of fuel, weight percent.
S(wt%) = weight percent of sulfur, per lab analysis by appropriate ASTM standard
S_i = Standard deviation of the hourly average inlet pollutant rates for each performance test period, ng/J (lb/million Btu).
S_o = Standard deviation of the hourly average emission rates for each performance test period, ng/J (lb/million Btu).
$\%S_p$, $\%S_r$ = Sulfur content of the product and raw fuel lots respectively, dry basis, weight percent.
SCF = standard cubic feet
SH = specific humidity, pounds of water per pound of air
$t_{0.95}$ = Values shown in Table 19-3 for the indicated number of data points n.
T_{amb} = ambient temperature, ^oF
W/D Factor = 1.0236 = conv. at 14.696 psia and
68 deg F (ref. Civil Eng. Ref. Manual, 7th Ed.)
X_{CO2}=CO_2 Correction factor, percent.
X_k = Fraction of total heat input from each type of fuel k.

EXAMPLE CALCULATIONS (FFACTOR)

RM 19, (02-27-14),
2.0 Summary of Method,
2.1 Emission Rates. Oxygen (O_2) or carbon dioxide (CO_2) concentrations and appropriate F factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant concentrations.

RM 19, (02-27-14),
12.2 Emission Rates of PM, SO_2, and NOx. Select from the following sections the applicable procedure to compute the PM, SO_2, or NOx emission rate (E) in lb/MMBtu. The pollutant concentration must be in lb/scf and the F factor must be in scf/MMBtu. If the pollutant concentration (C) is not in the appropriate units, use Table 19–1 in Section 17.0 to make the proper conversion. An F factor is the ratio of the gas volume of the products of combustion to the heat content of the fuel. The dry F factor (F_d) includes all components of combustion less water, the wet F factor (F_w) includes all components of combustion, and the carbon F factor (F_c) includes only carbon dioxide.

Mark's Std Hdbk, 10th ed.,pg 4-26
High Heat Value Dry (HHV_{dry}), calc for Methane (single component for the fuel gas)

$$HHV_{dry}(Btu/SCF) = \left[\left(\frac{M_{\%}}{100}\right) \times GCM\right]$$

$$HHV_{dry} = \frac{98.35\ \%}{100.00} \times \frac{994.85\ Btu}{SCF} = \frac{978.48\ Btu}{SCF}$$

Mark's Std Hdbk, 10th ed., pg 4-26
Low Heat Value Dry (LHV_{dry}), calc for Methane (single component for the fuel gas)

$$LHV_{dry}(Btu/SCF) = \left[\left(\frac{M_{\%}}{100}\right) \times NCM\right]$$

$$LHV_{dry} = \frac{98.35\ \%}{100.00} \times \frac{895.75\ Btu}{SCF} = \frac{881.02\ Btu}{SCF}$$

Civil Eng. Ref. Man.,7th Ed.,pg 14-9/GPA Ref. Bulletin 181-86, App. C
High Heat Value Wet (HHV_{wet}), calc for entire sample (all components of the fuel gas)

$$HHV_{wet}(Btu/SCF) = \frac{HHV_{dry}}{W/D.factor}$$

$$HHV_{wet} = \frac{998.79\ Btu/SCF}{1.0236} = 975.76\ Btu/SCF$$

Civil Eng. Ref. Man.,7th Ed.,pg 14-9/GPA Ref. Bulletin 181-86, App. C
Low Heat Value Wet (LHV_{wet}), calc for entire sample (all components of the fuel gas)

$$LHV_{wet}(Btu/SCF) = \frac{LHV_{dry}}{W/D.factor}$$

$$LHV_{wet} = \frac{899.60\ Btu/SCF}{1.0236} = 878.86\ Btu/SCF$$

Lbs Component per Lb-Mol of Gas (CM), calc for Methane (single component for the fuel gas)

$$CM(lb/lb-mol) = \left[\left(\frac{M_{\%}}{100}\right) \times MW\right]$$

$$CM = \frac{98.35\ \%}{100.00} \times \frac{16.04\ lb}{lb\text{-}mol} = 15.78\ lb/lb\text{-}mol$$

ASTM D 3588
Fuel Molecular Weight (MW_{Fuel})

$$MW_{Fuel}(lb/lb \cdot mol) = \left[\sum(CM)\right]$$

MW_{Fuel} = 15.78 lb/lb-mol
\+ 0.34 lb/lb-mol
\+ etc. = 16.307 lb/lb-mol

Btu per Lb of Gas Gross (**GCV**)

$$GCV(Btu/lb) = \left[\frac{HHV_{dry} \times G}{MW_{Fuel}}\right]$$

$$GCV = \frac{998.79\ Btu/SCF \times 385.23\ ft^3/lbmol}{16.307\ lb/lb\text{-}mol} = 23{,}595.43\ Btu/lb$$

ASTM D 3588 (SG)
Specific Gravity

$$SG = \left[\frac{MW_{Fuel}}{MW_{AIR}}\right]$$

$$SG = \frac{16.31\ lb/lb\text{-}mol}{28.96\ lb/lb\text{-}mol} = 0.5630$$

Btu per Lb of Gas Net (**NCV**)

$$NCV(Btu/lb) = \left[\frac{LHV_{dry} \times G}{MW_{Fuel}}\right]$$

$$NCV = \frac{899.60\ Btu/SCF \times 385.23\ ft^3/lbmol}{16.307\ lb/lb\text{-}mol} = 21{,}252.13\ Btu/lb$$

Weight Percent of Component ($C_{\%}$), methane

$$C_{\%}(\%) = \left[\left(\frac{CM}{MW_{Fuel}}\right) \times 100\right]$$

$$C_{\%} = \frac{15.78\ lb/lb\text{-}mol}{16.31\ lb/lb\text{-}mol} \times 100 = 96.76\ \%$$

Weight Percent of Volatile Organic Compounds ($VOC_{\%}$)

$$VOC_{\%}(\%) = \left[\sum_{C_3H_8}^{C_8H_{18}} Wt_{\%}\right]$$

$VOC_{\%}$ = 0.05 % + 0.00 % + 0.00 % + etc. = 0.06 %

RM 19, (02-27-14), 12.3.2 Determined **F Factors**. If the fuel burned is not listed in Table 19–2 or if the owner or operator chooses to determine an F factor rather than use the values in Table 19–2, use the procedure below: 12.3.2.1 Equations. Use the eq

$$F_d = \frac{K(K_{hd}\%H + K_c\%C + K_s\%S + K_n\%N - K_o\%O)}{GCV} \quad \text{Eq. 19-13}$$

RM 19, (02-27-14),
12.1 Nomenclature

K (scf/lb)/%

H	3.64
C	1.53
S	0.57
N_2	0.14
O_2	0.46

$$F_d = \frac{10^6 Btu}{MMBtu} \times \left\{\frac{3.64\ SCF}{lb \cdot \%} \times 24.75\ \% + \frac{1.53\ SCF}{lb \cdot \%} \times 74.35\ \% + \frac{0.57\ SCF}{lb \cdot \%} \times 0.00\ \% + \frac{0.14\ SCF}{lb \cdot \%} \times 0.38\ \% - \frac{0.46\ SCF}{lb \cdot \%} \times 0.51\ \%\right\} \times \frac{lb}{23{,}595.43\ Btu} = \frac{8{,}631.70\ SCF}{MMBtu}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Methane and Ethane subtraction from THC to determine VOC)

VOC (as propane)

Using a THC analyzer calibrated with propane and an FTIR, GC, or other type of analyzer that reads methane and ethane on a methane and ethane basis, respectively; first convert the wet based methane to a wet based propane equivalent by dividing the number by three, if FTIR is the analysis method, a 1.1 multiplier is applied as the correction factor; then convert the wet based ethane to a wet based propane equivalent by multiplying the number by two and then dividing by three. Once all concentrations are in wet based equivalent units, subtract the methane (as propane) and ethane (as propane) from the THC concentration. If the calculation results in a negative number, which is fairly common when subtracting fairly large numbers, the result will be assumed as zero.

$$VOC(ppm) = C_{THC\,(propane)} - \left(\frac{C_{CH_4\,(methane)}}{3}\right)_{(propane)} \times 1.1 - \left(\frac{C_{C_2H_6\,(ethane)} \times 2}{3}\right)_{(propane)}$$

$$VOC\ (ppm) = 157.35\ ppm - \frac{417.32\ ppm}{3} \times 1.1 - \frac{0.52\ ppm \times 2}{3} = 3.99\ ppm$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (INFORMATION)

Specific Humidity (RH_{sp})

Note: RHsp (gr/lb) calculated using temperature, relative humidity, and barometric pressure with psychrometric chart, psychrometric calculator, or built in psychrometric algorithm.

$$RH_{sp}(lb/lb) = \left[\left(\frac{gr}{lb}\right) \times \frac{lb}{7000\,gr}\right]$$

$$RH_{sp} = \frac{146.84\ gr}{lb} \times \frac{l\ lb}{7000\ gr} = 0.020978\ \frac{lb\ H_2O}{lb\ Air}$$

EXAMPLE CALCULATIONS (CALIBRATION)

Calibration Error and Estimated Point, RM 25A, THC/VOC Analyzer

RM 25A, (02-27-14), 8.4 Calibration Error Test. Immediately prior to the test series (within 2 hours of the start of the test), introduce zero gas and high-level calibration gas at the calibration valve assembly. Adjust the analyzer output to the appropriate levels, if necessary. Calculate the predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level response. Then introduce low-level and mid-level calibration gases successively to the measurement system. ... These differences must be less than 5 percent of the respective calibration gas value. (calc for THC/VOC analyzer mid gas, if applicable)

$$E_P = \frac{C_{Dir(H)} - C_{Dir(Z)}}{C_{V(H)} - C_{V(Z)}} \times C_{Dir(M)} + C_{Dir(Z)}$$

Eq. of a line
y=mx+b

$$E_p = \frac{808.45\ ppm - 1.42\ ppm}{802.00\ ppm - 0.00\ ppm} \times 456.00\ ppm + 1.42 = 460.28\ ppm$$

$$ACE = \left(\frac{C_{Dir} - C_V}{CS}\right) \times 100$$

Eq. 7E-1

$$ACE_{THC\,(} = \frac{461.70\ ppm - 460.28\ ppm}{456.00\ ppm} \times 100 = 0.31\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (RUNS)

Stack Exhaust Flow (Q_S) - RM19

$$Q_S = \left(\frac{FFactor \times Q_f \times HHV}{1{,}000{,}000}\right) \times \left(\frac{20.9\%}{20.9\% - C_{Gas(O2)}}\right)$$

Note: Equation presented in EPA Emission Measurement Center (EMC), Frequently Asked Questions (FAQ) for Method 19

$$Q_S = \frac{8{,}631.70 \text{ SCF}}{\text{MMBtu}} \times \frac{14{,}625.00 \text{ SCF}}{\text{hr}} \times \frac{998.79 \text{ Btu}}{\text{SCF}} \times \frac{\text{MMBtu}}{10^6 \text{ Btu}} \times \left[\frac{20.90\%}{20.9\% - 8.7\ \%}\right] = 215{,}406.45 \text{ SCFH}$$

Moisture Correction

RM 7E, (02-27-14), 12.10 Moisture Correction. Use Equation 7E-10 if your measurements need to be corrected to a dry basis. (calc for NOx analyzer, Run 1, if applicable) Note: Calculations may not match as Run 1 results are typically also bias adjusted

$$C_W = C_D \times (1 - B_{WS})$$

$$C_D = \frac{C_W}{1 - B_{WS}}$$ Eq. 7E-10

$$C_D = \frac{6.97 \text{ ppmvw}}{1 - 0.14} = 8.15 \text{ ppmvc}$$ or inversely, $$C_W = 8.15 \text{ ppmvd} \times \left(1 - 0.14\right) = 6.97 \text{ ppmvw}$$

Diluent-Corrected Pollutant Concentration, O_2 Based

RM 20, (11-26-02), 7.3.1 Correction of Pollutant Concentration Using O_2 Concentration. Calculate the O_2 corrected pollutant concentration, as follows: (calc for NOx gas, Run 1, if applicable) [now contained in applicable Subpart]

$$C_{adj} = C_{Gas(Target)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}}\right)$$ Eq. 20-4

$$C_{adj} = 8.15 \text{ ppm} \times \left(\frac{20.9\% - 15.00\ \%}{20.9\% - 8.67\ \%}\right) = 3.93 \text{ ppm@15\%}O_2$$

Emissions Rate (lb/hr)

Calculation for pound per hour emission rate. Calculate, as follows: (calc for NOx gas Run 1, if applicable)

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

$$E_{lb/hr} = \frac{8.15 \text{ ppmvd}}{10^6 \text{ ppm/part}} \times \frac{215{,}406 \text{ DSCFH} \times 46.01 \text{ lb/lb-mol}}{385.23 \text{ SCF/lb-mol}} = \frac{0.21 \text{ lb}}{\text{hr}}$$

Emissions Rate (g/kW-hr)

Calculation for grams per horsepower-hour. Calculate, as follows: (calc for NOx gas Run 1, if applicable)

$$E_{g/hp\text{-}hr} = \frac{E_{lb/hr} \times 453.6}{mw \times 1341.022} \text{ or } \frac{E_{lb/hr} \times 453.6}{hp}$$

$$E_{g/hp\text{-}hr} = \frac{0.21 \text{ lb}}{\text{hr}} \times \frac{453.6 \text{ g}}{\text{lb}} \times \frac{1}{1{,}810 \text{ hp}} \times \frac{\text{hp}}{0.7456 \text{ kW}} = \frac{0.0704 \text{ g}}{\text{kW*hr}}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

Method 320 Equation 3, Dilution Factor (DF)

(example calculation for Trial #1, where applicable)

$$DF = \frac{SF_{6\,(spk)}}{SF_{6\,(dir)}} = \frac{(SF_{6\,(spk+native)} - SF_{6\,(native)})}{SF_{6\,(dir)}}\ OR\ \frac{(CO_{2(native)} - CO_{2(spk+native)})}{CO_{2(native)}}$$

DF (SF_6) = (0.4082 - -0.0034 ppmvw) / (5.61 ppmvw) = 0.0734

Test Method 320, Section 9.0 Quality Control

Where,

$SF_{6(dir)}$ = SF_6 (or tracer gas) concentration measured directly in undiluted spike gas

$SF_{6(spk)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample

$SF_{6(spk)} = SF_{6(spk+native)} - SF_{6(native)}$

$SF_{6(spk+native)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample in stack gas

$SF_{6(native)}$ = SF_6 (or tracer gas) concentration measured in a native stack gas sample

Unspike = Native concentration of analytes in unspiked samples

$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by filling the FTIR cell directly

Dilution Factor Ratio

(example calculation for Trial #1, where applicable)

$$DF\ Ratio = \frac{SF_{6\,(dir)}}{SF_{6\,(spk)}} = \frac{SF_{6\,(dir)}}{(SF_{6\,(spk+native)} - SF_{6\,(native)})}\ OR\ \frac{CO_{2(native)}}{CO_{2(native)} - CO_{2(spk+native}} \geq 10$$

DF Ratio = (5.61 ppmvw) / (0.4082 - -0.0034 ppmvw) =

Spike Ratio = 13.6 : 1 ≥ 10

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield *(example calculation for Trial #1 (SF_6), where applicable)*

$$CS = DF \times Spike_{dir} + Unspike\ (1 - DF)$$

CS = 0.0734 X 5.6103 ppmvw + -0.0034 ppmvw X (1 - 0.0734) = 0.4085 ppmvw

Method 320 Spiked vs Expected

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

(example calculation for Trial #1 (SF_6), where applicable)

% Recovery = (0.4082 ppmvw) / (0.4085 ppmvw) x 100 = 99.940 %

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield *(example calculation for Trial #1 (C_2H_4O), where applicable)*

$$CS = DF \times Spike_{dir} + Unspike\ (1 - DF)$$

CS = 0.0734 X 47.1138 ppmvw + 0.4382 ppmvw X (1 - 0.0734) = 3.8626 ppmvw

Method 320 Spiked vs Expected

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

(example calculation for Trial #1 (C_2H_4O), where applicable)

% Recovery = (3.6232 ppmvw) / (3.8626 ppmvw) x 100 = 93.802 %

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

Method 320 Equation 3, Dilution Factor (DF)

(example calculation for Trial #2, where applicable)

$$DF = \frac{SF_{6\,(spk)}}{SF_{6\,(dir)}} = \frac{(SF_{6\,(spk+native)} - SF_{6\,(native)})}{SF_{6\,(dir)}}\ OR\ \frac{(CO_{2(native)} - CO_{2(spk+native)})}{CO_{2(native)}}$$

$$DF\,(SF_6) = \frac{0.4291 \text{ - } -0.0011 \text{ ppmvw}}{5.61 \text{ ppmvw}} = 0.0767$$

Test Method 320, Section 9.0 Quality Control

Where,

$SF_{6(dir)}$ = SF_6 (or tracer gas) concentration measured directly in undiluted spike gas

$SF_{6(spk)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample

$SF_{6(spk)} = SF_{6(spk+native)} - SF_{6(native)}$

$SF_{6(spk+native)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample in stack gas

$SF_{6(native)}$ = SF_6 (or tracer gas) concentration measured in a native stack gas sample

Unspike = Native concentration of analytes in unspiked samples

$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by filling the FTIR cell directly

Dilution Factor Ratio

(example calculation for Trial #2, where applicable)

$$DF\ Ratio = \frac{SF_{6\,(dir)}}{SF_{6\,(spk)}} = \frac{SF_{6\,(dir)}}{(SF_{6\,(spk+native)} - SF_{6\,(native)})}\ OR\ \frac{CO_{2(native)}}{CO_{2(native)} - CO_{2(spk+native}} \geq 10$$

$$DF\ Ratio = \frac{5.61 \text{ ppmvw}}{0.4291 \text{ - } -0.0011 \text{ ppmvw}} =$$

Spike Ratio = 13.0 : 1 ≥ 10

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield

(example calculation for Trial #2 (SF_6), where applicable)

$$CS = DF \times Spike_{dir} + Unspike\,(1 - DF)$$

CS = 0.0767 X 5.6103 ppmvw + -0.0011 ppmvw X (1 - 0.0767) = 0.4292 ppmvw

Method 320 Spiked vs Expected

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

(example calculation for Trial #2 (SF_6), where applicable)

$$\%\ Recovery = \frac{0.4291 \text{ ppmvw}}{0.4292 \text{ ppmvw}} \times 100 = 99.981\ \%$$

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield

(example calculation for Trial #2 (C_2H_4O), where applicable)

$$CS = DF \times Spike_{dir} + Unspike\,(1 - DF)$$

CS = 0.0767 X 47.1138 ppmvw + 0.4477 ppmvw X (1 - 0.0767) = 4.0257 ppmvw

Method 320 Spiked vs Expected

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

(example calculation for Trial #2 (C_2H_4O), where applicable)

$$\%\ Recovery = \frac{4.1004 \text{ ppmvw}}{4.0257 \text{ ppmvw}} \times 100 = 101.856\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

Method 320 Equation 3, Dilution Factor (DF)

(example calculation for Trial #3, where applicable)

$$DF = \frac{SF_{6\,(spk)}}{SF_{6\,(dir)}} = \frac{(SF_{6\,(spk+native)} - SF_{6\,(native)})}{SF_{6\,(dir)}}\ OR\ \frac{(CO_{2(native)} - CO_{2(spk+native)})}{CO_{2(native)}}$$

$$DF\ (SF_6) = \frac{0.4383\ -\ 0.0018\ \text{ppmvw}}{5.61\ \text{ppmvw}} = 0.0778$$

Test Method 320, Section 9.0 Quality Control

Where,

$SF_{6(dir)}$ = SF_6 (or tracer gas) concentration measured directly in undiluted spike gas

$SF_{6(spk)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample

$SF_{6(spk)} = SF_{6(spk+native)} - SF_{6(native)}$

$SF_{6(spk+native)}$ = Diluted SF_6 (or tracer gas) concentration measured in a spiked sample in stack gas

$SF_{6(native)}$ = SF_6 (or tracer gas) concentration measured in a native stack gas sample

Unspike = Native concentration of analytes in unspiked samples

$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by filling the FTIR cell directly

Dilution Factor Ratio

(example calculation for Trial #3, where applicable)

$$DF\ Ratio = \frac{SF_{6\,(dir)}}{SF_{6\,(spk)}} = \frac{SF_{6\,(dir)}}{(SF_{6\,(spk+native)} - SF_{6\,(native)})}\ OR\ \frac{CO_{2(native)}}{CO_{2(native)} - CO_{2(spk+native}} \geq 10$$

$$DF\ Ratio = \frac{5.61\ \text{ppmvw}}{0.4383\ -\ 0.0018\ \text{ppmvw}} =$$

Spike Ratio = 12.9 : 1 ≥ 10

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield *(example calculation for Trial #3 (SF_6), where applicable)*

$$CS = DF \times Spike_{dir} + Unspike\ (1 - DF)$$

CS = 0.0778 X 5.6103 ppmvw + 0.0018 ppmvw X (1 - 0.0778) = 0.4382 ppmvw

Method 320 Spiked vs Expected

(example calculation for Trial #3 (SF_6), where applicable)

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

$$\%\ Recovery = \frac{0.4383\ \text{ppmvw}}{0.4382\ \text{ppmvw}} \times 100 = 100.031\ \%$$

Method 320 Equation 4 [Method 321 Equation 2], Excepted Concentration of the Spiked Samples

Ideal Spike Yield *(example calculation for Trial #3 (C_2H_4O), where applicable)*

$$CS = DF \times Spike_{dir} + Unspike\ (1 - DF)$$

CS = 0.0778 X 47.1138 ppmvw + 0.3622 ppmvw X (1 - 0.0778) = 4.0003 ppmvw

Method 320 Spiked vs Expected

(example calculation for Trial #3 (C_2H_4O), where applicable)

$$Spiked\ vs\ Expected = \frac{Actual\ Spike\ Yield}{Ideal\ Spike\ Yield} \times 100$$

$$\%\ Recovery = \frac{4.3142\ \text{ppmvw}}{4.0003\ \text{ppmvw}} \times 100 = 107.849\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

TEST RESULTS AND CALCULATIONS

75% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O Emissions Data

CATERPILLAR, G3520 TALE 75% LOAD DATA SUMMARY

Parameter	75% Load, Run - 2-1	75% Load, Run - 2-2	75% Load, Run - 2-3	Average
Date (mm/dd/yy)	07/30/21	07/30/21	07/30/21	07/30/21
Start Time (hh:mm:ss)	13:45:23	15:00:23	16:27:23	13:45:23
End Time (hh:mm:ss)	14:44:53	15:59:53	17:26:53	17:26:53
Run Duration (min / run)	60	60	60	60
Bar. Pressure (in. Hg)	29.89	29.87	29.85	29.87
Amb. Temp. (°F)	94	97	97	96
Rel. Humidity (%)	53	47	42	47
Spec. Humidity (lb water / lb air)	0.018296	0.017841	0.015856	0.017331
Engine Fuel Flow (SCFH)	20,603	20,591	20,172	20,455
Stack Flow (RM19) (SCFH)	310,849	310,873	303,928	308,550
Stack Moisture (% Method 320)	13.9	13.9	13.6	13.8
Power Output (horsepower)	2,691.4	2,698.1	2,616.3	2,668.6
Engine Timing (BTDC)	23.0	23.0	23.0	23.00
Actual Power (kW)	2,007.0	2,012.0	1,951.0	1,990.00
Amperes (A)	89.0	90.0	97.0	92.00
Air Manifold Temp. (F)	131.0	131.0	129.0	130.33
Engine Speed (rpm)	1,800.0	1,800.0	1,800.0	1,800.00
NOx (as NO_2) (ppmvd)	6.49	6.25	6.05	6.26
NOx (as NO_2) (ppm@15%O_2)	3.20	3.09	2.98	3.09
NOx (as NO_2) (g/kW*hr)	0.0544	0.0523	0.0511	0.05
NO (ppmvd)	6.49	6.24	5.96	6.23
NO (ppm@15%O_2)	3.20	3.08	2.94	3.08
NO (g/kW*hr)	0.0355	0.0341	0.0328	0.0341
NO_2 (ppmvd)	0.00	0.01	0.09	0.03
NO_2 (ppm@15%O_2)	0.00	0.00	0.04	0.02
NO_2 (g/kW*hr)	0.0000	0.0000	0.0008	0.0003
CO (ppmvd)	3.23	4.20	3.59	3.68
CO (ppm@15%O_2)	1.60	2.08	1.77	1.81
CO (g/kW*hr)	0.02	0.02	0.02	0.02
THC (as C_3H_8) (ppmvd)	176.40	197.01	190.89	188.10
THC (as C_3H_8) (ppm@15%O_2)	74.99	83.86	81.34	80.06
THC (as C_3H_8) (g/kW*hr)	1.22	1.36	1.33	1.30
VOC (as C_3H_8) (ppmvd)	0.83	4.90	6.61	4.11
VOC (as C_3H_8) (ppm@15%O_2)	0.35	2.09	2.82	1.75
VOC (as C_3H_8) (g/kW*hr)	0.01	0.03	0.05	0.03
CH_4 (as C_3H_8) (ppmvd)	174.98	191.69	183.99	183.55
CH_4 (as C_3H_8) (ppm@15%O_2)	86.41	94.72	90.73	90.62
CH_4 (as C_3H_8) (g/kW*hr)	1.4073	1.5380	1.4883	1.4779
C_2H_6 (as C_3H_8) (ppmvd)	0.59	0.42	0.30	0.43
C_2H_6 (as C_3H_8) (ppm@15%O_2)	0.29	0.21	0.15	0.21
C_2H_6 (as C_3H_8) (g/kW*hr)	0.0047	0.0033	0.0024	0.0035
N_2O (ppmvd)	1.68	1.86	1.70	1.75
N_2O (ppm@15%O_2)	0.83	0.92	0.84	0.86
N_2O (g/kW*hr)	0.0135	0.0149	0.0137	0.0140
C_2H_4O (ppmvd)	1.12	3.50	4.87	3.16
C_2H_4O (ppm@15%O_2)	0.55	1.73	2.40	1.56
C_2H_4O (g/kW*hr)	0.0090	0.0280	0.0393	0.0255
HCHO (ppmvd)	0.00	0.00	0.00	0.00
HCHO (ppm@15%O_2)	0.00	0.00	0.00	0.00
HCHO (g/kW*hr)	0.0000	0.0000	0.0000	0.0000
NH_3 (ppmvd)	18.17	16.63	15.56	16.79
NH_3 (ppm@15%O_2)	8.97	8.22	7.67	8.29
NH_3 (g/kW*hr)	0.0564	0.0515	0.0486	0.0522
CO_2 (%)	6.57	6.55	6.66	6.59
CO_2 (lb/hr)	2,333.03	2,325.95	2,312.44	2,323.80
CO_2 (lb/kW*hr)	1,162.47	1,156.06	1,185.28	1,167.93
CO_2 (ton/year) at 8760 hr/year	10,218.67	10,187.65	10,128.47	10,178.26
CO_2 (lb/MMBtu)	115.63	115.63	115.63	115.63
CO_2 (g/kW*hr)	527.29	524.38	537.63	529.77
O_2 (%)	8.95	8.96	8.94	8.95

TEST RESULTS AND CALCULATIONS

100% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O Emissions Data

CATERPILLAR, G3520 TALE 100% LOAD DATA SUMMARY

Parameter	100% Load, Run - 3-1	100% Load, Run - 3-2	100% Load, Run - 3-3	Average
Date (mm/dd/yy)	09/01/21	09/01/21	09/02/21	09/01/21
Start Time (hh:mm:ss)	9:23:57	10:26:27	12:03:27	9:23:57
End Time (hh:mm:ss)	10:25:57	12:02:57	13:06:27	13:06:27
Run Duration (min / run)	62	97	64	74
Bar. Pressure (in. Hg)	29.73	29.73	29.74	29.73
Amb. Temp. (°F)	88	93	95	92
Rel. Humidity (%)	70	57	46	58
Spec. Humidity (lb water / lb air)	0.020202	0.019207	0.016410	0.018606
Engine Fuel Flow (SCFH)	26,278	26,278	26,278	26,278
Stack Flow (RM19) (SCFH)	386,201	399,898	406,400	397,500
Stack Moisture (% Method 320)	13.6	12.9	13.0	13.2
Power Output (horsepower)	3,598.0	3,598.0	3,598.0	3,598.0
Engine Timing (BTDC)	22.0	22.0	22.0	22.00
Actual Power (kW)	2,613.0	2,613.0	2,613.0	2,613.00
Amperes (A)	109.0	109.0	109.0	109.00
Air Manifold Temp. (F)	136.0	136.0	136.0	136.00
Engine Speed (rpm)	1,800.0	1,800.0	1,800.0	1,800.00
NOx (as NO_2) (ppmvd)	10.21	9.38	9.85	9.81
NOx (as NO_2) (ppm@15%O_2)	4.92	4.67	4.99	4.86
NOx (as NO_2) (g/kW*hr)	0.080	0.076	0.081	0.08
NO (ppmvd)	8.60	8.67	9.35	8.87
NO (ppm@15%O_2)	4.14	4.32	4.12	4.19
NO (g/kW*hr)	0.044	0.046	0.050	0.05
NO_2 (ppmvd)	1.61	0.71	0.50	0.94
NO_2 (ppm@15%O_2)	0.78	0.35	0.90	0.68
NO_2 (g/kW*hr)	0.013	0.006	0.004	0.01
CO (ppmvd)	4.36	2.18	1.58	2.71
CO (ppm@15%O_2)	2.10	1.09	0.80	1.33
CO (g/kW*hr)	0.021	0.011	0.008	0.01
THC (as C_3H_8) (ppmvd)	114.77	107.19	108.68	110.21
THC (as C_3H_8) (ppm@15%O_2)	47.70	46.52	47.86	47.36
THC (as C_3H_8) (g/kW*hr)	0.739	0.721	0.742	0.73
VOC (as C_3H_8) (ppmvd)	0.00	0.00	0.00	0.00
VOC (as C_3H_8) (ppm@15%O_2)	0.00	0.00	0.00	0.00
VOC (as C_3H_8) (g/kW*hr)	0.000	0.000	0.000	0.00
CH_4 (as C_3H_8) (ppmvd)	176.10	165.42	161.29	167.60
CH_4 (as C_3H_8) (ppm@15%O_2)	84.74	82.43	81.68	82.95
CH_4 (as C_3H_8) (g/kW*hr)	1.316	1.280	1.269	1.29
C_2H_6 (as C_3H_8) (ppmvd)	0.00	0.28	0.45	0.24
C_2H_6 (as C_3H_8) (ppm@15%O_2)	0.00	0.14	0.23	0.12
C_2H_6 (as C_3H_8) (g/kW*hr)	0.000	0.002	0.004	0.00
N_2O (ppmvd)	2.40	1.16	0.80	1.45
N_2O (ppm@15%O_2)	1.16	0.58	0.40	0.713
N_2O (g/kW*hr)	0.018	0.009	0.006	0.01
C_2H_4O (ppmvd)	0.91	0.96	0.94	0.94
C_2H_4O (ppm@15%O_2)	0.44	0.48	0.48	0.464
C_2H_4O (g/kW*hr)	0.007	0.007	0.007	0.0072
HCHO (ppmvd)	1.29	0.82	0.61	9.07E-01
HCHO (ppm@15%O_2)	0.62	0.41	0.31	4.46E-01
HCHO (g/kW*hr)	0.007	0.004	0.003	0.005
NH_3 (ppmvd)	0.68	2.65	13.33	5.56
NH_3 (ppm@15%O_2)	0.33	1.32	6.75	2.80
NH_3 (g/kW*hr)	0.002	0.008	0.041	0.02
CO_2 (%)	6.81	6.58	6.53	6.64
CO_2 (lb/hr)	3,004.47	3,005.35	3,030.75	3,013.53
CO_2 (lb/kW*hr)	1,119.81	1,120.14	1,129.60	1,123.18
CO_2 (ton/year) at 8760 hr/year	13,159.59	13,163.45	13,274.70	13,199.25
CO_2 (lb/MMBtu)	115.57	115.57	115.57	115.57
CO_2 (g/kW*hr)	507.94	508.08	512.38	509.47
O_2 (%)	8.64	9.06	9.25	8.98

TEST RESULTS AND CALCULATIONS

50% Load
PM Emissions Data

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Historical Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Run Start Time	09:34	12:05	14:23		hh:mm
Run Stop Time	11:24	13:59	15:58		hh:mm
Test Date	07/29/21	07/29/21	07/29/21		mm/dd/yy
Load	50%	50%	50%		% or w/DB
Meter Calibration Factor	0.986	0.986	0.986		
Pitot Tube Coefficient	0.8215	0.8230	0.8215		
Average Nozzle Diameter	0.311	0.311	0.311		in
Stack Test Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Initial Meter Volume	59.000	96.035	133.977		ft³
Final Meter Volume	95.989	133.682	171.362		ft³
Total Meter Volume	36.989	37.647	37.385	37.340	ft³
Total Sampling Time	90.00	90.00	90.00	90.00	min
Average Meter Temperature	87.00	94.63	93.96	91.86	°F
Average Stack Temperature	906.00	904.83	922.71	911.18	°F
Barometric Pressure	29.87	29.90	29.85	29.87	in Hg
Stack Static Pressure	0.07	0.07	0.07	0.07	in H_2O
Absolute Stack Pressure	29.88	29.91	29.86	29.88	in Hg
Average Orifice Pressure Drop	0.52	0.53	0.53	0.53	in H_2O
Absolute Meter Pressure	30.00	30.03	29.98	30.01	in Hg
Avg Square Root Pitot Pressure	0.41	0.42	0.41	0.41	$\sqrt{(\text{in } H_2O)}$
Moisture Content Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Impinger Water Weight Gain	117.70	117.80	115.30	116.93	g
Silica Gel Weight Gain	8.40	6.90	7.00	7.43	g
Total Water Volume Collected	126.33	124.92	122.52	124.59	ml
Standard Water Vapor Volume	5.95	5.88	5.77	5.86	scf
Standard Meter Volume	35.2	35.4	35.1	35.2	dscf
Standard Metric Meter Volume	1.0	1.0	1.0	1.0	dscm
Calculated Stack Moisture	14.45	14.26	14.11	14.27	%
Saturated Stack Moisture	100.00	100.00	100.00	100.00	%
Reported Stack Moisture Content	14.45	14.26	14.11	14.27	%
Gas Analysis Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Carbon Dioxide Content	6.7	6.7	6.8	6.7	%
Oxygen Content	8.7	8.7	8.8	8.7	%
Carbon Monoxide Content	6.0	6.0	6.4	6.1	ppm
Nitrogen Content	84.6	84.6	84.5	84.5	%
Stack Dry Molecular Weight	29.42	29.42	29.43	29.42	lb/lb-mole
Stack Wet Molecular Weight	27.77	27.79	27.82	27.79	lb/lb-mole
Calculated Fuel Factor	1.822	1.817	1.793	1.811	
Fuel F-Factor	8631.70	8631.70	8631.70	8631.70	dscf/MMBtu
Percent Excess Air	63.4	64.4	65.1	64.3	%

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Volumetric Flow Rate Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Average Stack Gas Velocity	37.36	37.43	37.48	37.42	ft/sec
Stack Cross-Sectional Area	5.54	5.54	5.54	5.54	ft²
Actual Stack Flow Rate	12,421	12,445	12,462	12,443	acfm
Wet Standard Stack Flow Rate	288	289	285	287	wkscfh
Dry Standard Stack Flow Rate	246,059	247,565	244,695	246,106	dscfh
Percent of Isokinetic Rate	100.2	99.9	100.3	100.1	%
Gravimetric Analysis	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	ml
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	mg
Emission Rate Data	**R-1 50%-1**	**R-1 50%-2**	**R-1 50%-3**	**Average**	**Units**
Total PM Mass	18.09	14.54	9.68	14.10	mg
Total PM Concentration	5.14E-04	4.11E-04	2.76E-04	4.00E-04	g/dscf
	7.93E-03	6.34E-03	4.26E-03	6.18E-03	gr/dscf
Total PM Emission Rate	0.13	0.10	0.07	0.10	kg/hr
	0.28	0.22	0.15	0.22	lb/hr
	1.22	0.98	0.65	0.95	tpy
	0.0167	0.0134	0.0091	0.0131	lb/MMBtu
Filterable PM Mass	11.69	10.89	7.98	10.19	mg
Filterable PM Concentration	3.32E-04	3.08E-04	2.27E-04	2.89E-04	g/dscf
	5.13E-03	4.75E-03	3.51E-03	4.46E-03	gr/dscf
Filterable PM Emission Rate	0.08	0.08	0.06	0.07	kg/hr
	0.18	0.17	0.12	0.16	lb/hr
	0.79	0.74	0.54	0.69	tpy
	0.0108	0.0101	0.0075	0.0094	lb/MMBtu
Condensable PM Mass	6.40	3.65	1.70	3.92	mg
Condensable PM Concentration	1.82E-04	1.03E-04	4.84E-05	1.11E-04	g/dscf
	2.81E-03	1.59E-03	7.47E-04	1.72E-03	gr/dscf
Condensable PM Emission Rate	0.04	0.03	0.01	0.03	kg/hr
	0.10	0.06	0.03	0.06	lb/hr
	0.43	0.25	0.11	0.26	tpy
	0.0059	0.0034	0.0016	0.0036	lb/MMBtu

Nomenclature

- $\%CO$ = carbon monoxide concentration (%)
- $\%CO_2$ = carbon dioxide concentration (%)
- $\%N_2$ = nitrogen concentration (%)
- $\%O_2$ = oxygen concentration (%)
- $\%O_{2,wet}$ = Oxygen content of gas stream, % by volume of wet gas. (Note: The oxygen percentage used in Method 201A, Equation 3 is on a wet gas basis. That means that since oxygen is typically measured on a dry gas basis, the measured percent O2 must be multiplied by the quantity (1 - B_{ws}) to convert to the actual volume fraction. Therefore, $\%O_{2,wet} = (1 - B_{ws}) * \%O_{2, dry}$)
- $(\%EA)_{avg}$ = average excess air (%)
- $(F_o)_{avg}$ = average calculated fuel factor
- $[(\Delta p)^{0.5}]_{avg}$ = Average of square roots of the velocity pressures measured during the preliminary traverse, inches W.C.
- μ = Gas viscosity, micropoise
- 12.0 = Constant calculated as 60 percent of 20.5 square inch cross-sectional area of combined cyclone head, square inches
- 17.03 = mg/milliequivalents for ammonium ion
- 22.4 = liters of ideal gas per lb-mol of substance at 0^oC and 1 atm (ref. Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg)
- 24.04 = liters of ideal gas per lb-mol of substance at 20^oC and 1 atm (ref. Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg)
- 5.02×10^4 = constant derived from the molecular weight and correcting standard temperature and pressure (ref. Bay Area Air Quality Management District, Source Test Procedure ST-1B, Ammonia Integrated Sampling, Adopted January 20, 1982, Regulation 7-303)
- A = distance upstream (in.)
- A_D = stack diameters upstream (dia.)
- An = Area of nozzle, square feet
- A_s = area of stack (ft^2)
- B = distance downstream (in.)
- B_D = stack diameters downstream (dia.)
- b_f = Average blockage factor calculated in Equation 26, dimensionless
- B_{wm} = meter moisture content (%)
- B_{ws} = stack moisture content (%)
- C = Cunningham correction factor for particle diameter, Dp, and calculated using the actual stack gas temperature, dimensionless
- C_1 = -150.3162 (micropoise)
- C_2 = 18.0614 (micropoise/$K^{0.5}$) = 13.4622 (micropoise/$R^{0.5}$)
- $C_3 = 1.19183 \times 10^6$ (micropoise/K^2) = 3.86153×10^6 (micropoise/R^2)
- C_4 = 0.591123 (micropoise)
- C_5 = 91.9723 (micropoise)
- $C_6 = 4.91705 \times 10^{-5}$ (micropoise/K^2) = 1.51761×10^{-5} (micropoise/R^2)
- C_a = Acetone blank concentration, mg/mg
- C_b = Concentration of NH3 ion in the back half of train (breakthrough)
- C_f = Concentration of NH3 ion in the front half of train (main catch)
- C_{fPM10} = Conc. of filterable PM_{10}, gr/dscf
- $C_{fPM2.5}$ = Conc. of filterable $PM_{2.5}$, gr/dscf
- C_k = K Factor Constant, 849.8

Nomenclature

- C_n = nozzle diameter constant, 0.03575
- C_p' = Coefficient for the pitot used in the preliminary traverse, dimensionless
- C_p = Pitot coefficient for the combined cyclone pitot, dimensionless
- C_{cpm} = Concentration of the condensable PM in the stack gas, dry basis, corrected to standard conditions, milligrams/dry standard cubic foot.
- C_r = Re-estimated Cunningham correction factor for particle diameter equivalent to the actual cut size diameter and calculated using the actual stack gas temperature, dimensionless
- D_{50} = Particle cut diameter, micrometers
- $D_{50(N+1)}$ = D_{50} value for cyclone IV calculated during the N+1 iterative step, micrometers
- D_{50-1} = Re-calculated particle cut diameters based on re-estimated C_r, micrometers
- D_{50LL} = Cut diameter for cyclone I corresponding to the 2.25 micrometer cut diameter for cyclone IV, micrometer
- D_{50N} = D_{50} value for cyclone IV calculated during the Nth iterative step, micrometers
- D_{50T} = Cyclone I cut diameter corresponding to the middle of the overlap zone shown in Method 201A, Figure 10 of Section 17, micrometers
- D_e = equivalent stack diameter (in.)
- ΔH@ = ΔH @ 0.75 scfm (in. H2O)
- ΔH_{avg} = average orifice pressure (in. H_2O)
- D_n = Inner diameter of sampling nozzle mounted on Cyclone I, inches
- D_{na} = actual nozzle diameter (in.)
- D_p = Physical particle size, micrometers
- Δp = velocity head (in. H_2O)
- Δp_1 = velocity head at first current traverse point (in. H_2O)
- $\Delta p'_1$ = velocity head at first preliminary traverse point (in. H_2O)
- Δp_{avg} = average pitot tube differential pressure (in. H_2O)
- Δp_n = velocity head at subsequent current traverse point (in. H_2O)
- Δp_{RM2} = method 2 velocity head (in. H_2O)
- D_s = diameter of stack (in.)
- F_d = fuel f-factor (dscf/MMBtu)
- f_{O2} = stack gas fraction of O_2, by volume, dry basis
- I = Percent isokinetic sampling, dimensionless
- K_1 = standard volume correction, 17.65^oR/in. Hg
- K_4 = isokinetic conversion constant, 0.0945min•in.Hg/sec•^oR
- K_5 = water mass to std water vapor, 0.04715 ft^3/g
- K_p = 85.49, ((ft/sec)/(pounds/mole -^oR))
- L = length of stack (in.)
- L_{fw} = distance to far wall of stack (in.)
- L_{nw} = distance to near wall of stack (in.) [reference]
- $m_{\#x}$ = weight measurements (g)
- M_1 = Milligrams of PM collected on the filter, less than or equal to 2.5 micrometers
- M_2 = Milligrams of PM recovered from Container #2 (acetone blank corrected), greater than 10 micrometers
- M_3 = Milligrams of PM recovered from Container #3 (acetone blank corrected), less than or equal to 10 and greater than 2.5 micrometers
- M_4 = Milligrams of PM recovered from Container #4 (acetone blank corrected), less than or equal to 2.5 micrometers

Nomenclature

- m_a = Mass of residue of acetone after evaporation, mg
- m_c = Mass of the NH4+ added to sample to form ammonium sulfate, mg
- m_{cpm} = Mass of the total condensable PM, mg
- M_d = Molecular weight of dry gas, pounds/pound mole
- m_{fb} = Mass of total CPM in field train recovery blank, mg
- m_{fx} = final weight, avg of last two measurements (g)
- mg = Milligram
- mg/L = Milligram per liter
- m_i = Mass of inorganic CPM, mg
- m_{ib} = Mass of inorganic CPM in field train recovery blank, mg
- M_n = total particulates (mg)
- m_o = Mass of organic CPM, mg
- m_{ob} = Mass of organic CPM in field train blank, mg
- m_r = Mass of dried sample from inorganic fraction, mg
- m_{tx} = tare weight (g)
- MW = molecular weight (lb/lb-mole)
- M_w = Molecular weight of wet gas, pounds/pound mole
- N = Normality of ammonium hydroxide titrant
- N_a = null angle (deg.)
- N_{re} = Reynolds number, dimensionless
- N_{tp} = Number of iterative steps or total traverse points
- P_b = P_{bar} = barometric pressure (in. Hg)
- P_{bar} = barometric pressure (in. Hg)
- ppmCO = carbon monoxide concentration (ppm)
- ppmv = Parts per million by volume
- ppmw = Parts per million by weight
- P_s = absolute stack pressure (in. Hg)
- P_{static} = static pressure (in. H_2O)
- P_{std} = standard pressure, 29.92 in. Hg
- Θ = total sampling time (min)
- Q_{aw} = average stack wet flow rate (ascf/min)
- Q_I = Sampling rate for cyclone I to achieve specified D_{50}
- Q_m = estimated orifice flow rate, 0.750 acfm, else Vm/Q from previous run
- Q_s = Sampling rate for cyclone I to achieve specified D_{50}
- $Q_{s(std)}$ = total cyclone flow rate at standard conditions (dscf/min)
- Q_{sd} = dry standard stack flow rate (dscfm)
- Q_{sST} = Dry gas sampling rate through the sampling assembly, dscfm
- Q_{sw} = wet standard stack flow rate (ascfm)
- R_{max} = Nozzle/stack velocity ratio parameter, dimensionless
- R_{min} = Nozzle/stack velocity ratio parameter, dimensionless
- t_1 = Sampling time at point 1, min
- t_m = average gas meter temperature (^oF)
- t_m = average meter temperature (^oF)
- T_m = Meter box and orifice gas temperature, ^oR
- t_n = Sampling time at point n, min

Nomenclature

- t_r = Total projected run time, min
- T_s = Absolute stack gas temperature, ^oR
- T_{std} = standard temperature, 68^{o}F, 528^{o}R
- T_u = absolute temperature offset, 460^{o}R
- V_a = Volume of acetone blank, ml
- V_{aw} = Volume of acetone used in sample recovery wash, ml
- V_b = Volume of aliquot taken for IC analysis, ml
- V_c = Quantity of water captured in impingers and silica gel, ml
- V_f = final impinger volume (ml)
- V_i = initial impinger volume (ml)
- V_{ic} = Volume of impinger contents sample, ml
- V_m = Dry gas meter volume sampled, acf
- $V_{m(std)}$ = standard meter volume (dscf)
- v_{max} = Maximum gas velocity calculated from Equations 18 or 19, ft/sec
- v_{max} = maximum nozzle velocity (ft/sec)
- V_{mf} = final dry gas meter reading (dcf)
- V_{mi} = initial dry gas meter reading (dcf)
- v_{min} = Minimum gas velocity calculated from Method 201A, Equations 16 or 17, ft/sec
- V_{ms} = Dry gas meter volume sampled, corrected to standard conditions, dscf
- v_n = Sample gas velocity in the nozzle, ft/sec
- v_{org} = organics wash volume (ml)
- V_p = Volume of water added during train purge
- v_s = average stack gas velocity (ft/sec)
- v_{sl} = local velocity (ft/sec)
- V_t = total impinger volume (ml) = ;(V_f-V_i)
- V_t = Volume of NH4OH titrant, ml
- $V_{w(std)}$ = volume of water vapor in gas sample at standard conditions (scf)
- v_x = blank volume (ml)
- W = width of stack (in.)
- $W_{2,3,4}$ = Weight of PM recovered from Containers #2, #3, and #4, mg
- W_a = Weight of blank residue in acetone used to recover samples, mg
- W_f = final impinger weight (g)
- W_i = initial impinger weight (g)
- W_t = total impinger weight (g) = ;(W_f-W_i)
- w_x = blank weight of solids (g)
- Y = meter calibration factor (a.k.a gamma)
- Z = Ratio between estimated cyclone IV D_{50} values, dimensionless
- γ = Dry gas meter gamma value, dimensionless
- ΔH = Meter box orifice pressure drop, inches W.C.
- $\Delta H@$ = Pressure drop across orifice at flow rate of 0.75 scfm at standard conditions, inches W.C. (Note: Specific to each orifice and meter box.)
- Δp_1 = Velocity pressure measured at point 1, inches W.C.
- Δp_{avg} = Average velocity pressure, inches W.C.
- Δp_m = Observed velocity pressure using S-type pitot tube in preliminary traverse, inches W.C.
- Δp_{max} = Maximum velocity pressure, inches W.C.

Nomenclature

- Δp_{min} = Minimum velocity pressure, inches W.C.
- Δp_n = Velocity pressure measured at point n during the test run, inches W.C.
- Δp_s = Velocity pressure calculated in Method 201a, Equation 25, inches W.C.
- Δp_{s1} = Velocity pressure adjusted for combined cyclone pitot tube, inches W.C.
- Δp_{s2} = Velocity pressure corrected for blockage, inches W.C.
- θ = Total run time, min
- ρ_a = Density of acetone, mg/ml (see label on bottle)
- Σ_n = total number of sampling points

EXAMPLE CALCULATIONS (Reference Method 1 - Circular Stack)

Diameter of Stack (in.)

$$D(in.) = L_{fw} - L_{nw}$$

D (in.) = 32.00 in. - 0.13 in. = 31.88 in.

Area of Stack (ft^2)

$$A_s(ft^2) = \pi \times \left(\frac{D}{2 \times 12}\right)^2$$

A_s (ft^2) = 3.14 x ($\frac{31.88 \text{ in.}}{2 \text{ x } 12\text{in./ft}}$)^2 = 5.54 ft^2

Stack Diameters Downstream

$$B_D(dia.) = \frac{B}{D}$$

B_D (dia.) = $\frac{64.00 \text{ in.}}{31.88 \text{ in.}}$ = 2.01 diameters

Stack Diameters Upstream

$$A_D(dia.) = \frac{A}{D}$$

A_D (dia.) = $\frac{16.00 \text{ in.}}{31.88 \text{ in.}}$ = 0.50 diameters

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Reference Method 3a) [Values from Run 1 test]

Carbon Monoxide Concentration (%)

$$\%CO = \frac{ppmCO}{10{,}000}$$

$$\%CO\ (\%) = \frac{6.03\ \text{ppm}}{10{,}000\ \text{ppm}/\%} = 0.0006\ \%$$

Nitrogen Concentration (%)

$$\%N_2 = 100 - \%CO_2 - \%O_2 - \%CO$$

$\%N_2$ (%) = 100 - 6.71 % - 8.67 % - 6.03 / 10,000 % = 84.62 %

Stack Dry Molecular Weight (lb/lb-mole)

$$M_d\,(lb/lb-mol) = \sum\left(\frac{MW_{comp}}{100} \times \%component\right)$$

$$M_d\ (\text{lb/lb-mol}) = \left(\frac{44\ \text{lb/lb-mol}}{100} \times 6.71\ \%\right) + \left(\frac{32\ \text{lb/lb-mol}}{100} \times 8.67\ \%\right) + \left(\frac{28\ \text{lb/lb-mol}}{100} \times \left[\frac{6.03}{10{,}000} + 84.62\right]\right) = \frac{29.42\ \text{lb}}{\text{lb-mol}}$$

Stack Wet Molecular Weight (lb/lb-mole)

$$M_S\,(lb/lb-mol) = \left[M_d \times \left(1 - \frac{B_{WS}}{100}\right)\right] + \left[MW_{H_2O} \times \frac{B_{WS}}{100}\right]$$

$$M_S\ (\text{lb/lb-mol}) = \left\{\frac{29.42\ \text{lb}}{\text{lb-mol}} \times \left(1 - \frac{14.45\ \%}{100}\right)\right\} + \left\{\frac{18\ \text{lb}}{\text{lb-mol}} \times \frac{14.45\ \%}{100}\right\} = \frac{27.77\ \text{lb}}{\text{lb-mol}}$$

Average Calculated Fuel Factor (F_o)

$$F_{o(avg)} = \frac{\left[20.9 - (\%O_2)_{avg} - \left(0.5 \times (\%CO)_{avg}\right)\right]}{(\%CO_2)_{avg} + (\%CO)_{avg}}$$

$$F_{o(avg)} = \frac{20.9\% - 8.67\ \% - (0.5 \times 0.001\ \%)}{6.71\ \% + 0.001\ \%} = 1.822$$

Average Excess Air (%)

$$\%EA_{avg}\ (\%) = \frac{100 \times \left[(\%O_2)_{avg} - \left(0.5 \times (\%CO)_{avg}\right)\right]}{\left(0.264 \times (N_2)_{avg}\right) - \left[(\%O_2)_{avg} - \left(0.5 \times (\%CO)_{avg}\right)\right]}$$

$$(\%EA)_{AVG} = \frac{100 \times \{8.67\ \% - (0.5 \times 0.001\ \%)\}}{(0.264 \times 84.62\ \%) - \{8.67\ \% - (0.5 \times 0.001\ \%)\}} = 63.38\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Reference Method 2) [Values from Run 1 test]

Absolute Stack Pressure (in. Hg)

$$P_S(in.Hg) = P_b + \frac{P_{static}}{13.6}$$

$$P_s\text{ (in. Hg)} = 29.87\text{ in. Hg} + \frac{0.07\text{ in. }H_2O}{13.6\text{ in. }H_2O\text{/in. Hg}} = 29.88\text{ in. Hg}$$

Average Stack Gas Velocity (ft/sec)

$$v_s(ft/\sec) = K_p \times C_p \times \left(\sqrt{\Delta p}\right)_{avg} \times \sqrt{\frac{(t_s)_{avg} + T_u}{P_s \times M_s}}$$

v_{sl} (ft/sec) =

$$\left(\frac{85.49\text{ ft}}{\text{sec}}\ \frac{\text{(lb/lb-mol)(in. Hg)}}{(^{o}R)(\text{in. }H_2O)}\right)^{1/2} \times 0.82 \times 0.41\text{ in.}H_2O^{1/2} \times \sqrt{\frac{906.00 + 460\ ^{o}R}{29.88\text{ in. Hg} \times 27.77\text{ lb/lb-mol}}} = \frac{37.3\text{ ft}}{\text{sec}}$$

Average Stack Dry Standard Flow Rate (dscfh)

$$Q_{sd}(dscfh) = \frac{60 \times 60 \times \left(1 - \frac{B_{ws}}{100}\right) \times v_s \times A_s \times T_{std} \times P_s}{(t_s + T_u) \times P_{std}}$$

$$Q_{sd}\text{ (dscf/hr)} = \frac{3600\text{ sec}}{\text{hr}} \times \left(1 - \frac{14.45\ \%}{100}\right) \times \frac{37.36\text{ ft}}{\text{sec}} \times 5.54\text{ ft}^2 \times \frac{68.00 + 460\ ^{o}R}{906.00 + 460\ ^{o}R} \times \frac{29.88\text{ in. Hg}}{29.92\text{ in. Hg}} = \frac{246{,}058.86\text{ dscf}}{\text{hr}}$$

Average Stack Wet Flow Rate (acfm)

$$Q_{aw}(acfm) = 60 \times v_s \times A_s$$

$$Q_{aw}\text{ (acf/min)} = \frac{60\text{ sec}}{\text{min}} \times \frac{37.36\text{ ft}}{\text{sec}} \times 5.54\text{ ft}^2 = \frac{12{,}420.94\text{ acf}}{\text{min}}$$

Average Stack Wet Standard Flow Rate (ascfh)

$$Q_{sw}(ascfh) = \frac{60 \times Q_{aw} \times T_{std} \times P_s}{(t_s + T_u) \times P_{std}}$$

$$Q_{sw}\text{ (ascf/hr)} = \frac{60\text{ min}}{\text{hr}} \times \frac{12{,}420.94\text{ acf}}{\text{min}} \times \frac{68.00 + 460\ ^{o}R}{906.00 + 460\ ^{o}R} \times \frac{29.88\text{ in. Hg}}{29.92\text{ in. Hg}} = \frac{287{,}632.16\text{ ascf}}{\text{hr}}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Reference Method 4) [Values from Run 1 test]

Water Volume Weighed (scf)

$$V_{wsg(std)}(scf) = W_t \times K_5$$

$V_{wsg(std)}$ = 126.10 g x 0.04715 ft^3/g = 5.946 scf

Standard Meter Volume (dscf)

$$V_{m(std)}(dscf) = \frac{K_1 \times Y \times V_m \times \left(P_b + \frac{\Delta H_{avg}}{13.6}\right)}{(t_m)_{avg} + T_u}$$

$$V_{m(std)} = \frac{\frac{17.65\ ^oR}{in.\ Hg} \times 0.99 \times 36.99\ dcf \times \left(29.87\ in.\ Hg + \frac{0.52\ in.\ H_2O}{13.6\ in.\ H_2O\ /\ in.\ Hg}\right)}{87.00\ ^oF + 460\ ^oR} = 35.19\ dscf$$

Calculated Moisture Content (%)

$$B_{ws(calc)}(\%) = 100 \times \frac{V_{wsg(std)}}{V_{wsg(std)} + V_{m(std)}}$$

$$B_{ws(calc)} = 100 \times \frac{5.95\ dscf}{5.95\ dscf + 35.19\ dscf} = 14.45\ \%$$

Saturated Moisture Content (%)

$$B_{ws(svp)}(\%) = 100 \times \frac{10^{6.691 - \frac{3144}{t_{s(avg)} + 390.86}}}{P_b + \frac{P_{static}}{13.6}} \leq 100$$

$$B_{ws(svp)} = 100 \times \frac{10^{\left(6.691 - \frac{3144}{906.00\ ^oF + 390.86}\right)}}{29.87\ in.\ Hg + \frac{0.07\ in.\ H_2O}{13.6\ in.\ H_2O\ /\ in.\ Hg}} \leq 100 = 100.00\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Isokinetic Sampling) [Values from Run 1 test]

Desired Orifice (in. H_2O) (first point)

$$\Delta H_d (in.H_2O) = K \times \Delta p$$

ΔH_d (in. H_2O) = 3.05 x 0.15 in. H_2O = 0.46 in. H_2O

Absolute Meter Pressure (in. Hg)

$$P_m (in.Hg) = P_b + \frac{\Delta H @}{13.6}$$

$$P_m \text{ (in. Hg)} = 29.87 \text{ in. Hg} + \frac{1.83 \text{ in. } H_2O}{13.6 \text{ in. } H_2O\text{/in. Hg}} = 30.00 \text{ in. Hg}$$

Recommended Nozzle Diameter (in.)

$$D_m (in.) = \sqrt{\frac{C_n \times Q_m \times P_m}{(t_m + T_u) \times C_p} \times \left(\frac{1 - \frac{B_{wm}}{100}}{1 - \frac{B_{ws}}{100}} \right) \times \sqrt{(t_s + T_u) \times \left[\frac{M_d \times \left(1 - \frac{B_{ws}}{100}\right) + \left(18 \times \frac{B_{ws}}{100}\right)}{P_s \times \Delta p_{avg}} \right]}}$$

$$D_{ni} \text{ (in.)} = \sqrt{\frac{\frac{0.03575 \text{ (lb-mole}\cdot{}^oR\cdot\text{in. } H_2O)^{1/2}\cdot\text{min}\cdot\text{in.}^2}{\text{acf}\cdot\text{in. Hg}^{3/4}\cdot\text{lb}^{1/2}} \times 0.75 \text{ acf} \times 30.00 \text{ in. Hg}}{(87.00\ {}^oF + 460{}^oR) \times 0.82} \times \left(\frac{1 - \frac{0.00\ \%}{100}}{1 - \frac{14.45\ \%}{100}} \right) \times \sqrt{(906.00\ {}^oF + 460{}^oR) \times \frac{\frac{29.42 \text{ lb}}{\text{lb-mole}} \times \left(1 - \frac{14.45\ \%}{100}\right) + \left(\frac{18 \text{ lb}}{\text{lb-mol}} \times \frac{14.45\ \%}{100}\right)}{29.88 \text{ in. Hg} \times 0.41 \text{ in. } H_2O}}} = 0.315 \text{ in.}$$

ΔP to ΔH Isokinetic Factor

$$K = C_k \times C_p^2 \times \Delta H @ \times D_{na}^4 \times \left[\frac{M_d \times \left(1 - \frac{B_{wm}}{100}\right) + \left(18 \times \frac{B_{wm}}{100}\right)}{M_d \times \left(1 - \frac{B_{ws}}{100}\right) + \left(18 \times \frac{B_{ws}}{100}\right)} \right] \times \left(\frac{1 - \frac{B_{ws}}{100}}{1 - \frac{B_{wm}}{100}} \right)^2 \times \left(\frac{t_m + T_u}{ts + T_u} \right) \times \frac{P_s}{P_m}$$

$$K = \frac{849.8}{\text{in. } H_2O\cdot\text{in.}^4} \times 0.82^2 \times 1.83 \text{ in. } H_2O \times 0.31^4 \times \left(\frac{1 - \frac{14.45\ \%}{100}}{1 - \frac{0.00\ \%}{100}} \right)^2 \times \left(\frac{87.00\ {}^oF + 460{}^oR}{906.00\ {}^oF + 460{}^oR} \right) \times \left(\frac{\frac{29.42 \text{ lb}}{\text{lb/mole}} \times \left(1 - \frac{0.00\ \%}{100}\right) + \left(\frac{18 \text{ lb}}{\text{lb-mol}} \times \frac{0.00\ \%}{100}\right)}{\frac{29.42 \text{ lb}}{\text{lb/mole}} \times \left(1 - \frac{14.45\ \%}{100}\right) + \left(\frac{18 \text{ lb}}{\text{lb-mol}} \times \frac{14.45\ \%}{100}\right)} \right) \times \frac{29.88 \text{ in. Hg}}{30.00 \text{ in. Hg}} = 3.05$$

Percent Isokinetic (%) (first point)

$$I(\%) = \frac{K_4 \times \left((t_s)_{avg} + T_u\right) \times V_{m(std)}}{\left(\Theta \times \left(v_{s(I)}\right)_{avg} \times P_s \times \pi \times \left(\frac{D_{na}}{2} \times \frac{1}{12}\right)^2\right) \times \left(1 - \frac{B_{ws}}{100}\right)}$$

$$I(\%) = \frac{\frac{0.0945 \text{ min}\cdot\text{in. Hg}}{\text{sec}\cdot{}^oR} \times (900.00\ {}^oF + 460\ {}^oR) \times 1.32 \text{ dscf}}{3.75 \text{ min} \times \frac{34.83 \text{ ft}}{\text{sec}} \times 29.88 \text{ in. Hg} \times 3.14 \times \left(\frac{0.31 \text{ in.}}{2} \times \frac{\text{ft.}}{12 \text{ in.}}\right)^2 \times \left(1 - \frac{14.45\ \%}{100}\right)} = 95.97\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Isokinetic Sampling) [Values from Run 1 test]

Cumulative Percent Isokinetic (%) (weighted average of all points)

$$I(\%) = \sum_{1-n} \frac{\lfloor I(\%) \times V_{m(std)} \rfloor_{1-n}}{V_{m(std)1-n}}$$

Using Method 5, Eq 5-8 to determine intermediate isokinetics at each point, weighted averaging of the cumulative isokinetics is necessary since all points are not equal, and determined by using the dry standard meter volume collected at each point to weight the cumulative average. Intermediate isokinetics and dry standard meter volumes are found at each point. At each point the cumulative sum is found of each value and the quotient of the two used to determine the cumulative isokinetics for each residual point (n).

Pt	In (%)	x	Vm(std)n	=	I (%)n	∑(I (%)n)	/	∑(Vm(std)n)	=	I (%)
A-1	95.97	x	1.318	=	126.45	126.45	/	1.32	=	96.0
A-2	98.04	x	1.472	=	144.30	270.76	/	2.79	=	97.1
A-3	97.62	x	1.424	=	138.97	409.72	/	4.21	=	97.3
A-4	98.77	x	1.354	=	133.70	543.42	/	5.57	=	97.6
A-5	99.56	x	1.450	=	144.34	687.76	/	7.02	=	98.0
A-6	101.42	x	1.601	=	162.36	850.12	/	8.62	=	98.7
A-7	97.68	x	1.505	=	146.99	997.11	/	10.12	=	98.5
A-8	99.63	x	1.492	=	148.69	1145.80	/	11.61	=	98.7
A-9	99.91	x	1.538	=	153.61	1299.41	/	13.15	=	98.8
A-10	100.38	x	1.544	=	155.01	1454.42	/	14.70	=	99.0
A-11	102.86	x	1.541	=	158.54	1612.95	/	16.24	=	99.3
A-12	95.96	x	1.398	=	134.20	1747.16	/	17.64	=	99.1
B-1	100.45	x	1.384	=	139.00	1886.16	/	19.02	=	99.2
B-2	97.66	x	1.384	=	135.15	2021.30	/	20.40	=	99.1
B-3	99.15	x	1.403	=	139.08	2160.39	/	21.81	=	99.1
B-4	101.47	x	1.479	=	150.04	2310.43	/	23.29	=	99.2
B-5	92.93	x	1.393	=	129.49	2439.92	/	24.68	=	98.9
B-6	109.72	x	1.646	=	180.64	2620.56	/	26.33	=	99.5
B-7	98.33	x	1.473	=	144.88	2765.45	/	27.80	=	99.5
B-8	97.10	x	1.417	=	137.57	2903.01	/	29.22	=	99.4
B-9	97.00	x	1.417	=	137.41	3040.43	/	30.63	=	99.3
B-10	107.27	x	1.565	=	167.87	3208.29	/	32.20	=	99.6
B-11	98.32	x	1.393	=	136.93	3345.22	/	33.59	=	99.6
B-12	112.75	x	1.599	=	180.25	3525.47	/	35.19	=>	100.2
Last Pt										

Percent Isokinetic (%) (intermediate equation, all points)
[equivalent to taking an average of point-by-point isokinetics without weighting the average (e.g. all points equal)]

$$I(\%) = \frac{K_4 \times \left((t_s)_{avg} + T_u \right) \times V_{m(std)}}{\left(\Theta \times (v_{s(l)})_{avg} \times P_s \times \pi \times \left(\frac{D_{na}}{2} \times \frac{1}{12} \right)^2 \right) \times \left(1 - \frac{B_{ws}}{100} \right)}$$

$$I(\%) = \frac{\frac{0.0945 \text{ min•in. Hg}}{\text{sec•}^o\text{R}} \times (906.00\ ^o\text{F} + 460\ ^o\text{R}) \times 35.19 \text{ dscf}}{90.00 \text{ min} \times \frac{37.36 \text{ ft}}{\text{sec}} \times 29.88 \text{ in. Hg} \times 3.14 \times \left(\frac{0.31 \text{ in.}}{2} \times \frac{\text{ft.}}{12 \text{ in.}} \right)^2 \times \left(1 - \frac{14.45\ \%}{100} \right)} = 100.00\ \%$$

Raw Data Percent Isokinetic (%)
[utilizes the raw data equation for isokinetics from Method 5]

$$I(\%) = \frac{100 \left((t_s)_{avg} + T_u \right) \left[K_4 V_{1c} + \frac{V_m Y}{(t_m)_{avg} + T_u} \left(P_{bar} + \frac{\Delta H}{13.6} \right) \right]}{60 \left(\Theta \times (v_{s(l)})_{avg} \times P_s \times \pi \times \left(\frac{D_{na}}{2} \times \frac{1}{12} \right)^2 \right)}$$

I (%) =

$$\frac{100 \times (906.00\ ^o\text{F} + 460\ ^o\text{R}) \times \left[\frac{0.002669 \text{ ft}^3\text{•in. Hg}}{\text{ml•}^o\text{R}} \times 126.3 \text{ ml} + \frac{36.99 \text{ dcf} \times 0.986}{87.00\ ^o\text{F} + 460\ ^o\text{R}} \left(29.87 \text{ in Hg} + \frac{0.415}{13.6} \right) \right]}{60 \times 90.00 \text{ min} \times \frac{37.36 \text{ ft}}{\text{sec}} \times 29.88 \text{ in. Hg} \times 3.14 \times \left(\frac{0.31 \text{ in.}}{2} \times \frac{\text{ft.}}{12 \text{ in.}} \right)^2} = 99.93\ \%$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Gravimetric Analysis) [Values from Run 1 test]

Blank Concentration [Acetone Blank Weight of Solids] (mg/ml)

$$C_x(mg/ml) = \frac{1000 \times w_x}{v_x}$$

C_x (mg/ml) = $\frac{1000\ mg}{g}$ x $\frac{0.0004\ g}{137.00\ ml}$ = $\frac{0.0026\ mg}{ml}$ = $\frac{\quad mg}{ml}$

Blank Adjustment [Acetone Blank Weight of Solids and Probe Wash] (mg)

$$W_x(mg) = v_x \times C_x$$

W_x (mg) = 200.00 ml x 0.0026 mg/ml = 0.51 mg < Sample Gain

Sample Gain [Probe Wash] (mg)

$$m_x(mg) = (m_{fx} - m_{tx}) \times 1000$$

m_x (mg) = $\frac{1000\ mg}{g}$ x (126.00 g - 125.99 g) = 9.50 mg

Adjusted Sample Gain [Probe Wash] (mg)

$$m_{xadj}(mg) = m_x - W_x$$

m_{xadj} (mg) = 9.50 mg - 0.51 mg = 8.99 mg

0.1N NH_4OH Correction (mg)

$$m_c(mg) = 17.03 \times V_t \times N$$

m_c (mg) = 17.03 x 0.00 ml x 0.1 N = 0.00 mg

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (Analysis) [Values from Run 1 test - Total PM Mass]

Stack Total Concentration (g/dscf)

$$c_s(g/dscf) = 0.001 \times \frac{M_n}{V_{m(std)}}$$

$$c_s \text{ (g/dscf)} = \frac{\text{g}}{\text{1000 mg}} \times \frac{\text{18.09 mg}}{\text{35.19 dscf}} = \frac{\text{5.14E-04 g}}{\text{dscf}}$$

Stack Total Concentration (gr/dscf)

$$c_s^{'}(gr/dscf) = 0.001 \times \frac{M_n}{V_{m(std)}} \times \frac{7000}{453.592}$$

$$c'_s \text{ (gr/dscf)} = \frac{\text{g}}{\text{1000 mg}} \times \frac{\text{18.09 mg}}{\text{35.19 dscf}} \times \frac{\text{7000 gr}}{\text{lb}} \times \frac{\text{lb}}{\text{453.592 g}} = \frac{\text{7.93E-03 gr}}{\text{dscf}}$$

Total Emissions Rate (kg/hr)

$$E(kg/hr) = c_s \times Q_{sd} \times \frac{kg}{1000\ g}$$

$$E \text{ (kg/hr)} = \frac{\text{kg}}{\text{1000 g}} \times \frac{\text{5.14E-04 g}}{\text{dscf}} \times \frac{\text{246,059 dscf}}{\text{hr}} = \frac{\text{0.13 kg}}{\text{hr}}$$

Total Emissions Rate (lb/hr)

$$E^{'}(lb/hr) = \frac{M_n \times Q_{sd}}{V_{m(std)}} \times \frac{lb \times g}{453.592g \times 1000mg}$$

$$E' \text{ (lb/hr)} = \frac{\text{g}}{\text{1000 mg}} \times \frac{\text{lb}}{\text{453.592 g}} \times \frac{\text{18.09 mg}}{\text{35.19 dscf}} \times \frac{\text{246,059 dscf}}{\text{hr}} = \frac{\text{0.28 lb}}{\text{hr}}$$

Total Emissions Rate (tpy)

$$E^{''}(ton/yr) = E^{'} \times \frac{8760}{2000}$$

$$E'' \text{ (tpy)} = \frac{\text{ton}}{\text{2000 lb}} \times \frac{\text{8,760 hr}}{\text{yr}} \times \frac{\text{0.28 lb}}{\text{hr}} = \frac{\text{1.22 ton}}{\text{yr}}$$

Total Emissions Rate (lb/MMBtu)

Oxygen Based:

$$E'''(lb/MMBtu) = \frac{M_n \times F_d}{V_{m(std)} \times 1000 \times 453.592} \times \left(\frac{20.9}{20.9 - \%O_2}\right)$$

$$E''' \text{ (lb/MMBtu)} = \frac{\text{g}}{\text{1000 mg}} \times \frac{\text{lb}}{\text{453.592 g}} \times \frac{\text{18.09 mg}}{\text{35.19 dscf}} \times \frac{\text{8,631.70 dscf}}{\text{MMBtu}} \times \left(\frac{20.9}{20.9 - 8.7\ \%}\right) = \frac{\text{0.0167 lb}}{\text{MMBtu}}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

TEST RESULTS AND CALCULATIONS

75% Load
PM Emissions Data

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Historical Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Run Start Time	08:08	13:17	15:25		hh:mm
Run Stop Time	09:42	14:56	17:01		hh:mm
Test Date	07/30/21	07/30/21	07/30/21		mm/dd/yy
Load	75%	75%	75%		% or w/DB
Meter Calibration Factor	0.986	0.986	0.986		
Pitot Tube Coefficient	0.8230	0.8230	0.8230		
Average Nozzle Diameter	0.311	0.311	0.311		in
Stack Test Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Initial Meter Volume	171.591	224.575	278.408		ft³
Final Meter Volume	224.305	278.151	332.354		ft³
Total Meter Volume	52.714	53.576	53.946	53.412	ft³
Total Sampling Time	90.00	90.00	90.00	90.00	min
Average Meter Temperature	82.33	92.13	94.79	89.75	°F
Average Stack Temperature	911.54	908.79	910.17	910.17	°F
Barometric Pressure	29.89	29.90	29.86	29.88	in Hg
Stack Static Pressure	0.21	0.21	0.21	0.21	in H_2O
Absolute Stack Pressure	29.91	29.92	29.88	29.90	in Hg
Average Orifice Pressure Drop	1.14	1.09	1.12	1.11	in H_2O
Absolute Meter Pressure	30.02	30.03	29.99	30.02	in Hg
Avg Square Root Pitot Pressure	0.60	0.59	0.60	0.60	√(in H_2O)
Moisture Content Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Impinger Water Weight Gain	168.90	161.90	157.20	162.67	g
Silica Gel Weight Gain	9.20	9.70	11.10	10.00	g
Total Water Volume Collected	178.42	171.91	168.60	172.98	ml
Standard Water Vapor Volume	8.40	8.09	7.94	8.14	scf
Standard Meter Volume	50.7	50.6	50.7	50.7	dscf
Standard Metric Meter Volume	1.4	1.4	1.4	1.4	dscm
Calculated Stack Moisture	14.21	13.78	13.54	13.85	%
Saturated Stack Moisture	100.00	100.00	100.00	100.00	%
Reported Stack Moisture Content	14.21	13.78	13.54	13.85	%
Gas Analysis Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Carbon Dioxide Content	6.6	6.5	6.7	6.6	%
Oxygen Content	9.0	9.0	8.9	8.9	%
Carbon Monoxide Content	3.2	4.2	3.6	3.7	ppm
Nitrogen Content	84.5	84.5	84.4	84.5	%
Stack Dry Molecular Weight	29.41	29.41	29.42	29.41	lb/lb-mole
Stack Wet Molecular Weight	27.79	27.83	27.88	27.83	lb/lb-mole
Calculated Fuel Factor	1.819	1.823	1.796	1.813	
Fuel F-Factor	8632.09	8632.09	8632.09	8632.09	dscf/MMBtu
Percent Excess Air	67.1	67.1	67.0	67.1	%

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Volumetric Flow Rate Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Average Stack Gas Velocity	53.86	53.62	53.76	53.75	ft/sec
Stack Cross-Sectional Area	5.54	5.54	5.54	5.54	ft²
Actual Stack Flow Rate	17,907	17,828	17,876	17,870	acfm
Wet Standard Stack Flow Rate	413	413	413	413	wkscfh
Dry Standard Stack Flow Rate	354,670	355,692	356,802	355,721	dscfh
Percent of Isokinetic Rate	100.0	99.5	99.4	99.6	%
Gravimetric Analysis	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	ml
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	mg
Emission Rate Data	**R-1 75%-1**	**R-1 75%-2**	**R-1 75%-3**	**Average**	**Units**
Total PM Mass	6.11	7.36	5.34	6.27	mg
Total PM Concentration	1.20E-04	1.45E-04	1.05E-04	1.24E-04	g/dscf
	1.86E-03	2.24E-03	1.63E-03	1.91E-03	gr/dscf
Total PM Emission Rate	0.04	0.05	0.04	0.04	kg/hr
	0.09	0.11	0.08	0.10	lb/hr
	0.41	0.50	0.36	0.43	tpy
	0.0040	0.0048	0.0035	0.0041	lb/MMBtu
Filterable PM Mass	4.31	5.91	3.89	4.70	mg
Filterable PM Concentration	8.50E-05	1.17E-04	7.68E-05	9.29E-05	g/dscf
	1.31E-03	1.80E-03	1.19E-03	1.43E-03	gr/dscf
Filterable PM Emission Rate	0.03	0.04	0.03	0.03	kg/hr
	0.07	0.09	0.06	0.07	lb/hr
	0.29	0.40	0.26	0.32	tpy
	0.0028	0.0039	0.0026	0.0031	lb/MMBtu
Condensable PM Mass	1.80	1.45	1.45	1.57	mg
Condensable PM Concentration	3.55E-05	2.86E-05	2.86E-05	3.09E-05	g/dscf
	5.48E-04	4.42E-04	4.42E-04	4.77E-04	gr/dscf
Condensable PM Emission Rate	0.01	0.01	0.01	0.01	kg/hr
	0.03	0.02	0.02	0.02	lb/hr
	0.12	0.10	0.10	0.11	tpy
	0.0012	0.0010	0.0010	0.0010	lb/MMBtu

TEST RESULTS AND CALCULATIONS

100% Load
PM Emissions Data

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Historical Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Run Start Time	09:36	12:05	14:24		hh:mm
Run Stop Time	11:17	13:44	16:05		hh:mm
Test Date	08/31/21	08/31/21	08/31/21		mm/dd/yy
Load	100%	100%	100%		% or w/DB
Meter Calibration Factor	0.970	0.970	0.970		
Pitot Tube Coefficient	0.8230	0.8230	0.8230		
Average Nozzle Diameter	0.293	0.293	0.293		in
Stack Test Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Initial Meter Volume	921.610	984.410	48.125		ft³
Final Meter Volume	984.105	1046.875	110.390		ft³
Total Meter Volume	62.495	62.465	62.265	62.408	ft³
Total Sampling Time	90.00	90.00	90.00	90.00	min
Average Meter Temperature	83.54	91.46	76.50	83.83	°F
Average Stack Temperature	877.75	878.08	876.67	877.50	°F
Barometric Pressure	29.72	29.71	29.66	29.70	in Hg
Stack Static Pressure	-0.36	-0.36	-0.36	-0.36	in H_2O
Absolute Stack Pressure	29.69	29.68	29.63	29.67	in Hg
Average Orifice Pressure Drop	1.41	1.43	1.47	1.43	in H_2O
Absolute Meter Pressure	29.85	29.84	29.79	29.83	in Hg
Avg Square Root Pitot Pressure	0.76	0.76	0.76	0.76	$\sqrt{(in\ H_2O)}$
Moisture Content Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Impinger Water Weight Gain	189.10	184.70	233.10	202.30	g
Silica Gel Weight Gain	15.10	15.60	15.30	15.33	g
Total Water Volume Collected	204.57	200.66	248.85	218.03	ml
Standard Water Vapor Volume	9.63	9.44	11.71	10.26	scf
Standard Meter Volume	58.7	57.8	59.1	58.5	dscf
Standard Metric Meter Volume	1.7	1.6	1.7	1.7	dscm
Calculated Stack Moisture	14.09	14.04	16.53	14.89	%
Saturated Stack Moisture	100.00	100.00	100.00	100.00	%
Reported Stack Moisture Content	14.09	14.04	16.53	14.89	%
Gas Analysis Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Carbon Dioxide Content	6.8	6.6	6.6	6.7	%
Oxygen Content	8.6	9.1	9.1	8.9	%
Carbon Monoxide Content	4.4	2.2	2.2	2.9	ppm
Nitrogen Content	84.6	84.4	84.4	84.4	%
Stack Dry Molecular Weight	29.44	29.41	29.41	29.42	lb/lb-mole
Stack Wet Molecular Weight	27.82	27.81	27.53	27.72	lb/lb-mole
Calculated Fuel Factor	1.800	1.800	1.800	1.800	
Fuel F-Factor	8631.42	8631.42	8631.42	8631.42	dscf/MMBtu
Percent Excess Air	63.2	68.6	68.6	66.8	%

METHOD 5 (FRONT) AND 202 (BACK) - RESULTS

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Volumetric Flow Rate Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Average Stack Gas Velocity	68.00	68.19	68.64	68.28	ft/sec
Stack Cross-Sectional Area	5.54	5.54	5.54	5.54	ft²
Actual Stack Flow Rate	22,611	22,673	22,821	22,702	acfm
Wet Standard Stack Flow Rate	531	533	536	533	wkscfh
Dry Standard Stack Flow Rate	456,526	457,773	447,146	453,815	dscfh
Percent of Isokinetic Rate	102.0	99.9	104.6	102.2	%
Gravimetric Analysis	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	ml
NH_4OH Correction	0.0000	0.0000	0.0000	0.0000	mg
Emission Rate Data	**R-1 100%-1**	**R-1 100%-2**	**R-1 100%-3**	**Average**	**Units**
Total PM Mass	6.05	1.64	2.75	3.48	mg
Total PM Concentration	1.03E-04	2.84E-05	4.65E-05	5.93E-05	g/dscf
	1.59E-03	4.38E-04	7.18E-04	9.15E-04	gr/dscf
Total PM Emission Rate	0.05	0.01	0.02	0.03	kg/hr
	0.10	0.03	0.05	0.06	lb/hr
	0.45	0.13	0.20	0.26	tpy
	0.0033	0.0010	0.0016	0.0020	lb/MMBtu
Filterable PM Mass	3.60	1.05	0.00	1.55	mg
Filterable PM Concentration	6.13E-05	1.82E-05	0.00E+00	2.65E-05	g/dscf
	9.46E-04	2.80E-04	0.00E+00	4.09E-04	gr/dscf
Filterable PM Emission Rate	0.03	0.01	0.00	0.01	kg/hr
	0.06	0.02	0.00	0.03	lb/hr
	0.27	0.08	0.00	0.12	tpy
	0.0020	0.0006	0.0000	0.0009	lb/MMBtu
Condensable PM Mass	2.45	0.59	2.75	1.93	mg
Condensable PM Concentration	4.17E-05	1.02E-05	4.65E-05	3.28E-05	g/dscf
	6.44E-04	1.58E-04	7.18E-04	5.06E-04	gr/dscf
Condensable PM Emission Rate	0.02	0.00	0.02	0.01	kg/hr
	0.04	0.01	0.05	0.03	lb/hr
	0.18	0.05	0.20	0.14	tpy
	0.0014	0.0003	0.0016	0.0011	lb/MMBtu

APPENDIX B

EMISSION DATA RECORDS

EMISSION DATA RECORDS

Operating Data
(provided by Catalytic Combustion Corporation)

Catalytic Combustion Corporation	
Plant Name or Location:	Stewart & Stevenson Integration Center
Project Number:	catc-21-houston.tx-start#1
Manufacturer & Equipment:	Caterpillar
Model:	G3520 TALE
Test Load:	multiple
Tester(s) / Test Unit(s):	C. King / P. McGovern / J. Wolrab / 217

		RUN								
	UNITS	**1-1**	**1-2**	**1-3**	**2-1**	**2-2**	**2-3**	**3-1**	**3-2**	**3-3**
Start Time	hh:mm:ss	09:34:23	12:05:23	14:23:23	13:45:23	15:00:23	16:27:23	09:23:57	10:26:27	12:03:27
End Time	hh:mm:ss	10:33:53	13:04:53	15:22:53	14:44:53	15:59:53	17:26:53	10:25:57	12:02:57	13:06:27
Bar. Pressure	in. Hg	29.90	29.90	29.84	29.89	29.87	29.85	29.73	29.73	29.74
Amb. Temp.	°F	98	99	96	94	97	97	88	93	95
Rel. Humidity	%	53	49	49	53	47	42	70	57	46
Spec. Humidity	lb water / lb air	0.020978	0.019455	0.018009	0.018296	0.017841	0.015856	0.020202	0.019207	0.016410
Date	mm/dd/yy	07/29/21	07/29/21	07/29/21	07/30/21	07/30/21	07/30/21	09/01/21	09/01/21	09/02/21
Load Designator		50%	50%	50%	75%	75%	75%	100%	100%	100%
Engine Fuel Flow	SCFH	14,625	14,511	14,541	20,603	20,591	20,172	26,278	26,278	26,278
Stack Moisture	% Method 320	14.41	14.43	14.39	13.91	13.86	13.59	13.64	12.89	13.03
Power Output	horsepower	1,810.4	1,813.0	1,810.4	2,691.4	2,698.1	2,616.3	3,598.0	3,598.0	3,598.0
Air Manifold Press.	psia	25.20	25.40	25.30	36.80	36.70	35.60	473.00	473.00	473.00
Air Manifold Temp.	F	122.00	122.00	124.00	131.00	131.00	129.00	136.00	136.00	136.00
Engine Speed	rpm	1,799.00	1,799.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00
Actual Power	kW	1,350.00	1,352.00	1,350.00	2,007.00	2,012.00	1,951.00	2,613.00	2,613.00	2,613.00
Amperes	A	56.00	57.00	56.00	89.00	90.00	97.00	109.00	109.00	109.00
Engine Timing	BTDC	23.00	23.00	23.00	23.00	23.00	23.00	22.00	22.00	22.00

-Brake horsepower available from engine panel and/or site personnel.

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EMISSION DATA RECORDS

50% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O
Reference Method Data

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,625	SCFH

Weather Data

Barometric Pressure	29.90	in. Hg
Relative Humidity	53	%
Ambient Temperature	98	°F
Specific Humidity	0.020978	lb H_2O / lb air

Unit Data

Unit Load	1,810.4	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	215,406	SCFH

50% Load, Run - 1-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 09:34:23	64260	8.64	7.86	5.26	154.78	5.81	1.26	0.25	7.86	0.00	0.62	0.06	412.89	0.43	13.81
07/29/21 09:34:53	64290	8.65	7.74	5.30	155.11	5.79	1.21	0.44	7.74	0.00	0.64	0.10	411.55	0.56	14.08
07/29/21 09:35:23	64320	8.65	7.58	5.22	154.88	5.75	1.29	0.43	7.58	0.00	0.63	0.09	410.71	0.57	14.48
07/29/21 09:35:53	64350	8.64	7.82	5.31	155.59	5.81	1.28	0.48	7.82	0.00	0.60	0.09	411.45	0.58	13.77
07/29/21 09:36:23	64380	8.66	7.59	5.21	156.36	5.80	1.29	0.17	7.59	0.00	0.62	0.02	413.14	0.39	13.89
07/29/21 09:36:53	64410	8.67	7.66	5.22	154.14	5.72	1.23	0.58	7.66	0.00	0.59	0.16	407.82	0.41	14.77
07/29/21 09:37:23	64440	8.67	7.60	5.33	155.38	5.80	1.28	0.69	7.60	0.00	0.59	0.10	413.59	0.41	13.93
07/29/21 09:37:53	64470	8.68	7.65	5.30	158.32	5.85	1.29	0.25	7.65	0.00	0.57	0.03	418.84	0.54	13.40
07/29/21 09:38:23	64500	8.66	8.33	5.33	157.36	5.91	1.29	0.53	8.32	0.01	0.58	0.00	418.45	0.50	12.81
07/29/21 09:38:53	64530	8.67	7.37	5.20	155.95	5.74	1.27	0.66	7.37	0.00	0.60	0.09	413.16	0.60	14.45
07/29/21 09:39:23	64560	8.67	7.57	5.27	157.13	5.84	1.32	0.51	7.57	0.00	0.57	0.03	417.11	0.56	13.50
07/29/21 09:39:53	64590	8.66	7.52	5.27	156.37	5.82	1.32	0.08	7.52	0.00	0.54	0.06	414.39	0.44	13.72
07/29/21 09:40:23	64620	8.66	7.53	5.28	157.35	5.85	1.32	-0.02	7.53	0.00	0.56	0.15	417.90	0.47	13.41
07/29/21 09:40:53	64650	8.65	7.27	5.24	156.81	5.80	1.34	0.28	7.27	0.00	0.57	0.08	415.08	0.60	13.89
07/29/21 09:41:23	64680	8.66	6.98	5.23	153.86	5.64	1.29	0.37	6.98	0.00	0.58	0.13	406.46	0.53	15.59
07/29/21 09:41:53	64710	8.66	6.98	5.24	155.66	5.72	1.29	0.41	6.98	0.00	0.55	0.09	411.26	0.51	14.77
07/29/21 09:42:23	64740	8.66	7.08	5.29	155.72	5.74	1.29	0.39	7.08	0.00	0.58	0.07	412.49	0.52	14.72
07/29/21 09:42:53	64770	8.65	7.42	5.35	154.90	5.79	1.27	0.25	7.42	0.00	0.57	0.09	412.41	0.45	14.19
07/29/21 09:43:23	64800	8.65	7.46	5.21	156.74	5.80	1.30	0.38	7.46	0.00	0.52	0.11	414.00	0.47	13.82
07/29/21 09:43:53	64830	8.65	7.85	5.23	156.47	5.84	1.34	0.58	7.85	0.00	0.55	0.08	415.90	0.48	13.49
07/29/21 09:44:23	64860	8.65	7.19	5.23	155.54	5.69	1.27	0.05	7.19	0.00	0.54	0.03	410.51	0.64	14.97
07/29/21 09:44:53	64890	8.65	7.27	5.29	156.10	5.83	1.33	0.31	7.27	0.00	0.53	0.02	415.84	0.46	13.68
07/29/21 09:45:23	64920	8.65	7.64	5.32	156.06	5.83	1.32	0.72	7.64	0.00	0.52	0.05	414.28	0.69	13.67
07/29/21 09:45:53	64950	8.66	7.76	5.18	151.33	5.56	1.23	0.62	7.76	0.00	0.57	0.31	400.48	0.53	16.76
07/29/21 09:46:23	64980	8.66	7.68	5.36	156.15	5.82	1.33	0.51	7.68	0.00	0.53	0.10	413.91	0.58	13.79
07/29/21 09:46:53	65010	8.66	7.94	5.41	156.70	5.85	1.37	0.73	7.94	0.00	0.53	0.15	415.92	0.52	13.53
07/29/21 09:47:23	65040	8.67	7.41	5.26	156.29	5.75	1.31	0.21	7.41	0.00	0.53	0.06	413.46	0.51	14.44
07/29/21 09:47:53	65070	8.66	7.54	5.38	157.28	5.79	1.32	0.48	7.54	0.00	0.52	0.10	416.22	0.52	13.93
07/29/21 09:48:23	65100	8.65	7.31	5.35	155.73	5.78	1.31	0.51	7.31	0.00	0.52	0.10	413.92	0.53	14.18
07/29/21 09:48:53	65130	8.67	7.54	5.24	152.05	5.65	1.26	0.43	7.54	0.00	0.57	0.16	404.25	0.36	16.05
07/29/21 09:49:23	65160	8.67	6.93	5.25	155.15	5.72	1.29	0.31	6.93	0.00	0.51	0.08	412.31	0.52	14.72
07/29/21 09:49:53	65190	8.67	7.61	5.24	157.01	5.79	1.34	0.26	7.61	0.00	0.51	0.01	414.69	0.55	14.03
07/29/21 09:50:23	65220	8.67	7.36	5.25	158.02	5.80	1.36	0.36	7.36	0.00	0.50	0.07	417.65	0.35	13.99
07/29/21 09:50:53	65250	8.67	7.17	5.11	152.90	5.63	1.29	0.39	7.17	0.00	0.55	0.21	405.00	0.39	16.22
07/29/21 09:51:23	65280	8.67	7.26	5.24	156.56	5.76	1.31	0.53	7.26	0.00	0.49	0.02	414.46	0.46	14.34
07/29/21 09:51:53	65310	8.68	7.53	5.27	157.12	5.80	1.37	0.58	7.53	0.00	0.52	0.03	415.96	0.49	13.91
07/29/21 09:52:23	65340	8.68	7.31	5.25	155.62	5.76	1.39	0.56	7.31	0.00	0.49	0.10	413.86	0.40	14.28
07/29/21 09:52:53	65370	8.69	6.93	5.01	152.16	5.46	1.26	0.51	6.93	0.00	0.55	0.30	400.23	0.53	17.60
07/29/21 09:53:23	65400	8.68	6.93	5.25	157.83	5.74	1.33	0.00	6.93	0.00	0.49	0.00	416.19	0.63	14.47
07/29/21 09:53:53	65430	8.67	6.42	5.22	156.91	5.65	1.30	0.40	6.42	0.00	0.49	0.20	413.78	0.51	15.42
07/29/21 09:54:23	65460	8.67	6.94	5.06	152.99	5.49	1.26	0.48	6.94	0.00	0.56	0.24	402.97	0.43	17.51
07/29/21 09:54:53	65490	8.67	6.91	5.17	157.38	5.74	1.34	0.26	6.91	0.00	0.51	0.07	416.00	0.45	14.44
07/29/21 09:55:23	65520	8.67	6.85	5.16	156.86	5.70	1.32	0.58	6.85	0.00	0.49	0.02	413.18	0.33	14.89
07/29/21 09:55:53	65550	8.67	6.90	5.07	153.00	5.63	1.28	0.31	6.90	0.00	0.51	0.19	406.91	0.42	16.15
07/29/21 09:56:23	65580	8.66	6.69	5.24	155.68	5.68	1.32	0.43	6.69	0.00	0.48	0.08	412.23	0.37	15.24
07/29/21 09:56:53	65610	8.67	6.97	5.09	152.57	5.60	1.28	0.43	6.97	0.00	0.53	0.13	404.35	0.34	16.62
07/29/21 09:57:23	65640	8.66	6.58	5.28	155.53	5.66	1.34	0.44	6.58	0.00	0.49	0.13	412.16	0.52	15.34
07/29/21 09:57:53	65670	8.67	6.36	5.22	156.76	5.66	1.31	0.41	6.36	0.00	0.49	0.11	413.16	0.58	15.30
07/29/21 09:58:23	65700	8.66	6.58	5.21	154.91	5.65	1.26	0.40	6.58	0.00	0.49	0.06	408.84	0.50	15.58
07/29/21 09:58:53	65730	8.67	7.30	5.03	153.53	5.68	1.30	0.57	7.30	0.00	0.52	0.07	407.78	0.38	15.67
07/29/21 09:59:23	65760	8.66	7.43	5.20	153.92	5.68	1.33	0.57	7.43	0.00	0.53	0.03	408.27	0.34	15.67
07/29/21 09:59:53	65790	8.67	6.87	5.30	155.32	5.67	1.33	0.48	6.87	0.00	0.47	0.13	410.96	0.46	15.29
07/29/21 10:00:23	65820	8.67	6.83	5.20	157.56	5.72	1.31	0.27	6.83	0.00	0.48	0.15	414.63	0.64	14.74
07/29/21 10:00:53	65850	8.67	7.35	5.25	157.37	5.81	1.40	0.33	7.35	0.00	0.47	0.07	417.59	0.57	13.78
07/29/21 10:01:23	65880	8.67	7.53	5.26	159.10	5.89	1.43	0.62	7.53	0.00	0.44	0.06	422.35	0.44	12.91
07/29/21 10:01:53	65910	8.67	7.14	5.38	159.41	5.88	1.45	0.12	7.14	0.00	0.44	-0.02	424.89	0.46	12.44
07/29/21 10:02:23	65940	8.69	7.37	5.33	160.28	5.90	1.45	0.38	7.37	0.00	0.41	0.07	425.29	0.58	12.09
07/29/21 10:02:53	65970	8.70	7.13	5.17	157.58	5.85	1.42	0.66	7.13	0.00	0.42	0.02	419.90	0.43	13.24
07/29/21 10:03:23	66000	8.69	7.10	5.14	157.75	5.79	1.41	0.62	7.10	0.00	0.42	0.06	419.81	0.51	13.73
07/29/21 10:03:53	66030	8.69	7.15	5.23	157.78	5.79	1.40	0.52	7.15	0.00	0.42	0.21	418.35	0.33	13.67
07/29/21 10:04:23	66060	8.69	7.44	5.21	157.72	5.80	1.43	0.49	7.44	0.00	0.39	0.08	419.66	0.62	13.52
07/29/21 10:04:53	66090	8.70	6.64	5.17	157.56	5.71	1.42	0.22	6.64	0.00	0.44	0.13	416.02	0.67	14.71
07/29/21 10:05:23	66120	8.70	7.35	5.22	157.35	5.81	1.37	0.57	7.35	0.00	0.44	0.09	418.70	0.48	13.74
07/29/21 10:05:53	66150	8.72	7.22	5.26	158.63	5.86	1.44	0.19	7.22	0.00	0.40	0.09	422.70	0.42	13.11
07/29/21 10:06:23	66180	8.73	7.36	5.15	159.51	5.88	1.41	0.54	7.36	0.00	0.40	0.05	426.25	0.52	12.70
07/29/21 10:06:53	66210	8.72	6.96	5.24	161.63	5.86	1.47	0.32	6.96	0.00	0.39	-0.04	428.99	0.55	12.52
07/29/21 10:07:23	66240	8.71	6.95	5.23	162.42	5.88	1.47	0.47	6.95	0.00	0.39	0.02	430.75	0.51	12.30
07/29/21 10:07:53	66270	8.71	6.84	5.10	156.90	5.72	1.36	0.23	6.84	0.00	0.40	0.09	418.11	0.50	14.51
07/29/21 10:08:23	66300	8.71	6.66	5.08	157.89	5.70	1.40	0.56	6.66	0.00	0.42	0.13	418.07	0.64	14.75
07/29/21 10:08:53	66330	8.72	7.21	5.07	152.75	5.50	1.29	0.39	7.21	0.00	0.47	0.23	405.70	0.61	17.06
07/29/21 10:09:23	66360	8.72	7.06	5.22	159.18	5.78	1.46	0.54	7.06	0.00	0.41	0.14	423.51	0.68	13.88
07/29/21 10:09:53	66390	8.72	6.95	5.16	159.67	5.77	1.45	0.50	6.95	0.00	0.40	0.18	423.30	0.68	13.97
07/29/21 10:10:23	66420	8.72	6.66	5.04	157.74	5.67	1.39	0.15	6.66	0.00	0.41	0.06	418.97	0.49	14.88
07/29/21 10:10:53	66450	8.72	6.82	5.08	158.41	5.71	1.42	0.59	6.82	0.00	0.41	0.11	420.84	0.63	14.59
07/29/21 10:11:23	66480	8.72	6.77	5.11	158.91	5.75	1.42	0.62	6.77	0.00	0.43	0.16	423.31	0.45	14.30
07/29/21 10:11:53	66510	8.71	6.61	5.02	155.78	5.65	1.34	0.69	6.61	0.00	0.45	0.17	414.60	0.44	15.92
07/29/21 10:12:23	66540	8.71	6.62	5.12	158.94	5.75	1.40	0.69	6.62	0.00	0.37	0.10	422.13	0.49	14.35
07/29/21 10:12:53	66570	8.71	6.64	5.07	159.08	5.75	1.40	0.46	6.64	0.00	0.43	0.08	421.03	0.61	14.34
07/29/21 10:13:23	66600	8.70	6.52	5.06	158.62	5.71	1.36	0.30	6.52	0.00	0.38	0.13	420.44	0.60	14.77
07/29/21 10:13:53	66630	8.72	6.42	5.09	157.86	5.67	1.34	0.40	6.42	0.00	0.40	0.09	417.93	0.40	15.09
07/29/21 10:14:23	66660	8.71	6.64	4.99	159.67	5.76	1.42	0.52	6.64	0.00	0.40	0.23	424.81	0.54	13.97
07/29/21 10:14:53	66690	8.70	6.62	5.01	158.59	5.77	1.41	0.56	6.62	0.00	0.39	0.15	422.71	0.50	14.24
07/29/21 10:15:23	66720	8.70	6.43	5.11	158.14	5.76	1.42	0.59	6.43	0.00	0.39	0.03	422.97	0.56	14.18
07/29/21 10:15:53	66750	8.71	6.24	5.05	158.96	5.70	1.36	0.45	6.24	0.00	0.37	0.08	421.67	0.57	14.71
07/29/21 10:16:23	66780	8.71	6.76	5.17	159.48	5.77	1.42	0.44	6.76	0.00	0.40	-0.02	423.51	0.54	14.04
07/29/21 10:16:53	66810	8.70	6.32	5.09	158.58	5.75	1.41	0.13	6.32	0.00	0.40	0.04	422.02	0.58	14.31
07/29/21 10:17:23	66840	8.69	6.56	5.04	157.96	5.74	1.40	0.31	6.56	0.00	0.40	0.01	420.49	0.57	14.55
07/29/21 10:17:53	66870	8.70	6.80	4.99	154.72	5.59	1.33	0.52	6.80	0.00	0.44	0.14	411.17	0.46	16.33
07/29/21 10:18:23	66900	8.71	6.57	5.05	158.74	5.76	1.40	0.37	6.57	0.00	0.39	0.07	421.03	0.54	14.26
07/29/21 10:18:53	66930	8.70	6.03	5.06	157.97	5.63	1.37	0.48	6.03	0.00	0.41	0.03	417.19	0.49	15.46
07/29/21 10:19:23	66960	8.71	6.66	4.95	156.20	5.67	1.37	0.47	6.66	0.00	0.42	0.10	414.46	0.45	15.85
07/29/21 10:19:53	66990	8.70	6.27	5.10	159.48	5.73	1.37	0.27	6.27	0.00	0.38	0.02	422.14	0.58	14.48
07/29/21 10:20:23	67020	8.70	6.71	5.03	159.47	5.77	1.40	0.69	6.71	0.00	0.37	0.06	422.56	0.55	14.09
07/29/21 10:20:53	67050	8.71	6.74	5.10	159.48	5.78	1.42	0.27	6.74	0.00	0.40	0.18	422.83	0.56	13.90
07/29/21 10:21:23	67080	8.71	6.74	5.13	158.99	5.78	1.39	0.74	6.74	0.00	0.37	0.13	422.22	0.65	13.75
07/29/21 10:21:53	67110	8.72	6.60	5.11	159.46	5.77	1.38	0.70	6.60	0.00	0.38	0.09	423.55	0.66	13.89
07/29/21 10:22:23	67140	8.71	6.96	5.13	158.50	5.78	1.43	0.64	6.96	0.00	0.37	0.06	422.56	0.69	13.89
07/29/21 10:22:53	67170	8.71	6.85	5.18	159.38	5.78	1.38	0.59	6.85	0.00	0.40	0.03	423.54	0.67	13.83
07/29/21 10:23:23	67200	8.71	6.95	5.23	159.56	5.84	1.43	0.63	6.95	0.00	0.38	0.08	425.93	0.65	13.40
07/29/21 10:23:53	67230	8.71	7.25	5.21	160.73	5.85	1.39	0.43	7.25	0.00	0.38	0.08	426.85	0.51	13.26

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,625	SCFH

Weather Data

Barometric Pressure	29.90	in. Hg
Relative Humidity	53	%
Ambient Temperature	98	°F
Specific Humidity	0.020978	lb H_2O / lb air

Unit Data

Unit Load	1,810.4	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	215,406	SCFH

50% Load, Run - 1-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 10:24:23	67260	8.71	7.08	5.07	156.27	5.64	1.39	0.47	7.08	0.00	0.39	0.17	413.62	0.50	15.82
07/29/21 10:24:53	67290	8.72	6.60	5.11	160.35	5.81	1.44	0.56	6.60	0.00	0.37	0.04	426.11	0.47	13.57
07/29/21 10:25:23	67320	8.71	6.65	5.08	159.82	5.78	1.45	0.26	6.65	0.00	0.36	0.02	423.42	0.50	13.83
07/29/21 10:25:53	67350	8.72	6.28	5.07	157.14	5.66	1.42	0.56	6.28	0.00	0.38	0.09	415.31	0.52	15.27
07/29/21 10:26:23	67380	8.74	5.86	5.08	157.56	5.62	1.41	0.57	5.86	0.00	0.37	0.12	416.39	0.48	15.59
07/29/21 10:26:53	67410	8.72	6.63	4.96	156.44	5.65	1.37	0.43	6.63	0.00	0.41	0.10	413.82	0.45	15.79
07/29/21 10:27:23	67440	8.73	5.97	4.86	153.01	5.40	1.33	0.37	5.97	0.00	0.43	0.15	403.75	0.55	18.18
07/29/21 10:27:53	67470	8.75	6.32	5.09	158.31	5.65	1.41	0.08	6.32	0.00	0.39	0.11	417.51	0.64	15.24
07/29/21 10:28:23	67500	8.75	6.48	5.11	160.05	5.72	1.44	0.44	6.48	0.00	0.37	0.13	423.17	0.54	14.46
07/29/21 10:28:53	67530	8.73	6.34	5.05	161.20	5.77	1.47	0.59	6.34	0.00	0.36	0.07	425.53	0.41	13.89
07/29/21 10:29:23	67560	8.75	6.88	5.09	161.83	5.81	1.48	0.66	6.88	0.00	0.33	0.10	427.71	0.60	13.43
07/29/21 10:29:53	67590	8.75	6.79	5.07	160.96	5.83	1.46	0.38	6.79	0.00	0.35	0.12	428.39	0.50	13.22
07/29/21 10:30:23	67620	8.74	6.66	5.05	161.91	5.85	1.50	0.59	6.66	0.00	0.37	-0.02	430.14	0.45	13.16
07/29/21 10:30:53	67650	8.74	6.77	5.01	160.93	5.84	1.50	0.51	6.77	0.00	0.34	0.03	428.55	0.66	13.37
07/29/21 10:31:23	67680	8.74	6.20	5.05	160.09	5.76	1.44	0.66	6.20	0.00	0.35	0.01	426.08	0.56	13.99
07/29/21 10:31:53	67710	8.74	6.02	4.99	158.94	5.70	1.42	0.36	6.02	0.00	0.33	0.09	422.59	0.65	14.59
07/29/21 10:32:23	67740	8.73	6.44	4.96	160.40	5.76	1.43	0.62	6.44	0.00	0.34	0.17	425.67	0.50	13.81
07/29/21 10:32:53	67770	8.73	6.37	5.02	159.65	5.77	1.41	0.60	6.37	0.00	0.31	0.15	425.11	0.50	13.72
07/29/21 10:33:23	67800	8.73	6.12	5.00	160.39	5.71	1.44	0.46	6.12	0.00	0.37	0.09	424.68	0.37	14.53
07/29/21 10:33:53	67830	8.72	6.47	4.94	159.83	5.76	1.43	0.47	6.47	0.00	0.36	0.15	424.18	0.41	13.94
RAW AVERAGE		**8.69**	**6.97**	**5.16**	**157.35**	**5.74**	**1.36**	**0.45**	**6.97**	**0.00**	**0.46**	**0.09**	**417.32**	**0.52**	**14.41**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
	Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.03			2.53										
	Final Zero	0.07			0.12										
	Avg. Zero	0.05			1.33										
	Initial UpScale	12.03			306.71										
	Final UpScale	11.98			307.25										
	Avg. UpScale	12.01			306.98										
Upscale Cal Gas		11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.67	8.15	6.03	183.85	6.71	1.59	0.52	8.15	0.00	0.54	0.11	178.78	0.40	4.67
Corrected Raw Average (ppm/% wet basis)	7.41	6.97	5.16	157.35	5.74	1.36	0.45	6.97	0.00	0.46	0.09	153.02	0.34	3.99
Concentration (ppm@ 15%O_2)	N/A	3.93	2.91	75.89	3.24	0.77	0.25	3.93	0.00	0.26	0.05	86.22	0.19	1.93
Emission Rate (g/kW*hr)	N/A	0.0704	0.0317	1.3008	555	0.0132	0.0043	0.0459	0.0000	0.0017	0.0006	1.4813	0.0033	0.0330
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,511	SCFH

Weather Data

Barometric Pressure	29.90	in. Hg
Relative Humidity	49	%
Ambient Temperature	99	°F
Specific Humidity	0.019455	lb H_2O / lb air

Unit Data

Unit Load	1,813.0	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	215,084	SCFH

50% Load, Run - 1-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 12:05:23	73320	8.74	5.65	4.97	157.72	5.52	1.61	0.36	5.65	0.00	0.33	0.20	417.26	0.55	16.96
07/29/21 12:05:53	73350	8.74	6.03	4.98	157.68	5.64	1.61	0.81	6.03	0.00	0.32	0.06	421.08	0.48	15.97
07/29/21 12:06:23	73380	8.74	6.02	4.99	158.22	5.59	1.59	0.76	6.02	0.00	0.34	0.19	420.26	0.50	16.24
07/29/21 12:06:53	73410	8.75	5.75	5.02	161.33	5.69	1.61	0.28	5.75	0.00	0.23	0.08	428.43	0.69	14.82
07/29/21 12:07:23	73440	8.75	5.85	5.07	162.11	5.72	1.67	0.53	5.85	0.00	0.29	0.06	429.42	0.55	14.38
07/29/21 12:07:53	73470	8.76	5.84	5.07	162.44	5.65	1.63	0.61	5.84	0.00	0.27	0.01	429.28	0.59	14.98
07/29/21 12:08:23	73500	8.76	5.90	5.23	163.11	5.72	1.65	0.71	5.90	0.00	0.27	0.06	432.71	0.51	14.28
07/29/21 12:08:53	73530	8.75	5.97	5.05	163.07	5.73	1.62	0.38	5.97	0.00	0.27	-0.07	431.95	0.50	14.29
07/29/21 12:09:23	73560	8.76	6.16	5.01	159.80	5.58	1.60	0.49	6.16	0.00	0.29	0.19	422.74	0.46	16.30
07/29/21 12:09:53	73590	8.76	5.53	5.17	162.08	5.66	1.63	0.65	5.53	0.00	0.26	0.06	429.14	0.52	14.97
07/29/21 12:10:23	73620	8.76	5.75	5.01	162.41	5.70	1.64	0.70	5.75	0.00	0.28	0.05	430.34	0.59	14.61
07/29/21 12:10:53	73650	8.76	5.95	5.02	160.19	5.60	1.59	0.69	5.95	0.00	0.34	0.05	422.99	0.50	16.17
07/29/21 12:11:23	73680	8.77	5.99	4.93	159.46	5.62	1.59	0.72	5.99	0.00	0.31	0.06	422.94	0.40	16.00
07/29/21 12:11:53	73710	8.75	5.34	5.08	161.91	5.65	1.60	0.81	5.34	0.00	0.26	0.10	428.06	0.54	14.98
07/29/21 12:12:23	73740	8.76	5.42	5.09	163.03	5.67	1.63	0.68	5.42	0.00	0.25	0.09	431.63	0.58	14.81
07/29/21 12:12:53	73770	8.76	6.03	5.09	159.97	5.64	1.62	0.52	6.03	0.00	0.29	-0.04	425.37	0.59	15.70
07/29/21 12:13:23	73800	8.75	5.49	4.99	162.34	5.65	1.61	0.55	5.49	0.00	0.25	0.04	428.83	0.67	15.12
07/29/21 12:13:53	73830	8.75	5.38	5.09	162.23	5.67	1.64	0.66	5.38	0.00	0.28	0.02	430.28	0.50	14.83
07/29/21 12:14:23	73860	8.75	5.76	5.04	162.72	5.71	1.65	0.65	5.76	0.00	0.26	0.05	431.55	0.51	14.57
07/29/21 12:14:53	73890	8.75	6.15	5.02	164.38	5.82	1.67	0.50	6.15	0.00	0.23	0.04	436.74	0.41	13.44
07/29/21 12:15:23	73920	8.75	6.26	5.17	164.12	5.85	1.65	0.65	6.26	0.00	0.25	-0.03	437.36	0.41	13.25
07/29/21 12:15:53	73950	8.74	5.80	5.04	163.03	5.75	1.65	0.45	5.80	0.00	0.26	0.00	433.84	0.51	14.21
07/29/21 12:16:23	73980	8.74	6.14	5.08	163.39	5.81	1.67	0.19	6.14	0.00	0.26	0.01	435.61	0.59	13.54
07/29/21 12:16:53	74010	8.75	6.02	5.04	162.71	5.76	1.66	0.21	6.02	0.00	0.26	0.07	434.03	0.53	14.00
07/29/21 12:17:23	74040	8.75	6.47	5.25	164.94	5.84	1.72	0.58	6.47	0.00	0.25	0.01	438.59	0.53	13.05
07/29/21 12:17:53	74070	8.74	6.12	5.10	163.82	5.80	1.71	0.20	6.12	0.00	0.26	0.06	435.23	0.70	13.60
07/29/21 12:18:23	74100	8.75	6.05	5.15	163.94	5.81	1.68	0.60	6.05	0.00	0.26	0.04	436.18	0.58	13.60
07/29/21 12:18:53	74130	8.75	6.10	5.08	163.23	5.78	1.67	0.55	6.10	0.00	0.25	0.05	434.74	0.56	13.79
07/29/21 12:19:23	74160	8.74	6.47	5.11	165.21	5.88	1.71	0.38	6.37	0.09	0.24	0.12	440.00	0.48	12.74
07/29/21 12:19:53	74190	8.74	6.21	5.07	163.65	5.80	1.69	0.55	6.21	0.00	0.25	0.05	436.94	0.62	13.63
07/29/21 12:20:23	74220	8.74	6.18	5.19	163.88	5.79	1.70	0.81	6.18	0.00	0.23	0.01	436.29	0.59	13.73
07/29/21 12:20:53	74250	8.73	6.15	5.18	163.61	5.85	1.72	0.35	6.15	0.00	0.25	0.05	437.19	0.44	13.17
07/29/21 12:21:23	74280	8.74	6.20	5.06	163.47	5.82	1.69	0.72	6.20	0.00	0.23	0.08	435.26	0.59	13.46
07/29/21 12:21:53	74310	8.73	5.79	5.11	162.29	5.66	1.63	0.52	5.79	0.00	0.25	0.04	427.68	0.61	15.15
07/29/21 12:22:23	74340	8.73	6.17	5.17	163.74	5.80	1.70	0.33	6.17	0.00	0.26	-0.02	434.80	0.60	13.69
07/29/21 12:22:53	74370	8.74	6.33	5.08	164.41	5.83	1.73	0.25	6.33	0.00	0.27	0.03	435.66	0.58	13.35
07/29/21 12:23:23	74400	8.73	5.27	5.06	160.25	5.62	1.65	0.61	5.27	0.00	0.26	0.08	425.18	0.53	15.56
07/29/21 12:23:53	74430	8.73	5.98	5.11	158.20	5.57	1.57	0.49	5.98	0.00	0.32	0.20	418.90	0.49	16.73
07/29/21 12:24:23	74460	8.73	5.57	4.96	157.07	5.48	1.62	0.75	5.57	0.00	0.28	0.16	415.73	0.55	17.73
07/29/21 12:24:53	74490	8.74	5.37	5.07	157.41	5.49	1.61	0.43	5.37	0.00	0.29	0.20	417.50	0.59	17.52
07/29/21 12:25:23	74520	8.74	5.58	5.10	158.52	5.58	1.62	0.69	5.58	0.00	0.32	0.18	421.52	0.53	16.56
07/29/21 12:25:53	74550	8.75	5.53	5.14	162.47	5.68	1.65	0.47	5.53	0.00	0.26	0.06	432.09	0.51	14.99
07/29/21 12:26:23	74580	8.75	5.80	5.21	164.01	5.78	1.67	0.59	5.80	0.00	0.25	0.13	435.94	0.47	13.87
07/29/21 12:26:53	74610	8.74	6.47	5.26	164.86	5.90	1.74	0.85	6.34	0.13	0.26	0.10	438.28	0.58	12.72
07/29/21 12:27:23	74640	8.74	6.22	5.22	166.45	5.88	1.77	0.54	6.22	0.00	0.26	-0.05	442.81	0.69	12.23
07/29/21 12:27:53	74670	8.74	5.91	5.30	165.83	5.86	1.73	0.41	5.91	0.00	0.24	0.03	441.50	0.69	12.59
07/29/21 12:28:23	74700	8.73	6.07	5.32	166.04	5.87	1.78	0.02	6.07	0.00	0.26	0.03	442.40	0.62	12.23
07/29/21 12:28:53	74730	8.73	6.27	5.28	166.98	5.92	1.77	0.43	6.27	0.00	0.20	-0.05	444.80	0.80	11.80
07/29/21 12:29:23	74760	8.74	6.11	5.30	166.98	5.91	1.79	0.30	6.11	0.00	0.23	0.00	444.26	0.77	12.00
07/29/21 12:29:53	74790	8.74	6.58	5.25	162.42	5.88	1.75	0.53	6.50	0.08	0.25	0.03	436.52	0.57	12.95
07/29/21 12:30:23	74820	8.75	5.78	5.29	166.17	5.86	1.76	0.44	5.78	0.00	0.21	0.11	442.71	0.62	12.33
07/29/21 12:30:53	74850	8.75	6.15	5.18	166.93	5.86	1.81	0.50	6.15	0.00	0.21	0.01	442.86	0.73	12.32
07/29/21 12:31:23	74880	8.75	6.48	5.21	163.60	5.86	1.76	0.48	6.44	0.04	0.27	-0.03	436.85	0.64	12.95
07/29/21 12:31:53	74910	8.75	6.59	5.24	164.08	5.90	1.79	0.59	6.47	0.13	0.26	-0.06	440.15	0.54	12.68
07/29/21 12:32:23	74940	8.75	5.79	5.18	162.49	5.67	1.72	1.04	5.79	0.00	0.26	0.13	430.90	0.64	15.02
07/29/21 12:32:53	74970	8.77	6.46	5.17	163.21	5.81	1.77	0.51	6.46	0.00	0.23	0.11	435.69	0.61	13.41
07/29/21 12:33:23	75000	8.77	6.39	5.22	164.40	5.81	1.71	0.83	6.39	0.00	0.24	0.16	437.64	0.62	13.43
07/29/21 12:33:53	75030	8.77	6.04	5.19	163.14	5.73	1.70	0.61	6.04	0.00	0.24	-0.01	434.37	0.64	14.22
07/29/21 12:34:23	75060	8.76	6.39	5.07	159.93	5.62	1.66	0.59	6.14	0.25	0.31	0.16	426.09	0.51	15.71
07/29/21 12:34:53	75090	8.77	6.12	5.05	162.94	5.73	1.70	0.86	6.12	0.00	0.24	0.09	434.06	0.58	14.36
07/29/21 12:35:23	75120	8.77	6.13	5.12	164.71	5.74	1.71	0.76	6.13	0.00	0.25	0.07	437.40	0.63	14.16
07/29/21 12:35:53	75150	8.76	6.16	5.21	164.42	5.78	1.75	0.74	6.16	0.00	0.24	0.03	437.52	0.59	13.73
07/29/21 12:36:23	75180	8.77	6.63	5.24	166.47	5.87	1.71	0.72	6.50	0.13	0.28	-0.01	441.97	0.46	12.81
07/29/21 12:36:53	75210	8.77	5.82	5.06	163.57	5.71	1.68	0.45	5.82	0.00	0.27	0.09	433.06	0.50	14.50
07/29/21 12:37:23	75240	8.77	6.15	5.13	164.88	5.79	1.72	0.58	6.15	0.00	0.24	0.01	437.65	0.63	13.65
07/29/21 12:37:53	75270	8.78	6.28	5.08	165.53	5.81	1.74	0.56	6.28	0.00	0.26	0.01	439.28	0.47	13.26
07/29/21 12:38:23	75300	8.77	5.58	4.97	163.95	5.68	1.69	0.29	5.58	0.00	0.24	-0.02	433.38	0.60	14.80
07/29/21 12:38:53	75330	8.77	6.04	5.16	164.05	5.78	1.70	0.42	6.04	0.00	0.26	0.06	436.84	0.50	13.71
07/29/21 12:39:23	75360	8.76	6.10	5.12	165.45	5.77	1.70	0.39	6.10	0.00	0.24	0.05	438.92	0.65	13.81
07/29/21 12:39:53	75390	8.76	5.42	5.11	163.66	5.63	1.66	0.53	5.42	0.00	0.24	0.10	432.93	0.49	15.34
07/29/21 12:40:23	75420	8.77	5.98	5.11	163.72	5.76	1.70	0.76	5.98	0.00	0.25	0.04	435.37	0.66	14.01
07/29/21 12:40:53	75450	8.76	5.36	5.08	162.30	5.64	1.67	0.67	5.36	0.00	0.26	0.08	431.41	0.50	15.21
07/29/21 12:41:23	75480	8.76	5.93	5.03	163.13	5.73	1.69	0.43	5.93	0.00	0.24	0.06	432.88	0.66	14.33
07/29/21 12:41:53	75510	8.76	6.16	5.20	163.65	5.76	1.69	0.59	6.16	0.00	0.24	0.10	435.09	0.68	13.93
07/29/21 12:42:23	75540	8.76	5.48	5.07	162.03	5.64	1.65	0.66	5.48	0.00	0.23	0.01	430.44	0.53	15.14
07/29/21 12:42:53	75570	8.77	6.03	5.15	164.31	5.77	1.69	0.91	6.03	0.00	0.24	0.10	438.15	0.72	13.89
07/29/21 12:43:23	75600	8.76	5.64	5.11	163.91	5.71	1.67	0.57	5.64	0.00	0.24	0.10	436.43	0.75	14.20
07/29/21 12:43:53	75630	8.76	5.76	5.08	159.52	5.54	1.59	0.50	5.76	0.00	0.25	0.13	422.67	0.52	16.76
07/29/21 12:44:23	75660	8.75	5.27	4.96	158.25	5.48	1.59	0.71	5.27	0.00	0.28	0.16	418.87	0.57	17.54
07/29/21 12:44:53	75690	8.75	5.45	4.94	158.55	5.53	1.62	0.73	5.45	0.00	0.27	0.14	421.18	0.62	17.09
07/29/21 12:45:23	75720	8.75	5.99	5.06	158.98	5.61	1.63	0.79	5.99	0.00	0.28	0.14	423.23	0.59	16.25
07/29/21 12:45:53	75750	8.75	5.56	5.02	158.75	5.56	1.63	0.97	5.56	0.00	0.29	0.21	421.82	0.61	16.70
07/29/21 12:46:23	75780	8.76	5.56	5.00	160.57	5.59	1.63	0.55	5.56	0.00	0.29	0.18	424.76	0.55	16.54
07/29/21 12:46:53	75810	8.75	5.09	4.96	158.23	5.44	1.61	0.75	5.09	0.00	0.28	0.20	417.03	0.44	17.99
07/29/21 12:47:23	75840	8.75	5.79	5.05	159.97	5.59	1.62	0.91	5.79	0.00	0.30	0.08	422.93	0.51	16.37
07/29/21 12:47:53	75870	8.75	5.33	5.05	162.45	5.61	1.63	0.52	5.33	0.00	0.24	0.08	429.46	0.56	15.49
07/29/21 12:48:23	75900	8.75	5.50	5.10	162.70	5.68	1.67	0.48	5.50	0.00	0.24	0.03	432.46	0.66	15.02
07/29/21 12:48:53	75930	8.75	5.96	5.11	163.85	5.74	1.68	0.76	5.96	0.00	0.25	0.02	434.46	0.57	14.27
07/29/21 12:49:23	75960	8.75	5.80	5.05	164.03	5.73	1.71	0.74	5.80	0.00	0.24	-0.01	434.25	0.55	14.24
07/29/21 12:49:53	75990	8.76	5.98	5.08	165.09	5.76	1.69	0.37	5.98	0.00	0.26	0.05	436.73	0.57	14.11
07/29/21 12:50:23	76020	8.76	5.73	5.11	164.95	5.73	1.70	0.65	5.73	0.00	0.22	0.02	435.93	0.58	14.36
07/29/21 12:50:53	76050	8.76	5.67	5.10	163.86	5.72	1.66	0.60	5.67	0.00	0.23	0.01	433.77	0.58	14.47
07/29/21 12:51:23	76080	8.75	6.02	5.21	164.77	5.74	1.72	0.76	6.02	0.00	0.22	0.04	435.93	0.40	14.13
07/29/21 12:51:53	76110	8.75	5.95	5.15	163.95	5.76	1.70	0.35	5.95	0.00	0.22	0.06	434.96	0.63	13.93
07/29/21 12:52:23	76140	8.77	6.17	5.19	164.30	5.79	1.70	0.62	6.17	0.00	0.24	0.01	436.08	0.41	13.68
07/29/21 12:52:53	76170	8.75	6.25	5.16	165.23	5.84	1.73	0.79	6.25	0.00	0.23	0.12	439.02	0.60	13.16
07/29/21 12:53:23	76200	8.75	6.37	5.19	166.19	5.86	1.75	0.95	6.36	0.01	0.23	-0.02	440.99	0.60	12.84
07/29/21 12:53:53	76230	8.75	5.84	5.29	168.38	5.85	1.76	0.32	5.84	0.00	0.21	-0.03	446.24	0.60	12.51
07/29/21 12:54:23	76260	8.76	5.77	5.25	168.62	5.85	1.74	0.46	5.77	0.00	0.20	0.05	447.07	0.50	12.38
07/29/21 12:54:53	76290	8.76	5.90	5.15	168.23	5.86	1.75	0.42	5.90	0.00	0.20	0.00	447.33	0.53	12.26

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,511	SCFH

Weather Data

Barometric Pressure	29.90	in. Hg
Relative Humidity	49	%
Ambient Temperature	99	°F
Specific Humidity	0.019455	lb H_2O / lb air

Unit Data

Unit Load	1,813.0	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	215,084	SCFH

50% Load, Run - 1-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 12:55:23	76320	8.76	6.06	5.10	167.19	5.86	1.74	0.41	6.06	0.00	0.18	-0.07	445.98	0.62	12.24
07/29/21 12:55:53	76350	8.76	5.92	5.16	167.99	5.86	1.75	0.55	5.92	0.00	0.21	-0.03	445.39	0.45	12.28
07/29/21 12:56:23	76380	8.76	5.93	5.23	167.33	5.84	1.75	0.29	5.93	0.00	0.19	-0.02	444.51	0.60	12.45
07/29/21 12:56:53	76410	8.75	6.08	5.05	163.58	5.73	1.68	0.58	6.08	0.00	0.24	0.12	434.27	0.47	14.32
07/29/21 12:57:23	76440	8.76	5.80	5.20	167.64	5.85	1.73	0.50	5.80	0.00	0.19	-0.09	445.33	0.52	12.41
07/29/21 12:57:53	76470	8.75	6.40	5.17	165.84	5.84	1.74	0.46	6.40	0.00	0.18	0.05	440.59	0.54	13.04
07/29/21 12:58:23	76500	8.76	6.01	5.12	167.99	5.85	1.75	0.51	6.01	0.00	0.19	-0.07	446.51	0.59	12.43
07/29/21 12:58:53	76530	8.77	6.31	5.12	167.32	5.85	1.76	0.69	6.31	0.00	0.21	-0.02	443.84	0.43	12.92
07/29/21 12:59:23	76560	8.75	6.21	5.26	164.10	5.76	1.72	1.11	6.21	0.00	0.21	-0.02	436.99	0.65	13.94
07/29/21 12:59:53	76590	8.75	6.01	5.18	163.97	5.73	1.73	0.53	6.01	0.00	0.20	-0.01	435.04	0.53	14.37
07/29/21 13:00:23	76620	8.75	5.60	5.03	160.43	5.57	1.63	0.75	5.60	0.00	0.26	0.11	423.43	0.33	16.72
07/29/21 13:00:53	76650	8.75	5.60	4.94	159.29	5.56	1.64	0.59	5.60	0.00	0.28	0.19	421.81	0.39	16.76
07/29/21 13:01:23	76680	8.75	5.64	4.93	158.82	5.53	1.65	0.57	5.64	0.00	0.26	0.13	420.39	0.33	17.09
07/29/21 13:01:53	76710	8.75	5.70	5.08	159.50	5.57	1.64	0.81	5.70	0.00	0.26	0.03	422.34	0.49	16.78
07/29/21 13:02:23	76740	8.76	5.64	5.11	159.63	5.58	1.68	0.75	5.64	0.00	0.27	0.05	424.61	0.45	16.71
07/29/21 13:02:53	76770	8.76	5.52	5.04	159.95	5.56	1.66	0.68	5.52	0.00	0.27	0.19	423.86	0.58	16.81
07/29/21 13:03:23	76800	8.77	5.67	5.04	161.08	5.59	1.66	0.63	5.67	0.00	0.27	0.26	427.24	0.49	16.33
07/29/21 13:03:53	76830	8.76	5.26	5.05	163.14	5.62	1.65	0.43	5.26	0.00	0.22	0.04	431.38	0.58	15.40
07/29/21 13:04:23	76860	8.77	5.78	5.15	163.71	5.70	1.71	0.32	5.78	0.00	0.22	0.08	433.27	0.63	14.61
07/29/21 13:04:53	76890	8.78	6.05	5.14	164.89	5.78	1.75	0.54	6.05	0.00	0.23	0.13	439.92	0.49	13.61
RAW AVERAGE		**8.75**	**5.92**	**5.11**	**163.11**	**5.72**	**1.68**	**0.58**	**5.91**	**0.01**	**0.25**	**0.06**	**433.10**	**0.56**	**14.43**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
	Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.07			0.12										
	Final Zero	0.08			0.21										
	Avg. Zero	0.08			0.17										
	Initial UpScale	11.98			307.25										
	Final UpScale	11.97			317.42										
	Avg. UpScale	11.98			312.34										
Upscale Cal Gas		11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.74	6.92	5.97	190.60	6.69	1.97	0.68	6.91	0.01	0.29	0.07	185.57	0.44	4.59
Corrected Raw Average (ppm/% wet basis)	7.47	5.92	5.11	163.11	5.72	1.68	0.58	5.91	0.01	0.25	0.06	158.80	0.37	3.93
Concentration (ppm@ 15%O_2)	N/A	3.36	2.90	79.16	3.25	0.95	0.33	3.35	0.004	0.14	0.03	90.07	0.21	1.91
Emission Rate (g/hp*hr)	N/A	0.0596	0.0313	1.3443	552	0.0162	0.0056	0.0388	0.0001	0.0009	0.0004	1.5330	0.0036	0.0324
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,541	SCFH

Weather Data

Barometric Pressure	29.84	in. Hg
Relative Humidity	49	%
Ambient Temperature	96	°F
Specific Humidity	0.018009	lb H_2O / lb air

Unit Data

Unit Load	1,810.4	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	216,383	SCFH

50% Load, Run - 1-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 14:23:23	81600	8.78	4.95	5.16	160.80	5.49	1.63	2.32	4.95	0.00	0.53	-0.04	424.48	0.33	17.94
07/29/21 14:23:53	81630	8.80	5.37	5.46	161.71	5.56	1.63	2.68	5.37	0.00	0.53	0.19	427.08	0.20	17.27
07/29/21 14:24:23	81660	8.79	5.31	5.38	165.50	5.71	1.74	1.99	5.31	0.00	0.48	-0.04	437.77	0.18	15.00
07/29/21 14:24:53	81690	8.79	5.86	5.38	167.69	5.82	1.74	2.19	5.86	0.00	0.49	0.14	442.26	0.28	13.92
07/29/21 14:25:23	81720	8.79	6.05	5.45	168.15	5.88	1.81	2.56	6.05	0.00	0.47	0.04	446.56	0.07	13.27
07/29/21 14:25:53	81750	8.80	6.27	5.44	169.12	5.92	1.77	2.07	6.27	0.00	0.49	0.09	449.64	0.14	12.83
07/29/21 14:26:23	81780	8.79	5.52	5.43	170.76	5.88	1.80	2.33	5.52	0.00	0.46	-0.05	452.62	0.34	12.62
07/29/21 14:26:53	81810	8.78	5.61	5.46	171.47	5.91	1.85	2.73	5.61	0.00	0.46	-0.10	452.40	0.08	12.43
07/29/21 14:27:23	81840	8.79	5.77	5.52	169.64	5.93	1.82	3.17	5.77	0.00	0.46	-0.14	452.20	0.28	12.27
07/29/21 14:27:53	81870	8.80	5.66	5.54	170.61	5.91	1.80	2.67	5.66	0.00	0.46	-0.01	452.92	0.41	12.32
07/29/21 14:28:23	81900	8.80	5.91	5.48	172.15	5.93	1.81	2.80	5.91	0.00	0.48	0.09	453.61	0.46	12.23
07/29/21 14:28:53	81930	8.80	6.28	5.45	169.39	5.92	1.78	2.81	6.28	0.00	0.48	0.08	449.09	0.27	12.78
07/29/21 14:29:23	81960	8.79	6.28	5.44	168.54	5.88	1.82	2.37	6.28	0.00	0.50	0.01	445.93	0.21	13.28
07/29/21 14:29:53	81990	8.79	5.36	5.54	166.36	5.64	1.69	2.73	5.36	0.00	0.54	0.07	436.27	0.31	15.67
07/29/21 14:30:23	82020	8.79	5.22	5.39	165.98	5.72	1.71	2.83	5.22	0.00	0.55	0.04	439.28	0.01	15.06
07/29/21 14:30:53	82050	8.79	5.43	5.55	166.77	5.75	1.70	2.43	5.43	0.00	0.51	0.07	441.40	0.14	14.62
07/29/21 14:31:23	82080	8.78	6.19	5.48	169.12	5.91	1.82	3.16	6.19	0.00	0.51	0.02	449.39	-0.01	12.93
07/29/21 14:31:53	82110	8.78	5.34	5.43	168.06	5.72	1.74	2.96	5.34	0.00	0.53	0.09	441.58	0.19	15.00
07/29/21 14:32:23	82140	8.77	5.89	5.57	167.80	5.84	1.69	2.57	5.89	0.00	0.51	0.04	444.75	0.10	13.63
07/29/21 14:32:53	82170	8.78	5.16	5.45	164.86	5.66	1.72	3.25	5.16	0.00	0.50	-0.09	434.52	0.03	15.59
07/29/21 14:33:23	82200	8.79	5.16	5.45	166.79	5.70	1.72	3.17	5.16	0.00	0.53	-0.05	438.21	0.22	15.35
07/29/21 14:33:53	82230	8.78	5.78	5.49	167.12	5.80	1.78	2.88	5.78	0.00	0.53	0.07	442.07	0.03	14.33
07/29/21 14:34:23	82260	8.78	5.58	5.58	167.75	5.77	1.74	3.29	5.58	0.00	0.52	0.10	442.15	0.17	14.54
07/29/21 14:34:53	82290	8.78	6.06	5.47	168.78	5.87	1.82	2.75	6.06	0.00	0.51	0.12	444.97	-0.08	13.60
07/29/21 14:35:23	82320	8.79	5.56	5.45	166.09	5.73	1.72	3.07	5.56	0.00	0.50	-0.13	440.25	0.18	14.83
07/29/21 14:35:53	82350	8.80	5.09	5.58	164.50	5.66	1.74	3.84	5.09	0.00	0.51	0.11	435.81	-0.11	15.61
07/29/21 14:36:23	82380	8.80	5.39	5.38	166.11	5.69	1.76	3.86	5.39	0.00	0.53	0.15	438.50	0.33	15.35
07/29/21 14:36:53	82410	8.80	5.16	5.48	166.36	5.68	1.73	3.63	5.16	0.00	0.49	-0.02	438.78	0.17	15.48
07/29/21 14:37:23	82440	8.80	5.38	5.47	167.09	5.72	1.79	2.63	5.38	0.00	0.50	0.03	440.56	0.23	15.21
07/29/21 14:37:53	82470	8.79	5.73	5.49	167.74	5.77	1.76	2.23	5.73	0.00	0.53	0.05	442.68	0.30	14.51
07/29/21 14:38:23	82500	8.79	5.93	5.57	167.54	5.84	1.81	2.20	5.93	0.00	0.50	0.05	442.88	0.33	13.72
07/29/21 14:38:53	82530	8.80	5.92	5.52	167.15	5.85	1.78	1.34	5.92	0.00	0.46	-0.08	444.54	0.37	13.64
07/29/21 14:39:23	82560	8.80	5.96	5.39	168.48	5.86	1.81	1.79	5.96	0.00	0.43	-0.07	446.71	0.10	13.57
07/29/21 14:39:53	82590	8.80	6.15	5.53	168.85	5.85	1.79	2.09	6.15	0.00	0.49	-0.01	445.04	0.05	13.56
07/29/21 14:40:23	82620	8.80	5.75	5.52	164.93	5.67	1.72	2.59	5.75	0.00	0.55	0.10	434.83	-0.15	15.92
07/29/21 14:40:53	82650	8.80	5.73	5.42	167.39	5.81	1.77	2.46	5.73	0.00	0.50	0.11	444.58	0.13	14.15
07/29/21 14:41:23	82680	8.80	5.98	5.47	168.67	5.81	1.80	2.56	5.98	0.00	0.49	-0.04	444.49	0.10	13.93
07/29/21 14:41:53	82710	8.80	5.91	5.49	168.80	5.81	1.73	2.74	5.91	0.00	0.50	0.01	443.84	0.23	14.01
07/29/21 14:42:23	82740	8.81	6.11	5.59	169.71	5.90	1.79	2.94	6.11	0.00	0.46	0.03	448.08	0.23	13.04
07/29/21 14:42:53	82770	8.81	5.80	5.47	172.69	5.90	1.83	3.45	5.80	0.00	0.48	-0.14	452.83	0.24	12.42
07/29/21 14:43:23	82800	8.80	5.81	5.67	172.59	5.91	1.78	3.07	5.81	0.00	0.42	0.02	453.92	0.20	12.45
07/29/21 14:43:53	82830	8.81	5.09	5.50	167.01	5.66	1.72	3.62	5.09	0.00	0.47	0.08	438.48	0.14	15.58
07/29/21 14:44:23	82860	8.79	5.39	5.49	167.29	5.70	1.72	3.40	5.39	0.00	0.52	0.01	439.63	0.23	15.14
07/29/21 14:44:53	82890	8.81	5.62	5.48	163.22	5.61	1.70	3.82	5.62	0.00	0.55	0.05	429.02	-0.14	16.69
07/29/21 14:45:23	82920	8.81	5.73	5.30	164.65	5.69	1.71	2.95	5.73	0.00	0.52	0.13	434.04	-0.01	15.68
07/29/21 14:45:53	82950	8.81	5.69	5.28	163.51	5.67	1.70	3.23	5.69	0.00	0.54	0.05	432.98	0.05	16.07
07/29/21 14:46:23	82980	8.81	6.03	5.40	170.06	5.83	1.77	3.20	6.03	0.00	0.51	0.06	446.16	0.41	13.87
07/29/21 14:46:53	83010	8.82	6.23	5.39	170.35	5.89	1.76	3.11	6.23	0.00	0.49	0.01	449.65	0.18	13.15
07/29/21 14:47:23	83040	8.81	6.42	5.45	172.15	5.91	1.80	3.33	6.42	0.00	0.49	-0.06	451.03	0.22	12.83
07/29/21 14:47:53	83070	8.81	6.29	5.41	170.90	5.91	1.78	3.93	6.29	0.00	0.47	0.19	450.96	-0.10	13.04
07/29/21 14:48:23	83100	8.81	5.86	5.54	171.81	5.87	1.73	3.40	5.86	0.00	0.47	0.17	450.39	0.44	13.33
07/29/21 14:48:53	83130	8.79	5.77	5.48	168.01	5.79	1.75	3.23	5.77	0.00	0.49	0.08	442.59	0.37	14.26
07/29/21 14:49:23	83160	8.80	6.08	5.36	167.93	5.85	1.82	3.41	6.08	0.00	0.49	0.02	444.75	0.08	13.75
07/29/21 14:49:53	83190	8.80	6.31	5.45	170.99	5.91	1.77	3.96	6.31	0.00	0.48	0.19	449.23	0.05	13.02
07/29/21 14:50:23	83220	8.80	5.93	5.47	171.70	5.91	1.78	3.28	5.87	0.05	0.51	0.04	453.00	0.17	12.99
07/29/21 14:50:53	83250	8.79	6.14	5.57	168.75	5.85	1.79	3.45	6.14	0.00	0.47	-0.04	446.83	0.16	13.73
07/29/21 14:51:23	83280	8.79	5.42	5.64	167.50	5.73	1.75	2.88	5.42	0.00	0.54	0.11	442.06	0.09	14.99
07/29/21 14:51:53	83310	8.79	6.01	5.55	168.48	5.85	1.79	3.30	6.01	0.00	0.50	-0.03	444.62	0.41	13.68
07/29/21 14:52:23	83340	8.79	5.94	5.55	169.27	5.87	1.82	3.90	5.94	0.00	0.49	-0.04	446.93	0.16	13.47
07/29/21 14:52:53	83370	8.80	5.89	5.56	168.39	5.83	1.74	3.97	5.89	0.00	0.48	-0.04	445.78	0.05	13.98
07/29/21 14:53:23	83400	8.79	5.57	5.34	168.40	5.79	1.78	3.78	5.57	0.00	0.48	0.10	441.72	0.12	14.29
07/29/21 14:53:53	83430	8.79	5.23	5.32	166.81	5.67	1.70	3.95	5.23	0.00	0.48	-0.01	438.21	-0.05	15.51
07/29/21 14:54:23	83460	8.79	5.75	5.46	169.85	5.83	1.80	4.03	5.75	0.00	0.49	0.01	445.59	0.49	13.88
07/29/21 14:54:53	83490	8.81	6.50	5.57	170.05	5.91	1.82	3.84	6.50	0.00	0.47	0.15	450.21	-0.16	12.90
07/29/21 14:55:23	83520	8.81	6.34	5.53	171.04	5.92	1.82	4.12	6.31	0.03	0.45	-0.08	451.16	0.11	12.84
07/29/21 14:55:53	83550	8.81	5.69	5.52	173.10	5.88	1.84	3.64	5.65	0.04	0.45	-0.04	454.28	0.42	12.59
07/29/21 14:56:23	83580	8.80	5.85	5.58	173.02	5.93	1.81	3.85	5.85	0.00	0.46	-0.01	456.06	0.10	12.21
07/29/21 14:56:53	83610	8.81	5.93	5.43	170.25	5.79	1.74	4.21	5.93	0.00	0.48	0.10	444.80	0.23	14.05
07/29/21 14:57:23	83640	8.80	5.96	5.61	172.82	5.94	1.85	3.63	5.96	0.00	0.47	0.15	456.92	0.30	12.07
07/29/21 14:57:53	83670	8.79	5.48	5.41	168.27	5.76	1.75	3.36	5.48	0.00	0.45	-0.04	440.87	-0.17	14.76
07/29/21 14:58:23	83700	8.79	6.16	5.55	170.26	5.89	1.80	3.95	6.16	0.00	0.47	-0.03	447.57	-0.08	13.34
07/29/21 14:58:53	83730	8.79	6.30	5.43	169.57	5.90	1.80	2.96	6.30	0.00	0.46	-0.07	446.85	0.00	13.17
07/29/21 14:59:23	83760	8.80	5.48	5.41	168.55	5.69	1.73	3.24	5.48	0.00	0.52	0.06	439.03	0.29	15.22
07/29/21 14:59:53	83790	8.80	5.60	5.43	168.31	5.75	1.76	4.09	5.60	0.00	0.48	0.17	442.60	0.10	14.72
07/29/21 15:00:23	83820	8.81	6.18	5.55	169.79	5.83	1.77	3.53	6.18	0.00	0.47	-0.07	446.44	0.08	13.82
07/29/21 15:00:53	83850	8.81	5.39	5.68	168.20	5.72	1.75	3.67	5.39	0.00	0.48	-0.02	440.72	0.15	15.05
07/29/21 15:01:23	83880	8.82	5.86	5.43	169.35	5.81	1.80	3.03	5.86	0.00	0.52	0.01	444.94	0.03	14.15
07/29/21 15:01:53	83910	8.82	5.97	5.54	170.24	5.81	1.78	3.21	5.97	0.00	0.47	0.01	443.65	0.24	14.05
07/29/21 15:02:23	83940	8.83	5.84	5.68	167.48	5.80	1.78	3.69	5.84	0.00	0.47	-0.03	443.09	0.17	14.20
07/29/21 15:02:53	83970	8.83	5.58	5.40	169.33	5.74	1.76	3.61	5.58	0.00	0.48	0.10	443.91	-0.01	14.65
07/29/21 15:03:23	84000	8.84	5.62	5.52	167.59	5.63	1.65	3.67	5.62	0.00	0.54	0.00	433.48	-0.04	16.41
07/29/21 15:03:53	84030	8.84	5.14	5.51	168.47	5.67	1.73	3.41	5.14	0.00	0.51	0.03	444.23	0.05	15.37
07/29/21 15:04:23	84060	8.84	5.48	5.57	169.24	5.73	1.74	3.83	5.48	0.00	0.49	-0.01	443.99	0.04	14.65
07/29/21 15:04:53	84090	8.83	5.57	5.52	169.56	5.76	1.77	3.80	5.57	0.00	0.47	-0.11	444.55	0.38	14.39
07/29/21 15:05:23	84120	8.82	6.21	5.45	171.41	5.82	1.74	3.69	6.21	0.00	0.47	0.01	449.65	-0.30	13.84
07/29/21 15:05:53	84150	8.83	5.86	5.56	171.77	5.86	1.78	4.10	5.86	0.00	0.44	0.15	450.25	0.06	13.34
07/29/21 15:06:23	84180	8.82	6.37	5.48	171.82	5.92	1.76	3.60	6.37	0.00	0.47	0.03	451.57	-0.10	12.87
07/29/21 15:06:53	84210	8.82	6.18	5.48	172.46	5.92	1.78	4.10	6.17	0.02	0.45	0.14	453.60	-0.09	12.76
07/29/21 15:07:23	84240	8.82	5.98	5.60	173.28	5.91	1.84	3.70	5.91	0.06	0.46	-0.15	455.70	0.22	12.45
07/29/21 15:07:53	84270	8.82	5.54	5.53	173.84	5.89	1.83	4.09	5.54	0.00	0.43	0.00	456.88	0.39	12.57
07/29/21 15:08:23	84300	8.81	5.91	5.46	169.43	5.85	1.82	3.76	5.91	0.00	0.43	-0.04	447.24	0.01	13.58
07/29/21 15:08:53	84330	8.81	6.06	5.54	169.44	5.83	1.79	3.38	6.06	0.00	0.44	0.02	448.37	-0.11	13.61
07/29/21 15:09:23	84360	8.80	5.36	5.60	168.83	5.69	1.70	4.23	5.36	0.00	0.46	0.18	440.51	0.14	15.13
07/29/21 15:09:53	84390	8.80	5.53	5.58	165.71	5.67	1.71	4.25	5.53	0.00	0.55	0.21	434.75	0.06	16.22
07/29/21 15:10:23	84420	8.79	5.59	5.53	165.92	5.69	1.70	4.14	5.59	0.00	0.56	0.01	436.94	-0.06	16.03
07/29/21 15:10:53	84450	8.81	5.64	5.46	165.12	5.62	1.69	4.03	5.64	0.00	0.54	0.07	429.58	-0.03	16.81
07/29/21 15:11:23	84480	8.82	5.29	5.57	164.78	5.60	1.68	4.33	5.29	0.00	0.53	0.13	432.58	0.02	16.76
07/29/21 15:11:53	84510	8.82	5.32	5.62	165.11	5.60	1.67	3.95	5.32	0.00	0.54	0.05	433.01	-0.20	16.87
07/29/21 15:12:23	84540	8.82	5.57	5.52	167.08	5.61	1.68	3.49	5.57	0.00	0.54	0.08	431.95	-0.42	16.78
07/29/21 15:12:53	84570	8.83	5.68	5.54	165.45	5.62	1.66	4.48	5.68	0.00	0.56	0.07	432.92	0.12	16.64

Catalytic Combustion Corporation
July 29, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	14,541	SCFH

Weather Data

Barometric Pressure	29.84	in. Hg
Relative Humidity	49	%
Ambient Temperature	96	°F
Specific Humidity	0.018009	lb H_2O / lb air

Unit Data

Unit Load	1,810.4	horsepower
Meas. Stack Moisture	14.4	%
Stack Exhaust Flow (M19)	216,383	SCFH

50% Load, Run - 1-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/29/21 15:13:23	84600	8.83	5.44	5.44	166.88	5.62	1.73	4.17	5.44	0.00	0.53	0.11	434.57	-0.12	16.46
07/29/21 15:13:53	84630	8.83	5.45	5.59	165.37	5.65	1.74	4.43	5.45	0.00	0.52	0.05	436.67	0.11	16.28
07/29/21 15:14:23	84660	8.84	5.64	5.58	166.92	5.67	1.71	4.63	5.64	0.00	0.51	0.08	439.81	0.23	15.99
07/29/21 15:14:53	84690	8.82	5.33	5.32	167.29	5.67	1.66	3.85	5.33	0.00	0.47	0.12	438.81	0.29	15.82
07/29/21 15:15:23	84720	8.83	5.72	5.51	167.33	5.70	1.68	4.61	5.72	0.00	0.49	0.19	439.77	0.12	15.62
07/29/21 15:15:53	84750	8.84	5.48	5.48	167.20	5.58	1.70	4.46	5.48	0.00	0.52	0.13	436.46	-0.02	16.86
07/29/21 15:16:23	84780	8.83	4.91	5.28	165.62	5.56	1.67	4.50	4.91	0.00	0.53	0.01	434.79	0.11	17.17
07/29/21 15:16:53	84810	8.82	5.64	5.51	167.92	5.71	1.75	4.60	5.64	0.00	0.51	0.09	438.72	0.29	15.73
07/29/21 15:17:23	84840	8.82	5.13	5.57	171.10	5.70	1.71	4.33	5.13	0.00	0.46	0.13	445.85	-0.17	15.16
07/29/21 15:17:53	84870	8.81	5.32	5.38	170.30	5.72	1.68	4.57	5.32	0.00	0.46	0.25	445.14	-0.16	14.85
07/29/21 15:18:23	84900	8.81	5.08	5.30	171.02	5.75	1.70	3.91	5.08	0.00	0.45	0.12	447.31	-0.31	14.63
07/29/21 15:18:53	84930	8.79	5.48	5.47	171.50	5.77	1.72	3.81	5.48	0.00	0.46	0.09	446.19	0.02	14.61
07/29/21 15:19:23	84960	8.80	5.41	5.48	171.19	5.78	1.69	4.40	5.41	0.00	0.44	-0.08	447.68	-0.01	14.47
07/29/21 15:19:53	84990	8.79	5.67	5.46	169.93	5.81	1.78	4.45	5.67	0.00	0.47	0.03	445.17	0.23	14.41
07/29/21 15:20:23	85020	8.79	5.59	5.39	169.78	5.81	1.79	3.92	5.59	0.00	0.46	0.10	445.79	0.26	14.37
07/29/21 15:20:53	85050	8.79	5.52	5.50	171.61	5.80	1.70	4.43	5.52	0.00	0.49	0.00	445.75	-0.18	14.27
07/29/21 15:21:23	85080	8.78	5.59	5.52	170.83	5.80	1.71	4.20	5.59	0.00	0.49	0.25	446.24	-0.02	14.29
07/29/21 15:21:53	85110	8.78	5.50	5.50	169.00	5.82	1.69	5.14	5.50	0.00	0.45	0.10	446.38	-0.10	14.24
07/29/21 15:22:23	85140	8.79	5.73	5.27	171.34	5.82	1.74	4.55	5.73	0.00	0.45	-0.17	447.28	0.18	14.15
07/29/21 15:22:53	85170	8.79	5.84	5.43	172.11	5.82	1.74	3.65	5.84	0.00	0.44	-0.16	446.95	-0.30	14.16
RAW AVERAGE		**8.80**	**5.71**	**5.48**	**168.64**	**5.78**	**1.75**	**3.45**	**5.71**	**0.00**	**0.49**	**0.04**	**443.69**	**0.11**	**14.39**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
	Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.08			0.21										
Bias	**Final Zero**	0.09			0.17										
Bias	**Avg. Zero**	0.09			0.19										
Bias	**Initial UpScale**	11.97			317.42										
Bias	**Final UpScale**	11.98			314.03										
Bias	**Avg. UpScale**	11.98			315.73										
Upscale Cal Gas		11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.79	6.67	6.40	197.00	6.75	2.05	4.04	6.67	0.00	0.57	0.05	190.04	0.09	6.87
Corrected Raw Average (ppm/% wet basis)	7.51	5.71	5.48	168.64	5.78	1.75	3.45	5.71	0.00	0.49	0.04	162.69	0.07	5.88
Concentration (ppm@ 15%O_2)	N/A	3.25	3.12	82.17	3.29	1.00	1.97	3.25	0.00	0.28	0.02	92.60	0.04	2.86
Emission Rate (g/hp*hr)	N/A	0.0579	0.0338	1.4004	561	0.0170	0.0336	0.0378	0.0000	0.0018	0.0003	1.5817	0.0007	0.0488
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

EMISSION DATA RECORDS

75% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O
Reference Method Data

Catalytic Combustion Corporation
July 30, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,603	SCFH

Weather Data

Barometric Pressure	29.89	in. Hg
Relative Humidity	53	%
Ambient Temperature	94	°F
Specific Humidity	0.018296	lb H_2O / lb air

Unit Data

Unit Load	2,691.4	horsepower
Meas. Stack Moisture	13.9	%
Stack Exhaust Flow (M19)	310,849	SCFH

75% Load, Run - 2-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 13:45:23	165720	8.94	5.59	2.67	149.97	5.60	1.40	0.37	5.59	0.00	15.45	-0.16	407.90	0.76	14.54
07/30/21 13:45:53	165750	8.93	5.69	2.63	149.97	5.62	1.44	0.54	5.69	0.00	15.26	-0.27	407.38	0.93	14.22
07/30/21 13:46:23	165780	8.94	5.80	2.79	150.51	5.65	1.42	0.03	5.80	0.00	14.83	-0.23	408.24	0.74	14.05
07/30/21 13:46:53	165810	8.94	5.78	2.72	150.09	5.61	1.43	0.80	5.78	0.00	14.78	-0.23	406.16	0.96	14.26
07/30/21 13:47:23	165840	8.95	5.79	2.65	150.57	5.61	1.41	0.51	5.79	0.00	15.18	-0.16	407.80	0.82	14.30
07/30/21 13:47:53	165870	8.94	5.73	2.78	152.51	5.64	1.43	0.24	5.73	0.00	15.41	-0.15	407.10	0.84	14.11
07/30/21 13:48:23	165900	8.94	6.01	2.73	150.28	5.62	1.43	0.60	6.01	0.00	15.24	-0.15	406.97	0.89	14.24
07/30/21 13:48:53	165930	8.93	5.79	2.71	148.46	5.57	1.42	0.67	5.79	0.00	15.98	-0.28	403.63	0.96	14.87
07/30/21 13:49:23	165960	8.94	5.69	2.70	152.44	5.59	1.41	0.58	5.69	0.00	16.27	-0.17	407.02	0.84	14.53
07/30/21 13:49:53	165990	8.94	5.69	2.68	150.92	5.59	1.46	0.58	5.69	0.00	16.09	-0.24	405.18	0.80	14.38
07/30/21 13:50:23	166020	8.94	5.87	2.83	149.52	5.63	1.47	0.39	5.87	0.00	15.75	-0.15	406.61	0.86	14.26
07/30/21 13:50:53	166050	8.95	5.87	2.82	151.94	5.63	1.43	0.48	5.87	0.00	15.40	-0.15	408.83	0.91	14.19
07/30/21 13:51:23	166080	8.95	5.96	2.86	149.85	5.63	1.44	0.35	5.96	0.00	15.33	-0.14	407.04	0.80	14.19
07/30/21 13:51:53	166110	8.97	6.04	2.84	150.42	5.63	1.47	0.38	6.04	0.00	15.39	-0.21	407.58	1.03	14.16
07/30/21 13:52:23	166140	8.97	5.99	2.72	149.87	5.61	1.52	0.60	5.99	0.00	15.35	-0.11	407.75	0.79	14.07
07/30/21 13:52:53	166170	9.00	5.92	2.73	150.51	5.60	1.49	0.49	5.92	0.00	15.19	-0.14	409.27	0.96	13.99
07/30/21 13:53:23	166200	8.98	5.58	2.79	150.71	5.62	1.44	0.29	5.58	0.00	15.04	-0.20	408.53	0.93	13.98
07/30/21 13:53:53	166230	8.95	5.73	2.83	150.82	5.66	1.41	0.67	5.73	0.00	14.75	-0.19	410.88	0.85	13.91
07/30/21 13:54:23	166260	8.97	5.46	2.80	151.19	5.65	1.40	0.61	5.46	0.00	14.33	-0.19	411.87	0.92	13.76
07/30/21 13:54:53	166290	8.97	5.68	2.67	153.46	5.67	1.45	0.71	5.68	0.00	13.91	-0.27	411.25	1.04	13.66
07/30/21 13:55:23	166320	8.96	5.52	2.79	151.54	5.66	1.42	0.59	5.52	0.00	13.72	-0.14	411.56	0.70	13.73
07/30/21 13:55:53	166350	8.96	5.38	2.66	151.37	5.64	1.41	0.75	5.38	0.00	13.94	-0.14	411.48	0.84	13.79
07/30/21 13:56:23	166380	8.97	5.82	2.75	152.50	5.64	1.42	0.36	5.82	0.00	14.23	-0.10	410.88	0.66	13.82
07/30/21 13:56:53	166410	8.98	6.10	2.68	150.29	5.65	1.46	0.99	6.10	0.00	14.63	-0.09	409.47	0.76	13.86
07/30/21 13:57:23	166440	8.97	5.96	2.67	150.64	5.64	1.44	0.45	5.96	0.00	14.80	-0.16	408.48	0.72	13.80
07/30/21 13:57:53	166470	8.96	5.37	2.83	150.92	5.66	1.43	0.93	5.37	0.00	14.66	-0.13	410.90	0.71	13.75
07/30/21 13:58:23	166500	8.97	5.53	2.72	151.61	5.67	1.43	0.46	5.53	0.00	14.19	-0.28	410.92	0.72	13.67
07/30/21 13:58:53	166530	8.97	5.37	2.83	153.19	5.63	1.44	0.58	5.37	0.00	14.14	-0.19	409.85	0.84	14.09
07/30/21 13:59:23	166560	8.96	5.36	2.78	150.89	5.65	1.43	0.23	5.36	0.00	13.96	-0.23	411.30	0.61	13.89
07/30/21 13:59:53	166590	8.96	5.35	2.81	151.49	5.64	1.43	0.29	5.35	0.00	13.69	-0.21	411.12	0.75	13.92
07/30/21 14:00:23	166620	8.96	5.36	2.77	152.13	5.67	1.41	0.66	5.36	0.00	13.36	-0.23	412.37	0.85	13.61
07/30/21 14:00:53	166650	8.96	5.53	2.68	152.22	5.70	1.42	0.49	5.53	0.00	13.05	-0.18	414.28	0.77	13.25
07/30/21 14:01:23	166680	8.96	5.73	2.73	152.80	5.72	1.45	0.42	5.73	0.00	12.83	-0.23	414.58	0.88	13.05
07/30/21 14:01:53	166710	8.94	5.63	2.82	152.68	5.75	1.44	0.76	5.63	0.00	12.60	-0.20	415.96	0.91	12.85
07/30/21 14:02:23	166740	8.94	5.75	2.85	152.33	5.76	1.41	0.84	5.75	0.00	12.43	-0.01	415.38	0.90	12.79
07/30/21 14:02:53	166770	8.96	5.79	2.87	152.72	5.75	1.44	0.99	5.79	0.00	12.30	-0.19	416.46	0.86	12.84
07/30/21 14:03:23	166800	8.95	5.83	2.87	152.76	5.75	1.43	0.63	5.83	0.00	12.38	-0.17	416.53	0.97	12.84
07/30/21 14:03:53	166830	8.95	5.78	2.80	152.87	5.75	1.48	0.16	5.78	0.00	12.58	-0.22	416.46	0.95	12.93
07/30/21 14:04:23	166860	8.95	6.02	2.73	153.08	5.77	1.46	0.35	6.02	0.00	12.74	-0.23	417.47	0.72	12.80
07/30/21 14:04:53	166890	8.97	6.26	2.75	152.62	5.76	1.57	0.22	6.26	0.00	12.89	-0.31	416.15	0.76	12.79
07/30/21 14:05:23	166920	8.97	6.13	2.76	154.06	5.75	1.52	0.47	6.13	0.00	13.16	-0.22	415.82	0.82	12.77
07/30/21 14:05:53	166950	8.97	6.03	2.80	151.98	5.75	1.50	0.88	6.03	0.00	13.43	-0.21	414.42	0.76	12.81
07/30/21 14:06:23	166980	8.97	5.72	2.72	153.39	5.61	1.44	0.76	5.72	0.00	14.26	-0.22	411.88	0.77	14.20
07/30/21 14:06:53	167010	8.98	5.59	2.78	151.06	5.62	1.40	0.56	5.59	0.00	14.60	-0.02	408.23	0.63	14.29
07/30/21 14:07:23	167040	8.97	6.05	2.74	153.83	5.71	1.50	0.65	6.05	0.00	14.62	-0.21	413.85	0.78	13.26
07/30/21 14:07:53	167070	8.98	6.02	2.78	151.59	5.74	1.49	0.55	6.02	0.00	14.53	-0.23	412.80	0.83	13.04
07/30/21 14:08:23	167100	8.97	5.59	2.74	151.39	5.59	1.43	0.42	5.59	0.00	15.29	-0.23	407.53	0.75	14.60
07/30/21 14:08:53	167130	8.96	5.84	2.77	150.86	5.68	1.50	0.49	5.84	0.00	15.30	-0.17	408.89	0.67	13.62
07/30/21 14:09:23	167160	8.96	5.88	2.77	150.77	5.69	1.45	0.86	5.88	0.00	15.35	-0.12	410.34	0.81	13.47
07/30/21 14:09:53	167190	8.97	5.86	2.86	150.95	5.67	1.49	0.88	5.86	0.00	15.45	-0.19	411.50	0.74	13.57
07/30/21 14:10:23	167220	8.96	5.37	2.77	150.82	5.58	1.44	0.70	5.37	0.00	16.26	-0.18	408.68	0.91	14.68
07/30/21 14:10:53	167250	8.97	5.46	2.68	150.73	5.58	1.45	0.71	5.46	0.00	16.65	-0.21	408.83	0.89	14.65
07/30/21 14:11:23	167280	8.96	5.68	2.78	150.28	5.65	1.51	0.90	5.68	0.00	16.98	-0.27	409.45	0.71	14.07
07/30/21 14:11:53	167310	8.97	5.41	2.87	151.28	5.65	1.47	1.08	5.41	0.00	16.77	-0.32	411.15	0.79	13.85
07/30/21 14:12:23	167340	8.97	5.82	2.71	151.71	5.67	1.46	0.95	5.82	0.00	16.65	-0.11	410.56	0.66	13.86
07/30/21 14:12:53	167370	8.96	5.64	2.78	151.38	5.68	1.48	0.38	5.64	0.00	16.27	-0.33	411.61	0.76	13.64
07/30/21 14:13:23	167400	8.97	5.57	2.72	151.56	5.66	1.49	0.41	5.57	0.00	16.18	-0.18	411.72	0.85	13.87
07/30/21 14:13:53	167430	8.97	5.44	2.86	150.30	5.65	1.46	0.92	5.44	0.00	16.44	-0.26	409.70	0.91	14.09
07/30/21 14:14:23	167460	8.98	5.32	2.71	150.51	5.61	1.48	0.97	5.32	0.00	16.70	-0.21	408.13	0.78	14.36
07/30/21 14:14:53	167490	8.97	5.29	2.78	151.40	5.60	1.40	1.01	5.29	0.00	16.91	-0.23	409.96	0.69	14.57
07/30/21 14:15:23	167520	8.95	5.33	2.78	151.65	5.60	1.44	0.68	5.33	0.00	16.89	-0.32	406.99	0.71	14.70
07/30/21 14:15:53	167550	8.97	5.23	2.76	150.30	5.58	1.40	0.64	5.23	0.00	17.05	-0.20	406.37	0.76	14.79
07/30/21 14:16:23	167580	8.97	5.29	2.76	151.76	5.57	1.43	0.83	5.29	0.00	17.24	-0.23	405.60	0.86	14.82
07/30/21 14:16:53	167610	8.97	5.32	2.76	152.52	5.58	1.48	0.99	5.32	0.00	17.29	-0.41	407.48	0.82	14.78
07/30/21 14:17:23	167640	8.97	5.20	2.77	148.96	5.56	1.37	1.00	5.20	0.00	17.40	-0.18	405.60	0.90	14.85
07/30/21 14:17:53	167670	8.98	5.15	2.78	149.51	5.55	1.41	1.24	5.15	0.00	17.55	-0.17	405.45	0.77	14.89
07/30/21 14:18:23	167700	8.99	5.13	2.66	150.60	5.56	1.40	1.03	5.13	0.00	17.95	-0.32	408.53	0.54	14.97
07/30/21 14:18:53	167730	8.99	5.10	2.64	147.55	5.30	1.34	0.69	5.10	0.00	21.05	-0.20	392.60	0.58	18.31
07/30/21 14:19:23	167760	8.97	5.45	2.70	146.48	5.43	1.40	1.02	5.45	0.00	21.12	-0.28	398.24	0.66	17.06
07/30/21 14:19:53	167790	8.97	5.32	2.78	151.30	5.55	1.43	0.96	5.32	0.00	19.53	-0.19	404.85	0.77	15.01
07/30/21 14:20:23	167820	8.98	5.39	2.75	153.59	5.59	1.46	1.03	5.39	0.00	19.11	-0.27	409.77	0.86	14.78
07/30/21 14:20:53	167850	8.98	5.40	2.81	153.02	5.60	1.44	1.15	5.40	0.00	18.90	-0.27	410.05	0.80	14.61
07/30/21 14:21:23	167880	8.97	5.38	2.69	150.69	5.62	1.46	1.55	5.38	0.00	18.70	-0.20	407.43	0.69	14.52
07/30/21 14:21:53	167910	8.97	5.32	2.87	151.85	5.61	1.40	1.03	5.32	0.00	18.34	-0.19	408.54	0.78	14.42
07/30/21 14:22:23	167940	8.96	5.37	2.72	150.84	5.63	1.43	1.01	5.37	0.00	18.20	-0.25	409.61	0.75	14.35
07/30/21 14:22:53	167970	8.97	5.42	2.68	152.57	5.62	1.38	1.06	5.42	0.00	17.92	-0.11	409.94	0.82	14.28
07/30/21 14:23:23	168000	8.97	5.53	2.75	150.73	5.65	1.43	1.20	5.53	0.00	17.66	-0.31	408.91	0.54	14.16
07/30/21 14:23:53	168030	8.97	5.35	2.78	151.08	5.65	1.45	1.26	5.35	0.00	16.82	-0.18	410.78	0.65	14.06
07/30/21 14:24:23	168060	8.97	5.47	2.71	151.78	5.65	1.40	1.20	5.47	0.00	16.74	-0.24	410.85	0.60	14.01
07/30/21 14:24:53	168090	8.98	5.50	2.72	152.46	5.65	1.41	1.29	5.50	0.00	16.85	-0.16	411.60	0.74	13.97
07/30/21 14:25:23	168120	8.98	5.50	2.74	154.42	5.66	1.44	1.29	5.50	0.00	16.22	-0.27	411.95	0.73	13.88
07/30/21 14:25:53	168150	8.98	5.74	2.77	151.75	5.68	1.42	1.25	5.74	0.00	15.81	-0.24	408.75	0.66	13.83
07/30/21 14:26:23	168180	8.97	5.76	2.74	151.91	5.68	1.46	0.86	5.76	0.00	15.69	-0.20	410.32	0.62	13.75
07/30/21 14:26:53	168210	8.97	5.55	2.75	152.28	5.69	1.43	1.21	5.55	0.00	15.52	-0.15	409.68	0.75	13.56
07/30/21 14:27:23	168240	8.97	5.61	2.74	151.61	5.64	1.43	1.00	5.61	0.00	15.65	-0.19	410.85	0.90	14.03
07/30/21 14:27:53	168270	8.97	5.15	2.74	149.88	5.60	1.42	1.09	5.15	0.00	16.78	-0.17	408.06	0.66	14.67
07/30/21 14:28:23	168300	8.97	5.58	2.78	152.81	5.66	1.45	1.48	5.58	0.00	16.37	-0.28	412.10	0.73	13.90
07/30/21 14:28:53	168330	8.97	5.53	2.80	151.52	5.70	1.46	1.35	5.53	0.00	16.16	-0.26	412.63	0.77	13.58
07/30/21 14:29:23	168360	8.96	5.75	2.80	151.20	5.69	1.44	1.52	5.75	0.00	15.89	-0.21	409.70	0.70	13.64
07/30/21 14:29:53	168390	8.96	5.53	2.86	152.91	5.68	1.48	1.29	5.53	0.00	16.36	-0.24	414.01	0.60	13.81
07/30/21 14:30:23	168420	8.97	5.69	2.72	151.43	5.68	1.46	1.04	5.69	0.00	16.41	-0.15	412.16	0.71	13.56
07/30/21 14:30:53	168450	8.98	5.69	2.89	153.60	5.71	1.46	1.33	5.69	0.00	16.05	-0.28	411.95	0.82	13.43
07/30/21 14:31:23	168480	8.98	5.91	2.78	154.44	5.72	1.46	1.24	5.91	0.00	15.65	-0.25	413.67	0.81	13.36
07/30/21 14:31:53	168510	8.96	5.75	2.75	151.74	5.73	1.47	1.43	5.75	0.00	15.47	-0.19	412.60	0.51	13.31
07/30/21 14:32:23	168540	8.97	5.67	2.82	151.82	5.70	1.42	1.50	5.67	0.00	15.58	-0.13	411.89	0.75	13.53
07/30/21 14:32:53	168570	8.97	5.92	2.83	151.82	5.74	1.50	1.62	5.92	0.00	15.53	-0.27	412.14	0.61	13.23
07/30/21 14:33:23	168600	8.96	5.74	2.72	154.57	5.72	1.48	1.56	5.74	0.00	15.25	-0.41	412.25	0.61	13.35
07/30/21 14:33:53	168630	8.97	5.58	2.78	152.39	5.67	1.47	1.46	5.58	0.00	15.77	-0.18	410.05	0.54	13.92
07/30/21 14:34:23	168660	8.97	5.48	2.82	153.52	5.66	1.42	1.42	5.48	0.00	16.79	-0.32	410.92	0.62	14.27
07/30/21 14:34:53	168690	8.96	5.32	2.83	151.54	5.63	1.44	1.65	5.32	0.00	17.22	-0.20	407.18	0.57	14.41

Catalytic Combustion Corporation
July 30, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,603	SCFH

Weather Data

Barometric Pressure	29.89	in. Hg
Relative Humidity	53	%
Ambient Temperature	94	°F
Specific Humidity	0.018296	lb H_2O / lb air

Unit Data

Unit Load	2,691.4	horsepower
Meas. Stack Moisture	13.9	%
Stack Exhaust Flow (M19)	310,849	SCFH

75% Load, Run - 2-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 14:35:23	168720	8.97	5.15	2.77	152.90	5.61	1.44	1.70	5.15	0.00	17.43	-0.22	410.71	0.68	14.44
07/30/21 14:35:53	168750	8.98	5.40	2.85	151.24	5.63	1.43	1.41	5.40	0.00	17.47	-0.22	409.78	0.62	14.36
07/30/21 14:36:23	168780	8.98	5.53	2.83	152.34	5.65	1.43	1.65	5.53	0.00	17.28	-0.26	410.71	0.62	14.21
07/30/21 14:36:53	168810	8.99	5.38	2.91	154.17	5.64	1.42	1.54	5.38	0.00	17.27	-0.19	411.62	0.69	14.34
07/30/21 14:37:23	168840	9.00	5.24	2.91	153.21	5.64	1.45	1.13	5.24	0.00	17.28	-0.24	411.68	0.64	14.28
07/30/21 14:37:53	168870	8.97	5.47	2.81	152.42	5.65	1.45	1.78	5.47	0.00	17.10	-0.23	411.69	0.63	14.20
07/30/21 14:38:23	168900	8.98	5.42	2.80	152.65	5.66	1.43	1.48	5.42	0.00	16.90	-0.19	411.89	0.77	14.12
07/30/21 14:38:53	168930	8.99	5.44	2.91	152.73	5.67	1.44	1.58	5.44	0.00	16.52	-0.24	414.89	0.86	13.76
07/30/21 14:39:23	168960	8.98	5.79	2.93	152.87	5.72	1.50	1.54	5.79	0.00	15.56	-0.26	412.79	0.49	13.53
07/30/21 14:39:53	168990	8.99	5.89	2.98	152.32	5.73	1.48	1.86	5.89	0.00	14.95	-0.12	414.92	0.77	13.45
07/30/21 14:40:23	169020	8.98	5.65	2.83	154.63	5.74	1.52	1.71	5.65	0.00	14.64	-0.23	416.08	0.77	13.25
07/30/21 14:40:53	169050	8.98	5.95	2.86	152.01	5.76	1.49	1.69	5.95	0.00	14.33	-0.14	414.33	0.54	13.02
07/30/21 14:41:23	169080	8.99	5.76	2.87	153.24	5.75	1.46	2.06	5.76	0.00	14.00	-0.22	417.51	0.76	12.78
07/30/21 14:41:53	169110	8.98	5.81	2.91	152.70	5.76	1.44	1.49	5.81	0.00	13.88	-0.26	415.53	0.71	12.75
07/30/21 14:42:23	169140	8.98	5.69	2.88	154.77	5.77	1.50	1.65	5.69	0.00	13.94	-0.31	416.26	0.70	12.77
07/30/21 14:42:53	169170	8.99	4.94	2.93	155.75	5.73	1.52	1.27	4.94	0.00	14.04	-0.47	419.17	0.92	12.69
07/30/21 14:43:23	169200	9.00	4.85	2.81	155.30	5.73	1.53	1.90	4.85	0.00	14.03	-0.27	419.67	0.70	12.52
07/30/21 14:43:53	169230	9.01	5.06	3.03	155.34	5.74	1.47	1.67	5.06	0.00	13.98	-0.31	422.97	0.78	12.44
07/30/21 14:44:23	169260	9.02	5.04	2.93	157.03	5.75	1.47	1.92	5.04	0.00	13.99	-0.26	421.95	0.75	12.44
07/30/21 14:44:53	169290	9.01	4.92	2.93	155.37	5.75	1.47	1.73	4.92	0.00	14.09	-0.32	420.53	0.76	12.47
RAW AVERAGE		**8.97**	**5.59**	**2.78**	**151.87**	**5.66**	**1.45**	**0.97**	**5.59**	**0.00**	**15.64**	**0.00**	**410.84**	**0.76**	**13.91**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
	Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.07			0.13										
Bias	**Final Zero**	0.06			0.27										
Bias	**Avg. Zero**	0.07			0.20										
Bias	**Initial UpScale**	12.01			304.51										
Bias	**Final UpScale**	11.97			310.21										
Bias	**Avg. UpScale**	11.99			307.36										
Upscale Cal Gas		11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.95	6.49	3.23	176.40	6.57	1.68	1.12	6.49	0.00	18.17	0.00	174.98	0.59	0.83
Corrected Raw Average (ppm/% wet basis)	7.70	5.59	2.78	151.87	5.66	1.45	0.97	5.59	0.00	15.64	0.00	150.64	0.51	0.72
Concentration (ppm@ 15%O_2)	N/A	3.20	1.60	74.99	3.24	0.83	0.55	3.20	0.00	8.97	0.00	86.41	0.29	0.35
Emission Rate (g/kw*hr)	N/A	0.0544	0.0165	1.2186	527	0.0135	0.0090	0.0355	0.0000	0.0564	0.0000	1.4073	0.0047	0.0058
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Catalytic Combustion Corporation
July 30, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,591	SCFH

Weather Data

Barometric Pressure	29.87	in. Hg
Relative Humidity	47	%
Ambient Temperature	97	°F
Specific Humidity	0.017841	lb H_2O / lb air

Unit Data

Unit Load	2,698.1	horsepower
Meas. Stack Moisture	13.9	%
Stack Exhaust Flow (M19)	310,873	SCFH

75% Load, Run - 2-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 15:00:23	170220	9.00	5.28	2.96	154.08	5.69	1.35	2.12	5.28	0.00	17.06	-0.04	414.63	0.44	13.70
07/30/21 15:00:53	170250	8.98	5.34	2.94	154.11	5.70	1.41	2.27	5.34	0.00	16.86	-0.22	412.25	0.31	13.74
07/30/21 15:01:23	170280	9.00	5.30	2.86	154.99	5.68	1.42	2.21	5.30	0.00	16.40	-0.15	415.77	0.50	13.68
07/30/21 15:01:53	170310	9.00	5.33	2.95	154.83	5.69	1.45	2.15	5.33	0.00	16.23	-0.09	412.74	0.82	13.66
07/30/21 15:02:23	170340	9.00	5.33	2.89	154.31	5.68	1.33	2.21	5.33	0.00	16.25	-0.25	410.69	0.72	13.66
07/30/21 15:02:53	170370	9.01	5.33	2.88	156.72	5.68	1.40	2.19	5.33	0.00	16.35	-0.19	416.89	0.74	13.69
07/30/21 15:03:23	170400	9.00	5.42	2.86	156.36	5.70	1.45	2.43	5.42	0.00	16.60	-0.20	415.69	0.58	13.71
07/30/21 15:03:53	170430	9.00	5.46	2.84	155.44	5.68	1.42	2.48	5.46	0.00	16.53	-0.23	415.13	0.41	13.69
07/30/21 15:04:23	170460	9.00	5.36	2.76	152.95	5.70	1.40	2.24	5.36	0.00	16.20	-0.17	413.52	0.61	13.66
07/30/21 15:04:53	170490	8.99	5.44	2.91	154.46	5.68	1.37	1.98	5.44	0.00	15.62	-0.27	410.42	0.79	13.67
07/30/21 15:05:23	170520	8.99	5.49	2.95	154.82	5.69	1.39	2.20	5.49	0.00	15.45	-0.19	410.93	0.67	13.67
07/30/21 15:05:53	170550	8.99	5.65	2.88	156.15	5.71	1.49	1.90	5.65	0.00	15.42	-0.56	413.05	0.45	13.65
07/30/21 15:06:23	170580	8.98	5.55	2.89	154.97	5.75	1.40	2.17	5.55	0.00	15.43	-0.38	411.31	0.41	13.49
07/30/21 15:06:53	170610	8.98	5.88	2.88	155.71	5.71	1.44	2.45	5.88	0.00	15.45	-0.16	413.83	0.54	13.58
07/30/21 15:07:23	170640	8.98	5.41	2.94	155.21	5.69	1.44	2.71	5.41	0.00	16.01	-0.22	410.80	0.40	13.77
07/30/21 15:07:53	170670	8.99	5.21	2.85	153.21	5.69	1.37	2.38	5.21	0.00	16.44	-0.19	412.71	0.48	13.73
07/30/21 15:08:23	170700	8.99	5.28	2.93	156.26	5.69	1.43	2.41	5.28	0.00	16.55	-0.21	413.90	0.79	13.75
07/30/21 15:08:53	170730	8.99	5.09	2.95	153.40	5.61	1.43	2.76	5.09	0.00	17.65	-0.20	408.10	0.53	14.82
07/30/21 15:09:23	170760	8.99	5.37	3.03	153.58	5.65	1.43	2.45	5.37	0.00	18.36	-0.20	409.03	0.45	14.45
07/30/21 15:09:53	170790	8.99	5.37	2.89	155.68	5.67	1.46	2.02	5.37	0.00	17.32	-0.27	411.40	0.40	13.96
07/30/21 15:10:23	170820	8.99	5.55	2.98	154.21	5.72	1.41	2.35	5.55	0.00	16.25	-0.17	412.97	0.45	13.56
07/30/21 15:10:53	170850	8.97	5.59	2.90	154.93	5.78	1.47	2.14	5.59	0.00	15.50	-0.42	411.69	0.66	13.33
07/30/21 15:11:23	170880	8.97	5.60	2.93	153.82	5.77	1.42	2.56	5.60	0.00	15.00	-0.29	413.84	0.61	13.14
07/30/21 15:11:53	170910	8.96	5.77	3.03	152.91	5.79	1.45	2.60	5.77	0.00	14.81	-0.30	411.83	0.28	13.16
07/30/21 15:12:23	170940	8.98	5.71	2.90	154.96	5.79	1.51	2.07	5.71	0.00	14.69	-0.19	413.08	0.68	12.87
07/30/21 15:12:53	170970	8.97	5.25	49.44	972.03	4.16	5.63	1.60	5.25	0.00	14.02	0.35	2,591.39	13.89	11.81
07/30/21 15:13:23	171000	8.96	4.53	35.32	615.49	0.45	16.68	1.57	4.16	0.37	14.81	1.32	1,673.96	0.66	10.89
07/30/21 15:13:53	171030	8.96	5.33	2.88	156.72	5.68	1.40	2.19	5.14	0.19	11.39	1.27	595.22	0.03	5.85
07/30/21 15:14:23	171060	8.96	5.42	2.86	156.36	5.70	1.45	2.43	5.42	0.00	11.41	1.83	554.73	-0.06	6.02
07/30/21 15:14:53	171090	8.97	5.46	2.84	155.44	5.68	1.42	2.48	5.46	0.00	13.64	0.19	231.15	0.08	12.48
07/30/21 15:15:23	171120	8.97	5.36	2.76	152.95	5.70	1.40	2.24	5.36	0.00	11.13	-0.01	289.72	-0.19	12.78
07/30/21 15:15:53	171150	8.97	5.44	2.91	154.46	5.68	1.37	1.98	5.44	0.00	16.35	-0.19	416.89	0.74	13.69
07/30/21 15:16:23	171180	8.97	5.49	2.95	154.82	5.69	1.39	2.20	5.49	0.00	16.60	-0.20	415.69	0.58	13.71
07/30/21 15:16:53	171210	8.98	5.65	2.88	156.15	5.71	1.49	1.90	5.65	0.00	16.53	-0.23	415.13	0.41	13.69
07/30/21 15:17:23	171240	8.97	5.55	2.89	154.97	5.75	1.40	2.17	5.55	0.00	16.20	-0.17	413.52	0.61	13.66
07/30/21 15:17:53	171270	8.95	5.88	2.88	155.71	5.71	1.44	2.45	5.88	0.00	15.62	-0.27	410.42	0.79	13.67
07/30/21 15:18:23	171300	8.95	5.41	2.94	155.21	5.69	1.44	2.71	5.41	0.00	15.45	-0.19	410.93	0.67	13.67
07/30/21 15:18:53	171330	8.95	5.21	2.85	153.21	5.69	1.37	2.38	5.21	0.00	15.42	-0.56	413.05	0.45	13.65
07/30/21 15:19:23	171360	8.95	6.23	2.93	153.34	5.80	1.55	2.28	6.23	0.00	15.43	-0.38	411.31	0.41	13.49
07/30/21 15:19:53	171390	8.93	5.82	2.84	159.23	5.78	1.52	2.45	5.82	0.00	15.45	-0.16	413.83	0.54	13.58
07/30/21 15:20:23	171420	8.93	6.13	2.78	162.43	5.81	1.51	2.58	6.13	0.00	15.42	-0.22	410.80	0.40	13.77
07/30/21 15:20:53	171450	8.93	6.34	2.79	162.71	5.82	1.47	2.94	6.34	0.00	15.43	-0.19	412.71	0.48	13.73
07/30/21 15:21:23	171480	8.94	6.00	2.83	163.18	5.81	1.52	2.14	6.00	0.00	15.45	-0.30	435.66	0.40	12.26
07/30/21 15:21:53	171510	8.93	5.81	2.90	162.58	5.78	1.52	2.30	5.81	0.00	16.01	-0.26	433.01	0.47	12.62
07/30/21 15:22:23	171540	8.92	5.81	2.79	158.77	5.68	1.45	2.65	5.81	0.00	16.44	-0.32	422.40	0.20	14.33
07/30/21 15:22:53	171570	8.94	5.88	2.86	158.19	5.68	1.44	2.56	5.88	0.00	16.55	-0.17	422.76	0.23	14.02
07/30/21 15:23:23	171600	8.94	6.26	2.79	160.29	5.80	1.50	2.40	6.26	0.00	17.65	-0.20	430.19	0.48	12.85
07/30/21 15:23:53	171630	8.94	5.89	2.92	160.26	5.69	1.44	2.52	5.89	0.00	18.36	-0.24	425.61	0.36	14.08
07/30/21 15:24:23	171660	8.94	6.01	2.74	161.11	5.76	1.48	2.67	6.01	0.00	17.32	-0.27	428.17	0.15	13.26
07/30/21 15:24:53	171690	8.94	5.69	2.75	161.33	5.73	1.48	2.37	5.69	0.00	16.25	-0.37	427.32	0.22	13.73
07/30/21 15:25:23	171720	8.94	6.32	2.84	160.38	5.77	1.46	3.06	6.32	0.00	12.05	-0.14	428.12	0.34	13.23
07/30/21 15:25:53	171750	8.94	5.52	2.96	159.66	5.64	1.41	2.81	5.52	0.00	13.02	-0.25	422.83	0.51	14.58
07/30/21 15:26:23	171780	8.94	5.20	2.89	158.70	5.62	1.42	3.04	5.20	0.00	13.55	-0.36	422.13	0.27	14.96
07/30/21 15:26:53	171810	8.94	5.61	2.80	157.68	5.58	1.39	2.98	5.61	0.00	14.30	-0.19	416.17	0.31	15.94
07/30/21 15:27:23	171840	8.94	4.85	2.97	159.58	5.58	1.39	3.26	4.85	0.00	14.48	-0.26	420.91	0.25	15.15
07/30/21 15:27:53	171870	8.92	4.86	2.82	158.95	5.60	1.40	3.06	4.86	0.00	15.07	-0.18	418.97	0.23	15.16
07/30/21 15:28:23	171900	8.94	4.97	2.89	158.70	5.61	1.40	2.78	4.97	0.00	15.27	-0.23	419.98	0.47	15.12
07/30/21 15:28:53	171930	8.94	5.09	3.03	158.28	5.58	1.36	3.15	5.09	0.00	15.48	-0.23	418.18	0.37	15.50
07/30/21 15:29:23	171960	8.94	5.19	2.87	155.45	5.49	1.32	3.61	5.19	0.00	16.64	-0.20	411.78	0.26	17.07
07/30/21 15:29:53	171990	8.94	5.10	3.01	156.35	5.53	1.38	3.48	5.10	0.00	16.92	-0.13	413.70	0.12	16.75
07/30/21 15:30:23	172020	8.94	5.22	2.94	157.11	5.57	1.36	3.84	5.22	0.00	16.76	-0.08	416.05	0.29	16.35
07/30/21 15:30:53	172050	8.94	5.48	2.88	156.36	5.62	1.35	2.95	5.48	0.00	16.16	-0.19	415.17	0.18	15.74
07/30/21 15:31:23	172080	8.93	5.41	2.94	158.75	5.60	1.40	3.13	5.41	0.00	15.28	-0.21	418.93	0.37	15.11
07/30/21 15:31:53	172110	8.93	5.10	2.94	159.54	5.65	1.41	2.79	5.10	0.00	14.66	-0.25	423.49	0.28	14.63
07/30/21 15:32:23	172140	8.94	5.18	2.96	160.89	5.69	1.46	2.90	5.18	0.00	14.22	-0.36	425.47	0.39	14.21
07/30/21 15:32:53	172170	8.93	5.24	3.02	160.73	5.72	1.42	2.83	5.24	0.00	13.77	-0.31	427.59	0.29	13.86
07/30/21 15:33:23	172200	8.93	5.27	3.03	161.50	5.73	1.46	2.96	5.27	0.00	13.51	-0.10	426.89	0.47	13.93
07/30/21 15:33:53	172230	8.94	5.25	3.00	162.31	5.71	1.45	3.03	5.25	0.00	13.40	-0.16	429.08	0.29	13.99
07/30/21 15:34:23	172260	8.94	5.60	2.98	160.39	5.71	1.44	3.23	5.60	0.00	13.31	-0.19	427.02	0.31	13.88
07/30/21 15:34:53	172290	8.94	5.35	3.01	161.73	5.71	1.41	2.73	5.35	0.00	13.24	-0.08	427.52	0.55	13.82
07/30/21 15:35:23	172320	8.94	5.25	3.02	159.98	5.72	1.42	3.32	5.25	0.00	13.17	-0.11	427.35	0.35	13.86
07/30/21 15:35:53	172350	8.94	5.47	2.99	161.41	5.74	1.48	3.68	5.47	0.00	13.06	-0.18	428.00	0.66	13.71
07/30/21 15:36:23	172380	8.95	5.30	2.92	160.96	5.73	1.41	3.13	5.30	0.00	13.14	-0.24	425.51	0.38	13.84
07/30/21 15:36:53	172410	8.94	5.38	2.98	161.64	5.72	1.46	2.97	5.38	0.00	13.06	-0.25	428.15	0.63	13.88
07/30/21 15:37:23	172440	8.94	5.23	2.97	161.13	5.73	1.40	3.51	5.23	0.00	12.97	-0.01	428.27	0.55	13.81
07/30/21 15:37:53	172470	8.93	5.06	3.01	161.90	5.71	1.46	3.43	5.06	0.00	12.88	-0.24	428.42	0.27	13.87
07/30/21 15:38:23	172500	8.94	5.20	3.02	161.55	5.70	1.42	3.68	5.20	0.00	12.84	-0.15	426.92	0.50	14.11
07/30/21 15:38:53	172530	8.94	5.30	3.00	161.75	5.71	1.44	3.32	5.30	0.00	12.69	-0.18	427.17	0.43	14.01
07/30/21 15:39:23	172560	8.94	5.16	3.10	161.35	5.70	1.44	3.01	5.16	0.00	12.82	-0.23	428.15	0.30	14.37
07/30/21 15:39:53	172590	8.94	4.76	3.05	160.77	5.68	1.43	2.91	4.76	0.00	12.96	-0.25	425.10	0.49	14.52
07/30/21 15:40:23	172620	8.94	4.93	2.94	160.16	5.64	1.38	2.48	4.93	0.00	13.28	-0.35	424.52	0.30	14.79
07/30/21 15:40:53	172650	8.93	4.83	3.06	161.08	5.63	1.35	2.98	4.83	0.00	13.57	-0.23	424.31	0.21	14.92
07/30/21 15:41:23	172680	8.93	4.88	3.04	160.45	5.63	1.38	3.01	4.88	0.00	13.86	-0.25	422.99	0.16	14.91
07/30/21 15:41:53	172710	8.94	5.00	3.01	160.16	5.65	1.41	2.75	5.00	0.00	13.80	-0.30	422.58	0.39	14.68
07/30/21 15:42:23	172740	8.94	4.99	3.03	160.76	5.67	1.46	3.48	4.99	0.00	13.47	-0.27	426.36	0.59	14.51
07/30/21 15:42:53	172770	8.94	5.07	3.08	160.43	5.66	1.44	3.70	5.07	0.00	13.24	-0.25	423.59	0.39	14.57
07/30/21 15:43:23	172800	8.94	5.18	3.11	160.86	5.68	1.44	4.23	5.18	0.00	13.30	-0.22	427.25	0.39	14.51
07/30/21 15:43:53	172830	8.94	5.35	3.05	160.98	5.69	1.40	3.77	5.35	0.00	13.41	-0.37	425.83	0.40	14.40
07/30/21 15:44:23	172860	8.95	5.51	3.12	161.01	5.69	1.43	3.91	5.51	0.00	13.39	-0.12	425.82	0.40	14.27
07/30/21 15:44:53	172890	8.95	5.38	3.02	159.22	5.70	1.38	3.96	5.38	0.00	13.31	-0.31	426.40	0.37	14.22
07/30/21 15:45:23	172920	8.94	4.81	2.96	161.41	5.66	1.43	4.19	4.81	0.00	13.48	-0.45	424.81	0.46	14.60
07/30/21 15:45:53	172950	8.94	4.90	3.07	161.82	5.59	1.42	4.06	4.90	0.00	14.13	-0.23	423.42	0.38	15.29
07/30/21 15:46:23	172980	8.95	5.31	2.96	161.20	5.66	1.47	3.87	5.31	0.00	13.71	-0.15	424.07	0.30	14.56
07/30/21 15:46:53	173010	8.94	5.07	3.08	160.88	5.69	1.48	3.86	5.07	0.00	13.51	-0.35	426.34	0.46	14.32
07/30/21 15:47:23	173040	8.94	5.17	2.98	160.06	5.70	1.48	3.56	5.17	0.00	13.35	-0.13	426.55	0.41	14.20
07/30/21 15:47:53	173070	8.95	5.41	3.09	161.01	5.70	1.44	3.67	5.41	0.00	13.15	-0.26	425.67	0.24	14.06
07/30/21 15:48:23	173100	8.95	5.24	3.08	161.73	5.72	1.50	3.77	5.24	0.00	12.93	-0.28	427.57	0.15	13.96
07/30/21 15:48:53	173130	8.95	5.53	3.08	162.80	5.71	1.44	4.09	5.53	0.00	12.74	-0.35	429.29	0.14	13.99
07/30/21 15:49:23	173160	8.96	5.24	3.09	161.82	5.72	1.42	3.29	5.24	0.00	12.79	-0.28	429.10	0.24	14.04
07/30/21 15:49:53	173190	8.95	5.34	3.02	162.42	5.71	1.45	3.28	5.34	0.00	12.83	-0.22	428.60	0.15	14.01

Catalytic Combustion Corporation
July 30, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,591	SCFH

Weather Data

Barometric Pressure	29.87	in. Hg
Relative Humidity	47	%
Ambient Temperature	97	°F
Specific Humidity	0.017841	lb H_2O / lb air

Unit Data

Unit Load	2,698.1	horsepower
Meas. Stack Moisture	13.9	%
Stack Exhaust Flow (M19)	310,873	SCFH

75% Load, Run - 2-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 15:50:23	173220	8.94	5.38	2.92	162.58	5.72	1.49	3.88	5.38	0.00	12.84	-0.17	428.03	0.17	13.94
07/30/21 15:50:53	173250	8.94	5.13	2.98	161.45	5.73	1.46	3.83	5.13	0.00	12.77	-0.24	428.88	0.14	13.93
07/30/21 15:51:23	173280	8.94	5.31	3.12	162.25	5.70	1.42	4.07	5.31	0.00	12.56	-0.27	428.79	0.28	13.84
07/30/21 15:51:53	173310	8.93	5.32	3.01	164.97	5.73	1.44	3.80	5.32	0.00	12.58	-0.12	430.57	0.05	13.87
07/30/21 15:52:23	173340	8.93	5.31	3.01	160.59	5.71	1.55	3.98	5.31	0.00	12.47	-0.20	427.20	0.59	13.79
07/30/21 15:52:53	173370	8.93	5.43	3.18	162.47	5.72	1.50	4.11	5.43	0.00	12.33	-0.21	429.06	0.40	13.77
07/30/21 15:53:23	173400	8.93	5.38	3.08	163.86	5.75	1.52	3.62	5.38	0.00	12.21	-0.34	432.27	0.73	13.78
07/30/21 15:53:53	173430	8.93	5.43	3.21	162.27	5.72	1.52	3.72	5.43	0.00	12.05	-0.28	430.05	0.76	13.78
07/30/21 15:54:23	173460	8.93	5.34	3.07	163.45	5.74	1.52	4.14	5.34	0.00	11.97	-0.42	429.83	0.53	13.79
07/30/21 15:54:53	173490	8.92	5.24	3.00	162.66	5.72	1.55	3.96	5.24	0.00	11.91	-0.21	431.25	0.57	13.77
07/30/21 15:55:23	173520	8.94	5.28	3.19	162.09	5.73	1.41	3.60	5.28	0.00	11.92	-0.28	429.57	0.60	13.80
07/30/21 15:55:53	173550	8.93	5.40	3.09	162.63	5.73	1.47	4.02	5.40	0.00	12.03	-0.43	429.29	0.68	13.80
07/30/21 15:56:23	173580	8.94	5.42	3.11	164.49	5.73	1.47	3.77	5.42	0.00	12.00	-0.30	430.85	0.50	13.79
07/30/21 15:56:53	173610	8.93	5.28	3.09	163.16	5.73	1.54	5.16	5.28	0.00	11.99	-0.37	430.41	0.47	13.79
07/30/21 15:57:23	173640	8.93	5.49	2.99	162.50	5.74	1.50	3.71	5.49	0.00	11.86	-0.29	430.53	0.42	13.78
07/30/21 15:57:53	173670	8.92	5.54	3.12	164.68	5.74	1.59	3.74	5.54	0.00	11.68	-0.38	431.24	0.41	13.78
07/30/21 15:58:23	173700	8.92	5.35	3.07	164.13	5.75	1.47	4.18	5.35	0.00	11.71	-0.34	430.66	0.69	13.79
07/30/21 15:58:53	173730	8.92	5.11	3.16	163.97	5.75	1.49	4.13	5.11	0.00	11.87	-0.47	430.71	0.75	13.79
07/30/21 15:59:23	173760	8.92	5.18	3.04	165.27	5.73	1.53	4.48	5.18	0.00	11.89	-0.39	431.55	0.73	13.79
07/30/21 15:59:53	173790	8.91	5.25	3.10	164.57	5.72	1.41	3.74	5.25	0.00	12.04	-0.22	431.44	0.54	13.80
RAW AVERAGE		**8.95**	**5.38**	**3.62**	**169.71**	**5.64**	**1.60**	**3.01**	**5.38**	**0.00**	**14.33**	**0.00**	**450.35**	**0.54**	**13.86**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
	Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.06			0.27										
Bias	**Final Zero**	0.04			0.44										
Bias	**Avg. Zero**	0.05			0.36										
Bias	**Initial UpScale**	11.97			310.21										
Bias	**Final UpScale**	11.95			303.21										
Bias	**Avg. UpScale**	11.96			306.71										
Upscale Cal Gas		11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.96	6.25	4.20	197.01	6.55	1.86	3.50	6.24	0.01	16.63	0.00	191.69	0.42	4.90
Corrected Raw Average (ppm/% wet basis)	7.71	5.38	3.62	169.71	5.64	1.60	3.01	5.38	0.00	14.33	0.00	165.13	0.36	4.22
Concentration (ppm@ 15%O_2)	N/A	3.09	2.08	83.86	3.24	0.92	1.73	3.08	0.00	8.22	0.00	94.72	0.21	2.09
Emission Rate (g/kw*hr)	N/A	0.0523	0.0214	1.3585	524	0.0149	0.0280	0.0341	0.0000	0.0515	0.0000	1.5380	0.0033	0.0338
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,172	SCFH

Weather Data

Barometric Pressure	29.85	in. Hg
Relative Humidity	42	%
Ambient Temperature	97	°F
Specific Humidity	0.015856	lb H_2O / lb air

Unit Data

Unit Load	2,616.3	horsepower
Meas. Stack Moisture	13.6	%
Stack Exhaust Flow (M19)	303,928	SCFH

75% Load, Run - 2-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 16:27:23	175440	8.96	5.20	3.09	162.24	5.68	1.52	4.26	5.20	0.00	13.65	-0.14	427.16	0.26	14.22
07/30/21 16:27:53	175470	8.96	5.51	3.11	161.66	5.68	1.55	4.06	5.51	0.00	13.76	-0.10	427.30	0.22	14.07
07/30/21 16:28:23	175500	8.97	5.37	3.07	162.33	5.70	1.57	4.19	5.37	0.00	13.70	-0.33	428.91	0.07	13.95
07/30/21 16:28:53	175530	8.98	5.45	3.14	161.73	5.70	1.52	3.78	5.45	0.00	13.56	-0.16	428.59	0.33	13.81
07/30/21 16:29:23	175560	8.98	5.37	3.16	163.32	5.69	1.46	3.41	5.37	0.00	13.58	-0.22	430.94	0.45	13.79
07/30/21 16:29:53	175590	8.96	5.32	3.18	162.36	5.70	1.51	4.28	5.32	0.00	13.59	-0.02	429.85	0.34	13.80
07/30/21 16:30:23	175620	8.96	5.28	3.15	162.84	5.71	1.49	3.61	5.28	0.00	13.58	-0.04	432.52	0.06	13.81
07/30/21 16:30:53	175650	8.97	5.19	3.02	164.45	5.71	1.51	3.37	5.19	0.00	13.74	-0.25	431.85	0.53	13.90
07/30/21 16:31:23	175680	8.98	5.32	3.01	163.06	5.71	1.56	3.86	5.32	0.00	13.86	-0.26	431.18	0.59	13.89
07/30/21 16:31:53	175710	8.98	5.37	3.06	163.49	5.70	1.54	4.16	5.37	0.00	13.87	-0.22	430.46	0.18	13.88
07/30/21 16:32:23	175740	8.97	5.23	3.12	161.58	5.71	1.50	3.96	5.23	0.00	13.73	-0.14	428.70	0.43	13.80
07/30/21 16:32:53	175770	8.97	5.20	3.09	161.94	5.71	1.48	3.71	5.20	0.00	13.67	-0.11	429.38	0.47	13.75
07/30/21 16:33:23	175800	8.97	5.26	3.09	161.52	5.71	1.48	3.36	5.26	0.00	13.54	-0.08	429.34	0.43	13.74
07/30/21 16:33:53	175830	8.96	5.21	3.09	162.99	5.71	1.53	3.70	5.21	0.00	13.48	-0.35	430.08	0.94	13.72
07/30/21 16:34:23	175860	8.97	5.15	3.05	162.67	5.70	1.46	3.61	5.15	0.00	13.42	-0.22	430.77	0.40	13.72
07/30/21 16:34:53	175890	8.97	5.11	3.09	161.73	5.69	1.52	3.26	5.11	0.00	13.41	-0.26	430.83	0.81	13.71
07/30/21 16:35:23	175920	8.97	5.29	3.02	163.62	5.71	1.48	3.99	5.29	0.00	13.35	-0.27	430.14	0.62	13.72
07/30/21 16:35:53	175950	8.97	5.16	3.16	165.32	5.70	1.51	3.04	5.16	0.00	13.34	-0.26	434.18	0.65	13.73
07/30/21 16:36:23	175980	8.96	5.23	3.00	163.44	5.72	1.51	3.74	5.23	0.00	13.35	-0.52	428.88	0.59	13.74
07/30/21 16:36:53	176010	8.96	5.45	2.93	163.48	5.70	1.52	4.05	5.45	0.00	13.30	-0.11	430.31	0.58	13.67
07/30/21 16:37:23	176040	8.96	5.37	2.92	164.02	5.70	1.49	3.34	5.37	0.00	13.36	-0.39	432.22	0.47	13.65
07/30/21 16:37:53	176070	8.95	5.34	2.94	164.51	5.72	1.52	3.73	5.34	0.00	13.47	-0.32	432.87	0.82	13.69
07/30/21 16:38:23	176100	8.95	5.38	3.20	164.50	5.72	1.53	3.24	5.38	0.00	13.48	-0.26	434.26	0.55	13.71
07/30/21 16:38:53	176130	8.95	5.59	3.11	166.19	5.73	1.57	4.16	5.59	0.00	13.54	-0.31	432.39	0.70	13.72
07/30/21 16:39:23	176160	8.95	5.41	3.16	165.30	5.72	1.49	3.55	5.41	0.00	13.64	-0.18	435.13	0.59	13.73
07/30/21 16:39:53	176190	8.94	5.41	3.17	163.86	5.73	1.53	3.69	5.41	0.00	13.72	-0.11	432.05	0.41	13.73
07/30/21 16:40:23	176220	8.94	5.31	3.04	165.67	5.72	1.53	4.04	5.31	0.00	13.74	0.02	433.43	0.32	13.73
07/30/21 16:40:53	176250	8.94	5.19	3.17	164.72	5.72	1.54	4.07	5.19	0.00	13.69	-0.12	433.49	0.53	13.74
07/30/21 16:41:23	176280	8.94	5.32	3.13	165.07	5.72	1.54	4.17	5.32	0.00	13.63	-0.12	433.90	0.26	13.74
07/30/21 16:41:53	176310	8.95	5.24	3.11	165.63	5.73	1.54	3.91	5.24	0.00	13.66	-0.20	432.97	0.71	13.73
07/30/21 16:42:23	176340	8.96	5.33	3.11	164.83	5.72	1.59	3.64	5.33	0.00	13.70	-0.32	433.01	0.41	13.74
07/30/21 16:42:53	176370	8.98	5.44	3.08	165.03	5.73	1.55	3.59	5.44	0.00	13.76	-0.08	434.03	0.53	13.74
07/30/21 16:43:23	176400	8.97	5.22	3.17	164.73	5.73	1.56	3.89	5.22	0.00	13.97	-0.28	432.25	0.71	13.72
07/30/21 16:43:53	176430	8.97	5.41	3.15	163.83	5.73	1.51	3.91	5.41	0.00	14.18	-0.26	431.82	0.60	13.74
07/30/21 16:44:23	176460	8.98	5.40	3.05	164.98	5.72	1.51	3.81	5.40	0.00	14.19	-0.29	433.20	0.61	13.75
07/30/21 16:44:53	176490	8.98	5.62	3.15	165.96	5.73	1.47	4.23	5.62	0.00	14.34	-0.07	432.68	0.28	13.73
07/30/21 16:45:23	176520	8.97	5.49	3.16	164.48	5.74	1.58	4.56	5.49	0.00	14.46	-0.21	432.58	0.58	13.73
07/30/21 16:45:53	176550	8.97	5.19	3.19	165.52	5.73	1.52	3.75	5.19	0.00	14.36	-0.17	434.05	0.33	13.76
07/30/21 16:46:23	176580	8.96	5.42	3.18	163.83	5.73	1.57	4.26	5.42	0.00	13.97	-0.21	431.62	0.46	13.76
07/30/21 16:46:53	176610	8.96	5.27	3.13	165.74	5.73	1.47	4.41	5.27	0.00	13.55	-0.28	432.33	0.33	13.76
07/30/21 16:47:23	176640	8.96	5.35	3.02	164.14	5.73	1.54	4.01	5.35	0.00	13.34	-0.27	432.18	0.30	13.76
07/30/21 16:47:53	176670	8.97	5.30	3.10	164.58	5.72	1.57	4.25	5.30	0.00	13.30	-0.21	431.82	0.48	13.77
07/30/21 16:48:23	176700	8.97	5.23	3.07	166.09	5.73	1.52	4.47	5.23	0.00	13.30	-0.14	433.25	0.59	13.79
07/30/21 16:48:53	176730	8.95	5.46	3.14	164.59	5.73	1.56	5.08	5.46	0.00	13.07	-0.29	433.13	0.24	13.75
07/30/21 16:49:23	176760	8.96	5.25	3.19	159.22	5.50	1.43	4.02	5.25	0.00	15.24	-0.25	414.50	0.38	16.82
07/30/21 16:49:53	176790	8.95	4.89	3.04	164.21	5.66	1.43	4.06	4.89	0.00	14.06	-0.22	429.74	0.34	14.43
07/30/21 16:50:23	176820	8.95	4.96	3.06	166.83	5.71	1.52	3.66	4.96	0.00	13.79	-0.18	431.24	0.32	13.95
07/30/21 16:50:53	176850	8.94	5.18	3.12	166.23	5.73	1.52	4.20	5.18	0.00	13.66	-0.29	434.25	0.69	13.79
07/30/21 16:51:23	176880	8.95	5.37	3.10	164.52	5.75	1.55	4.35	5.37	0.00	13.70	-0.28	432.03	0.29	13.76
07/30/21 16:51:53	176910	8.96	5.15	3.13	164.16	5.74	1.50	4.77	5.15	0.00	13.74	-0.05	432.73	0.29	13.65
07/30/21 16:52:23	176940	8.98	5.28	3.14	163.56	5.74	1.56	4.53	5.28	0.00	13.63	-0.06	431.91	0.57	13.48
07/30/21 16:52:53	176970	8.97	5.38	3.05	164.15	5.77	1.52	4.71	5.38	0.00	13.35	-0.12	433.33	0.53	13.29
07/30/21 16:53:23	177000	8.97	5.36	3.10	166.71	5.78	1.55	3.63	5.36	0.00	13.11	-0.36	435.10	0.46	13.15
07/30/21 16:53:53	177030	8.98	5.61	3.03	165.77	5.78	1.49	4.58	5.61	0.00	12.89	-0.08	437.33	0.21	13.09
07/30/21 16:54:23	177060	8.98	5.38	3.14	165.90	5.78	1.53	4.35	5.38	0.00	12.84	-0.24	436.28	0.56	13.04
07/30/21 16:54:53	177090	8.97	5.38	3.11	166.61	5.77	1.58	3.78	5.38	0.00	12.83	-0.28	436.12	0.34	12.92
07/30/21 16:55:23	177120	8.97	5.56	3.18	166.49	5.79	1.50	3.87	5.56	0.00	12.84	-0.22	438.02	0.45	12.91
07/30/21 16:55:53	177150	8.96	5.35	2.95	165.62	5.78	1.54	4.40	5.35	0.00	12.93	-0.23	438.22	0.58	12.94
07/30/21 16:56:23	177180	8.96	5.36	3.07	165.60	5.78	1.57	4.13	5.36	0.00	13.12	-0.29	436.74	0.55	12.95
07/30/21 16:56:53	177210	8.96	5.63	3.08	164.50	5.82	1.54	4.54	5.63	0.00	13.20	-0.27	435.95	0.44	12.83
07/30/21 16:57:23	177240	8.97	5.57	3.13	165.64	5.82	1.52	4.36	5.57	0.00	13.03	-0.26	435.31	0.75	12.78
07/30/21 16:57:53	177270	8.97	5.67	3.04	166.42	5.81	1.49	4.43	5.67	0.00	12.84	-0.10	439.44	0.63	12.76
07/30/21 16:58:23	177300	8.95	5.21	3.19	168.72	5.78	1.52	3.29	5.21	0.00	12.64	-0.40	443.47	0.22	12.46
07/30/21 16:58:53	177330	8.96	5.09	3.12	167.57	5.82	1.53	4.17	5.09	0.00	12.20	-0.25	441.46	0.54	12.15
07/30/21 16:59:23	177360	8.95	5.57	3.05	165.08	5.79	1.48	4.59	5.57	0.00	12.35	-0.18	436.65	0.44	13.08
07/30/21 16:59:53	177390	8.95	5.20	3.07	165.43	5.71	1.50	4.37	5.20	0.00	13.21	-0.20	432.50	0.63	13.83
07/30/21 17:00:23	177420	8.95	4.72	3.03	163.98	5.68	1.46	4.51	4.72	0.00	14.56	-0.07	430.28	0.48	14.40
07/30/21 17:00:53	177450	8.95	4.94	3.23	163.57	5.63	1.47	4.72	4.94	0.00	15.63	-0.37	425.06	0.34	14.83
07/30/21 17:01:23	177480	8.95	4.77	3.11	161.57	5.63	1.39	4.16	4.77	0.00	16.43	-0.18	424.39	-0.12	15.08
07/30/21 17:01:53	177510	8.96	5.03	3.18	162.96	5.63	1.47	5.02	5.03	0.00	16.61	-0.19	426.46	0.45	15.18
07/30/21 17:02:23	177540	8.95	4.83	3.13	162.40	5.62	1.41	5.00	4.83	0.00	16.63	-0.22	426.37	-0.05	15.18
07/30/21 17:02:53	177570	8.95	4.76	3.03	163.88	5.61	1.39	4.57	4.76	0.00	16.59	-0.25	427.03	0.07	14.97
07/30/21 17:03:23	177600	8.96	4.96	3.00	163.70	5.63	1.44	4.50	4.96	0.00	16.52	-0.31	427.79	0.12	14.83
07/30/21 17:03:53	177630	8.95	5.05	3.20	163.93	5.67	1.50	4.49	5.05	0.00	16.15	-0.27	430.47	0.51	14.61
07/30/21 17:04:23	177660	8.95	5.13	3.10	162.74	5.65	1.45	4.57	5.13	0.00	15.80	-0.13	428.17	0.40	14.66
07/30/21 17:04:53	177690	8.94	5.37	3.15	163.33	5.69	1.49	4.19	5.37	0.00	15.68	-0.25	427.48	0.01	14.48
07/30/21 17:05:23	177720	8.93	5.16	3.00	164.04	5.68	1.45	4.63	5.16	0.00	15.32	-0.48	428.47	0.17	14.31
07/30/21 17:05:53	177750	8.92	5.26	3.03	162.79	5.70	1.49	3.72	5.26	0.00	15.14	-0.42	429.04	0.15	14.32
07/30/21 17:06:23	177780	8.88	5.38	3.07	165.23	5.69	1.42	4.38	5.38	0.00	15.11	-0.18	428.39	0.25	14.24
07/30/21 17:06:53	177810	8.88	5.28	3.12	165.06	5.74	1.45	4.23	5.28	0.00	14.79	-0.35	431.88	0.28	14.15
07/30/21 17:07:23	177840	8.85	5.02	3.04	165.10	5.74	1.46	4.63	5.02	0.00	14.31	-0.18	435.08	0.28	14.01
07/30/21 17:07:53	177870	8.85	5.06	3.12	165.51	5.77	1.49	3.98	5.06	0.00	13.87	-0.23	432.15	0.20	13.82
07/30/21 17:08:23	177900	8.88	5.32	3.08	157.58	5.64	1.40	4.69	5.32	0.00	15.07	-0.13	421.98	-0.35	15.75
07/30/21 17:08:53	177930	8.88	4.76	3.09	163.85	5.71	1.49	4.85	4.76	0.00	14.61	-0.09	427.85	0.30	14.51
07/30/21 17:09:23	177960	8.89	5.24	3.08	165.21	5.81	1.52	4.24	5.24	0.00	13.39	-0.12	434.44	0.36	13.41
07/30/21 17:09:53	177990	8.87	5.48	3.12	165.49	5.83	1.55	4.18	5.48	0.00	13.01	-0.31	435.19	0.17	13.20
07/30/21 17:10:23	178020	8.88	5.23	3.16	165.44	5.82	1.47	4.72	5.20	0.03	12.95	-0.21	434.24	0.18	13.27
07/30/21 17:10:53	178050	8.88	5.06	3.10	164.78	5.81	1.53	4.08	2.46	2.60	13.06	-0.42	433.53	0.72	13.45
07/30/21 17:11:23	178080	8.88	5.32	3.36	166.12	5.81	0.92	4.53	-1.27	6.59	13.21	-0.12	435.76	0.46	13.34
07/30/21 17:11:53	178110	8.87	4.76	3.90	162.78	5.68	0.07	3.87	4.76	0.00	14.11	0.09	428.08	0.17	14.73
07/30/21 17:12:23	178140	8.85	5.24	4.16	165.06	5.82	0.06	4.44	5.24	0.00	11.99	0.14	434.76	0.26	13.13
07/30/21 17:12:53	178170	8.86	5.48	3.48	168.26	5.83	1.56	4.23	5.48	0.00	10.36	-0.25	441.64	0.63	12.60
07/30/21 17:13:23	178200	8.85	5.23	3.30	167.68	5.86	1.63	4.04	5.23	0.00	11.03	-0.39	442.96	-0.17	12.29
07/30/21 17:13:53	178230	8.85	5.11	3.08	167.84	5.87	1.58	4.51	5.11	0.00	10.62	-0.29	441.86	0.03	12.30
07/30/21 17:14:23	178260	8.85	5.14	3.02	167.62	5.85	1.47	3.79	5.14	0.00	10.61	-0.32	441.64	0.18	12.24
07/30/21 17:14:53	178290	8.85	5.04	3.12	168.82	5.88	1.53	4.15	5.04	0.00	11.60	0.00	444.13	0.25	12.13
07/30/21 17:15:23	178320	8.85	5.24	3.17	167.36	5.90	1.53	4.96	5.24	0.00	12.65	-0.32	442.58	0.82	11.88
07/30/21 17:15:53	178350	8.85	5.21	3.15	171.20	5.91	1.56	4.83	5.21	0.00	11.89	-0.22	444.79	0.37	11.83
07/30/21 17:16:23	178380	8.84	5.28	3.13	168.89	5.91	1.59	4.96	5.28	0.00	12.25	-0.21	445.74	0.25	11.81
07/30/21 17:16:53	178410	8.84	5.00	3.16	164.87	5.65	1.40	4.58	5.00	0.00	11.99	-0.09	429.12	0.11	15.29

Catalytic Combustion Corporation
July 30, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	20,172	SCFH

Weather Data

Barometric Pressure	29.85	in. Hg
Relative Humidity	42	%
Ambient Temperature	97	°F
Specific Humidity	0.015856	lb H_2O / lb air

Unit Data

Unit Load	2,616.3	horsepower
Meas. Stack Moisture	13.6	%
Stack Exhaust Flow (M19)	303,928	SCFH

75% Load, Run - 2-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%vd)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%vw)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvw)	NO_2 (ppmvw)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (ppmvw)	C_2H_6 (ppmvw)	H_2O (%)
07/30/21 17:17:23	178440	8.84	5.06	3.06	168.22	5.87	1.48	4.52	5.06	0.00	10.62	-0.27	444.05	0.73	12.33
07/30/21 17:17:53	178470	8.84	5.30	3.02	171.17	5.94	1.55	4.36	5.30	0.00	10.61	-0.28	447.17	0.31	11.65
07/30/21 17:18:23	178500	8.81	5.32	3.03	167.25	5.74	1.38	4.98	5.32	0.00	11.60	-0.13	434.22	0.22	14.18
07/30/21 17:18:53	178530	8.81	5.05	3.02	161.55	5.64	1.36	4.12	5.05	0.00	12.65	-0.12	423.40	0.04	16.10
07/30/21 17:19:23	178560	8.80	4.90	2.96	168.67	5.88	1.49	4.74	4.90	0.00	11.89	-0.21	443.32	0.42	12.45
07/30/21 17:19:53	178590	8.80	5.71	2.97	165.63	5.90	1.44	4.58	5.71	0.00	12.25	-0.32	437.62	0.22	12.82
07/30/21 17:20:23	178620	8.81	5.62	3.02	165.57	5.90	1.44	4.78	5.62	0.00	11.99	-0.36	437.27	0.63	12.83
07/30/21 17:20:53	178650	8.82	5.04	3.07	168.18	5.90	1.49	4.09	5.04	0.00	11.94	-0.29	442.26	0.29	12.23
07/30/21 17:21:23	178680	8.80	5.13	2.89	167.87	5.91	1.44	4.67	5.13	0.00	11.81	-0.22	443.18	0.14	12.13
07/30/21 17:21:53	178710	8.80	5.14	2.99	168.77	5.93	1.42	4.56	5.14	0.00	11.75	-0.17	445.98	0.37	11.95
07/30/21 17:22:23	178740	8.81	5.05	2.95	165.21	5.80	1.42	4.54	5.05	0.00	12.50	-0.16	432.28	0.24	13.83
07/30/21 17:22:53	178770	8.82	4.97	2.92	167.78	5.90	1.38	4.53	4.97	0.00	12.18	-0.19	442.61	0.30	12.28
07/30/21 17:23:23	178800	8.81	4.29	3.02	165.00	5.66	1.37	4.95	4.29	0.00	13.55	-0.21	430.24	0.68	15.27
07/30/21 17:23:53	178830	8.80	5.00	3.02	167.91	5.91	1.42	4.24	5.00	0.00	12.66	-0.44	444.46	0.53	12.03
07/30/21 17:24:23	178860	8.77	5.24	2.91	165.43	5.82	1.37	4.11	5.24	0.00	13.45	-0.35	433.08	-0.01	13.55
07/30/21 17:24:53	178890	8.78	5.14	2.98	163.19	5.82	1.43	4.20	5.14	0.00	13.33	-0.31	429.44	0.23	13.65
07/30/21 17:25:23	178920	8.78	5.15	2.94	164.70	5.89	1.45	4.45	5.15	0.00	13.14	-0.30	432.50	0.39	13.06
07/30/21 17:25:53	178950	8.76	5.27	3.04	166.33	5.89	1.39	4.44	5.27	0.00	13.25	-0.31	435.67	0.38	13.20
07/30/21 17:26:23	178980	8.75	4.69	2.97	166.88	5.91	1.41	4.39	4.69	0.00	13.03	-0.23	440.21	0.30	12.47
07/30/21 17:26:53	179010	8.76	4.62	3.00	167.04	5.91	1.42	4.54	4.62	0.00	13.10	-0.30	438.17	0.24	12.40
RAW AVERAGE		**8.91**	**5.23**	**3.10**	**164.95**	**5.75**	**1.47**	**4.21**	**5.15**	**0.08**	**13.44**	**0.00**	**433.59**	**0.38**	**13.59**

	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4	C_2H_6	H_2O
Serial Number:	INST-O2-0026	INST-IR-0005	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
	(%)			(ppmvw)										
Bias **Initial Zero**	0.04			0.44										
Final Zero	0.06			1.21										
Avg. Zero	0.05			0.83										
Initial UpScale	11.95			303.21										
Final UpScale	11.94			312.59										
Avg. UpScale	11.95			307.90										
Upscale Cal Gas	11.99			302.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.94	6.05	3.59	190.89	6.66	1.70	4.87	5.96	0.09	15.56	0.00	183.99	0.30	6.61
Corrected Raw Average (ppm/% wet basis)	7.71	5.23	3.10	164.95	5.75	1.47	4.21	5.15	0.08	13.44	0.00	158.98	0.26	5.71
Concentration (ppm@ 15%O_2)	N/A	2.98	1.77	81.34	3.28	0.84	2.40	2.94	0.04	7.67	0.00	90.73	0.15	2.82
Emission Rate (g/kw*hr)	N/A	0.0511	0.0184	1.3313	538	0.0137	0.0393	0.0328	0.0008	0.0486	0.0000	1.4883	0.0024	0.0461
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

EMISSION DATA RECORDS

100% Load
NOx, CO, THC, N_2O, C_2H_4O, NH_3, HCHO, CH_4, C_2H_6, and H_2O
Reference Method Data

Catalytic Combustion Corporation
September 1, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.73	in. Hg
Relative Humidity	70	%
Ambient Temperature	88	°F
Specific Humidity	0.020202	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	13.6	%
Stack Exhaust Flow (M19)	386,201	SCFH

100% Load, Run - 3-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvd)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 9:23:57	12140	8.62	15.56	4.29	96.72	5.91	1.12	0.80	12.77	2.79	0.60	1.33	412.49	-0.42	13.13
09/01/21 9:24:27	12170	8.61	14.59	4.28	97.14	5.91	1.07	0.84	12.15	2.44	0.66	1.37	411.33	-0.37	13.10
09/01/21 9:24:57	12200	8.61	13.74	4.22	98.52	5.88	1.26	0.76	12.95	0.80	0.60	1.30	410.45	-0.20	13.48
09/01/21 9:25:27	12230	8.62	14.09	4.13	98.75	5.90	1.31	0.83	13.01	1.08	0.58	1.25	412.16	-0.35	13.30
09/01/21 9:25:57	12260	8.61	13.84	3.64	98.21	5.84	1.33	0.94	12.72	1.12	0.62	1.27	409.75	-0.42	14.07
09/01/21 9:26:27	12290	8.61	15.11	3.67	98.45	5.87	1.34	0.88	13.46	1.65	0.61	1.32	411.82	-0.48	13.88
09/01/21 9:26:57	12320	8.61	14.09	4.16	98.85	5.92	1.32	0.77	13.21	0.87	0.66	1.25	412.09	-0.34	13.09
09/01/21 9:27:27	12350	8.62	15.47	3.67	98.04	5.82	1.40	0.85	11.72	3.74	0.67	1.30	406.15	-0.76	14.56
09/01/21 9:27:57	12380	8.61	14.73	3.64	97.91	5.87	1.38	0.85	12.00	2.73	0.65	1.32	413.16	-0.48	13.88
09/01/21 9:28:27	12410	8.60	15.08	3.79	97.37	5.89	1.36	0.78	12.51	2.57	0.63	1.28	413.74	-0.61	13.54
09/01/21 9:28:57	12440	8.61	14.66	3.70	98.69	5.91	1.38	0.86	12.77	1.89	0.64	1.31	409.17	-0.54	13.54
09/01/21 9:29:27	12470	8.60	14.26	3.51	99.77	5.66	1.35	0.86	12.12	2.14	0.63	1.26	396.82	-0.63	16.52
09/01/21 9:29:57	12500	8.62	14.33	3.68	99.41	5.88	1.35	0.86	13.23	1.09	0.60	1.34	411.48	-0.49	13.77
09/01/21 9:30:27	12530	8.60	13.37	4.16	99.32	5.91	1.33	0.74	13.00	0.37	0.65	1.24	412.99	-0.27	13.24
09/01/21 9:30:57	12560	8.61	12.95	4.18	98.88	5.90	1.35	0.75	12.62	0.33	0.58	1.26	412.49	-0.35	13.31
09/01/21 9:31:27	12590	8.61	11.75	4.20	98.87	5.91	1.32	0.83	10.55	1.20	0.63	1.23	415.45	-0.33	13.05
09/01/21 9:31:57	12620	8.58	12.15	4.26	98.90	5.93	1.35	0.80	10.26	1.88	0.62	1.18	418.34	-0.37	12.81
09/01/21 9:32:27	12650	8.60	12.47	4.23	98.83	5.95	1.34	0.83	10.05	2.42	0.62	1.21	414.49	-0.43	12.70
09/01/21 9:32:57	12680	8.61	12.08	4.31	99.55	5.93	1.33	0.81	10.56	1.52	0.61	1.22	414.63	-0.40	12.78
09/01/21 9:33:27	12710	8.61	11.71	4.29	99.63	5.92	1.39	0.74	10.06	1.65	0.58	1.24	414.51	-0.34	12.89
09/01/21 9:33:57	12740	8.61	11.73	3.60	99.19	5.86	1.56	0.85	9.61	2.12	0.53	1.23	410.55	-0.56	13.96
09/01/21 9:34:27	12770	8.61	11.85	4.04	99.10	5.90	1.50	0.72	10.28	1.57	0.58	1.19	417.42	-0.32	13.33
09/01/21 9:34:57	12800	8.60	12.40	4.07	99.20	5.92	1.57	0.75	9.69	2.71	0.62	1.18	414.89	-0.39	13.18
09/01/21 9:35:27	12830	8.60	11.63	3.65	98.54	5.73	1.56	1.07	10.25	1.37	0.62	1.25	407.38	-0.61	15.56
09/01/21 9:35:57	12860	8.60	10.48	4.01	98.58	5.91	1.55	0.73	9.29	1.19	0.61	1.15	416.02	-0.29	13.26
09/01/21 9:36:27	12890	8.59	10.35	3.95	97.36	5.91	1.55	0.76	8.63	1.72	0.60	1.17	413.49	-0.30	13.22
09/01/21 9:36:57	12920	8.60	11.02	3.62	97.01	5.86	1.55	0.80	9.55	1.46	0.59	1.19	413.11	-0.45	13.83
09/01/21 9:37:27	12950	8.59	10.68	3.49	97.85	5.85	1.58	0.76	8.76	1.92	0.63	1.23	410.69	-0.46	14.23
09/01/21 9:37:57	12980	8.60	11.40	3.67	97.87	5.89	1.59	0.81	8.45	2.94	0.66	1.19	414.51	-0.60	13.51
09/01/21 9:38:27	13010	8.59	10.81	3.59	96.68	5.83	1.59	0.91	9.17	1.64	0.56	1.22	412.72	-0.41	14.31
09/01/21 9:38:57	13040	8.59	11.02	3.55	96.65	5.88	1.60	0.87	9.62	1.40	0.58	1.20	412.59	-0.48	13.85
09/01/21 9:39:27	13070	8.60	10.74	3.57	97.43	5.87	1.58	0.81	9.35	1.39	0.58	1.18	415.48	-0.50	13.78
09/01/21 9:39:57	13100	8.59	10.94	3.47	97.90	5.68	1.46	1.08	8.77	2.17	0.51	1.23	405.34	-0.33	15.78
09/01/21 9:40:27	13130	8.61	10.60	3.58	97.97	5.83	1.55	0.84	9.10	1.49	0.57	1.17	412.95	-0.36	14.28
09/01/21 9:40:57	13160	8.61	11.05	3.63	98.84	5.88	1.58	0.79	9.11	1.95	0.63	1.17	417.33	-0.53	13.56
09/01/21 9:41:27	13190	8.58	10.68	3.97	98.42	5.89	1.54	0.80	8.66	2.02	0.70	1.17	413.48	-0.27	13.36
09/01/21 9:41:57	13220	8.59	9.90	4.06	98.57	5.90	1.53	0.69	8.18	1.72	0.57	1.13	416.94	-0.35	13.16
09/01/21 9:42:27	13250	8.59	9.71	4.09	99.03	5.91	1.57	0.61	8.34	1.37	0.57	1.17	416.75	-0.36	13.10
09/01/21 9:42:57	13280	8.59	10.09	3.61	98.64	5.81	1.62	0.78	8.32	1.77	0.60	1.16	410.12	-0.79	14.49
09/01/21 9:43:27	13310	8.60	9.59	3.96	98.71	5.90	1.56	0.74	8.46	1.13	0.57	1.16	414.07	-0.25	13.28
09/01/21 9:43:57	13340	8.58	9.51	4.01	98.46	5.88	1.53	0.71	8.56	0.95	0.62	1.16	412.61	-0.29	13.46
09/01/21 9:44:27	13370	8.60	10.70	4.07	98.15	5.89	1.54	0.76	8.08	2.62	0.64	1.15	414.87	-0.31	13.25
09/01/21 9:44:57	13400	8.59	10.03	4.07	99.17	5.92	1.55	0.72	7.65	2.38	0.56	1.11	419.67	-0.32	13.01
09/01/21 9:45:27	13430	8.60	10.44	4.19	98.32	5.93	1.58	0.71	7.88	2.56	0.60	1.16	416.90	-0.33	12.88
09/01/21 9:45:57	13460	8.60	10.32	4.10	97.91	5.93	1.56	0.77	7.77	2.55	0.59	1.13	417.20	-0.41	12.87
09/01/21 9:46:27	13490	8.58	10.05	4.14	97.87	5.93	1.58	0.72	7.74	2.31	0.58	1.12	417.22	-0.37	12.82
09/01/21 9:46:57	13520	8.60	8.91	3.27	97.69	5.76	1.67	0.87	7.76	1.15	0.58	1.15	408.08	-0.45	15.13
09/01/21 9:47:27	13550	8.58	8.82	4.08	98.83	5.90	1.74	0.69	7.41	1.41	0.55	1.09	416.95	-0.34	13.18
09/01/21 9:47:57	13580	8.59	9.00	3.97	98.81	5.91	1.77	0.67	7.67	1.33	0.57	1.06	417.72	-0.33	13.10
09/01/21 9:48:27	13610	8.60	9.05	3.96	98.90	5.92	1.73	0.70	7.20	1.85	0.64	1.08	414.75	-0.36	13.06
09/01/21 9:48:57	13640	8.59	8.78	3.94	99.05	5.92	1.79	0.75	7.16	1.62	0.58	1.08	414.08	-0.29	13.08
09/01/21 9:49:27	13670	8.59	9.13	3.33	98.52	5.82	1.75	0.78	7.22	1.91	0.58	1.16	412.21	-0.38	14.35
09/01/21 9:49:57	13700	8.58	8.77	3.92	98.09	5.90	1.75	0.77	7.25	1.51	0.59	1.05	419.28	-0.26	13.22
09/01/21 9:50:27	13730	8.58	8.83	3.57	97.72	5.86	1.77	0.83	7.02	1.81	0.61	1.08	418.58	-0.47	13.80
09/01/21 9:50:57	13760	8.59	8.48	4.00	98.23	5.94	1.75	0.81	6.97	1.50	0.60	1.08	416.36	-0.35	13.06
09/01/21 9:51:27	13790	8.56	8.49	3.93	99.06	5.92	1.80	0.72	6.88	1.61	0.56	1.06	418.98	-0.32	13.05
09/01/21 9:51:57	13820	8.58	8.58	3.93	99.00	5.91	1.71	0.79	6.95	1.63	0.63	1.06	417.16	-0.36	13.24
09/01/21 9:52:27	13850	8.57	8.55	3.64	98.96	5.89	1.89	0.93	6.93	1.62	0.56	1.08	415.79	-0.57	13.52
09/01/21 9:52:57	13880	8.58	8.48	3.38	99.12	5.82	1.97	0.89	6.85	1.63	0.61	1.07	411.76	-0.75	14.55
09/01/21 9:53:27	13910	8.58	8.45	3.51	98.30	5.87	1.97	0.82	7.15	1.30	0.61	1.08	414.58	-0.50	13.83
09/01/21 9:53:57	13940	8.59	8.35	3.50	99.04	5.89	1.99	0.80	7.15	1.19	0.55	1.05	411.33	-0.53	13.71
09/01/21 9:54:27	13970	8.60	8.39	3.56	99.26	5.88	1.96	0.77	6.81	1.57	0.57	1.02	417.51	-0.53	13.65
09/01/21 9:54:57	14000	8.58	8.30	3.37	99.28	5.88	1.98	0.83	6.83	1.47	0.58	1.06	414.58	-0.56	13.74
09/01/21 9:55:27	14030	8.60	8.23	3.45	99.35	5.68	1.91	1.05	6.97	1.26	0.57	1.09	400.14	-0.52	16.09
09/01/21 9:55:57	14060	8.60	8.12	3.48	100.20	5.87	1.96	0.90	6.98	1.14	0.59	1.10	408.98	-0.51	13.99
09/01/21 9:56:27	14090	8.60	8.27	3.46	100.16	5.88	1.99	0.77	6.82	1.45	0.57	1.09	414.46	-0.54	13.72
09/01/21 9:59:27	14270	8.59	9.27	3.95	100.53	5.91	2.15	0.61	9.19	0.08	0.60	1.01	416.64	-0.32	13.32
09/01/21 9:59:57	14300	8.60	8.52	3.40	100.14	5.85	2.17	0.88	6.82	1.70	0.60	1.06	412.98	-0.40	14.33
09/01/21 10:00:27	14330	8.60	8.41	3.97	100.85	5.91	2.16	0.74	6.82	1.60	0.62	1.02	414.99	-0.36	13.38
09/01/21 10:00:57	14360	8.58	8.21	3.85	100.80	5.92	2.16	0.72	6.94	1.27	0.65	1.04	416.17	-0.35	13.17
09/01/21 10:01:27	14390	8.60	8.26	3.87	100.37	5.91	2.16	0.69	6.94	1.32	0.59	1.01	416.91	-0.30	13.31
09/01/21 10:01:57	14420	8.59	8.28	3.61	100.45	5.90	2.21	0.85	6.78	1.51	0.60	1.05	415.39	-0.58	13.54
09/01/21 10:02:27	14450	8.59	8.23	3.43	100.23	5.83	2.20	0.80	6.80	1.43	0.56	1.05	412.23	-0.44	14.22
09/01/21 10:02:57	14480	8.59	8.01	3.29	99.98	5.84	2.20	0.84	6.93	1.08	0.58	1.05	411.67	-0.41	14.37
09/01/21 10:03:27	14510	8.60	8.27	3.42	99.44	5.91	2.21	0.82	6.74	1.53	0.58	1.03	415.85	-0.54	13.50
09/01/21 10:03:57	14540	8.60	8.20	3.48	98.91	5.89	2.20	0.83	6.79	1.41	0.54	1.07	414.51	-0.55	13.64
09/01/21 10:04:27	14570	8.59	8.07	3.49	99.41	5.89	2.22	0.89	6.71	1.36	0.57	1.05	414.58	-0.56	13.60
09/01/21 10:04:57	14600	8.58	8.07	3.45	99.49	5.90	2.44	0.82	6.78	1.29	0.55	1.01	412.05	-0.56	13.65
09/01/21 10:05:27	14630	8.58	8.03	3.21	98.64	5.83	2.53	0.87	6.77	1.26	0.53	1.02	413.53	-0.42	14.26
09/01/21 10:05:57	14660	8.58	7.83	3.33	98.56	5.87	2.53	0.82	6.85	0.98	0.56	1.01	415.54	-0.51	13.84
09/01/21 10:06:27	14690	8.59	8.00	3.35	98.75	5.88	2.56	0.86	6.69	1.31	0.55	1.00	416.79	-0.54	13.65
09/01/21 10:06:57	14720	8.58	7.97	3.51	98.94	5.87	2.57	0.86	6.76	1.21	0.52	1.01	419.78	-0.58	13.68
09/01/21 10:07:27	14750	8.57	8.00	3.47	99.34	5.89	2.54	0.82	6.68	1.31	0.57	1.02	418.44	-0.62	13.52
09/01/21 10:07:57	14780	8.58	7.88	3.26	99.41	5.70	2.53	1.00	6.80	1.08	0.53	1.06	403.54	-0.53	15.92
09/01/21 10:08:27	14810	8.58	7.87	3.31	99.49	5.88	2.56	0.79	6.83	1.04	0.55	1.03	416.11	-0.52	13.74
09/01/21 10:08:57	14840	8.58	7.90	3.32	99.29	5.89	2.80	0.81	6.76	1.14	0.59	1.02	415.14	-0.54	13.75
09/01/21 10:09:27	14870	8.58	7.85	3.28	100.08	5.89	2.97	0.74	6.82	1.04	0.54	1.04	415.48	-0.49	13.72
09/01/21 10:09:57	14900	8.57	7.90	3.39	100.32	5.90	2.96	0.74	6.71	1.19	0.56	1.01	419.10	-0.55	13.61
09/01/21 10:10:27	14930	8.57	7.82	3.23	100.04	5.82	2.96	0.71	6.79	1.03	0.59	0.96	411.92	-0.69	14.69
09/01/21 10:10:57	14960	8.58	7.85	3.42	100.60	5.90	3.00	0.82	6.65	1.20	0.54	1.01	415.14	-0.56	13.61
09/01/21 10:11:27	14990	8.57	7.78	3.74	101.49	5.90	2.93	0.66	6.73	1.05	0.55	0.97	418.57	-0.27	13.39
09/01/21 10:11:57	15020	8.58	7.75	3.68	101.37	5.91	2.99	0.68	6.73	1.02	0.55	0.97	416.79	-0.30	13.33
09/01/21 10:12:27	15050	8.59	9.54	3.70	100.61	5.92	2.97	0.70	8.36	1.18	0.57	0.98	412.63	-0.31	13.35
09/01/21 10:12:57	15080	8.60	11.29	3.25	100.40	5.73	2.98	1.00	8.48	2.81	0.60	0.99	404.06	-0.49	15.66
09/01/21 10:13:27	15110	8.61	9.43	3.41	100.42	5.91	3.10	0.70	8.81	0.62	0.63	0.98	416.01	-0.59	13.50
09/01/21 10:13:57	15140	8.61	9.52	3.75	99.57	5.92	3.29	0.64	8.66	0.86	0.58	0.99	416.15	-0.30	13.24
09/01/21 10:14:27	15170	8.59	9.40	3.69	99.05	5.92	3.31	0.65	8.64	0.77	0.61	0.95	417.73	-0.33	13.24
09/01/21 10:14:57	15200	8.61	10.52	3.22	99.12	5.85	3.32	0.77	8.34	2.18	0.55	1.01	415.63	-0.39	14.12
09/01/21 10:15:27	15230	8.60	10.73	3.72	99.85	5.91	3.31	0.69	7.97	2.76	0.53	0.96	419.75	-0.31	13.28
09/01/21 10:15:57	15260	8.61	9.93	3.78	100.53	5.92	3.32	0.73	8.30	1.63	0.61	0.95	419.37	-0.28	13.20

Catalytic Combustion Corporation
September 1, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.73	in. Hg
Relative Humidity	70	%
Ambient Temperature	88	°F
Specific Humidity	0.020202	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	13.6	%
Stack Exhaust Flow (M19)	386,201	SCFH

100% Load, Run - 3-1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvd)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 10:16:27	15290	8.62	10.37	4.21	100.42	5.91	2.01	0.77	8.11	2.26	0.60	1.20	420.56	-0.31	13.11
09/01/21 10:16:57	15320	8.61	9.64	4.55	100.63	5.91	1.82	0.75	8.64	1.01	0.57	1.28	418.11	-0.34	13.07
09/01/21 10:17:27	15350	8.60	9.75	5.27	100.75	5.90	0.25	0.86	8.98	0.77	0.69	1.50	415.16	-0.34	13.01
09/01/21 10:17:57	15380	8.61	10.53	5.44	100.90	5.90	0.17	0.90	8.51	2.02	0.64	1.54	417.24	-0.32	13.00
09/01/21 10:18:27	15410	8.61	11.35	5.43	100.92	5.90	0.16	0.95	8.17	3.18	0.62	1.58	416.38	-0.36	12.99
09/01/21 10:18:57	15440	8.61	10.94	4.39	99.68	5.91	2.50	0.70	8.34	2.60	0.57	1.21	420.61	-0.30	13.04
09/01/21 10:19:27	15470	8.61	10.43	3.76	99.80	5.93	3.33	0.68	8.33	2.10	0.59	0.99	421.58	-0.36	13.05
09/01/21 10:19:57	15500	8.60	9.92	3.75	99.99	5.93	3.39	0.72	8.09	1.82	0.57	0.95	419.50	-0.37	12.93
09/01/21 10:20:27	15530	8.61	9.98	3.85	99.09	5.92	3.37	0.60	8.58	1.40	0.56	0.95	424.30	-0.38	12.90
09/01/21 10:20:57	15560	8.60	10.48	3.13	97.99	5.87	3.32	0.76	8.36	2.12	0.54	1.01	418.67	-0.40	13.80
09/01/21 10:21:27	15590	8.59	10.26	3.34	99.07	5.90	3.34	0.74	8.19	2.07	0.67	1.02	418.01	-0.58	13.64
09/01/21 10:21:57	15620	8.62	9.95	3.80	99.01	5.93	3.34	0.65	8.52	1.43	0.52	0.94	422.67	-0.32	13.06
09/01/21 10:22:27	15650	8.62	10.12	3.22	99.20	5.86	3.37	0.78	8.95	1.17	0.53	1.03	416.90	-0.44	14.05
09/01/21 10:22:57	15680	8.62	10.52	3.73	98.72	5.92	3.47	0.67	8.79	1.74	0.59	0.97	420.37	-0.27	13.29
09/01/21 10:23:27	15710	8.63	9.89	3.68	99.65	5.92	3.48	0.69	8.60	1.29	0.59	0.97	421.08	-0.28	13.22
09/01/21 10:23:57	15740	8.61	10.24	3.64	100.07	5.91	3.48	0.68	9.07	1.17	0.55	0.97	418.20	-0.25	13.39
09/01/21 10:24:27	15770	8.62	11.18	3.73	99.70	5.90	3.46	0.63	9.19	1.99	0.54	0.96	419.60	-0.29	13.48
09/01/21 10:24:57	15800	8.64	10.63	3.66	99.94	5.89	3.40	0.63	9.15	1.48	0.60	0.96	421.90	-0.19	13.48
09/01/21 10:25:27	15830	8.63	10.99	3.28	99.85	5.74	3.46	0.97	9.12	1.88	0.65	1.05	409.91	-0.58	15.43
09/01/21 10:25:57	15860	8.64	12.22	3.34	99.24	5.91	3.75	0.68	8.99	3.23	0.59	0.97	417.11	-0.51	13.56
RAW AVERAGE		**8.60**	**10.21**	**3.76**	**99.12**	**5.88**	**2.08**	**0.79**	**8.60**	**1.61**	**0.59**	**1.12**	**414.75**	**0.00**	**13.64**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	H_2O
	Serial Number:	INST-O2-0026	INST-NX-0025	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-NX-0025	INST-NX-0025	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.01			0.19										
Bias	**Final Zero**	0.02			0.20										
Bias	**Avg. Zero**	0.02			0.20										
Bias	**Initial UpScale**	11.85			300.98										
Bias	**Final UpScale**	11.94			300.31										
Bias	**Avg. UpScale**	11.90			300.65										
Upscale Cal Gas		11.96			299.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	8.64	10.21	4.36	114.77	6.81	2.40	0.91	8.60	1.61	0.68	1.29	176.10	0.00	0.00
Corrected Raw Average (ppm/% wet basis)	7.46	8.82	3.76	99.12	5.88	2.08	0.79	7.43	1.39	0.59	1.12	152.08	0.00	0.00
Concentration (ppm@ 15%O_2)	N/A	4.92	2.10	47.70	3.28	1.16	0.44	4.14	0.78	0.33	0.62	84.74	0.00	0.00
Emission Rate (g/kw*hr)	N/A	0.0797	0.0207	0.7392	508	0.0179	0.0068	0.0437	0.0126	0.0020	0.0066	1.3162	0.0000	0.0000
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.73	in. Hg
Relative Humidity	57	%
Ambient Temperature	93	°F
Specific Humidity	0.019207	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	12.9	%
Stack Exhaust Flow (M19)	399,898	SCFH

100% Load, Run - 3-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvd)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 10:26:27	15890	8.63	10.93	3.24	99.31	5.91	3.81	0.76	9.15	1.78	0.63	0.97	417.84	-0.48	13.55
09/01/21 10:26:57	15920	8.62	10.77	3.37	99.38	5.91	3.80	0.70	9.23	1.54	0.64	0.94	417.36	-0.50	13.58
09/01/21 10:27:27	15950	8.62	11.03	3.20	99.52	5.90	3.80	0.75	9.08	1.95	0.58	0.97	418.06	-0.53	13.63
09/01/21 10:27:57	15980	8.64	11.41	3.23	99.55	5.90	3.80	0.72	9.23	2.18	0.54	0.97	418.20	-0.54	13.69
09/01/21 10:28:27	16010	8.63	10.75	3.16	100.19	5.76	3.83	0.75	9.29	1.47	0.60	0.96	411.88	-0.66	15.24
09/01/21 10:28:57	16040	8.62	11.56	3.16	100.40	5.86	3.77	0.67	9.07	2.49	0.65	0.97	419.57	-0.48	14.04
09/01/21 10:29:27	16070	8.64	10.82	3.21	100.54	5.87	3.82	0.74	9.16	1.66	0.60	1.01	417.74	-0.48	13.89
09/01/21 10:29:57	16100	8.63	11.67	3.30	100.76	5.90	3.81	0.72	8.47	3.20	0.68	1.03	417.82	-0.57	13.62
09/01/21 10:30:27	16130	8.63	11.55	3.24	101.14	5.88	3.79	0.65	8.51	3.04	0.61	0.94	416.35	-0.55	13.79
09/01/21 10:30:57	16160	8.62	11.02	3.18	100.86	5.86	3.81	0.76	9.11	1.91	0.73	0.99	417.79	-0.45	14.07
09/01/21 10:31:27	16190	8.64	10.62	3.60	100.74	5.91	3.80	0.72	9.30	1.32	0.78	0.90	417.79	-0.28	13.22
09/01/21 10:31:57	16220	8.63	10.90	3.63	100.52	5.93	3.79	0.54	8.61	2.29	0.69	0.91	418.91	-0.34	13.08
09/01/21 10:32:27	16250	8.62	10.51	3.66	100.73	5.94	3.85	0.59	8.86	1.65	0.72	0.92	423.48	-0.35	12.90
09/01/21 10:32:57	16280	8.63	11.03	3.76	100.97	5.95	3.85	0.59	9.04	2.00	0.73	0.96	422.53	-0.34	12.83
09/01/21 10:33:27	16310	8.63	11.24	3.72	101.35	5.96	3.82	0.64	8.07	3.17	0.72	0.95	423.24	-0.40	12.77
09/01/21 10:33:57	16340	8.62	11.70	3.79	101.21	5.94	2.89	0.66	8.48	3.22	0.76	0.95	421.14	-0.39	12.89
09/01/21 10:34:27	16370	8.63	11.19	4.01	100.92	5.95	2.11	0.75	9.39	1.80	0.72	1.03	419.17	-0.43	12.79
09/01/21 10:36:27	16490	9.10	12.43	3.44	94.25	5.82	2.06	0.76	11.49	0.94	0.76	1.08	418.85	-0.35	14.34
09/01/21 10:36:57	16520	9.10	11.91	3.53	92.81	5.90	2.05	0.85	11.10	0.80	0.72	1.01	417.41	-0.60	13.50
09/01/21 10:37:27	16550	9.11	11.35	3.52	92.70	5.86	2.11	0.80	10.63	0.72	0.79	1.05	416.14	-0.50	13.96
09/01/21 10:37:57	16580	9.10	10.93	3.93	92.36	5.91	2.05	0.72	10.22	0.71	0.82	1.01	420.27	-0.29	13.24
09/01/21 10:38:27	16610	9.12	10.18	3.96	92.36	5.92	2.08	0.70	9.89	0.29	0.76	1.01	419.51	-0.27	13.13
09/01/21 10:38:57	16640	9.12	9.99	3.98	92.28	5.92	2.09	0.65	9.07	0.92	0.76	1.01	421.75	-0.32	13.12
09/01/21 10:39:27	16670	9.12	9.84	4.04	92.08	5.94	2.06	0.65	9.75	0.09	0.68	1.04	419.46	-0.31	12.98
09/01/21 10:39:57	16700	9.13	10.03	4.04	92.56	5.95	2.06	0.68	9.38	0.65	0.73	1.02	419.79	-0.35	12.82
09/01/21 10:40:27	16730	9.13	10.20	4.11	92.74	5.95	2.05	0.76	9.55	0.65	0.80	1.02	421.15	-0.39	12.74
09/01/21 10:40:57	16760	9.13	9.77	4.10	92.69	5.93	2.11	0.74	9.42	0.35	0.79	0.99	420.08	-0.36	12.86
09/01/21 11:19:57	19100	9.13	9.83	1.47	92.40	5.64	0.19	0.91	9.06	0.77	1.06	0.72	386.10	0.58	12.92
09/01/21 11:20:27	19130	9.14	9.52	1.52	92.04	5.63	0.14	1.01	9.28	0.25	1.04	0.69	384.29	0.53	12.89
09/01/21 11:20:57	19160	9.16	9.84	1.57	91.43	5.64	0.17	0.98	9.41	0.43	1.08	0.68	382.45	0.46	12.83
09/01/21 11:21:27	19190	9.13	8.90	1.48	92.93	5.64	0.16	0.94	8.85	0.05	1.07	0.71	385.14	0.50	12.83
09/01/21 11:21:57	19220	9.12	8.91	1.47	94.59	5.64	0.18	0.96	8.43	0.48	1.03	0.73	386.35	0.56	12.83
09/01/21 11:22:27	19250	9.13	9.57	1.59	95.23	5.65	0.18	0.94	9.05	0.52	0.99	0.70	385.74	0.57	12.78
09/01/21 11:22:57	19280	9.13	9.12	1.51	96.70	5.66	0.16	0.86	8.55	0.57	0.99	0.71	386.92	0.53	12.74
09/01/21 11:23:27	19310	9.14	9.22	1.54	97.02	5.66	0.17	0.94	8.56	0.66	0.95	0.70	384.21	0.50	12.72
09/01/21 11:23:57	19340	9.13	9.05	1.53	94.70	5.67	0.18	0.91	8.31	0.73	0.97	0.69	385.10	0.47	12.71
09/01/21 11:24:27	19370	9.13	9.11	1.51	90.93	5.67	0.17	0.95	8.16	0.95	0.97	0.72	383.32	0.49	12.71
09/01/21 11:24:57	19400	9.12	8.84	1.62	90.99	5.67	0.19	0.94	7.96	0.89	0.96	0.67	385.77	0.54	12.68
09/01/21 11:25:27	19430	9.10	8.21	1.46	91.15	5.67	0.19	0.94	8.08	0.13	0.90	0.72	388.70	0.58	12.69
09/01/21 11:25:57	19460	9.10	9.17	1.50	91.11	5.65	0.19	1.04	8.46	0.70	0.89	0.70	387.60	0.53	12.69
09/01/21 11:26:27	19490	9.10	9.48	1.56	90.72	5.66	0.17	0.89	8.81	0.68	0.88	0.68	387.71	0.50	12.68
09/01/21 11:26:57	19520	9.11	8.98	1.48	91.72	5.66	0.18	0.93	8.60	0.38	0.96	0.71	385.46	0.48	12.67
09/01/21 11:27:27	19550	9.08	8.55	0.82	91.56	5.47	0.17	-0.28	8.32	0.24	1.49	0.64	366.29	1.65	15.26
09/01/21 11:27:57	19580	9.10	9.20	1.56	91.15	5.66	0.14	0.93	8.62	0.58	1.75	0.74	385.12	0.48	12.86
09/01/21 11:28:27	19610	9.10	9.17	1.37	91.47	5.65	0.15	1.01	8.32	0.85	1.19	0.71	386.86	0.68	12.47
09/01/21 11:28:57	19640	9.09	8.81	1.40	91.46	5.66	0.12	0.99	8.24	0.57	1.07	0.69	386.87	0.64	12.41
09/01/21 11:29:27	19670	9.08	8.29	1.33	90.05	5.67	0.16	1.00	7.93	0.36	0.95	0.71	380.96	0.62	12.39
09/01/21 11:29:57	19700	9.09	8.35	1.47	89.21	5.67	0.15	0.96	8.09	0.26	0.87	0.69	383.01	0.69	12.39
09/01/21 11:30:27	19730	9.07	8.22	1.46	89.57	5.66	0.17	1.01	7.70	0.51	0.89	0.71	394.32	0.76	12.32
09/01/21 11:30:57	19760	9.06	8.36	1.49	89.92	5.64	0.11	0.87	7.89	0.47	0.85	0.69	405.01	0.97	12.28
09/01/21 11:31:27	19790	9.05	8.46	1.45	89.80	5.65	0.18	1.00	8.02	0.44	0.86	0.69	401.42	0.85	12.19
09/01/21 11:31:57	19820	9.06	8.95	1.51	90.19	5.66	0.15	0.95	8.25	0.70	0.79	0.70	396.77	0.76	12.21
09/01/21 11:32:27	19850	9.06	8.67	1.48	90.23	5.67	0.15	1.07	8.98	-0.31	0.80	0.70	389.36	0.80	12.33
09/01/21 11:32:57	19880	9.07	9.01	1.54	90.66	5.65	0.14	0.93	8.87	0.14	0.80	0.67	387.85	0.73	12.45
09/01/21 11:33:27	19910	9.08	10.33	1.42	90.27	5.64	0.16	1.12	9.37	0.96	0.77	0.69	388.53	0.75	12.54
09/01/21 11:33:57	19940	9.08	8.74	1.42	91.42	5.66	0.17	0.95	8.16	0.59	0.92	0.68	388.58	0.55	12.60
09/01/21 11:34:27	19970	9.10	9.31	1.50	90.99	5.66	0.18	0.96	8.67	0.64	0.91	0.68	385.32	0.55	12.58
09/01/21 11:34:57	20000	9.08	9.12	1.63	90.81	5.67	0.16	0.93	8.58	0.54	0.88	0.66	387.04	0.48	12.59
09/01/21 11:35:27	20030	9.10	9.04	1.59	90.39	5.66	0.17	0.97	8.31	0.73	0.84	0.67	383.78	0.49	12.65
09/01/21 11:35:57	20060	9.09	9.00	1.50	89.96	5.66	0.18	0.97	8.40	0.60	0.80	0.66	382.67	0.51	12.64
09/01/21 11:36:27	20090	9.09	8.80	1.47	90.89	5.65	0.17	0.98	8.28	0.52	0.83	0.67	388.40	0.55	12.59
09/01/21 11:36:57	20120	9.06	8.73	1.40	91.08	5.64	0.12	1.01	8.35	0.38	0.73	0.72	385.69	0.70	12.53
09/01/21 11:37:27	20150	9.08	8.62	1.44	90.90	5.65	0.14	0.99	8.13	0.49	0.78	0.68	387.06	0.77	12.44
09/01/21 11:37:57	20180	9.06	8.64	1.46	90.51	5.66	0.13	1.01	8.42	0.22	0.71	0.68	386.21	0.72	12.34
09/01/21 11:38:27	20210	9.09	8.75	1.50	90.54	5.67	0.17	0.96	8.36	0.39	0.72	0.64	389.77	0.72	12.20
09/01/21 11:38:57	20240	9.09	9.33	1.46	89.88	5.68	0.15	1.05	8.78	0.55	0.68	0.66	386.33	0.64	12.07
09/01/21 11:39:27	20270	9.12	8.88	1.41	90.16	5.71	0.17	0.97	9.02	-0.14	0.67	0.67	389.41	0.60	11.79
09/01/21 11:39:57	20300	9.12	9.61	1.04	90.23	5.77	0.15	1.00	8.71	0.89	0.71	0.63	388.87	0.55	11.21
09/01/21 11:40:27	20330	9.11	8.52	1.20	90.92	5.81	0.16	1.07	8.05	0.47	0.66	0.63	387.92	0.37	10.75
09/01/21 11:40:57	20360	9.11	9.15	1.49	90.33	5.83	0.18	0.98	8.61	0.54	0.63	0.64	393.60	0.69	10.38
09/01/21 11:41:27	20390	9.13	9.74	1.50	89.92	5.82	0.19	0.95	9.09	0.66	0.65	0.65	392.46	0.65	10.39
09/01/21 11:41:57	20420	9.13	9.12	1.05	90.85	5.76	0.16	1.08	8.72	0.40	0.81	0.66	387.99	0.52	11.34
09/01/21 11:42:27	20450	9.15	9.45	1.54	90.61	5.68	0.14	1.02	8.72	0.73	0.71	0.71	389.72	0.70	12.25
09/01/21 11:42:57	20480	9.14	8.65	1.62	90.80	5.68	0.17	0.91	8.34	0.31	0.84	0.68	386.74	0.49	12.66
09/01/21 11:43:27	20510	9.13	8.74	1.68	90.79	5.69	0.21	0.96	8.46	0.28	0.77	0.67	379.77	0.48	12.67
09/01/21 11:43:57	20540	9.13	8.37	1.47	90.79	5.69	0.16	-0.33	8.33	0.04	0.75	0.51	364.77	1.64	13.21
09/01/21 11:44:27	20570	9.12	8.45	1.11	91.42	5.64	0.19	1.02	8.13	0.32	0.75	0.70	381.16	0.33	13.53
09/01/21 11:44:57	20600	9.10	7.99	1.50	92.23	5.64	0.14	0.98	7.92	0.08	0.75	0.68	387.41	0.63	13.26
09/01/21 11:45:27	20630	9.10	8.30	1.59	91.44	5.66	0.15	0.87	8.16	0.14	0.71	0.68	389.89	0.56	12.99
09/01/21 11:45:57	20660	9.11	9.13	0.93	91.18	5.56	0.19	1.03	8.42	0.70	0.78	0.74	380.54	0.63	14.40
09/01/21 11:46:27	20690	9.11	8.60	1.23	91.31	5.64	0.21	1.06	8.77	-0.17	1.04	0.68	379.87	0.36	13.53
09/01/21 11:46:57	20720	9.12	9.01	1.36	91.67	5.66	0.56	0.82	8.74	0.28	0.93	0.63	383.12	0.51	13.20
09/01/21 11:47:27	20750	9.12	8.53	1.36	92.91	5.65	0.61	0.87	7.93	0.60	0.81	0.59	381.49	0.59	13.23
09/01/21 11:47:57	20780	9.12	9.17	1.40	92.75	5.66	0.65	0.78	8.22	0.95	0.74	0.58	379.89	0.55	13.17
09/01/21 11:48:27	20810	9.14	9.09	1.39	92.08	5.68	0.66	0.81	8.81	0.28	0.83	0.56	383.25	0.51	12.84
09/01/21 11:48:57	20840	9.12	8.40	1.43	92.97	5.69	0.66	0.88	8.16	0.24	0.80	0.56	384.86	0.50	12.66
09/01/21 11:49:27	20870	9.11	8.74	1.26	92.94	5.67	0.67	0.92	8.25	0.49	0.81	0.57	383.78	0.52	13.01
09/01/21 11:49:57	20900	9.13	8.76	1.36	92.49	5.67	0.70	0.86	8.61	0.15	0.91	0.57	382.48	0.58	13.15
09/01/21 11:50:27	20930	9.13	8.71	1.42	92.73	5.68	0.72	0.78	8.29	0.42	1.33	0.56	382.83	0.50	12.99
09/01/21 11:50:57	20960	9.16	9.85	1.47	91.32	5.69	0.76	0.80	9.06	0.79	2.13	0.55	381.22	0.52	12.92
09/01/21 11:51:27	20990	9.17	9.49	1.44	91.22	5.67	0.74	0.83	9.12	0.36	2.99	0.55	379.61	0.51	13.09
09/01/21 11:51:57	21020	9.15	8.77	1.39	92.26	5.67	0.75	0.76	8.51	0.26	3.82	0.52	383.46	0.51	12.99
09/01/21 11:52:27	21050	9.17	8.63	1.48	91.98	5.71	0.73	0.75	8.49	0.14	4.44	0.51	389.34	0.54	12.67
09/01/21 11:52:57	21080	9.17	8.96	1.28	91.67	5.74	0.73	0.87	8.41	0.55	4.52	0.56	387.83	0.63	12.09
09/01/21 11:53:27	21110	9.18	8.55	0.90	92.22	5.79	0.72	0.97	8.57	-0.02	4.19	0.55	388.03	0.50	11.47
09/01/21 11:53:57	21140	9.16	8.32	0.95	92.51	5.81	0.71	0.97	7.98	0.34	3.87	0.55	392.71	0.47	10.95
09/01/21 11:54:27	21170	9.19	9.33	0.88	92.24	5.82	0.71	1.00	8.23	1.10	3.82	0.53	392.62	0.46	10.97
09/01/21 11:54:57	21200	9.19	9.60	1.40	91.96	5.76	0.70	0.90	9.32	0.27	3.96	0.54	391.09	0.59	11.77
09/01/21 11:55:27	21230	9.21	8.46	1.31	93.02	5.69	0.73	0.82	8.44	0.02	4.84	0.57	383.13	0.46	12.98
09/01/21 11:55:57	21260	9.19	8.76	1.36	93.33	5.65	0.67	0.88	8.57	0.20	5.89	0.51	386.06	0.64	13.38

Catalytic Combustion Corporation
September 1, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.73	in. Hg
Relative Humidity	57	%
Ambient Temperature	93	°F
Specific Humidity	0.019207	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	12.9	%
Stack Exhaust Flow (M19)	399,898	SCFH

100% Load, Run - 3-2

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvd)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 11:56:27	21290	9.19	8.39	1.39	94.33	5.66	0.71	0.86	7.90	0.49	7.12	0.53	384.79	0.66	13.46
09/01/21 11:56:57	21320	9.19	9.16	1.26	94.11	5.67	0.70	0.85	8.23	0.93	8.09	0.53	383.51	0.61	13.42
09/01/21 11:57:27	21350	9.20	8.84	1.34	94.21	5.70	0.71	0.85	8.56	0.28	8.45	0.53	380.88	0.52	13.17
09/01/21 11:57:57	21380	9.20	8.57	1.33	94.69	5.70	0.69	0.87	8.47	0.10	8.73	0.55	381.37	0.53	13.13
09/01/21 11:58:27	21410	9.20	8.53	1.49	95.06	5.71	0.71	0.85	8.32	0.21	8.69	0.53	384.53	0.53	12.94
09/01/21 11:58:57	21440	9.21	8.63	1.37	94.76	5.70	0.69	0.90	8.33	0.31	9.00	0.51	384.68	0.51	13.03
09/01/21 11:59:27	21470	9.21	8.33	1.29	95.18	5.72	0.69	0.87	8.05	0.28	9.28	0.52	382.22	0.53	13.05
09/01/21 11:59:57	21500	9.19	8.51	1.32	95.08	5.72	0.72	0.85	8.28	0.23	9.32	0.52	380.93	0.48	12.98
09/01/21 12:00:27	21530	9.21	8.51	0.75	95.15	5.50	0.70	-0.37	7.90	0.61	13.44	0.37	360.69	1.59	16.29
09/01/21 12:00:57	21560	9.19	8.54	1.33	94.65	5.70	0.71	0.81	8.15	0.38	11.42	0.53	381.65	0.59	13.46
09/01/21 12:01:27	21590	9.19	8.61	1.22	94.96	5.69	0.75	0.80	7.97	0.64	11.61	0.53	380.56	0.67	13.48
09/01/21 12:01:57	21620	9.16	8.79	0.86	94.88	5.61	0.79	-0.41	8.31	0.49	13.55	0.36	366.56	1.24	14.82
09/01/21 12:02:27	21650	9.18	9.53	1.00	93.89	5.71	0.79	0.93	9.08	0.45	12.76	0.55	380.90	0.30	13.50
09/01/21 12:02:57	21680	9.19	8.79	0.94	93.82	5.65	0.78	0.91	8.81	-0.02	13.04	0.53	368.61	0.42	14.38
RAW AVERAGE		**9.05**	**9.38**	**1.90**	**93.36**	**5.73**	**1.01**	**0.83**	**8.67**	**0.71**	**2.31**	**0.71**	**392.98**	**0.37**	**12.89**

	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	H_2O
Serial Number:	INST-O2-0026	INST-NX-0025	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-NX-0025	INST-NX-0025	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
	(%)			(ppmvw)										
Bias **Initial Zero**	0.02			0.20										
Final Zero	0.02			0.20										
Avg. Zero	0.02			0.20										
Initial UpScale	11.94			300.31										
Final UpScale	11.95			300.00										
Avg. UpScale	11.95			300.16										
Upscale Cal Gas	11.96			299.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	9.06	9.38	2.18	107.19	6.58	1.16	0.96	8.67	0.71	2.65	0.82	165.42	0.28	0.00
Corrected Raw Average (ppm/% wet basis)	7.89	8.17	1.90	93.36	5.73	1.01	0.83	7.55	0.61	2.31	0.71	144.09	0.24	0.00
Concentration (ppm@ 15%O_2)	N/A	4.67	1.09	46.52	3.28	0.58	0.48	4.32	0.35	1.32	0.41	82.43	0.14	0.00
Emission Rate (g/kw*hr)	N/A	0.0757	0.0107	0.7210	508	0.0090	0.0074	0.0457	0.0057	0.0079	0.0043	1.2803	0.0022	0.0000
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

Catalytic Combustion Corporation
September 2, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.74	in. Hg
Relative Humidity	46	%
Ambient Temperature	95	°F
Specific Humidity	0.016410	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	13.0	%
Stack Exhaust Flow (M19)	406,400	SCFH

100% Load, Run - 3-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 12:03:27	21710	9.20	8.82	1.25	94.00	5.72	0.75	0.76	8.39	0.43	12.99	0.51	379.09	0.56	13.46
09/01/21 12:03:57	21740	9.18	8.68	1.45	94.39	5.75	0.73	0.85	8.35	0.33	12.29	0.55	380.60	0.45	13.14
09/01/21 12:04:27	21770	9.19	8.42	0.90	95.02	5.68	0.74	0.98	7.81	0.60	12.27	0.57	369.55	0.34	14.12
09/01/21 12:04:57	21800	9.19	8.53	1.51	94.89	5.74	0.68	0.86	8.30	0.23	11.67	0.52	380.73	0.51	13.21
09/01/21 12:05:27	21830	9.19	8.80	1.39	94.85	5.75	0.72	0.79	8.20	0.60	10.89	0.53	370.24	0.40	12.86
09/01/21 12:05:57	21860	9.21	8.64	1.49	94.50	5.75	0.70	0.88	8.40	0.24	10.27	0.52	380.22	0.46	12.79
09/01/21 12:06:27	21890	9.21	8.76	1.49	94.15	5.74	0.72	0.92	8.17	0.60	10.28	0.54	384.31	0.47	12.84
09/01/21 12:06:57	21920	9.23	8.75	1.40	93.96	5.74	0.70	0.81	8.73	0.02	10.45	0.55	380.65	0.45	12.89
09/01/21 12:07:27	21950	9.23	9.33	0.90	93.20	5.63	0.71	0.90	8.92	0.41	11.19	0.55	369.54	0.54	14.31
09/01/21 12:07:57	21980	9.24	9.04	0.95	93.14	5.68	0.72	0.96	7.98	1.06	11.38	0.57	371.13	0.34	13.81
09/01/21 12:08:27	22010	9.24	8.81	0.91	92.33	5.70	0.72	0.99	8.20	0.61	11.19	0.53	371.09	0.27	13.56
09/01/21 12:08:57	22040	9.24	8.76	1.36	92.33	5.70	0.71	0.86	8.23	0.53	10.95	0.52	380.94	0.54	13.31
09/01/21 12:09:27	22070	9.26	9.03	1.48	92.91	5.71	0.71	0.82	8.59	0.45	10.71	0.55	380.08	0.51	13.20
09/01/21 12:09:57	22100	9.24	9.23	1.39	93.01	5.72	0.71	0.82	8.53	0.69	10.73	0.53	382.54	0.51	13.20
09/01/21 12:10:27	22130	9.24	8.66	1.38	93.57	5.72	0.72	0.85	8.19	0.47	10.83	0.54	380.95	0.55	13.20
09/01/21 12:10:57	22160	9.24	9.07	1.50	93.99	5.71	0.71	0.75	8.27	0.80	11.12	0.55	380.52	0.47	13.32
09/01/21 12:11:27	22190	9.24	8.76	1.06	94.38	5.54	0.69	-0.13	8.20	0.56	13.80	0.40	362.95	1.39	15.94
09/01/21 12:11:57	22220	9.24	8.59	1.10	94.46	5.68	0.73	0.85	8.12	0.47	12.22	0.53	369.62	0.22	13.74
09/01/21 12:12:27	22250	9.24	8.44	1.38	94.87	5.71	0.70	0.90	7.89	0.55	11.27	0.50	380.67	0.56	13.26
09/01/21 12:12:57	22280	9.24	8.48	1.41	95.22	5.70	0.70	0.80	7.90	0.58	10.95	0.56	371.17	0.47	13.13
09/01/21 12:13:27	22310	9.24	8.29	0.98	95.31	5.63	0.75	0.88	8.06	0.23	11.58	0.56	369.15	0.45	14.18
09/01/21 12:13:57	22340	9.21	8.34	1.38	95.52	5.71	0.69	0.93	7.90	0.44	11.56	0.54	381.76	0.55	13.24
09/01/21 12:14:27	22370	9.21	8.33	1.51	95.11	5.72	0.66	0.83	7.70	0.63	11.28	0.52	379.37	0.47	13.12
09/01/21 12:14:57	22400	9.22	8.71	1.43	94.66	5.72	0.74	0.86	8.37	0.34	10.70	0.55	378.82	0.53	12.98
09/01/21 12:15:27	22430	9.21	8.47	1.05	95.11	5.56	0.81	-0.30	8.03	0.44	11.59	0.37	363.41	1.33	14.84
09/01/21 12:15:57	22460	9.23	8.82	1.05	94.45	5.69	0.73	0.92	8.27	0.56	11.93	0.54	378.92	0.29	13.50
09/01/21 12:16:27	22490	9.22	8.61	1.43	94.01	5.70	0.76	0.82	8.53	0.08	11.65	0.53	382.00	0.53	13.13
09/01/21 12:16:57	22520	9.24	8.98	1.07	94.17	5.62	0.81	0.86	7.92	1.06	13.01	0.51	369.32	0.11	14.41
09/01/21 12:17:27	22550	9.24	8.35	1.41	95.01	5.68	0.71	0.77	8.04	0.32	12.81	0.53	383.23	0.60	13.41
09/01/21 12:17:57	22580	9.24	8.01	1.48	95.11	5.69	0.72	0.83	7.74	0.28	12.41	0.47	383.22	0.56	13.30
09/01/21 12:18:27	22610	9.22	7.83	1.42	94.98	5.69	0.73	0.85	7.30	0.53	11.92	0.54	386.66	0.60	13.30
09/01/21 12:18:57	22640	9.21	7.91	0.85	94.40	5.57	0.75	0.89	7.54	0.37	13.59	0.51	370.07	0.29	15.04
09/01/21 12:22:57	22880	9.22	10.09	1.41	94.04	5.71	0.68	0.90	9.52	0.56	10.74	0.52	383.50	0.68	12.52
09/01/21 12:23:27	22910	9.21	9.30	1.47	93.98	5.74	0.71	0.73	9.15	0.15	11.02	0.52	386.84	0.40	12.55
09/01/21 12:23:57	22940	9.22	9.11	1.64	93.69	5.74	0.72	0.86	8.58	0.54	11.10	0.49	385.22	0.46	12.56
09/01/21 12:24:27	22970	9.22	8.35	1.48	93.88	5.76	0.72	0.73	8.68	-0.32	10.90	0.53	383.27	0.44	12.57
09/01/21 12:24:57	23000	9.21	8.62	0.89	94.15	5.60	0.76	0.85	8.37	0.25	12.26	0.48	368.19	0.29	14.59
09/01/21 12:25:27	23030	9.21	8.65	1.43	94.41	5.69	0.70	0.87	7.78	0.87	12.32	0.51	369.70	0.54	13.39
09/01/21 12:25:57	23060	9.21	8.47	1.42	94.41	5.73	0.72	0.83	8.14	0.33	11.10	0.52	368.24	0.43	12.73
09/01/21 12:26:27	23090	9.21	8.49	1.56	94.65	5.72	0.75	0.82	8.11	0.38	11.02	0.51	382.43	0.48	12.69
09/01/21 12:26:57	23120	9.21	8.85	1.44	94.59	5.71	0.70	0.87	8.23	0.62	11.50	0.53	385.57	0.59	12.85
09/01/21 12:27:27	23150	9.21	8.77	1.03	94.43	5.65	0.76	0.95	8.25	0.52	12.45	0.54	379.50	0.37	13.74
09/01/21 12:27:57	23180	9.21	8.76	1.03	94.66	5.65	0.72	0.87	8.11	0.65	12.93	0.53	381.47	0.32	13.68
09/01/21 12:28:27	23210	9.22	8.50	1.41	94.45	5.69	0.72	0.82	8.31	0.19	11.85	0.53	383.29	0.59	13.04
09/01/21 12:28:57	23240	9.22	8.68	1.48	95.01	5.69	0.71	0.81	8.24	0.44	11.58	0.53	384.86	0.58	13.03
09/01/21 12:29:27	23270	9.22	8.19	1.35	94.77	5.70	0.72	0.91	8.44	-0.25	11.53	0.49	382.18	0.53	12.99
09/01/21 12:29:57	23300	9.23	8.80	1.04	95.08	5.58	0.77	-0.39	8.24	0.56	12.84	0.37	363.85	1.27	14.62
09/01/21 12:30:27	23330	9.22	8.20	1.38	95.59	5.68	0.68	0.83	7.80	0.40	11.63	0.54	380.69	0.46	12.96
09/01/21 12:30:57	23360	9.24	8.33	1.50	95.07	5.70	0.72	0.75	7.93	0.40	11.23	0.51	385.14	0.47	12.73
09/01/21 12:31:27	23390	9.22	8.62	1.48	94.91	5.70	0.73	0.83	7.84	0.78	11.05	0.53	384.18	0.44	12.64
09/01/21 12:31:57	23420	9.22	8.60	1.47	95.01	5.69	0.71	0.79	7.99	0.61	11.15	0.54	389.72	0.53	12.58
09/01/21 12:32:27	23450	9.22	8.66	1.33	95.13	5.68	0.67	0.88	7.99	0.67	11.14	0.53	386.42	0.67	12.46
09/01/21 12:32:57	23480	9.20	8.32	1.44	95.01	5.69	0.70	0.82	8.08	0.23	10.98	0.56	386.39	0.62	12.37
09/01/21 12:33:27	23510	9.22	8.55	1.43	94.97	5.68	0.71	0.92	7.56	0.99	11.03	0.57	389.28	0.65	12.34
09/01/21 12:33:57	23540	9.22	8.52	1.34	94.89	5.68	0.72	0.91	8.20	0.32	11.02	0.55	389.00	0.71	12.29
09/01/21 12:34:27	23570	9.22	8.37	1.34	95.20	5.69	0.66	0.84	7.98	0.39	10.97	0.53	388.62	0.61	12.22
09/01/21 12:34:57	23600	9.22	8.33	1.44	94.75	5.69	0.68	0.95	8.54	-0.20	10.97	0.54	389.14	0.68	12.19
09/01/21 12:35:27	23630	9.23	8.29	1.46	95.16	5.71	0.72	0.94	7.89	0.41	10.95	0.55	389.44	0.69	12.09
09/01/21 12:35:57	23660	9.21	8.14	1.44	95.65	5.72	0.68	0.93	7.85	0.29	10.82	0.51	389.83	0.60	11.99
09/01/21 12:36:27	23690	9.21	8.64	1.49	95.26	5.72	0.73	0.84	8.17	0.47	11.01	0.50	389.48	0.72	12.05
09/01/21 12:36:57	23720	9.21	8.73	1.37	95.23	5.71	0.69	0.89	7.84	0.89	11.15	0.53	388.48	0.67	12.11
09/01/21 12:37:27	23750	9.21	8.47	1.35	95.24	5.71	0.72	0.87	8.20	0.27	11.29	0.53	389.96	0.71	12.18
09/01/21 12:37:57	23780	9.23	8.17	1.48	95.47	5.66	0.70	0.83	7.99	0.18	12.02	0.53	384.67	0.69	13.14
09/01/21 12:38:27	23810	9.22	8.14	1.40	95.79	5.66	0.70	0.71	7.96	0.18	12.65	0.55	379.21	0.61	13.31
09/01/21 12:38:57	23840	9.23	8.48	1.31	95.72	5.72	0.68	0.85	7.92	0.55	11.23	0.52	384.88	0.65	12.15
09/01/21 12:39:27	23870	9.22	8.50	1.52	95.62	5.71	0.69	0.84	7.93	0.57	11.12	0.53	385.55	0.65	12.19
09/01/21 12:39:57	23900	9.23	8.39	1.38	95.52	5.70	0.70	0.95	7.84	0.55	11.25	0.53	387.23	0.69	12.32
09/01/21 12:40:27	23930	9.21	8.30	1.44	95.33	5.72	0.69	0.89	8.04	0.26	11.32	0.54	388.65	0.73	12.29
09/01/21 12:40:57	23960	9.21	8.37	1.43	94.80	5.64	0.70	0.83	8.42	-0.05	12.55	0.54	385.29	0.61	13.42
09/01/21 12:41:27	23990	9.22	8.77	1.36	95.02	5.72	0.68	0.88	8.26	0.51	11.55	0.54	388.04	0.71	12.18
09/01/21 12:41:57	24020	9.23	8.63	1.51	95.44	5.73	0.69	0.85	8.06	0.57	11.28	0.52	388.07	0.64	12.03
09/01/21 12:42:27	24050	9.21	8.53	1.44	95.30	5.71	0.69	0.93	8.31	0.22	11.15	0.54	386.78	0.62	12.13
09/01/21 12:42:57	24080	9.21	8.68	1.38	94.73	5.70	0.66	0.91	8.06	0.62	11.20	0.52	384.84	0.60	12.16
09/01/21 12:43:27	24110	9.21	8.74	1.43	94.68	5.69	0.67	0.96	8.28	0.46	11.16	0.55	387.19	0.69	12.28
09/01/21 12:43:57	24140	9.20	8.74	1.41	94.27	5.68	0.69	0.90	8.10	0.64	11.37	0.55	383.85	0.70	12.43
09/01/21 12:44:27	24170	9.23	8.56	1.60	93.94	5.68	0.70	0.95	8.21	0.34	11.63	0.50	384.25	0.42	12.67
09/01/21 12:44:57	24200	9.21	8.43	1.43	94.36	5.66	0.71	0.83	8.18	0.25	12.16	0.53	384.02	0.63	12.99
09/01/21 12:45:27	24230	9.22	8.52	1.39	95.11	5.62	0.69	0.84	7.82	0.71	13.24	0.55	383.81	0.64	13.38
09/01/21 12:45:57	24260	9.22	8.46	1.42	95.16	5.63	0.67	0.82	8.02	0.44	13.27	0.51	383.46	0.69	13.45
09/01/21 12:46:27	24290	9.22	8.68	1.51	95.11	5.64	0.69	0.88	8.45	0.23	13.02	0.50	383.61	0.64	13.30
09/01/21 12:46:57	24320	9.21	8.77	1.16	95.45	5.47	0.69	-0.03	8.10	0.67	15.31	0.41	363.59	1.45	15.59
09/01/21 12:47:27	24350	9.23	9.23	1.34	95.04	5.64	0.69	0.82	8.37	0.86	13.04	0.55	383.31	0.63	13.17
09/01/21 12:47:57	24380	9.24	8.68	1.57	94.98	5.66	0.71	0.84	8.33	0.35	12.67	0.53	384.86	0.60	12.94
09/01/21 12:48:27	24410	9.22	8.69	1.49	95.32	5.67	0.73	0.73	8.11	0.59	12.38	0.54	384.15	0.57	12.74
09/01/21 12:48:57	24440	9.24	8.68	1.47	95.51	5.67	0.71	0.85	8.24	0.44	12.47	0.53	386.14	0.58	12.73
09/01/21 12:49:27	24470	9.22	9.02	1.58	95.29	5.68	0.71	0.74	8.25	0.77	12.51	0.52	385.54	0.55	12.64
09/01/21 12:49:57	24500	9.22	8.01	1.45	95.76	5.61	0.66	0.72	8.22	-0.21	13.22	0.54	384.78	0.77	13.44
09/01/21 12:50:27	24530	9.23	8.89	1.44	95.42	5.65	0.68	0.77	8.36	0.53	13.66	0.53	387.09	0.68	13.15
09/01/21 12:50:57	24560	9.23	9.07	1.39	94.85	5.67	0.69	0.91	8.30	0.77	12.48	0.53	389.36	0.79	12.44
09/01/21 12:51:27	24590	9.24	8.53	1.25	94.72	5.68	0.70	0.89	7.99	0.54	12.34	0.55	390.79	0.73	12.41
09/01/21 12:51:57	24620	9.25	8.43	1.41	94.52	5.68	0.69	0.83	8.29	0.14	12.57	0.54	389.19	0.81	12.46
09/01/21 12:52:27	24650	9.25	8.48	1.40	94.51	5.68	0.69	0.91	7.72	0.76	12.56	0.54	388.90	0.73	12.42
09/01/21 12:52:57	24680	9.24	8.32	1.44	94.52	5.69	0.68	0.88	7.77	0.55	12.29	0.53	386.59	0.62	12.33
09/01/21 12:53:27	24710	9.23	8.13	1.32	94.27	5.70	0.69	0.90	7.77	0.37	11.92	0.53	387.71	0.67	12.15
09/01/21 12:53:57	24740	9.22	8.34	1.52	93.62	5.70	0.67	0.91	8.24	0.10	11.96	0.53	385.08	0.64	12.27
09/01/21 12:54:27	24770	9.23	8.33	1.31	93.30	5.68	0.67	0.85	8.44	-0.11	12.25	0.55	385.85	0.70	12.48
09/01/21 12:54:57	24800	9.24	8.36	1.48	93.64	5.69	0.73	0.87	7.94	0.42	12.44	0.52	386.25	0.42	12.56
09/01/21 12:55:27	24830	9.21	8.42	1.37	94.25	5.66	0.69	0.88	7.79	0.63	12.24	0.52	388.19	0.77	12.53
09/01/21 12:55:57	24860	9.23	8.51	1.44	93.81	5.68	0.72	0.85	7.97	0.54	12.60	0.51	389.87	0.53	12.60
09/01/21 12:56:27	24890	9.24	8.51	1.47	93.41	5.66	0.70	0.81	8.07	0.44	13.08	0.50	390.67	0.64	12.82

Catalytic Combustion Corporation
September 2, 2021
Caterpillar, G3520 TALE
Stewart & Stevenson Integration Center

Fuel Data

Fuel Fd factor	8,632	SCF exh/MMBtu
Fuel Heating Value (HHV)	999	Btu/SCF fuel
Engine Fuel Flow	26,278	SCFH

Weather Data

Barometric Pressure	29.74	in. Hg
Relative Humidity	46	%
Ambient Temperature	95	°F
Specific Humidity	0.016410	lb H_2O / lb air

Unit Data

Unit Load	3,598.0	horsepower
Meas. Stack Moisture	13.0	%
Stack Exhaust Flow (M19)	406,400	SCFH

100% Load, Run - 3-3

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvw)	CO (ppmvw)	THC (as C_3H_8) (ppmvw)	CO_2 (%)	N_2O (ppmvw)	C_2H_4O (ppmvw)	NO (ppmvd)	NO_2 (ppmvd)	NH_3 (ppmvw)	HCHO (ppmvw)	CH_4 (as C_3H_8) (ppmvw)	C_2H_6 (as C_3H_8) (ppmvw)	H_2O (%)
09/01/21 12:56:57	24920	9.27	8.90	1.02	92.98	5.58	0.72	0.91	8.60	0.29	14.90	0.55	384.09	0.61	14.16
09/01/21 12:57:27	24950	9.27	8.99	0.99	93.05	5.64	0.74	0.90	8.28	0.71	14.98	0.54	386.67	0.38	13.51
09/01/21 12:57:57	24980	9.25	8.38	1.38	93.31	5.64	0.51	0.85	8.01	0.38	14.34	0.53	386.40	0.61	13.24
09/01/21 12:58:27	25010	9.25	8.27	1.56	93.45	5.64	0.17	0.83	7.93	0.34	11.26	0.59	383.02	0.62	13.27
09/01/21 12:58:57	25040	9.26	8.72	1.66	93.61	5.62	0.17	0.91	8.15	0.58	8.75	0.66	383.84	0.67	13.27
09/01/21 12:59:27	25070	9.25	8.72	1.61	93.23	5.63	0.38	0.95	8.62	0.10	7.35	0.65	383.56	0.61	13.25
09/01/21 12:59:57	25100	9.26	9.57	1.49	93.36	5.63	0.62	0.84	8.17	1.40	6.80	0.58	384.97	0.59	13.21
09/01/21 13:00:27	25130	9.26	8.92	1.38	93.56	5.63	0.62	0.82	8.22	0.70	7.25	0.57	385.54	0.63	13.18
09/01/21 13:00:57	25160	9.26	8.64	1.45	93.69	5.63	0.65	0.82	8.14	0.50	7.80	0.56	387.60	0.59	13.14
09/01/21 13:01:27	25190	9.25	8.25	1.51	94.00	5.65	0.63	0.75	7.99	0.26	8.00	0.52	384.73	0.61	13.04
09/01/21 13:01:57	25220	9.26	8.21	1.47	94.11	5.65	0.66	0.81	7.99	0.22	8.36	0.55	386.38	0.68	13.01
09/01/21 13:02:27	25250	9.25	8.34	1.58	94.00	5.66	0.65	0.91	8.18	0.16	9.09	0.54	384.14	0.56	13.02
09/01/21 13:02:57	25280	9.24	8.36	1.46	94.18	5.66	0.68	0.84	7.62	0.74	9.96	0.50	385.19	0.67	13.02
09/01/21 13:03:27	25310	9.24	8.08	1.54	94.32	5.67	0.71	0.71	7.61	0.47	10.72	0.56	384.31	0.57	12.98
09/01/21 13:03:57	25340	9.25	7.91	1.55	94.48	5.66	0.71	0.83	8.06	-0.15	11.27	0.54	385.28	0.56	12.94
09/01/21 13:04:27	25370	9.23	7.66	1.47	95.32	5.67	0.73	0.83	7.43	0.22	11.55	0.50	385.02	0.59	12.92
09/01/21 13:04:57	25400	9.24	7.81	1.60	95.08	5.68	0.70	0.80	7.69	0.12	11.79	0.54	387.14	0.57	12.84
09/01/21 13:05:27	25430	9.23	8.14	1.56	94.16	5.69	0.70	0.81	8.03	0.12	11.93	0.52	386.98	0.58	12.77
09/01/21 13:05:57	25460	9.22	8.31	1.61	94.23	5.70	0.72	0.79	7.79	0.52	12.16	0.55	385.55	0.53	12.70
09/01/21 13:06:27	25490	9.23	8.50	1.17	94.16	5.60	0.77	0.93	8.05	0.45	13.16	0.57	379.72	0.50	13.81
RAW AVERAGE		**9.23**	**8.57**	**1.38**	**94.52**	**5.68**	**0.69**	**0.82**	**8.13**	**0.44**	**11.60**	**0.53**	**382.57**	**0.59**	**13.03**

		O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	H_2O
	Serial Number:	INST-O2-0026	INST-NX-0025	INST-IR-0005	INST-VC-0004	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-NX-0025	INST-NX-0025	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005	INST-IR-0005
		(%)			(ppmvw)										
Bias	**Initial Zero**	0.02			0.20										
Bias	**Final Zero**	0.02			0.21										
Bias	**Avg. Zero**	0.02			0.21										
Bias	**Initial UpScale**	11.95			300.00										
Bias	**Final UpScale**	11.90			299.31										
Bias	**Avg. UpScale**	11.93			299.66										
Upscale Cal Gas		11.96			299.00										

EMISSIONS DATA	O_2	NOx	CO	THC (as C_3H_8)	CO_2	N_2O	C_2H_4O	NO	NO_2	NH_3	HCHO	CH_4 (as C_3H_8)	C_2H_6 (as C_3H_8)	VOC (as C_3H_8)
Corrected Raw Average (ppm/% dry basis)	9.25	9.85	1.58	108.68	6.53	0.80	0.94	9.35	0.50	13.33	0.61	161.29	0.45	0.00
Corrected Raw Average (ppm/% wet basis)	8.04	8.57	1.38	94.52	5.68	0.69	0.82	8.13	0.44	11.60	0.53	140.27	0.39	0.00
Concentration (ppm@ 15%O_2)	N/A	4.99	0.80	47.86	3.31	0.40	0.48	4.12	0.90	6.75	0.31	81.68	0.23	0.00
Emission Rate (g/hp*hr)	N/A	0.0808	0.0079	0.7417	512	0.0062	0.0074	0.0500	0.0041	0.0405	0.0033	1.2686	0.0036	0.0000
Non-Bias Adjusted Averages Include:		*	*	*	*	*	*			*	*	*	*	*

EMISSION DATA RECORDS

50% Load
PM
Reference Method Data

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE

Source Information	
Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Fuel Type	Gas, Natural

Test Information			
Project #		catc-21-houston.tx-start#1	
Operator		JLW	
Date for Preliminary Run	(mm/dd/yy)	07/28/21	
Standard Temperature		68	°F
Standard Pressure		29.92	in Hg
Run Duration	≥ 2 min/point	90	minutes
Unit Number		1	
Base Run Number		R-1 50%	
Number of Ports Available		2	
Number of Ports Used		2	
Port Inside Diameter		4.00	in
Stack Shape		Circular	

Test Equipment Information					
Run		**1**	**2**	**3**	
Test Date	(mm/dd/yy)	07/29/21	07/29/21	07/29/21	
Load		50%	50%	50%	% or w/DB
Fuel F-Factor		8631.70	8631.70	8631.70	dscf/MMBtu
Meter Box Number	from ACS	samp-cp-0022	samp-cp-0022	samp-cp-0022	
Meter Calibration Factor	(Y)	0.986	0.986	0.986	
Orifice Meter Coefficient	($\Delta H_@$)	1.831	1.831	1.831	in H_2O
Non-Console Manometer Used		No	No	No	
Pitot Identification	from ACS	A6223	A5708	A6223	
Pitot Tube Coefficient	(C_p)	0.8215	0.8230	0.8215	
Nozzle Number	from ACS	G-10	G-10	G-10	
Nozzle Diameter	(D_n)	0.311	0.311	0.311	in
Probe Number	from ACS	samp-hp-0014	samp-hp-0079	samp-hp-0014	
Probe Length		60.0	60.0	60.0	in
(SS, Glass ….) Liner Material	from list	glass	glass	glass	
Sample Case / Oven Number	from ACS	samp-BH-0018	samp-BH-0018	samp-BH-0018	
Impinger Case Number	from ACS	samp-cc-0011	samp-cc-0011	samp-cc-0011	

Testing Company Information	
Company Name	Air Hygiene International, Inc. (Tulsa, Oklahoma)
Address	1600 W Tacoma Street
City, State Zip	Broken Arrow, Oklahoma 74012
Project Manager	Pat McGovern, Jr.
Phone Number	(918) 307-8865
Fax Number	(918) 307-9131

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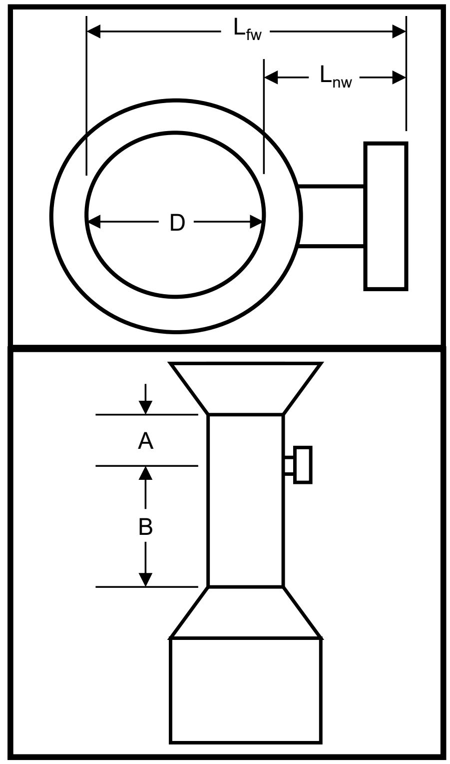
METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR CIRCULAR SOURCES

Plant Name	Stewart and Stevenson Integration Center	**Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Stack Type**	Circular
Operator	JLW	**Ports Available**	2
Project #	catc-21-houston.tx-start#1	**Ports Used**	2
Stack Size	Large (>24 inch diameter)	**Port ID (inches)**	4.00

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	32.00	in
Distance to Near Wall of Stack	(L_{nw})	0.125	in
Diameter of Stack	(D)	31.88	in
Area of Stack	(A_s)	5.54	ft²

Distance from Port to Disturbances			
Distance Upstream	(A)	16.00	in
Diameters Upstream	(A_D)	0.50	diameters
Distance Downstream	(B)	64.00	in
Diameters Downstream	(B_D)	2.01	diameters



Number of Traverse Points Required			
Diameters to Flow Disturbance		**Minimum Number of[1] Traverse Points**	
Down Stream	**Up Stream**	**Particulate Points**	**Velocity Points**
2.00-4.99	0.50-1.24	24	16
5.00-5.99	1.25-1.49	20	16
6.00-6.99	1.50-1.74	16	12
7.00-7.99	1.75-1.99	12	12
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]
Upstream Spec		24	16
Downstream Spec		24	16
Traverse Pts Required		24	16

[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches

- (●) Method 1 Trav
- ( ) 12 Point PM Trav (M201a ONLY)
- ( ) Velocity

Number of Traverse Points Used			
2	**Ports by**	12	**Across**
24	**Pts Used**	24	**Required**
Adjust Sample Points Out of Boundary Layer			

Location of Traverse Points in Circular Stacks (Fraction of Stack Dimension from Inside Wall to Traverse Point)									
Traverse Point Number	**Number of Traverse Points Across the Stack**								
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
1	.146	.067	.044	.032	.026	.021	.018	.016	.014
2	.854	.250	.146	.105	.082	.067	.057	.049	.044
3		.750	.296	.194	.146	.118	.099	.085	.075
4		.933	.704	.323	.226	.177	.146	.125	.109
5			.854	.677	.342	.250	.201	.169	.146
6			.956	.806	.658	.356	.269	.220	.188
7				.895	.774	.644	.366	.283	.236
8				.968	.854	.750	.634	.375	.296
9					.918	.823	.731	.625	.382
10					.974	.882	.799	.717	.618
11						.933	.854	.780	.704
12						.979	.901	.831	.764

Traverse Point Locations			
Traverse Point Number	**Fraction of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
		in	in
1	0.021	5/8	6/8
2	0.067	2 1/8	2 2/8
3	0.118	3 6/8	3 7/8
4	0.177	5 5/8	5 6/8
5	0.250	8	8 1/8
6	0.356	11 3/8	11 4/8
7	0.644	20 4/8	20 5/8
8	0.750	23 7/8	24
9	0.823	26 2/8	26 3/8
10	0.882	28 1/8	28 2/8
11	0.933	29 6/8	29 7/8
12	0.979	31 2/8	31 3/8

METHOD 2 - DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

Plant Name	Stewart and Stevenson Integration Center			
Sampling Location	Caterpillar G3520 TALE			
Operator	JLW			
Project #	catc-21-houston.tx-start#1			
Pitot Leak Check	x	**PreTest**	x	**PostTest**

Preliminary Run Date	07/28/21		
Stack Type	Circular		
Ports Available	2		
Thermocouple ID	samp-hp-0014		
Pitot Coefficient	0.8300	**Pitot Identification**	A6904

Stack Dimensions			
Area of Stack	(A_s)	5.54	ft²
Diameter of Stack	(D)	31.88	in

Pressures			
Barometric Pressure	(P_b)	29.87	in Hg
Static Pressure	(P_{static})	0.07	in H_2O
Absolute Stack Pressure	(P_s)	29.88	in Hg

Stack Gas Composition			
Composition Data:	**Estimated Composition**		
Carbon Dioxide Concentration	($\%CO_2$)	6.80	%vd
Oxygen Concentration	($\%O_2$)	8.60	%vd
Carbon Monoxide Concentration	(ppmCO)	5.00	ppmvd
Nitrogen Concentration	($\%N_2$)	84.60	%vd
Stack Moisture Content	(B_{ws})	14.00	%
Stack Dry Molecular Weight	(M_d)	29.43	lb/lb-mole
Stack Wet Molecular Weight	(M_w)	27.83	lb/lb-mole

Results			
Avg Stack Gas Velocity	(v_s)	37.77	ft/sec
Avg Stack Dry Std Flow Rate	(Q_{sd})	246,184	dscf/hr
Avg Stack Dry Std Flow Rate	(Q_{sd})	4,103	dscf/min
Avg Stack Wet Flow Rate	(Q_{aw})	12,560	acf/min
Avg Stack Wet Std Flow Rate	(Q_{sw})	286,261	ascf/hr

40 CFR 60, Method 2G, Section 8.11.1 (but applies to all Method 2 type static pressure measurements):
If a Type S probe is used for this measurement, position the probe at or between any traverse point(s) and rotate the probe until a null differential pressure reading is obtained. Disconnect the tubing from one of the pressure ports; read and record the ΔP. For pressure devices with one-directional scales, if a deflection in the positive direction is noted with the negative side disconnected, then the static pressure is positive. Likewise, if a deflection in the positive direction is noted with the positive side disconnected, then the static pressure is negative.

Stack Cross Section Schematic

Velocity Traverse Data					
Run Number	R-1 50%-V1				
Run Time	08:46	**Start**	08:59	**End**	
Traverse Point	**Velocity Head** (Δp)	**Null Angle** (N_a)	**Zero Deg Pressure** ($0^o{}_a$)	**Stack Temp** (t_s)	**Local Velocity** ($v_{s(l)}$)
	in H_2O	deg	in H_2O	°F	ft/sec
A-1	0.15	0	0.00	873	34.80
A-2	0.17	5	0.03	896	37.36
A-3	0.17	0	0.00	923	37.73
A-4	0.15	0	0.00	929	35.52
A-5	0.17	5	0.03	930	37.83
A-6	0.18	5	0.02	932	38.95
A-7	0.19	0	0.00	928	39.96
A-8	0.18	0	0.00	930	38.92
A-9	0.19	0	0.00	933	40.03
A-10	0.18	5	0.04	933	38.97
A-11	0.18	0	0.00	933	38.97
A-12	0.17	0	0.00	933	37.87
B-1	0.15	0	0.00	933	35.57
B-2	0.15	0	0.00	933	35.57
B-3	0.16	5	0.03	933	36.74
B-4	0.17	5	0.03	933	37.87
B-5	0.18	0	0.00	933	38.97
B-6	0.18	0	0.00	933	38.97
B-7	0.18	0	0.00	933	38.97
B-8	0.17	0	0.00	933	37.87
B-9	0.17	0	0.00	933	37.87
B-10	0.17	0	0.00	933	37.87
B-11	0.16	0	0.00	933	36.74
B-12	0.16	0	0.00	933	36.74
Average	0.17	1		928	
	0.41	**= Square roots of Δp**			
Standard deviation of null angles =				2.2	

METHOD 3a - DETERMINATION OF DRY MOLECULAR WEIGHT BY ANALYZER

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	07/28/21		
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW		
Project #	catc-21-houston.tx-start#1	**# of Ports Used**	1 (gas probe)		
Fuel Type	Gas, Natural	**Min. Fuel Factor**	1.600	**Max. Fuel Factor**	1.836

Gas Analysis Data

Run Number	R-1 50%-1	**Date**	07/29/21	**Run Start Time**	09:34	**Run Stop Time**	11:24
Sample Analysis Time	**CO_2 Conc.** (%CO_2)	**O_2 Conc.** (%O_2)	**CO Conc.** (ppmCO)	**N_2 Conc.** (%N_2)	**Dry Molecular Weight** (M_d)	**Calculated Fuel Factor** (Fo)avg	**Excess Air** (%EA)avg	**Fuel Factor in Range**
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:50	6.71	8.67	6.03	84.6	29.42	1.822	63.4	YES

Gas Analysis Data

Run Number	R-1 50%-2	**Date**	07/29/21	**Run Start Time**	12:05	**Run Stop Time**	13:59	
Sample Analysis Time	**CO_2 Conc.** (%CO_2)	**O_2 Conc.** (%O_2)	**CO Conc.** (ppmCO)	**N_2 Conc.** (%N_2)	**Dry Molecular Weight** (M_d)	**Calculated Fuel Factor** (Fo)avg	**Excess Air** (%EA)avg	**Fuel Factor in Range**
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:54	6.69	8.74	5.97	84.6	29.42	1.817	64.4	YES

Gas Analysis Data

Run Number	R-1 50%-3	**Date**	07/29/21	**Run Start Time**	14:23	**Run Stop Time**	15:58	
Sample Analysis Time	**CO_2 Conc.** (%CO_2)	**O_2 Conc.** (%O_2)	**CO Conc.** (ppmCO)	**N_2 Conc.** (%N_2)	**Dry Molecular Weight** (M_d)	**Calculated Fuel Factor** (Fo)avg	**Excess Air** (%EA)avg	**Fuel Factor in Range**
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:35	6.75	8.79	6.40	84.5	29.43	1.793	65.1	YES

METHOD 4 - DETERMINATION OF MOISTURE CONTENT IN STACK GASES

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW
Project #	catc-21-houston.tx-start#1	**Ports Used**	2

Scale Daily Calibration					
Scale Number	Extra	**Standard**	**Result**	**Difference**	**Pass/Fail**
Date		(g)	(g)	(g)	(± 0.5 g)
Preliminary Date	07/28/21	500	499.5	-0.5	Pass
Test Day 1	07/29/21	500	500.5	0.5	Pass

Moisture Content Data									
Run Number		R-1 50%-1		**Date**	07/29/21	**Start Time**	09:34	**Stop Time**	11:24
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	36.989	dcf	**Barometric Pressure**		(P_b)	29.87	in Hg
Average Stack Temp		$(t_s)_{avg}$	906	°F	**Stack Static Pressure**		(P_{static})	0.07	in H_2O
Average Meter Temp		$(t_m)_{avg}$	87	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	0.52	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	456.80	612.90	720.10	856.20				
Initial Value	$(V_i),(W_i)$	350.70	612.50	708.90	847.80				
Net Value	$(V_n),(W_n)$	106.1	0.4	11.2	8.4				
Results									
Total Weight		(W_t)	126.10	g	**Water Vol Weighed**		$(V_{wsg(std)})$	5.946	scf
Std Meter Volume		$(V_{m(std)})$	35.190	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.45	%	**Final Moisture Content**		(B_{ws})	14.45	%

Moisture Content Data									
Run Number		R-1 50%-2		**Date**	07/29/21	**Start Time**	12:05	**Stop Time**	13:59
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	37.647	dcf	**Barometric Pressure**		(P_b)	29.90	in Hg
Average Stack Temp		$(t_s)_{avg}$	905	°F	**Stack Static Pressure**		(P_{static})	0.07	in H_2O
Average Meter Temp		$(t_m)_{avg}$	95	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	0.53	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	473.40	601.90	721.10	823.40				
Initial Value	$(V_i),(W_i)$	357.60	600.50	720.50	816.50				
Net Value	$(V_n),(W_n)$	115.8	1.4	0.6	6.9				
Results									
Total Weight		(W_t)	124.70	g	**Water Vol Weighed**		$(V_{wsg(std)})$	5.880	scf
Std Meter Volume		$(V_{m(std)})$	35.360	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.26	%	**Final Moisture Content**		(B_{ws})	14.26	%

Moisture Content Data									
Run Number		R-1 50%-3		**Date**	07/29/21	**Start Time**	14:23	**Stop Time**	15:58
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	37.385	dcf	**Barometric Pressure**		(P_b)	29.85	in Hg
Average Stack Temp		$(t_s)_{avg}$	923	°F	**Stack Static Pressure**		(P_{static})	0.07	in H_2O
Average Meter Temp		$(t_m)_{avg}$	94	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	0.53	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	463.70	614.80	722.80	863.20				
Initial Value	$(V_i),(W_i)$	351.30	614.60	720.10	856.20				
Net Value	$(V_n),(W_n)$	112.4	0.2	2.7	7.0				
Results									
Total Weight		(W_t)	122.30	g	**Water Vol Weighed**		$(V_{wsg(std)})$	5.766	scf
Std Meter Volume		$(V_{m(std)})$	35.098	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.11	%	**Final Moisture Content**		(B_{ws})	14.11	%

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/29/21
Operator	JLW
Run Number	R-1 50%-1

Filter #
00713
R-1 50%-1-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8215	A6223
Average Stack Temp	(t_s)	906.0	°F
Average Meter Temp	(t_m)	87.0	
Orifice Meter Coefficient	($\Delta H@$)	1.831	in H_2O
Square Root ΔP	($\Delta p^{1/2}_{avg}$)	0.41	in H_2O
Stack Moisture Content	(B_{ws})	14.45	%
Stack Dry Molecular Weight	(M_d)	29.42	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.75	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.05	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
PASS	**Pre (-)**	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
	Post (+)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.3148	in
Probe Number	samp-hp-0014		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.87	in Hg
Stack Static Pressure	(P_{static})	0.07	in H_2O
Absolute Stack Pressure	(P_s)	29.88	in Hg
Absolute Meter Pressure	(P_m)	30.00	in Hg

Nozzle Measurements			**ID: G-10**	
Pre	0.311	0.311	0.312	**PASS**
Post	0.311	0.311	0.312	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	09:34	**End**	11:24

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	350.7	612.5	708.9	847.8				
Post	456.8	612.9	720.1	856.2				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0014	samp-hp-0014	samp-BH-0018	samp-cc-0011			samp-cp-0022		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity (v_s)$_i$**	**Cumul. Meter Volume (V_m)$_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume (V_m)$_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	59.000	0.15	0.457	0.45	900	250	249	62	70	81	81	81	1.0	0.39	34.83	1.318	96.0	31.623
A-2	3.8	00:03:45	60.370	0.18	0.549	0.54	905	250	249	60	73	81	81	81	1.0	0.42	38.22	2.789	97.1	33.473
A-3	7.5	00:07:30	61.900	0.17	0.518	0.51	906	250	249	60	72	80	81	81	1.0	0.41	37.16	4.213	97.3	33.704
A-4	11.3	00:11:15	63.380	0.15	0.457	0.45	905	250	250	60	74	80	82	82	1.0	0.39	34.89	5.567	97.6	33.400
A-5	15.0	00:15:00	64.790	0.17	0.518	0.51	910	250	251	58	52	80	82	82	1.0	0.41	37.21	7.016	98.0	33.679
A-6	18.8	00:18:45	66.300	0.20	0.610	0.60	912	250	250	58	50	80	83	83	1.0	0.45	40.39	8.617	98.7	34.469
A-7	22.5	00:22:30	67.970	0.19	0.579	0.57	908	250	249	57	50	79	83	83	1.0	0.44	39.31	10.122	98.5	34.704
A-8	26.3	00:26:15	69.540	0.18	0.549	0.54	911	250	249	57	51	79	84	84	1.0	0.42	38.30	11.615	98.7	34.844
A-9	30.0	00:30:00	71.100	0.19	0.579	0.57	911	250	252	58	52	79	85	85	1.0	0.44	39.35	13.152	98.8	35.072
A-10	33.8	00:33:45	72.710	0.19	0.579	0.57	912	250	251	58	52	79	86	86	1.0	0.44	39.37	14.696	99.0	35.271
A-11	37.5	00:37:30	74.330	0.18	0.549	0.54	910	250	249	58	54	80	87	87	1.0	0.42	38.29	16.238	99.3	35.427
A-12	41.3	00:41:15	75.950	0.17	0.518	0.51	908	250	249	57	55	79	87	87	1.0	0.41	37.18	17.636	99.1	35.272
B-1	45.0	00:45:00	77.420	0.15	0.457	0.45	891	250	249	66	61	81	89	89	1.0	0.39	34.71	19.020	99.2	35.113
B-2	48.8	00:48:45	78.880	0.16	0.488	0.48	902	250	249	62	60	79	89	89	1.0	0.40	35.99	20.404	99.1	34.978
B-3	52.5	00:52:30	80.340	0.16	0.488	0.48	906	250	249	62	71	79	89	89	1.0	0.40	36.05	21.806	99.1	34.890
B-4	56.3	00:56:15	81.820	0.17	0.518	0.51	908	250	249	60	71	80	89	89	1.0	0.41	37.18	23.285	99.2	34.928
B-5	60.0	01:00:00	83.380	0.18	0.549	0.54	908	252	250	60	74	80	89	89	1.0	0.42	38.26	24.679	98.9	34.840
B-6	63.8	01:03:45	84.850	0.18	0.549	0.54	906	248	248	60	74	79	90	90	1.0	0.42	38.23	26.325	99.5	35.100
B-7	67.5	01:07:30	86.590	0.18	0.549	0.54	910	251	250	62	75	80	91	91	1.0	0.42	38.29	27.798	99.5	35.114
B-8	71.3	01:11:15	88.150	0.17	0.518	0.51	905	249	251	64	77	81	91	91	1.0	0.41	37.14	29.215	99.4	35.058
B-9	75.0	01:15:00	89.650	0.17	0.518	0.51	902	250	252	64	77	81	91	91	1.0	0.41	37.10	30.632	99.3	35.008
B-10	78.8	01:18:45	91.150	0.17	0.518	0.51	905	248	251	62	75	80	92	92	1.0	0.41	37.14	32.197	99.6	35.124
B-11	82.5	01:22:30	92.810	0.16	0.488	0.48	903	250	250	62	75	80	93	93	1.0	0.40	36.01	33.589	99.6	35.050
B-12	86.3	01:26:15	94.290	0.16	0.488	0.48	900	250	249	62	75	79	93	93	1.0	0.40	35.97	35.188	100.2	35.188
Last Pt	90.0	01:30:00	95.989																	
Final Val	90.0	01:30:00	95.989											**Max Vac**	1.0	**Final Values**		35.188	100.2	
Average Values				0.17		0.52	906	250	250	60	65	80	87	87		0.41	37.36			
													87							

Notes:

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/29/21
Operator	JLW
Run Number	R-1 50%-2

Filter #
0652
R-1 50%-2-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	904.8	°F
Average Meter Temp	(t_m)	94.6	
Orifice Meter Coefficient	$(\Delta H@)$	1.831	in H_2O
Square Root ΔP	$(\Delta p^{1/2}_{avg})$	0.42	in H_2O
Stack Moisture Content	(B_{ws})	14.26	%
Stack Dry Molecular Weight	(M_d)	29.42	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.39	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.12	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	4.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.2255	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.90	in Hg
Stack Static Pressure	(P_{static})	0.07	in H_2O
Absolute Stack Pressure	(P_s)	29.91	in Hg
Absolute Meter Pressure	(P_m)	30.03	in Hg

Nozzle Measurements		**ID: G-10**		
Pre	0.311	0.312	0.311	**PASS**
Post	0.311	0.312	0.311	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	12:05	**End**	13:59

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	357.6	600.5	720.5	816.5				
Post	473.4	601.9	721.1	823.4				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0079	samp-hp-0079	samp-BH-0018	samp-cc-0011			samp-cp-0022		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP $(\Delta p^{1/2})$**	**Local Stack Velocity $(v_s)_i$**	**Cumul. Meter Volume $(V_m)_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume $(V_m)_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	96.035	0.17	0.530	0.52	910	248	250	53	50	70	92	92	2.0	0.41	37.24	1.430	97.8	34.313
A-2	3.8	00:03:45	97.550	0.16	0.499	0.49	908	250	249	53	51	70	92	92	2.0	0.40	36.11	2.845	98.7	34.142
A-3	7.5	00:07:30	99.050	0.16	0.499	0.49	908	251	250	55	49	71	92	92	2.0	0.40	36.11	4.261	99.0	34.085
A-4	11.3	00:11:15	100.550	0.17	0.530	0.53	910	250	250	55	50	71	93	93	2.0	0.41	37.24	5.730	99.4	34.381
A-5	15.0	00:15:00	102.110	0.18	0.561	0.56	909	249	251	56	52	73	93	93	2.0	0.42	38.31	7.256	99.8	34.831
A-6	18.8	00:18:45	103.730	0.19	0.592	0.60	912	250	251	56	52	73	93	93	2.0	0.44	39.40	8.830	100.2	35.319
A-7	22.5	00:22:30	105.400	0.18	0.561	0.56	908	249	249	57	52	73	94	94	2.0	0.42	38.30	10.316	100.0	35.368
A-8	26.3	00:26:15	106.980	0.17	0.530	0.52	905	250	249	57	53	74	94	94	2.0	0.41	37.18	11.773	99.9	35.319
A-9	30.0	00:30:00	108.530	0.17	0.530	0.52	903	251	250	57	53	74	94	94	2.0	0.41	37.15	13.221	99.8	35.256
A-10	33.8	00:33:45	110.070	0.16	0.499	0.49	903	250	249	58	55	75	95	95	2.0	0.40	36.04	14.620	99.6	35.087
A-11	37.5	00:37:30	111.560	0.16	0.499	0.49	903	249	252	57	56	75	95	95	2.0	0.40	36.04	16.065	99.8	35.051
A-12	41.3	00:41:15	113.100	0.16	0.499	0.49	903	250	250	57	56	75	95	95	2.0	0.40	36.04	17.465	99.7	34.930
B-1	45.0	00:45:00	114.592	0.16	0.499	0.49	903	249	249	65	52	73	95	95	2.0	0.40	36.04	18.862	99.6	34.822
B-2	48.8	00:48:45	116.080	0.17	0.530	0.52	899	250	251	56	53	73	95	95	2.0	0.41	37.10	20.326	99.6	34.845
B-3	52.5	00:52:30	117.640	0.17	0.530	0.52	900	251	250	56	53	73	95	95	2.0	0.41	37.11	21.753	99.4	34.804
B-4	56.3	00:56:15	119.160	0.16	0.499	0.49	902	251	250	56	53	74	96	96	2.0	0.40	36.03	23.214	99.7	34.821
B-5	60.0	01:00:00	120.720	0.17	0.530	0.52	904	250	252	56	53	74	96	96	2.0	0.41	37.16	24.666	99.6	34.823
B-6	63.8	01:03:45	122.270	0.19	0.592	0.58	904	250	250	56	54	75	96	96	2.0	0.44	39.29	26.212	99.6	34.950
B-7	67.5	01:07:30	123.920	0.18	0.561	0.55	902	251	251	56	54	75	96	96	2.0	0.42	38.21	27.740	99.7	35.040
B-8	71.3	01:11:15	125.550	0.18	0.561	0.55	904	250	249	57	56	76	96	96	2.0	0.42	38.24	29.276	99.8	35.132
B-9	75.0	01:15:00	127.190	0.19	0.592	0.58	906	250	250	57	56	76	96	96	2.0	0.44	39.32	30.851	99.9	35.258
B-10	78.8	01:18:45	128.870	0.19	0.592	0.58	906	249	250	57	56	76	96	96	2.0	0.44	39.32	32.425	100.0	35.373
B-11	82.5	01:22:30	130.550	0.18	0.561	0.55	904	251	250	57	56	76	96	96	2.0	0.42	38.24	33.933	100.0	35.409
B-12	86.3	01:26:15	132.160	0.17	0.530	0.52	900	250	250	57	56	76	96	96	2.0	0.41	37.11	35.359	99.9	35.359
Last Pt	90.0	01:30:00	133.682																	
Final Val	90.0	01:30:00	133.682											**Max Vac**	2.0	**Final Values**		35.359	99.9	
Average Values				0.17		0.53	905	250	250	57	53	74	95	95		0.42	37.43			
													95							

Notes: PAUSED 14:39 in

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/29/21
Operator	JLW
Run Number	R-1 50%-3

Filter #
0722
R-1 50%-3-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8215	A6223
Average Stack Temp	(t_s)	922.7	°F
Average Meter Temp	(t_m)	94.0	
Orifice Meter Coefficient	$(\Delta H@)$	1.831	in H_2O
Square Root ΔP	$(\Delta p^{1/2}{}_{avg})$	0.41	in H_2O
Stack Moisture Content	(B_{ws})	14.11	%
Stack Dry Molecular Weight	(M_d)	29.43	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.39	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.07	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.2273	in
Probe Number	samp-hp-0014		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.85	in Hg
Stack Static Pressure	(P_{static})	0.07	in H_2O
Absolute Stack Pressure	(P_s)	29.86	in Hg
Absolute Meter Pressure	(P_m)	29.98	in Hg

Nozzle Measurements		**ID: G-10**	
Pre 0.312	0.311	0.311	**PASS**
Post 0.312	0.311	0.311	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	14:23	**End**	15:58

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	351.3	614.6	720.1	856.2				
Post	463.7	614.8	722.8	863.2				

Wash Volumes					ml
					ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0014	samp-hp-0014	samp-BH-0018	samp-cc-0011			**samp-cp-0022**		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP $(\Delta p^{1/2})$**	**Local Stack Velocity $(v_s)_i$**	**Cumul. Meter Volume $(V_m)_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume $(V_m)_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	133.977	0.15	0.461	0.47	926	248	250	59	53	79	92	92	2.0	0.39	35.14	1.406	103.1	33.754
A-2	3.8	00:03:45	135.470	0.16	0.491	0.50	928	250	249	59	53	79	92	92	2.0	0.40	36.32	2.801	101.1	33.609
A-3	7.5	00:07:30	136.950	0.16	0.491	0.50	925	251	250	59	53	79	92	92	2.0	0.40	36.28	4.261	102.0	34.087
A-4	11.3	00:11:15	138.500	0.17	0.522	0.53	927	250	250	57	56	80	92	92	2.0	0.41	37.42	5.655	100.5	33.932
A-5	15.0	00:15:00	139.980	0.18	0.553	0.56	925	251	249	58	57	80	92	92	2.0	0.42	38.48	7.172	100.7	34.427
A-6	18.8	00:18:45	141.590	0.18	0.553	0.56	923	250	250	58	57	80	92	92	2.0	0.42	38.45	8.708	101.1	34.832
A-7	22.5	00:22:30	143.220	0.18	0.553	0.56	922	251	249	57	55	81	93	93	2.0	0.42	38.44	10.194	100.8	34.951
A-8	26.3	00:26:15	144.800	0.17	0.522	0.53	923	250	250	57	55	81	93	93	2.0	0.41	37.37	11.680	101.0	35.040
A-9	30.0	00:30:00	146.380	0.17	0.522	0.53	925	249	251	57	55	81	93	93	2.0	0.41	37.39	13.138	100.9	35.034
A-10	33.8	00:33:45	147.930	0.17	0.522	0.53	922	250	250	58	56	80	94	94	2.0	0.41	37.35	14.612	101.0	35.068
A-11	37.5	00:37:30	149.500	0.15	0.461	0.47	924	251	249	58	57	80	94	94	2.0	0.39	35.11	15.963	100.8	34.829
A-12	41.3	00:41:15	150.940	0.16	0.491	0.50	922	250	250	58	57	79	94	94	2.0	0.40	36.24	17.409	100.9	34.818
B-1	45.0	00:45:00	152.480	0.16	0.491	0.50	918	249	252	60	59	81	94	94	2.0	0.40	36.18	18.845	101.0	34.791
B-2	48.8	00:48:45	154.010	0.16	0.491	0.50	924	249	250	59	58	81	94	94	2.0	0.40	36.26	20.262	101.0	34.735
B-3	52.5	00:52:30	155.520	0.17	0.522	0.53	922	250	249	58	57	80	94	94	2.0	0.41	37.35	21.727	101.0	34.763
B-4	56.3	00:56:15	157.080	0.17	0.522	0.53	919	248	249	58	57	80	95	95	2.0	0.41	37.31	23.161	100.8	34.741
B-5	60.0	01:00:00	158.610	0.18	0.553	0.56	922	249	251	56	55	78	95	95	2.0	0.42	38.44	24.697	100.9	34.867
B-6	63.8	01:03:45	160.250	0.19	0.584	0.59	922	250	250	56	55	78	95	95	2.0	0.44	39.49	26.244	100.9	34.992
B-7	67.5	01:07:30	161.900	0.18	0.553	0.56	924	251	253	56	56	78	95	95	2.0	0.42	38.46	27.724	100.8	35.020
B-8	71.3	01:11:15	163.480	0.18	0.553	0.56	923	249	247	56	58	79	96	96	2.0	0.42	38.45	29.193	100.7	35.032
B-9	75.0	01:15:00	165.050	0.19	0.584	0.59	922	248	248	56	58	79	96	96	2.0	0.44	39.49	30.709	100.6	35.096
B-10	78.8	01:18:45	166.670	0.18	0.553	0.56	922	250	249	57	60	80	96	96	2.0	0.42	38.44	32.168	100.4	35.092
B-11	82.5	01:22:30	168.230	0.18	0.553	0.56	920	249	250	57	60	80	96	96	2.0	0.42	38.41	33.665	100.4	35.128
B-12	86.3	01:26:15	169.830	0.17	0.522	0.53	915	251	250	57	60	80	96	96	2.0	0.41	37.26	35.098	100.3	35.098
Last Pt	90.0	01:30:00	171.362																	
Final Val	90.0	01:30:00	171.362											**Max Vac**	2.0	**Final Values**		35.098	100.3	
Average Values				0.17		0.53	923	250	250	58	57	80	94	94		0.41	37.48			
													94							

Notes:

AIR HYGIENE

PM (EPA METHOD 5) DATA SHEET

Project Code: catc-21-houston.tx-start#1

Site Info.		Console Info.	
Plant Name.		Console.	samp-cp-0022
Sampling Location.		Meter Calibratrion Factor	0.986
Unit #		Orifice Meter Coefficient	1.831
Date.	7.29.21		

PM RUNS

Run#: 1	Load: 50% normal				Box#: 5310			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	(V_f),(W_f)	456.8	612.9	720.1	856.2			
Initial Value	(V_i),(W_i)	350.7	~~708.9~~ 612.5	~~612.5~~ 708.9	847.8			
Filter #	00713		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

CPM - 5736 EXIT - 8471 COND. - 3006

Run#: 2	Load: 50% normal				Box#: samp-cc-0011			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	(V_f),(W_f)	473.4	601.9	721.1	823.4			
Initial Value	(V_i),(W_i)	357.6	600.5	720.5	816.5			
Filter #	0652		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

CPM - 1004 EXIT - 8609 COND. - 2917

Run#: 3	Load: 50% normal				Box#:			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	(V_f),(W_f)	463.7	614.8	722.8	863.2			
Initial Value	(V_i),(W_i)	351.3	614.6	720.1	856.2			
Filter #	0722		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Run#:	Load: normal				Box#:			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	(V_f),(W_f)							
Initial Value	(V_i),(W_i)							
Filter #			Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Signature [signature]

EMISSION DATA RECORDS

75% Load
PM
Reference Method Data

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE

Source Information	
Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Fuel Type	Gas, Natural

Test Information			
Project #		catc-21-houston.tx-start#1	
Operator		JLW	
Date for Preliminary Run	(mm/dd/yy)	07/28/21	
Standard Temperature		68	°F
Standard Pressure		29.92	in Hg
Run Duration	≥ 2 min/point	90	minutes
Unit Number		1	
Base Run Number		R-1 75%	
Number of Ports Available		2	
Number of Ports Used		2	
Port Inside Diameter		4.00	in
Stack Shape		Circular	

Test Equipment Information					
Run		**1**	**2**	**3**	
Test Date	(mm/dd/yy)	07/30/21	07/30/21	07/30/21	
Load		75%	75%	75%	% or w/DB
Fuel F-Factor		8632.09	8632.09	8632.09	dscf/MMBtu
Meter Box Number	from ACS	samp-cp-0022	samp-cp-0022	samp-cp-0022	
Meter Calibration Factor	(Y)	0.986	0.986	0.986	
Orifice Meter Coefficient	($\Delta H_@$)	1.831	1.831	1.831	in H_2O
Non-Console Manometer Used		No	No	No	
Pitot Identification	from ACS	A5708	A5708	A5708	
Pitot Tube Coefficient	(C_p)	0.8230	0.8230	0.8230	
Nozzle Number	from ACS	G-10	G-10	G-10	
Nozzle Diameter	(D_n)	0.311	0.311	0.311	in
Probe Number	from ACS	samp-hp-0079	samp-hp-0079	samp-hp-0079	
Probe Length		60.0	60.0	60.0	in
(SS, Glass ….) Liner Material	from list	glass	glass	glass	
Sample Case / Oven Number	from ACS	samp-BH-0018	samp-BH-0018	samp-BH-0018	
Impinger Case Number	from ACS	samp-cc-0011	samp-cc-0011	samp-cc-0011	

Testing Company Information	
Company Name	Air Hygiene International, Inc. (Tulsa, Oklahoma)
Address	1600 W Tacoma Street
City, State Zip	Broken Arrow, Oklahoma 74012
Project Manager	Pat McGovern, Jr.
Phone Number	(918) 307-8865
Fax Number	(918) 307-9131

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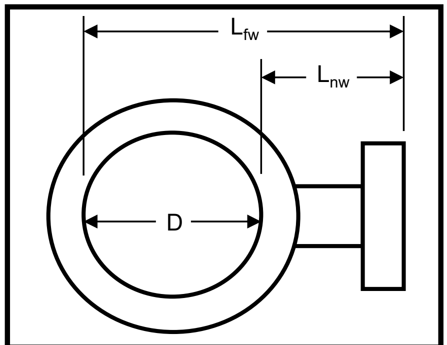
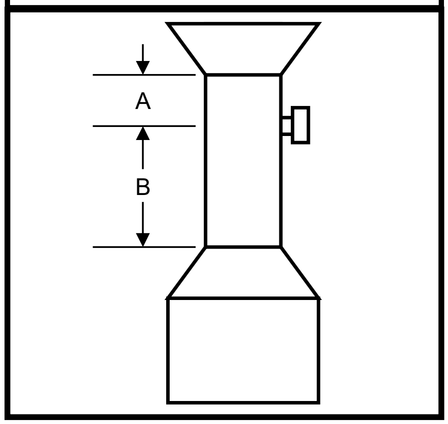
METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR CIRCULAR SOURCES

Plant Name	Stewart and Stevenson Integration Center	**Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Stack Type**	Circular
Operator	JLW	**Ports Available**	2
Project #	catc-21-houston.tx-start#1	**Ports Used**	2
Stack Size	Large (>24 inch diameter)	**Port ID (inches)**	4.00

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	32.00	in
Distance to Near Wall of Stack	(L_{nw})	0.13	in
Diameter of Stack	(D)	31.88	in
Area of Stack	(A_s)	5.54	ft²



Distance from Port to Disturbances			
Distance Upstream	(A)	16.00	in
Diameters Upstream	(A_D)	0.50	diameters
Distance Downstream	(B)	64.00	in
Diameters Downstream	(B_D)	2.01	diameters



Number of Traverse Points Required			
Diameters to Flow Disturbance		**Minimum Number of[1] Traverse Points**	
Down Stream	**Up Stream**	**Particulate Points**	**Velocity Points**
2.00-4.99	0.50-1.24	24	16
5.00-5.99	1.25-1.49	20	16
6.00-6.99	1.50-1.74	16	12
7.00-7.99	1.75-1.99	12	12
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]
Upstream Spec		24	16
Downstream Spec		24	16
Traverse Pts Required		24	16

[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches

(●) Method 1 Trav
( ) 12 Point PM Trav (M201a ONLY)
( ) Velocity

Number of Traverse Points Used			
2	**Ports by**	12	**Across**
24	**Pts Used**	24	**Required**
Adjust Sample Points Out of Boundary Layer			

Location of Traverse Points in Circular Stacks
(Fraction of Stack Dimension from Inside Wall to Traverse Point)

Traverse Point Number	Number of Traverse Points Across the Stack: 2	4	6	8	10	12	14	16	18
1	.146	.067	.044	.032	.026	.021	.018	.016	.014
2	.854	.250	.146	.105	.082	.067	.057	.049	.044
3		.750	.296	.194	.146	.118	.099	.085	.075
4		.933	.704	.323	.226	.177	.146	.125	.109
5			.854	.677	.342	.250	.201	.169	.146
6			.956	.806	.658	.356	.269	.220	.188
7				.895	.774	.644	.366	.283	.236
8				.968	.854	.750	.634	.375	.296
9					.918	.823	.731	.625	.382
10					.974	.882	.799	.717	.618
11						.933	.854	.780	.704
12						.979	.901	.831	.764

Traverse Point Locations

Traverse Point Number	Fraction of Stack Diameter	Distance from Inside Wall	Distance Including Reference Length
		in	in
1	0.021	5/8	6/8
2	0.067	2 1/8	2 2/8
3	0.118	3 6/8	3 7/8
4	0.177	5 5/8	5 6/8
5	0.250	8	8 1/8
6	0.356	11 3/8	11 4/8
7	0.644	20 4/8	20 5/8
8	0.750	23 7/8	24
9	0.823	26 2/8	26 3/8
10	0.882	28 1/8	28 2/8
11	0.933	29 6/8	29 7/8
12	0.979	31 2/8	31 3/8

METHOD 2 - DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

Plant Name	Stewart and Stevenson Integration Center			
Sampling Location	Caterpillar G3520 TALE			
Operator	JLW			
Project #	catc-21-houston.tx-start#1			
Pitot Leak Check	x	**PreTest**	x	**PostTest**

Preliminary Run Date	07/28/21		
Stack Type	Circular		
Ports Available	2		
Thermocouple ID	samp-hp-0079		
Pitot Coefficient	0.8215	**Pitot Identification**	A6223

Stack Dimensions			
Area of Stack	(A_s)	5.54	ft²
Diameter of Stack	(D)	31.88	in

Pressures			
Barometric Pressure	(P_b)	29.89	in Hg
Static Pressure	(P_{static})	0.21	in H_2O
Absolute Stack Pressure	(P_s)	29.91	in Hg

Stack Gas Composition			
Composition Data:	**Estimated Composition**		
Carbon Dioxide Concentration	(%CO_2)	5.80	%vd
Oxygen Concentration	(%O_2)	8.80	%vd
Carbon Monoxide Concentration	(ppmCO)	5.00	ppmvd
Nitrogen Concentration	(%N_2)	85.40	%vd
Stack Moisture Content	(B_{ws})	14.00	%
Stack Dry Molecular Weight	(M_d)	29.28	lb/lb-mole
Stack Wet Molecular Weight	(M_w)	27.70	lb/lb-mole

Results			
Avg Stack Gas Velocity	(v_s)	52.84	ft/sec
Avg Stack Dry Std Flow Rate	(Q_{sd})	363,978	dscf/hr
Avg Stack Dry Std Flow Rate	(Q_{sd})	6,066	dscf/min
Avg Stack Wet Flow Rate	(Q_{aw})	17,569	acf/min
Avg Stack Wet Std Flow Rate	(Q_{sw})	423,231	ascf/hr

40 CFR 60, Method 2G, Section 8.11.1 (but applies to all Method 2 type static pressure measurements):
If a Type S probe is used for this measurement, position the probe at or between any traverse point(s) and rotate the probe until a null differential pressure reading is obtained. Disconnect the tubing from one of the pressure ports; read and record the ΔP. For pressure devices with one-directional scales, if a deflection in the positive direction is noted with the negative side disconnected, then the static pressure is positive. Likewise, if a deflection in the positive direction is noted with the positive side disconnected, then the static pressure is negative.

Stack Cross Section Schematic

Velocity Traverse Data					
Run Number	R-1 75%-V1				
Run Time	07:06	**Start**	07:21	**End**	
Traverse Point	**Velocity Head** (Δp)	**Null Angle** (N_a)	**Zero Deg Pressure** ($0^o{}_a$)	**Stack Temp** (t_s)	**Local Velocity** ($v_{s(l)}$)
	in H_2O	deg	in H_2O	°F	ft/sec
A-1	0.40	5	0.07	826	55.34
A-2	0.39	5	0.06	830	54.73
A-3	0.38	10	0.12	834	54.11
A-4	0.41	5	0.04	838	56.29
A-5	0.41	10	0.10	838	56.29
A-6	0.41	5	0.05	839	56.31
A-7	0.40	5	0.05	841	55.66
A-8	0.39	10	0.10	843	55.01
A-9	0.38	5	0.04	842	54.27
A-10	0.37	0	0.00	842	53.56
A-11	0.37	5	0.04	844	53.60
A-12	0.35	0	0.00	846	52.17
B-1	0.30	0	0.00	854	48.45
B-2	0.27	5	0.06	863	46.12
B-3	0.28	5	0.04	871	47.11
B-4	0.30	5	0.04	873	48.80
B-5	0.32	0	0.00	872	50.38
B-6	0.34	5	0.06	873	51.95
B-7	0.35	0	0.00	874	52.72
B-8	0.35	5	0.04	875	52.74
B-9	0.35	5	0.05	874	52.72
B-10	0.36	0	0.00	874	53.47
B-11	0.36	0	0.00	872	53.43
B-12	0.35	0	0.00	869	52.63
Average	0.36	4		854	
	0.60	**= Square roots of Δp**			
Standard deviation of null angles =				3.3	

METHOD 3a - DETERMINATION OF DRY MOLECULAR WEIGHT BY ANALYZER

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	07/28/21		
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW		
Project #	catc-21-houston.tx-start#1	**# of Ports Used**	1 (gas probe)		
Fuel Type	Gas, Natural	**Min. Fuel Factor**	1.600	**Max. Fuel Factor**	1.836

Gas Analysis Data

Run Number	R-1 75%-1		**Date**	07/30/21	**Run Start Time**	08:08	**Run Stop Time**	09:42
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:34	6.57	8.95	3.23	84.5	29.41	1.819	67.1	YES

Gas Analysis Data

Run Number	R-1 75%-2		**Date**	07/30/21	**Run Start Time**	13:17	**Run Stop Time**	14:56
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:39	6.55	8.96	4.20	84.5	29.41	1.823	67.1	YES

Gas Analysis Data

Run Number	R-1 75%-3		**Date**	07/30/21	**Run Start Time**	15:25	**Run Stop Time**	17:01
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:36	6.66	8.94	3.59	84.4	29.42	1.796	66.9	YES

METHOD 4 - DETERMINATION OF MOISTURE CONTENT IN STACK GASES

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW
Project #	catc-21-houston.tx-start#1	**Ports Used**	2

Scale Daily Calibration					
Scale Number	Extra	**Standard**	**Result**	**Difference**	**Pass/Fail**
Date		(g)	(g)	(g)	(± 0.5 g)
Preliminary Date	07/28/21	500	499.5	-0.5	Pass
Test Day 1	07/30/21	500	499.5	-0.5	Pass

Moisture Content Data									
Run Number		R-1 75%-1		**Date**	07/30/21	**Start Time**	08:08	**Stop Time**	09:42
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	52.714	dcf	**Barometric Pressure**		(P_b)	29.89	in Hg
Average Stack Temp		$(t_s)_{avg}$	912	°F	**Stack Static Pressure**		(P_{static})	0.21	in H_2O
Average Meter Temp		$(t_m)_{avg}$	82	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	1.14	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	524.30	605.50	724.50	832.60				
Initial Value	$(V_i),(W_i)$	360.00	604.30	721.10	823.40				
Net Value	$(V_n),(W_n)$	164.3	1.2	3.4	9.2				
Results									
Total Weight		(W_t)	178.10	g	**Water Vol Weighed**		$(V_{wsg(std)})$	8.397	scf
Std Meter Volume		$(V_{m(std)})$	50.693	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.21	%	**Final Moisture Content**		(B_{ws})	14.21	%

Moisture Content Data									
Run Number		R-1 75%-2		**Date**	07/30/21	**Start Time**	13:17	**Stop Time**	14:56
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	53.576	dcf	**Barometric Pressure**		(P_b)	29.90	in Hg
Average Stack Temp		$(t_s)_{avg}$	909	°F	**Stack Static Pressure**		(P_{static})	0.21	in H_2O
Average Meter Temp		$(t_m)_{avg}$	92	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	1.09	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	505.30	615.70	730.50	872.90				
Initial Value	$(V_i),(W_i)$	351.70	615.10	722.80	863.20				
Net Value	$(V_n),(W_n)$	153.6	0.6	7.7	9.7				
Results									
Total Weight		(W_t)	171.60	g	**Water Vol Weighed**		$(V_{wsg(std)})$	8.091	scf
Std Meter Volume		$(V_{m(std)})$	50.619	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	13.78	%	**Final Moisture Content**		(B_{ws})	13.78	%

Moisture Content Data									
Run Number		R-1 75%-3		**Date**	07/30/21	**Start Time**	15:25	**Stop Time**	17:01
Meter Box Number		samp-cp-0022				**Meter Cal Factor**	(Y)	0.986	
Total Meter Volume		(V_m)	53.946	dcf	**Barometric Pressure**		(P_b)	29.86	in Hg
Average Stack Temp		$(t_s)_{avg}$	910	°F	**Stack Static Pressure**		(P_{static})	0.21	in H_2O
Average Meter Temp		$(t_m)_{avg}$	95	°F	**Avg Orifice Pressure**		$(\Delta H)_{avg}$	1.12	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	516.00	603.50	726.60	834.40				
Initial Value	$(V_i),(W_i)$	359.80	604.60	724.50	823.30				
Net Value	$(V_n),(W_n)$	156.2	-1.1	2.1	11.1				
Results									
Total Weight		(W_t)	168.30	g	**Water Vol Weighed**		$(V_{wsg(std)})$	7.935	scf
Std Meter Volume		$(V_{m(std)})$	50.659	dscf	**Sat. Moisture Content**		$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	13.54	%	**Final Moisture Content**		(B_{ws})	13.54	%

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/30/21
Operator	JLW
Run Number	R-1 75%-1

Filter #
0523
R-1 75%-1-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	911.5	°F
Average Meter Temp	(t_m)	82.3	
Orifice Meter Coefficient	(ΔH@)	1.831	in H_2O
Square Root ΔP	($\Delta p^{1/2}_{avg}$)	0.60	in H_2O
Stack Moisture Content	(B_{ws})	14.21	%
Stack Dry Molecular Weight	(M_d)	29.41	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.75	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.04	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.2888	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.89	in Hg
Stack Static Pressure	(P_{static})	0.21	in H_2O
Absolute Stack Pressure	(P_s)	29.91	in Hg
Absolute Meter Pressure	(P_m)	30.02	in Hg

Nozzle Measurements			**ID: G-10**	
Pre	0.312	0.311	0.311	**PASS**
Post	0.312	0.311	0.311	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	08:08	**End**	09:42

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	360.0	604.3	721.1	823.4				
Post	524.3	605.5	724.5	832.6				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0079	samp-hp-0079	samp-BH-0018	samp-cc-0011	2917	1004	samp-cp-0022		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity ($v_s)_i$**	**Cumul. Meter Volume ($V_m)_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume ($V_m)_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	171.591	0.40	1.215	1.30	884	250	250	60	64	83	74	74	3.0	0.63	56.59	2.324	102.6	55.786
A-2	3.8	00:03:45	173.970	0.39	1.185	1.20	911	248	248	60	66	82	74	74	3.0	0.62	56.44	4.542	101.4	54.502
A-3	7.5	00:07:30	176.240	0.39	1.185	1.20	912	248	247	62	65	81	74	74	3.0	0.62	56.46	6.769	101.1	54.152
A-4	11.3	00:11:15	178.520	0.41	1.245	1.30	912	250	249	63	66	81	75	75	3.0	0.64	57.89	9.070	101.2	54.423
A-5	15.0	00:15:00	180.880	0.41	1.245	1.30	914	250	250	63	68	81	76	76	3.0	0.64	57.93	11.397	101.4	54.705
A-6	18.8	00:18:45	183.270	0.40	1.215	1.30	911	250	250	64	71	82	77	77	3.0	0.63	57.16	13.651	101.3	54.604
A-7	22.5	00:22:30	185.590	0.40	1.215	1.30	911	250	250	62	72	83	78	78	3.0	0.63	57.16	15.940	101.4	54.651
A-8	26.3	00:26:15	187.950	0.39	1.185	1.20	912	248	250	62	53	80	79	79	3.0	0.62	56.46	18.146	101.2	54.439
A-9	30.0	00:30:00	190.230	0.37	1.124	1.20	910	249	249	62	50	79	80	80	3.0	0.61	54.95	20.349	101.3	54.263
A-10	33.8	00:33:45	192.510	0.37	1.124	1.20	912	250	250	62	50	78	81	81	3.0	0.61	54.99	22.537	101.3	54.090
A-11	37.5	00:37:30	194.780	0.36	1.094	1.20	910	249	249	63	51	79	82	82	3.0	0.60	54.20	24.684	101.2	53.855
A-12	41.3	00:41:15	197.010	0.35	1.063	1.10	909	250	250	63	53	79	83	83	3.0	0.59	53.43	26.756	101.0	53.512
B-1	45.0	00:45:00	199.168	0.30	0.911	0.96	915	250	251	59	42	84	84	84	3.0	0.55	49.57	28.751	101.2	53.079
B-2	48.8	00:48:45	201.250	0.27	0.820	0.86	917	248	250	60	42	83	84	84	3.0	0.52	47.06	30.591	101.1	52.441
B-3	52.5	00:52:30	203.170	0.28	0.851	0.90	915	250	249	61	43	82	85	85	3.0	0.53	47.89	32.494	101.1	51.990
B-4	56.3	00:56:15	205.160	0.29	0.881	0.93	915	249	251	61	44	82	85	85	3.0	0.54	48.74	34.426	101.1	51.639
B-5	60.0	01:00:00	207.180	0.32	0.972	1.00	914	250	250	61	46	82	86	86	3.0	0.57	51.18	36.431	101.1	51.432
B-6	63.8	01:03:45	209.280	0.33	1.002	1.10	913	250	251	61	48	82	87	87	3.0	0.57	51.95	38.462	101.0	51.283
B-7	67.5	01:07:30	211.410	0.35	1.063	1.10	913	250	249	60	47	82	87	87	3.0	0.59	53.50	40.493	100.8	51.149
B-8	71.3	01:11:15	213.540	0.35	1.063	1.10	916	249	251	61	49	82	88	88	3.0	0.59	53.56	42.520	100.6	51.023
B-9	75.0	01:15:00	215.670	0.35	1.063	1.10	917	249	250	61	50	83	89	89	3.0	0.59	53.58	44.533	100.4	50.895
B-10	78.8	01:18:45	217.790	0.37	1.124	1.20	915	250	250	61	51	83	89	89	3.0	0.61	55.05	46.614	100.2	50.852
B-11	82.5	01:22:30	219.980	0.36	1.094	1.20	911	248	251	61	53	83	89	89	3.0	0.60	54.22	48.676	100.1	50.792
B-12	86.3	01:26:15	222.150	0.34	1.033	1.10	908	250	250	61	54	83	90	90	3.0	0.58	52.64	50.719	100.0	50.719
Last Pt	90.0	01:30:00	224.305																	
Final Val	90.0	01:30:00	224.305											**Max Vac**	3.0	**Final Values**		50.719	100.0	
Average Values				0.36		1.14	912	249	250	61	54	82	82	82		0.60	53.86			
													82							

Notes:

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/30/21
Operator	JLW
Run Number	R-1 75%-2

Filter #
0916
R-1 75%-2-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	908.8	°F
Average Meter Temp	(t_m)	92.1	
Orifice Meter Coefficient	($\Delta H@$)	1.831	in H_2O
Square Root ΔP	($\Delta p^{1/2}_{avg}$)	0.59	in H_2O
Stack Moisture Content	(B_{ws})	13.78	%
Stack Dry Molecular Weight	(M_d)	29.41	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.56	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.12	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.2482	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.90	in Hg
Stack Static Pressure	(P_{static})	0.21	in H_2O
Absolute Stack Pressure	(P_s)	29.92	in Hg
Absolute Meter Pressure	(P_m)	30.03	in Hg

Nozzle Measurements			**ID: G-10**	
Pre	0.311	0.312	0.311	**PASS**
Post	0.311	0.312	0.311	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	13:17	**End**	14:56

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	351.7	615.1	722.8	863.2				
Post	505.3	615.7	730.5	872.9				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0079	samp-hp-0079	samp-BH-0018	samp-cc-0011	3006	8471	samp-cp-0022		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity (v_s)$_i$**	**Cumul. Meter Volume (V_m)$_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume (V_m)$_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	224.575	0.28	0.875	0.86	896	250	249	66	65	72	85	85	2.0	0.53	47.51	1.822	96.1	43.737
A-2	3.8	00:03:45	226.480	0.27	0.844	0.82	904	247	250	65	56	74	86	86	2.0	0.52	46.79	3.636	96.9	43.637
A-3	7.5	00:07:30	228.380	0.28	0.875	0.86	908	249	251	65	55	74	86	86	2.0	0.53	47.72	5.508	97.7	44.064
A-4	11.3	00:11:15	230.340	0.29	0.906	0.89	911	249	252	64	55	74	87	87	2.0	0.54	48.62	7.405	98.0	44.429
A-5	15.0	00:15:00	232.330	0.31	0.969	0.95	911	249	250	64	57	74	88	88	2.0	0.56	50.27	9.384	98.4	45.044
A-6	18.8	00:18:45	234.410	0.32	1.000	0.98	914	250	250	65	60	73	88	88	2.0	0.57	51.13	11.354	98.3	45.417
A-7	22.5	00:22:30	236.480	0.35	1.093	1.10	912	251	249	65	62	74	89	89	2.0	0.59	53.43	13.445	98.4	46.096
A-8	26.3	00:26:15	238.680	0.35	1.093	1.10	912	250	250	64	63	74	90	90	2.0	0.59	53.43	15.541	98.6	46.622
A-9	30.0	00:30:00	240.890	0.36	1.125	1.10	912	250	251	64	60	75	91	91	2.0	0.60	54.19	17.624	98.4	46.996
A-10	33.8	00:33:45	243.090	0.37	1.156	1.10	911	250	249	63	60	75	92	92	2.0	0.61	54.92	19.712	98.2	47.309
A-11	37.5	00:37:30	245.300	0.36	1.125	1.10	911	250	250	63	60	75	92	92	2.0	0.60	54.17	21.857	98.4	47.689
A-12	41.3	00:41:15	247.570	0.34	1.062	1.00	910	250	251	63	60	75	93	93	2.0	0.58	52.62	23.891	98.4	47.782
B-1	45.0	00:45:00	249.726	0.40	1.250	1.20	893	248	250	55	63	78	93	93	2.0	0.63	56.72	26.103	98.3	48.189
B-2	48.8	00:48:45	252.070	0.40	1.250	1.20	899	251	250	59	63	78	93	93	2.0	0.63	56.85	28.320	98.3	48.548
B-3	52.5	00:52:30	254.420	0.39	1.218	1.20	905	250	249	59	65	79	94	94	2.0	0.62	56.26	30.552	98.4	48.883
B-4	56.3	00:56:15	256.790	0.40	1.250	1.20	909	250	250	60	65	79	94	94	2.0	0.63	57.06	32.831	98.6	49.247
B-5	60.0	01:00:00	259.210	0.41	1.281	1.30	911	249	249	60	66	78	95	95	2.0	0.64	57.81	35.201	98.9	49.696
B-6	63.8	01:03:45	261.730	0.40	1.250	1.20	912	251	250	60	66	78	95	95	2.0	0.63	57.12	37.505	99.1	50.006
B-7	67.5	01:07:30	264.180	0.39	1.218	1.20	912	249	249	58	66	78	96	96	2.0	0.62	56.40	39.804	99.4	50.279
B-8	71.3	01:11:15	266.630	0.39	1.218	1.20	915	249	250	58	65	77	96	96	2.0	0.62	56.46	42.085	99.6	50.501
B-9	75.0	01:15:00	269.060	0.38	1.187	1.20	912	249	251	58	66	78	97	97	2.0	0.62	55.67	44.352	99.8	50.687
B-10	78.8	01:18:45	271.480	0.37	1.156	1.10	911	250	251	58	67	78	97	97	2.0	0.61	54.92	46.468	99.7	50.693
B-11	82.5	01:22:30	273.740	0.35	1.093	1.10	911	250	249	58	67	78	97	97	2.0	0.59	53.41	48.519	99.6	50.629
B-12	86.3	01:26:15	275.930	0.35	1.093	1.10	909	250	251	58	67	78	97	97	2.0	0.59	53.37	50.599	99.5	50.599
Last Pt	90.0	01:30:00	278.151																	
Final Val	90.0	01:30:00	278.151											**Max Vac**	2.0	**Final Values**		50.599	99.5	
Average Values				0.35		1.09	909	250	250	61	62	76	92	92		0.59	53.62			
													92							

Notes:

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	07/30/21
Operator	JLW
Run Number	R-1 75%-3

Filter #
0917
R-1 75%-3-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	910.2	°F
Average Meter Temp	(t_m)	94.8	
Orifice Meter Coefficient	(ΔH@)	1.831	in H_2O
Square Root ΔP	($\Delta p^{1/2}{}_{avg}$)	0.60	in H_2O
Stack Moisture Content	(B_{ws})	13.54	%
Stack Dry Molecular Weight	(M_d)	29.42	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.56	acfm
ΔP to ΔH Isokinetic Factor	(K)	3.15	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	7.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0022		
Meter Cal Factor	(Y)	0.986	
Nozzle Number	G-10		
Average Nozzle Diameter	(D_{na})	0.3113	in
Suggested Nozzle Diameter	(D_{ni})	0.2474	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0018		
Impinger Case Number	samp-cc-0011		

Pressures			
Barometric Pressure	(P_b)	29.86	in Hg
Stack Static Pressure	(P_{static})	0.21	in H_2O
Absolute Stack Pressure	(P_s)	29.88	in Hg
Absolute Meter Pressure	(P_m)	29.99	in Hg

Nozzle Measurements			ID: G-10	
Pre	0.311	0.312	0.311	**PASS**
Post	0.311	0.312	0.311	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
Extra

Run Time			
Start	15:25	**End**	17:01

Weights	Imp 1	Imp 2	Imp 3	Imp 4	Imp 5	Imp 6	Imp 7	Imp 8
Pre	359.8	604.6	724.5	823.3				
Post	516.0	603.5	726.6	834.4				

Wash Volumes						ml
						ml

Identification Nos.		samp-cp-0022	samp-cp-0022	samp-cp-0022			samp-hp-0079	samp-hp-0079	samp-BH-0018	samp-cc-0011	2917	1004	samp-cp-0022		samp-cp-0022					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity ($(v_s)_I$)**	**Cumul. Meter Volume ($(V_m)_{std}$)**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume ($(V_m)_{std}$)**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	278.408	0.38	1.197	1.20	909	249	252	64	60	81	91	91	3.0	0.62	55.61	2.253	102.3	54.066
A-2	3.8	00:03:45	280.790	0.39	1.229	1.20	911	250	252	64	60	80	91	91	3.0	0.62	56.38	4.418	99.8	53.022
A-3	7.5	00:07:30	283.080	0.39	1.229	1.20	912	248	250	63	61	79	91	91	3.0	0.62	56.40	6.688	100.5	53.506
A-4	11.3	00:11:15	285.480	0.41	1.292	1.30	914	250	252	63	61	78	91	91	3.0	0.64	57.87	8.864	99.3	53.184
A-5	15.0	00:15:00	287.780	0.41	1.292	1.30	913	250	249	62	62	78	92	92	3.0	0.64	57.85	11.262	100.5	54.059
A-6	18.8	00:18:45	290.320	0.40	1.260	1.30	915	249	252	62	64	78	93	93	3.0	0.63	57.18	13.694	101.8	54.776
A-7	22.5	00:22:30	292.900	0.39	1.229	1.20	914	251	250	62	64	78	93	93	3.0	0.62	56.44	15.880	101.3	54.447
A-8	26.3	00:26:15	295.220	0.38	1.197	1.20	912	248	251	62	65	78	94	94	3.0	0.62	55.67	18.044	101.0	54.131
A-9	30.0	00:30:00	297.520	0.38	1.197	1.20	912	249	249	63	65	79	94	94	3.0	0.62	55.67	20.217	100.7	53.911
A-10	33.8	00:33:45	299.830	0.37	1.166	1.20	913	250	250	63	65	79	95	95	3.0	0.61	54.95	22.442	100.9	53.860
A-11	37.5	00:37:30	302.200	0.36	1.134	1.10	911	249	252	63	66	80	95	95	3.0	0.60	54.16	24.544	100.7	53.551
A-12	41.3	00:41:15	304.440	0.35	1.103	1.10	909	250	250	64	67	80	96	96	3.0	0.59	53.37	26.650	100.6	53.300
B-1	45.0	00:45:00	306.687	0.30	0.945	0.94	895	250	250	65	68	79	95	95	3.0	0.55	49.16	28.595	100.5	52.791
B-2	48.8	00:48:45	308.760	0.28	0.882	0.88	905	249	250	65	68	79	95	95	3.0	0.53	47.66	30.471	100.4	52.237
B-3	52.5	00:52:30	310.760	0.29	0.914	0.91	908	249	249	64	67	79	95	95	3.0	0.54	48.56	32.376	100.3	51.802
B-4	56.3	00:56:15	312.790	0.30	0.945	0.94	911	249	250	64	67	79	96	96	3.0	0.55	49.44	34.296	100.2	51.444
B-5	60.0	01:00:00	314.840	0.32	1.008	1.00	910	250	252	64	67	79	96	96	3.0	0.57	51.05	36.301	100.2	51.248
B-6	63.8	01:03:45	316.980	0.33	1.040	1.00	912	248	250	65	68	80	97	97	3.0	0.57	51.88	38.311	100.1	51.082
B-7	67.5	01:07:30	319.130	0.35	1.103	1.10	912	248	250	65	68	80	97	97	3.0	0.59	53.43	40.350	99.9	50.969
B-8	71.3	01:11:15	321.310	0.35	1.103	1.10	911	249	252	65	68	80	97	97	3.0	0.59	53.41	42.352	99.6	50.822
B-9	75.0	01:15:00	323.450	0.35	1.103	1.10	911	248	249	65	67	79	97	97	3.0	0.59	53.41	44.494	99.7	50.850
B-10	78.8	01:18:45	325.740	0.36	1.134	1.10	910	250	251	66	67	79	98	98	3.0	0.60	54.14	46.529	99.5	50.759
B-11	82.5	01:22:30	327.920	0.36	1.134	1.10	909	251	250	66	67	79	98	98	3.0	0.60	54.12	48.602	99.4	50.715
B-12	86.3	01:26:15	330.140	0.34	1.071	1.10	905	249	250	66	67	79	98	98	3.0	0.58	52.52	50.669	99.4	50.669
Last Pt	90.0	01:30:00	332.354																	
Final Val	90.0	01:30:00	332.354											**Max Vac**	3.0	**Final Values**		50.669	99.4	
Average Values				0.36		1.12	910	249	251	64	65	79	95	95		0.60	53.76			
													95							

Notes:

AIR HYGIENE

PM (EPA METHOD 5) DATA SHEET

Project Code: catc-21-houston.tx-start#1

Site Info.
Plant Name. . . . .
Sampling Location. . . . . . .
Unit # . . . .
Date. 7.30.21

Console Info.
Console. samp-cp-0022
Meter Calibratrion Factor 0.986
Orifice Meter Coefficient 1.831

PM RUNS

Run#: 1	Load: 75% normal				Box#: Samp-ee-0011			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	$(V_f),(W_f)$	524.3	605.5	724.5	~~823.4~~	832.6		
Initial Value	$(V_i),(W_i)$	360.0	604.3	721.1	823.4			
Filter #	0523		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Run#: 2	Load: 75% normal				Box#:			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	$(V_f),(W_f)$	505.3	615.7	730.5	872.9			
Initial Value	$(V_i),(W_i)$	351.7	615.1	722.8	863.2			
Filter #	0916		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Run#: 3	Load: normal				Box#:			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	$(V_f),(W_f)$	516.0	603.5	726.6	834.4			
Initial Value	$(V_i),(W_i)$	359.8	604.6	724.5	823.3			
Filter #	0917		Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Run#:	Load: normal				Box#:			
		Impinger 1	Impinger 2	Impinger 3	Impinger 4	Impinger 5	Impinger 6	Impinger 7
		(g)	(g)	(g)	(g)			
Contents		Dry	Di Water	Dry	Sil Gel			
Final Value	$(V_f),(W_f)$							
Initial Value	$(V_i),(W_i)$							
Filter #			Probe #		Probe (in.)			
Pitot #			Nozzle #		Nozzle Meas			

Signature [signature]

EMISSION DATA RECORDS

100% Load
PM
Reference Method Data

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE

Source Information	
Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Fuel Type	Gas, Natural

Test Information			
Project #		catc-21-houston.tx-start#1	
Operator		TP	
Date for Preliminary Run	(mm/dd/yy)	08/31/21	
Standard Temperature		68	°F
Standard Pressure		29.92	in Hg
Run Duration	≥ 2 min/point	90	minutes
Unit Number		1	
Base Run Number		R-1 100%	
Number of Ports Available		2	
Number of Ports Used		2	
Port Inside Diameter		4.00	in
Stack Shape		Circular	

Test Equipment Information					
Run		1	2	3	
Test Date	(mm/dd/yy)	08/31/21	08/31/21	08/31/21	
Load		100%	100%	100%	% or w/DB
Fuel F-Factor		8631.42	8631.42	8631.42	dscf/MMBtu
Meter Box Number	from ACS	samp-cp-0021	samp-cp-0021	samp-cp-0021	
Meter Calibration Factor	(Y)	0.970	0.970	0.970	
Orifice Meter Coefficient	($\Delta H_@$)	1.812	1.812	1.812	in H_2O
Non-Console Manometer Used		No	No	No	
Pitot Identification	from ACS	A5708	A5708	A5708	
Pitot Tube Coefficient	(C_p)	0.8230	0.8230	0.8230	
Nozzle Number	from ACS	H-10	H-10	H-10	
Nozzle Diameter	(D_n)	0.293	0.293	0.293	in
Probe Number	from ACS	samp-hp-0079	samp-hp-0079	samp-hp-0079	
Probe Length		60.0	60.0	60.0	in
(SS, Glass ….) Liner Material	from list	glass	glass	glass	
Sample Case / Oven Number	from ACS	samp-BH-0036	samp-BH-0036	samp-BH-0036	
Impinger Case Number	from ACS	samp-cc-0009	samp-cc-0009	samp-cc-0009	

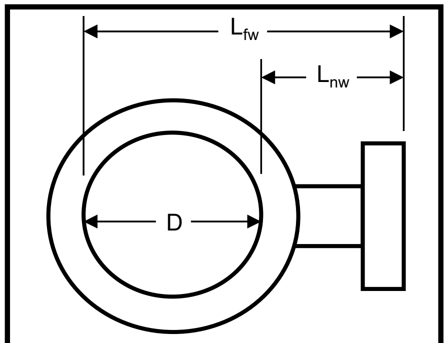
Testing Company Information	
Company Name	Air Hygiene International, Inc. (Tulsa, Oklahoma)
Address	1600 W Tacoma Street
City, State Zip	Broken Arrow, Oklahoma 74012
Project Manager	Matt McBride
Phone Number	(918) 307-8865
Fax Number	(918) 307-9131

Created with Isocalc-AHI v20210708

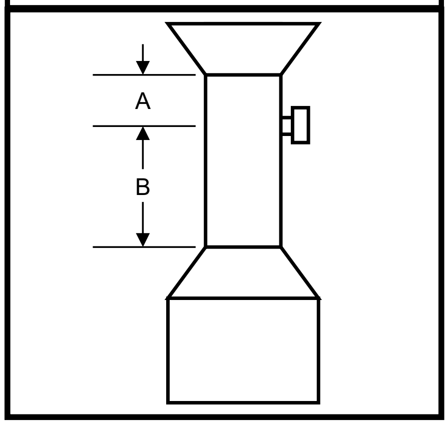
METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR CIRCULAR SOURCES

Plant Name	Stewart and Stevenson Integration Center	**Date**	08/31/21
Sampling Location	Caterpillar G3520 TALE	**Stack Type**	Circular
Operator	TP	**Ports Available**	2
Project #	catc-21-houston.tx-start#1	**Ports Used**	2
Stack Size	Large (>24 inch diameter)	**Port ID (inches)**	4.00

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	32.00	in
Distance to Near Wall of Stack	(L_{nw})	0.125	in
Diameter of Stack	(D)	31.88	in
Area of Stack	(A_s)	5.54	ft²



Distance from Port to Disturbances			
Distance Upstream	(A)	16.00	in
Diameters Upstream	(A_D)	0.50	diameters
Distance Downstream	(B)	64.00	in
Diameters Downstream	(B_D)	2.01	diameters



Number of Traverse Points Required			
Diameters to Flow Disturbance		**Minimum Number of[1] Traverse Points**	
Down Stream	**Up Stream**	**Particulate Points**	**Velocity Points**
2.00-4.99	0.50-1.24	24	16
5.00-5.99	1.25-1.49	20	16
6.00-6.99	1.50-1.74	16	12
7.00-7.99	1.75-1.99	12	12
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]
Upstream Spec		24	16
Downstream Spec		24	16
Traverse Pts Required		24	16

[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches

◉ Method 1 Trav
○ 12 Point PM Trav (M201a ONLY)
○ Velocity

Number of Traverse Points Used			
2	**Ports by**	12	**Across**
24	**Pts Used**	24	**Required**
Adjust Sample Points Out of Boundary Layer			

Location of Traverse Points in Circular Stacks
(Fraction of Stack Dimension from Inside Wall to Traverse Point)

Traverse Point Number	2	4	6	8	10	12	14	16	18
1	.146	.067	.044	.032	.026	.021	.018	.016	.014
2	.854	.250	.146	.105	.082	.067	.057	.049	.044
3		.750	.296	.194	.146	.118	.099	.085	.075
4		.933	.704	.323	.226	.177	.146	.125	.109
5			.854	.677	.342	.250	.201	.169	.146
6			.956	.806	.658	.356	.269	.220	.188
7				.895	.774	.644	.366	.283	.236
8				.968	.854	.750	.634	.375	.296
9					.918	.823	.731	.625	.382
10					.974	.882	.799	.717	.618
11						.933	.854	.780	.704
12						.979	.901	.831	.764

Traverse Point Locations			
Traverse Point Number	**Fraction of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
		in	in
1	0.021	5/8	6/8
2	0.067	2 1/8	2 2/8
3	0.118	3 6/8	3 7/8
4	0.177	5 5/8	5 6/8
5	0.250	8	8 1/8
6	0.356	11 3/8	11 4/8
7	0.644	20 4/8	20 5/8
8	0.750	23 7/8	24
9	0.823	26 2/8	26 3/8
10	0.882	28 1/8	28 2/8
11	0.933	29 6/8	29 7/8
12	0.979	31 2/8	31 3/8

METHOD 2 - DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

Plant Name	Stewart and Stevenson Integration Center		
Sampling Location	Caterpillar G3520 TALE		
Operator	TP		
Project #	catc-21-houston.tx-start#1		
Pitot Leak Check	x	**PreTest**	x	**PostTest**

Preliminary Run Date	08/31/21		
Stack Type	Circular		
Ports Available	2		
Thermocouple ID	samp-hp-0079		
Pitot Coefficient	0.8300	**Pitot Identification**	A6904

Stack Dimensions			
Area of Stack	(A_s)	5.54	ft²
Diameter of Stack	(D)	31.88	in

Pressures			
Barometric Pressure	(P_b)	29.69	in Hg
Static Pressure	(P_{static})	-0.36	in H_2O
Absolute Stack Pressure	(P_s)	29.66	in Hg

Stack Gas Composition			
Composition Data:	**Estimated Composition**		
Carbon Dioxide Concentration	(%CO_2)	6.66	%vd
Oxygen Concentration	(%O_2)	8.94	%vd
Carbon Monoxide Concentration	(ppmCO)	3.59	ppmvd
Nitrogen Concentration	(%N_2)	84.40	%vd
Stack Moisture Content	(B_{ws})	14.00	%
Stack Dry Molecular Weight	(M_d)	29.42	lb/lb-mole
Stack Wet Molecular Weight	(M_w)	27.82	lb/lb-mole

Results			
Avg Stack Gas Velocity	(v_s)	62.17	ft/sec
Avg Stack Dry Std Flow Rate	(Q_{sd})	418,383	dscf/hr
Avg Stack Dry Std Flow Rate	(Q_{sd})	6,973	dscf/min
Avg Stack Wet Flow Rate	(Q_{aw})	20,670	acf/min
Avg Stack Wet Std Flow Rate	(Q_{sw})	486,492	ascf/hr

40 CFR 60, Method 2G, Section 8.11.1 (but applies to all Method 2 type static pressure measurements):
If a Type S probe is used for this measurement, position the probe at or between any traverse point(s) and rotate the probe until a null differential pressure reading is obtained. Disconnect the tubing from one of the pressure ports; read and record the ΔP. For pressure devices with one-directional scales, if a deflection in the positive direction is noted with the negative side disconnected, then the static pressure is positive. Likewise, if a deflection in the positive direction is noted with the positive side disconnected, then the static pressure is negative.

Stack Cross Section Schematic

Velocity Traverse Data					
Run Number	R-1 100%-V1				
Run Time	07:14	**Start**	07:38	**End**	
Traverse Point	**Velocity Head** (Δp)	**Null Angle** (N_a)	**Zero Deg Pressure** ($0^o{}_a$)	**Stack Temp** (t_s)	**Local Velocity** ($v_{s(l)}$)
	in H_2O	deg	in H_2O	°F	ft/sec
A-1	0.53	-5	0.20	878	65.77
A-2	0.53	-5	0.20	879	65.80
A-3	0.53	5	-0.05	878	65.77
A-4	0.56	10	-0.10	879	67.63
A-5	0.58	15	-0.10	882	68.91
A-6	0.60	-5	0.20	882	70.08
A-7	0.50	15	-0.05	873	63.76
A-8	0.43	0	0.00	866	58.98
A-9	0.39	5	-0.03	867	56.19
A-10	0.37	0	0.00	866	54.71
A-11	0.36	0	0.00	865	53.94
A-12	0.36	0	0.00	865	53.94
B-1	0.50	-5	0.04	877	63.86
B-2	0.50	-5	0.04	878	63.88
B-3	0.51	5	-0.04	878	64.52
B-4	0.53	10	-0.05	879	65.80
B-5	0.61	5	-0.10	880	70.61
B-6	0.63	5	-0.06	881	71.79
B-7	0.52	-5	0.05	874	65.05
B-8	0.44	5	-0.03	873	59.82
B-9	0.40	5	-0.04	873	57.03
B-10	0.39	-5	0.04	872	56.29
B-11	0.36	0	0.00	872	54.08
B-12	0.36	0	0.00	871	54.06
Average	0.48	5		875	
	0.69	**= Square roots of Δp**			
Standard deviation of null angles =				4.2	

METHOD 3a - DETERMINATION OF DRY MOLECULAR WEIGHT BY ANALYZER

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	08/31/21		
Sampling Location	Caterpillar G3520 TALE	**Operator**	TP		
Project #	catc-21-houston.tx-start#1	**# of Ports Used**	1 (gas probe)		
Fuel Type	Gas, Natural	**Min. Fuel Factor**	1.600	**Max. Fuel Factor**	1.836

Gas Analysis Data

Run Number	R-1 100%-1		**Date**	08/31/21	**Run Start Time**	09:36	**Run Stop Time**	11:17
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:41	6.81	8.64	4.36	84.6	29.44	1.800	63.1	YES

Gas Analysis Data

Run Number	R-1 100%-2		**Date**	08/31/21	**Run Start Time**	12:05	**Run Stop Time**	13:44
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:39	6.58	9.06	2.18	84.4	29.41	1.800	68.6	YES

Gas Analysis Data

Run Number	R-1 100%-3		**Date**	08/31/21	**Run Start Time**	14:24	**Run Stop Time**	16:05
Sample Analysis Time	**CO_2 Conc.**	**O_2 Conc.**	**CO Conc.**	**N_2 Conc.**	**Dry Molecular Weight**	**Calculated Fuel Factor**	**Excess Air**	**Fuel Factor in Range**
	($\%CO_2$)	($\%O_2$)	(ppmCO)	($\%N_2$)	(M_d)	(Fo)avg	(%EA)avg	
hh:mm	%	%	ppm	%	lb/lb-mole		%	
01:41	6.58	9.06	2.18	84.4	29.41	1.800	68.6	YES

METHOD 4 - DETERMINATION OF MOISTURE CONTENT IN STACK GASES

Plant Name	Stewart and Stevenson Integration Center	**Preliminary Run Date**	08/31/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	TP
Project #	catc-21-houston.tx-start#1	**Ports Used**	2

Scale Daily Calibration					
Scale Number	SAMP-SC-0025	**Standard**	**Result**	**Difference**	**Pass/Fail**
Date		(g)	(g)	(g)	(± 0.5 g)
Test Day 1	08/31/21	500	499.5	-0.5	Pass

Moisture Content Data									
Run Number		R-1 100%-1		**Date**	08/31/21	**Start Time**	09:36	**Stop Time**	11:17
Meter Box Number		samp-cp-0021				**Meter Cal Factor**	(Y)	0.970	
Total Meter Volume		(V_m)	62.495	dcf		**Barometric Pressure**	(P_b)	29.72	in Hg
Average Stack Temp		$(t_s)_{avg}$	878	°F		**Stack Static Pressure**	(P_{static})	-0.36	in H_2O
Average Meter Temp		$(t_m)_{avg}$	84	°F		**Avg Orifice Pressure**	$(\Delta H)_{avg}$	1.41	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	540.00	641.60	676.30	874.30				
Initial Value	$(V_i),(W_i)$	360.60	635.70	672.50	859.20				
Net Value	$(V_n),(W_n)$	179.4	5.9	3.8	15.1				
Results									
Total Weight		(W_t)	204.20	g		**Water Vol Weighed**	$(V_{wsg(std)})$	9.628	scf
Std Meter Volume		$(V_{m(std)})$	58.697	dscf		**Sat. Moisture Content**	$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.09	%		**Final Moisture Content**	(B_{ws})	14.09	%

Moisture Content Data									
Run Number		R-1 100%-2		**Date**	08/31/21	**Start Time**	12:05	**Stop Time**	13:44
Meter Box Number		samp-cp-0021				**Meter Cal Factor**	(Y)	0.970	
Total Meter Volume		(V_m)	62.465	dcf		**Barometric Pressure**	(P_b)	29.71	in Hg
Average Stack Temp		$(t_s)_{avg}$	878	°F		**Stack Static Pressure**	(P_{static})	-0.36	in H_2O
Average Meter Temp		$(t_m)_{avg}$	91	°F		**Avg Orifice Pressure**	$(\Delta H)_{avg}$	1.43	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	521.40	609.40	723.30	860.10				
Initial Value	$(V_i),(W_i)$	346.10	604.10	719.20	844.50				
Net Value	$(V_n),(W_n)$	175.3	5.3	4.1	15.6				
Results									
Total Weight		(W_t)	200.30	g		**Water Vol Weighed**	$(V_{wsg(std)})$	9.444	scf
Std Meter Volume		$(V_{m(std)})$	57.810	dscf		**Sat. Moisture Content**	$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	14.04	%		**Final Moisture Content**	(B_{ws})	14.04	%

Moisture Content Data									
Run Number		R-1 100%-3		**Date**	08/31/21	**Start Time**	14:24	**Stop Time**	16:05
Meter Box Number		samp-cp-0021				**Meter Cal Factor**	(Y)	0.970	
Total Meter Volume		(V_m)	62.265	dcf		**Barometric Pressure**	(P_b)	29.66	in Hg
Average Stack Temp		$(t_s)_{avg}$	877	°F		**Stack Static Pressure**	(P_{static})	-0.36	in H_2O
Average Meter Temp		$(t_m)_{avg}$	77	°F		**Avg Orifice Pressure**	$(\Delta H)_{avg}$	1.47	in H_2O
		Impinger 1	**Impinger 2**	**Impinger 3**	**Impinger 4**	**Impinger 5**	**Impinger 6**	**Impinger 7**	**Impinger 8**
		(g)	(g)	(g)	(g)				
Contents		Dry	Dry	DI Water	Sil Gel				
Final Value	$(V_f),(W_f)$	573.90	618.50	758.30	870.70				
Initial Value	$(V_i),(W_i)$	347.60	615.30	754.70	855.40				
Net Value	$(V_n),(W_n)$	226.3	3.2	3.6	15.3				
Results									
Total Weight		(W_t)	248.40	g		**Water Vol Weighed**	$(V_{wsg(std)})$	11.712	scf
Std Meter Volume		$(V_{m(std)})$	59.138	dscf		**Sat. Moisture Content**	$(B_{ws(svp)})$	100.00	%
Calc Moisture Content		$(B_{ws(calc)})$	16.53	%		**Final Moisture Content**	(B_{ws})	16.53	%

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	08/31/21
Operator	TP
Run Number	R-1 100%-1

Filter #
0523
R-1 100%-1-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	877.8	°F
Average Meter Temp	(t_m)	83.5	
Orifice Meter Coefficient	($\Delta H@$)	1.812	in H_2O
Square Root ΔP	($\Delta p^{1/2}_{avg}$)	0.76	in H_2O
Stack Moisture Content	(B_{ws})	14.09	%
Stack Dry Molecular Weight	(M_d)	29.44	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.75	acfm
ΔP to ΔH Isokinetic Factor	(K)	2.43	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	4.5	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	5.1	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	5.2	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0021		
Meter Cal Factor	(Y)	0.970	
Nozzle Number	H-10		
Average Nozzle Diameter	(D_{na})	0.2930	in
Suggested Nozzle Diameter	(D_{ni})	0.2696	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0036		
Impinger Case Number	samp-cc-0009		

Pressures			
Barometric Pressure	(P_b)	29.72	in Hg
Stack Static Pressure	(P_{static})	-0.36	in H_2O
Absolute Stack Pressure	(P_s)	29.69	in Hg
Absolute Meter Pressure	(P_m)	29.85	in Hg

Nozzle Measurements		**ID: H-10**	
Pre 0.293	0.292	0.294	**PASS**
Post 0.293	0.292	0.294	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
SAMP-SC-0025

Run Time			
Start	09:36	**End**	11:17

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	360.6	635.7	672.5	859.2				
Post	540.0	641.6	676.3	874.3				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0021	samp-cp-0021	samp-cp-0021			samp-hp-0079	samp-hp-0079	samp-BH-0036	samp-cc-0009	**2917**	**1004**	**samp-cp-0021**		samp-cp-0021					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity ($v_s)_i$**	**Cumul. Meter Volume ($V_m)_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume ($V_m)_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	921.610	0.65	1.577	1.60	888	888	252	53	73	84	77	77	4.5	0.81	72.46	2.402	94.3	57.638
A-2	3.8	00:03:45	924.135	0.66	1.601	1.60	890	890	253	56	77	85	79	79	5.0	0.81	73.07	5.097	100.0	61.170
A-3	7.5	00:07:30	926.980	0.65	1.577	1.60	888	888	249	56	85	84	79	79	5.0	0.81	72.46	7.817	102.3	62.536
A-4	11.3	00:11:15	929.850	0.71	1.722	1.70	887	887	249	54	83	82	79	79	5.0	0.84	75.70	10.566	102.6	63.394
A-5	15.0	00:15:00	932.750	0.72	1.746	1.80	885	885	250	58	85	81	81	81	5.0	0.85	76.17	13.584	104.8	65.201
A-6	18.8	00:18:45	935.945	0.75	1.819	1.80	882	882	253	55	82	79	80	80	5.0	0.87	77.66	15.836	101.5	63.343
A-7	22.5	00:22:30	938.325	0.65	1.577	1.60	875	875	252	57	81	81	81	81	5.0	0.81	72.11	18.607	102.5	63.794
A-8	26.3	00:26:15	941.260	0.56	1.358	1.30	874	874	248	61	82	83	83	83	3.5	0.75	66.90	21.079	102.7	63.236
A-9	30.0	00:30:00	943.890	0.49	1.188	1.20	862	862	256	63	73	83	82	82	3.5	0.70	62.30	23.437	103.0	62.498
A-10	33.8	00:33:45	946.395	0.40	0.970	0.98	863	863	246	60	74	83	84	84	3.5	0.63	56.31	25.762	104.1	61.828
A-11	37.5	00:37:30	948.875	0.39	0.946	0.95	855	855	248	61	69	83	84	84	3.0	0.62	55.43	27.754	103.8	60.553
A-12	41.3	00:41:15	951.000	0.39	0.946	0.95	855	855	256	66	74	85	84	84	3.0	0.62	55.43	29.628	103.2	59.257
B-1	45.0	00:45:00	953.000	0.51	1.237	1.20	882	882	256	66	73	85	85	85	3.5	0.71	64.04	31.805	102.7	58.717
B-2	48.8	00:48:45	955.325	0.53	1.286	1.30	884	884	246	52	77	82	84	84	4.0	0.73	65.33	34.198	102.8	58.624
B-3	52.5	00:52:30	957.875	0.57	1.383	1.40	884	884	251	50	75	78	85	85	4.0	0.75	67.75	36.600	102.6	58.560
B-4	56.3	00:56:15	960.440	0.61	1.480	1.50	885	885	250	54	55	78	84	84	4.0	0.78	70.11	39.003	102.3	58.505
B-5	60.0	01:00:00	963.000	0.63	1.528	1.50	886	886	254	55	55	79	85	85	4.0	0.79	71.28	41.486	102.1	58.568
B-6	63.8	01:03:45	965.650	0.66	1.601	1.60	886	886	250	57	57	80	86	86	4.5	0.81	72.96	44.077	102.0	58.769
B-7	67.5	01:07:30	968.420	0.71	1.722	1.70	882	882	253	58	60	79	86	86	4.5	0.84	75.56	46.631	101.7	58.903
B-8	71.3	01:11:15	971.150	0.65	1.577	1.60	878	878	253	58	66	84	86	86	4.5	0.81	72.19	49.297	101.8	59.157
B-9	75.0	01:15:00	974.000	0.58	1.407	1.40	876	876	249	59	62	85	87	87	4.5	0.76	68.14	51.836	102.0	59.241
B-10	78.8	01:18:45	976.720	0.56	1.358	1.40	875	875	251	60	59	85	87	87	4.5	0.75	66.93	54.286	102.0	59.221
B-11	82.5	01:22:30	979.345	0.47	1.140	1.10	870	870	251	56	57	85	88	88	3.5	0.69	61.20	56.515	102.0	58.972
B-12	86.3	01:26:15	981.740	0.46	1.116	1.10	874	874	255	63	61	85	89	89	3.5	0.68	60.64	58.713	102.0	58.713
Last Pt	90.0	01:30:00	984.105																	
Final Val	90.0	01:30:00	984.105											**Max Vac**	5.0	**Final Values**		58.713	102.0	
Average Values				0.58		1.41	878	878	251	58	71	82	84	84		0.76	68.00			
													84							

Notes:

Probe temp out of specification due to: stack temp

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	08/31/21
Operator	TP
Run Number	R-1 100%-2

Filter #
0916
R-1 100%-2-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	878.1	°F
Average Meter Temp	(t_m)	91.5	
Orifice Meter Coefficient	($\Delta H@$)	1.812	in H_2O
Square Root ΔP	($\Delta p^{1/2}_{avg}$)	0.76	in H_2O
Stack Moisture Content	(B_{ws})	14.04	%
Stack Dry Molecular Weight	(M_d)	29.41	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.65	acfm
ΔP to ΔH Isokinetic Factor	(K)	2.46	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	4.6	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	4.3	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	5.1	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	4.3	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0021		
Meter Cal Factor	(Y)	0.970	
Nozzle Number	H-10		
Average Nozzle Diameter	(D_{na})	0.2930	in
Suggested Nozzle Diameter	(D_{ni})	0.2494	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0036		
Impinger Case Number	samp-cc-0009		

Pressures			
Barometric Pressure	(P_b)	29.71	in Hg
Stack Static Pressure	(P_{static})	-0.36	in H_2O
Absolute Stack Pressure	(P_s)	29.68	in Hg
Absolute Meter Pressure	(P_m)	29.84	in Hg

Nozzle Measurements			**ID: H-10**	
Pre	0.293	0.292	0.294	**PASS**
Post	0.293	0.292	0.294	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
SAMP-SC-0025

Run Time			
Start	12:05	**End**	13:44

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	346.1	604.1	719.2	844.5				
Post	521.4	609.4	723.3	860.1				

Wash Volumes					ml
					ml

Identification Nos.		samp-cp-0021	samp-cp-0021	samp-cp-0021			samp-hp-0079	samp-hp-0079	samp-BH-0036	samp-cc-0009	**3006**	**8471**	**samp-cp-0021**		samp-cp-0021					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity ($(v_s)_i$)**	**Cumul. Meter Volume ($(V_m)_{std}$)**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume ($(V_m)_{std}$)**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	984.410	0.60	1.477	1.50	883	883	255	64	46	84	88	88	4.5	0.77	69.51	2.534	103.3	60.807
A-2	3.8	00:03:45	987.130	0.60	1.477	1.50	881	881	251	59	47	84	87	87	4.5	0.77	69.46	5.025	102.4	60.303
A-3	7.5	00:07:30	989.800	0.64	1.576	1.60	883	883	247	56	50	76	88	88	4.5	0.80	71.79	7.541	101.3	60.327
A-4	11.3	00:11:15	992.500	0.63	1.551	1.50	883	883	254	56	51	73	88	88	4.5	0.79	71.23	10.009	100.6	60.056
A-5	15.0	00:15:00	995.150	0.64	1.576	1.60	882	882	250	56	57	73	89	89	4.5	0.80	71.76	12.627	101.1	60.611
A-6	18.8	00:18:45	997.965	0.68	1.674	1.70	882	882	247	56	63	77	90	90	4.5	0.82	73.97	15.074	99.9	60.296
A-7	22.5	00:22:30	1000.600	0.62	1.527	1.50	878	878	251	57	49	76	92	92	4.5	0.79	70.53	17.686	100.6	60.639
A-8	26.3	00:26:15	1003.425	0.56	1.379	1.40	874	874	250	56	49	72	91	91	4.5	0.75	66.93	20.104	100.7	60.311
A-9	30.0	00:30:00	1006.035	0.53	1.305	1.30	873	873	253	55	47	71	92	92	4.0	0.73	65.09	22.414	100.6	59.772
A-10	33.8	00:33:45	1008.535	0.47	1.157	1.10	872	872	253	56	48	70	93	93	3.5	0.69	61.27	24.637	100.7	59.128
A-11	37.5	00:37:30	1010.945	0.44	1.083	1.10	867	867	256	57	50	71	93	93	3.5	0.66	59.17	26.785	100.8	58.441
A-12	41.3	00:41:15	1013.275	0.44	1.083	1.10	862	862	251	56	52	71	94	94	3.5	0.66	59.06	28.880	100.7	57.759
B-1	45.0	00:45:00	1015.550	0.63	1.551	1.50	884	884	254	68	59	85	94	94	4.0	0.79	71.25	31.321	100.4	57.824
B-2	48.8	00:48:45	1018.200	0.63	1.551	1.50	886	886	252	56	64	84	94	94	4.0	0.79	71.31	33.781	100.2	57.911
B-3	52.5	00:52:30	1020.870	0.64	1.576	1.60	889	889	247	57	69	83	94	94	4.5	0.80	71.95	36.279	100.1	58.046
B-4	56.3	00:56:15	1023.580	0.67	1.650	1.60	884	884	248	61	52	80	96	96	4.5	0.82	73.48	38.915	100.2	58.372
B-5	60.0	01:00:00	1026.450	0.67	1.650	1.60	883	883	247	64	55	69	97	97	4.5	0.82	73.45	41.344	99.8	58.368
B-6	63.8	01:03:45	1029.100	0.69	1.699	1.70	882	882	249	63	55	70	96	96	4.5	0.83	74.51	44.145	100.3	58.860
B-7	67.5	01:07:30	1032.150	0.69	1.699	1.70	882	882	256	64	61	71	95	95	4.5	0.83	74.51	46.519	99.7	58.761
B-8	71.3	01:11:15	1034.730	0.70	1.724	1.70	887	887	254	64	66	73	93	93	4.5	0.84	75.19	49.124	99.7	58.948
B-9	75.0	01:15:00	1037.550	0.55	1.354	1.30	879	879	249	67	71	74	90	90	4.0	0.74	66.45	51.526	99.8	58.887
B-10	78.8	01:18:45	1040.140	0.45	1.108	1.10	878	878	254	64	52	74	88	88	3.5	0.67	60.09	53.764	100.0	58.652
B-11	82.5	01:22:30	1042.545	0.41	1.010	1.00	860	860	255	63	50	72	87	87	3.0	0.64	56.97	55.801	100.0	58.227
B-12	86.3	01:26:15	1044.730	0.42	1.034	1.00	860	860	248	67	48	73	86	86	3.0	0.65	57.66	57.804	99.9	57.804
Last Pt	90.0	01:30:00	1046.875																	
Final Val	90.0	01:30:00	1046.875											**Max Vac**	4.5	**Final Values**		57.804	99.9	
Average Values				0.58		1.43	878	878	251	60	55	75	91	91		0.76	68.19			
													91							

Notes:

Probe temp out of specification due to: stack temp

METHOD 5 (FRONT) AND 202 (BACK) SOURCE SAMPLING TITLE PAGE ISOKINETIC SAMPLING DATA

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Date	08/31/21
Operator	TP
Run Number	R-1 100%-3

Filter #
0917
R-1 100%-3-CPM

Ideal Nozzle Diameter and IsoKinetic Factor Setup			
Pitot Coefficient / ID	(C_p)	0.8230	A5708
Average Stack Temp	(t_s)	876.7	°F
Average Meter Temp	(t_m)	76.5	
Orifice Meter Coefficient	($\Delta H@$)	1.812	in H_2O
Square Root ΔP	($\Delta p^{1/2}{}_{avg}$)	0.76	in H_2O
Stack Moisture Content	(B_{ws})	16.53	%
Stack Dry Molecular Weight	(M_d)	29.41	lb/lb-mole
Estimated Orifice Flow Rate	(Q_m)	0.64	acfm
ΔP to ΔH Isokinetic Factor	(K)	2.28	

Leak Checks		*[change]*		*[level]*		*[time]*	
Train	**Pre**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
PASS	**Post**	0.000	ft³/min@	15.0	in Hg for	60.0	sec [≥60]
Pitot	**Pre (+)**	0.00	in H_2O	5.0	in H_2O for	15.0	sec [≥15]
	Pre (-)	0.00	in H_2O	6.0	in H_2O for	15.0	sec [≥15]
PASS	**Post (+)**	0.00	in H_2O	5.8	in H_2O for	15.0	sec [≥15]
	Post (-)	0.00	in H_2O	5.2	in H_2O for	15.0	sec [≥15]

Sampling Equipment			
Meter Box Number	samp-cp-0021		
Meter Cal Factor	(Y)	0.970	
Nozzle Number	H-10		
Average Nozzle Diameter	(D_{na})	0.2930	in
Suggested Nozzle Diameter	(D_{ni})	0.2501	in
Probe Number	samp-hp-0079		in
Probe Length	60		in
Liner Material	glass		
Sample Case / Oven Number	samp-BH-0036		
Impinger Case Number	samp-cc-0009		

Pressures			
Barometric Pressure	(P_b)	29.66	in Hg
Stack Static Pressure	(P_{static})	-0.36	in H_2O
Absolute Stack Pressure	(P_s)	29.63	in Hg
Absolute Meter Pressure	(P_m)	29.79	in Hg

Nozzle Measurements			**ID: H-10**	
Pre	0.293	0.292	0.294	**PASS**
Post	0.293	0.292	0.294	**PASS**

Barometer ID
SAMP-WE-0014
Scale ID
SAMP-SC-0025

Run Time			
Start	14:24	**End**	16:05

Weights	**Imp 1**	**Imp 2**	**Imp 3**	**Imp 4**	**Imp 5**	**Imp 6**	**Imp 7**	**Imp 8**
Pre	347.6	615.3	754.7	855.4				
Post	573.9	618.5	758.3	870.7				

Wash Volumes					
					ml
					ml

Identification Nos.		samp-cp-0021	samp-cp-0021	samp-cp-0021			samp-hp-0079	samp-hp-0079	samp-BH-0036	samp-cc-0009	**2917**	**1004**	**samp-cp-0021**		samp-cp-0021					
Traverse Point #	**Sampling Time (Θ)**	**Timer Time**	**Dry Gas Meter Reading (V_m)**	**Velocity Head (Δp)**	**Desired Orifice ΔH (ΔH_d)**	**Actual Orifice ΔH (ΔH_a)**	**Stack Temp (t_s)**	**Probe Temp (248±25°F)**	**Filter Temp (248±25°F)**	**Impinger Exit Temp (≤68°F)**	**Cond. Temp (≤85°F)**	**CPM Filter Temp (76.5±8.5°F)**	**Meter Inlet Temp (t_{mi})**	**Meter Outlet Temp (t_{mo})**	**Pump Vacuum**	**Square Root ΔP ($\Delta p^{1/2}$)**	**Local Stack Velocity (v_s)$_l$**	**Cumul. Meter Volume (V_m)$_{std}$**	**Cumul. Percent IsoKinetic (I)**	**Est-Run Meter Volume (V_m)$_{std}$**
	min	hh:mm:ss	ft³	in H_2O	in H_2O	in H_2O	°F	°F	°F	°F	°F	°F	°F	°F	in Hg	√(in H_2O)	ft/sec	dscf	%	dscf
A-1	0.0	00:00:00	48.125	0.63	1.439	1.60	885	885	251	67	38	84	72	72	3.5	0.79	71.71	2.597	106.0	62.317
A-2	3.8	00:03:45	50.835	0.63	1.439	1.60	888	888	252	58	41	76	73	73	3.5	0.79	71.79	5.140	105.0	61.684
A-3	7.5	00:07:30	53.495	0.72	1.645	1.80	890	890	249	55	43	71	75	75	3.5	0.85	76.80	7.843	104.4	62.742
A-4	11.3	00:11:15	56.330	0.75	1.713	1.90	886	886	255	55	43	68	75	75	3.5	0.87	78.27	10.675	104.8	64.047
A-5	15.0	00:15:00	59.300	0.75	1.713	1.90	885	885	254	55	43	68	75	75	3.5	0.87	78.24	13.487	104.9	64.739
A-6	18.8	00:18:45	62.250	0.72	1.645	1.80	881	881	254	54	44	68	76	76	3.5	0.85	76.55	16.246	104.9	64.986
A-7	22.5	00:22:30	65.150	0.66	1.508	1.60	880	880	255	52	44	68	76	76	3.5	0.81	73.26	18.862	104.8	64.668
A-8	26.3	00:26:15	67.900	0.60	1.371	1.50	877	877	255	52	46	69	76	76	3.5	0.77	69.77	21.476	105.3	64.428
A-9	30.0	00:30:00	70.650	0.48	1.097	1.20	877	877	253	52	43	68	76	76	3.0	0.69	62.41	23.937	106.3	63.831
A-10	33.8	00:33:45	73.240	0.40	0.914	1.00	865	865	257	52	41	69	77	77	2.5	0.63	56.71	26.060	106.4	62.544
A-11	37.5	00:37:30	75.480	0.37	0.845	0.91	862	862	249	51	42	69	77	77	2.5	0.61	54.48	28.040	106.3	61.179
A-12	41.3	00:41:15	77.570	0.36	0.822	0.90	854	854	254	54	44	70	77	77	2.5	0.60	53.58	29.954	106.0	59.909
B-1	45.0	00:45:00	79.590	0.65	1.485	1.60	882	882	248	63	38	74	75	75	3.0	0.81	72.76	32.489	105.7	59.979
B-2	48.8	00:48:45	82.250	0.65	1.485	1.60	882	882	250	50	38	68	75	75	3.0	0.81	72.76	35.061	105.5	60.105
B-3	52.5	00:52:30	84.950	0.71	1.622	1.80	883	883	251	49	38	68	75	75	3.5	0.84	76.07	37.635	105.1	60.216
B-4	56.3	00:56:15	87.650	0.74	1.691	1.80	884	884	248	52	41	68	77	77	3.5	0.86	77.69	40.484	105.2	60.726
B-5	60.0	01:00:00	90.650	0.75	1.713	1.85	881	881	251	51	39	68	78	78	3.5	0.87	78.12	43.186	104.9	60.968
B-6	63.8	01:03:45	93.500	0.75	1.713	1.85	882	882	249	51	40	69	78	78	3.5	0.87	78.15	45.982	104.9	61.310
B-7	67.5	01:07:30	96.450	0.55	1.257	1.40	874	874	252	51	39	69	78	78	3.0	0.74	66.73	48.416	105.0	61.157
B-8	71.3	01:11:15	99.020	0.53	1.211	1.30	875	875	248	51	40	70	79	79	3.0	0.73	65.53	50.797	105.0	60.957
B-9	75.0	01:15:00	101.540	0.46	1.051	1.10	870	870	255	50	39	70	79	79	2.5	0.68	60.93	52.932	104.8	60.494
B-10	78.8	01:18:45	103.800	0.39	0.891	1.00	862	862	251	51	40	70	79	79	2.0	0.62	55.94	54.986	104.9	59.985
B-11	82.5	01:22:30	105.975	0.44	1.005	1.10	868	868	255	52	39	69	79	79	2.5	0.66	59.55	57.064	104.7	59.545
B-12	86.3	01:26:15	108.175	0.44	1.005	1.10	867	867	249	53	39	70	79	79	2.5	0.66	59.52	59.156	104.6	59.156
Last Pt	90.0	01:30:00	110.390																	
Final Val	90.0	01:30:00	110.390											**Max Vac**	3.5	**Final Values**		59.156	104.6	
Average Values				0.59		1.47	877	877	252	53	41	70	77	77		0.76	68.64			
													77							

Notes:

Probe temp out of specification due to: stack temp

APPENDIX C

CALIBRATION GAS CERTIFICATIONS

RED BALL TECHNICAL GAS SERVICES

Assay Laboratory: Red Ball TGS
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150

CERTIFICATE OF ANALYSIS
(Zero Ambient Nitrogen)

Cylinder Number:	CC727745	**Certification Date:**	03/16/2021
Product ID Number:	121026	**Expiration Date:**	03/14/2029
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	RBTGS-Shreveport-LA
COA #	CC727745.20210316-0	**Lot Number:**	CC727745.20210316
Customer PO. NO.:		**Tracking Number:**	098853339
Customer:		**Previous Certification Dates:**	

This mixture is for laboratory use only, not for drug, household or other use.
This mixture is certified in Mole % to be within ±2% of the actual number reported with a confidence of 95%.
This mixture was manufactured by scale; weights traceable to N.I.S.T. Certificate #822/266926-02.
Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Composing Material: Zero Ambient Nitrogen, Cert., Sz152

Component	Specification	Concentration
Nitrogen	Balance	Balance
Oxygen as Impurity	<1.0 PPM	<1.0 PPM
Carbon Dioxide as Impurity	<0.5 PPM	<0.5 PPM
Carbon Monoxide as Impurity	<0.5 PPM	<0.5 PPM
Total Oxides of Nitrogen as Impurity	<0.1 PPM	<0.1 PPM
Sulfur Dioxide as Impurity	<0.1 PPM	<0.1 PPM
Total Hydrocarbons as Impurity	<0.1 PPM	<0.1 PPM

Red Ball Technical Gas Service
PGVP Vendor ID # G12021
Information and Ordering
800-551-8150
Fax (318-425-6309)

PJLA Calibration and Testing
Accreditation #62754

Brandon Theus
Laboratory Supervisor

Version 02-B, Revised on 2015-05-27

Red Ball Technical Gas Service
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150
PGVP Vendor ID # G12018

PJLA Calibration and Testing
Accreditation #62754

EPA PROTOCOL GAS CERTIFICATE OF ANALYSIS

Cylinder Number:	EB0059402	**Certification Date:**	06/06/2018
Product ID Number:	124605	**Expiration Date:**	06/04/2026
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	- Shreveport - LA
COA #	EB0059402.20180530-0	**Lot Number:**	EB0059402.20180530
Customer PO. NO.:		**Tracking Number:**	074332991
Customer:		**Previous Certification Dates:**	

This calibration standard has been certified per the May 2012 EPA Traceability Protocol, Document EPA-600/R-12/531, using procedure G2.

Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Certified Concentration(s)

Component	Concentration	Uncertainty	Analytical Principle	Assayed On
Carbon Dioxide	**19.0 %**	±0.19 %	NDIR	06/06/2018
Oxygen	**21.0 %**	±0.11 %	MPA	06/05/2018
Nitrogen	Balance			

Analytical Measurement Data Available Online.

Reference Standard(s)

Serial Number	Lot	Expiration	Type	Balance	Component	Concentration	Uncertainty(%)	NIST Reference
CC237204	CC237204.071001a	04/05/2023	NTRM	N2	O2	24.31 %	0.49	071001
EB0034340	EB0034340.20170209	05/09/2026	GMIS	N2	O2	20 %	0.5	071001
EB0072967	EB0072967.20170424	11/25/2025	GMIS	N2	CO2	9.52 %	0.753	C1309410.01

Analytical Instrumentation

Component	Principle	Make	Model	Serial	MPC Date
O2	MPA	Thermo	410i	1162980025	05/11/2018
CO2	NDIR	Thermo	410i	1162980025	06/06/2018

SMART-CERT

This is to certify the gases referenced have been calibrated/tested, and verified to meet the defined specifications. This calibration/test was performed using Gases or Scales that are traceable through National Institute of Standards and Technology (NIST) to the International System of Units (SI). The basis of compliance stated is a comparison of the measurement parameters to the specified or required calibration/testing process. The expanded uncertainties use a coverage factor of k=2 to approximate the 95% confidence level of the measurement, unless otherwise noted. This calibration certificate applies only to the item described and shall not be reproduced other than in full, without written approval from Red Ball Technical Gas Services. If not included, the uncertainty of calibrations are available upon request and were taken into account when determining pass or fail.

Brandon Theus
Analytical Chemist
Assay Laboratory: Red Ball TGS
Version 02-I, Revised on 2017-09-07

Red Ball Technical Gas Service
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150
PGVP Vendor ID # G12021

PJLA Calibration and Testing
Accreditation #62754

EPA PROTOCOL GAS CERTIFICATE OF ANALYSIS

Cylinder Number:	CC712952	**Certification Date:**	04/16/2021
Product ID Number:	124606	**Expiration Date:**	04/14/2029
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	- Shreveport - LA
COA #	CC712952.20210412-0	**Lot Number:**	CC712952.20210412
Customer PO. NO.:		**Tracking Number:**	097024578
Customer:		**Previous Certification Dates:**	

This calibration standard has been certified per the May 2012 EPA Traceability Protocol, Document EPA-600/R-12/531, using procedure G1.

Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Certified Concentration(s)

Component	Concentration	Uncertainty	Analytical Principle	Assayed On
Carbon Dioxide	**8.95 %**	±0.08 %	NDIR	04/16/2021
Oxygen	**11.99 %**	±0.03 %	MPA	04/16/2021
Nitrogen	Balance			

Analytical Measurement Data Available Online.

Reference Standard(s)

Serial Number	Lot	Expiration	Type	Balance	Component	Concentration	Uncertainty(%)	NIST Reference
FF61011	71-F-34	02/27/2026	SRM	N2	O2	20.753 %	0.101	SRM 2659a
EB0007615	EB0007615.20190610	11/24/2027	GMIS	N2	CO2	24.71 %	0.274	C1579010.02
EB0059422	EB0059422.20191017	01/07/2028	GMIS	N2	O2	12.02 %	0.139	SRM 2659a
EB0087520	EB0087520.20191025	03/08/2029	GMIS	N2	CO2	9.48 %	0.331	C1847810.03

Analytical Instrumentation

Component	Principle	Make	Model	Serial	MPC Date
CO2	NDIR	Thermo	410i	1162980025	04/09/2021
O2	MPA	Thermo	410i	1162980025	04/08/2021

SMART-CERT

This is to certify the gases referenced have been calibrated/tested, and verified to meet the defined specifications. This calibration/test was performed using Gases or Scales that are traceable through National Institute of Standards and Technology (NIST) to the International System of Units (SI). The basis of compliance stated is a comparison of the measurement parameters to the specified or required calibration/testing process. The expanded uncertainties use a coverage factor of k=2 to approximate the 95% confidence level of the measurement, unless otherwise noted. This calibration certificate applies only to the item described and shall not be reproduced other than in full, without written approval from Red Ball Technical Gas Services. If not included, the uncertainty of calibrations are available upon request and were taken into account when determining pass or fail.

Amisha Jewitt
Analytical Chemist
Assay Laboratory: Red Ball TGS
Version 02-J, Revised on 2018-09-17

Assay Laboratory: Red Ball TGS
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150

EPA PROTOCOL GAS CERTIFICATE OF ANALYSIS

Cylinder Number:	EB0034654	**Certification Date:**	03/10/2014
Product ID Number:	125021	**Expiration Date:**	03/08/2022
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	RBTGS-Shreveport-LA
COA #	EB0034654.20140306-0	**Lot Number:**	EB0034654.20140306
Customer PO. NO.:		**Tracking Number:**	056563667
Customer:		**Previous Certification Dates:**	

This calibration standard has been certified per the May 2012 EPA Traceability Protocol, Document EPA-600/R-12/531, using procedure G1.

Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Certified Concentration(s)

Component	Concentration	Uncertainty	Analytical Principle
Propane	**802 PPM**	±2 PPM	FTIR
Nitrogen	Balance		

Analyitcal Measurement Data Available Online.

Reference Standard(s)

Lot	Expiration	Type	Balance	Component	Concentration	Uncertainty(%)	NIST Reference
GC1302210752	06/14/2021	GMIS	N2	C3H8	1003 PPM	0.587	2647a

Analytical Instrumentation

Component	Analytical Principle	Make	Model	Serial	MPC Date
C3H8	FTIR	MKS	MKS 2031DJG2EKVS13T	017146467	3/10/2014 10:30:00 AM

Red Ball Technical Gas Service
PGVP Vendor ID # G12014
Information and Ordering
800-551-8150
Fax (318-425-6309)

Fred Holt

Fred Holt
Analyst

Assay Laboratory: Red Ball TGS
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150

EPA PROTOCOL GAS CERTIFICATE OF ANALYSIS

Cylinder Number:	EB0093622	**Certification Date:**	05/16/2017
Product ID Number:	125267	**Expiration Date:**	05/14/2025
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	RBTGS-Shreveport-LA
COA #	EB0093622.20170427-0	**Lot Number:**	EB0093622.20170427
Customer PO. NO.:		**Tracking Number:**	095483935
Customer:		**Previous Certification Dates:**	

This calibration standard has been certified per the May 2012 EPA Traceability Protocol, Document EPA-600/R-12/531, using procedure G1.

Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Certified Concentration(s)

Component	Concentration	Uncertainty	Analytical Principle	Assayed On
Propane	**456 PPM**	±1.5 PPM	FTIR	05/16/2017
Nitrogen	Balance			

Analytical Measurement Data Available Online.

Reference Standard(s)

Serial Number	Lot	Expiration	Type	Balance	Component	Concentration	Uncertainty(%)	NIST Reference
EB0031829	EB0031829.20160114g	05/17/2024	GMIS	N2	C3H8	2461 PPM	0.57	2647a

Analytical Instrumentation

Component	Analytical Principle	Make	Model	Serial	MPC Date
C3H8	FTIR	MKS	MKS 2031DJG2EKVS13T	017146467	05/16/2017

Red Ball Technical Gas Service
PGVP Vendor ID # G12017
Information and Ordering
800-551-8150
Fax (318-425-6309)

PJLA Calibration and Testing
Accreditation #62754

Brandon Theus
Analytical Chemist

This is to certify the gases referenced have been calibrated/tested, and verified to meet the defined specifications. This calibration/test was performed using Gases or Scales that are traceable through National Institute of Standards and Technology (NIST) to the International System of Units (SI). The basis of compliance stated is a comparison of the measurement parameters to the specified or required calibration/testing process. The expanded uncertainties use a coverage factor of k=2 to approximate the 95% confidence level of the measurement, unless otherwise noted. This calibration certificate applies only to the item described and shall not be reproduced other than in full, without written approval from Red Ball Technical Gas Services. If not included, the uncertainty of calibrations are available upon request and were taken into account when determining pass or fail.

Version 02-E, Revised on 2016-04-27

Assay Laboratory: Red Ball TGS
555 Craig Kennedy Way
Shreveport, LA 71107
800-551-8150

EPA PROTOCOL GAS CERTIFICATE OF ANALYSIS

Cylinder Number:	EB0032453	**Certification Date:**	03/10/2014
Product ID Number:	125020	**Expiration Date:**	03/08/2022
Cylinder Pressure:	1900 PSIG	**MFG Facility:**	RBTGS-Shreveport-LA
COA #	EB0032453.20140306-0	**Lot Number:**	EB0032453.20140306
Customer PO. NO.:		**Tracking Number:**	056560484
Customer:		**Previous Certification Dates:**	

This calibration standard has been certified per the May 2012 EPA Traceability Protocol, Document EPA-600/R-12/531, using procedure G1.

Do Not Use This Cylinder Below 100 psig (0.7 Megapascal).

Certified Concentration(s)

Component	Concentration	Uncertainty	Analytical Principle
Propane	**302 PPM**	±2 PPM	FTIR
Nitrogen	Balance		

Analyitcal Measurement Data Available Online.

Reference Standard(s)

Lot	Expiration	Type	Balance	Component	Concentration	Uncertainty(%)	NIST Reference
GC1302210752	06/14/2021	GMIS	N2	C3H8	1003 PPM	0.587	2647a

Analytical Instrumentation

Component	Analytical Principle	Make	Model	Serial	MPC Date
C3H8	FTIR	MKS	MKS 2031DJG2EKVS13T	017146467	3/10/2014 10:30:00 AM

Red Ball Technical Gas Service
PGVP Vendor ID # G12014
Information and Ordering
800-551-8150
Fax (318-425-6309)

Fred Holt

Fred Holt
Analyst

APPENDIX D

QUALITY ASSURANCE AND QUALITY CONTROL DATA

QA/QC PROGRAM

AIR HYGIENE ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA team and encompasses six major areas:

1. Field Qualifications
2. QA reviews of reports, laboratory work, and field testing;
3. Equipment calibration and maintenance;
4. Chain-of-custody;
5. Training; and
6. Knowledge of current test methods

Field Qualifications

Air Hygiene personnel are required to gain and maintain competence with testing methods and techniques according to their job titles and the roles they play during field testing events. Qualifications for each job description include:

Staff Technician - An entry level position with responsibility to test on the stack by performing duties that include: keep trucks and trailers stocked and clean, travel to and from job site, be the "hands of the test" on the stack; stay on a stack during the sample test, set up and tear down equipment on-site, perform maintenance on equipment in the shop and on-site.

Test Technician or Specialist - Acts as the "hands of the test" on the stack by performing duties that include: stay on a stack during the sample test, migrate to the testing trailer and learn the different analyzers and testing methods used on site, set up and tear down testing equipment on site, learn the system for testing from Testing Managers and Project Managers, travel to and from job site; including driving responsibilities under DOT requirements, follow directions of Testing Managers and Project Managers, learn the proper way to conduct on-site test of stationary stacks

Test Manager or Engineer - Directs and coordinates all aspects of a successful test by performing the following duties personally or through subordinate supervisors including: operating analyzers and consoles during testing along with QA/QC procedures, supervise set up and tear down of equipment on site, writing, reviewing, and revising final test reports, working with the client or state personnel while on the job site, managing pre-test checklists and onsite testing procedures, diagnose and repair any problems that may arise with the equipment, safely operate a man lift and drive a truck with or without a trailer, act as crew leader in the field, write protocols and reports, maintain project log of services performed on the job, verify all equipment needed for a job was loaded on the trailer. Test Managers must hold at least one QSTI certificate.

Project Manager - Directs and coordinates all aspects of a successful test by performing the following duties personally or through subordinate supervisors including: operating analyzers and consoles during testing along with QA/QC procedures, supervise set up and tear down of equipment on site, writing, reviewing, and revising final test reports, working with the client or state personnel while on the job site, managing pre-test checklists and onsite testing procedures, diagnose and repair any problems that may arise with the equipment, safely operate a man lift and drive a truck with or without a trailer, act as crew leader in the field, write protocols and reports, maintain project log of services performed on the job, verify all equipment needed for a job was loaded on the trailer. Project Managers typically hold QSTI certificates in Groups 1 through 4.

QA Reviews

Air Hygiene's review procedure includes review of each source test report, along with laboratory and fieldwork, by the QA Team. The most important review is the one that takes place before a test program begins. The QA Team works closely with technical division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance

The equipment used to conduct the emission measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the Environmental Protection Agency. Quality control checks are also conducted in the field for each test program. In conformance with ASTM D7036 Section 15.3.15, all metering and monitoring equipment meets or exceeds the uncertainty criteria contained in the method language that pertains to that equipment.

Chain-of-Custody

Air Hygiene maintains full chain-of-custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, Air Hygiene documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.). Samples are stored in a locked area to which only Air Hygiene personnel have access. Field data sheets are secured at Air Hygiene's offices upon return from the field.

Training

Personnel's training is essential to ensure quality testing. Air Hygiene has formal and informal training programs, which include:

1. Attendance at EPA-sponsored training courses
2. Enrollment in EPA correspondence courses
3 A requirement for all technicians to read and understand Air Hygiene's QA manual
4. In-house training and QA meetings on a regular basis
5. Maintenance of training records

Knowledge of Current Test Methods

With the constant updating of standard test methods and the wide variety of emerging test procedures, it is essential that any qualified source tester keep abreast of new developments. Air Hygiene subscribes to services, which provide updates on EPA reference methods, rules, and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences. Air Hygiene personnel maintain membership in the Air and Waste Management Association and the American Industrial Hygiene Association.

Reproduction and Distribution Policy

Reproducing portions of this test report may omit critical or substantial documentation or be taken out of context and due care must be exercised in this regard. Furthermore, this test report and its associated data shall not be reproduced in full or in part without the written consent of the customer.

Data Provided by Client

Data provided by the Client is clearly identified in the report. Air Hygiene accepts data provided by the Client as accurate.

COMBUSTION TESTING QUALITY ASSURANCE ACTIVITIES

In conformance with ASTM D7036 Section 15.3.11 and 13, all testing was performed without any real or apparent errors, with the exception of those that would be listed in Section 2.0 of this report. In addition, all testing was conducted according to the approved testing protocol, test methods, Air Hygiene Quality Manual, or ASTM D7036, with the exception of specifics noted in Section 2.0 of this report. A number of quality assurance activities were undertaken before, during, and after this testing project. This section of the report combined with the documentation in Appendix C describes each of those activities.

Each instrument's response was checked and adjusted in the field prior to the collection of data via multi-point calibration. The instrument's linearity was checked by adjusting its zero and span responses to zero nitrogen and an upscale calibration gas in the range of the expected concentrations. The instrument response was then challenged with other calibration gases of known concentration and accepted as being linear if the response of the other calibration gases agreed within plus or minus two percent of the range of predicted values. NO_2 to NO conversion was checked via direct connect with an EPA Protocol certified concentration of NO_2 in a balance of air or nitrogen. Conversion was verified to be between 90 and 110 percent.

After each test run, the analyzers were checked for zero and span drift. This allowed each test run to be bracketed by calibrations and documents the precision of the data just collected. The criterion for acceptable data is that the instrument drift is no more than three percent of the full-scale response. The quality assurance worksheets in the following pages summarize all multipoint calibration checks and zero to span checks performed during the tests. These worksheets (as prepared from the data records of Appendix A) show that no drifts in excess of three percent occurred in the zero to span checks following each test run.

The sampling systems were leak checked by demonstrating that a vacuum greater than 10 in Hg could be held for at least one minute with a decline of less than one inch of Hg. A leak test was conducted after the sample system was set up and before the system was dismantled. This test was conducted to ensure that ambient air had not diluted the sample. Any leakage detected prior to the tests would be repaired and another leak check conducted before testing commenced. No leaks were found during the pre or post-test leak checks.

The absence of leaks in the sampling system was also verified by a sampling system bias check. The sampling system's integrity was tested by comparing the responses of the analyzers to the calibration gases introduced via two paths. The first path was directly into the analyzer and the second path via the sample system at the sample probe. Any difference in the instrument responses by these two methods was attributed to sampling system bias or leakage. The criterion for acceptance is agreement within five percent of the span of the analyzer.

The control gases used to calibrate the instruments were analyzed and certified by the compressed gas vendors to plus or minus one percent accuracy for all gases. EPA Protocol No. 1 was used, where applicable to assign the concentration values traceable to the National Institute of Standards and Technology (NIST), Standard Reference Materials (SRM's). The gas calibration sheets as prepared by the vendor are contained in Appendix C.

Air Hygiene collected and reported the enclosed test data in accordance with the procedures and quality assurance activities described in this test report. Air Hygiene makes no warranty as to the suitability of the test methods. Air Hygiene also assumes no liability relating to the interpretation and use of the test data.

INSTRUMENTAL ANALYSIS
QUALITY ASSURANCE DATA

Date: July 29-30, 2021
Company: Catalytic Combustion Corporation
Location: Houston, Texas
Techs: PM / CK / WN

Sample System Leak Check

Date	Sample System	Leak Rate (l/min)
July 29-30, 2021	1	0

catc-21-houston.tx-start#1-rpt

Accredited Laboratory

A2LA has accredited

AIR HYGIENE INTERNATIONAL, INC.

Broken Arrow, OK

for technical competence in the field of

Environmental Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the A2LA *R219 – Specific Requirements – TNI Field Sampling and Measurement Organization Accreditation Program*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 18th day of December 2019

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3796.01
Valid to August 31, 2021

For the tests to which this accreditation applies, please refer to the laboratory's Envrionmental Scope of Accreditation.

STAC
STACK TESTING ACCREDITATION COUNCIL

A2LA

American Association for Laboratory Accreditation

Accredited Air Emission Testing Body

A2LA has accredited

AIR HYGIENE INTERNATIONAL, INC.

In recognition of the successful completion of the joint A2LA and Stack Testing Accreditation Council (STAC) evaluation process, this laboratory is accredited to perform testing activities in compliance with ASTM D7036:2004 - Standard Practice for Competence of Air Emission Testing Bodies.

Presented this 18th day of December 2019.

AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION
CORPORATE SEAL 1978 DISTRICT OF COLUMBIA
A2LA

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3796.02
Valid to August 31, 2021

This accreditation program is not included under the A2LA ILAC Mutual Recognition Arrangement.

Texas Commission on Environmental Quality

NELAP-Recognized Laboratory Accreditation is hereby awarded to

Air Hygiene International, Inc.

1600 West Tacoma
Broken Arrow, OK 74102-1483

in accordance with Texas Water Code Chapter 5, Subchapter R, Title 30 Texas Administrative Code Chapter 25, and the National Environmental Laboratory Accreditation Program.

The laboratory's scope of accreditation includes the fields of accreditation that accompany this certificate. Continued accreditation depends upon successful ongoing participation in the program. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current location(s) and accreditation status for particular methods and analyses (www.tceq.texas.gov/goto/lab). Accreditation does not imply that a product, process, system or person is approved by the Texas Commission on Environmental Quality.

Certificate Number: T104704523-21-9
Effective Date: 3/1/2021
Expiration Date: 2/28/2022

Executive Director Texas Commission on Environmental Quality

Texas Commission on Environmental Quality

NELAP-Recognized Laboratory Accreditation is hereby awarded to

Air Hygiene International, Inc. - Mobile Lab (OK 6782JZ)

1600 West Tacoma
Broken Arrow, OK 74102-1483

in accordance with Texas Water Code Chapter 5, Subchapter R, Title 30 Texas Administrative Code Chapter 25, and the National Environmental Laboratory Accreditation Program.

The laboratory's scope of accreditation includes the fields of accreditation that accompany this certificate. Continued accreditation depends upon successful ongoing participation in the program. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current location(s) and accreditation status for particular methods and analyses (www.tceq.texas.gov/goto/lab). Accreditation does not imply that a product, process, system or person is approved by the Texas Commission on Environmental Quality.

Certificate Number: 1M104704523-21-9
Effective Date: 3/1/2021
Expiration Date: 2/28/2022

Executive Director Texas Commission on Environmental Quality

SOURCE EVALUATION SOCIETY

Qualified Source Testing Individual

LET IT BE KNOWN THAT

PATRICK K. McGOVERN, Jr.

HAS SUCCESSFULLY PASSED A COMPREHENSIVE EXAMINATION AND SATISFIED EXPERIENCE REQUIREMENTS IN ACCORDANCE WITH THE GUIDELINES ISSUED BY THE SES QUALIFIED SOURCE TEST INDIVIDUAL REVIEW BOARD FOR

MANUAL GAS VOLUME MEASUREMENTS AND ISOKINETIC PARTICULATE SAMPLING METHODS

ISSUED THIS 4TH DAY OF SEPTEMBER 2020 AND EFFECTIVE UNTIL SEPTEMBER 3RD, 2025

Peter R. Westlin, QSTI/QSTO Review Board

J. Wade Bice, QSTI/QSTO Review Board

Peter S. Pakalnis, QSTI/QSTO Review Board

Karen D. Kajiya-Mills , QSTI/QSTO Review Board

Tina Sanderson, QSTI/QSTO Review Board

Bruce Randall QSTI/QSTO Review Board

CERTIFICATE NO. 2008-133

SOURCE EVALUATION SOCIETY

Qualified Source Testing Individual

LET IT BE KNOWN THAT

PATRICK K. McGOVERN, Jr.

HAS SUCCESSFULLY PASSED A COMPREHENSIVE EXAMINATION AND SATISFIED EXPERIENCE REQUIREMENTS IN ACCORDANCE WITH THE GUIDELINES ISSUED BY THE SES QUALIFIED SOURCE TEST INDIVIDUAL REVIEW BOARD FOR

GASEOUS POLLUTANTS INSTRUMENTAL SAMPLING METHODS

ISSUED THIS 10TH DAY OF NOVEMBER 2017 AND EFFECTIVE UNTIL NOVEMBER 9TH, 2022

Peter R. Westlin, QSTI/QSTO Review Board

Peter S. Pakalnis, QSTI/QSTO Review Board

Theresa Lowe, QSTI/QSTO Review Board

J. Wade Bice, QSTI/QSTO Review Board

Karen D. Kajiya-Mills , QSTI/QSTO Review Board

Bruce Randall QSTI/QSTO Review Board

CERTIFICATE NO. 2008-133

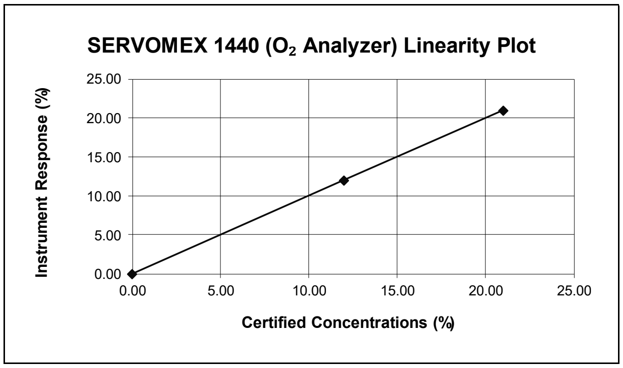
QUALITY ASSURANCE AND QUALITY CONTROL DATA

Reference Method Analyzer Daily Calibration Data

Calibration Date: July 29, 2021 **Location:** Stewart & Stevenson Integration Center -
Client: Catalytic Combustion Corporation

O_2 Span (%) = 21.00

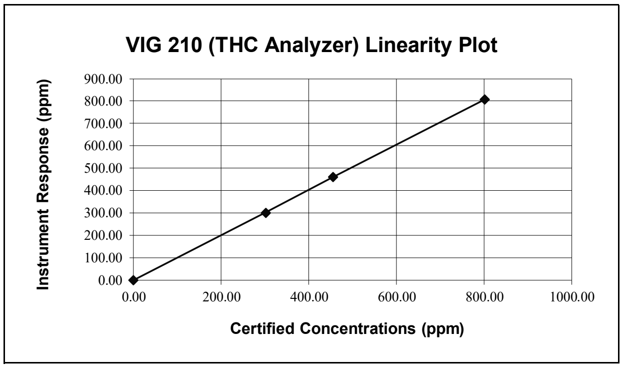
SERVOMEX 1440 (O_2 Analyzer)				
Certified Concentration (%)	**Instrument Response (%)**	**Calibration Error (%)**	**Absolute Conc. (%)**	**Pass (±2%, ≤0.5%)**
0.00	0.05	0.24	0.05	YES (%)
11.99	12.02	0.14	0.03	YES (%)
21.00	21.01	0.05	0.01	YES (%)
Linearity = 1.002				



THC (as C_3H_8) Range (ppm) = 1000

VIG 210 (THC Analyzer)				
Certified Concentration (ppm)	**Instrument Response (ppm)**	**Calibration Error (%)**	**Estimated Point (ppm)**	**Pass (±2,5%)[1]**
0.00	1.42	0.14	N/A	YES
302.00	304.24	-0.36	305.31	YES
456.00	461.70	0.31	460.28	YES
802.00	808.45	0.65	N/A	YES
Linearity = 0.993				

[1]-zero/high based on 2% of span, low/mid based on 5% of concentration

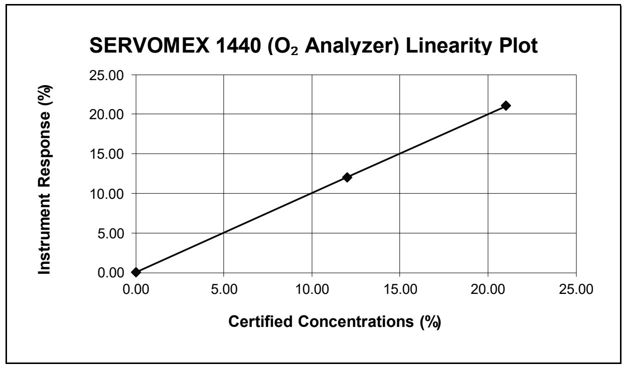


Calibration Date: July 30, 2021 **Location:** Stewart & Stevenson Integration Center -
Client: Catalytic Combustion Corporation

O_2 Span (%) = 21.00

SERVOMEX 1440 (O_2 Analyzer)				
Certified Concentration (%)	**Instrument Response (%)**	**Calibration Error (%)**	**Absolute Conc. (%)**	**Pass (±2%, ≤0.5%)**
0.00	0.06	0.29	0.06	YES (%)
11.99	12.03	0.19	0.04	YES (%)
21.00	21.06	0.29	0.06	YES (%)

Linearity = 1.000

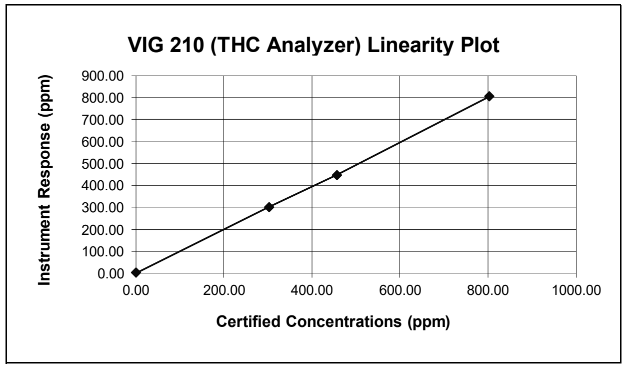


THC (as C_3H_8) Range (ppm) = 1000

VIG 210 (THC Analyzer)				
Certified Concentration (ppm)	**Instrument Response (ppm)**	**Calibration Error (%)**	**Estimated Point (ppm)**	**Pass (±2,5%)[1]**
0.00	1.86	0.19	N/A	YES
302.00	301.28	-1.04	304.43	YES
456.00	446.31	-2.72	458.72	YES
802.00	805.37	0.34	N/A	YES

Linearity = 0.987

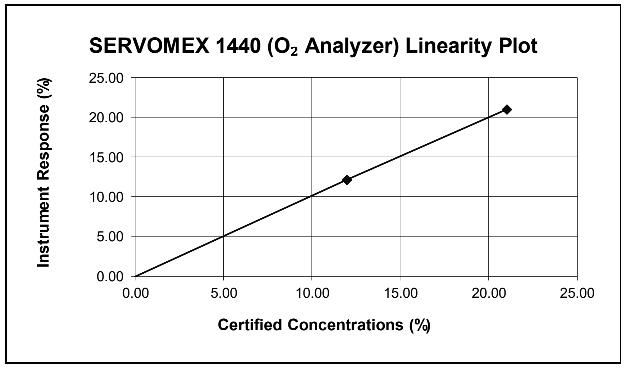
[1]-zero/high based on 2% of span,low/mid based on 5% of concentration



Calibration Date: **September 1, 2021** **Location:** **Stewart & Stevenson Integration Center**
Client: **Catalytic Combustion Corporation**

O_2 Span (%) = 21.00

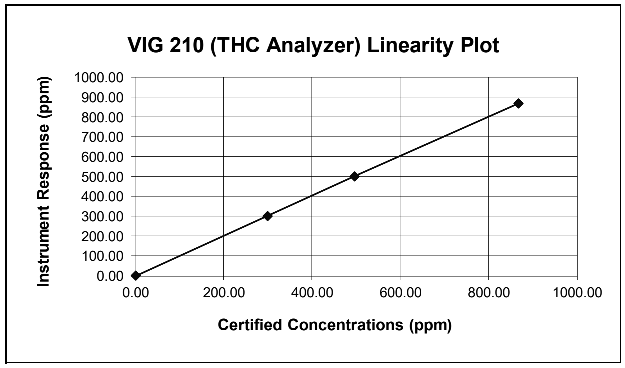
SERVOMEX 1440 (O_2 Analyzer)				
Certified Concentration (%)	**Instrument Response (%)**	**Calibration Error (%)**	**Absolute Conc. (%)**	**Pass (±2%, ≤0.5%)**
0.00	0.00	-0.01	0.00	YES (%)
11.96	12.09	0.62	0.13	YES (%)
21.00	20.97	-0.14	0.03	YES (%)
Linearity = 1.001				



THC (as C_3H_8) Range (ppm) = 1000

VIG 210 (THC Analyzer)				
Certified Concentration (ppm)	**Instrument Response (ppm)**	**Calibration Error (%)**	**Estimated Point (ppm)**	**Pass (±2,5%)[1]**
0.00	0.19	0.02	N/A	YES
299.00	300.99	0.50	299.51	YES
495.00	500.30	0.93	495.71	YES
867.00	868.10	0.11	N/A	YES
Linearity = 1.003				

[1]-zero/high based on 2% of span,low/mid based on 5% of concentration



DRIFT AND BIAS CHECK
AND
RESPONSE TIME CALCULATOR

Strat Test Pre and Post QA/QC Check	O_2	NOx
Initial Zero	0.03	0.66
Final Zero	0.05	0.21
Avg. Zero	0.04	0.44
Initial UpScale	11.98	10.99
Final UpScale	11.97	10.97
Avg. UpScale	11.98	10.98
Sys Resp (Zero)	0.05	0.00
Sys Resp (Upscale)	12.02	11.00
Upscale Cal Gas	11.99	10.80
Initial Zero Bias	-0.10%	3.03%
Final Zero Bias	0.00%	0.96%
Zero Drift	0.10%	2.06%
Initial Upscale Bias	-0.19%	-0.05%
Final Upscale Bias	-0.24%	-0.14%
Upscale Drift	0.05%	0.09%
Alternative Specification Abs Diff — **Initial Zero**	0.02	0.66
Final Zero	0.00	0.21
Initial Upscale	0.04	0.01
Final Upscale	0.05	0.03
Calibration Span	21.00	21.80
3% of Cal. Span (drift)	0.63	0.65
5% of Cal. Span (bias)	1.05	1.09

Response Time (min)	0.8	1.2
Sys. Response (min)	1.2	

Date/Time mm/dd/yy hh:mm:ss	z	O_2 %-10	s	z	NOx ppm-10	s	**INJECTIONS**
07/30/21 10:20:43		8.92			6.51		x
07/30/21 10:20:53		8.92			6.51		
07/30/21 10:21:03		8.91			6.56		
07/30/21 10:21:13		8.79			6.62		
07/30/21 10:21:23		10.25			6.73		
07/30/21 10:21:33		**11.72**	x		6.63		
07/30/21 10:21:43		**11.94**			3.53		
07/30/21 10:21:53		**11.96**		x	**0.70**		
07/30/21 10:22:03		**11.97**			**0.64**		
07/30/21 10:22:13		**11.97**			**0.56**		
07/30/21 10:22:23		**11.97**			**0.66**		
07/30/21 10:22:33		**11.98**			**0.77**		x
07/30/21 10:22:43		**11.98**			**0.52**		
07/30/21 10:22:53		**11.79**			**0.39**		
07/30/21 10:23:03		8.98			**0.88**		
07/30/21 10:23:13		2.37			1.65		
07/30/21 10:23:23	x	**0.38**			6.15		
07/30/21 10:23:33		**0.16**			10.27		
07/30/21 10:23:43		**0.04**			**10.59**	x	
07/30/21 10:23:53		**0.04**			**10.95**		
07/30/21 10:24:03		**0.03**			**10.95**		
07/30/21 10:24:13		**0.03**			**10.99**		

DRIFT AND BIAS CHECK		
50% Load, Run - 1-1	O_2	THC (as C_3H_8)
Raw Average	8.69	157.35
Corrected Average	8.67	183.85
Initial Zero	0.03	2.53
Final Zero	0.07	0.12
Avg. Zero	0.05	1.33
Initial UpScale	12.03	306.71
Final UpScale	11.98	307.25
Avg. UpScale	12.01	306.98
Sys Resp (Zero)	0.05	1.42
Sys Resp (Upscale)	12.02	304.24
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	-0.10%	0.11%
Final Zero Bias	0.10%	-0.13%
Zero Drift	0.19%	0.24%
Initial Upscale Bias	0.05%	0.25%
Final Upscale Bias	-0.19%	0.30%
Upscale Drift	0.24%	0.05%
Alternative Specification Abs Diff — **Initial Zero**	0.02	--
Final Zero	0.02	--
Initial Upscale	0.01	--
Final Upscale	0.04	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
50% Load, Run - 1-2	O_2	THC (as C_3H_8)
Raw Average	8.75	163.11
Corrected Average	8.74	190.60
Initial Zero	0.07	0.12
Final Zero	0.08	0.21
Avg. Zero	0.08	0.17
Initial UpScale	11.98	307.25
Final UpScale	11.97	317.42
Avg. UpScale	11.98	312.34
Sys Resp (Zero)	0.05	1.42
Sys Resp (Upscale)	12.02	304.24
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	0.10%	-0.13%
Final Zero Bias	0.14%	-0.12%
Zero Drift	0.05%	0.01%
Initial Upscale Bias	-0.19%	0.30%
Final Upscale Bias	-0.24%	1.32%
Upscale Drift	0.05%	1.02%
Alternative Specification Abs Diff — **Initial Zero**	0.02	--
Final Zero	0.03	--
Initial Upscale	0.04	--
Final Upscale	0.05	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
50% Load, Run - 1-3	O_2	THC (as C_3H_8)
Raw Average	8.80	168.64
Corrected Average	8.79	197.00
Initial Zero	0.08	0.21
Final Zero	0.09	0.17
Avg. Zero	0.09	0.19
Initial UpScale	11.97	317.42
Final UpScale	11.98	314.03
Avg. UpScale	11.98	315.73
Sys Resp (Zero)	0.05	1.42
Sys Resp (Upscale)	12.02	304.24
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	0.14%	-0.12%
Final Zero Bias	0.19%	-0.13%
Zero Drift	0.05%	0.00%
Initial Upscale Bias	-0.24%	1.32%
Final Upscale Bias	-0.19%	0.98%
Upscale Drift	0.05%	0.34%
Alternative Specification Abs Diff **Initial Zero**	0.03	--
Final Zero	0.04	--
Initial Upscale	0.05	--
Final Upscale	0.04	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
75% Load, Run - 2-1	O_2	THC (as C_3H_8)
Raw Average	8.97	151.87
Corrected Average	8.95	176.40
Initial Zero	0.07	0.13
Final Zero	0.06	0.27
Avg. Zero	0.07	0.20
Initial UpScale	12.01	304.51
Final UpScale	11.97	310.21
Avg. UpScale	11.99	307.36
Sys Resp (Zero)	0.06	1.86
Sys Resp (Upscale)	12.03	301.28
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	0.05%	-0.17%
Final Zero Bias	0.00%	-0.16%
Zero Drift	0.05%	0.01%
Initial Upscale Bias	-0.10%	0.32%
Final Upscale Bias	-0.29%	0.89%
Upscale Drift	0.19%	0.57%
Alternative Specification Abs Diff **Initial Zero**	0.01	--
Final Zero	0.00	--
Initial Upscale	0.02	--
Final Upscale	0.06	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
75% Load, Run - 2-2	O_2	THC (as C_3H_8)
Raw Average	8.95	169.71
Corrected Average	8.96	197.01
Initial Zero	0.06	0.27
Final Zero	0.04	0.44
Avg. Zero	0.05	0.36
Initial UpScale	11.97	310.21
Final UpScale	11.95	303.21
Avg. UpScale	11.96	306.71
Sys Resp (Zero)	0.06	1.86
Sys Resp (Upscale)	12.03	301.28
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	0.00%	-0.16%
Final Zero Bias	-0.10%	-0.14%
Zero Drift	0.10%	0.02%
Initial Upscale Bias	-0.29%	0.89%
Final Upscale Bias	-0.38%	0.19%
Upscale Drift	0.10%	0.70%
Alternative Specification Abs Diff — Initial Zero	0.00	--
Alternative Specification Abs Diff — Final Zero	0.02	--
Alternative Specification Abs Diff — Initial Upscale	0.06	--
Alternative Specification Abs Diff — Final Upscale	0.08	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
75% Load, Run - 2-3	O_2	THC (as C_3H_8)
Raw Average	8.91	164.95
Corrected Average	8.94	190.89
Initial Zero	0.04	0.44
Final Zero	0.06	1.21
Avg. Zero	0.05	0.83
Initial UpScale	11.95	303.21
Final UpScale	11.94	312.59
Avg. UpScale	11.95	307.90
Sys Resp (Zero)	0.06	1.86
Sys Resp (Upscale)	12.03	301.28
Upscale Cal Gas	11.99	302.00
Initial Zero Bias	-0.10%	-0.14%
Final Zero Bias	0.00%	-0.07%
Zero Drift	0.10%	0.08%
Initial Upscale Bias	-0.38%	0.19%
Final Upscale Bias	-0.43%	1.13%
Upscale Drift	0.05%	0.94%
Alternative Specification Abs Diff — Initial Zero	0.02	--
Alternative Specification Abs Diff — Final Zero	0.00	--
Alternative Specification Abs Diff — Initial Upscale	0.08	--
Alternative Specification Abs Diff — Final Upscale	0.09	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
100% Load, Run - 3-1	O_2	THC (as C_3H_8)
Raw Average	8.60	99.12
Corrected Average	8.64	114.77
Initial Zero	0.01	0.19
Final Zero	0.02	0.20
Avg. Zero	0.02	0.20
Initial UpScale	11.85	300.98
Final UpScale	11.94	300.31
Avg. UpScale	11.90	300.65
Sys Resp (Zero)	0.00	0.19
Sys Resp (Upscale)	12.09	300.99
Upscale Cal Gas	11.96	299.00
Initial Zero Bias	0.08%	0.00%
Final Zero Bias	0.11%	0.00%
Zero Drift	0.03%	0.00%
Initial Upscale Bias	-1.14%	0.00%
Final Upscale Bias	-0.71%	-0.07%
Upscale Drift	0.43%	0.07%
Alternative Specification Abs Diff: Initial Zero	0.02	--
Final Zero	0.02	--
Initial Upscale	0.24	--
Final Upscale	0.15	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
100% Load, Run - 3-2	O_2	THC (as C_3H_8)
Raw Average	9.05	93.36
Corrected Average	9.06	107.19
Initial Zero	0.02	0.20
Final Zero	0.02	0.20
Avg. Zero	0.02	0.20
Initial UpScale	11.94	300.31
Final UpScale	11.95	300.00
Avg. UpScale	11.95	300.16
Sys Resp (Zero)	0.00	0.19
Sys Resp (Upscale)	12.09	300.99
Upscale Cal Gas	11.96	299.00
Initial Zero Bias	0.11%	0.00%
Final Zero Bias	0.11%	0.00%
Zero Drift	0.00%	0.00%
Initial Upscale Bias	-0.71%	-0.07%
Final Upscale Bias	-0.67%	-0.10%
Upscale Drift	0.05%	0.03%
Alternative Specification Abs Diff: Initial Zero	0.02	--
Final Zero	0.02	--
Initial Upscale	0.15	--
Final Upscale	0.14	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

DRIFT AND BIAS CHECK		
100% Load, Run - 3-3	O_2	THC (as C_3H_8)
Raw Average	9.23	94.52
Corrected Average	9.25	108.68
Initial Zero	0.02	0.20
Final Zero	0.02	0.21
Avg. Zero	0.02	0.21
Initial UpScale	11.95	300.00
Final UpScale	11.90	299.31
Avg. UpScale	11.93	299.66
Sys Resp (Zero)	0.00	0.19
Sys Resp (Upscale)	12.09	300.99
Upscale Cal Gas	11.96	299.00
Initial Zero Bias	0.11%	0.00%
Final Zero Bias	0.11%	0.00%
Zero Drift	0.00%	0.00%
Initial Upscale Bias	-0.67%	-0.10%
Final Upscale Bias	-0.90%	-0.17%
Upscale Drift	0.24%	0.07%
Alternative Specification Abs Diff — Initial Zero	0.02	--
Final Zero	0.02	--
Initial Upscale	0.14	--
Final Upscale	0.19	--
Calibration Span	21.00	1,000.00
3% of Cal. Span (drift)	0.63	30.00
5% of Cal. Span (bias)	1.05	50.00

ENGINE TEST - FIELD DATA SHEET

Company:	Catalytic Combustion Corporation
Facility Name:	Stewart & Stevenson Intergration Center
Location (county & state):	Houston, Texas
Physical Address or	10750 Telge Road
GPS Coordinates:	Houston, Texas
Project Code:	catc-21-houston.tx-start#1
Date:	7/29/2021
Unit Make and Model:	
Unit Number:	
Serial Number:	
Data Recorded By:	CK
Tested With AHI Unit(s):	Truck(s): 173 Trailer(s): 217
LDEQ Warmup/Cal Req:	On (Day/Time): Cal (Day/Time):

RUN INFORMATION	Run #1	Run #2	Run #3
Time Start (hh:mm:ss)	9:34:23	12:05:23	14:27:23
Time Stop (hh:mm:ss)	10:33:53	13:04:53	15:22:53
Barometric Pressure (in. Hg)	29.9	29.9	29.84
Ambient Temperature (°F)	98	99	96
Relative Humidity (%)	53	49	49
Stack Temperature (°F)			
Fuel Usage (btu/hp*hr or SCFM)			
Rated Horsepower (hp)			
Rated Engine RPM			
Load % or BHP from panel	50%	50%	50%
Engine Speed RPM	1799	1799	1800
Air Manifold Pressure (psig or in. Hg)	25.2	25.4	25.3
Air Manifold Temperature (°F)	122	122	124
Kilowatts (KW)	1350	1352	1358
Amperes (A)	56	57	56
Engine Operating Hours			
Engine Timing (degrees)	23	23	23

CYLINDER SERIAL NUMBERS		O_2	VOC	
	N2/Low	CC727745	EB0032453	
	Mid	CC712952	EB0093622	
	High	EB0059402	EB0034654	
		NOx	CO	
	N2/Low			
	Mid			
	High			

NO_2 CONVERSION	
NO_2 Gas (ppm)	
NO Reading (ppm)	
NOx Reading (ppm)	
Cylinder Num	
Time	

Stack Height	Stack Diameter

Probe Used:
Multi Point Rake
Pre-Hung
Shepherd's hook
Ports where used

High Level Diluted Gas Validation Table

Trial #	Diluter Output (18.0%)	Instrument Response (%)
1		
2		
3		

Mid Level Diluted Gas Validation Table

Trial #	Diluter Output (11.0%)	Instrument Response (%)
1		
2		
3		

Mid Level Protocol Gas Validation Table

Trial #	Certified Value (%)	Instrument Response (%)
1		
2		
3		

REPORT INFORMATION

INSTRUMENT		SERIAL #
O_2		
NOX		
CO		
Dilutor		
VOC		
FTIR		

Customer Number:	
Regulated Entity Number:	
Permit ID:	

CALIBRATION	O_2 Conc.	O_2 Actual	NOx Conc.	NOx Actual	CO Conc.	CO Actual	VOC Conc.	VOC Actual	Conc.	Actual
Zero Gas	0	.05					0	1.42		
Low Gas							302	309.39		
Mid Gas	12.0	12.02					456	461.70		
High Gas	21	21.01					802	804.45		

BIAS	O_2 Zero	O_2 Mid	NOx Zero	NOx Mid	CO Zero	CO Mid	VOC Zero	VOC Mid	Zero	Mid
Initial/Run #1	.03	12.03					2.53	306.71		
Run #1/Run #2	.07	11.98					.12	307.25		
Run #2/Run #3	.08	11.97					.21	317.42		
Run #3/Run #4										
Run #4/Final										
Bias Gas Actual Conc.										

AIR HYGIENE

Signature:

ENGINE TEST - FIELD DATA SHEET

Company:	Catalytic Combustion Corporation
Facility Name:	Stewart & Stevenson Intergration Center
Location (county & state):	Houston, Texas
Physical Address or GPS Coordinates:	10750 Telge Road Houston, Texas
Project Code:	catc-21-houston.tx-start#1
Date:	7/30/2021
Unit Make and Model:	
Unit Number:	
Serial Number:	
Data Recorded By:	CK
Tested With AHI Unit(s):	Truck(s): 173 Trailer(s): 217
LDEQ Warmup/Cal Req:	On (Day/Time): Cal (Day/Time):

RUN INFORMATION	Run #1	Run #2	Run #3
Time Start (hh:mm:ss)	13:45:23	15:00:23	16:27:23
Time Stop (hh:mm:ss)	14:44:53	15:59:53	17:26:53
Barometric Pressure (in. Hg)	29.89	29.87	29.85
Ambient Temperature (°F)	94	97	97°
Relative Humidity (%)	53	47	42
Stack Temperature (°F)			
Fuel Usage (btu/hp*hr or SCFM)			
Rated Horsepower (hp)			
Rated Engine RPM			
Load % or BHP from panel	75	75	75
Engine Speed RPM	1800	1800	1800
Air Manifold Pressure (psig or in. Hg)	36.4	36.7	35.6
Air Manifold Temperature (°F)	131	131	129
Kilowatts (KW)	2007	2012	1951
Amperes (A)	89	90	97
Engine Operating Hours			
Engine Timing (degrees)	23	23	27

CYLINDER SERIAL NUMBERS		O_2	VOC	
	N2/Low	CC727745	EB0032453	
	Mid	CC712952	EB0093622	
	High	EB0059402	EB0034654	
		NOx	CO	
	N2/Low			
	Mid			
	High			

NO_2 CONVERSION	
NO_2 Gas (ppm)	
NO Reading (ppm)	
NOx Reading (ppm)	
Cylinder Num	
Time	

Stack Height	Stack Diameter

Probe Used:	
	Multi Point Rake
	Pre-Hung
	Shepherd's hook
	Ports where used

High Level Diluted Gas Validation Table

Trial #	Diluter Output (18.0%)	Instrument Response (%)
1		
2		
3		

REPORT INFORMATION	
INSTRUMENT	SERIAL #
O_2	
NOX	
CO	
Dilutor	
VOC	
FTIR	

Mid Level Diluted Gas Validation Table

Trial #	Diluter Output (11.0%)	Instrument Response (%)
1		
2		
3		

Customer Number:	
Regulated Entity Number:	
Permit ID:	

Mid Level Protocol Gas Validation Table

Trial #	Certified Value (%)	Instrument Response (%)
1		
2		
3		

CALIBRATION	O_2		NOx		CO		VOC			
	Conc.	Actual	Conc.	Actual	Conc.	Actual	Conc.	Actual	Conc.	Actual
Zero Gas	0	.06					0	1.86		
Low Gas							302	301.28		
Mid Gas	12.0	12.03					456	446.31		
High Gas	21	21.06					802	805.37		

BIAS	O_2		NOx		CO		VOC			
	Zero	Mid	Zero	Mid	Zero	Mid	Zero	Mid	Zero	Mid
Initial/Run #1	.07	12.01					.13	304.51		
Run #1/Run #2	.06	11.97					.27	310.21		
Run #2/Run #3	.04	11.95					.44	307.2		
Run #3/Run #4										
Run #4/Final										
Bias Gas Actual Conc.										

AIR HYGIENE

Signature:

QUALITY ASSURANCE AND QUALITY CONTROL DATA

Fourier Transform Infrared Analyzer Daily QA Data

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Sampling System Leak Check	Flow (LPM)	Date (dd/mm/yy)	Time (hh:mm)
	≤0.2	07/29/21	6:00

FTIR No:	509/ INST-IR-0005
Make Model:	MKS 2030

Analytical System Leak Checks	**Vacuum Leak Check**

Spectrum	Date (dd/mm/yy)	Time (hh:mm:ss)	Vacuum (atm)
0729-PRE_000015.LAB	07/29/21	6:11:04	0.99216
0729-PRE_000016.LAB	07/29/21	6:11:34	0.99222
0729-PRE_000017.LAB	07/29/21	6:12:04	0.99226
0729-PRE_000018.LAB	07/29/21	6:12:34	0.99232
0729-PRE_000019.LAB	07/29/21	6:13:04	0.99235
0729-PRE_000020.LAB	07/29/21	6:13:34	0.99241
0729-PRE_000021.LAB	07/29/21	6:14:04	0.99239
0729-PRE_000022.LAB	07/29/21	6:14:34	0.99237
0729-PRE_000023.LAB	07/29/21	6:15:04	0.99289

Pressure Elements	Vacuum (atm)
Average, P_s	0.99237
Maximum	0.99289
Minimum	0.99216
Difference, ΔP_v	0.00073

Time Elements	Results (min)
Signal Integration, t_{ss}	0.50
Test Duration, t_d	4.00

Analytical System Leak Checks	**Pressure Leak Check**

Spectrum	Date (dd/mm/yy)	Time (hh:mm:ss)	Pressure (atm)
0729-PRE_000002.LAB	07/29/21	6:04:33	1.10579
0729-PRE_000003.LAB	07/29/21	6:05:03	1.10579
0729-PRE_000004.LAB	07/29/21	6:05:33	1.10579
0729-PRE_000005.LAB	07/29/21	6:06:03	1.10579
0729-PRE_000006.LAB	07/29/21	6:06:33	1.10579
0729-PRE_000007.LAB	07/29/21	6:07:03	1.10579
0729-PRE_000008.LAB	07/29/21	6:07:33	1.10579
0729-PRE_000009.LAB	07/29/21	6:08:03	1.10579
0729-PRE_000010.LAB	07/29/21	6:08:33	1.10579
0729-PRE_000011.LAB	07/29/21	6:09:03	1.10579

Pressure Elements	Pressure (atm)
Average, P_s	1.10579
Maximum	1.10579
Minimum	1.10579
Difference, ΔP_p	0.00000

Station Pressure (in. Hg)	29.90

Time Elements	Results (min)
Signal Integration, t_{ss}	0.50
Test Duration, t_d	4.50

Parameter	**Vacuum**	**Pressure**	**Max ΔP**
Test Duration, t_d	4.00	4.50	4.00
Signal Integ., t_{ss}	0.50	0.50	0.50
Difference, ΔP	0.00073	0.00000	0.00073
Average, P_s	0.99237	1.10579	0.99237
Leak Volume, $\%V_L$	0.009	0.000	0.009
Pass, ≤4%	yes	yes	yes

$$\%V_L = \frac{100\%}{t_d} t_{ss} \frac{\Delta P_{max}}{P_S}$$

Method 320, Section 8.2.2.4, Equation 2
expanded to account for sample duration

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Protocol No. 1, CO_2 Cylinder Concentration:	8.95 %vd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/29/21	6:22:49	0729-PRE_000035.LAB	191.3	0.99	8.9948	0.0225
07/29/21	6:23:19	0729-PRE_000036.LAB	191.3	0.99	9.0258	0.0065
07/29/21	6:23:49	0729-PRE_000037.LAB	191.3	0.99	9.0322	-0.0002
07/29/21	6:24:19	0729-PRE_000038.LAB	191.3	0.99	9.0356	0.0066
07/29/21	6:24:49	0729-PRE_000039.LAB	191.3	0.99	9.0464	0.0034
	Average		**191.3**	**0.99**	**9.0270**	**0.0078**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/29/21	17:07:51	0729-R3_000460.LAB	191.4	0.99	9.1068	0.8887
07/29/21	17:08:21	0729-R3_000461.LAB	191.4	0.99	9.1768	0.2897
07/29/21	17:09:51	0729-R3_000464.LAB	191.4	0.99	9.2146	0.1001
07/29/21	17:10:21	0729-R3_000465.LAB	191.3	0.99	9.2266	0.1005
07/29/21	17:10:51	0729-R3_000466.LAB	191.4	0.99	9.2030	0.0946
	Average		**191.4**	**0.99**	**9.1856**	**0.2947**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153

Post-Test Background						
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2**	**H_2O (%)**
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR CO_2 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	8.95	9.03	0.86	YES
Post-Test Direct	8.95	9.19	2.63	YES

Pre / Post Comparison	FTIR CO_2 Maximum	FTIR CO_2 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	9.05	9.11	0.66	YES
Post-Test Direct	9.23		1.30	YES

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Certified, NH_3 Cylinder Concentration:	49 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092	0.0729
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085	0.0730
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019	0.0763

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/29/21	7:26:34	0729-PRE_000163.LAB	191.3	0.99	0.0016	0.0092	46.2851
07/29/21	7:28:34	0729-PRE_000167.LAB	191.3	0.99	-0.0024	0.0120	47.2974
07/29/21	7:29:04	0729-PRE_000168.LAB	191.3	0.99	0.0013	0.0064	46.2767
07/29/21	7:29:34	0729-PRE_000169.LAB	191.3	0.99	0.0097	0.0036	47.1397
07/29/21	7:30:04	0729-PRE_000170.LAB	191.3	0.99	0.0069	0.0053	46.8958
Average			**191.3**	**0.99**	**0.0034**	**0.0073**	**46.7789**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/29/21	17:31:53	0729-R3_000508.LAB	191.4	0.99	0.0023	-0.0039	46.6088
07/29/21	17:32:24	0729-R3_000509.LAB	191.4	0.99	0.0178	0.0033	46.7044
07/29/21	17:32:54	0729-R3_000510.LAB	191.4	0.99	0.0233	-0.0043	46.6023
07/29/21	17:33:24	0729-R3_000511.LAB	191.4	0.99	0.0205	-0.0039	46.8212
07/29/21	17:33:54	0729-R3_000512.LAB	191.4	0.99	0.0073	0.0111	46.7872
Average			**191.4**	**0.99**	**0.0142**	**0.0005**	**46.7048**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234	0.7380
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113	0.7408
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153	0.7300

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**NH_3 (ppmvw)**
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR NH_3 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	49.00	46.78	4.53	YES
Post-Test Direct	49.00	46.70	4.68	YES

Pre / Post Comparison	FTIR NH_3 Maximum	FTIR NH_3 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	47.30	46.74	1.17	YES
Post-Test Direct	46.82		0.17	YES

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Certified, C_2H_6 Cylinder Concentration:	100 ppmvd

Pre-Test Background							**FTIR:** 509/ INST-IR-0005
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

Pre-Test Direct Zero							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092	-0.0143
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085	-0.2806
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019	-0.1091

Pre-Test Direct Calibration Transfer Spectra							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:26:19	0729-PRE_000042.LAB	191.3	0.99	0.0046	0.0038	101.0654
07/29/21	6:26:49	0729-PRE_000043.LAB	191.3	0.99	0.0091	-0.0046	101.3680
07/29/21	6:27:19	0729-PRE_000044.LAB	191.3	0.99	-0.0013	0.0043	101.0983
07/29/21	6:27:50	0729-PRE_000045.LAB	191.3	0.99	0.0055	-0.0011	101.4527
07/29/21	6:28:20	0729-PRE_000046.LAB	191.3	0.99	0.0024	-0.0025	101.4251
		Average	**191.3**	**0.99**	**0.0040**	**0.0000**	**101.2819**

Post-Test Direct Calibration Transfer Spectra							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	17:15:52	0729-R3_000476.LAB	191.4	0.99	0.0099	0.0079	99.9658
07/29/21	17:16:22	0729-R3_000477.LAB	191.4	0.99	0.0164	0.0016	99.3676
07/29/21	17:16:52	0729-R3_000478.LAB	191.4	0.99	0.0052	0.0063	99.9686
07/29/21	17:17:22	0729-R3_000479.LAB	191.4	0.99	0.0139	0.0039	99.3839
07/29/21	17:17:52	0729-R3_000480.LAB	191.4	0.99	0.0141	-0.0024	99.2374
		Average	**191.4**	**0.99**	**0.0119**	**0.0035**	**99.5847**

Post-Test Direct Zero							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234	-0.4644
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113	-0.3360
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153	-0.7831

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**C_2H_6 (ppmvw)**
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR C_2H_6 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	100.00	101.28	1.28	YES
Post-Test Direct	100.00	99.58	0.42	YES

Pre / Post Comparison	FTIR C_2H_6 Maximum	FTIR C_2H_6 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	101.45	100.43	1.00	YES
Post-Test Direct	99.97		0.46	YES

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Protocol No. 1, NOx Cylinder Concentration:	116.1 ppmvd

Pre-Test Background							**FTIR:** 509/ INST-IR-0005
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

Pre-Test Direct Zero							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092	-0.1679
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085	-0.0946
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019	-0.1183

Pre-Test Direct Calibration Transfer Spectra							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	118.4758
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	118.2633
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	117.9127
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	118.9113
07/29/21	6:31:20	0729-PRE_000052.LAB	191.3	0.99	-0.0412	0.0002	119.3122
		Average	**191.3**	**0.99**	**-0.0342**	**0.0028**	**118.5751**

Post-Test Direct Calibration Transfer Spectra							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	17:12:22	0729-R3_000469.LAB	191.4	0.99	-0.0204	0.0499	120.3651
07/29/21	17:12:52	0729-R3_000470.LAB	191.4	0.99	-0.0230	0.0303	120.2399
07/29/21	17:13:22	0729-R3_000471.LAB	191.4	0.99	-0.0332	0.0140	120.4058
07/29/21	17:13:52	0729-R3_000472.LAB	191.4	0.99	-0.0284	0.0138	120.5176
07/29/21	17:14:22	0729-R3_000473.LAB	191.4	0.99	-0.0239	0.0099	120.2993
		Average	**191.4**	**0.99**	**-0.0258**	**0.0236**	**120.3655**

Post-Test Direct Zero							
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(ppmvw)**	**(%)**	**(ppmvw)**
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234	-0.7746
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113	-0.2312
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153	-0.1751

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**NOx (ppmvw)**
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR NOx Average	Error (%)	Pass (≤5%)
Pre-Test Direct	116.10	118.58	2.13	YES
Post-Test Direct	116.10	120.37	3.67	YES

Pre / Post Comparison	FTIR NOx Maximum	FTIR NOx Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	119.31	119.47	0.13	YES
Post-Test Direct	120.52		0.87	YES

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Protocol No. 1, CO Cylinder Concentration:	122 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092	-0.0233
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085	-0.0104
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019	0.0645

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	121.3862
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	120.7858
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	120.6875
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	121.4610
07/29/21	6:31:20	0729-PRE_000052.LAB	191.3	0.99	-0.0412	0.0002	121.9527
	Average		**191.3**	**0.99**	**-0.0342**	**0.0028**	**121.2546**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	17:12:22	0729-R3_000469.LAB	191.4	0.99	-0.0204	0.0499	122.9462
07/29/21	17:12:52	0729-R3_000470.LAB	191.4	0.99	-0.0230	0.0303	122.7267
07/29/21	17:13:22	0729-R3_000471.LAB	191.4	0.99	-0.0332	0.0140	123.2405
07/29/21	17:13:52	0729-R3_000472.LAB	191.4	0.99	-0.0284	0.0138	122.9788
07/29/21	17:14:22	0729-R3_000473.LAB	191.4	0.99	-0.0239	0.0099	122.6847
	Average		**191.4**	**0.99**	**-0.0258**	**0.0236**	**122.9154**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234	0.1207
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113	0.2300
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153	0.0047

Post-Test Background

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR CO Average	Error (%)	Pass (≤5%)
Pre-Test Direct	122.00	121.25	0.61	YES
Post-Test Direct	122.00	122.92	0.75	YES

Pre / Post Comparison	FTIR CO Maximum	FTIR CO Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	121.95	122.09	0.11	YES
Post-Test Direct	123.24		0.94	YES

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Certified, C_2H_4O Cylinder Concentration:	47.4 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/29/21	6:21:13	0729-PRE_000032BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/29/21	6:18:04	0729-PRE_000029.LAB	191.3	0.99	0.0060	0.0092	-0.3305
07/29/21	6:18:35	0729-PRE_000030.LAB	191.3	0.99	-0.0087	0.0085	-0.1519
07/29/21	6:19:04	0729-PRE_000031.LAB	191.3	0.99	-0.0089	0.0019	-0.4129

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/29/21	6:32:20	0729-PRE_000054.LAB	191.3	0.99	0.0102	-0.0025	46.1720
07/29/21	6:32:50	0729-PRE_000055.LAB	191.3	0.99	0.0016	-0.0038	47.2898
07/29/21	6:33:20	0729-PRE_000056.LAB	191.3	0.99	0.0070	-0.0048	47.6549
07/29/21	6:33:50	0729-PRE_000057.LAB	191.3	0.99	0.0126	-0.0068	47.3384
07/29/21	6:34:20	0729-PRE_000058.LAB	191.3	0.99	0.0030	-0.0075	47.8559
	Average		**191.3**	**0.99**	**0.0069**	**-0.0051**	**47.2622**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/29/21	17:18:52	0729-R3_000482.LAB	191.4	0.99	0.0101	0.0408	49.2208
07/29/21	17:19:22	0729-R3_000483.LAB	191.4	0.99	0.0057	-0.0063	49.2790
07/29/21	17:19:52	0729-R3_000484.LAB	191.4	0.99	0.0063	-0.0058	48.3237
07/29/21	17:20:22	0729-R3_000485.LAB	191.4	0.99	0.0040	-0.0059	49.9271
07/29/21	17:20:52	0729-R3_000486.LAB	191.4	0.99	0.0152	-0.0042	49.7117
	Average		**191.4**	**0.99**	**0.0083**	**0.0037**	**49.2925**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/29/21	17:45:10	0729-R3_000534.LAB	191.4	0.99	0.0618	-0.0234	0.6676
07/29/21	17:45:40	0729-R3_000535.LAB	191.5	0.99	0.0086	-0.0113	0.4959
07/29/21	17:46:10	0729-R3_000536.LAB	191.4	0.99	0.0130	-0.0153	0.3050

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**C_2H_4O (ppmvw)**
07/29/21	17:48:27	0729-R3_000537BKG.LAB	191.4	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR C_2H_4O Average	Error (%)	Pass (≤5%)
Pre-Test Direct	47.40	47.26	0.29	YES
Post-Test Direct	47.40	49.29	3.99	YES

Pre / Post Comparison	FTIR C_2H_4O Maximum	FTIR C_2H_4O Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	47.86	48.28	0.88	YES
Post-Test Direct	49.93		3.30	YES

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Trial #1		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**NH_3**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	7:26:34	0729-PRE_000163.LAB	191.3	0.99	0.0016	0.0092	11.0529	46.2851
07/29/21	7:28:34	0729-PRE_000167.LAB	191.3	0.99	-0.0024	0.0120	11.0578	47.2974
07/29/21	7:29:04	0729-PRE_000168.LAB	191.3	0.99	0.0013	0.0064	11.0505	46.2767
07/29/21	7:29:34	0729-PRE_000169.LAB	191.3	0.99	0.0097	0.0036	11.0187	47.1397
	Average		**191.3**	**0.99**	**0.0026**	**0.0078**	**11.0450**	**46.7497**

Trial #1		Pre-Spike - Native Samples						
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**NH_3**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	13:27:28	0729-R3_000020.LAB	191.4	1.03	5.7788	13.7763	-0.0029	0.2584
07/29/21	13:27:58	0729-R3_000021.LAB	191.4	1.03	5.7773	13.8252	-0.0016	0.2776
07/29/21	13:28:28	0729-R3_000022.LAB	191.4	1.03	5.8095	13.3030	-0.0010	0.2552
07/29/21	13:28:59	0729-R3_000023.LAB	191.4	1.03	5.8209	13.3611	0.0007	0.2444
	Average		**191.4**	**1.03**	**5.7966**	**13.5664**	**-0.0012**	**0.2589**

Trial #1		Spiked Samples						
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**NH_3**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	13:50:01	0729-R3_000065.LAB	191.4	1.02	5.2051	16.0779	0.7052	2.5695
07/29/21	13:50:31	0729-R3_000066.LAB	191.4	1.02	5.2154	16.1184	0.7046	2.2878
07/29/21	13:51:01	0729-R3_000067.LAB	191.4	1.02	5.1984	15.5626	0.6996	2.3897
07/29/21	13:51:31	0729-R3_000068.LAB	191.4	1.03	5.1159	17.0782	0.7039	2.0829
	Average		**191.4**	**1.03**	**5.1837**	**16.2093**	**0.7033**	**2.3325**

Trial #2		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**NH_3**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	7:26:34	0729-PRE_000163.LAB	191.3	0.99	0.0016	0.0092	11.0529	46.2851
07/29/21	7:28:34	0729-PRE_000167.LAB	191.3	0.99	-0.0024	0.0120	11.0578	47.2974
07/29/21	7:29:04	0729-PRE_000168.LAB	191.3	0.99	0.0013	0.0064	11.0505	46.2767
07/29/21	7:29:34	0729-PRE_000169.LAB	191.3	0.99	0.0097	0.0036	11.0187	47.1397
	Average		**191.3**	**0.99**	**0.0026**	**0.0078**	**11.0450**	**46.7497**

Trial #2		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	15:29:41	0729-R3_000264.LAB	191.4	1.03	6.0871	10.4932	0.0086	0.3996
07/29/21	15:30:11	0729-R3_000265.LAB	191.4	1.03	6.0964	10.4971	0.0088	0.4470
07/29/21	15:30:41	0729-R3_000266.LAB	191.4	1.03	6.0418	10.9671	0.0082	0.4291
07/29/21	15:31:11	0729-R3_000267.LAB	191.4	1.03	6.0821	10.6008	0.0035	0.4249
		Average	**191.4**	**1.03**	**6.0768**	**10.6396**	**0.0073**	**0.4251**

Trial #2		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	15:36:42	0729-R3_000278.LAB	191.4	1.02	5.0614	16.8342	0.8971	3.3038
07/29/21	15:37:12	0729-R3_000279.LAB	191.4	1.02	5.2201	14.6879	0.8932	2.9650
07/29/21	15:37:42	0729-R3_000280.LAB	191.4	1.02	5.2446	14.2924	0.9011	2.9494
07/29/21	15:38:12	0729-R3_000281.LAB	191.4	1.03	5.3618	12.4385	0.9063	2.8430
		Average	**191.4**	**1.02**	**5.2220**	**14.5633**	**0.8995**	**3.0153**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	7:26:34	0729-PRE_000163.LAB	191.3	0.99	0.0016	0.0092	11.0529	46.2851
07/29/21	7:28:34	0729-PRE_000167.LAB	191.3	0.99	-0.0024	0.0120	11.0578	47.2974
07/29/21	7:29:04	0729-PRE_000168.LAB	191.3	0.99	0.0013	0.0064	11.0505	46.2767
07/29/21	7:29:34	0729-PRE_000169.LAB	191.3	0.99	0.0097	0.0036	11.0187	47.1397
		Average	**191.3**	**0.99**	**0.0026**	**0.0078**	**11.0450**	**46.7497**

Trial #3		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	15:53:14	0729-R3_000311.LAB	191.4	1.03	5.8236	13.9644	0.0020	0.7851
07/29/21	15:53:43	0729-R3_000312.LAB	191.4	1.03	5.8299	13.9946	0.0003	0.7793
07/29/21	15:54:14	0729-R3_000313.LAB	191.4	1.03	5.8400	13.9150	0.0015	0.7948
07/29/21	15:54:44	0729-R3_000314.LAB	191.4	1.03	5.8328	13.9310	-0.0022	0.7720
		Average	**191.4**	**1.03**	**5.8316**	**13.9513**	**0.0004**	**0.7828**

Trial #3		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	16:08:15	0729-R3_000341.LAB	191.4	1.03	5.4136	13.4491	0.7531	3.9385
07/29/21	16:08:45	0729-R3_000342.LAB	191.4	1.03	5.4074	13.4088	0.7539	3.8026
07/29/21	16:09:15	0729-R3_000343.LAB	191.4	1.03	5.4029	13.3926	0.7544	3.7165
07/29/21	16:09:45	0729-R3_000344.LAB	191.4	1.03	5.4003	13.3926	0.7529	3.6759
		Average	**191.4**	**1.03**	**5.4061**	**13.4108**	**0.7536**	**3.7834**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Sulfur Hexafluoride (SF_6)	(ppmvw)	11.04	11.04	11.04
Direct Verified Concentration of Ammonia (NH_3)	(ppmvw)	46.75	46.75	46.75
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.797	6.077	5.832
Stack (Native, Unspiked) H_2O Concentration	(%)	13.566	10.640	13.951
Stack (Native, Unspiked) SF_6 Concentration	(ppmvw)	-0.001	0.007	0.000
Stack (Native, Unspiked) NH_3 Concentration	(ppmvw)	0.259	0.425	0.783
Stack + Spike CO_2 Concentration	(%vw)	5.184	5.222	5.406
Stack + Spike H_2O Concentration	(%)	16.209	14.563	13.411
Stack + Spike SF_6 Concentration	(ppmvw)	0.703	0.899	0.754
Stack + Spike NH_3 Concentration	(ppmvw)	2.332	3.015	3.783
Dilution Factor, calc. from SF_6 (ppmvw)		0.064	0.081	0.068
Dilution Factor, as the ratio of dir to spk	(ratio)	15.7 : 1	12.4 : 1	14.7 : 1
Expected Concentration of the SF_6 Spike+Native, CS	(ppmvw)	0.703	0.899	0.754
Expected Concentration of the NH_3 Spike+Native, CS	(ppmvw)	3.225	4.167	3.917
Method 320 Spiked / Expected SF_6	%	99.99	100.07	100.00
Method 320 Spiked / Expected NH_3	%	72.33	72.36	96.58
Method 320 Passing SF_6 (70-130%)		YES	YES	YES
Method 320 Passing NH_3 (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

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Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		Spike Gas Direct Verification				FTIR: 509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:26:19	0729-PRE_000042.LAB	191.3	0.99	0.0046	0.0038	101.0654
07/29/21	6:26:49	0729-PRE_000043.LAB	191.3	0.99	0.0091	-0.0046	101.3680
07/29/21	6:27:19	0729-PRE_000044.LAB	191.3	0.99	-0.0013	0.0043	101.0983
07/29/21	6:27:50	0729-PRE_000045.LAB	191.3	0.99	0.0055	-0.0011	101.4527
		Average	**191.3**	**0.99**	**0.0045**	**0.0006**	**101.2461**

Trial #1		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	7:54:07	0729-PRE_000218.LAB	191.4	1.03	5.9875	11.5338	0.6056
07/29/21	7:54:37	0729-PRE_000219.LAB	191.4	1.03	5.9302	12.1485	0.4878
07/29/21	7:55:07	0729-PRE_000220.LAB	191.4	1.03	5.9536	11.8260	0.6502
07/29/21	7:55:37	0729-PRE_000221.LAB	191.4	1.03	5.7779	12.4808	0.5425
		Average	**191.4**	**1.03**	**5.9123**	**11.9973**	**0.5715**

Trial #1		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	7:57:37	0729-PRE_000225.LAB	191.4	1.03	5.4423	13.3304	6.8719
07/29/21	7:58:07	0729-PRE_000226.LAB	191.4	1.03	5.4336	13.4652	6.6892
07/29/21	7:58:37	0729-PRE_000227.LAB	191.3	1.03	5.4348	13.3763	6.6564
07/29/21	7:59:07	0729-PRE_000228.LAB	191.4	1.03	5.4500	13.4160	6.8767
		Average	**191.4**	**1.03**	**5.4402**	**13.3970**	**6.7735**

Trial #2		Spike Gas Direct Verification				FTIR: 509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:26:19	0729-PRE_000042.LAB	191.3	0.99	0.0046	0.0038	101.0654
07/29/21	6:26:49	0729-PRE_000043.LAB	191.3	0.99	0.0091	-0.0046	101.3680
07/29/21	6:27:19	0729-PRE_000044.LAB	191.3	0.99	-0.0013	0.0043	101.0983
07/29/21	6:27:50	0729-PRE_000045.LAB	191.3	0.99	0.0055	-0.0011	101.4527
		Average	**191.3**	**0.99**	**0.0045**	**0.0006**	**101.2461**

Trial #2		Pre-Spike - Native Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	9:07:29	0729-R1_000016.LAB	191.4	1.03	5.6801	15.1958	0.4539
07/29/21	9:07:59	0729-R1_000017.LAB	191.4	1.03	5.7495	14.5253	0.4642
07/29/21	9:08:29	0729-R1_000018.LAB	191.4	1.03	5.7714	14.4530	0.6337
07/29/21	9:08:59	0729-R1_000019.LAB	191.4	1.03	5.7488	14.5817	0.6257
		Average	**191.4**	**1.03**	**5.7375**	**14.6889**	**0.5444**

Trial #2		Spiked Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	9:11:29	0729-R1_000024.LAB	191.4	1.03	5.3331	13.9803	7.4505
07/29/21	9:11:59	0729-R1_000025.LAB	191.4	1.03	5.3881	13.5880	7.4152
07/29/21	9:12:29	0729-R1_000026.LAB	191.4	1.03	5.3839	13.3244	7.6570
07/29/21	9:12:59	0729-R1_000027.LAB	191.4	1.03	5.4045	12.8692	7.9010
		Average	**191.4**	**1.03**	**5.3774**	**13.4405**	**7.6059**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	6:26:19	0729-PRE_000042.LAB	191.3	0.99	0.0046	0.0038	101.0654
07/29/21	6:26:49	0729-PRE_000043.LAB	191.3	0.99	0.0091	-0.0046	101.3680
07/29/21	6:27:19	0729-PRE_000044.LAB	191.3	0.99	-0.0013	0.0043	101.0983
07/29/21	6:27:50	0729-PRE_000045.LAB	191.3	0.99	0.0055	-0.0011	101.4527
		Average	**191.3**	**0.99**	**0.0045**	**0.0006**	**101.2461**

Trial #3		Pre-Spike - Native Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	9:14:30	0729-R1_000030.LAB	191.4	1.03	5.8943	12.9276	0.5478
07/29/21	9:15:00	0729-R1_000031.LAB	191.4	1.03	5.8058	13.9653	0.5314
07/29/21	9:15:30	0729-R1_000032.LAB	191.4	1.03	5.7807	14.0679	0.6174
07/29/21	9:16:00	0729-R1_000033.LAB	191.4	1.02	5.5559	16.7870	0.5112
		Average	**191.4**	**1.03**	**5.7592**	**14.4370**	**0.5519**

Trial #3		Spiked Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**C_2H_6**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	9:17:30	0729-R1_000036.LAB	191.4	1.03	5.3371	13.5885	7.9238
07/29/21	9:18:00	0729-R1_000037.LAB	191.4	1.03	5.4023	12.9546	8.1480
07/29/21	9:18:30	0729-R1_000038.LAB	191.4	1.03	5.3772	13.1870	8.0203
07/29/21	9:19:00	0729-R1_000039.LAB	191.4	1.03	5.4150	12.7563	8.1687
		Average	**191.4**	**1.03**	**5.3829**	**13.1216**	**8.0652**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Ethane (C_2H_6)	(ppmvw)	101.25	101.25	101.25
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.912	5.737	5.759
Stack (Native, Unspiked) H_2O Concentration	(%)	11.997	14.689	14.437
Stack (Native, Unspiked) C_2H_6 Concentration	(ppmvw)	0.572	0.544	0.552
Stack + Spike CO_2 Concentration	(%vw)	5.440	5.377	5.383
Stack + Spike H_2O Concentration	(%)	13.397	13.440	13.122
Stack + Spike C_2H_6 Concentration	(ppmvw)	6.774	7.606	8.065
Dilution Factor, calc. from CO_2 (%vw)		0.080	0.063	0.065
Dilution Factor, as the ratio of dir to spk	(ratio)	12.5 : 1	15.9 : 1	15.3 : 1
Expected Concentration of the C_2H_6 Spike+Native, CS	(ppmvw)	8.611	6.864	7.131
Method 320 Spiked / Expected C_2H_6	%	78.66	110.81	113.10
Method 320 Passing C_2H_6 (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

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Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		**Spike Gas Direct Verification**				**FTIR:**	**509/ INST-IR-0005**
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	118.4758
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	118.2633
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	117.9127
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	118.9113
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**118.3908**

Trial #1		**Pre-Spike - Native Samples**					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	8:03:08	0729-PRE_000236.LAB	191.3	1.03	5.3847	13.9361	18.9449
07/29/21	8:03:38	0729-PRE_000237.LAB	191.3	1.03	5.5921	14.3319	19.4786
07/29/21	8:04:08	0729-PRE_000238.LAB	191.4	1.03	5.7245	14.8875	19.1555
07/29/21	8:04:38	0729-PRE_000239.LAB	191.4	1.02	5.4752	18.0467	19.5173
		Average	**191.3**	**1.02**	**5.5441**	**15.3006**	**19.2741**

Trial #1		**Spiked Samples**					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	8:09:08	0729-PRE_000248.LAB	191.2	1.03	5.1639	14.2613	28.2136
07/29/21	8:09:38	0729-PRE_000249.LAB	191.1	1.03	5.2596	13.4329	29.8942
07/29/21	8:10:08	0729-PRE_000250.LAB	191.1	1.03	5.2123	13.9439	29.3501
07/29/21	8:10:39	0729-PRE_000251.LAB	191.2	1.03	5.2120	13.9711	28.4101
		Average	**191.2**	**1.03**	**5.2119**	**13.9023**	**28.9670**

Trial #2		**Spike Gas Direct Verification**				**FTIR:**	**509/ INST-IR-0005**
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	118.4758
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	118.2633
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	117.9127
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	118.9113
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**118.3908**

Trial #2		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:41:16	0729-R1_000203.LAB	191.4	1.04	6.0667	9.8749	6.6883
07/29/21	10:41:46	0729-R1_000204.LAB	191.4	1.04	6.0394	10.4201	7.0146
07/29/21	10:42:17	0729-R1_000205.LAB	191.4	1.04	6.0349	10.5369	7.0232
07/29/21	10:42:47	0729-R1_000206.LAB	191.4	1.04	5.9472	10.1020	7.0688
		Average	**191.4**	**1.04**	**6.0221**	**10.2335**	**6.9487**

Trial #2		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:44:16	0729-R1_000209.LAB	191.4	1.04	5.5818	9.2504	15.0471
07/29/21	10:44:47	0729-R1_000210.LAB	191.4	1.03	5.3310	12.2215	14.6741
07/29/21	10:45:17	0729-R1_000211.LAB	191.4	1.03	5.2587	13.6691	14.9002
07/29/21	10:45:47	0729-R1_000212.LAB	191.4	1.03	5.2719	13.6722	15.1687
		Average	**191.4**	**1.03**	**5.3609**	**12.2033**	**14.9475**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	118.4758
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	118.2633
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	117.9127
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	118.9113
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**118.3908**

Trial #3		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:46:47	0729-R1_000214.LAB	191.4	1.03	5.6735	14.9820	6.0733
07/29/21	10:47:17	0729-R1_000215.LAB	191.4	1.02	5.4686	17.7606	5.7500
07/29/21	10:47:47	0729-R1_000216.LAB	191.4	1.02	5.5923	16.5758	6.2012
07/29/21	10:48:17	0729-R1_000217.LAB	191.4	1.03	5.6718	15.1855	5.8747
		Average	**191.4**	**1.03**	**5.6015**	**16.1260**	**5.9748**

Trial #3		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:51:47	0729-R1_000224.LAB	191.4	1.03	5.1912	14.5061	14.5892
07/29/21	10:52:17	0729-R1_000225.LAB	191.4	1.03	5.1831	14.6822	14.4297
07/29/21	10:52:47	0729-R1_000226.LAB	191.4	1.03	5.1944	14.6065	14.5221
07/29/21	10:53:17	0729-R1_000227.LAB	191.3	1.03	5.2487	13.9940	14.6695
		Average	**191.4**	**1.03**	**5.2044**	**14.4472**	**14.5526**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Nitrogen Oxides (NOx)	(ppmvw)	118.39	118.39	118.39
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.544	6.022	5.602
Stack (Native, Unspiked) H_2O Concentration	(%)	15.301	10.233	16.126
Stack (Native, Unspiked) NOx Concentration	(ppmvw)	19.274	6.949	5.975
Stack + Spike CO_2 Concentration	(%vw)	5.212	5.361	5.204
Stack + Spike H_2O Concentration	(%)	13.902	12.203	14.447
Stack + Spike NOx Concentration	(ppmvw)	28.967	14.948	14.553
Dilution Factor, calc. from CO_2 (%vw)		0.060	0.110	0.071
Dilution Factor, as the ratio of dir to spk	(ratio)	16.7 : 1	9.1 : 1	14.1 : 1
Expected Concentration of the NOx Spike+Native, CS	(ppmvw)	25.213	19.185	13.946
Method 320 Spiked / Expected NOx	%	114.89	77.91	104.35
Method 320 Passing NOx (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		Spike Gas Direct Verification				FTIR: 509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	121.3862
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	120.7858
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	120.6875
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	121.4610
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**121.0801**

Trial #1		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	8:03:08	0729-PRE_000236.LAB	191.3	1.03	5.3847	13.9361	3.9106
07/29/21	8:03:38	0729-PRE_000237.LAB	191.3	1.03	5.5921	14.3319	4.0740
07/29/21	8:04:08	0729-PRE_000238.LAB	191.4	1.03	5.7245	14.8875	4.3006
07/29/21	8:04:38	0729-PRE_000239.LAB	191.4	1.02	5.4752	18.0467	4.1830
		Average	**191.3**	**1.02**	**5.5441**	**15.3006**	**4.1170**

Trial #1		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	8:08:38	0729-PRE_000247.LAB	191.3	1.03	5.1809	14.2651	14.3805
07/29/21	8:09:08	0729-PRE_000248.LAB	191.2	1.03	5.1639	14.2613	14.4930
07/29/21	8:09:38	0729-PRE_000249.LAB	191.1	1.03	5.2596	13.4329	14.6522
07/29/21	8:10:08	0729-PRE_000250.LAB	191.1	1.03	5.2123	13.9439	14.5963
		Average	**191.2**	**1.03**	**5.2042**	**13.9758**	**14.5305**

Trial #2		Spike Gas Direct Verification				FTIR: 509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	121.3862
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	120.7858
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	120.6875
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	121.4610
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**121.0801**

Trial #2		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:41:46	0729-R1_000204.LAB	191.4	1.04	6.0394	10.4201	5.1958
07/29/21	10:42:17	0729-R1_000205.LAB	191.4	1.04	6.0349	10.5369	5.1412
07/29/21	10:42:47	0729-R1_000206.LAB	191.4	1.04	5.9472	10.1020	5.0784
07/29/21	10:43:17	0729-R1_000207.LAB	191.4	1.04	5.5778	9.5137	4.7623
		Average	**191.4**	**1.04**	**5.8998**	**10.1432**	**5.0444**

Trial #2		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:44:16	0729-R1_000209.LAB	191.4	1.04	5.5818	9.2504	13.6473
07/29/21	10:44:47	0729-R1_000210.LAB	191.4	1.03	5.3310	12.2215	14.0312
07/29/21	10:45:17	0729-R1_000211.LAB	191.4	1.03	5.2587	13.6691	13.9973
07/29/21	10:45:47	0729-R1_000212.LAB	191.4	1.03	5.2719	13.6722	14.0508
		Average	**191.4**	**1.03**	**5.3609**	**12.2033**	**13.9317**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	6:29:20	0729-PRE_000048.LAB	191.3	0.99	-0.0356	0.0132	121.3862
07/29/21	6:29:50	0729-PRE_000049.LAB	191.3	0.99	-0.0345	0.0001	120.7858
07/29/21	6:30:20	0729-PRE_000050.LAB	191.3	0.99	-0.0255	-0.0019	120.6875
07/29/21	6:30:50	0729-PRE_000051.LAB	191.3	0.99	-0.0344	0.0022	121.4610
		Average	**191.3**	**0.99**	**-0.0325**	**0.0034**	**121.0801**

Trial #3		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:47:17	0729-R1_000215.LAB	191.4	1.02	5.4686	17.7606	4.9024
07/29/21	10:47:47	0729-R1_000216.LAB	191.4	1.02	5.5923	16.5758	4.8346
07/29/21	10:48:17	0729-R1_000217.LAB	191.4	1.03	5.6718	15.1855	5.0380
07/29/21	10:48:47	0729-R1_000218.LAB	191.4	1.03	5.7312	14.3712	5.0990
		Average	**191.4**	**1.03**	**5.6160**	**15.9733**	**4.9685**

Trial #3		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/29/21	10:50:17	0729-R1_000221.LAB	191.4	1.03	5.3414	12.8845	14.0327
07/29/21	10:50:47	0729-R1_000222.LAB	191.3	1.03	5.2080	14.3284	13.9683
07/29/21	10:51:17	0729-R1_000223.LAB	191.3	1.03	5.1211	15.2920	13.8946
07/29/21	10:51:47	0729-R1_000224.LAB	191.4	1.03	5.1912	14.5061	13.8609
		Average	**191.4**	**1.03**	**5.2154**	**14.2527**	**13.9391**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Carbon Monoxide (CO)	(ppmvw)	121.08	121.08	121.08
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.544	5.900	5.616
Stack (Native, Unspiked) H_2O Concentration	(%)	15.301	10.143	15.973
Stack (Native, Unspiked) CO Concentration	(ppmvw)	4.117	5.044	4.968
Stack + Spike CO_2 Concentration	(%vw)	5.204	5.361	5.215
Stack + Spike H_2O Concentration	(%)	13.976	12.203	14.253
Stack + Spike CO Concentration	(ppmvw)	14.530	13.932	13.939
Dilution Factor, calc. from CO_2 (%vw)		0.061	0.091	0.071
Dilution Factor, as the ratio of dir to spk	(ratio)	16.3 : 1	10.9 : 1	14 : 1
Expected Concentration of the CO Spike+Native, CS	(ppmvw)	11.289	15.645	13.250
Method 320 Spiked / Expected CO	%	128.71	89.05	105.20
Method 320 Passing CO (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

July 29, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		**Spike Gas Direct Verification**				**FTIR:** 509/ INST-IR-0005		
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**C_2H_4O**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	6:32:20	0729-PRE_000054.LAB	191.3	0.99	0.0102	-0.0025	5.6174	46.1720
07/29/21	6:32:50	0729-PRE_000055.LAB	191.3	0.99	0.0016	-0.0038	5.6081	47.2898
07/29/21	6:33:20	0729-PRE_000056.LAB	191.3	0.99	0.0070	-0.0048	5.6041	47.6549
07/29/21	6:33:50	0729-PRE_000057.LAB	191.3	0.99	0.0126	-0.0068	5.6117	47.3384
		Average	**191.3**	**0.99**	**0.0078**	**-0.0045**	**5.6103**	**47.1138**

Trial #1		**Pre-Spike - Native Samples**						
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**C_2H_4O**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	8:13:09	0729-PRE_000256.LAB	191.3	1.03	5.8412	13.6062	-0.0029	0.1604
07/29/21	8:13:39	0729-PRE_000257.LAB	191.4	1.03	5.7654	14.4985	-0.0054	0.4411
07/29/21	8:14:09	0729-PRE_000258.LAB	191.4	1.03	5.7930	14.2263	-0.0039	0.8452
07/29/21	8:14:39	0729-PRE_000259.LAB	191.4	1.03	5.4426	14.6566	-0.0013	0.3062
		Average	**191.4**	**1.03**	**5.7106**	**14.2469**	**-0.0034**	**0.4382**

Trial #1		**Spiked Samples**						
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**C_2H_4O**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	8:17:09	0729-PRE_000264.LAB	191.4	1.03	5.4266	12.7225	0.4138	3.7061
07/29/21	8:17:39	0729-PRE_000265.LAB	191.4	1.03	5.2023	15.0338	0.4087	3.6254
07/29/21	8:18:09	0729-PRE_000266.LAB	191.4	1.03	5.3755	13.2563	0.4079	3.6457
07/29/21	8:18:39	0729-PRE_000267.LAB	191.4	1.03	5.3797	13.4089	0.4026	3.5155
		Average	**191.4**	**1.03**	**5.3460**	**13.6054**	**0.4082**	**3.6232**

Trial #2		**Spike Gas Direct Verification**				**FTIR:** 509/ INST-IR-0005		
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**SF_6**	**C_2H_4O**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**	**(ppmvw)**
07/29/21	6:32:20	0729-PRE_000054.LAB	191.3	0.99	0.0102	-0.0025	5.6174	46.1720
07/29/21	6:32:50	0729-PRE_000055.LAB	191.3	0.99	0.0016	-0.0038	5.6081	47.2898
07/29/21	6:33:20	0729-PRE_000056.LAB	191.3	0.99	0.0070	-0.0048	5.6041	47.6549
07/29/21	6:33:50	0729-PRE_000057.LAB	191.3	0.99	0.0126	-0.0068	5.6117	47.3384
		Average	**191.3**	**0.99**	**0.0078**	**-0.0045**	**5.6103**	**47.1138**

Trial #2		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	C_2H_4O
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	10:58:18	0729-R1_000237.LAB	191.4	1.03	5.8150	13.6099	0.0006	0.3406
07/29/21	10:58:48	0729-R1_000238.LAB	191.4	1.03	5.8728	12.9194	-0.0025	0.5241
07/29/21	10:59:18	0729-R1_000239.LAB	191.4	1.03	5.8676	12.9379	-0.0025	0.6039
07/29/21	10:59:48	0729-R1_000240.LAB	191.4	1.03	5.4829	12.5593	0.0002	0.3223
		Average	**191.4**	**1.03**	**5.7596**	**13.0067**	**-0.0011**	**0.4477**

Trial #2		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	C_2H_4O
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	11:01:49	0729-R1_000244.LAB	191.5	1.03	5.2712	13.8200	0.4242	3.7331
07/29/21	11:02:19	0729-R1_000245.LAB	191.5	1.03	5.3219	13.2850	0.4282	4.2742
07/29/21	11:02:49	0729-R1_000246.LAB	191.5	1.03	5.3687	12.7560	0.4313	4.0858
07/29/21	11:03:18	0729-R1_000247.LAB	191.5	1.03	5.3000	13.5442	0.4326	4.3084
		Average	**191.5**	**1.03**	**5.3154**	**13.3513**	**0.4291**	**4.1004**

Trial #3		Spike Gas Direct Verification				FTIR: 509/ INST-IR-0005		
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	C_2H_4O
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	6:32:20	0729-PRE_000054.LAB	191.3	0.99	0.0102	-0.0025	5.6174	46.1720
07/29/21	6:32:50	0729-PRE_000055.LAB	191.3	0.99	0.0016	-0.0038	5.6081	47.2898
07/29/21	6:33:20	0729-PRE_000056.LAB	191.3	0.99	0.0070	-0.0048	5.6041	47.6549
07/29/21	6:33:50	0729-PRE_000057.LAB	191.3	0.99	0.0126	-0.0068	5.6117	47.3384
		Average	**191.3**	**0.99**	**0.0078**	**-0.0045**	**5.6103**	**47.1138**

Trial #3		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	C_2H_4O
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	11:04:19	0729-R1_000249.LAB	191.5	1.03	5.8610	12.4156	0.0084	0.5578
07/29/21	11:04:49	0729-R1_000250.LAB	191.4	1.03	5.7812	13.8925	-0.0013	0.2429
07/29/21	11:05:19	0729-R1_000251.LAB	191.4	1.03	5.8004	13.6536	0.0004	0.3584
07/29/21	11:05:49	0729-R1_000252.LAB	191.5	1.03	5.7415	14.2661	-0.0004	0.2898
		Average	**191.5**	**1.03**	**5.7960**	**13.5570**	**0.0018**	**0.3622**

Trial #3		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	C_2H_4O
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/29/21	11:08:19	0729-R1_000257.LAB	191.5	1.03	5.3438	13.0895	0.4337	4.2009
07/29/21	11:08:49	0729-R1_000258.LAB	191.4	1.03	5.3372	12.6090	0.4378	4.1634
07/29/21	11:09:19	0729-R1_000259.LAB	191.5	1.03	5.3282	12.4337	0.4382	4.3737
07/29/21	11:09:49	0729-R1_000260.LAB	191.4	1.04	5.3419	13.0188	0.4436	4.5190
		Average	**191.5**	**1.03**	**5.3378**	**12.7877**	**0.4383**	**4.3142**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Sulfur Hexafluoride (SF_6)	(ppmvw)	5.61	5.61	5.61
Direct Verified Concentration of Acetaldehyde (C_2H_4O)	(ppmvw)	47.11	47.11	47.11
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.711	5.760	5.796
Stack (Native, Unspiked) H_2O Concentration	(%)	14.247	13.007	13.557
Stack (Native, Unspiked) SF_6 Concentration	(ppmvw)	-0.003	-0.001	0.002
Stack (Native, Unspiked) C_2H_4O Concentration	(ppmvw)	0.438	0.448	0.362
Stack + Spike CO_2 Concentration	(%vw)	5.346	5.315	5.338
Stack + Spike H_2O Concentration	(%)	13.605	13.351	12.788
Stack + Spike SF_6 Concentration	(ppmvw)	0.408	0.429	0.438
Stack + Spike C_2H_4O Concentration	(ppmvw)	3.623	4.100	4.314
Dilution Factor, calc. from SF_6 (ppmvw)		0.073	0.077	0.078
Dilution Factor, as the ratio of dir to spk	(ratio)	13.6 : 1	13 : 1	12.9 : 1
Expected Concentration of the SF_6 Spike+Native, CS	(ppmvw)	0.408	0.429	0.438
Expected Concentration of the C_2H_4O Spike+Native, CS	(ppmvw)	3.863	4.026	4.000
Method 320 Spiked / Expected SF_6	%	99.94	99.98	100.03
Method 320 Spiked / Expected C_2H_4O	%	93.80	101.86	107.85
Method 320 Passing SF_6 (70-130%)		YES	YES	YES
Method 320 Passing C_2H_4O (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

July 30, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Sampling System Leak Check	Flow (LPM)	Date (dd/mm/yy)	Time (hh:mm)
	≤0.2	07/30/21	5:30

FTIR No:	509/ INST-IR-0005
Make Model:	MKS 2030

Analytical System Leak Checks	**Vacuum Leak Check**

Spectrum	Date (dd/mm/yy)	Time (hh:mm:ss)	Vacuum (atm)
0730-PRE_000014.LAB	07/30/21	6:03:12	0.99459
0730-PRE_000015.LAB	07/30/21	6:03:42	0.99447
0730-PRE_000016.LAB	07/30/21	6:04:12	0.99512
0730-PRE_000017.LAB	07/30/21	6:04:42	0.99520
0730-PRE_000018.LAB	07/30/21	6:05:12	0.99500
0730-PRE_000019.LAB	07/30/21	6:05:42	0.99504
0730-PRE_000020.LAB	07/30/21	6:06:12	0.99529
0730-PRE_000021.LAB	07/30/21	6:06:42	0.99537
0730-PRE_000022.LAB	07/30/21	6:07:12	0.99551

Pressure Elements	Vacuum (atm)
Average, P_s	0.99507
Maximum	0.99551
Minimum	0.99447
Difference, ΔP_v	0.00104

Time Elements	Results (min)
Signal Integration, t_{ss}	0.50
Test Duration, t_d	4.00

Analytical System Leak Checks	**Pressure Leak Check**

Spectrum	Date (dd/mm/yy)	Time (hh:mm:ss)	Pressure (atm)
0730-PRE_000002.LAB	07/30/21	5:57:11	1.10579
0730-PRE_000003.LAB	07/30/21	5:57:41	1.10579
0730-PRE_000004.LAB	07/30/21	5:58:11	1.10579
0730-PRE_000005.LAB	07/30/21	5:58:41	1.10579
0730-PRE_000006.LAB	07/30/21	5:59:11	1.10579
0730-PRE_000007.LAB	07/30/21	5:59:42	1.10579
0730-PRE_000008.LAB	07/30/21	6:00:12	1.10579
0730-PRE_000009.LAB	07/30/21	6:00:42	1.10579
0730-PRE_000010.LAB	07/30/21	6:01:12	1.10579
0730-PRE_000011.LAB	07/30/21	6:01:42	1.10579

Pressure Elements	Pressure (atm)
Average, P_s	1.10579
Maximum	1.10579
Minimum	1.10579
Difference, ΔP_p	0.00000

Station Pressure (in. Hg)	29.89

Time Elements	Results (min)
Signal Integration, t_{ss}	0.50
Test Duration, t_d	4.50

Parameter	Vacuum	Pressure	Max ΔP
Test Duration, t_d	4.00	4.50	4.00
Signal Integ., t_{ss}	0.50	0.50	0.50
Difference, ΔP	0.00104	0.00000	0.00104
Average, P_s	0.99507	1.10579	0.99507
Leak Volume, $\%V_L$	0.013	0.000	0.013
Pass, ≤4%	yes	yes	yes

$$\%V_L = \frac{100\%}{t_d} t_{ss} \frac{\Delta P_{max}}{P_S}$$

Method 320, Section 8.2.2.4, Equation 2
expanded to account for sample duration

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Protocol No. 1, CO_2 Cylinder Concentration:	8.95 %vd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/30/21	6:16:09	0730-PRE_000036.LAB	191.3	1.00	8.9894	0.0085
07/30/21	6:16:39	0730-PRE_000037.LAB	191.3	1.00	9.0392	0.0043
07/30/21	6:17:09	0730-PRE_000038.LAB	191.4	1.00	9.0308	0.0029
07/30/21	6:17:39	0730-PRE_000039.LAB	191.4	1.00	8.9392	-0.0020
07/30/21	6:18:09	0730-PRE_000040.LAB	191.4	1.00	8.9547	0.0015
	Average		**191.4**	**1.00**	**8.9907**	**0.0030**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/30/21	20:08:00	0730-R3_000443.LAB	191.4	0.99	9.0504	0.0024
07/30/21	20:08:30	0730-R3_000444.LAB	191.4	0.99	9.0830	-0.0011
07/30/21	20:09:00	0730-R3_000445.LAB	191.4	0.99	9.0399	0.0029
07/30/21	20:09:30	0730-R3_000446.LAB	191.4	0.99	9.0417	-0.0021
07/30/21	20:10:00	0730-R3_000447.LAB	191.4	0.99	9.0313	-0.0045
	Average		**191.4**	**0.99**	**9.0492**	**-0.0005**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2	H_2O (%)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060

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Post-Test Background						
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2**	**H_2O (%)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR CO_2 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	8.95	8.99	0.45	YES
Post-Test Direct	8.95	9.05	1.11	YES

Pre / Post Comparison	FTIR CO_2 Maximum	FTIR CO_2 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	9.04	9.02	0.21	YES
Post-Test Direct	9.08		0.69	YES

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Certified, NH_3 Cylinder Concentration:	49 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042	0.0083
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009	-0.0388
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014	-0.0227

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/30/21	6:38:41	0730-PRE_000081.LAB	191.4	1.00	0.0045	0.0037	46.4683
07/30/21	6:39:11	0730-PRE_000082.LAB	191.4	1.00	0.0114	0.0074	46.4068
07/30/21	6:39:41	0730-PRE_000083.LAB	191.4	1.00	0.0126	0.0106	47.4780
07/30/21	6:40:11	0730-PRE_000084.LAB	191.4	1.00	0.0086	0.0062	47.5915
07/30/21	6:41:11	0730-PRE_000086.LAB	191.4	1.00	0.0281	0.7565	48.0381
	Average		**191.4**	**1.00**	**0.0130**	**0.1569**	**47.1965**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/30/21	19:53:28	0730-R3_000414.LAB	191.3	1.00	-0.0003	0.0082	47.5248
07/30/21	19:53:58	0730-R3_000415.LAB	191.3	1.00	0.0067	0.0095	46.4149
07/30/21	19:54:28	0730-R3_000416.LAB	191.3	1.00	0.0161	0.0061	45.7153
07/30/21	19:54:58	0730-R3_000417.LAB	191.2	1.00	0.0057	0.0043	45.8208
07/30/21	19:55:28	0730-R3_000418.LAB	191.2	1.00	0.0145	0.0039	47.3945
	Average		**191.3**	**1.00**	**0.0085**	**0.0064**	**46.5741**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NH_3 (ppmvw)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023	1.0692
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021	0.9469
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060	0.8690

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**NH_3 (ppmvw)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR NH_3 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	49.00	47.20	3.68	YES
Post-Test Direct	49.00	46.57	4.95	YES

Pre / Post Comparison	FTIR NH_3 Maximum	FTIR NH_3 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	48.04	46.89	2.40	YES
Post-Test Direct	47.52		1.35	YES

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Certified, C_2H_6 Cylinder Concentration:	100 ppmvd

Pre-Test Background						**FTIR:**	509/ INST-IR-0005
Date (mm/dd/yy)	**Time** (hh:mm:ss)	**Spectrum** (File Name)	**Cell Temp** (°C)	**Cell Press** (atm)	**CO_2** (ppmvw)	**H_2O** (%)	**C_2H_6** (ppmvw)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000	0.0000

Pre-Test Direct Zero							
Date (mm/dd/yy)	**Time** (hh:mm:ss)	**Spectrum** (File Name)	**Cell Temp** (°C)	**Cell Press** (atm)	**CO_2** (ppmvw)	**H_2O** (%)	**C_2H_6** (ppmvw)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042	-0.0546
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009	0.0040
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014	-0.0639

Pre-Test Direct Calibration Transfer Spectra							
Date (mm/dd/yy)	**Time** (hh:mm:ss)	**Spectrum** (File Name)	**Cell Temp** (°C)	**Cell Press** (atm)	**CO_2** (ppmvw)	**H_2O** (%)	**C_2H_6** (ppmvw)
07/30/21	6:19:39	0730-PRE_000043.LAB	191.3	1.00	0.0072	0.0011	100.6868
07/30/21	6:20:09	0730-PRE_000044.LAB	191.4	1.00	0.0030	-0.0006	100.9227
07/30/21	6:20:39	0730-PRE_000045.LAB	191.4	1.00	0.0058	-0.0020	100.6889
07/30/21	6:21:09	0730-PRE_000046.LAB	191.4	1.00	-0.0050	-0.0002	101.1251
07/30/21	6:21:39	0730-PRE_000047.LAB	191.4	1.00	0.0032	0.0017	101.2393
	Average		**191.4**	**1.00**	**0.0028**	**0.0000**	**100.9326**

Post-Test Direct Calibration Transfer Spectra							
Date (mm/dd/yy)	**Time** (hh:mm:ss)	**Spectrum** (File Name)	**Cell Temp** (°C)	**Cell Press** (atm)	**CO_2** (ppmvw)	**H_2O** (%)	**C_2H_6** (ppmvw)
07/30/21	20:04:59	0730-R3_000437.LAB	191.5	0.99	0.0128	0.0883	94.9111
07/30/21	20:05:29	0730-R3_000438.LAB	191.4	0.99	0.0051	0.0921	96.0914
07/30/21	20:05:59	0730-R3_000439.LAB	191.4	0.99	-0.0016	0.1057	95.6295
07/30/21	20:06:29	0730-R3_000440.LAB	191.4	0.99	0.0089	0.1073	95.1082
07/30/21	20:06:59	0730-R3_000441.LAB	191.4	0.99	0.0170	0.0381	99.3170
	Average		**191.4**	**0.99**	**0.0084**	**0.0863**	**96.2115**

Post-Test Direct Zero							
Date (mm/dd/yy)	**Time** (hh:mm:ss)	**Spectrum** (File Name)	**Cell Temp** (°C)	**Cell Press** (atm)	**CO_2** (ppmvw)	**H_2O** (%)	**C_2H_6** (ppmvw)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023	-0.2236
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021	-0.1017
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060	-0.3388

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**C_2H_6 (ppmvw)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR C_2H_6 Average	Error (%)	Pass (≤5%)
Pre-Test Direct	100.00	100.93	0.93	YES
Post-Test Direct	100.00	96.21	3.79	YES

Pre / Post Comparison	FTIR C_2H_6 Maximum	FTIR C_2H_6 Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	101.24	98.57	2.63	YES
Post-Test Direct	99.32		0.75	YES

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Protocol No. 1, NOx Cylinder Concentration:	116.1 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NOx (ppmvw)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NOx (ppmvw)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042	0.0301
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009	-0.0634
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014	0.0144

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NOx (ppmvw)
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	118.1741
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	118.8564
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	118.6155
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	117.8215
07/30/21	6:24:39	0730-PRE_000053.LAB	191.4	1.00	-0.0356	-0.0027	118.2811
Average			**191.4**	**1.00**	**-0.0372**	**0.0030**	**118.3497**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NOx (ppmvw)
07/30/21	20:01:59	0730-R3_000431.LAB	191.4	0.99	-0.0372	0.0002	119.2568
07/30/21	20:02:29	0730-R3_000432.LAB	191.4	0.99	-0.0273	-0.0001	118.8093
07/30/21	20:02:59	0730-R3_000433.LAB	191.4	0.99	-0.0241	0.0010	118.7938
07/30/21	20:03:29	0730-R3_000434.LAB	191.4	0.99	-0.0204	-0.0029	118.3085
07/30/21	20:03:59	0730-R3_000435.LAB	191.4	0.99	-0.0253	-0.0007	118.3400
Average			**191.4**	**0.99**	**-0.0268**	**-0.0005**	**118.7017**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	NOx (ppmvw)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023	-0.0462
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021	-0.1749
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060	-0.0298

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**NOx (ppmvw)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR NOx Average	Error (%)	Pass (≤5%)
Pre-Test Direct	116.10	118.35	1.94	YES
Post-Test Direct	116.10	118.70	2.24	YES

Pre / Post Comparison	FTIR NOx Maximum	FTIR NOx Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	118.86	118.53	0.28	YES
Post-Test Direct	119.26		0.61	YES

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Protocol No. 1, CO Cylinder Concentration:	122 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042	0.0440
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009	-0.0435
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014	0.0030

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	120.7373
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	121.4913
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	121.2086
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	120.4047
07/30/21	6:24:39	0730-PRE_000053.LAB	191.4	1.00	-0.0356	-0.0027	120.4995
	Average		**191.4**	**1.00**	**-0.0372**	**0.0030**	**120.8683**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/30/21	20:01:59	0730-R3_000431.LAB	191.4	0.99	-0.0372	0.0002	122.2379
07/30/21	20:02:29	0730-R3_000432.LAB	191.4	0.99	-0.0273	-0.0001	121.5142
07/30/21	20:02:59	0730-R3_000433.LAB	191.4	0.99	-0.0241	0.0010	121.3072
07/30/21	20:03:29	0730-R3_000434.LAB	191.4	0.99	-0.0204	-0.0029	120.9053
07/30/21	20:03:59	0730-R3_000435.LAB	191.4	0.99	-0.0253	-0.0007	120.6371
	Average		**191.4**	**0.99**	**-0.0268**	**-0.0005**	**121.3203**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	CO (ppmvw)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023	-0.0600
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021	-0.1378
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060	-0.0268

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**CO (ppmvw)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

CTS Results	Protocol No. 1 Concentration	FTIR CO Average	Error (%)	Pass (≤5%)
Pre-Test Direct	122.00	120.87	0.93	YES
Post-Test Direct	122.00	121.32	0.56	YES

Pre / Post Comparison	FTIR CO Maximum	FTIR CO Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	121.49	121.09	0.33	YES
Post-Test Direct	122.24		0.94	YES

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Certified, C_2H_4O Cylinder Concentration:	47.4 ppmvd

Pre-Test Background — **FTIR:** 509/ INST-IR-0005

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/30/21	6:13:32	0730-PRE_000031BKG.LAB	191.4	1.00	0.0000	0.0000	0.0000

Pre-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/30/21	6:14:09	0730-PRE_000032.LAB	191.3	1.00	-0.0033	0.0042	0.2031
07/30/21	6:14:38	0730-PRE_000033.LAB	191.4	1.00	0.0086	-0.0009	0.0650
07/30/21	6:15:08	0730-PRE_000034.LAB	191.3	1.00	-0.0026	0.0014	0.1599

Pre-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/30/21	6:25:40	0730-PRE_000055.LAB	191.4	1.00	0.0066	0.0047	46.2794
07/30/21	6:26:10	0730-PRE_000056.LAB	191.4	1.00	0.0073	-0.0029	47.4824
07/30/21	6:26:40	0730-PRE_000057.LAB	191.4	1.00	-0.0018	0.0002	48.0103
07/30/21	6:27:10	0730-PRE_000058.LAB	191.4	1.00	-0.0025	-0.0030	48.0884
07/30/21	6:27:40	0730-PRE_000059.LAB	191.4	1.00	0.0059	-0.0068	48.1908
Average			**191.4**	**1.00**	**0.0031**	**-0.0015**	**47.6103**

Post-Test Direct Calibration Transfer Spectra

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/30/21	19:58:59	0730-R3_000425.LAB	191.4	0.99	0.0109	-0.0057	44.9843
07/30/21	19:59:29	0730-R3_000426.LAB	191.4	0.99	0.0138	-0.0121	45.1049
07/30/21	19:59:59	0730-R3_000427.LAB	191.4	0.99	0.0118	-0.0089	45.3844
07/30/21	20:00:29	0730-R3_000428.LAB	191.4	0.99	0.0115	-0.0111	45.3527
07/30/21	20:00:59	0730-R3_000429.LAB	191.4	0.99	0.0119	-0.0026	45.4163
Average			**191.4**	**0.99**	**0.0120**	**-0.0081**	**45.2485**

Post-Test Direct Zero

Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (ppmvw)	H_2O (%)	C_2H_4O (ppmvw)
07/30/21	20:15:00	0730-R3_000457.LAB	191.4	0.99	0.0107	-0.0023	-0.0450
07/30/21	20:15:30	0730-R3_000458.LAB	191.4	0.99	0.0023	-0.0021	0.2411
07/30/21	20:16:00	0730-R3_000459.LAB	191.4	0.99	0.0115	-0.0060	0.3815

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Post-Test Background							
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (ppmvw)**	**H_2O (%)**	**C_2H_4O (ppmvw)**
07/30/21	20:18:25	0730-R3_000460BKG.LAB	191.3	0.99	0.0000	0.0000	0.0000

CTS Results	Certified Concentration	FTIR C_2H_4O Average	Error (%)	Pass (≤5%)
Pre-Test Direct	47.40	47.61	0.44	YES
Post-Test Direct	47.40	45.25	4.54	YES

Pre / Post Comparison	FTIR C_2H_4O Maximum	FTIR C_2H_4O Pre/Post Mean	Error (%)	Pass (≤5%)
Pre-Test Direct	48.19	46.43	3.66	YES
Post-Test Direct	45.42		2.23	YES

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Trial #1		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	NH_3 (ppmvw)
07/30/21	6:38:41	0730-PRE_000081.LAB	191.4	1.00	0.0045	0.0037	11.0592	46.4683
07/30/21	6:39:11	0730-PRE_000082.LAB	191.4	1.00	0.0114	0.0074	11.0565	46.4068
07/30/21	6:39:41	0730-PRE_000083.LAB	191.4	1.00	0.0126	0.0106	11.0569	47.4780
07/30/21	6:40:11	0730-PRE_000084.LAB	191.4	1.00	0.0086	0.0062	11.0642	47.5915
		Average	**191.4**	**1.00**	**0.0093**	**0.0070**	**11.0592**	**46.9861**

Trial #1		Pre-Spike - Native Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	NH_3 (ppmvw)
07/30/21	17:29:43	0730-R3_000127.LAB	191.4	1.03	5.8899	13.0638	-0.0051	13.1427
07/30/21	17:30:13	0730-R3_000128.LAB	191.4	1.02	5.8880	13.1952	-0.0051	13.2455
07/30/21	17:30:43	0730-R3_000129.LAB	191.5	1.03	5.9085	12.4733	-0.0025	13.0278
07/30/21	17:31:13	0730-R3_000130.LAB	191.5	1.03	5.9130	12.4050	-0.0035	13.1000
		Average	**191.5**	**1.03**	**5.8999**	**12.7843**	**-0.0041**	**13.1290**

Trial #1		Spiked Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	NH_3 (ppmvw)
07/30/21	17:41:44	0730-R3_000151.LAB	191.4	1.01	5.1125	16.8425	4.0957	21.6241
07/30/21	17:42:14	0730-R3_000152.LAB	191.4	1.03	4.5930	11.9125	4.0952	21.1914
07/30/21	17:42:44	0730-R3_000153.LAB	191.4	1.03	4.7731	13.8540	4.0957	22.1734
07/30/21	17:43:14	0730-R3_000154.LAB	191.3	1.02	5.1449	13.8670	4.0952	22.5789
		Average	**191.4**	**1.02**	**4.9059**	**14.1190**	**4.0954**	**21.8920**

Trial #2		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	NH_3 (ppmvw)
07/30/21	6:38:41	0730-PRE_000081.LAB	191.4	1.00	0.0045	0.0037	11.0592	46.4683
07/30/21	6:39:11	0730-PRE_000082.LAB	191.4	1.00	0.0114	0.0074	11.0565	46.4068
07/30/21	6:39:41	0730-PRE_000083.LAB	191.4	1.00	0.0126	0.0106	11.0569	47.4780
07/30/21	6:40:11	0730-PRE_000084.LAB	191.4	1.00	0.0086	0.0062	11.0642	47.5915
		Average	**191.4**	**1.00**	**0.0093**	**0.0070**	**11.0592**	**46.9861**

Trial #2		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/30/21	18:52:21	0730-R3_000292.LAB	191.3	1.04	5.5552	14.4346	-0.0093	1.8100
07/30/21	18:52:51	0730-R3_000293.LAB	191.3	1.03	5.5539	14.6010	-0.0090	1.5328
07/30/21	18:53:22	0730-R3_000294.LAB	191.3	1.03	5.5866	14.1337	-0.0094	1.3203
07/30/21	18:53:52	0730-R3_000295.LAB	191.3	1.03	5.6429	13.7381	-0.0080	1.1878
Average			**191.3**	**1.03**	**5.5847**	**14.2269**	**-0.0089**	**1.4628**

Trial #2		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/30/21	19:15:54	0730-R3_000339.LAB	191.3	1.03	4.6391	13.2155	0.8064	4.0219
07/30/21	19:16:24	0730-R3_000340.LAB	191.2	1.03	4.9884	11.5188	0.8079	4.1450
07/30/21	19:16:54	0730-R3_000341.LAB	191.3	1.03	4.5691	11.4957	0.8030	3.3466
07/30/21	19:17:24	0730-R3_000342.LAB	191.3	1.03	4.3604	10.6202	0.7988	3.0584
		Average	**191.3**	**1.03**	**4.6393**	**11.7125**	**0.8040**	**3.6430**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/30/21	6:38:41	0730-PRE_000081.LAB	191.4	1.00	0.0045	0.0037	11.0592	46.4683
07/30/21	6:39:11	0730-PRE_000082.LAB	191.4	1.00	0.0114	0.0074	11.0565	46.4068
07/30/21	6:39:41	0730-PRE_000083.LAB	191.4	1.00	0.0126	0.0106	11.0569	47.4780
07/30/21	6:40:11	0730-PRE_000084.LAB	191.4	1.00	0.0086	0.0062	11.0642	47.5915
		Average	**191.4**	**1.00**	**0.0093**	**0.0070**	**11.0592**	**46.9861**

Trial #3		Pre-Spike - Native Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/30/21	19:20:24	0730-R3_000348.LAB	191.3	1.02	5.4440	16.3774	-0.0033	1.9032
07/30/21	19:20:55	0730-R3_000349.LAB	191.3	1.02	5.5524	14.7458	-0.0042	1.7367
07/30/21	19:21:24	0730-R3_000350.LAB	191.4	1.02	5.6631	13.6230	-0.0057	1.6003
07/30/21	19:21:55	0730-R3_000351.LAB	191.3	1.03	5.6113	14.0821	-0.0035	1.5597
		Average	**191.3**	**1.02**	**5.5677**	**14.7071**	**-0.0042**	**1.7000**

Trial #3		Spiked Samples						
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	SF_6	NH_3
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)	(ppmvw)
07/30/21	19:28:55	0730-R3_000365.LAB	191.3	1.03	5.1457	13.9195	0.8066	4.5177
07/30/21	19:29:25	0730-R3_000366.LAB	191.3	1.02	5.1848	13.5242	0.8021	3.9342
07/30/21	19:29:55	0730-R3_000367.LAB	191.3	1.03	5.2114	13.0419	0.8058	3.4876
07/30/21	19:30:25	0730-R3_000368.LAB	191.3	1.03	5.2138	12.5100	0.8088	3.5619
		Average	**191.3**	**1.03**	**5.1889**	**13.2489**	**0.8058**	**3.8754**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Sulfur Hexafluoride (SF_6)	(ppmvw)	11.06	11.06	11.06
Direct Verified Concentration of Ammonia (NH_3)	(ppmvw)	46.99	46.99	46.99
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.900	5.585	5.568
Stack (Native, Unspiked) H_2O Concentration	(%)	12.784	14.227	14.707
Stack (Native, Unspiked) SF_6 Concentration	(ppmvw)	-0.004	-0.009	-0.004
Stack (Native, Unspiked) NH_3 Concentration	(ppmvw)	13.129	1.463	1.700
Stack + Spike CO_2 Concentration	(%vw)	4.906	4.639	5.189
Stack + Spike H_2O Concentration	(%)	14.119	11.713	13.249
Stack + Spike SF_6 Concentration	(ppmvw)	4.095	0.804	0.806
Stack + Spike NH_3 Concentration	(ppmvw)	21.892	3.643	3.875
Dilution Factor, calc. from SF_6 (ppmvw)		0.371	0.074	0.073
Dilution Factor, as the ratio of dir to spk	(ratio)	2.7 : 1	13.6 : 1	13.7 : 1
Expected Concentration of the SF_6 Spike+Native, CS	(ppmvw)	4.097	0.805	0.806
Expected Concentration of the NH_3 Spike+Native, CS	(ppmvw)	25.679	4.809	5.017
Method 320 Spiked / Expected SF_6	%	99.96	99.92	99.96
Method 320 Spiked / Expected NH_3	%	85.25	75.75	77.25
Method 320 Passing SF_6 (70-130%)		YES	YES	YES
Method 320 Passing NH_3 (70-130%)		YES	YES	YES

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Trial #1		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:19:39	0730-PRE_000043.LAB	191.3	1.00	0.0072	0.0011	100.6868
07/30/21	6:20:09	0730-PRE_000044.LAB	191.4	1.00	0.0030	-0.0006	100.9227
07/30/21	6:20:39	0730-PRE_000045.LAB	191.4	1.00	0.0058	-0.0020	100.6889
07/30/21	6:21:09	0730-PRE_000046.LAB	191.4	1.00	-0.0050	-0.0002	101.1251
		Average	**191.4**	**1.00**	**0.0027**	**-0.0004**	**100.8559**

Trial #1		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:07:14	0730-PRE_000138.LAB	191.4	1.04	6.0532	8.9759	0.7175
07/30/21	7:07:44	0730-PRE_000139.LAB	191.4	1.04	6.0684	8.6764	1.0738
07/30/21	7:08:14	0730-PRE_000140.LAB	191.4	1.04	5.4819	8.8570	0.7126
07/30/21	7:08:44	0730-PRE_000141.LAB	191.4	1.03	5.4148	11.0471	0.4528
		Average	**191.4**	**1.03**	**5.7546**	**9.3891**	**0.7392**

Trial #1		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:10:14	0730-PRE_000144.LAB	191.4	1.03	5.4320	10.5697	8.4013
07/30/21	7:10:44	0730-PRE_000145.LAB	191.4	1.03	5.2716	13.0538	8.3076
07/30/21	7:11:14	0730-PRE_000146.LAB	191.4	1.03	5.2550	12.5253	8.4825
07/30/21	7:11:44	0730-PRE_000147.LAB	191.4	1.03	5.3563	11.4675	8.3991
		Average	**191.4**	**1.03**	**5.3287**	**11.9041**	**8.3976**

Trial #2		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:19:39	0730-PRE_000043.LAB	191.3	1.00	0.0072	0.0011	100.6868
07/30/21	6:20:09	0730-PRE_000044.LAB	191.4	1.00	0.0030	-0.0006	100.9227
07/30/21	6:20:39	0730-PRE_000045.LAB	191.4	1.00	0.0058	-0.0020	100.6889
07/30/21	6:21:09	0730-PRE_000046.LAB	191.4	1.00	-0.0050	-0.0002	101.1251
		Average	**191.4**	**1.00**	**0.0027**	**-0.0004**	**100.8559**

Trial #2		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:12:45	0730-PRE_000149.LAB	191.4	1.03	5.8000	12.8597	0.7345
07/30/21	7:13:15	0730-PRE_000150.LAB	191.4	1.03	5.8314	11.8100	0.7608
07/30/21	7:13:45	0730-PRE_000151.LAB	191.4	1.03	5.6332	14.6153	0.7099
07/30/21	7:14:15	0730-PRE_000152.LAB	191.4	1.02	5.5540	16.2007	0.7127
		Average	**191.4**	**1.03**	**5.7047**	**13.8714**	**0.7295**

Trial #2		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:15:45	0730-PRE_000155.LAB	191.4	1.02	5.1139	14.9382	8.2753
07/30/21	7:16:15	0730-PRE_000156.LAB	191.4	1.03	5.1541	14.3975	8.4375
07/30/21	7:16:45	0730-PRE_000157.LAB	191.4	1.03	5.2980	12.8197	8.5701
07/30/21	7:17:15	0730-PRE_000158.LAB	191.4	1.03	5.2867	12.7394	8.4587
		Average	**191.4**	**1.03**	**5.2132**	**13.7237**	**8.4354**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:19:39	0730-PRE_000043.LAB	191.3	1.00	0.0072	0.0011	100.6868
07/30/21	6:20:09	0730-PRE_000044.LAB	191.4	1.00	0.0030	-0.0006	100.9227
07/30/21	6:20:39	0730-PRE_000045.LAB	191.4	1.00	0.0058	-0.0020	100.6889
07/30/21	6:21:09	0730-PRE_000046.LAB	191.4	1.00	-0.0050	-0.0002	101.1251
		Average	**191.4**	**1.00**	**0.0027**	**-0.0004**	**100.8559**

Trial #3		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:18:15	0730-PRE_000160.LAB	191.4	1.03	5.7401	13.4425	0.7732
07/30/21	7:18:45	0730-PRE_000161.LAB	191.4	1.02	5.5498	15.5749	0.5713
07/30/21	7:19:15	0730-PRE_000162.LAB	191.4	1.03	5.6786	14.0766	0.7417
07/30/21	7:19:45	0730-PRE_000163.LAB	191.4	1.03	5.5581	15.0022	0.8356
		Average	**191.4**	**1.03**	**5.6316**	**14.5241**	**0.7304**

Trial #3		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	C_2H_6
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:21:15	0730-PRE_000166.LAB	191.4	1.03	5.2190	13.6704	8.3180
07/30/21	7:21:46	0730-PRE_000167.LAB	191.4	1.03	5.2700	13.0154	8.5543
07/30/21	7:22:16	0730-PRE_000168.LAB	191.5	1.03	5.2269	13.5371	8.5568
07/30/21	7:22:46	0730-PRE_000169.LAB	191.4	1.03	5.2680	13.1603	8.5293
		Average	**191.4**	**1.03**	**5.2460**	**13.3458**	**8.4896**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Ethane (C_2H_6)	(ppmvw)	100.86	100.86	100.86
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.755	5.705	5.632
Stack (Native, Unspiked) H_2O Concentration	(%)	9.389	13.871	14.524
Stack (Native, Unspiked) C_2H_6 Concentration	(ppmvw)	0.739	0.729	0.730
Stack + Spike CO_2 Concentration	(%vw)	5.329	5.213	5.246
Stack + Spike H_2O Concentration	(%)	11.904	13.724	13.346
Stack + Spike C_2H_6 Concentration	(ppmvw)	8.398	8.435	8.490
Dilution Factor, calc. from CO_2 (%vw)		0.074	0.086	0.068
Dilution Factor, as the ratio of dir to spk	(ratio)	13.5 : 1	11.6 : 1	14.6 : 1
Expected Concentration of the C_2H_6 Spike+Native, CS	(ppmvw)	8.148	9.356	7.587
Method 320 Spiked / Expected C_2H_6	%	103.06	90.16	111.89
Method 320 Passing C_2H_6 (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

July 30, 2021

Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		**Spike Gas Direct Verification**				**FTIR:**	**509/ INST-IR-0005**
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	118.1741
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	118.8564
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	118.6155
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	117.8215
	Average		**191.4**	**1.00**	**-0.0376**	**0.0044**	**118.3669**

Trial #1		**Pre-Spike - Native Samples**					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	7:23:46	0730-PRE_000171.LAB	191.4	1.03	5.6918	13.9245	16.6396
07/30/21	7:24:16	0730-PRE_000172.LAB	191.4	1.03	5.7387	13.4806	16.3643
07/30/21	7:24:46	0730-PRE_000173.LAB	191.4	1.03	5.6194	14.7534	16.1108
07/30/21	7:25:16	0730-PRE_000174.LAB	191.4	1.02	5.5866	15.0709	15.4793
	Average		**191.4**	**1.03**	**5.6591**	**14.3073**	**16.1485**

Trial #1		**Spiked Samples**					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	7:27:16	0730-PRE_000178.LAB	191.4	1.03	5.1608	13.8424	24.2100
07/30/21	7:27:46	0730-PRE_000179.LAB	191.4	1.03	5.2530	12.8052	25.1630
07/30/21	7:28:16	0730-PRE_000180.LAB	191.4	1.03	5.2479	12.9054	25.2521
07/30/21	7:28:46	0730-PRE_000181.LAB	191.4	1.03	5.2082	13.2288	24.2115
	Average		**191.4**	**1.03**	**5.2175**	**13.1954**	**24.7091**

Trial #2		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	118.1741
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	118.8564
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	118.6155
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	117.8215
		Average	**191.4**	**1.00**	**-0.0376**	**0.0044**	**118.3669**

Trial #2		Pre-Spike - Native Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	14:44:02	0730-PRE_001049.LAB	191.4	1.03	5.7369	12.4441	5.0561
07/30/21	14:44:32	0730-PRE_001050.LAB	191.4	1.03	5.7460	12.4431	5.0416
07/30/21	14:45:02	0730-PRE_001051.LAB	191.4	1.03	5.7463	12.4741	4.9203
07/30/21	14:45:32	0730-PRE_001052.LAB	191.4	1.03	5.7250	12.5610	4.9086
		Average	**191.4**	**1.03**	**5.7386**	**12.4806**	**4.9816**

Trial #2		Spiked Samples					
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	14:47:32	0730-PRE_001056.LAB	191.5	1.03	5.2360	13.3371	13.5438
07/30/21	14:48:02	0730-PRE_001057.LAB	191.5	1.02	5.1899	13.6994	13.3789
07/30/21	14:48:32	0730-PRE_001058.LAB	191.4	1.02	5.1590	13.9761	13.0878
07/30/21	14:49:02	0730-PRE_001059.LAB	191.5	1.02	5.1399	14.2498	13.1142
		Average	**191.5**	**1.02**	**5.1812**	**13.8156**	**13.2812**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	**Time**	**Spectrum**	**Cell Temp**	**Cell Press**	**CO_2**	**H_2O**	**NOx**
(mm/dd/yy)	**(hh:mm:ss)**	**(File Name)**	**(°C)**	**(atm)**	**(%vw)**	**(%)**	**(ppmvw)**
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	118.1741
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	118.8564
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	118.6155
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	117.8215
		Average	**191.4**	**1.00**	**-0.0376**	**0.0044**	**118.3669**

Trial #3		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:50:03	0730-PRE_001061.LAB	191.5	1.02	5.5992	14.9701	5.0871
07/30/21	14:50:32	0730-PRE_001062.LAB	191.5	1.02	5.5984	14.7950	5.0964
07/30/21	14:51:02	0730-PRE_001063.LAB	191.4	1.02	5.6097	14.6418	5.1337
07/30/21	14:51:32	0730-PRE_001064.LAB	191.4	1.02	5.5973	14.7381	5.1409
		Average	**191.4**	**1.02**	**5.6012**	**14.7862**	**5.1145**

Trial #3		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	NOx
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:53:03	0730-PRE_001067.LAB	191.4	1.02	5.1934	13.8151	13.2145
07/30/21	14:53:33	0730-PRE_001068.LAB	191.4	1.03	5.2220	13.6576	13.4804
07/30/21	14:54:03	0730-PRE_001069.LAB	191.4	1.02	5.2084	13.5414	13.4392
07/30/21	14:54:33	0730-PRE_001070.LAB	191.4	1.03	5.2343	13.4546	13.7276
		Average	**191.4**	**1.03**	**5.2145**	**13.6172**	**13.4654**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Nitrogen Oxides (NOx)	(ppmvw)	118.37	118.37	118.37
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.659	5.739	5.601
Stack (Native, Unspiked) H_2O Concentration	(%)	14.307	12.481	14.786
Stack (Native, Unspiked) NOx Concentration	(ppmvw)	16.149	4.982	5.115
Stack + Spike CO_2 Concentration	(%vw)	5.217	5.181	5.215
Stack + Spike H_2O Concentration	(%)	13.195	13.816	13.617
Stack + Spike NOx Concentration	(ppmvw)	24.709	13.281	13.465
Dilution Factor, calc. from CO_2 (%vw)		0.078	0.097	0.069
Dilution Factor, as the ratio of dir to spk	(ratio)	12.8 : 1	10.3 : 1	14.5 : 1
Expected Concentration of the NOx Spike+Native, CS	(ppmvw)	24.125	15.995	12.932
Method 320 Spiked / Expected NOx	%	102.42	83.03	104.12
Method 320 Passing NOx (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

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Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	120.7373
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	121.4913
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	121.2086
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	120.4047
		Average	**191.4**	**1.00**	**-0.0376**	**0.0044**	**120.9605**

Trial #1		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:23:46	0730-PRE_000171.LAB	191.4	1.03	5.6918	13.9245	2.4183
07/30/21	7:24:16	0730-PRE_000172.LAB	191.4	1.03	5.7387	13.4806	2.4016
07/30/21	7:24:46	0730-PRE_000173.LAB	191.4	1.03	5.6194	14.7534	2.4795
07/30/21	7:25:16	0730-PRE_000174.LAB	191.4	1.02	5.5866	15.0709	2.5247
		Average	**191.4**	**1.03**	**5.6591**	**14.3073**	**2.4560**

Trial #1		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	7:27:16	0730-PRE_000178.LAB	191.4	1.03	5.1608	13.8424	11.6753
07/30/21	7:27:46	0730-PRE_000179.LAB	191.4	1.03	5.2530	12.8052	11.8689
07/30/21	7:28:16	0730-PRE_000180.LAB	191.4	1.03	5.2479	12.9054	12.0123
07/30/21	7:28:46	0730-PRE_000181.LAB	191.4	1.03	5.2082	13.2288	12.0099
		Average	**191.4**	**1.03**	**5.2175**	**13.1954**	**11.8916**

Trial #2		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	120.7373
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	121.4913
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	121.2086
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	120.4047
		Average	**191.4**	**1.00**	**-0.0376**	**0.0044**	**120.9605**

Trial #2		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:43:02	0730-PRE_001047.LAB	191.4	1.03	5.7266	12.6880	2.9336
07/30/21	14:43:32	0730-PRE_001048.LAB	191.4	1.03	5.7343	12.5239	2.8088
07/30/21	14:44:02	0730-PRE_001049.LAB	191.4	1.03	5.7369	12.4441	3.0307
07/30/21	14:44:32	0730-PRE_001050.LAB	191.4	1.03	5.7460	12.4431	2.9345
		Average	**191.4**	**1.03**	**5.7360**	**12.5248**	**2.9269**

Trial #2		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:47:32	0730-PRE_001056.LAB	191.5	1.03	5.2360	13.3371	11.4735
07/30/21	14:48:02	0730-PRE_001057.LAB	191.5	1.02	5.1899	13.6994	11.3942
07/30/21	14:48:32	0730-PRE_001058.LAB	191.4	1.02	5.1590	13.9761	11.3660
07/30/21	14:49:02	0730-PRE_001059.LAB	191.5	1.02	5.1399	14.2498	11.5300
		Average	**191.5**	**1.02**	**5.1812**	**13.8156**	**11.4409**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	6:22:39	0730-PRE_000049.LAB	191.4	1.00	-0.0302	0.0182	120.7373
07/30/21	6:23:09	0730-PRE_000050.LAB	191.4	1.00	-0.0389	0.0025	121.4913
07/30/21	6:23:39	0730-PRE_000051.LAB	191.4	1.00	-0.0431	-0.0001	121.2086
07/30/21	6:24:09	0730-PRE_000052.LAB	191.4	1.00	-0.0383	-0.0029	120.4047
		Average	**191.4**	**1.00**	**-0.0376**	**0.0044**	**120.9605**

Trial #3		Pre-Spike - Native Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:50:03	0730-PRE_001061.LAB	191.5	1.02	5.5992	14.9701	2.9415
07/30/21	14:50:32	0730-PRE_001062.LAB	191.5	1.02	5.5984	14.7950	2.9191
07/30/21	14:51:02	0730-PRE_001063.LAB	191.4	1.02	5.6097	14.6418	2.8402
07/30/21	14:51:32	0730-PRE_001064.LAB	191.4	1.02	5.5973	14.7381	2.8936
		Average	**191.4**	**1.02**	**5.6012**	**14.7862**	**2.8986**

Trial #3		Spiked Samples					
Date	Time	Spectrum	Cell Temp	Cell Press	CO_2	H_2O	CO
(mm/dd/yy)	(hh:mm:ss)	(File Name)	(°C)	(atm)	(%vw)	(%)	(ppmvw)
07/30/21	14:53:03	0730-PRE_001067.LAB	191.4	1.02	5.1934	13.8151	11.4955
07/30/21	14:53:33	0730-PRE_001068.LAB	191.4	1.03	5.2220	13.6576	11.5884
07/30/21	14:54:03	0730-PRE_001069.LAB	191.4	1.02	5.2084	13.5414	11.5316
07/30/21	14:54:33	0730-PRE_001070.LAB	191.4	1.03	5.2343	13.4546	11.4985
		Average	**191.4**	**1.03**	**5.2145**	**13.6172**	**11.5285**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Carbon Monoxide (CO)	(ppmvw)	120.96	120.96	120.96
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.659	5.736	5.601
Stack (Native, Unspiked) H_2O Concentration	(%)	14.307	12.525	14.786
Stack (Native, Unspiked) CO Concentration	(ppmvw)	2.456	2.927	2.899
Stack + Spike CO_2 Concentration	(%vw)	5.217	5.181	5.215
Stack + Spike H_2O Concentration	(%)	13.195	13.816	13.617
Stack + Spike CO Concentration	(ppmvw)	11.892	11.441	11.529
Dilution Factor, calc. from CO_2 (%vw)		0.078	0.097	0.069
Dilution Factor, as the ratio of dir to spk	(ratio)	12.8 : 1	10.3 : 1	14.5 : 1
Expected Concentration of the CO Spike+Native, CS	(ppmvw)	11.704	14.343	11.048
Method 320 Spiked / Expected CO	%	101.60	79.77	104.35
Method 320 Passing CO (70-130%)		YES	YES	YES

Catalytic Combustion Corporation

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Caterpillar, G3520 TALE

Stewart & Stevenson Integration Center

Trial #1		**Spike Gas Direct Verification**				**FTIR:**	509/ INST-IR-0005	
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (%vw)**	**H_2O (%)**	**SF_6 (ppmvw)**	**C_2H_4O (ppmvw)**
07/30/21	6:25:40	0730-PRE_000055.LAB	191.4	1.00	0.0066	0.0047	5.6053	46.2794
07/30/21	6:26:10	0730-PRE_000056.LAB	191.4	1.00	0.0073	-0.0029	5.6165	47.4824
07/30/21	6:26:40	0730-PRE_000057.LAB	191.4	1.00	-0.0018	0.0002	5.6054	48.0103
07/30/21	6:27:10	0730-PRE_000058.LAB	191.4	1.00	-0.0025	-0.0030	5.6293	48.0884
		Average	**191.4**	**1.00**	**0.0024**	**-0.0002**	**5.6141**	**47.4651**

Trial #1		**Pre-Spike - Native Samples**						
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (%vw)**	**H_2O (%)**	**SF_6 (ppmvw)**	**C_2H_4O (ppmvw)**
07/30/21	16:08:24	0730-R2_000146.LAB	191.4	1.02	5.7713	13.7720	-0.0059	3.6044
07/30/21	16:08:54	0730-R2_000147.LAB	191.4	1.02	5.7267	13.9990	-0.0055	3.7065
07/30/21	16:09:24	0730-R2_000148.LAB	191.4	1.02	5.7083	14.1170	-0.0069	3.7018
07/30/21	16:09:54	0730-R2_000149.LAB	191.4	1.02	5.7255	14.1603	-0.0066	4.5399
		Average	**191.4**	**1.02**	**5.7330**	**14.0121**	**-0.0062**	**3.8881**

Trial #1		**Spiked Samples**						
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (%vw)**	**H_2O (%)**	**SF_6 (ppmvw)**	**C_2H_4O (ppmvw)**
07/30/21	16:12:54	0730-R2_000155.LAB	191.4	1.02	5.2999	13.0120	0.4156	7.8255
07/30/21	16:13:24	0730-R2_000156.LAB	191.4	1.02	5.3080	12.8405	0.4238	7.8915
07/30/21	16:13:54	0730-R2_000157.LAB	191.4	1.03	5.3199	12.7503	0.4258	7.8579
07/30/21	16:14:25	0730-R2_000158.LAB	191.5	1.03	5.3166	12.7834	0.4263	7.4489
		Average	**191.4**	**1.03**	**5.3111**	**12.8465**	**0.4229**	**7.7559**

Trial #2		**Spike Gas Direct Verification**				**FTIR:**	509/ INST-IR-0005	
Date (mm/dd/yy)	**Time (hh:mm:ss)**	**Spectrum (File Name)**	**Cell Temp (°C)**	**Cell Press (atm)**	**CO_2 (%vw)**	**H_2O (%)**	**SF_6 (ppmvw)**	**C_2H_4O (ppmvw)**
07/30/21	6:25:40	0730-PRE_000055.LAB	191.4	1.00	0.0066	0.0047	5.6053	46.2794
07/30/21	6:26:10	0730-PRE_000056.LAB	191.4	1.00	0.0073	-0.0029	5.6165	47.4824
07/30/21	6:26:40	0730-PRE_000057.LAB	191.4	1.00	-0.0018	0.0002	5.6054	48.0103
07/30/21	6:27:10	0730-PRE_000058.LAB	191.4	1.00	-0.0025	-0.0030	5.6293	48.0884
		Average	**191.4**	**1.00**	**0.0024**	**-0.0002**	**5.6141**	**47.4651**

Trial #2		Pre-Spike - Native Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	C_2H_4O (ppmvw)
07/30/21	16:15:55	0730-R2_000161.LAB	191.4	1.02	5.7123	14.0511	-0.0053	4.6214
07/30/21	16:16:25	0730-R2_000162.LAB	191.4	1.02	5.7120	14.1027	-0.0031	3.8296
07/30/21	16:16:55	0730-R2_000163.LAB	191.5	1.02	5.4558	17.3753	-0.0039	4.3182
07/30/21	16:17:25	0730-R2_000164.LAB	191.5	1.02	5.6095	15.7793	-0.0044	3.8522
		Average	**191.4**	**1.02**	**5.6224**	**15.3271**	**-0.0042**	**4.1554**

Trial #2		Spiked Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	C_2H_4O (ppmvw)
07/30/21	16:18:55	0730-R2_000167.LAB	191.4	1.03	5.2392	13.7149	0.4266	7.5391
07/30/21	16:19:25	0730-R2_000168.LAB	191.5	1.02	5.2282	13.8275	0.4253	7.4193
07/30/21	16:19:55	0730-R2_000169.LAB	191.5	1.03	5.2383	13.7240	0.4255	7.7933
07/30/21	16:20:25	0730-R2_000170.LAB	191.5	1.03	5.2524	13.6092	0.4256	7.9073
		Average	**191.5**	**1.03**	**5.2395**	**13.7189**	**0.4257**	**7.6648**

Trial #3		Spike Gas Direct Verification				FTIR:	509/ INST-IR-0005	
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	C_2H_4O (ppmvw)
07/30/21	6:25:40	0730-PRE_000055.LAB	191.4	1.00	0.0066	0.0047	5.6053	46.2794
07/30/21	6:26:10	0730-PRE_000056.LAB	191.4	1.00	0.0073	-0.0029	5.6165	47.4824
07/30/21	6:26:40	0730-PRE_000057.LAB	191.4	1.00	-0.0018	0.0002	5.6054	48.0103
07/30/21	6:27:10	0730-PRE_000058.LAB	191.4	1.00	-0.0025	-0.0030	5.6293	48.0884
		Average	**191.4**	**1.00**	**0.0024**	**-0.0002**	**5.6141**	**47.4651**

Trial #3		Pre-Spike - Native Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	C_2H_4O (ppmvw)
07/30/21	16:21:25	0730-R2_000172.LAB	191.5	1.02	5.7333	13.6223	-0.0018	3.9788
07/30/21	16:21:55	0730-R2_000173.LAB	191.5	1.02	5.7138	14.0067	-0.0041	3.9006
07/30/21	16:22:25	0730-R2_000174.LAB	191.4	1.02	5.7115	14.1215	-0.0078	3.8331
07/30/21	16:22:56	0730-R2_000175.LAB	191.5	1.02	5.6979	14.2024	-0.0028	4.1707
		Average	**191.5**	**1.02**	**5.7142**	**13.9882**	**-0.0041**	**3.9708**

Trial #3		Spiked Samples						
Date (mm/dd/yy)	Time (hh:mm:ss)	Spectrum (File Name)	Cell Temp (°C)	Cell Press (atm)	CO_2 (%vw)	H_2O (%)	SF_6 (ppmvw)	C_2H_4O (ppmvw)
07/30/21	16:23:56	0730-R2_000177.LAB	191.4	1.02	5.1967	14.0712	0.4185	7.4727
07/30/21	16:24:26	0730-R2_000178.LAB	191.4	1.03	5.2160	13.7566	0.4194	7.6900
07/30/21	16:24:56	0730-R2_000179.LAB	191.5	1.03	5.2569	13.4089	0.4242	7.6490
07/30/21	16:25:26	0730-R2_000180.LAB	191.4	1.03	5.2622	13.4270	0.4228	7.9476
		Average	**191.4**	**1.03**	**5.2329**	**13.6659**	**0.4212**	**7.6898**

Parameter	Units	Trial #1	Trial #2	Trial #3
Direct Verified Concentration of Sulfur Hexafluoride (SF_6)	(ppmvw)	5.61	5.61	5.61
Direct Verified Concentration of Acetaldehyde (C_2H_4O)	(ppmvw)	47.47	47.47	47.47
Stack (Native, Unspiked) CO_2 Concentration	(%vw)	5.733	5.622	5.714
Stack (Native, Unspiked) H_2O Concentration	(%)	14.012	15.327	13.988
Stack (Native, Unspiked) SF_6 Concentration	(ppmvw)	-0.006	-0.004	-0.004
Stack (Native, Unspiked) C_2H_4O Concentration	(ppmvw)	3.888	4.155	3.971
Stack + Spike CO_2 Concentration	(%vw)	5.311	5.240	5.233
Stack + Spike H_2O Concentration	(%)	12.847	13.719	13.666
Stack + Spike SF_6 Concentration	(ppmvw)	0.423	0.426	0.421
Stack + Spike C_2H_4O Concentration	(ppmvw)	7.756	7.665	7.690
Dilution Factor, calc. from SF_6 (ppmvw)		0.076	0.077	0.076
Dilution Factor, as the ratio of dir to spk	(ratio)	13.1 : 1	13.1 : 1	13.2 : 1
Expected Concentration of the SF_6 Spike+Native, CS	(ppmvw)	0.423	0.426	0.422
Expected Concentration of the C_2H_4O Spike+Native, CS	(ppmvw)	7.219	7.472	7.266
Method 320 Spiked / Expected SF_6	%	99.89	99.93	99.93
Method 320 Spiked / Expected C_2H_4O	%	107.44	102.58	105.83
Method 320 Passing SF_6 (70-130%)		YES	YES	YES
Method 320 Passing C_2H_4O (70-130%)		YES	YES	YES

QUALITY ASSURANCE AND QUALITY CONTROL DATA

50% Load
PM Laboratory Data

SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Name	Stewart and Stevenson Integration Center	**Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW
Project #	catc-21-houston.tx-start#1		

Run History Data				
Run Number	R-1 50%-1	R-1 50%-2	R-1 50%-3	
Run Start Time	09:34	12:05	14:23	(hh:mm)
Run Stop Time	11:24	13:59	15:58	(hh:mm)
Train Prepared By	PKM	PKM	PKM	
Train Recovered By	PKM	PKM	PKM	
Recovery Date	07/29/21	07/29/21	07/29/21	(mm/dd/yy)
Relinquished By	PKM	PKM	PKM	
Relinquished Date	08/02/21	08/02/21	08/02/21	(mm/dd/yy)

Equipment Identification Numbers			
Impinger Case	samp-BH-0018	samp-BH-0018	samp-BH-0018
Sample Box	samp-cc-0011	samp-cc-0011	samp-cc-0011
PM Filter	00713	0652	0722
CPM Filter	R-1 50%-1-CPM	R-1 50%-2-CPM	R-1 50%-3-CPM

Sample Blank Taken	☑	YES

Moisture Content Data					
Impingers 1, 2, and 3 - Liquid Weight					
Final Weight	(W_f)	1789.8	1796.4	1801.3	g
Initial Weight	(W_i)	1672.1	1678.6	1686.0	g
Net Weight	(W_n)	117.7	117.8	115.3	g
Comments					
Impinger 4 - Silica Gel Weight					
Final Weight	(W_f)	856.2	823.4	863.2	g
Initial Weight	(W_i)	847.8	816.5	856.2	g
Net Weight	(W_n)	8.4	6.9	7.0	g
Comments					
Total Water Collected					
Total Weight	(W_{lc})	126.1	124.7	122.3	g
Total Volume	(V_{lc})	126.3	124.9	122.5	ml

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 50%-1	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0652	08/11/21	14:10
Probe Wash	250-747	08/11/21	14:10
Inorganic Impinger Contents	250-302	08/11/21	14:10
Organic Impinger Contents	439	08/11/21	14:10

Weight Data			**Run**		1	**Start Time** 09:34
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	48.7912	08/17/21	07:43	45%	66.6	
Measurement 2	48.7914	08/17/21	14:14	43%	68.9	
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	125.9982	08/17/21	07:43	45%	66.6	
Measurement 2	125.9986	08/17/21	14:14	43%	68.9	
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	118.6959	08/17/21	07:43	45%	66.6	
Measurement 2	118.6962	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	1.7596	08/17/21	07:43	45%	66.6	
Measurement 2	1.7597	08/17/21	14:14	43%	68.9	

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**		1	**Start Time** 09:34
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	48.7913	0.3503	2.7000	--	--	2.7000
Filter Beaker		48.4383		--	--	
Probe Wash	125.9984	125.9889	9.5000	200.0000	0.5109	8.9891
Inorganic Impinger Contents	118.6961	118.6933	2.7500	333.3080	1.2703	1.4797
Organic Impinger Contents	1.7597	1.7540	5.6500	66.0000	0.7297	4.9203

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 50%-2	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	Sample Number	Date	Time
Filter	0713	08/11/21	14:10
Probe Wash	250-494	08/11/21	14:10
Inorganic Impinger Contents	250-685	08/11/21	14:10
Organic Impinger Contents	430	08/11/21	14:10

Weight Data			**Run**		2	**Start Time**	12:05
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)	
Measurement 1	68.0982	08/17/21	07:43	45%	66.6		
Measurement 2	68.0984	08/17/21	14:14	43%	68.9		
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)	
Measurement 1	120.7377	08/17/21	07:43	45%	66.6		
Measurement 2	120.7381	08/17/21	14:14	43%	68.9		
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)	
Measurement 1	122.7244	08/17/21	07:43	45%	66.6		
Measurement 2	122.7249	08/17/21	14:14	43%	68.9		
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)	
Measurement 1	1.7682	08/17/21	07:43	45%	66.6		
Measurement 2	1.7683	08/17/21	14:14	43%	68.9		

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**		2	**Start Time** 12:05
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	68.0983	0.3468	5.2000	--	--	5.2000
Filter Beaker		67.7464		--	--	
Probe Wash	120.7379	120.7318	6.1000	162.0000	0.4139	5.6861
Inorganic Impinger Contents	122.7247	122.7208	3.8500	342.5887	1.2703	2.5797
Organic Impinger Contents	1.7683	1.7665	1.8000	60.0000	0.7297	1.0703

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 50%-3	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0722	08/11/21	14:10
Probe Wash	250-665	08/11/21	14:10
Inorganic Impinger Contents	250-741	08/11/21	14:10
Organic Impinger Contents	446	08/11/21	14:10

Weight Data			**Run**		3	**Start Time** 14:23
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	48.2665	08/17/21	07:43	45%	66.6	
Measurement 2	48.2668	08/17/21	14:14	43%	68.9	
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	123.1212	08/17/21	07:43	45%	66.6	
Measurement 2	123.1211	08/17/21	14:14	43%	68.9	
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	127.5165	08/17/21	07:43	45%	66.6	
Measurement 2	127.5170	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	1.7761	08/17/21	07:43	45%	66.6	
Measurement 2	1.7763	08/17/21	14:14	43%	68.9	

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**		3	**Start Time** 14:23
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	48.2667	0.3583	2.3500	--	--	2.3500
Filter Beaker		47.9060		--	--	
Probe Wash	123.1212	123.1152	5.9500	124.0000	0.3168	5.6332
Inorganic Impinger Contents	127.5168	127.5147	2.1000	407.1970	1.2703	0.8297
Organic Impinger Contents	1.7762	1.7746	1.6000	72.0000	0.7297	0.8703

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 50%-FB	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Inorganic Impinger Contents	250-478	08/11/21	14:10
Organic Impinger Contents	464	08/11/21	14:10

Weight Data			**Run**		R-1 50%-FB	**Start Time**
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	121.8241	08/17/21	07:43	45%	66.6	
Measurement 2	121.8246	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7720	08/17/21	07:43	45%	66.6	
Measurement 2	1.7721	08/17/21	14:14	43%	68.9	

Gravimetric Concentrations					**Actual Gain**
Sample Portion	**Final**	**Tare**	**Gain**		
	(g)	(g)	(mg)		(mg)
Inorganic Impinger Contents	121.8244	121.8220	1.2703	max 2 mg total blank adjustment, proportioned	2.3500
Organic Impinger Contents	1.7721	1.7707	0.7297		1.3500

EQUIPMENT / INSTRUMENTATION IDENTIFICATION

Equipment / Instrumentation	Identification No.
Acetone Lot	20120533
Hexane Lot	21030109
Filterable Particulate Matter Oven ID	SAMP-OV-0007
Condensable Particulate Matter Oven ID	SAMP-OV-0008
Sonic Bath ID	SAMP-UB-0001
SAMP-SC-0003 Scale Weight Set ID (1st weights)	LABS-WT-0001
SAMP-SC-0003 Scale Weight Set ID (2nd weights)	
SAMP-SC-0003 Scale Weight Set ID (3rd weights)	
SAMP-SC-0003 Scale Weight Set ID (4th weights)	

Requested Standard Analysis - 5-10 business days after receipt at lab

SAMPLE DESCRIPTION AND LABELING RECORD

Contact Information (deliver results to)

Name:

Phone: (918) 307-8865

Email:

Air Hygiene International, Inc.
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
(888) 461-8778
www.airhygiene.com

Project Number:	catc-21-houston.tx-start#1			Laboratory Analysis Requested:			
Person Taking Samples:	JLW			Gravimetric			
Sample Number	Location	Date	Volume	Analysis Method			
				RM 5	RM 202	--	--
R-1 50%-1-F	40 Unit R-1 50% - Run 1 - Filter	07/29/21	N/A	X	100-284	0652	
R-1 50%-1-PW	41 Unit R-1 50% - Run 1 - Probe Wash	07/29/21	Specks	X	250-741	200	
R-1 50%-1-IC	42 Unit R-1 50% - Run 1 - Inorganic Impinger Contents	07/29/21			X	250-302	440
R-1 50%-1-Hex	43 Unit R-1 50% - Run 1 - Organic Impinger Contents	07/29/21			X	439	66
R-1 50%-1-CPM	44 Unit R-1 50% - Run 1 - CPM Filter	07/29/21	N/A		X		
R-1 50%-2-F	45 Unit R-1 50% - Run 2 - Filter	07/29/21	N/A	X	100-648	0713	
R-1 50%-2-PW	46 Unit R-1 50% - Run 2 - Probe Wash	07/29/21	Specks	X	250-494	162	
R-1 50%-2-IC	47 Unit R-1 50% - Run 2 - Inorganic Impinger Contents	07/29/21			X	250-685	460
R-1 50%-2-Hex	48 Unit R-1 50% - Run 2 - Organic Impinger Contents	07/29/21			X	430	60
R-1 50%-2-CPM	49 Unit R-1 50% - Run 2 - CPM Filter	07/29/21	N/A		X		
R-1 50%-3-F	50 Unit R-1 50% - Run 3 - Filter	07/29/21	N/A	X	100-782	0722	
R-1 50%-3-PW	51 Unit R-1 50% - Run 3 - Probe Wash	07/29/21	Specks	X	250-665	124	
R-1 50%-3-IC	52 Unit R-1 50% - Run 3 - Inorganic Impinger Contents	07/29/21			X	250-741	52
R-1 50%-3-Hex	53 Unit R-1 50% - Run 3 - Organic Impinger Contents	07/29/21			X	446	72
R-1 50%-3-CPM	54 Unit R-1 50% - Run 3 - CPM Filter	07/29/21	N/A		X		
R-1 50%-FB-IC	70 Unit R-1 50% - Run FB - Inorganic Impinger Contents	FB			X	250-478	375
R-1 50%-FB-Hex	71 Unit R-1 50% - Run FB - Organic Impinger Contents	FB			X	464	74
R-1 50%-FB-CPM	72 Unit R-1 50% - Run FB - CPM Filter	FB	N/A		X		
R-1 50%-B1-Acetone	210 810-37 Unit R-1 50% - Blank - Acetone	07/30/21	200		X	491	137
R-1 50%-B2-DI Water	38 Unit R-1 50% - Blank - DI Water	07/30/21	200	X		100-652	224
R-1 50%-B3-Hexane	39 Unit R-1 50% - Blank - Hexane	07/30/21	200		X	501	123

Signature	Date	Time	Signature	Date	Time
[signature]	8/2/21	13:30	@ [signature]	8/3/21	10:40

Isocalc-AHI v20210708 CATC 50%

SD&L

QUALITY ASSURANCE AND QUALITY CONTROL DATA

75% Load
PM Laboratory Data

SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Name	Stewart and Stevenson Integration Center	**Date**	07/28/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	JLW
Project #	catc-21-houston.tx-start#1		

Run History Data				
Run Number	R-1 75%-1	R-1 75%-2	R-1 75%-3	
Run Start Time	08:08	13:17	15:25	(hh:mm)
Run Stop Time	09:42	14:56	17:01	(hh:mm)
Train Prepared By	PKM	PKM	PKM	
Train Recovered By	PKM	PKM	PKM	
Recovery Date	07/30/21	07/30/21	07/30/21	(mm/dd/yy)
Relinquished By	PKM	PKM	PKM	
Relinquished Date	08/02/21	08/02/21	08/02/21	(mm/dd/yy)

Equipment Identification Numbers			
Impinger Case	samp-BH-0018	samp-BH-0018	samp-BH-0018
Sample Box	samp-cc-0011	samp-cc-0011	samp-cc-0011
PM Filter	0523	0916	0917
CPM Filter	R-1 75%-1-CPM	R-1 75%-2-CPM	R-1 75%-3-CPM

Sample Blank Taken	☑	YES

Moisture Content Data					
Impingers 1, 2, and 3 - Liquid Weight					
Final Weight	(W_f)	1854.3	1851.5	1846.1	g
Initial Weight	(W_i)	1685.4	1689.6	1688.9	g
Net Weight	(W_n)	168.9	161.9	157.2	g
Comments					
Impinger 4 - Silica Gel Weight					
Final Weight	(W_f)	832.6	872.9	834.4	g
Initial Weight	(W_i)	823.4	863.2	823.3	g
Net Weight	(W_n)	9.2	9.7	11.1	g
Comments					
Total Water Collected					
Total Weight	(W_{lc})	178.1	171.6	168.3	g
Total Volume	(V_{lc})	178.4	171.9	168.6	ml

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 75%-1	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0523	08/11/21	14:10
Probe Wash	250-853	08/11/21	14:10
Inorganic Impinger Contents	250-338	08/11/21	14:10
Organic Impinger Contents	438	08/11/21	14:10

Weight Data			**Run**	1	**Start Time**	08:08
Filter and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	69.3936	08/17/21	07:43	45%	66.6	
Measurement 2	69.3938	08/17/21	14:14	43%	68.9	
Probe Wash and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	121.8107	08/17/21	07:43	45%	66.6	
Measurement 2	121.8110	08/17/21	14:14	43%	68.9	
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	112.7466	08/17/21	07:43	45%	66.6	
Measurement 2	112.7470	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7471	08/17/21	07:43	45%	66.6	
Measurement 2	1.7473	08/17/21	14:14	43%	68.9	

Blank and Titration Concentrations				
Blank Type	**Weight**	**Volume**	**Concentration**	**Mass**
	(g)	(ml)	(mg/ml)	(mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**	1	**Start Time**	08:08
Sample Portion	**Final**	**Tare**	**Gain**	**Volume**	**Blank Adjustment**	**Adjusted Gain**
	(g)	(g)	(mg)	(ml)	(mg)	(mg)
Filter	69.3937	0.3451	1.2500	--	--	1.2500
Filter Beaker		69.0474		--	--	
Probe Wash	121.8109	121.8075	3.4000	134.0000	0.3423	3.0577
Inorganic Impinger Contents	112.7468	112.7446	2.2000	279.2016	1.2703	0.9297
Organic Impinger Contents	1.7472	1.7456	1.6000	118.0000	0.7297	0.8703

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 75%-2	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0916	08/11/21	14:10
Probe Wash	250-506	08/11/21	14:10
Inorganic Impinger Contents	250-510	08/11/21	14:10
Organic Impinger Contents	463	08/11/21	14:10

Weight Data			**Run**		2	**Start Time** 13:17
Filter and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	66.5723	08/17/21	07:43	45%	66.6	
Measurement 2	66.5724	08/17/21	14:14	43%	68.9	
Probe Wash and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	119.5037	08/17/21	07:43	45%	66.6	
Measurement 2	119.5042	08/17/21	14:14	43%	68.9	
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	115.4424	08/17/21	07:43	45%	66.6	
Measurement 2	115.4429	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7476	08/17/21	07:43	45%	66.6	
Measurement 2	1.7478	08/17/21	14:14	43%	68.9	

Blank and Titration Concentrations				
Blank Type	**Weight**	**Volume**	**Concentration**	**Mass**
	(g)	(ml)	(mg/ml)	(mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**	2	**Start Time**	13:17
Sample Portion	**Final**	**Tare**	**Gain**	**Volume**	**Blank Adjustment**	**Adjusted Gain**
	(g)	(g)	(mg)	(ml)	(mg)	(mg)
Filter	66.5724	0.3617	0.9000	--	--	0.9000
Filter Beaker		66.2098		--	--	
Probe Wash	119.5040	119.4984	5.5500	210.0000	0.5365	5.0135
Inorganic Impinger Contents	115.4427	115.4407	2.0000	320.5219	1.2703	0.7297
Organic Impinger Contents	1.7477	1.7463	1.4500	102.0000	0.7297	0.7203

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 75%-3	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0917	08/11/21	14:10
Probe Wash	250-497	08/11/21	14:10
Inorganic Impinger Contents	250-748	08/11/21	14:10
Organic Impinger Contents	455	08/11/21	14:10

Weight Data			**Run**	3	**Start Time**	15:25
Filter and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	49.3830	08/17/21	07:43	45%	66.6	
Measurement 2	49.3833	08/17/21	14:14	43%	68.9	
Probe Wash and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	119.3830	08/17/21	07:43	45%	66.6	
Measurement 2	119.3834	08/17/21	14:14	43%	68.9	
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	125.3623	08/17/21	07:43	45%	66.6	
Measurement 2	125.3624	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7394	08/17/21	07:43	45%	66.6	
Measurement 2	1.7395	08/17/21	14:14	43%	68.9	

Blank and Titration Concentrations				
Blank Type	**Weight**	**Volume**	**Concentration**	**Mass**
	(g)	(ml)	(mg/ml)	(mg)
Acetone Blank Weight of Solids	0.0004	137.0000	0.002555	--
DI Water Blank Weight of Solids	0.0002	224.0000	0.000759	--
Hexane Blank Weight of Solids	0.0000	123.0000	0.000000	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**	3	**Start Time**	15:25
Sample Portion	**Final**	**Tare**	**Gain**	**Volume**	**Blank Adjustment**	**Adjusted Gain**
	(g)	(g)	(mg)	(ml)	(mg)	(mg)
Filter	49.3832	0.3598	1.0000	--	--	1.0000
Filter Beaker		49.0224		--	--	
Probe Wash	119.3832	119.3800	3.2500	140.0000	0.3577	2.8923
Inorganic Impinger Contents	125.3624	125.3607	1.7000	319.6203	1.2703	0.4297
Organic Impinger Contents	1.7395	1.7377	1.7500	96.0000	0.7297	1.0203

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 75%-FB	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	Sample Number	Date	Time
Inorganic Impinger Contents	250-478	08/11/21	14:10
Organic Impinger Contents	464	08/11/21	14:10

Weight Data			**Run**		R-1 75%-FB	**Start Time**
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	121.8241	08/17/21	07:43	45%	66.6	
Measurement 2	121.8246	08/17/21	14:14	43%	68.9	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7720	08/17/21	07:43	45%	66.6	
Measurement 2	1.7721	08/17/21	14:14	43%	68.9	

Gravimetric Concentrations					**Actual Gain**
Sample Portion	**Final**	**Tare**	**Gain**		
	(g)	(g)	(mg)		(mg)
Inorganic Impinger Contents	121.8244	121.8220	1.2703	max 2 mg total blank adjustment, proportioned	2.3500
Organic Impinger Contents	1.7721	1.7707	0.7297		1.3500

Requested Standard Analysis - 5-10 business days after receipt at lab

SAMPLE DESCRIPTION AND LABELING RECORD

Contact Information (deliver results to)
Name: Pat McGovern, Jr.
Phone: (918) 307-8865
Email:

Air Hygiene International, Inc.
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
(888) 461-8778
www.airhygiene.com

Project Number:	catc-21-houston.tx-start#1			Laboratory Analysis Requested:			
Person Taking Samples:	JLW			Gravimetric			
Sample Number	Location	Date	Volume	Analysis Method			
				RM 5	RM 202	--	--
R-1 75%-1-F	210810-55 Unit R-1 75% - Run 1 - Filter	07/30/21	N/A	X	1a-746	0523	
R-1 75%-1-PW	56 Unit R-1 75% - Run 1 - Probe Wash	07/30/21	specks	X	250-853	134	
R-1 75%-1-IC	57 Unit R-1 75% - Run 1 - Inorganic Impinger Contents	07/30/21			X	250-338	445
R-1 75%-1-Hex	58 Unit R-1 75% - Run 1 - Organic Impinger Contents	07/30/21			X	438	118
R-1 75%-1-CPM	59 Unit R-1 75% - Run 1 - CPM Filter	07/30/21	N/A		X		
R-1 75%-2-F	60 Unit R-1 75% - Run 2 - Filter	07/30/21	N/A	X	1a-633	0916	
R-1 75%-2-PW	61 Unit R-1 75% - Run 2 - Probe Wash	07/30/21		X	250-506	210	
R-1 75%-2-IC	62 Unit R-1 75% - Run 2 - Inorganic Impinger Contents	07/30/21			X	250-510	475
R-1 75%-2-Hex	63 Unit R-1 75% - Run 2 - Organic Impinger Contents	07/30/21			X	463	102
R-1 75%-2-CPM	64 Unit R-1 75% - Run 2 - CPM Filter	07/30/21	N/A		X		
R-1 75%-3-F	65 Unit R-1 75% - Run 3 - Filter	07/30/21	N/A	X	1a-083	0917	
R-1 75%-3-PW	66 Unit R-1 75% - Run 3 - Probe Wash	07/30/21		X	250-497	140	
R-1 75%-3-IC	67 Unit R-1 75% - Run 3 - Inorganic Impinger Contents	07/30/21			X	250-748	475
R-1 75%-3-Hex	68 Unit R-1 75% - Run 3 - Organic Impinger Contents	07/30/21			X	455	96
R-1 75%-3-CPM	69 Unit R-1 75% - Run 3 - CPM Filter	07/30/21	N/A		X		

[signature] 8/2/21 13:30 @ [signature] 8/3/21 10:00
Signature Date Time Signature Date Time

Signature Date Time Signature Date Time

A: 2020533

catc-21-houston.tx-start#1-EG1-75-PM

SD&L

QUALITY ASSURANCE AND QUALITY CONTROL DATA

100% Load
PM Laboratory Data

SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Name	Stewart and Stevenson Integration Center	**Date**	08/31/21
Sampling Location	Caterpillar G3520 TALE	**Operator**	TP
Project #	catc-21-houston.tx-start#1		

Run History Data				
Run Number	R-1 100%-1	R-1 100%-2	R-1 100%-3	
Run Start Time	09:36	12:05	14:24	(hh:mm)
Run Stop Time	11:17	13:44	16:05	(hh:mm)
Train Prepared By	PKM	PKM	PKM	
Train Recovered By	PKM	PKM	PKM	
Recovery Date	07/30/21	07/30/21	07/30/21	(mm/dd/yy)
Relinquished By	PKM	PKM	PKM	
Relinquished Date	08/02/21	08/02/21	08/02/21	(mm/dd/yy)

Equipment Identification Numbers			
Impinger Case	samp-BH-0036	samp-BH-0036	samp-BH-0036
Sample Box	samp-cc-0009	samp-cc-0009	samp-cc-0009
PM Filter	0523	0916	0917
CPM Filter	R-1 100%-1-CPM	R-1 100%-2-CPM	R-1 100%-3-CPM

Sample Blank Taken ☑ YES

Moisture Content Data					
Impingers 1, 2, and 3 - Liquid Weight					
Final Weight	(W_f)	1857.9	1854.1	1950.7	g
Initial Weight	(W_i)	1668.8	1669.4	1717.6	g
Net Weight	(W_n)	189.1	184.7	233.1	g
Comments					
Impinger 4 - Silica Gel Weight					
Final Weight	(W_f)	874.3	860.1	870.7	g
Initial Weight	(W_i)	859.2	844.5	855.4	g
Net Weight	(W_n)	15.1	15.6	15.3	g
Comments					
Total Water Collected					
Total Weight	(W_{lc})	204.2	200.3	248.4	g
Total Volume	(V_{lc})	204.6	200.7	248.8	ml

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 100%-1	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	1023	09/10/21	15:42
Probe Wash	250-726	09/10/21	15:42
Inorganic Impinger Contents	250-802	09/10/21	15:42
Organic Impinger Contents	0597	09/10/21	15:42

Weight Data			**Run**		1	**Start Time** 09:36
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	48.0276	09/14/21	11:15	45%	68	
Measurement 2	48.0279	09/15/21	13:55	45%	68	
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	122.1851	09/14/21	11:15	45%	68	
Measurement 2	122.1854	09/15/21	13:55	45%	68	
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	126.0307	09/14/21	11:15	45%	68	
Measurement 2	126.0310	09/15/21	13:55	45%	68	
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	1.7512	09/14/21	11:15	45%	68	
Measurement 2	1.7513	09/15/21	13:55	45%	68	

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0000	420.0000	0.000000	--
DI Water Blank Weight of Solids	0.0001	240.0000	0.000417	--
Hexane Blank Weight of Solids	0.0002	430.0000	0.000349	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**		1	**Start Time** 09:36
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	48.0278	0.3602	-0.4000	--	--	0.0000
Filter Beaker		47.6680		--	--	
Probe Wash	122.1853	122.1817	3.6000	140.0000	0.0000	3.6000
Inorganic Impinger Contents	126.0309	126.0276	3.2500	484.3659	1.5904	1.6596
Organic Impinger Contents	1.7513	1.7501	1.2000	80.0000	0.4096	0.7904

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 100%-2	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	Sample Number	Date	Time
Filter	0806	09/10/21	15:42
Probe Wash	250-846	09/10/21	15:42
Inorganic Impinger Contents	250-857	09/10/21	15:42
Organic Impinger Contents	0594	09/10/21	15:42

Weight Data			**Run**	2	**Start Time**	12:05
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	67.0374	09/14/21	11:15	45%	68	
Measurement 2	67.0376	09/15/21	13:55	45%	68	
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	123.8782	09/14/21	11:15	45%	68	
Measurement 2	123.8785	09/15/21	13:55	45%	68	
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	123.3015	09/14/21	11:15	45%	68	
Measurement 2	123.3018	09/15/21	13:55	45%	68	
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	1.7514	09/14/21	11:15	45%	68	
Measurement 2	1.7515	09/15/21	13:55	45%	68	

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0000	420.0000	0.000000	--
DI Water Blank Weight of Solids	0.0001	240.0000	0.000417	--
Hexane Blank Weight of Solids	0.0002	430.0000	0.000349	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**	2	**Start Time**	12:05
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	67.0375	0.3586	-0.6500	--	--	0.0000
Filter Beaker		66.6796		--	--	
Probe Wash	123.8784	123.8773	1.0500	235.0000	0.0000	1.0500
Inorganic Impinger Contents	123.3017	123.3002	1.5000	509.0743	1.5904	0.0000
Organic Impinger Contents	1.7515	1.7505	1.0000	66.0000	0.4096	0.5904

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 100%-3	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Filter	0852	09/10/21	15:42
Probe Wash	250-357	09/10/21	15:42
Inorganic Impinger Contents	250-083	09/10/21	15:42
Organic Impinger Contents	0584	09/10/21	15:42

Weight Data			**Run**	3	**Start Time**	14:24
Filter and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	68.7259	09/14/21	11:15	45%	68	
Measurement 2	68.7262	09/15/21	13:55	45%	68	
Probe Wash and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	113.7084	09/14/21	11:15	45%	68	
Measurement 2	113.7087	09/15/21	13:55	45%	68	
Inorganic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	101.7787	09/14/21	11:15	45%	68	
Measurement 2	101.7791	09/15/21	13:55	45%	68	
Organic Impinger Contents and Beaker Weight	**Weight** (g)	**Date** (mm/dd/yy)	**Time** (hh:mm)	**Humidity** (%)	**Temp** °F	**Calibration Audit** (g)
Measurement 1	1.7379	09/14/21	11:15	45%	68	
Measurement 2	1.7380	09/15/21	13:55	45%	68	

Blank and Titration Concentrations				
Blank Type	**Weight** (g)	**Volume** (ml)	**Concentration** (mg/ml)	**Mass** (mg)
Acetone Blank Weight of Solids	0.0000	420.0000	0.000000	--
DI Water Blank Weight of Solids	0.0001	240.0000	0.000417	--
Hexane Blank Weight of Solids	0.0002	430.0000	0.000349	--
0.1N NH_4OH Correction	--	0.0000	--	0.0000

Gravimetric Concentrations			**Run**	3	**Start Time**	14:24
Sample Portion	**Final** (g)	**Tare** (g)	**Gain** (mg)	**Volume** (ml)	**Blank Adjustment** (mg)	**Adjusted Gain** (mg)
Filter	68.7261	0.3657	-0.3000	--	--	0.0000
Filter Beaker		68.3607		--	--	
Probe Wash	113.7086	113.7088	-0.2500	190.0000	-0.2500	0.0000
Inorganic Impinger Contents	101.7789	101.7746	4.3000	480.0862	1.5904	2.7096
Organic Impinger Contents	1.7380	1.7375	0.4500	60.0000	0.4096	0.0404

SAMPLE ANALYTICAL DATA SHEET

Plant Name	Stewart and Stevenson Integration Center
Sampling Location	Caterpillar G3520 TALE
Project #	catc-21-houston.tx-start#1

Analytical Data		**Run**	R-1 100%-FB	
Sample Leakage Evident	NO	**Estimated Leak Volume**	0.00	(mg)

Sample Type	**Sample Number**	**Date**	**Time**
Inorganic Impinger Contents	250-374	09/10/21	15:42
Organic Impinger Contents	0571	09/10/21	15:42

Weight Data			**Run**	R-1 100%-FB	**Start Time**	
Inorganic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	116.6108	09/14/21	11:15	45%	68	
Measurement 2	116.6112	09/15/21	13:55	45%	68	
Organic Impinger Contents and Beaker Weight	**Weight**	**Date**	**Time**	**Humidity**	**Temp**	**Calibration Audit**
	(g)	(mm/dd/yy)	(hh:mm)	(%)	°F	(g)
Measurement 1	1.7403	09/14/21	11:15	45%	68	
Measurement 2	1.7404	09/15/21	13:55	45%	68	

Gravimetric Concentrations					
Sample Portion	**Final**	**Tare**	**Gain**		**Actual Gain**
	(g)	(g)	(mg)		(mg)
Inorganic Impinger Contents	116.6110	116.6077	1.5904	max 2 mg total blank adjustment, proportioned	3.3000
Organic Impinger Contents	1.7404	1.7395	0.4096		0.8500

EQUIPMENT / INSTRUMENTATION IDENTIFICATION

Equipment / Instrumentation	Identification No.
Acetone Lot	21040287
Hexane Lot	21030109
Filterable Particulate Matter Oven ID	LABS-OV-0007
Condensable Particulate Matter Oven ID	LABS-0V-0008
Sonic Bath ID	LABS-UB-0001
LABS-SC-0004 Scale Weight Set ID (1st weights)	LABS-WT--0001
LABS-SC-0004 Scale Weight Set ID (2nd weights)	LABS-WT--0001
LABS-SC-0004 Scale Weight Set ID (3rd weights)	
LABS-SC-0004 Scale Weight Set ID (4th weights)	

A - 21040287
H - 21030109

Requested Standard Analysis - 5-10 business days after receipt at lab

SAMPLE DESCRIPTION AND LABELING RECORD

Contact Information (deliver results to)

Name: Matt McBride
Phone: (918) 307-8865
Email: mmcbride@airhygiene.com

Air Hygiene International, Inc.
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
(888) 461-8778
www.airhygiene.com

Project Number:	catc-21-houston.tx-start#1	Laboratory Analysis Requested:
Person Taking Samples:	TP	Gravimetric

Sample Number	Location	Date	Volume	Analysis Method			
				RM 5	RM 202	--	--
R-1 100%-1-F	4 Unit R-1 100% - Run 1 - Filter	08/31/21	N/A	X		1023	100-766
R-1 100%-1-PW	5 Unit R-1 100% - Run 1 - Probe Wash	08/31/21	As Marked	X		140mL	250-726
R-1 100%-1-IC	6 Unit R-1 100% - Run 1 - Inorganic Impinger Contents	08/31/21	As Marked		X	670mL	250-802
R-1 100%-1-Hex	7 Unit R-1 100% - Run 1 - Organic Impinger Contents	08/31/21	As Marked		X	80mL	597
R-1 100%-1-CPM	8 Unit R-1 100% - Run 1 - CPM Filter	08/31/21	N/A		X		
R-1 100%-2-F	9 Unit R-1 100% - Run 2 - Filter	08/31/21	N/A	X		806	100-669
R-1 100%-2-PW	10 Unit R-1 100% - Run 2 - Probe Wash	08/31/21	As Marked	X		235mL	250-846
R-1 100%-2-IC	11 Unit R-1 100% - Run 2 - Inorganic Impinger Contents	08/31/21	As Marked		X	690mL	250-857
R-1 100%-2-Hex	12 Unit R-1 100% - Run 2 - Organic Impinger Contents	08/31/21	As Marked		X	66mL	594
R-1 100%-2-CPM	13 Unit R-1 100% - Run 2 - CPM Filter	08/31/21	N/A		X		
R-1 100%-3-F	14 Unit R-1 100% - Run 3 - Filter	08/31/21	N/A	X		852	100-745
R-1 100%-3-PW	15 Unit R-1 100% - Run 3 - Probe Wash	08/31/21	As Marked	X		190mL	250-357
R-1 100%-3-IC	16 Unit R-1 100% - Run 3 - Inorganic Impinger Contents	08/31/21	As Marked		X	710mL	250-083
R-1 100%-3-Hex	17 Unit R-1 100% - Run 3 - Organic Impinger Contents	08/31/21	As Marked		X	60mL	584
R-1 100%-3-CPM	18 Unit R-1 100% - Run 3 - CPM Filter	08/31/21	N/A		X		
R-1 100%-FB-IC	19 Unit R-1 100% - Run FB - Inorganic Impinger Contents	FB	As Marked		X	385mL	250-374
R-1 100%-FB-Hex	20 Unit R-1 100% - Run FB - Organic Impinger Contents	FB	As Marked		X	80mL	571
R-1 100%-FB-CPM	21 Unit R-1 100% - Run FB - CPM Filter	FB	N/A		X		
R-1 100%-B1-Acetone	210907-1 Unit R-1 100% - Blank - Acetone	08/31/21	200		X	420mL	606
R-1 100%-B2-DI Water	2 Unit R-1 100% - Blank - DI Water	08/31/21	200	X		240mL	100-658
R-1 100%-B3-Hexane	3 Unit R-1 100% - Blank - Hexane	08/31/21	200		X	430mL	610

[signature] 9/2/21 21:00 @ lus
Signature Date Time

[signature] 9/3/21 9:00
Signature Date Time

Signature Date Time

Signature Date Time

catc-21-houston.tx-start#1-EG1-PM-100.xlsm

SD&L

APPENDIX E

FUEL ANALYSIS RECORDS

Client: Catalytic Combustion Corporation
Location: Stewart & Stevenson Integration Center
Date: July 29, 2021
Project #: catc-21-houston.tx-start#1

Natural Gas - Fuel Analysis Standardized to 68 deg F and 14.696 psia - EPA Standards

Gas Component		Mole (%)	Molecular[1] Weight (lb/lb-mole)	Lbs Component per Lb-Mole of Gas	Wt. % of Component	Ideal Gross[1,3] Heating Value (Btu/ft³)	Fuel Heat Value [HHV] (Btu/SCF)	Ideal Net[1,3] Heating Value (Btu/ft³)	Fuel Heat Value [LHV] (Btu/SCF)
Methane	CH_4	98.3548	16.0430	15.78	96.76	994.85	978.48	895.75	881.02
Ethane	C_2H_6	1.1343	30.0700	0.34	2.09	1,743.15	19.77	1,594.41	18.09
Propane	C_3H_8	0.0197	44.0970	0.01	0.05	2,478.35	0.49	2,280.17	0.45
iso-Butane	iC_4H_{10}	0.0005	58.1230	0.00	0.00	3,203.11	0.02	2,955.38	0.01
n-Butane	nC_4H_{10}	0.0005	58.1230	0.00	0.00	3,213.35	0.02	2,965.62	0.01
Iso-Pentane	iC_5H_{12}	0.0000	72.1500	0.00	0.00	3,940.87	0.00	3,643.50	0.00
n-Pentane	nC_5H_{12}	0.0000	72.1500	0.00	0.00	3,948.75	0.00	3,648.32	0.00
Hexanes	C_6H_{14}	0.0001	86.1770	0.00	0.00	4,684.54	0.00	4,337.82	0.00
Heptanes	C_7H_{16}	0.0000	100.2040	0.00	0.00	5,419.94	0.00	5,023.77	0.00
Octanes	C_8H_{18}	0.0000	114.2310	0.00	0.00	6,155.14	0.00	5,709.23	0.00
Carbon Dioxide	CO_2	0.2558	44.0100	0.11	0.69	0.00	0.00	0.00	0.00
Nitrogen	N_2	0.2239	28.0134	0.06	0.38	0.00	0.00	0.00	0.00
Hydrogen Sulfide	H_2S	0.0000	34.0800	0.00	0.00	627.54	0.00	578.00	0.00
Oxygen	O_2	0.0057	31.9988	0.00	0.01	0.00	0.00	0.00	0.00
Helium	He	0.0000	4.0026	0.00	0.00	0.00	0.00	0.00	0.00
Hydrogen	H_2	0.0047	2.0159	0.00	0.00	319.34	0.02	269.82	0.01
Totals		**100.0000**		**16.31**	**100.00**	**dry**	**998.79**	**dry**	**899.60**
						wet[2,5]	**975.76**	**wet[2,5]**	**878.86**

Characteristics of Fuel Gas		
Molecular Weight of gas =	16.307	lb/lb-mole
Btu per lb. of gas[4] =	23,595.430	gross (HHV)
Btu per lb. of gas[4] =	21,252.128	net (LHV)
Density of fuel gas[2] =	0.0423	lb/cu. ft
Wt % VOC in fuel gas =	0.06	%
Specific Gravity[1] =	0.5630	

Component	Wt%
carbon	74.35
oxygen	0.51
hydrogen	24.75
nitrogen	0.38
helium	0.00
sulfur	0.00
Total	**100.00**

F-Factor (SCF dry exhaust per MMBtu [HHV]) = 8,631.70
(Based on EPA RM-19) at 68 deg F and 14.696 psia

F-Factor Calculation:

F-Factor = 1,000,000*((3.64*%H)+(1.53*%C)+(0.57*%S)+(0.14*%N)-(0.46*%O))/GCV

GCV = Gross Btu per lb. of gas (HHV)

%H, %C, %S, %N, & %O are percent weight values calculated from fuel analysis and have units of (scf/lb)/%

Density of natural gas based on specific gravity multiplied by density of air at 68 deg F and 14.696 psia.

References:

[1] ASTM D 3588
[2] Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg
[3] Mark's Standard Handbook for Mechanical Engineers, 10th ed. - Eugene A. Avallone, Theodore Baumeister III
[4] Introduction to Fluid Mechanics, 3rd ed. - William S. Janna
[5] GPA Reference Bulletin 181-86, revised 1986, reprinted 1995

Client: Catalytic Combustion Corporation
Location: Stewart & Stevenson Integration Center
Date: July 30, 2021
Project #: catc-21-houston.tx-start#1

Natural Gas - Fuel Analysis Standardized to 68 deg F and 14.696 psia - EPA Standards

Gas Component		Mole (%)	Molecular[1] Weight (lb/lb-mole)	Lbs Component per Lb-Mole of Gas	Wt. % of Component	Ideal Gross[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [HHV] (Btu/SCF)	Ideal Net[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [LHV] (Btu/SCF)
Methane	CH_4	98.2687	16.0430	15.77	96.57	994.85	977.62	895.75	880.25
Ethane	C_2H_6	1.2050	30.0700	0.36	2.22	1,743.15	21.00	1,594.41	19.21
Propane	C_3H_8	0.0205	44.0970	0.01	0.06	2,478.35	0.51	2,280.17	0.47
iso-Butane	iC_4H_{10}	0.0003	58.1230	0.00	0.00	3,203.11	0.01	2,955.38	0.01
n-Butane	nC_4H_{10}	0.0002	58.1230	0.00	0.00	3,213.35	0.01	2,965.62	0.01
Iso-Pentane	iC_5H_{12}	0.0000	72.1500	0.00	0.00	3,940.87	0.00	3,643.50	0.00
n-Pentane	nC_5H_{12}	0.0000	72.1500	0.00	0.00	3,948.75	0.00	3,648.32	0.00
Hexanes	C_6H_{14}	0.0003	86.1770	0.00	0.00	4,684.54	0.01	4,337.82	0.01
Heptanes	C_7H_{16}	0.0000	100.2040	0.00	0.00	5,419.94	0.00	5,023.77	0.00
Octanes	C_8H_{18}	0.0000	114.2310	0.00	0.00	6,155.14	0.00	5,709.23	0.00
Carbon Dioxide	CO_2	0.2992	44.0100	0.13	0.81	0.00	0.00	0.00	0.00
Nitrogen	N_2	0.1976	28.0134	0.06	0.34	0.00	0.00	0.00	0.00
Hydrogen Sulfide	H_2S	0.0000	34.0800	0.00	0.00	627.54	0.00	578.00	0.00
Oxygen	O_2	0.0033	31.9988	0.00	0.01	0.00	0.00	0.00	0.00
Helium	He	0.0000	4.0026	0.00	0.00	0.00	0.00	0.00	0.00
Hydrogen	H_2	0.0049	2.0159	0.00	0.00	319.34	0.02	269.82	0.01
Totals		**100.000**		**16.33**	**100.00**	**dry**	**999.18**	**dry**	**899.97**
						wet[2,5]	**976.14**	**wet[2,5]**	**879.22**

Characteristics of Fuel Gas		
Molecular Weight of gas =	16.325	lb/lb-mole
Btu per lb. of gas[4] =	23,577.669	gross (HHV)
Btu per lb. of gas[4] =	21,236.549	net (LHV)
Density of fuel gas[2] =	0.0424	lb/cu. ft
Wt % VOC in fuel gas =	0.06	%
Specific Gravity[1] =	0.5637	

Component	Wt%
carbon	74.34
oxygen	0.59
hydrogen	24.73
nitrogen	0.34
helium	0.00
sulfur	0.00
Total	**100.00**

F-Factor (SCF dry exhaust per MMBtu [HHV]) = 8,632.09
(Based on EPA RM-19) at 68 deg F and 14.696 psia

F-Factor Calculation:

F-Factor = 1,000,000*((3.64*%H)+(1.53*%C)+(0.57*%S)+(0.14*%N)-(0.46*%O))/GCV

GCV = Gross Btu per lb. of gas (HHV)

%H, %C, %S, %N, & %O are percent weight values calculated from fuel analysis and have units of (scf/lb)/%

Density of natural gas based on specific gravity multiplied by density of air at 68 deg F and 14.696 psia.

References:

[1] ASTM D 3588
[2] Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg
[3] Mark's Standard Handbook for Mechanical Engineers, 10th ed. - Eugene A. Avallone, Theodore Baumeister III
[4] Introduction to Fluid Mechanics, 3rd ed. - William S. Janna
[5] GPA Reference Bulletin 181-86, revised 1986, reprinted 1995

Client: Catalytic Combustion Corporation
Location: Stewart & Stevenson Integration Center
Date: August 31, 2021
Project #: catc-21-houston.tx-start#1

Natural Gas - Fuel Analysis

Standardized to 68 deg F and 14.696 psia - EPA Standards

Gas Component		Mole (%)	Molecular[1] Weight (lb/lb-mole)	Lbs Component per Lb-Mole of Gas	Wt. % of Component	Ideal Gross[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [HHV] (Btu/SCF)	Ideal Net[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [LHV] (Btu/SCF)
Methane	CH_4	98.4117	16.0430	15.79	96.85	994.85	979.04	895.75	881.53
Ethane	C_2H_6	1.0600	30.0700	0.32	1.96	1,743.15	18.48	1,594.41	16.90
Propane	C_3H_8	0.0198	44.0970	0.01	0.05	2,478.35	0.49	2,280.17	0.45
iso-Butane	iC_4H_{10}	0.0003	58.1230	0.00	0.00	3,203.11	0.01	2,955.38	0.01
n-Butane	nC_4H_{10}	0.0002	58.1230	0.00	0.00	3,213.35	0.01	2,965.62	0.01
Iso-Pentane	iC_5H_{12}	0.0000	72.1500	0.00	0.00	3,940.87	0.00	3,643.50	0.00
n-Pentane	nC_5H_{12}	0.0000	72.1500	0.00	0.00	3,948.75	0.00	3,648.32	0.00
Hexanes	C_6H_{14}	0.0000	86.1770	0.00	0.00	4,684.54	0.00	4,337.82	0.00
Heptanes	C_7H_{16}	0.0000	100.2040	0.00	0.00	5,419.94	0.00	5,023.77	0.00
Octanes	C_8H_{18}	0.0000	114.2310	0.00	0.00	6,155.14	0.00	5,709.23	0.00
Carbon Dioxide	CO_2	0.2813	44.0100	0.12	0.76	0.00	0.00	0.00	0.00
Nitrogen	N_2	0.2106	28.0134	0.06	0.36	0.00	0.00	0.00	0.00
Hydrogen Sulfide	H_2S	0.0000	34.0800	0.00	0.00	627.54	0.00	578.00	0.00
Oxygen	O_2	0.0115	31.9988	0.00	0.02	0.00	0.00	0.00	0.00
Helium	He	0.0000	4.0026	0.00	0.00	0.00	0.00	0.00	0.00
Hydrogen	H_2	0.0046	2.0159	0.00	0.00	319.34	0.01	269.82	0.01
Totals		**100.0000**		**16.30**	**100.00**	**dry**	**998.04**	**dry**	**898.91**
						wet[2,5]	**975.03**	**wet[2,5]**	**878.18**

Characteristics of Fuel Gas		
Molecular Weight of gas =	16.303	lb/lb-mole
Btu per lb. of gas[4] =	23,583.835	gross (HHV)
Btu per lb. of gas[4] =	21,241.243	net (LHV)
Density of fuel gas[2] =	0.0423	lb/cu. ft
Wt % VOC in fuel gas =	0.06	%
Specific Gravity[1] =	0.5629	

Component	Wt%
carbon	74.32
oxygen	0.57
hydrogen	24.74
nitrogen	0.36
helium	0.00
sulfur	0.00
Total	**100.00**

F-Factor (SCF dry exhaust per MMBtu [HHV]) =	8,631.42
(Based on EPA RM-19) at 68 deg F and 14.696 psia	

F-Factor Calculation:

F-Factor = 1,000,000*((3.64*%H)+(1.53*%C)+(0.57*%S)+(0.14*%N)-(0.46*%O))/GCV

GCV = Gross Btu per lb. of gas (HHV)

%H, %C, %S, %N, & %O are percent weight values calculated from fuel analysis and have units of (scf/lb)/%

Density of natural gas based on specific gravity multiplied by density of air at 68 deg F and 14.696 psia.

References:

[1] ASTM D 3588
[2] Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg
[3] Mark's Standard Handbook for Mechanical Engineers, 10th ed. - Eugene A. Avallone, Theodore Baumeister III
[4] Introduction to Fluid Mechanics, 3rd ed. - William S. Janna
[5] GPA Reference Bulletin 181-86, revised 1986, reprinted 1995

Certificate of Analysis

SINCE 1985

Quality Controlled Through Analysis

10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (281) 495-2400
FAX: (281) 495-2410

CLIENT:	Air Hygiene International	**REQUESTED BY:**	Dr. Sean Barnes
CLIENT PROJECT:	catc-21-houston-start#1	**PURCHASE ORDER NO:**	PENDING
LABORATORY NO:	95248-001 Page 1 of 2	**REPORT DATE:**	August 06, 2021
SAMPLE:	Natural Gas (Primary # 4651) (4651) 2021-07-29		

Composition of Natural Gas by Gas Chromatography (TCD/FID), GPA 2261

	Results, Mol %
Hydrogen	0.0047
Oxygen	0.0057
Nitrogen	0.2239
Carbon Dioxide	0.2558
Methane	98.3548
Ethane	1.1343
Propane	0.0197
iso-Butane	0.0005
n-Butane	0.0005
iso-Pentane	0.0000
n-Pentane	0.0000
Hexane Plus	0.0001
TOTAL	**100.0000**

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 60°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	913.3
Gross (Dry basis), BTU/scf	1,014
NET (Dry basis), BTU/lb	21,257
Gross (Dry basis), BTU/lb	23,599

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 68°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	899.5
Gross (Dry basis), BTU/scf	998.6
NET (Dry basis), BTU/lb	21,257
Gross (Dry basis), BTU/lb	23,599

Certificate of Analysis

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10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274
TEL: (281) 495-2400
FAX: (281) 495-2410

CLIENT:	Air Hygiene International	**REQUESTED BY:**	Dr. Sean Barnes
CLIENT PROJECT:	catc-21-houston-start#1	**PURCHASE ORDER NO:**	PENDING
LABORATORY NO:	95248-001 Page 2 of 2	**REPORT DATE:**	August 06, 2021
SAMPLE:	Natural Gas (Primary # 4651) (4651) 2021-07-29		

Respectfully submitted
For Texas OilTech Laboratories, L.P.

Mr. Ikenna "Ike" Ezeji
Laboratory Director

Certificate of Analysis

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10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (281) 495-2400
FAX: (281) 495-2410

CLIENT:	Air Hygiene International	**REQUESTED BY:**	Dr. Sean Barnes
CLIENT PROJECT:	catc-21-houston-start#1	**PURCHASE ORDER NO:**	PENDING
LABORATORY NO:	95248-003 Page 1 of 2	**REPORT DATE:**	August 06, 2021
SAMPLE:	Natural Gas (Primary # 4893) (4893) 2021-07-30		

Composition of Natural Gas by Gas Chromatography (TCD/FID), GPA 2261

	Results, Mol %
Hydrogen	0.0049
Oxygen	0.0033
Nitrogen	0.1976
Carbon Dioxide	0.2992
Methane	98.2687
Ethane	1.2050
Propane	0.0205
iso-Butane	0.0003
n-Butane	0.0002
iso-Pentane	0.0000
n-Pentane	0.0000
Hexane Plus	0.0003
TOTAL	**100.0000**

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 60°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	913.7
Gross (Dry basis), BTU/scf	1,014
NET (Dry basis), BTU/lb	21,241
Gross (Dry basis), BTU/lb	23,581

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 68°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	899.8
Gross (Dry basis), BTU/scf	999.0
NET (Dry basis), BTU/lb	21,241
Gross (Dry basis), BTU/lb	23,581

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10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (281) 495-2400
FAX: (281) 495-2410

CLIENT:	Air Hygiene International	**REQUESTED BY:**	Dr. Sean Barnes
CLIENT PROJECT:	catc-21-houston-start#1	**PURCHASE ORDER NO:**	PENDING
LABORATORY NO:	95248-003 Page 2 of 2	**REPORT DATE:**	August 06, 2021
SAMPLE:	Natural Gas (Primary # 4893) (4893) 2021-07-30		

Respectfully submitted
For Texas OilTech Laboratories, L.P.

Mr. Ikenna "Ike" Ezeji
Laboratory Director

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Quality Controlled Through Analysis

10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (281) 495-2400
FAX: (281) 495-2410

Conversion Factors (Gas Analysis) to adjust BTU/ft^3 and Sulfur content @60ºF and 68ºF

NET (Dry Basis) BTU/scf @60ºF, factor= 1

NET (Dry Basis) BTU/scf @68ºF, factor= 0.984839

Gross (Dry Basis) BTU/scf @60ºF, factor = 1

Gross (Dry Basis) BTU/scf @68ºF, factor = 0.984839

NET (Dry Basis) BTU/lb @60ºF, factor = 1

NET (Dry Basis) BTU/lb @68ºF, factor = 1

GROSS (Dry Basis) BTU/lb @60ºF, factor= 1

GROSS (Dry Basis) BTU/lb @68ºF, factor= 1

Sulfur Total Volatile, ASTM D 6667 @60ºF, wt% or ppmwt, factor= 1

Sulfur Total Volatile, ASTM D 6667 @68ºF, wt% or ppmwt, factor= 0.984839

Sulfur Total Volatile, ASTM D 6667 @60ºF, grains/100scf = ppmwt @60ºF x 0.0300

Sulfur Total Volatile, ASTM D 6667 @68ºF, grains/100scf = ppmwt @60ºF x 0.0295

Conversion Factors (Liquid Fuel Analysis)

Liquid Fuel BTU/lb @60ºF= Liquid fuel BTU/lb @68ºF

SAMPLE DESCRIPTION AND CHAIN OF CUSTODY RECORD

pmcgovern@airhygiene.com

Air Hygiene International, Inc.
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
(888) 461-8778
www.airhygiene.com

Project Number:	catc-21-houston.tx-start#1	Laboratory Analysis Requested:
Person Taking Samples:	C.King	Fuel Component Analysis

Sample Number	Location	Date	Volume	Analysis Method(s) [and target(s)]: GPA2261/ASTM 1945 [component analysis]						
4651	______ Natural Gas Sample [Primary]	07/29/21		x						
4611	______ Natural Gas Sample [Backup]	07/29/21		as necessary						
4893	______ Natural Gas Sample [primary]	7/30/21		X						
5109	______ Natural Gas Sample [backup]	7/30/21		as necessary						
	~~______ Natural Gas Sample [primary]~~			~~X~~						
	~~______ Natural Gas Sample [backup]~~			~~as necessary~~						

Relinquished by: (Signature) [signature] Date: 8/2/21 Time: 13:30 Received by: (Signature) [signature] Date: 8/3/21 Time: 10:47

Relinquished by: (Signature) ______ Date: ______ Time: ______ Received by: (Signature) ______ Date: ______ Time: ______

catc-21-houston.tx-start#1-FuelCOC

Certificate of Analysis

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Quality Controlled Through Analysis

10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (281) 495-2400
FAX: (281) 495-2410

CLIENT:	Air Hygiene International	**REQUESTED BY:**	Dr. Sean Barnes
CLIENT PROJECT:	catc-21-Houston-Tx-Start#1	**PURCHASE ORDER NO:**	21011220
LABORATORY NO:	95477-001	**REPORT DATE:**	September 08, 2021
SAMPLE:	Primary Fuel line (3713) 2021-08-31		

TEST **RESULT**

Composition of Natural Gas by Gas Chromatography (TCD/FID), GPA 2261

	Results, Mol %
Hydrogen	0.0046
Oxygen	0.0115
Nitrogen	0.2106
Carbon Dioxide	0.2813
Methane	98.4117
Ethane	1.0600
Propane	0.0198
iso-Butane	0.0003
n-Butane	0.0002
iso-Pentane	0.0000
n-Pentane	0.0000
Hexane Plus	0.0000
TOTAL	**100.0000**

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 60°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	912.6
Gross (Dry basis), BTU/scf	1,013
NET (Dry basis), BTU/lb	21,246
Gross (Dry basis), BTU/lb	23,587

Calorific Value and Specific Gravity, Calculated at 14.696 psia and 68°F, ASTM D 3588.e

	Results
NET (Dry basis), BTU/scf	898.8
Gross (Dry basis), BTU/scf	997.9
NET (Dry basis), BTU/lb	21,246
Gross (Dry basis), BTU/lb	23,587

Respectfully submitted
For Texas OilTech Laboratories, L.P.

Mr. Ikenna "Ike" Ezeji
Laboratory Director

Cert # L19-636,C2018-02457
Quality Management System Certified to ISO 9001:2015, and ISO/IEC 17025:2017

SINCE 1985
Quality Controlled Through Analysis
10630 FALLSTONE RD. HOUSTON, TEXAS 77099
P.O. BOX 741905, HOUSTON, TEXAS 77274
TEL: (281) 495-2400
FAX: (281) 495-2410

Conversion Factors (Gas Analysis) to adjust BTU/ft³ and Sulfur content @60ºF and 68ºF

NET (Dry Basis) BTU/scf @60ºF, factor= 1

NET (Dry Basis) BTU/scf @68ºF, factor= 0.984839

Gross (Dry Basis) BTU/scf @60ºF, factor = 1

Gross (Dry Basis) BTU/scf @68ºF, factor = 0.984839

NET (Dry Basis) BTU/lb @60ºF, factor = 1

NET (Dry Basis) BTU/lb @68ºF, factor = 1

GROSS (Dry Basis) BTU/lb @60ºF, factor= 1

GROSS (Dry Basis) BTU/lb @68ºF, factor= 1

Sulfur Total Volatile, ASTM D 6667 @60ºF, wt% or ppmwt, factor= 1

Sulfur Total Volatile, ASTM D 6667 @68ºF, wt% or ppmwt, factor= 0.984839

Sulfur Total Volatile, ASTM D 6667 @60ºF, grains/100scf = ppmwt @60ºF x 0.0300

Sulfur Total Volatile, ASTM D 6667 @68ºF, grains/100scf = ppmwt @60ºF x 0.0295

Conversion Factors (Liquid Fuel Analysis)

Liquid Fuel BTU/lb @60ºF= Liquid fuel BTU/lb @68ºF

SAMPLE DESCRIPTION AND CHAIN OF CUSTODY RECORD

Air Hygiene International, Inc.
1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
(888) 461-8778
www.airhygiene.com

Project Number:	catc-21-houston.tx-start#1	Laboratory Analysis Requested:	Fuel analysis
Person Taking Samples:	MM	GPA-2261-M	

Sample Number	Location	Date	Volume	Analysis Method			
				GPA-2261-M			
3713	Primary Fuel Line	31-Aug	2000	X			
4108	Primary Fuel Line (Backup Sample)	31-Aug	2000	X (If needed)			

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	9/2/2021	21:00	[signature]	9/3/21	9:00
			[signature]	9/7/21	9:10

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APPENDIX F

STRATIFICATION TEST DATA

Source Information	
Company	Catalytic Combustion
Plant Name	Stewart and Stevenson Integration Center
Equipment	Caterpillar engine
Location	Houston, Texas

Test Information	
Date	07/29/21
Project #	catc-21-houston.tx-start#1
Unit Number	G3520 TALE
Load	50%
Number of Ports Available	2
Number of Ports Used	2

Stack and Test Type			
○	Isokinetic Traverse (Wet Chemistry Testing)		**Circular Stack**
○	Velocity Traverse (Flow and Flow RATA Test)		
◉	**Stratification Traverse (Compliance Test)**	☐ RM 20	
○	Stratification Traverse (RATA) ☐ Part 60	☐ Part 75	

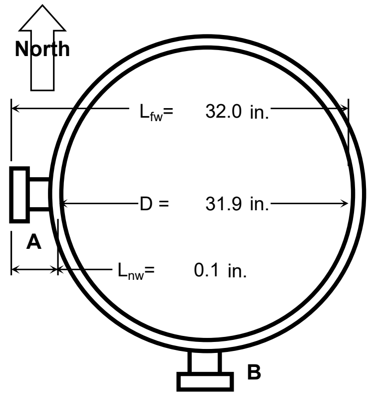
Created with Traverse-AHI v20200108

catc-21-houston.tx-start#1-EG1-Strat

METHOD 1 - STRATIFICATION TEST FOR A CIRCULAR SOURCE

Company	Catalytic Combustion	**Date**	07/29/21
Plant Name	Stewart and Stevenson Integration Center	**Project #**	catc-21-houston.tx-start#1
Equipment	Caterpillar engine	**# of Ports Available**	2
Location	Houston, Texas	**# of Ports Used**	2

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	32.00	in.
Distance to Near Wall of Stack	(L_{nw})	0.125	in.
Diameter of Stack	(D)	31.88	in.
Area of Stack	(A_s)	5.54	ft^2

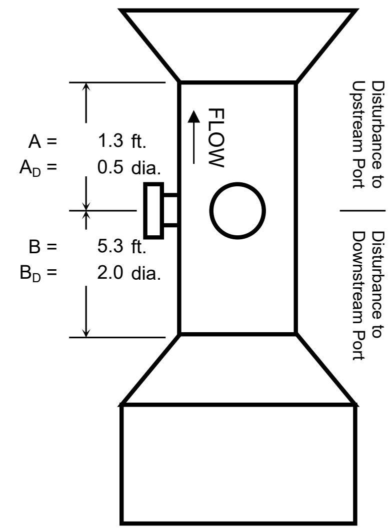


Distance from Disturbances to Port			
Distance Upstream	(A)	16.00	in.
Diameters Upstream	(A_D)	0.50	diameters
Distance Downstream	(B)	64.00	in.
Diameters Downstream	(B_D)	2.01	diameters

Number of Traverse Points Required					
Diameters to Flow Disturbance		Minimum Number of[1] Traverse Points		**Minimum Number of Traverse Points**	
Down (B_D) Stream	Up (A_D) Stream	Particulate Points	Velocity Points	**Comp Stratification Criteria**	**Points**
2.00-4.99	0.50-1.24	24	16	RM 7E 8.1.2	12 RM1 pts (selected)
5.00-5.99	1.25-1.49	20	16	Alt 7E 8.1.2	3 points
6.00-6.99	1.50-1.74	16	12	12 points	
7.00-7.99	1.75-1.99	12	12		
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]	Minimum Number of	
Upstream Spec		24	16	Traverse Points	
Downstream Spec		24	16	RATA Stratification	
Traverse Pts Required		24	16	Criteria	Points
				Part75/60	12 RM1 pts
				75 abrv (a)	3 points
				75 abrv (b)	6 points

[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

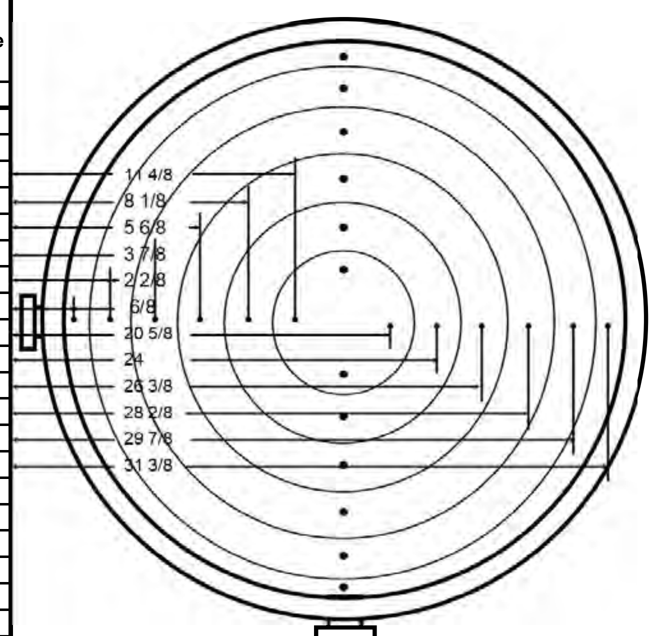
[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches



Number of Traverse Points Used				
2	**Ports by**	12	**Pts / port**	**Stratification Traverse (Compliance Test)**
24	**Pts Used**	12	**Required**	

Traverse Point Locations			
Traverse Point Number	**Percent of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
	%	in.	in.
1	2.1%	5/8	6/8
2	6.7%	2 1/8	2 2/8
3	11.8%	3 6/8	3 7/8
4	17.7%	5 5/8	5 6/8
5	25.0%	8	8 1/8
6	35.6%	11 3/8	11 4/8
7	64.4%	20 4/8	20 5/8
8	75.0%	23 7/8	24
9	82.3%	26 2/8	26 3/8
10	88.2%	28 1/8	28 2/8
11	93.3%	29 6/8	29 7/8
12	97.9%	31 2/8	31 3/8
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

Adjust Sample Points Out of Boundary Layer



STRATIFICATION TRAVERSE (COMPLIANCE TEST) RESULTS

Company	Catalytic Combustion	**Date**	07/29/21
Plant Name	Stewart and Stevenson Integration Center	**Project #**	catc-21-houston.tx-start#1
Equipment	Caterpillar engine	**# of Ports Available**	2
Location	Houston, Texas	**# of Ports Used**	2

Stack Dimensions				**Traverse Data**			
Diameter or Length of Stack	(D)	31.88	in.	2	**Ports by**	12	**Pts / port**
Width of Stack	(W)		in.	24	**Pts Used**	12	**Required**
Area of Stack	(A_s)	5.54	ft^2	**Run Start**	11:00:23	**Run End**	12:10:23

Traverse Point	**Time Per Point**	**Point Start Time**	**Point Stop Time (Reading)**	**O_2**	**Percent Difference**	**NOx**	**Percent Difference**	
	min.	hh:mm:ss	hh:mm:ss	%	%	ppm	%	
B-12	2.50	11:00:23	11:02:53	8.90	0.44%	4.85	4.17%	
B-11	2.50	11:02:53	11:05:23	8.89	0.55%	4.62	0.77%	side
B-10	2.50	11:05:23	11:07:53	8.88	0.67%	4.59	1.42%	
B-9	2.50	11:07:53	11:10:23	8.88	0.67%	4.84	3.95%	
B-8	2.50	11:10:23	11:12:53	8.88	0.67%	4.27	8.29%	
B-7	2.50	11:12:53	11:15:23	8.87	0.78%	4.74	1.80%	
B-6	2.50	11:15:23	11:17:53	8.88	0.67%	4.36	6.36%	
B-5	2.50	11:17:53	11:20:23	8.90	0.44%	4.02	13.66%	
B-4	2.50	11:20:23	11:22:53	8.88	0.67%	3.77	19.03%	
B-3	2.50	11:22:53	11:25:23	8.87	0.78%	4.04	13.23%	
B-2	2.50	11:25:23	11:27:53	8.92	0.22%	3.65	21.61%	
B-1	2.50	11:27:53	11:30:23	8.90	0.44%	3.47	**25.47%**	
A-12	2.50	11:40:23	11:42:53	9.00	0.68%	5.32	14.26%	
A-11	2.50	11:42:53	11:45:23	8.96	0.23%	5.01	7.60%	front
A-10	2.50	11:45:23	11:47:53	8.95	0.12%	4.54	2.49%	
A-9	2.50	11:47:53	11:50:23	8.94	0.00%	4.76	2.23%	
A-8	2.50	11:50:23	11:52:53	8.91	0.33%	4.53	2.71%	
A-7	2.50	11:52:53	11:55:23	8.89	0.55%	4.26	8.51%	
A-6	2.50	11:55:23	11:57:53	8.92	0.22%	4.79	2.88%	
A-5	2.50	11:57:53	12:00:23	8.88	0.67%	4.64	0.34%	
A-4	2.50	12:00:23	12:02:53	8.88	0.67%	5.47	17.48%	
A-3	2.50	12:02:53	12:05:23	9.09	1.68%	5.74	23.28%	
A-2	2.50	12:05:23	12:07:53	9.14	2.24%	5.80	24.66%	
A-1	2.50	12:07:53	12:10:23	9.34	**4.48%**	5.66	21.56%	
Average				8.94		4.66		

			O_2		NOx		
			Criteria	**Results**	**Criteria**	**Results**	**AND criteria**
Strat Method 7E	Non-Stratified %	≤	5%	Non (%)	5%		Under Method 7E criteria at least one measured pollutant or diluent demonstrates a stratified stack with subsequent testing from 12 points.
	Non-Stratified Δ	≤	0.3		0.5		
	Minimally-Stratified %	≤	10%		10%		
	Minimally-Stratified Δ	≤	0.5		1		
	Stratified	>	10%		10%	Strat (%)	
	Outcome		1 point		12 points		
	Location		closest to the mean		Method 1 points		
	Maximum Concentration		9.34		5.80		
	Upscale Δ = Max Concentration - Average		0.40	Mini	1.15	Strat	
	Upscale % Difference		4.48%	Non	24.66%	Strat	
	Minimum Concentration		8.87		3.47		
	Downscale Δ = Average - Min Concentration		0.07	Non	1.19	Strat	
	Downscale % Difference		0.78%	Non	25.47%	Strat	
	First Point on List Closest to Average		A-8		A-4		
Port Averages with Maximum Concentration Indicator	**Port A Average**		9.00	<max	5.07	<max	
	Port B Average		8.89		4.13		
	Port C Average						
	Port D Average						
	Port E Average						
	Port F Average						
	Port G Average						

STRAT TEST DETERMINED SAMPLE POINTS FOR CIRCULAR STACK

Company	Catalytic Combustion	**Date**	07/29/21
Plant Name	Stewart and Stevenson Integration Center	**Project #**	catc-21-houston.tx-start#1
Equipment	Caterpillar engine	**# of Ports Available**	2
Location	Houston, Texas	**# of Ports Used**	2

Stack Dimensions				**Traverse Data**			
Diameter or Length of Stack	(D)	31.88	in.	2	**Ports by**	12	**Pts / port**
Width of Stack	(W)		in.	24	**Pts Used**	12	**Required**
Area of Stack	(A_s)	5.54	ft^2	**Run Start**	11:00:23	**Run End**	12:10:23

40 CFR 60, Appendix A, Method 7E Criteria

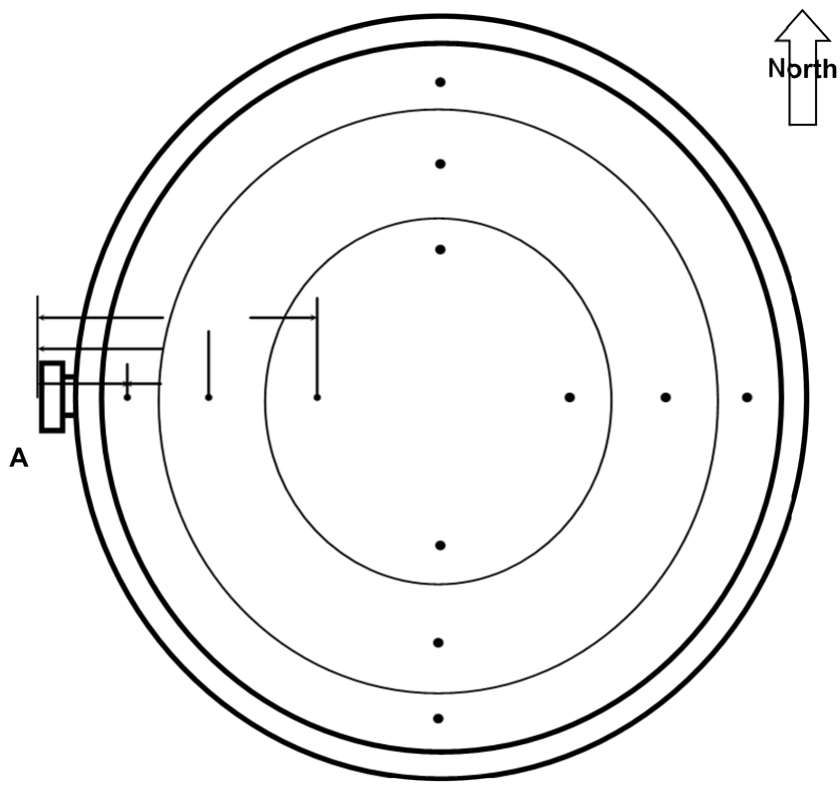
Stratification Results		
Maximum Percent Difference	25.47	% for NOx
Maximum Pollutant Conc. Diff.	1.19	ppm for NOx
Maximum Diluent Conc. Diff.	0.40	% for O_2

Stratification Conclusions	
Comparison	all diluents/pollutants
Stack Diameter	D ≤ 93.6 in.

Under Method 7E criteria at least one measured pollutant or diluent demonstrates a stratified stack with subsequent testing from 12 points.

Traverse Point Number	**Percent of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
	%	in.	in.
1			
2			
3			

Test Type
- ☐ Moisture, for MW
- ☐ Moisture, for wet-to-dry
- ☑ Gas
- ☐
- ☐ 6.5.6(b)(2) alt. points do not apply



APPENDIX G

EQUIPMENT CALIBRATION RECORDS

APEX INSTRUMENTS SOURCE TESTING EQUIPMENT

Apex Instruments, Inc.
204 Technology Park Lane
Fuquay-Varina, NC 27526

S-TYPE PITOT TUBE CALIBRATION SHEET

Reference USEPA Reference Method 2 (40CFR60, App. A, Meth. 2)

PITOT SERIAL#	A5708	**CALIBRATION DATE:**	17-Nov-14	
PITOT TYPE:	S	**BAROMETRIC PRESSURE:**	29.40	in Hg
STD. PITOT TYPE:	HEMISPHERICAL	**STATIC PRESSURE**	-0.6	in H_20
Cp(std):	0.990	**BLOCKAGE %:**	<2%	
PROBE SERIAL#	N/A	**CORRECTION FACTOR:**	1.00	

	SIDE "A" CALIBRATION			
RUN NO.	**Δ Pstd in H_2O**	**Δ Ps in H_2O**	**Cp(s)**	**DEVIATION Cp(s) - avg.Cp(s)**
1	**0.550**	**0.793**	**0.824**	**0.001**
2	**0.550**	**0.798**	**0.822**	**-0.001**
3	**0.550**	**0.795**	**0.823**	**0.000**
		"A" AVERAGE	**0.823**	**0.0013** (must be ≤ 0.01)

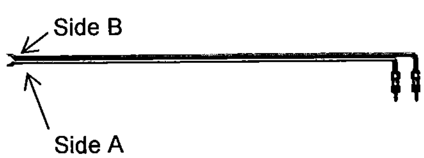
	SIDE "B" CALIBRATION			
RUN NO.	**Δ Pstd in H_2O**	**Δ Ps in H_2O**	**Cp(s)**	**DEVIATION Cp(s) - avg.Cp(s)**
1	**0.551**	**0.793**	**0.825**	**0.002**
2	**0.550**	**0.797**	**0.822**	**0.000**
3	**0.551**	**0.802**	**0.821**	**-0.002**
		"B" AVERAGE	**0.823**	**0.0023** (must be ≤ 0.01)

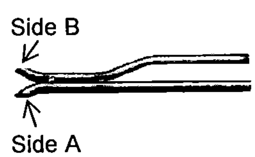
ACCEPTANCE CRITERIA

AVERAGE **0.0005** AVG. Cp (A) - AVG. Cp (B) must be ≤ 0.01

If the Average <u>and</u> both Deviation Averages "A" & "B" are ≤ 0.01, then the OVERALL AVERAGE below may be used.
*** If NOT, use the "A" Average <u>OR</u> "B" Average.**

OVERALL AVERAGE **0.8230**





I certify that the above pitot tube was tested in accordance with the US EPA Method 2 standards.
See the Code of Federal Regulations, Title 40, Part 60, Appendix A, Method 2, Item 4.

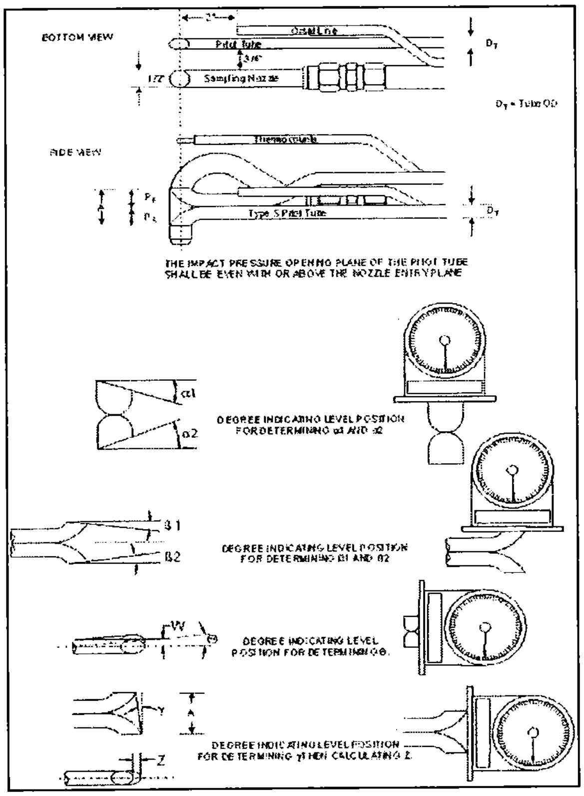
Print Name: BO PRITCHARD

Signature:

Date 11/17/2014

APEX INSTRUMENTS SOURCE TESTING EQUIPMENT

Type S Pitot Tube Inspection Form



PITOT TUBE/PROBE # 5708

Parameter	Value	Allowable Range	Check
Assembly Level?	yes	Yes	OK
Ports Damaged?	no	No	OK
α1	0	-10° < α1 < +10°	OK
α2	0	-10° < α2 < +10°	OK
1	0	-5° < b1 < +5°	OK
1	1	-5° < β2 < +5°	OK
γ	0		
θ	1		
Z = A tan γ	0.000	Z ≤ .125"	OK
W = A tan θ	0.015	W ≤ .031"	OK
Dt	0.375	.188" to .375"	OK
A/2Dt	1.136	$1.05 \leq P_A/D_t \leq 1.5$	OK
A	0.852	$2.1D_t \leq A \leq 3D_t$	OK

Certification

I certify that pitot tube/probe number 5708 meets or exceeds all specifications, criteria and/or applicable design features and is hereby assigned a pitot tube certification factor of 0.84. See 40 CFR Pt. 60, App. A, EPA Method 2.

Certified by: [signature] 11-12-14
Personnel (Signature/Date)

5708-2014

Apex Instruments, Inc.
204 Technology Park Lane
Fuquay-Varina, NC 27526

S-TYPE PITOT TUBE CALIBRATION SHEET

Reference USEPA Reference Method 2 (40CFR60, App. A, Meth. 2)

PITOT SERIAL#	A6223	**CALIBRATION DATE:**	11-Aug-15	
PITOT TYPE:	S	**BAROMETRIC PRESSURE:**	29.65	in Hg
STD. PITOT TYPE:	ELLIPSOIDAL	**STATIC PRESSURE**	-0.6	in H_2O
Cp(std):	0.990	**BLOCKAGE %:**	N/A	
PROBE SERIAL#	N/A	**CORRECTION FACTOR:**	1.00	

SIDE "A" CALIBRATION

RUN NO.	Δ Pstd in H_2O	Δ Ps in H_2O	Cp(s)	DEVIATION Cp(s) - avg.Cp(s)
1	0.560	0.808	0.824	-0.002
2	0.560	0.806	0.825	-0.001
3	0.561	0.802	0.828	0.002
		"A" AVERAGE	**0.826**	**0.0020**

(must be ≤ 0.01)

SIDE "B" CALIBRATION

RUN NO.	Δ Pstd in H_2O	Δ Ps in H_2O	Cp(s)	DEVIATION Cp(s) - avg.Cp(s)
1	0.559	0.823	0.816	-0.001
2	0.559	0.822	0.816	-0.001
3	0.561	0.819	0.819	0.002
		"B" AVERAGE	**0.817**	**0.0019**

(must be ≤ 0.01)

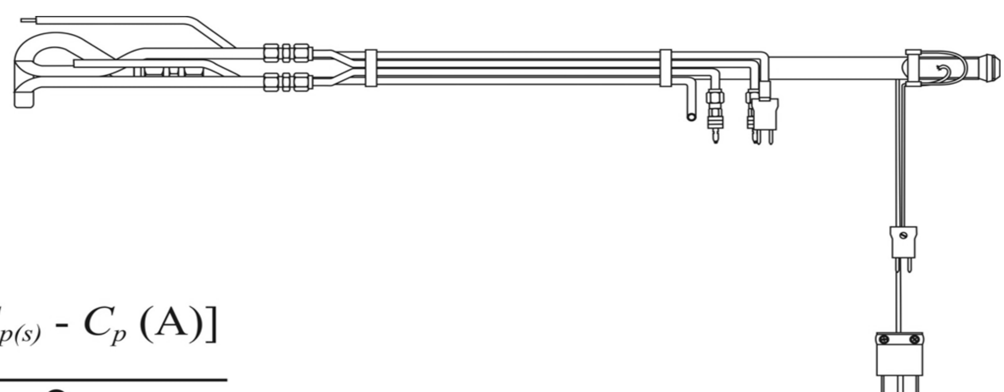
ACCEPTANCE CRITERIA

AVERAGE **0.0086** AVG. Cp (A) - AVG. Cp (B) must be ≤ 0.01

If the Average and both Deviation Averages "A" & "B" are ≤ 0.01, then the OVERALL AVERAGE below may be used.
*** If NOT, use the "A" Average OR "B" Average.**

OVERALL AVERAGE **0.8215**

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}}$$



$$\text{Deviation} = C_{p(s)} - \overline{C_p}(A)$$

$$\text{Avg Dev} = \sigma(A) = \frac{\sum_{1}^{3} [C_{p(s)} - C_p(A)]}{3}$$

Method 2 Section 10.1.4.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see section 10.1.4.4).

I certify that the above pitot tube was tested in accordance with the US EPA Method 2 standards.
See the Code of Federal Regulations, Title 40, Part 60, Appendix A, Method 2, Item 4.

Print Name: BO PRITCHARD

Date 8/11/2015

Signature: [signature]

APEX SOURCE TESTING EQUIPMENT INSTRUMENTS

Apex Instruments, Inc.
204 Technology Park Lane
Fuquay-Varina, NC 27526

S-TYPE PITOT TUBE CALIBRATION SHEET

Reference USEPA Reference Method 2 (40CFR60, App. A, Meth. 2)

PITOT SERIAL#	A6904	CALIBRATION DATE:	27-May-16
PITOT TYPE:	S	BAROMETRIC PRESSURE:	30.16 in Hg
STD. PITOT TYPE:	ELLIPSOIDAL	STATIC PRESSURE	-0.6 in H_2O
Cp(std):	0.990	BLOCKAGE %:	N/A
PROBE SERIAL#	N/A	CORRECTION FACTOR:	1.00

SIDE "A" CALIBRATION

RUN NO.	Δ Pstd in H_2O	Δ Ps in H_2O	Cp(s)	DEVIATION Cp(s) - avg.Cp(s)
1	0.565	0.804	0.830	0.001
2	0.561	0.803	0.827	-0.002
3	0.562	0.800	0.830	0.001
		"A" AVERAGE	0.829	0.0014

(must be ≤ 0.01)

SIDE "B" CALIBRATION

RUN NO.	Δ Pstd in H_2O	Δ Ps in H_2O	Cp(s)	DEVIATION Cp(s) - avg.Cp(s)
1	0.565	0.804	0.830	-0.001
2	0.566	0.803	0.831	0.000
3	0.565	0.801	0.831	0.001
		"B" AVERAGE	0.831	0.0008

(must be ≤ 0.01)

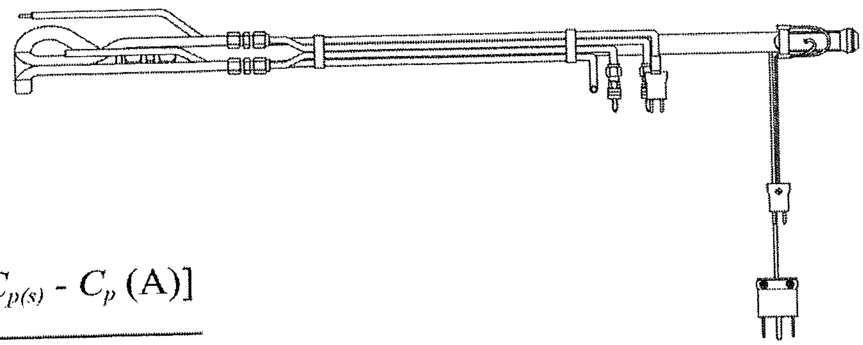
ACCEPTANCE CRITERIA

AVERAGE -0.0018 AVG. Cp (A) - AVG. Cp (B) must be ≤ 0.01

If the Average and both Deviation Averages "A" & "B" are ≤ 0.01, then the OVERALL AVERAGE below may be used.
*** If NOT, use the "A" Average OR "B" Average.**

OVERALL AVERAGE 0.8300

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}}$$



$$\text{Deviation} = C_{p(s)} - \overline{C_p}(A)$$

$$\text{Avg Dev} = \sigma(A) = \frac{\sum_{1}^{3} [C_{p(s)} - C_p(A)]}{3}$$

Method 2 Section 10.1.4.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see section 10.1.4.4).

I certify that the above pitot tube was tested in accordance with the US EPA Method 2 standards.
See the Code of Federal Regulations, Title 40, Part 60, Appendix A, Method 2, Item 4.

Print Name: Scott Bulger

Signature: [signature]

Date 5/27/2016

METERING SYSTEM DRY GAS METER CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration
Air Hygiene Assett ID: samp-cp-0021

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]Original (5 point)

Make: apex
Model #: 522
Serial #: 1204012

Date: 11/11/20
Barometric Pressure: 29.28 (in. Hg)
Theoretical Critical Vacuum: 13.81 (in. Hg)

DRY GAS METER READINGS

ΔH (in. H2O)	Time (min)	Volume Initial (ft³)	Volume Final (ft³)	Volume Total (ft³)	Initial Temperature Inlet (°F)	Initial Temperature Outlet (°F)
0.33	17.00	490.230	495.820	5.590	76.0	76.0
0.67	12.00	495.820	501.510	5.690	77.0	77.0
1.10	10.00	501.510	507.780	6.270	77.0	77.0
2.00	10.00	507.780	515.930	8.150	78.0	78.0
3.50	10.00	515.930	527.070	11.140	79.0	79.0

Final Temperature Inlet (°F)	Final Temperature Outlet (°F)	Orifice Serial# (number)	K' Orifice Coefficient (see above)	Actual Vacuum (in. Hg)	Ambient Temperature Initial (°F)	Ambient Temperature Final (°F)	Ambient Temperature Average (°F)
77.0	77.0	214	0.2433	16.0	73.2	73.5	73.4
77.0	77.0	240	0.3500	16.0	73.5	73.4	73.5
78.0	78.0	255	0.4634	16.0	73.4	73.8	73.6
79.0	79.0	263	0.5993	16.0	73.8	74.1	74.0
80.0	80.0	273	0.8208	16.0	74.1	74.0	74.1

RESULTS

DRY GAS METER VOLUME CORRECTED Vm(std) (ft³)	DRY GAS METER VOLUME CORRECTED Vm(std) (liters)	ORIFICE VOLUME CORRECTED Vcr(std) (ft³)	ORIFICE VOLUME CORRECTED Vcr(std) (liters)	ORIFICE VOLUME NOMINAL Vcr (ft³)
5.386	152.53	5.244	148.5	5.415
5.482	155.25	5.324	150.8	5.499
6.042	171.10	5.874	166.3	6.068
7.856	222.49	7.594	215.1	7.850
10.759	304.69	10.400	294.5	10.753

DRY GAS METER CALIBRATION FACTOR Y Variation (number)	DRY GAS METER CALIBRATION FACTOR Y Value (number)	ORIFICE CALIBRATION FACTOR ΔH@ Value (in. H2O)	ORIFICE CALIBRATION FACTOR ΔH@ Value (mm H2O)	ORIFICE CALIBRATION FACTOR ΔH@ Variation (in. H2O)
0.004	0.974	1.879	47.72	0.067
0.001	0.971	1.842	46.79	0.030
0.002	0.972	1.724	43.79	-0.088
-0.003	0.967	1.872	47.55	0.060
-0.003	0.967	1.743	44.28	-0.069
AVERAGE:	**0.970**	**1.812**	46.02	**PASSED**

Notes:

For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter,acceptable tolerance of individual values from the average is +/- 0.02. For Orifice Calibration Factor dH@, the orifice differential pressure in inches of H_20 that equates to 0.75 cfm of air at 68 ^oF and 29.92 inches of Hg, acceptable tolerance of individual values from the average is +/- 0.2. For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above. The Critical Orifice Coefficient, K', must be entered in English units, (ft)^3*(deg R)^0.5/((in.Hg)*(min)).

SIGNATURE: Craig McCarty

DATE: 11/11/20 11/11/20

METERING SYSTEM THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration
Air Hygiene Assett ID: samp-cp-0021

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]Original (5 point)

Make: apex
Model #: 522
Serial #: 1204012

Date: 11/11/20
Barometric Pressure: 29.28 (in. Hg)
Temperature (ASTM cal): 72.00 (°F)

Thermocouple	100 (°F)		600 (°F)		1200 (°F)	
	Reading	% Error	Reading	% Error	Reading	% Error
Stack	101.00	0.50	602.00	0.33	1206.00	0.50
Probe	101.00	0.50	602.00	0.33	1206.00	0.50
Filter	101.00	0.50	602.00	0.33	1206.00	0.50
Dryer	101.00	0.50	602.00	0.33	1206.00	0.50
Aux.	101.00	0.50	602.00	0.33	1206.00	0.50

Note: Calibrated against an ALTEK Thermocouple Source Series 22, ID: samp-tc-0004
Direct temperature output calibrated to ASTM and IPTS standards as outlined in ALTEK Data Sheet 22.

Thermocouple	72.00 (°F)		Responded to heating/cooling with the anticipated outcome?
	Reading	(±°F)	
DGM In	72.0	0.00	yes
DGM Out	72.0	0.00	yes

Note: Calibrated against Reference Thermometer ID: a070800

SIGNATURE: Craig McCarty DATE: 11/11/20 11/11/20

Standard for Calibration of Console Thermocouple Systems

40 CFR, Part 60
Appendix A, Method 5
10.3.2 The temperature data recorded in the field shall be considered valid. If, during calibration, the absolute temperature measured with the sensor being calibrated and the reference sensor **agree within 1.5 percent**, the temperature data taken in the field shall be considered valid.

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

PROBE (STACK), HOTBOX (FILTER), AND GOOSENECK (EXIT) THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration

Air Hygiene Assett ID(s): **Probe:** samp-hp-0086 **Hotbox:** samp-bh-0012 **Gooseneck:** samp-ad-0046

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]Original (5 point)

Barometric Pressure: 29.26

Thermo-couples		Temps (°F)	Signature		Date	
Stack	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				
Probe	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				
Filter	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				
Cond.	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				
CPM	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				
Exit	**Ref**	72.00	Craig McCarty		11/11/20	11/11/20
	Read	72.00				
	±°F	0.00				

Note: Calibrated against Reference Thermometer ID: a070800

Thermocouple	Responded to heating/cooling with the anticipated outcome?
Stack	yes
Probe	yes
Filter	yes
Cond.	yes
CPM	yes
Exit	yes

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

METERING SYSTEM DRY GAS METER CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration
Air Hygiene Assett ID: samp-cp-0021

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]9-7-21 (3 point)

Make: Apex — Date: 09/08/21
Model #: XC-522 — Barometric Pressure: 29.22 (in. Hg)
Serial #: 1204012 — Theoretical Critical Vacuum: 13.78 (in. Hg)

DRY GAS METER READINGS

ΔH (in. H2O)	Time (min)	Volume Initial (ft³)	Volume Final (ft³)	Volume Total (ft³)	Initial Temperature Inlet (°F)	Initial Temperature Outlet (°F)
1.90	10.00	111.800	119.800	8.000	72.0	72.0
1.90	10.00	119.800	127.800	8.000	72.0	72.0
1.90	10.00	127.800	135.810	8.010	73.0	73.0

Final Temperature Inlet (°F)	Final Temperature Outlet (°F)	Orifice Serial# (number)	K' Orifice Coefficient (see above)	Actual Vacuum (in. Hg)	Ambient Temperature Initial (°F)	Ambient Temperature Final (°F)	Ambient Temperature Average (°F)
72.0	72.0	163	0.5930	16.0	72.2	72.7	72.5
73.0	73.0	163	0.5930	16.0	72.7	73.1	72.9
74.0	74.0	163	0.5930	16.0	73.1	73.7	73.4

RESULTS

DRY GAS METER VOLUME CORRECTED Vm(std) (ft³)	DRY GAS METER VOLUME CORRECTED Vm(std) (liters)	ORIFICE VOLUME CORRECTED Vcr(std) (ft³)	ORIFICE VOLUME CORRECTED Vcr(std) (liters)	ORIFICE VOLUME NOMINAL Vcr (ft³)
7.788	220.56	7.509	212.7	7.757
7.781	220.35	7.506	212.6	7.760
7.776	220.21	7.503	212.5	7.764

DRY GAS METER CALIBRATION FACTOR Y Variation (number)	DRY GAS METER CALIBRATION FACTOR Y Value (number)	ORIFICE CALIBRATION FACTOR ΔH@ Value (in. H2O)	ORIFICE CALIBRATION FACTOR ΔH@ Value (mm H2O)	ORIFICE CALIBRATION FACTOR ΔH@ Variation (in. H2O)
0.000	0.964	1.837	46.66	0.001
0.000	0.965	1.837	46.66	0.001
0.000	0.965	1.835	46.61	-0.001
AVERAGE:	**0.965**	**1.836**	46.64	**PASSED**
LAST 5-PT:	**0.970**	**1.812**	**PASSED**	5-PT Date:
% DIFF:	**0.6%**	**1.3%**		11/11/20

40 CFR - CHAPTER I - PART 60
Appendix A, Method 5
10.3.2 Calibration After Use
After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test)....Calculate the average value of the DGM calibration factor. If the value has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as detailed in Section 10.3.1.

10.3.3 Acceptable Variation in Calibration
If the DGM coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

Notes: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter,acceptable tolerance of individual values from the average is +/- 0.02. For Orifice Calibration Factor dH@, the orifice differential pressure in inches of H_20 that equates to 0.75 cfm of air at 68 ^oF and 29.92 inches of Hg, acceptable tolerance of individual values from the average is +/- 0.2. For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above. The Critical Orifice Coefficient, K', must be entered in English units, (ft)^3*(deg R)^0.5/((in.Hg)*(min)).

SIGNATURE: Craig McCarty

DATE: 09/08/21 09/08/21

METERING SYSTEM THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration
Air Hygiene Assett ID: samp-cp-0021

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]9-7-21 (3 point)

Make: Apex
Model #: XC-522
Serial #: 1204012

Date: 09/08/21
Barometric Pressure: 29.22 (in. Hg)
Temperature (ASTM cal): 73.70 (°F)

Thermocouple	100 (°F)		600 (°F)		1200 (°F)	
	Reading	% Error	Reading	% Error	Reading	% Error
Stack	101.00	0.50	604.00	0.67	1206.00	0.50
Probe	101.00	0.50	604.00	0.67	1206.00	0.50
Filter	101.00	0.50	604.00	0.67	1206.00	0.50
Dryer	101.00	0.50	604.00	0.67	1206.00	0.50
Aux.	101.00	0.50	604.00	0.67	1206.00	0.50

Note: Calibrated against an ALTEK Thermocouple Source Series 22, ID: samp-tc-0004
Direct temperature output calibrated to ASTM and IPTS standards as outlined in ALTEK Data Sheet 22.

Thermocouple	73.70 (°F)		Responded to heating/cooling with the anticipated outcome?
	Reading	(±°F)	
DGM In	74.0	0.30	yes
DGM Out	74.0	0.30	yes

Note: Calibrated against Reference Thermometer ID: a070717

SIGNATURE: Craig McCarty

DATE: 09/08/21 09/08/21

Standard for Calibration of Console Thermocouple Systems

40 CFR, Part 60
Appendix A, Method 5
10.3.2 The temperature data recorded in the field shall be considered valid. If, during calibration, the absolute temperature measured with the sensor being calibrated and the reference sensor **agree within 1.5 percent**, the temperature data taken in the field shall be considered valid.

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

PROBE (STACK), HOTBOX (FILTER), AND GOOSENECK (EXIT) THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration

Air Hygiene Assett ID(s): **Probe:** samp-hp-0086 **Hotbox:** samp-bh-0012 **Gooseneck:** samp-ad-0046

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0021 Calibration 11-11-20.xls]9-7-21 (3 point)

Barometric Pressure: 29.22

Thermo-couples		Temps (°F)	Signature		Date	
Stack	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				
Probe	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				
Filter	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				
Cond.	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				
CPM	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				
Exit	Ref	73.20	Craig McCarty		09/08/21	09/08/21
	Read	74.00				
	±°F	0.80				

Note: Calibrated against Reference Thermometer ID: a070717

Thermocouple	Responded to heating/cooling with the anticipated outcome?
Stack	yes
Probe	yes
Filter	yes
Cond.	yes
CPM	yes
Exit	yes

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

METERING SYSTEM DRY GAS METER CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration
Air Hygiene Assett ID: samp-cp-0022

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]Original (5 point)

Make: apex
Model #: 522
Serial #:

Date: 07/14/21
Barometric Pressure: 29.29 (in. Hg)
Theoretical Critical Vacuum: 13.82 (in. Hg)

DRY GAS METER READINGS

ΔH	Time	Volume			Initial Temperature	
		Initial	Final	Total	Inlet	Outlet
(in. H2O)	(min)	(ft³)	(ft³)	(ft³)	(°F)	(°F)
0.31	17.00	23.400	28.710	5.310	75.0	75.0
0.62	12.00	28.710	34.060	5.350	75.0	75.0
1.10	10.00	34.060	40.120	6.060	76.0	76.0
1.90	10.00	40.120	48.000	7.880	77.0	77.0
3.50	10.00	48.000	58.830	10.830	78.0	78.0

Final Temperature		Orifice	K' Orifice	Actual	Ambient Temperature		
Inlet	Outlet	Serial#	Coefficient	Vacuum	Initial	Final	Average
(°F)	(°F)	(number)	(see above)	(in. Hg)	(°F)	(°F)	(°F)
75.0	75.0	140	0.2355	16.0	76.7	76.9	76.8
76.0	76.0	148	0.3374	16.0	76.9	77.2	77.1
77.0	77.0	155	0.4565	16.0	77.0	77.4	77.2
78.0	78.0	163	0.5930	16.0	77.4	77.6	77.5
80.0	80.0	173	0.8149	15.0	77.6	77.8	77.7

RESULTS

DRY GAS METER		ORIFICE		
VOLUME CORRECTED Vm(std) (ft³)	VOLUME CORRECTED Vm(std) (liters)	VOLUME CORRECTED Vcr(std) (ft³)	VOLUME CORRECTED Vcr(std) (liters)	VOLUME NOMINAL Vcr (ft³)
5.132	145.34	5.061	143.3	5.258
5.170	146.41	5.117	144.9	5.319
5.852	165.73	5.769	163.4	5.998
7.611	215.54	7.492	212.2	7.794
10.473	296.59	10.293	291.5	10.712

DRY GAS METER CALIBRATION FACTOR Y		ORIFICE CALIBRATION FACTOR ΔH@		
Variation (number)	Value (number)	Value (in. H2O)	Value (mm H2O)	Variation (in. H2O)
0.000	0.986	1.901	48.28	0.069
0.004	0.990	1.851	47.02	0.020
0.000	0.986	1.791	45.50	-0.040
-0.001	0.984	1.831	46.51	0.000
-0.003	0.983	1.782	45.26	-0.049
AVERAGE:	**0.986**	**1.831**	46.51	**PASSED**

Notes:

For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter,acceptable tolerance of individual values from the average is +/- 0.02. For Orifice Calibration Factor dH@, the orifice differential pressure in inches of H_20 that equates to 0.75 cfm of air at 68 ^oF and 29.92 inches of Hg, acceptable tolerance of individual values from the average is +/- 0.2. For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above. The Critical Orifice Coefficient, K', must be entered in English units, (ft)^3*(deg R)^0.5/((in.Hg)*(min)).

SIGNATURE: Craig McCarty

DATE: 07/14/21 07/14/21

METERING SYSTEM THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration
Air Hygiene Assett ID: samp-cp-0022

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]Original (5 point)

Make:	apex	Date:	07/14/21
Model #:	522	Barometric Pressure:	29.29 (in. Hg)
Serial #:		Temperature (ASTM cal):	76.70 (°F)

Thermocouple	100 (°F)		600 (°F)		1200 (°F)	
	Reading	% Error	Reading	% Error	Reading	% Error
Stack	100.00	0.00	599.00	0.17	1199.00	0.08
Probe	100.00	0.00	599.00	0.17	1199.00	0.08
Filter	100.00	0.00	599.00	0.17	1199.00	0.08
Dryer	100.00	0.00	599.00	0.17	1199.00	0.08
Aux.	100.00	0.00	599.00	0.17	1199.00	0.08

Note: Calibrated against an ALTEK Thermocouple Source Series 22, ID: samp-tc-0004

Direct temperature output calibrated to ASTM and IPTS standards as outlined in ALTEK Data Sheet 22.

Thermocouple	76.70 (°F)		Responded to heating/cooling with the anticipated outcome?
	Reading	(±°F)	
DGM In	75.0	1.70	yes
DGM Out	75.0	1.70	yes

Note: Calibrated against Reference Thermometer ID: a070717

SIGNATURE: Craig McCarty

DATE: 07/14/21 07/14/21

Standard for Calibration of Console Thermocouple Systems

40 CFR, Part 60
Appendix A, Method 5
10.3.2 The temperature data recorded in the field shall be considered valid. If, during calibration, the absolute temperature measured with the sensor being calibrated and the reference sensor **agree within 1.5 percent**, the temperature data taken in the field shall be considered valid.

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

PROBE (STACK), HOTBOX (FILTER), AND GOOSENECK (EXIT) THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Pre-Test Calibration

Air Hygiene Assett ID(s): **Probe:** samp-hp-0086 **Hotbox:** samp-bh-0012 **Gooseneck:** samp-ad-0046

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]Original (5 point)

Barometric Pressure: 29.29

Thermo-couples		Temps (°F)	Signature		Date	
Stack	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				
Probe	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				
Filter	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				
Cond.	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				
CPM	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				
Exit	**Ref**	76.80	Craig McCarty		07/14/21	07/14/21
	Read	77.00				
	±°F	0.20				

Note: Calibrated against Reference Thermometer ID: a070717

Thermocouple	Responded to heating/cooling with the anticipated outcome?
Stack	yes
Probe	yes
Filter	yes
Cond.	yes
CPM	yes
Exit	yes

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

METERING SYSTEM DRY GAS METER CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration
Air Hygiene Assett ID: samp-cp-0022

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]8-18-21 (3 point)

Make: Apex | Date: 08/18/21
Model #: XC-522 | Barometric Pressure: 29.20 (in. Hg)
Serial #: 1204013 | Theoretical Critical Vacuum: 13.77 (in. Hg)

DRY GAS METER READINGS

ΔH (in. H2O)	Time (min)	Volume Initial (ft³)	Volume Final (ft³)	Volume Total (ft³)	Initial Temperature Inlet (°F)	Initial Temperature Outlet (°F)
1.90	10.00	862.800	870.790	7.990	78.0	78.0
1.90	10.00	870.790	878.790	8.000	77.0	77.0
1.90	10.00	878.790	886.800	8.010	78.0	78.0

Final Temperature Inlet (°F)	Final Temperature Outlet (°F)	Orifice Serial# (number)	K' Orifice Coefficient (see above)	Actual Vacuum (in. Hg)	Ambient Temperature Initial (°F)	Ambient Temperature Final (°F)	Ambient Temperature Average (°F)
77.0	77.0	163	0.5930	16.0	74.0	73.9	74.0
78.0	78.0	163	0.5930	16.0	73.9	74.1	74.0
78.0	78.0	163	0.5930	16.0	74.1	74.1	74.1

RESULTS

DRY GAS METER		ORIFICE		
VOLUME CORRECTED Vm(std) (ft³)	VOLUME CORRECTED Vm(std) (liters)	VOLUME CORRECTED Vcr(std) (ft³)	VOLUME CORRECTED Vcr(std) (liters)	VOLUME NOMINAL Vcr (ft³)
7.693	217.88	7.494	212.2	7.768
7.703	218.15	7.493	212.2	7.768
7.706	218.22	7.492	212.2	7.769

DRY GAS METER CALIBRATION FACTOR Y		ORIFICE CALIBRATION FACTOR ΔH@		
Variation (number)	Value (number)	Value (in. H2O)	Value (mm H2O)	Variation (in. H2O)
0.001	0.974	1.825	46.35	0.000
0.000	0.973	1.825	46.35	0.001
-0.001	0.972	1.823	46.32	-0.001
AVERAGE:	**0.973**	**1.824**	46.34	**PASSED**

LAST 5-PT:	**0.986**	**1.831**	**PASSED**	5-PT Date:
% DIFF:	**1.3%**	**0.4%**		07/14/21

40 CFR - CHAPTER I - PART 60
Appendix A, Method 5
10.3.2 Calibration After Use
After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test)....Calculate the average value of the DGM calibration factor. If the value has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as detailed in Section 10.3.1.

10.3.3 Acceptable Variation in Calibration
If the DGM coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

Notes: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter,acceptable tolerance of individual values from the average is +/- 0.02. For Orifice Calibration Factor dH@, the orifice differential pressure in inches of H_20 that equates to 0.75 cfm of air at 68 °F and 29.92 inches of Hg, acceptable tolerance of individual values from the average is +/- 0.2. For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above. The Critical Orifice Coefficient, K', must be entered in English units, (ft)^3*(deg R)^0.5/((in.Hg)*(min)).

SIGNATURE: Craig McCarty

DATE: 08/18/21 08/18/21

METERING SYSTEM THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration
Air Hygiene Assett ID: samp-cp-0022

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]8-18-21 (3 point)

Make: Apex
Model #: XC-522
Serial #: 1204013

Date: 08/18/21
Barometric Pressure: 29.19 (in. Hg)
Temperature (ASTM cal): 74.00 (°F)

Thermocouple	100 (°F)		600 (°F)		1200 (°F)	
	Reading	% Error	Reading	% Error	Reading	% Error
Stack	100.00	0.00	599.00	0.17	1198.00	0.17
Probe	100.00	0.00	599.00	0.17	1198.00	0.17
Filter	100.00	0.00	599.00	0.17	1198.00	0.17
Dryer	100.00	0.00	599.00	0.17	1198.00	0.17
Aux.	100.00	0.00	599.00	0.17	1198.00	0.17

Note: Calibrated against an ALTEK Thermocouple Source Series 22, ID: samp-tc-0004
Direct temperature output calibrated to ASTM and IPTS standards as outlined in ALTEK Data Sheet 22.

Thermocouple	74.00 (°F)		Responded to heating/cooling with the anticipated outcome?
	Reading	(±°F)	
DGM In	75.0	1.00	yes
DGM Out	75.0	1.00	yes

Note: Calibrated against Reference Thermometer ID: a070717

SIGNATURE: Craig McCarty

DATE: 08/18/21 08/18/21

Standard for Calibration of Console Thermocouple Systems

40 CFR, Part 60
Appendix A, Method 5
10.3.2 The temperature data recorded in the field shall be considered valid. If, during calibration, the absolute temperature measured with the sensor being calibrated and the reference sensor **agree within 1.5 percent**, the temperature data taken in the field shall be considered valid.

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

PROBE (STACK), HOTBOX (FILTER), AND GOOSENECK (EXIT) THERMOCOUPLE CALIBRATION SHEET
EPA Reference Method
Metering System Post-Test Calibration

Air Hygiene Assett ID(s): **Probe:** samp-hp-0086 **Hotbox:** samp-bh-0012 **Gooseneck:** samp-ad-0046

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\PM-Equipment\M-5 Consoles\Calibration Sheet v4.1\Current\[SAMP-CP-0022 Calibration 7-14-21.xls]8-18-21 (3 point)

Barometric Pressure: 29.19

Thermo-couples		Temps (°F)	Signature		Date	
Stack	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	74.00				
	±°F	0.00				
Probe	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	74.00				
	±°F	0.00				
Filter	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	74.00				
	±°F	0.00				
Cond.	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	75.00				
	±°F	1.00				
CPM	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	75.00				
	±°F	1.00				
Exit	Ref	74.00	Craig McCarty		08/18/21	08/18/21
	Read	74.00				
	±°F	0.00				

Note: Calibrated against Reference Thermometer ID: a070717

Thermocouple	Responded to heating/cooling with the anticipated outcome?
Stack	yes
Probe	yes
Filter	yes
Cond.	yes
CPM	yes
Exit	yes

Standard for Calibration of Individual Thermocouples

EMC, ALT-011: After each test run series, check the accuracy (and, hence, the calibration) of each thermocouple system at ambient temperature, or any other temperature, within the range specified by the manufacturer, using a reference thermometer (either ASTM reference thermometer or a thermometer that has been calibrated against an ASTM reference thermometer). The temperatures of the thermocouple and reference thermometers shall **agree to within ±2°F**.

Check the continuity of the thermocouple by subjecting it to a change in the temperature (e.g.., removing it from the stack or touching an ice cube). This step will also check for loose connections and reversed connections (noted by a wrong change in the temperature).

Field Balance Weight Verfication
Annual 500g Field Balance Stock Weight vs. 500g ISO 17025 Traceable Weight
Air Hygiene Asset ID: samp-sc-0025

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\Field Balance Weights\2021\[samp-sc-0025_225.xlsm]Balance
Make: Ohaus
Model #: Scout Pro SP2001-US
Serial #: 7130410278
Field Weight #: sc-0025
Trailer #: 221

ISO 17025 Weight ID LABS-WT-0005
ISO S/N 1000128090
ISO Cal Due 8/4/2021

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	499.60	0.40
		must be <0.5

Sean Barnes (signature) 01/19/21 (date)

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	500.10	0.10
		must be <0.5

Sean Barnes (signature) 01/19/21 (date)

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	500.00	0.00
		must be <0.5

Sean Barnes (signature) 01/19/21 (date)

Note: Calibrated against ISO 17025 Certified weight LABS-WT-0005

EPA Method 4 - Section 10.3, EPA Method 5 - Section 10.7, EPA Method 202 - Section 10.3: Field Balance Calibration Check. Check the calibration of the balance used to weigh impingers with a weight that is at least 500g or within 50g of a loaded impinger. The weight must be ASTM E617-13 "Standard Specification for Laboratory Weights and Precision Mass Standards" Class 6 (or better). Daily before used, the field balance must meausure within ±0.5g of the certified mass. If the daily balance calibration check fails, perform corrective measures and repeat the check before using balance.

ISO 17025 Certified 500g Weight is certified annually. Certified weight is used to verify Class 6 or better weight that accompanies each field balance on the balance it will be used. Acceptance critieria is certified weight must be within ±0.5g of Class 6 or better weight.

Field Balance Weight Verfication
Annual 500g Field Balance Stock Weight vs. 500g ISO 17025 Traceable Weight
Air Hygiene Asset ID: samp-sc-0015

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\Field Balance Weights\2021\[samp-sc-7130100125_Extra.xlsm]Balance
Make: Ohaus
Model #: Scout Pro SP2001-US
Serial #: 7130100125
Field Weight #:
Trailer #: extra

ISO 17025 Weight ID LABS-WT-0005
ISO S/N 1000128090
ISO Cal Due 8/4/2021

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	500.00	0.00
Sean Barnes (signature)		01/19/21 (date) must be <0.5

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	499.70	0.30
Sean Barnes (signature)		01/19/21 (date) must be <0.5

ISO 17025 Certfified Weight (g)	Field Balance Weight (g)	± g
500.00	499.80	0.20
Sean Barnes (signature)		01/19/21 (date) must be <0.5

Note: Calibrated against ISO 17025 Certified weight LABS-WT-0005

EPA Method 4 - Section 10.3, EPA Method 5 - Section 10.7, EPA Method 202 - Section 10.3: Field Balance Calibration Check. Check the calibration of the balance used to weigh impingers with a weight that is at least 500g or within 50g of a loaded impinger. The weight must be ASTM E617-13 "Standard Specification for Laboratory Weights and Precision Mass Standards" Class 6 (or better). Daily before used, the field balance must meausure within ±0.5g of the certified mass. If the daily balance calibration check fails, perform corrective measures and repeat the check before using balance.

ISO 17025 Certified 500g Weight is certified annually. Certified weight is used to verify Class 6 or better weight that accompanies each field balance on the balance it will be used. Acceptance critieria is certified weight must be within ±0.5g of Class 6 or better weight.

WEATHER STATION CALIBRATION SHEET
Temperature, Barometric Pressure, and Relative Humidity Periodic Calibration
Air Hygiene Asset ID: samp-we-0014

Filename: \\AHI-FILESVR\public\Shared\QAQC\Calibrations\Weather Stations\2021\[SAMP-WE-0014_224-012221.xlsm]112013
Make: Kestrel — ISO 17025 Weather Station ID SAMP-WE-0033
Model #: 4000 — ISO 17025 S/N A026334
Serial #: 671144 — ISO 17025 Cal Due 7/22/2021

ASTM Temp (deg F) (±1.5°)	Thermo. (deg F)	± deg F	ASTM Barometer (in. Hg) (±0.1 in Hg)	Barometric (in. Hg)	± in. Hg	Time
68.60	67.90	0.70	29.31	29.30	0.01	12:05

Sean Barnes Sean Barnes (signature) 01/22/21 (date)

ASTM Temp (deg F) (±1.5°)	Thermo. (deg F)	± deg F	ASTM Barometer (in. Hg) (±0.1 in Hg)	Barometric (in. Hg)	± in. Hg	Time
69.30	69.20	0.10	29.28	29.30	0.02	12:35

Sean Barnes Sean Barnes (signature) 01/22/21 (date)

ASTM Temp (deg F) (±1.5°)	Thermo. (deg F)	± deg F	ASTM Barometer (in. Hg) (±0.1 in Hg)	Barometric (in. Hg)	± in. Hg	Time
68.90	69.00	0.10	29.27	29.29	0.02	12:55

Sean Barnes Sean Barnes (signature) 01/22/21 (date)

ASTM Temp (deg F) (±1.5°)	Thermo. (deg F)	± deg F	ASTM Barometer (in. Hg) (±0.1 in Hg)	Barometric (in. Hg)	± in. Hg	Time
68.70	68.80	0.10	29.27	29.28	0.01	13:20

Sean Barnes Sean Barnes (signature) 01/22/21 (date)

Note: Verified against ISO 17025 Traceable Barometer and Thermometer (SAMP-WE-0033).

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end of report

United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

EPA-600/7-79-251a
November 1979

EPA

Effects of Pathogenic and Toxic Materials Transported Via Cooling Device Drift - Volume 1. Technical Report

Interagency Energy/Environment R&D Program Report

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

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EPA REVIEW NOTICE

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Effects of Pathogenic and Toxic Materials Transported Via Cooling Device Drift - Volume 1. Technical Report

by

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ABSTRACT

The report describes a mathematical model that predicts the percent of the population affected by a pathogen or toxic substance emitted in a cooling tower plume, and gives specific applications of the model. Eighty-five pathogens (or diseases) are cataloged as potentially occurring in U.S. waters, but there is insufficient data to predict the probability of occurrence or relate their occurrence to public health, population, or pollution. Sixty-five toxic substances are cataloged as potentially occurring in U.S. waters, but the actual number is probably many times the EPA-supplied list. Toxic concentrations to persons, animals, and plants are known for only a few of the chemicals: most toxic levels can be only inferred from animal studies. In the population as a whole, the epidemiological impact of a pathogen is a function of age, sex distribution, racial (genetic) distribution, general health and well-being, prior exposure, and immunological deficiency states. While cooling device drift may not be directly responsible for epidemics, it may potentiate the burden in an already weakened population, raising a segment of the population into the clinical state. The effect of toxic substances is difficult to evaluate because of inadequate data on humans. The effect is a function of concentration in susceptible tissue, and is much less dependent than pathogens on host resistance.

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LIST OF ABBREVIATIONS AND SYMBOLS

BTU	British Thermal Unit
BW	Biological Warfare
Ca	Calcium
Cl	Chlorine
cm	centimeter
DAT	Dynamic Aerosol Toroid
EMV	Encephalomyocarditis Virus
EST	Eastern Standard Time
FD	Forced Draft Cooling Device
Fe	Iron
g	grams
gpm	gallons per minute
HCO_3^-	bicarbonate ion
ID	Induced Draft Cooling Device
K	Kelvin
Km	Kilometer
l	liter
L/G	Water rate/air rate (lbs/time)
m	meter
m^3	cubic meter
mb	millibar
mm	millimeter
mg	milligrams
mw	megawatt
Na	Sodium
O	Oxygen
$(OH)^-$	Hydroxide ion
ppm	parts per million
r	radius
RH	Relative Humidity
SO_4^{2-}	Sulfate
SV_{40}	Simian Virus 40
Teo	ambient temperature near exit from tower
Tpo	plume temperature
μ	micron
VSV	Vesicular Stomatitis virus
WB	Wet Bulb

SECTION 1

INTRODUCTION

The recent trend in the electric power generating industry and major industries has been the use of closed circuit cooling devices. The use of these devices supercedes the use of once-through cooling systems which had the disadvantage of harmful thermal discharges into surface waters and fish impingement or entrainment. However, the closed circuit systems, or cooling towers, have potential problems, too.

Previous studies have shown that a potential health hazard could exist if pathogens were to be dispersed in cooling tower drift (Lewis, 1974; Cummings, 1964; Dvorn and Wilcox, 1972). This could occur as a result of drawing make-up water from highly polluted surface waters or from the use of processed wastewater (reclaimed water) with inadequate microbial control. In addition to the direct effects on plants such aerosols might potentially cause severe environmental damage, and present legal difficulties to the source operator, especially if the aerosol source impacted dense population centers.

Two prior studies were conducted by H2M for the Consolidated Edison Company of New York (Con Ed) and for a midwest utility that prefers to remain anonymous. Under the provisions of the work statement for the Con Ed study, H2M was to:

a. Inventory the sources of possible pathogen pollution in the Hudson, from the Bronx to Albany.

b. Prepare a catalogue of all possible organisms which could reasonably occur in the area and be transported by the cooling tower drift route.

c. Estimate the magnitude of the severity of the problem.

d. Describe the water treatment methods which would be needed to provide positive control over pathogens and totally eliminate the problem.

The one month study, based entirely upon published data and no field observations, drew the following conclusions:

a. Based upon coliform bacterial levels, used as indicators of fecal pollution, the contamination of the Hudson is sufficiently high to present the possibility of the occurrence of pathogens.

b. The physical conditions of temperature, pressure and flow in the cooling tower circuit will not attenuate pathogens, and during some months, may even prolong survival. The biocides which are added for algae control are ineffective against many pathogens (viruses, spores, etc.).

c. Many pathogens will survive aerosolization and can be transported in a virulent condition over thousands of square miles.

On the basis of the findings of this early study, it was concluded that the possibility of disease transmission through cooling tower drift exists. It was also concluded that the probability of this happening is very low. However, it is remotely possible that the proper combination of a badly contaminated slug of water, inadequate biocidal treatment, plus unfavorable atmospheric conditions could disperse millions of virulent organisms. Even if not particularly virulent, the constant loading of the atmosphere with biological and chemical respiratory offenders presented a potential of a general increase in "colds" and allergies, contributing to the overall discomfort and loss of productivity of populated areas.

That study did not produce firm recommendations due to the inadequacy of factual information. It did however conclude that the problem is sufficiently critical to warrant further study.

A study performed by NUS in 1974 for Public Service Gas and Electric Company of New Jersey, on the potential virus hazard from their Bergen, Burlington and Mercer plants concluded that there would be no hazard. But the authors neither sampled virus from the rivers of the respective plants, nor did they discuss any literature addressing specific organisms. Meanwhile, a very comprehensive review of the "health significance of airborne microorganisms from wastewater treatment processes," by Hickey and Reist (1975) stated:

> "The body of evidence is persuasive that some as yet undetermined health effects occur from viable wastewater aerosols."

This premise was confirmed by Walka (1976) in a thesis on the distribution of bacterial aerosols from a sewage treatment plant. He concluded that a survey is needed, especially examining the epidemiological effect of aerosols on populations surrounding wastewater treatment facilities. It was not felt that additional microbial monitoring around aeration tanks would be productive.

Work currently in progress by Lewis and Adams (1978) includes development of a sampling program seeking opportunistic bacteria, indicated by coliforms, in cooling device drift. Sampling was performed at five sites, drawing make up water from a variety of polluted sources. One completed study examines asbestos in cooling waters and a subsequent study is planned to sample for asbestos in the ambient environment.

Work has proceeded in examining the chemistry and effects of biocides in cooling towers (Jolley, 1977), and on the health of humans and aquatic organisms. The Electric Power Research Institute (EPRI) has acknowledged the need for further research and has been looking into the state of the art.

SECTION 2

CONCLUSIONS

In summary, the following conclusions may be drawn from this study.

I. OCCURRENCE

1. Pathogens Potentially Present

Eighty-five (85) pathogens (or diseases) have been catalogued as potentially occurring in United States waters. There is insufficient data to predict the probability of occurrence or relate their occurrence to public health, population, or pollution. The coliform test has no proven relationship between the occurrence of coliforms and specific pathogens, except for the one case of Salmonellae in which the frequency of occurrence varied directly with coliform values, (Geldreich and Van Donsel, 1970). It must be assumed that polluted water or sanitary effluent may carry pathogenic viruses, bacteria, fungi, protozoa, or helminths, either as indigenous organisms or introduced through any of several natural or anthropogenci routes.

2. Toxic Substances Potentially Present

Sixty-five (65) toxic substances have been catalogued as potentially occurring in United States waters, although the actual number is probably many times this EPA-supplied list. The occurrence of specific substances has been definitely related to land usage. Toxic concentrations to man, other animals and plants are known for only a few of the chemicals, for most toxic levels can be only inferred from animal studies. Concentrations in natural waters or wastewater effluent are not well documented, but toxic levels have been reported in many parts of the country. Although it is a natural goal to remove these materials from the environment, it must be assumed that they may be present. It must also be assumed that these substances are capable of producing clinical or sub-clinical toxic reactions in humans and other living organisms, even though the relationship has not always been demonstrated.

3. Use of Polluted Natural and Waste Waters as Make-Up Water

If cooling devices draw make-up water from polluted natural waters or wastewater with less than total purification, it must therefore be assumed that microorganisms and toxic substances capable of producing disease may be incorporated into the circulating water of the device. As major cooling devices withdraw large quantities of water to replace that lost by evaporation (e.g. 16 mgd for a 1,000 megawatt fossil fuel power plant), the probability of taking up pathogens or chemical substances is great if these occur in the source of make-up water.

II. SURVIVAL IN THE COOLING DEVICE

1. Pathogens

Most cooling devices have a mean circulating water temperature close to human body temperature and the temperature which favors the growth of mammalian pathogens. Therefore, in the absence of biocides, the microorganism will survive and may multiply if suitable nutrients are present. Biocides, of the type usually used to control algal growth, may have limited efficiency in destroying, or attenuating pathogens, and even the strongest of commercial disinfectants may have little effect on viruses. The removal of some of the circulating water through "blow-down" may establish a steady state population of viable organisms in the circulating water.

2. Toxic Substances

Dissolved or suspended toxic substances will not normally be attenuated in circulating water within the cooling device. Pretreatment of make-up water, or the use of water "conditioners" may precipitate-out or otherwise attenuate the concentration of these substances. Removal of the substances in the "blow-down" may establish a steady state concentration.

3. Survival and Persistence

It must be assumed that pathogens and toxic substances will survive and persist within the cooling device environment.

III. CONVERSION INTO DRIFT

1. Droplet Size and Composition

As drift is produced as droplets of water, the size of the droplets is adequate to contain almost all pathogenic microorganisms and dissolved or suspended toxic materials. The drift will have essentially the same chemical and biological composition as the circulating water.

2. Quantity of Loss through Drift

Although the loss of water as drift is a small percentage of the circulating water, the quantities are still large in major cooling devices. (e.g. a 1,000 megawatt fossil fuel power plant may release 13 mgd of water as drift, equivalent to the water consumption of a city of 250,000 people.)

3. Passage of Pathogens and Toxic Substances into Aerosol State

The potential is therefore great for the passage of substantial quantities of pathogens and toxins into drift, if these are present in the circulating water.

IV. TRANSPORT IN AEROSOL DRIFT

1. Deposition of Drift

A substantial portion of the drift will be deposited in the vicinity of the cooling device, as demonstrated in drift models and studies with drift generating devices. However, meteorological phenomena could incorporate the drift into strong surface winds, clouds, or the upper atmosphere, resulting in transport over hundreds of miles.

2. Pathogen Transport in Aerosol Drift

Pathogens are of such size that they are capable of being transported in the drift or atmosphere for substantial distances. This transport has been documented.

3. Toxin Transport in Aerosol Drift

Toxic substances will behave as the water droplets in the drift.

V. SURVIVAL IN AEROSOL DRIFT

1. Pathogen Survival in Aerosol Drift

Microorganisms in drift are normally attenuated by dessication, temperature and ultraviolet radiation. A drift produced in an arid climate during the day would show a great reduction of some pathogens, principally bacteria and protozoa. A drift produced in a humid atmosphere, at cold temperatures, and at night would have little attenuation. Drift droplets that freeze would insure survival of almost all pathogens. Dense cloud cover, or the density of the plume itself, would restrict UV penetration, and would reduce attenuation.

2. Toxic Substance Integrity in Aerosol Drift

Few of the toxic substances considered were sensitive to light or moisture. Attenuation in the drift would be negligible. Even if the water of the drift evaporates, most substances would be suspended as gas, aerosols or particles, without modification. In some cases, toxic materials could undergo photochemical reactions, increasing their toxicity.

3. Effect of Ambient Environment on Survival and Integrity

It must be assumed that drift can transport pathogens and toxins without significant attenuation. Ambient site characteristics influence the viability of some microorganisms, but have little effect on toxic molecules as a whole.

VI. PRODUCTION OF DISEASE OR CLINICAL MANIFESTATIONS

1. Human Susceptibility

Pathogens

The pathogens' ability to produce disease or clinical manifestations is a function of arrival of a sufficient number of infective particles at a suitable portal of entry and the susceptibility of the host. Bacterial infectivity is a function of a stoichiometric relationship between the number of organisms and hosts' antibodies, and the number required may vary from a few to several hundred thousand. For viruses, protozoa, fungi, and worms, the number of infective particles may be as few as one. As the half life of pathogens in the environment may be long, accumulation or continuous exposure could bring the number of particles to critical levels.

In the population as a whole, the epidemiological impact is a function of age, sex distribution, racial (genetic) distribution, general health and well-being, prior exposure and immunological deficiency states. While cooling device drift itself may not be directly responsible for epidemics, it may potentiate the burden in an already weakened population, raising a segment of the population into the clinical state.

Toxic Substances

The effect of toxic substances is difficult to evaluate because of inadequate data on humans. The effect is a function of concentration in susceptible tissue, and is much less dependent on host resistance than for pathogens. Immunity can not be acquired either.

Death directly due to most drift borne toxic substances is unlikely, based upon the concentrations implied by the limited data. Cancers are most likely, but the data is also insufficient to draw any conclusions. A highly probable but speculative impact is the weakening of individuals, making them susceptible to infection, or allergic reactions.

2. Animal Susceptibility

Pathogens

The general pathogen considerations for animals are the same as for humans, except that herbivores graze directly on vegetation and therefore have a greater potential for accumulating infectious particles from plants exposed to drift.

Toxic Substances

The accumulation of toxic substances on vegetation presents a greater probability of accumulation to toxic levels within grazing herbivores.

3. Vegetation Susceptibility

Pathogens

Only the fungi and viruses are significant as pathogens, and the usual route of transfer is by vectors or dry wind. Cooling device drift is not a significant factor.

Toxic Substances

The effect of the toxic substances considered is not well documented, but drift transport does not appear to be a significant factor. The water droplets themselves, humidity, or ordinary salts in the drift are documented as causes of plant disease.

VII. PROBABILITY OF OCCURRENCE

In determining the relative probability of host contamination, a number of assumptions and parameters had to be worked into the mathematical model. These specifically include:

a. Cooling tower height: 400 ft.

b. Top diameter: 300 ft.

c. Exit air volume: 23×10^6 cubic feet per min.

d. Evaporative loss: 13 cubic feet per second

e. Aerosol loss: 0.01 cubic feet per second

f. Wind Speed: 30 feet per second

g. Air temperature: 300 K.

h. Relative humidity: 70%

i. Circulating water volume: 5×10^6 cubic feet

j. Blow-down: Complete blow-down @ 1.5:1 concentration ratio

Other parameters which were selected for inclusion in the model were based on typical power plant load profiles and weather conditions for 24 hour periods. Each 24 hour period was divided into four hour segments and it was assumed that conditions remained constant over this period. The numerical values which were chosen and integrated into the model were considered typical for a natural draft cooling tower for a plant of approximately 1000 MW capacity. These parameters include drift fraction e.g. 5x10 $^{-5}$ glg, salt concentration ratios of 30%, weather conditions for typical seasonal, day and evening instances, plant operating capacity and atmospheric stability. The specific values assigned to the parameters are detailed on the printout of each case.

A calculation was then performed to determine the probability of contamination using those assumptions and parameters. The following is a sample of the results achieved for a summer's day case.

-------------- 24 HOUR TOTALS --------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .34

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	0.0	0.0
0.15	1107339.0	454345.4
0.20	311119.8	129253.4
0.30	98662.0	41190.6
0.50	105227.0	232410.3
0.75	215556.6	369901.7
1.00	280964.0	379159.9
1.50	155911.4	141004.1
2.00	94571.7	58955.1
2.50	66768.6	33844.5
3.00	50172.2	21953.7
4.00	17523.1	5660.8
5.00	12931.0	3511.6
7.00	8573.2	1983.8
9.00	6487.0	1202.0
10.00	5151.9	756.5
12.00	4226.6	604.1
15.00	1685.0	230.4
20.00	986.8	107.6
25.00	664.9	54.7

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	0.0	0.000
0.15	1561684.4	18.135
0.20	440373.2	0.486
0.30	139852.6	1.223
0.50	337637.3	20.000
0.75	585458.3	9.244
1.00	660123.9	13.324
1.50	296915.5	18.221
2.00	153526.8	11.626
2.50	100613.1	10.064
3.00	72125.9	5.507
4.00	23183.9	0.486
5.00	16442.5	1.914
7.00	10557.1	0.318
9.00	7689.0	0.006
10.00	5908.4	0.000
12.00	4830.7	0.000
15.00	1915.4	0.000
20.00	1094.5	0.409
25.00	719.6	0.215

SECTION 3
RECOMMENDATIONS

I. General Epidemiology and Microbiology

As in all public health and water supply work, the confidence in health hazard projections is low because of inadequate data. To compensate for the inability to make accurate projections, the United States had adopted a technology of extra caution in water treatment. While this has brought this nation an absence of infectious disease heretofore unknown in the history of mankind, it has imparted cost, energy and environmental penalties, as well as possible health hazards of the non-infectious type.

A. Society must establish the level of public health that it is willing to accept, together with the economic and social cost. This is a political decision beyond the scope of cooling devices alone, but it is incumbent upon science and engineering to develop the costs and benefits of alternative technologies. Studies to develop these, and measure public attitudes, should be performed.

B. The use of the coliform test as an indicator of health hazard is a poor substitute for actual pathogen monitoring, justifiable only when no alternative methods were feasible. Today, equipment and procedures exist for rapidly identifying specific pathogens. The advances of space technology and diagnostic medical microbiology should be applied to water monitoring, for cooling devices and all other water use sciences.

C. Aerobiological and aerochemical studies should be performed in the United States and Europe to determine if the microbiological and chemical load imposed upon the atmosphere by cooling device drift is so significantly above background as to constitute a possible health hazard. Studies using "tagged" organisms and chemicals should be considered in addition to environmental monitoring.

D. Epidemiological studies should be conducted in areas in which major cooling devices have been in use, especially those which use polluted water for make-up. The selection of sites is very critical. They must have adequate health data prior to the use of the cooling device, and the general level of health should be good. Such study sites may be found in Europe.

E. Laboratory models should be constructed, using polluted water, cooling device drift simulation, and animals, to experimentally derive data on health impact.

F. Special attention should be given to subclinical and allergic manifestations of infection and toxicity produced by cooling device drift and other sources of air pollution. Current health data suggest an increase of health problems directly related to environmental pollution. Those which result in clinical symptoms are easiest to document, however, there appears to be an increase in those conditions which cause discomfort, decrease resistance to infectious disease, initiate autoimmune "cancerous" conditions, and generally shorten life or decrease productivity. These are typified by allergies, "colds," etc., i.e. those conditions which do not call for a medical practitioner, but are nevertheless debilitating or unrecognizable.

II. Cooling Device Technology

A. In as much as cooling devices may be used in close proximity to sources of gaseous or particle emissions, such as smoke stacks, studies should be conducted on the relationship between drift and capture and transport of atmospheric pollutants. These studies should be field monitoring as well as laboratory simulation.

B. The need and means of controlling the emission of pathogens and toxic substances should be investigated, irrespective of any findings under epidemiology. The epidemiological, microbiological, and chemical studies on drift may be inconclusive, and will certainly be of long duration. If public policy is to avoid potential risks, as it does in public water supply, then safety precautions should be imposed on cooling device design and operation. Such precautions should represent a Best Available Control Technology (BACT).

C. The viability of pathogens in drift should be studied to develop biological half-life projections as a function of atmospheric conditions. This is necessary because it does not appear that the historical concepts of aerobiology and attenuation of organisms apply to dense aerosols.

III. Modeling

Procedures should be further refined for mathematical modeling of the health impact of cooling device drift. This requires more precise input on variables which have been only assumed in this study, and better integration of drift and infectivity models.

SECTION 4

OBJECTIVES

The objective of this study was to complete a comprehensive review and analysis of potential hazards to humans, plants and animals that might be caused by pathogens and toxins transported via cooling device drift.

For the purpose of program organization and control, the project was divided into six tasks, which are shown on the following Information Flow Diagram (Figure 1) and detailed in the following sections. Two pathways were postulated. The "normal pathway" represents situations which might occur in the everyday ambient environment under normal conditions. The worst case pathway represents the highest possible concentrations of pathogens or toxic substances in cooling water, failure of water treatment or biocide systems in the cooling device, atmospheric conditions insuring pathogen viability, toxin integrity, and entry into a susceptible host in sufficient concentration to produce disease.

TASK I

The primary function within this task was to inventory the types of pathogens and toxic substances which may be present in cooling device drift. The inventoried pathogens and toxins originate in recycled industrial, municipal and/or agricultural wastewaters, and polluted river waters, which would be used as cooling tower makeup. It was deemed necessary to include polluted river waters because power plants using treated effluent will generally require a back-up source of surface water in case of wastewater treatment failure or supply inadequacy.

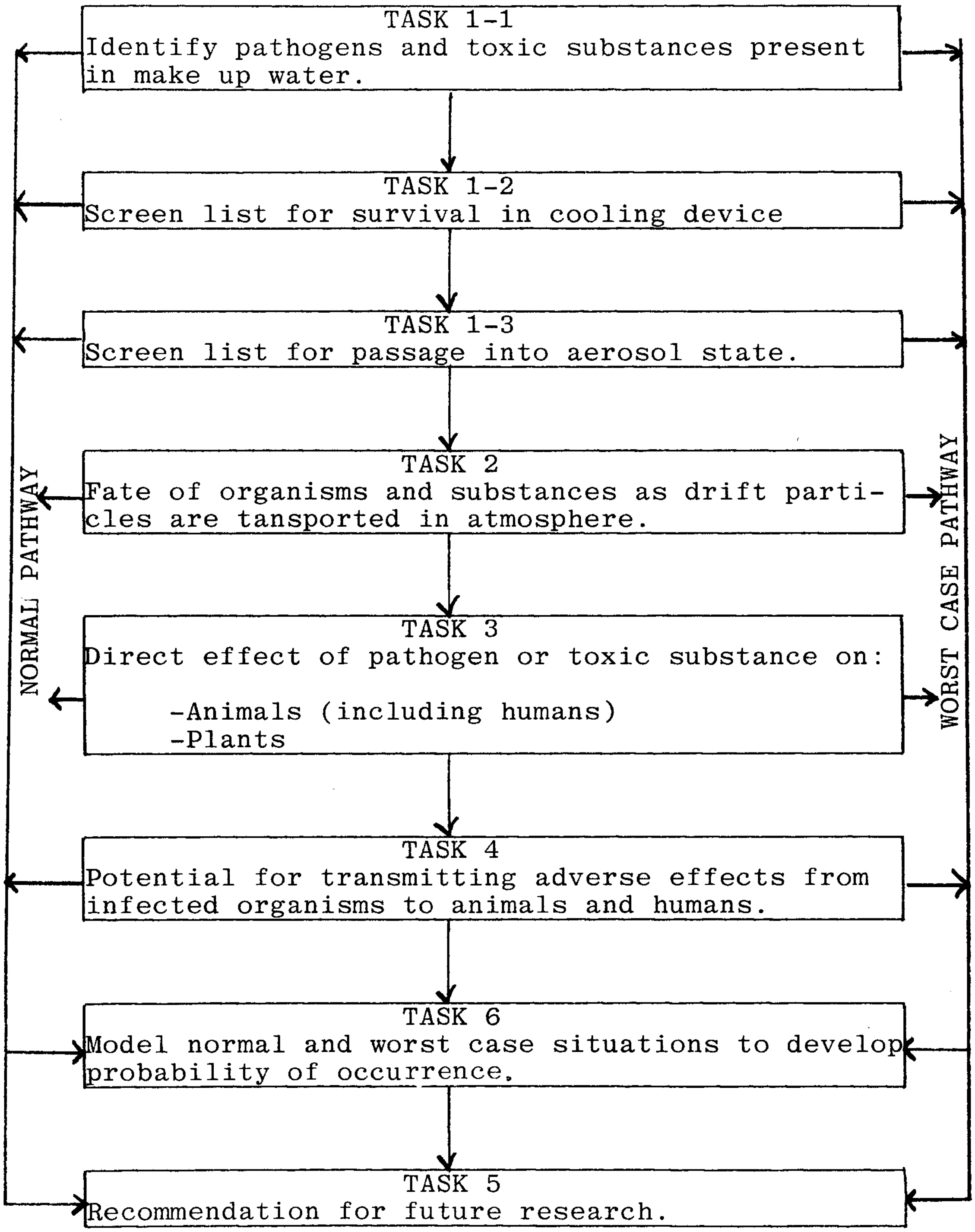
The process of preparing the inventory was to:

1. List most commonly known pathogens and toxic substances found in wastewater and polluted water, with typical concentrations when known. The microorganisms which were surveyed included the following groups:

Viruses	Pleuropneumonia-like Organisms (PPLO)
Richettsia	Protozoa
Bacteria	Invertebrate Parasites
Fungi	

FIGURE 1
INFORMATION FLOW DIAGRAM

Effect of Pathogenic and Toxic Materials
Transported via Cooling Device Drift



Only those organisms which could reasonably be found in America were catalogued. This list also included certain foreign species which are being imported by world travelers, and which are recognized as potential health hazards.

Chemical substances which were surveyed included:

1. Metals
   a. Heavy metals
   b. Transitional metals
2. Macronutrients
3. Micronutrients (Organic and Inorganic)
4. Chlorinated Hydrocarbons
5. Chlorinated and Ozonated Amines
6. Petrochemicals
7. Other toxic organics (e.g. pharmaceuticals)
8. Industrial Chemicals
   a. Plasticizers and other organics
   b. Process wastes
   c. Radioactive wastes.

2. The list was screened and categorized as to the susceptibility of organisms and substances to control by wastewater treatment or natural water purification processes.

3. The list from Step 2 was further screened to characterize only those organisms and substances which could be aerosolized. This step required input and coordination with the aerosol physics aspects of the program.

The end product of this task is a CATALOGUE which lists separately for each organism and toxic substance the following data:

Organism name or chemical substance
Disease name
Medical significance
Location of occurrence
Frequency of occurrence
Survivability in surface water
Survivability in treated effluent
Survivability in air and/or aerosol fomites
Control methods in water or effluents

The catalogue treats microorganisms as both infectious agents and allergens. Chemical irritants were considered in a slightly different manner including concentration as a parameter, when available.

There is also an estimated probability of occurrence in water. Except for a few cases where data was available, this was a qualitative judgment.

TASK II

Under this task the transport of pathogens and toxic substances in aerosol drift is assessed. Utilizing the inventory of substances and organisms produced under Task I, Task II investigates three areas:

1. A review and evaluation of the production of drift by cooling devices and the atmospheric physics of drift particles.

2. The transport of toxic substance in drift.

3. The aerobiology of organisms in drift.

Drift Physics

The primary objective here is to define drift as a function of selected cooling device designs. The data provided includes the following:

Drift size distribution
Drift mass distribution
Drift composition
Drift emission rate based on liquid flow to air flow ratio
Parameters as functions of wet-bulb/day, bulb temperature, relative humidity
Heat capacity
Exit velocity.

The matrix on the following page depicts the types of devices that were considered (Table 1).

The analysis concentrated on the cooling devices of larger sizes, from 10^9 to 10^{10} BTU/hr., since these have the greatest impact. Consideration was given to units which are capable of producing drift and of using polluted water. Although spray pond cooling devices do produce drift they were not considered because their impact is extremely localized. Therefore, the emphasis of this task is the examination of large capacity evaporative cooling devices.

Special attention was given to physical size. There is a significant difference between the mechanical type towers and the natural draft towers in the following aspects.

1. The bulk of the towers is conducive to wake entrainment at elevated wind-speeds.

TABLE 1

TYPES OF COOLING TOWERS

	Mechanical Draft Forced	Mechanical Draft Induced	Natural Draft	Mixed
Wet				
Crossflow	no	yes	yes	yes
Counterflow	yes	yes	yes	yes
Wet-Dry				
Parallel flow	no	yes (note a)	no	no

Note a: This type is to be considered only when in the wet mode.

2. The height of the towers contributes to the drift particle growth and dispersion patterns.

3. The height of the towers and their emissions will determine the potential for scrubbing action of chemicals and microorganisms from the local ambient atmosphere.

Drift emission rate was considered. The amount of drift is a tower design function. Previous design practice has been to use as an upper limit, a guaranteed drift rate not to exceed 0.2% of the water circulation rate. Recent designs of drift eliminators have resulted in drift guarantees of from 0.05% to 0.002% of the circulating water flow. These values may be interpreted in terms of parts per million by using a design ratio, L/G, which is the ratio of the water rate to the air rate, both in pounds per unit of time.

Data was evaluated on the initial drop size distribution. This is an area of great uncertainty. The drop size distribution in the cooling tower drift was related to tower design parameters. Estimates were made of the limiting size, which must be such that the gravitational fall velocity of a droplet is less than the air speed at the exit of the tower. Estimates were also made of the water mass distribution, and finally, the initial composition of the drift particles was described in relation to the make up water.

Transport of Toxic Substances

The transport of toxic substances in the changing structure and composition of the plume, relative to the ambient air, and the distribution of drift over the terrain was evaluated.

The following device parameters were taken into account with respect to the incorporation of toxic substance into drift:

Downwash
Supersaturation
Effect of effluent latent heat on plume rise
Effect of saturated ambient air on plume rise
Prediction of condensation

Existing models were critically screened and typical results were evaluated with respect to the general task objective. Evaluations for transport and fate were made on the basis of the following functions:

Selected cooling device types - considering the range of operational characteristics.
Ambient seasonal climatology.
Terrain characteristics (shoreline, valley, plains, urban, rural, etc.).

Conditions conducive to survival of organisms (humidity, UV screening, temperature).

Deposition rates were evaluated in order to determine the loss of compounds from the plume and concentrations of compounds in the receiving environment.

The effects of oxidation or photochemistry upon toxic materials were assessed. Taken into consideration were atmospheric conditions, plume density, and particles resident time in the atmosphere. This evaluation essentially relates toxic substance concentration to time and distance.

Aerobiology

The ability of each pathogen group to be effectively transmitted by aerosols was reviewed and documented. This process took into account the following factors for the different particle size ranges:

1. Attenuation due to desiccation
2. Attenuation due to solar radiation
3. Protective mechanisms due to dissolved chemicals in the aerosols.

This information was gathered from published scientific and medical literature, and from personal liaison with former participants in biological warfare (BW) study programs which have now become declassified.

TASK III

The potential effects upon inhalation by, or contact with, animals or plants.

The arrival of a pathogen or toxic substance at a plant or animal does not, per se, mean the manifestation of disease. The offender must interact with the body and overcome the body's defense mechanisms.

For each pathogen or toxic substance which was identified in Task I, and which survived aerosol transport, an assessment was made of the probability of initiation or aggravation of disease. This assessment included:

a. A description of the normal means of entry of the offending agent into the body.
b. A description of the normal body susceptibility.

This information was abstracted from epidemiological literature for plants, animals and humans.

The result of this task is an estimate of the probability of a pathogen or toxin producing disease, after arriving within capture range of the host. This probability is expressed in general terms based on an analysis of factors including:

a. Induced or natural immunity
b. Strain resistance
c. Synergistic or antagonistic factors
d. Age
e. Sex
f. Route of entry

These factors were evaluated in relation to occurrence and transmission, and faction. Where possible chronic and acute severity is also discussed for both individuals and population groups.

TASK IV

Potential for transporting adverse effects from affected plants and animals to other animals and humans.

This task is very closely related to the objectives of Task III. For pathogens, literature review and assessment covered zoonoses. Within this epidemiological evaluation, transmission of pathogens from plants to humans considered their role as fomites and vectors.

An effort was made to identify those toxic substances which would be assimilated in edible plant parts and phytoplankton. Consideration was given to detoxification mechanisms in plants and where possible estimates were given for residual concentrations which could be consumed by herbivores.

The data from this task was, as in Task III, incorporated into the catalogue format for a comprehensive review of each pathogen and toxin.

TASK V

Conclusions and recommendations for future research.

Regardless of the specific conclusions which were drawn from the study, it was obvious that there is little data available. Data gaps exist, identifying areas to be researched. Further comments were made in the areas of:

1. Theoretical and analogue simulation, and modeling.
2. Field measurements on the actual occurrence of pathogens in the drift in the vicinity of cooling devices.
3. Technological methods of control.
4. Epidemiology in the vicinity of polluted water cooling towers.

TASK VI

Predicative model development.

One very useful way to evaluate the possible impact of cooling tower drift on public health is by the establishment of suitable predicative mathematical models. It is clear for this case, as in many other systems modeled, that all the desired parameters, constants and variables may not be clearly identifiable or definable. However, this does not at all preclude the development of utilitarian models that can be modified as more data become available and as it becomes apparent that some "tuning" of the model is necessary as a result of experience.

The question approached in the predicative model development was the liklihood of a pathogenic organism or toxic substance reaching and affecting the public. Because answers to this type of inquiry are probabilistic, they should be answered by the development of a stochastic (probabilistic) rather than deterministic model. Less work has been done with stochastic models because they are more difficult to deal with. Even so, their use has become increasingly common as the shortcomings of completely deterministic models became more apparent.

There is a logical sequence involved in evaluating the possible erosion of public health as a result of cooling tower drift. Some of the major events in this sequence, which were discussed are:

1. Probability of occurrence of pathogens or toxic substances in makeup or other input waters.
2. Probability of survival of pathogens or toxic substances in cooling towers.
3. Probability of hazardous materials being carried into the atmosphere.
4. Probability and time duration of survival of hazardous materials in the atmosphere.
5. Probability of interception by an appropriate host or vector.
6. Probability of development of harmful effects.

Each of these events were developed from other events which are probabilistic in and of themselves (e.g. presence of sunlight, air and water temperatures, residence times, wind direction and velocity, etc.). Knowing something about the parameters that affect each event postulated, the predicative model was developed for each event that establishes the possiblity of that event occurring. A serial model, as outlined above has a condition that the possibility of the preceeding event occurring must exist. In the modeling of this system as outlined, it is apparent that there are many similarities to the extensive simulations for reliability and availability predictions for electronic systems. There is extensive literature on such simulations and predicative models and as applicable serves as a base for the establishment of the proposed predicative model.

The problem of random events was solved by substituting for the actual event or function, a simpler one where the desired probability laws are obtained by drawing random numbers. These methods, based on game theory are called Monte Carlo methods. These techniques have been well developed for the investigation of predicative stochastic models such as are suited to this study and form the basis for aspects of the model development.

In this task, a predicative mathematical model is developed. To the extent possible that known (or suspected) variables can be included, either on the basis of known or hypothetical grounds, the model incorporates them. Areas of question are identified and provisions are made for incorporation of new or speculative items as required. Model testing is accomplished using routine establishment of probabilities using available statistical data, and by using Monte Carlo methods for prediction of probabilities. The models developed are carefully documented in flow chart design and development of algorithms. Also the programming was written in one of the higher level languages (FORTRAN). This allows for future building on the developed model as more data becomes available from future work.

SECTION 5

METHODOLOGY

This study attempts to further define and assess the potential health hazards resulting from cooling tower drift. Although it has already been shown that data is lacking, this study attempts to answer questions and make a valid assessment utilizing existing sources and references. It is certainly hoped that this investigation will provide some answers, but it will also be considered a significant effort to direct the need for future study.

To complete the study a staff of outstanding subcontractors and consultants were assembled. The specialists and their fields are as follows:

1. Aerosol Physics and Cooling Tower Emissions. (Subcontract to York Research Corp., Stamford, Conn.) Edward J. Kaplin, M.S.: Principal Scientist. Alan D. Goldman: Environmental Meterologist. Experience in theoretical and applied design of cooling devices, and monitoring emissions.

2. Microbiology. Henry David Isenberg, Ph.D.: Chairman, American Board Medical Microbiology; Editor, Journal of Clinical Microbiology; Chief of Microbiology, Long Island Jewish Medical Center.

3. Epidemiology. Cyrus C. Hopkins, M.D.: Hospital Epidemiologist, Massachusetts General Hospital; Assistant Physician, Massachusetts General Hospital; Assistant Professor Medicine, Harvard Medical School.

   Robert Harold Rubin, M.D.: Infectious Disease Unit, Massachusetts General Hospital; Assistant Professor of Medicine, Harvard Medical School.

4. Zoology and Animal Pathology. Basil P. Tangredi, D.V.M.: Practicing veterinarian.

   Sydney Anderson, Ph.D.: Curator of Mammals, American Museum of Natural History, New York.

5. Botany and Plant Pathology.
   Leonard Weinstein, Ph.D.: Director, Environmental Laboratory, Boyce Thompson Institute.

   Delbert C. McCune, Ph.D.: Plant physiologist, Boyce Thompson Institute.

6. Aerobiology.
   Philip Cooper, M.S.: Formerly a research scientist at the United States Air Force Air Medical Research Laboratory.

These specialists were assigned their scope of work under the task structure described in the Objectives (see Figure 2). All research was secondary, to be taken from known and accepted sources. Data was submitted according to a task schedule and compiled in house.

FIGURE 2
TASK ASSIGNMENT DIAGRAM

Effect of Pathogenic and Toxic Materials
Transported via Cooling Device Drift

TASK 1-1
Identify pathogens and toxic substances present in make up water.
H2M, Drs. Hopkins, Rubin & Isenberg

TASK 1-2
Screen list for survival in cooling device.
H2M, Dr. Isenberg

TASK 1-3
Screen list for passage into aerosol state.
H2M, York Research

TASK 2
Fate of organisms and substances as drift particles are transported in atmosphere.
York, H2M, Dr. Isenberg, Mr. Cooper

TASK 3
Direct effect of pathogen or toxic substance on:
- Animals (including humans)
  Drs. Hopkins & Rubin (humans)
  Drs. Andersen & Tangredi (animals)
- Plants
  Drs. McCune & Weinstein

TASK 4
Potential for transmitting adverse effects from infected organisms to animals and humans.
Animals - Drs. Andersen & Tangredi
Humans - Drs. Hopkins & Rubin

TASK 6
Model normal and worst case situations to develop probability of occurrence.
Dr. Uzzo

TASK 5
Recommendation for future research.
H2M

SECTION 6

RESULTS

RESULTS OF TASK I - INVENTORY

Disease means any pathological manifestation, caused either by micro-organisms or by nonliving substances. There are several major routes for the transmission of disease:

1. Water
2. Air
3. Vectors (e.g. insects)
4. Fomites (contaminated food, dust, aerosols, etc.)
5. Direct contact with diseased organisms

Of these, water is probably the most serious. Water becomes contaminated easily, it can transport germs or dissolved substances greater distances, and it is universally required in large quantities by all living things.

The principal source of contamination with human pathogens is through fecal discharge, and to a lesser extent, with other products of human metabolism (mucus, pus, etc.). As a solvent and flushing agent, water picks up and carries contaminated road and field sediments, food and industrial wastes, animal feces, etc.

Contamination of surface waters must be accepted as an accomplished fact due to the combination of storm runoff and the lack of adequate sewage treatment. Natural surface and ground waters are also subject to purification mechanisms, such as settling, aeration solar radiation and phagocytosis. The extent to which contaminated waters can purify themselves is a function of the pollution concentration, the time available for action, and the biological properties of the organisms. Whether or not contaminated waters are capable of producing disease in humans is a function of the etiology of either of two types of pathogens which may be present.

1. Certain organisms, such as many of the enteric viruses, are normal inhabitants of the human intestine and continue to exist in a circulating stock so long as humans are present. Illness does not occur, because populations acquire immunity, either naturally or artificially.

The poliomyelitis virus is an example of such an organism. Immunization prevents the appearance of clinical symptoms of the disease, but the threat can never be removed and the unprotected human will continue to develop the disease.

A particular danger with these indigenous organisms is that they change to produce new strains, and there is no assurance that the immunity against one strain will protect against another strain. While many avenues of research are promising, there is still no effective drug or body substance that will confer broad resistance against all present and new pathogens.

2. Other organisms are not indigenous, and can be introduced only from a diseased person. For example, if no cholera is present in the population, there can be no source of the bacterium. Obviously the key to the control of these diseases lies in maintaining a healthy population.

The United States has been very effective in achieving a marked reduction or elimination of diseases which were dreaded less than a century ago. Recently, however, there has been an increase in the incidence of those diseases that were considered things of the past, because of the proliferation of world-wide travel. Tuberculosis, for example, has risen to such an extent that New York hospitals are reopening T. B. clinics that had been closed.

In addition to the importation of foreign diseases, another source of pathogenic organisms is the "carrier," or one who harbors the disease organisms but does not manifest clinical symptoms. Such an individual can continue to contaminate waters and escape detection and cure.

The inventory of diseases which can be transmitted through the water route is substantial. Here in the United States, water borne diseases have been kept under control by meticulous attention to the purification of public water supplies, and health standards for private water supplies, recreational waters and shellfish. Although there is a national effort to purify sewage, the fact remains that most of the country has no sewage treatment or only primary treatment.

Table 2 lists those pathogens which are most likely to be found in polluted waters. Also included in this list are pathogens which are indigenous abroad but may be introduced into the U.S. by travelers. Pathogens that may not naturally occur in surface or ground waters, but may be introduced into waters from external sources, are also included.

Toxic materials are introduced into surface water as a result of raw or inadequately treated wastewater, storm water runoff, solid waste leachate from landfills, rainfall, dredge spoiling, and a variety of other activities. As a result of the recent national effort to reduce point source pollution, the quantity of toxic materials introduced into surface water is being attenuated. However, because of the magnitude of the non-point pollution control problem, it is doubtful that surface water pollution will ever be reduced to zero in the vicinity of human habitation. Cooling devices that draw water from such areas will intake chemical substances which will eventually incorporate into the aerosol drift.

TABLE 2

PATHOGENS MOST LIKELY TO OCCUR IN
COOLING TOWER MAKEUP WATER SOURCES

Absidia corymbifera

Absidia ramosa

Acanthamoeba (Naeglenia)

Actinomyces israeli

Actinomyces keratolytica

Actinomyces spp.

Adenovirus and Para influenza virus

Aspergillus spp.

Aspergillus flavus

Aspergillus fumigatus

Aspergillus nidulans

Aspergillus niger

Aspergillus niveus

Aspergillus restrictus

Aspergillus terreus

Bacillus anthracis

Bacillus cereus

Bacillus subtilis

Bacteriodes spp.

Basidiobolus haptosporus

Blastomyces dermatitidis

Bordetella spp.

Bordetella parapertussis

Brucella abortus

Brucella canis

Brucella melitensis

Brucella suis

Candida albicans

Candida spp.

Cladosporium spp.

Clostridium botolinum

Clostridium perfingens

Coccidioides immitis

Conidiobolus coronatus

Corynebacterium spp.

Corynebacterium diphtheriae

Corynebacterium ulcerans

Cryptococcus neoformans

TABLE 2 cont.

Dermatophilus congolensis

Echo virus, coxsackie A & B, Polio

Enterobacteriaceae

Escherichia coli

Fuscobacterium spp.

Geotricium candidium

Haemophilus aegyptius

Haemophilus influenzae

Klebsiella pneumonia

Listeria monocytogenes

Mucor pusillus

Mucor ramosissimus

Mucor spp.

Mycobacterium spp.

Mycobacterium tuberculosis

Nocardia asteroides

Nocardia brasiliensis

Nocardia caviae

Peptococcus spp.

Peptostreptococcus spp.

Phialophora spp.

Proteus mirabilis

Prototheca spp.

Pseudomonas aeruginosa

Pseudomonas mallei

Pseudomonas pseudomallei

Rhinocladiella spp.

Rhizopus arrhizos

Rhizopus oryzae

Salmonella spp.

Salmonella typhi

Shigella spp.

Shigella boydii

Shigella dysenteriae

Shigella flexneri

Shigella sonnei

Sporothrix schenckii

Staphylococcus agalactiae

Staphylococcus aureus

Staphylococcus spp.

Streptococcus faealis

Streptococcus pneumoniae

Streptococcus pyogenes

Streptococcus pyogenes (Group A)

Streptococus spp.

Torulopsis glabrata

Vibrio parahemolyticus

Yersinia enterocolitica

Yersinia pestis (Pasteurella)

Yersinia pseudotuberculosis

Zygomycetes (Phycomycetes)

Various viruses, nematodes and protozoans

Salt, although it is naturally occurring substance in estuarine waters, might be considered a toxic material for terrestrial plants. Salt drift has been identified as a potentially serious cause of injury to sensitive species of natural foliage and crops in the vicinity of cooling devices.

The effect of airborn toxic material on human health has been intensively studied, but the impact is highly controversial. Toxic substances, including acid sulfates and nitrates, and certain metallic compounds may produce acute or chronic respiratory symptoms, including increased airway resistance, asthma, bronchitis, cardio-pulmonary disease, increased sputum, and even death.

Allergens, although not necessarily toxic, may cause asthma and hay fever, two of man's most annoying diseases. Airborne pollutants may potentiate or mimic allergens on sensitive individuals. "Red tide" aerosols from dinoflagellate blooms have been documented.

Environmental pollutants may also be the principal cause of cancer or may serve as co-carcinogens. This has been documented for the particulates such as asbestos and beryllium, and for self-inflicted gaseous chemicals from smoking tobacco. The extent to which industrial and transportation emissions are related to cancer of the lungs, stomach, intestine, and of the immune system may be related to environmental pollutants.

The origin of most gaseous (or small particle) pollutants is combustion. Since cooling tower aerosols may be generated adjacent to combustion exhausts, or may pass over industrial emissions, they may contribute to the transport of pollutants by solubilizing gases or trapping particles in the aerosol droplets. This is outside the scope of the present study, but it should be recognized that under those conditions, cooling tower drift may potentiate health problems, if not be directly responsible for them.

Toxic chemicals in cooling tower water can also originate directly from the biological and chemical reactions that occur in the system. These reactions are dependent upon the characteristics of the device and the make-up water. All cooling devices can be subject to the following:

1. Scaling on heat exchange surfaces.
   Scaling is a land adherent type of deposit caused by the precipitation of hardness elements from the water in the form of salts or oxides.

Principal scales are calcium carbonate and magnesium silicate. A characteristic of these salts they have inverse water solubilities with respect to temperature. Increased scaling can occur as the water temperature increases in a cooling system or as the concentration of salts increases through evaporation. Factors that determine or control scaling include such analytical values associated with water quality as pH, calcium content, total alkalinity, dissolved solids and temperature.

Scaling is generally controlled by chemical adjustment of the alkalinity and/or recycle times. The alkalinity is controlled by the addition of acid - usually sulfuric acid - to maintain a pH range between 6.0 - 7.0 and/or by using surface active phosphates and organic agents. It is noted that pH also affects corrosion inhibition so that a balance is necessary.

2. Sludge formation on heat exchange surfaces. Sludge formations are caused by combinations of dirt, oil, calcium and magnesium salts, organics, and other chemical products, particularly phosphates. These fouling masses can mechanically filter dust from circulating water and serve as focal points for difficulties in the form of reduced heat transfer and corrosions. Additive control agents function through a physical phenomenon which results in an extremely thin layer of contaminant being deposited on surfaces in the cooling tower system while the rest is maintained in suspension.

3. Corrosion of piping, pumps and heat exchanges. Corrosion is caused primarily by the dissolved oxygen content of the water although a high chloride content in the water will also lead to corrosion. By the very nature of wet cooling towers, the contact of the water with air assures that the circulating water will be continuously saturated with dissolved oxygen and is thus the major single source of corrosion difficulties.

Corrosive inhibitors are generally combinations of chromates, zinc and phosphates. The chromates and phosphates act as anodic inhibitors. They form a surface film which restrains the anodic corrosive reaction:

$$Fe \rightleftharpoons Fe^{++} + 2e$$

When used alone, anodic inhibitors must be present in a large quantity. This can be substantially reduced with the addition of zinc, a cathodic inhibitor. the cathodic reaction is:

$$O_2 + 2H_2O + 4e \rightleftharpoons 4(OH)^-$$

This reaction is the rate controller and it is limited by the rate at which oxygen can diffuse to the metal surface. The cathodic reaction generates hydroxide ions which increase the pH at the cathodic area. The zinc precipitates with the increased pH and forms a barrier to oxygen diffusion:

4. Biological fouling.
The tremendous potential for biological fouling through slime, algae formation and all forms of microbiological growth exists in a wet tower system because of the high average water temperature, oxygen - saturated environment that is provided. The seed organisms are always in fresh supply by the process of scrubbing from the tower air as well as from any make-up water.

In so far as the cooling tower operation is concerned, biological fouling can greatly decrease heat transfer. This can be attributable not only to the organisms themselves but also to their metabolic products. The bulk, once deposited, serves as a further trap for debris, chemical and otherwise.

The principal microbiological organisms involved are bacteria, fungi and algae. The bacteria are the most troublesome type of organism. Aerobic slime-forming bacteria thrive in tower environs both in the bulkwater and on exposed surfaces.

The control of biological growths in circulating water requires its periodic treatment with biocides. Chlorine, chlorinated phenols and non-oxydizing biocides are effective as growth controls.

Chlorine may in some instances be depleted by its reactions with other treatment chemicals in a system. Non-oxidizing biocides may be used to supplement chlorine treatment or as a replacement. It is noted, however, that for non-oxidizing biocides to be effective they must be present in toxic dosages.

The addition of copper citrate, cholophenates, tribictyl tin, quaternary amines, methylene bis-thiocyante and chlorination are only a few of the biological control compounds and methods used.

5. Delignification of wood parts.
Delignification of wood surfaces in a cooling tower proceeds by two basic mechanisms: chemical attack and biological attack.

The chemical attack is a function of high alkalinity content of the circulating water which is generally a function of high alkalinity of make-up water. This condition is alleviated by pH control, usually with sulfuric acid.

A more important delignification mechanism is the attack on the wood or fill cellulose by fungi. Their control is by preservative coatings on wood surfaces, and chlorination and/ or non-oxidizing biocides.

It should be noted that wood preservative methods have included the impregnation of the wood, prior to usage, with a copper salt followed by an arsenic salt to precipitate copper arsenic within the wood or the impregnation of the wood with creosote.

Without specific consideration to the type of make-up water to be used in any given drift-generating cooling device, it is seen that chemical additives are in routine use for reasons which include:

a. The assurance of continued effective heat removal.
b. The reduction of metal and wood deterioration.
c. The minimization of investment and utility costs.
d. The influencing and development of design practices.
e. The making practical of less costly designs

The consideration of make-up water in the form of recycled industrial, municipal and/or agricultural wastewater must now be evaluated in respect to treatment requirements necessary for proper operation of an appropriate cooling device as well as for the presence of pathogens and/or toxic chemicals that will pass through the device. This becomes necessary based on the premise that each drift particle droplet will be a microcosm of the water mixture within the cooling device itself.

In any given operational environs, the make-up water will be a function of local and prior usage by industrial, municipal and agricultural sources. It will be affected by the degree of reclamation treatment by each user prior to their recycle efforts. This treatment effort may range anywhere from 0-100%. On this basis, specific categorization of any given water source, in general, will be difficult without prior knowledge of its past and present history, and knowledge of constituent residence times. In these considerations radiological waste discharges are also important. Of equal importance is the water source itself, its size (volume), flushing rate and/or drainage, or percolation rate separate from the constituent residence time.

In terms of industrial wastes and to some extent agricultural wastes, broad categories can be defined immediately with some brief delineations:

1. Wastes Containing Mineral Impurities.
   Examples of wastewater containing large and/or detrimental amounts of mineral impurities are steel-pickling liquors, copper-bearing wastes, electroplating wastes, oil-field brines, petroleum refinery wastes and mining wastes.

2. Wastes Containing Organic Impurities.
   The most important organic waste producers are milk-processing plants, meat packing establishments, breweries, distilleries, canneries, and medical institutions (e.g. hospitals, nursing homes).

   It is noted that stock-yards associated with meat-packing are also a source of organics and pathogenic organisms.

3. Wastes Containing Both Organic and Mineral Impurities.
   Some examples include the textile industry, laundries, tanneries and paper mills, as well as the fertilizer industry.

4. Radioactive Wastes.
   The wastes may originate in hospitals and research laboratories and in the laundries serving them; in water-cooled nuclear reactors and chemical plants that process reactor fuels; and from mining operations.

The types of substances potentially present in cooling device drift due to agricultural and industrial wastes, internal reactions, leachate, runoff and other surface waters were considered and incorporated into the inventory of toxic substances. Many of the substances examined are known or suspected carcinogens. A list of such substances was supplied by EPA Corvallis and then expanded to include others of interest. Table 3 is a listing of the toxic substances included in the inventory.

TABLE 3

TOXIC SUBSTANCES POTENTIALLY PRESENT IN

COOLING MAKE-UP WATER

Acenaphthene	Chlorine
Acetone	Chloroform
Acreolein	2-Chlorophenol
Acrylonitrile	Chromium and compounds
Aldrin	Copper and compounds
Antimony and compounds	Cyanides (barium, calcium, hydrogen, potassium, sodium, zinc)
Arsenic and compounds	DDT and metabolites
Asbestos	Diabyl ethers
Benzene	Dichlorobenzenes
Beryllium and compounds	Dichlorobenzidine
Biphenyl	Dichloroethylene
1, 2 Bis-chloroethyoxy ethane (haloether)	2, 4 Dichlorophenol
Bromochlorobenzene (chlorinated benzene)	Dichloropropane and Dichloropropene
Cadmium and compounds	Dieldrin
Carbon tetrachloride	2, 4 Dimethylphenol
Chlordane	2, 6 Dinitrotoluene
Chlorinated benzenes	Diphenylhydrazine
Chlorinated ethanes	Endosulfan and metabolites
Chlorinated napthalene	Endrin and metabolites

Ethylbenze

Haloether

Halomethane

Heptachlor and metabolites

Hexachloro 1,3 Butadiene

Isophorone

Lead and inorganic compounds

Lindane

Mercury and compounds

Methyl ethyl ketone (Butanone)

Naphthalene

Nickel and compounds

Nitrites

Nitrobenzene

Nitrophenols (m,o,p)

Nitrosamines

Pentachlorophenol

Phenols

Polychlorinated biphenyl's (pcb's)

Phthalate esters

Secondary amines

Selenium and compounds

Silver and compounds

Sodium chloride

Styrene

Thallium and compound

Toluene

Toxaphene

Vinyl chloride

Zinc and compounds

RESULTS OF TASK I - ATTENUATION OF ORGANISMS AND SUBSTANCES

Naturally, not every toxin or pathogen found in sources of make-up water will enter the cooling device. As stated earlier, the quantity of toxic materials in surface waters is being attenuated in a effort to reduce point source pollution. "Common" pathogens, generally bacteria, are attenuated through the processes of chlorination, and occasionally sedimentation, filtering or addition of biocides.

The initial inventory of pathogens and toxins was screened for attenuation through water treatment. For the purposes of our study, there are three general classifications of treatment; physical, chemical and biological.

Physical treatment normally includes settling, centrifugation, filtration and UV or nuclear radiation. Conceivably heat or sonic energy could also be used. Chemical treatment is by chlorination, or other biocides (e.g. silver, organic alogens) and control of pH. More specific processes such as addition of corrosion inhibitors, or measures required by specific industries are also included. Biological treatment encompasses any of the methods presently employed in treatment of sludge and sewage.

The following matrices (Tables 4 and 5), screen the inventory of pathogens and toxins indicating those which would not be attenuated by any means of wastewater treatment or natural purification processes. This study is primarily concerned with these substances and organisms. It is expected that due to the inability to control these, cooling device operators should be concerned with their possible dissemination.

Within the tables, the attenuating treatment(s) is identified for each pathogen and toxic substance in our inventory. Because some of these substances may only be treated by one type of treatment process, and others by two or three, there is a distinction made between those retained for a worst case situation.

Under the status column are the letters P,S,T, or W. These indicate the following:

P - Is not attenuated by any treatment process. This pathogen is of primary importance.
S - Attenuated by one process, therefore, the organism or substance is of secondary importance. It would be a significant concern should the appropriate treatment

process fail for any of these.

T - These pathogens or toxins can be controlled by two processes. It is less likely that both treatments should fail, or not be applied. Therefore, these are of tertiary concern.

W - It is least likely that pathogens and toxins which may be treated by all three types of treatment processes will be present in make-up water. These are reserved for a worst case situation.

TABLE 4

ATTENUATION OF PATHOGENS

AND STATUS IN MAKE-UP WATER

PATHOGEN	TREATMENT PROCESS Biological	Chemical	Physical	STATUS
Absidia corymbifera	x	x	x	W
Absidia ramosa	x	x	x	W
Acanthamoeba (Naegleria)				
Actinomyces israeli		x	x	T
Actinomyces keratolytica	x	x	x	W
Actinomyces spp.		x	x	T
Adenovirus and Parainfluenza				P
Aspergillus spp.	x	x	x	W
Aspergillus flavus	x	x	x	W
Aspergillus fumigatus	x	x	x	W
Aspergillus nidulans	x	x	x	W
Aspergillus niger	x	x	x	W
Aspergillus niveus	x	x	x	W
Aspergillus restrictus	x	x	x	W
Aspergillus terreus	x	x	x	W
Bacillus anthracis			x	S
Bacillus cereus	x	x	x	W
Bacillus subtilis		x	x	T
Bacteroides spp.	x	x	x	W
Basidiobolus haptosporus	x	x	x	W
Blastomyces dermatitidis	x	x	x	W
Bordettela spp.	x	x	x	W
Bordettela parapertussis	x	x	x	W
Brucella abortus		x		S
Brucella canis		x		S
Brucella melitensis		x		S
Brucella suis		x		S
Candida albicans		x	x	T

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 4

ATTENUATION OF PATHOGENS

AND STATUS IN MAKE-UP WATER

PATHOGEN	TREATMENT PROCESS Biological	Chemical	Physical	STATUS
Candida spp.		x	x	T
Cladosporium spp.		x	x	T
Clostridium botulinum			x	S
Clostridium perfingens	x	x	x	W
Clostridium tetani			x	S
Coccidioides immitis		x	x	T
Conidiobolus coronatus		x	x	T
Corynebacterium diptheriae		x	x	T
Corynebacterium spp.		x	x	T
Corynebacterium ulcerans		x	x	T
Cryptococcus neoformans		x	x	T
Dermatophilus congolensis	x	x	x	W
Echovirus, Coxsackie A & B, Polio				P
Enterobacteriaceae	x	x	x	W
Escherichia coli	x	x	x	W
Fuscobacterium spp.	x	x	x	W
Geotricium candidium	x	x	x	W
Haemophilus aegyptius	x	x	x	W
Haemophilus influenzae	x	x	x	W
Histoplasma capsulatum		x	x	T
Klebsiella pneumonia				
Listeria monocytogenes	x	x	x	W
Mucor pusillus		x	x	T
Mucor ramosissimus		x	x	T
Mucor spp.		x	x	T
Mycobacterium spp.		x	x	T
Mycobacterium tuberculosis	x	x	x	W
Nocardia asteroides		x	x	T

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 4

ATTENUATION OF PATHOGENS

AND STATUS IN MAKE-UP WATER

PATHOGEN	TREATMENT PROCESS Biological	Chemical	Physical	STATUS
Nocardia basiliensis		x	x	T
Nocardia caviae		x	x	T
Peptococcus spp.	x	x	x	W
Peptostreptococcus spp.	x	x	x	W
Phialophora spp.		x	x	T
Proteus mirabilis	x	x	x	W
Prototheca spp.	x	x	x	W
Pseudomonas aeruginosa	x	x	x	W
Pseudomonas mallei		x	x	T
Pseudomonas pseudomallei	x	x	x	W
Rhinocladiella spp.		x	x	T
Rhizopus arrhizus		x	x	T
Rhizopus oryzae		x	x	T
Salmonella spp.	x	x	x	W
Salmonella typhi	x	x	x	W
Shigella boydii	x	x	x	W
Shigella dysenteriae	x	x	x	W
Shigella flexneri	x	x	x	W
Shigella sonnei	x	x	x	W
Shigella spp.	x	x	x	W
Sporothrix schenckii	x	x	x	W
Staphylococcus agalactiae	x	x	x	W
Staphylococcus aureus	x	x	x	W
Staphylococcus spp.	x	x	x	W
Streptococcus faealis	x	x	x	W
Streptococcus pneumoniae		x	x	T
Streptococcus pyogenes		x	x	T
Streptococcus pyogenes (Group A)	x	x	x	W

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 4

ATTENUATION OF PATHOGENS

AND STATUS IN MAKE-UP WATER

PATHOGEN	TREATMENT PROCESS			STATUS
	Biological	Chemical	Physical	
Streptococcus spp.	x	x	x	W
Torulopsis glabrata	x	x	x	W
Vibrio parahemolyticus	x	x	x	W
Yersinia enterocolitica	x	x	x	W
Yersinia pestis (Pasteurella)	x	x	x	W
Yersinia pseudotuberculosis	x	x	x	W
Zygomycetes (Phycomycetes)	x	x	x	W
Var. Nematodes, Protozoans, and viruses				P

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 5

ATTENUATION OF TOXIC SUBSTANCES

AND STATUS IN MAKE-UP WATER

TOXIC SUBSTANCE	TREATMENT PROCESS			STATUS
	Biological	Chemical	Physical	
Acenaphthene			x	S
Acetone	x		x	T
Acrolein			x	S
Acrylonitrile			x	S
Aldrin			x	S
Antimony and compounds		x	x	T
Arsenic and compounds		x		S
Asbestos				S
Benzene	x		x	T
Benzidine			x	S
Beryllium and compounds		x		S
Biphenyl		x	x	T
Cadmium and compounds		x		S
Carbon Tetrachloride			x	S
Chlordane			x	S
Chlorinated Benzene			x	S
Chlorinated Ethanes			x	S
Chlorinated Ethylenes			x	S
Chlorinated Napthalene			x	S
Chlorine			x	S
Chloroform			x	S
2-Chlorophenol			x	S
Chromium and compounds		x		S
Copper and compounds		x		S
Cyanides		x		S
DDT and metabolites			x	S
Diabyl Ethers			x	S
Dichlorobenezenes			x	S

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 5

ATTENUATION OF TOXIC SUBSTANCES

AND STATUS IN MAKE-UP WATER

TOXIC SUBSTANCE	TREATMENT PROCESS Biological	Chemical	Physical	STATUS
Dichlorobenzidine			x	S
Dichloroethylene			x	S
2,4 Dichlorophenol			x	S
Dichloropropane and Dichloropropene			x	S
Dieldrin			x	S
2,4 Dimethyl Phenol	x		x	T
2,6 Dinitrotoluene	x		x	T
Diphenylhydrazine			x	S
Endosulfan and metabolites			x	S
Endrin and metabolites			x	S
Ethylbenzene	x		x	T
Halo Ether			x	S
Halo Methane			x	S
Heptachlor and metabolites			x	S
Hexachloro-1,3-Butadiene			x	S
Isophorone			x	S
Lead & inorganic compounds		x		S
Lindane			x	S
Mercury and compounds		x		S
Methyl Ethyl Ketone (Butanone)	x		x	T
Naphthalene	x		x	T
Nickel and compounds		x		S
Nitrites			x	S
Nitrobenzene	x		x	T

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

TABLE 5

ATTENUATION OF TOXIC SUBSTANCES

AND STATUS IN MAKE-UP WATER

TOXIC SUBSTANCE	TREATMENT PROCESS Biological	Chemical	Physical	STATUS
Nitrophenols (m,o,p)			x	S
Nitrosamines			x	S
Pentachlorophenol			x	S
Phenols			x	S
Phthalate Esters	x	x	x	W
Polychlorinated Biphenyl's (PCB's)			x	S
Secondary Amines			x	S
Selenium and compounds		x	x	T
Silver and compounds		x		S
Sodium Chloride			x	S
Styrene			x	S
Thallium and compounds		x	x	T
Toluene	x		x	T
Toxaphene			x	S
Vinyl Chloride			x	S
Zinc and compounds		x		S

P - of primary concern
S - of secondary concern
T - of tertiary concern
W - retain for worst case

After screening the lists of pathogens and toxins and their methods of attenuation, a "FAILURE" list was derived. The pathogens included in this list, Table 6, are retained to be used in generating "WORST CASE" probabilities, should all methods of attenuation fail.

The same screening was applied to the list of toxins. It was determined that none may be retained in a "FAILURE" list. The toxic substances which are being examined in this study may only be attenuated by one or two of the possible three types of treatment. Because they have fewer means of control, toxic substances are more subject to treatment system failure.

TABLE 6

PATHOGENS POTENTIALLY PRESENT ONLY IN A WORST CASE SITUATION

Absidia corymbifera
Absidia ramosa
Actinomyces keratolytica
Aspergillus flavus

Aspergillus fumigatus
Aspergillus nidulans
Aspergillus niger
Aspergillus restrictus

Aspergillus terreus
Bacillus cereus
Bacteroides spp.
Basidiobolus haptosporus

Blastomyces dermati+idis
Brodetella spp.
Bordetella parapertussis
Clostridium perfingens

Dermatophilus congolensis
Enterobacteriaceae
Escherichia coli
Fuscobacterium

Geotrichium candidium
Haemophilus aegyptius
Haemophilus influenza
Listeria monocytogenes

Mycobacterium tuberculosis
Peptococcus spp.
Peptostriptococcus spp.
Proteus mirabilis

Prototheca spp.
Pseudomonas aeruginosa
Pseudomonas pseudomallei
Salmonella spp.

Salmonella typhi
Shigella boydii
Shigella dysenteriae
Shigella flexnei

Shigella sonnei
Shigella spp.
Sporothrix schenckii
Staphylococcus agalactiae

Staphylococcus aureus
Staphylococcus spp.
Streptococcus faealis
Streptococcus pyogenes (Group A)

Streptococcus spp.
Torulopsis glabrata
Vibrio parahemolyticus
Yersinia enterocolitica

Yersinia pestis (Pasteurella)
Yersinia pseudotuberculosis
Zygomycetes (Phycomycetes)

Aerosolization of Organisms and Substances.

The next step was to screen the remaining pathogens and all of the toxic substances to determine which could become aerosolized. The results are shown in Tables 7 and 8.

Essentially the pathogens and toxins which are listed in these tables are those with which cooling device operators should be most concerned. These may be controlled by only one or two means of treatment, if any. Should the appropriate means fail, these organisms and substances may become aerosolized. Further evaluation in the study discusses the aerosol transport of, and potential health effects on plant, animal and human life from these pathogens and toxins.

Complete discussion of the treatment methods and aerosolization of each pathogen and toxin is found in the Catalogue of Aerosol Drift Health Hazard Assessment, Appendix A. (Volume II)

TABLE 7

SCREENED PATHOGENS CAPABLE OF BECOMING AEROSOLIZED

Actinomyces israeli
Actinomyces spp.
Bacillus anthracis
Bacillus subtilis

Brucella abortus
Brucella canis
Brucella melitensis
Brucella suis

Candida albincans
Candida spp.
Cladosporium spp.
Clostridium botulinum

Clostridium tetani
Coccicioices immitis
Conidiobolus coronatus
Corynebacterium spp.

Corynebacterium ulcerans
Cryptococcus neoformans
Histoplasma capsulatun
Mucor pusillus

Mucor ramossissimus
Mucor spp.
Mycobacterium spp.
Nocardis asteroides

Nocardia brasiliensis
Nocardia caviae
Phialophora spp.
Pseudomonas aeruginosa

Pseudomonas mallei
Rhinocladiella spp.
Rhizopur arrhizus
Rhizopus oryzae

Streptococcus pneumoniae
Streptococcus pyogenes
Var. nematodes, protozoans and Viruses

TABLE 8

TOXINS CAPABLE OF BECOMING AEROSOLIZED

Acetone	Endrin and metabolites
Acrolein	Halomethane
Acrylonitrile	Heptachlor and metabolites
Arsenic and compounds	Mercury and compounds
Asbestos	Methyl Ethyl Ketone (Butanone)
Benzene	Napthalene
Cadmium and compounds	Nitrites
Carbon Tetrachloride	Nitrobenzenes
Chlordane	Nitrophenols (m,o.p)
Chlorinated Ethanes	Nitrosamines
Chlorinated Ethylenes	Pentachlorophenol
Chlorine	Phenols
Chloroform	Secondary Amines
2-Chlorophenol	Selenium and compounds
Cyanides	Styrene
2, 4 - Dichlorophenol	Toluene
Dieldrin	Vinyl Chloride
2, 4 - Dimethylphenol	

RESULTS OF TASK II - TRANSPORT

The function of this task is to provide the necessary information for determining the potential for the transport of pathogenic organisms and toxic substances via atmospheric dispersion of drift produced by cooling systems. The function of a cooling system is to move waste heat from a primary system to a heat sink, usually air or water, where the heat is dissipated. Of the many types of cooling systems, the ones that produce drift utilize evaporative cooling where heat is dissipated to the atmosphere by evaporation of a portion of the water used for cooling. The vast majority of evaporative cooling systems utilize cooling towers.

In the process of circulating water through a cooling tower, a small percentage of the water splashing over the fill becomes entrained in the exiting air flow. The entrained water is in the form of liquid droplets. These droplets constitute the cooling tower drift and have essentially the same chemical composition as the circulating water. The drift droplets are dispersed into the atmosphere and deposited downwind of the tower. Therefore, if there are pathogenic and/or toxic substances present in the circulating cooling water, these same substances can be transported from the cooling tower into the atmosphere as part of a liquid droplet. A number of droplets reach the ground before they have completely evaporated. Any pathogens or toxins found in the remaining droplets evaporate reaching the ground as dry particles.

In order to evaluate the potential for the transport and survival of pathogenic and toxic substances released in drift it is necessary to know the cooling device and power plant design conditions and the concentrations of pathogenic microorganisms and toxic substances in the make-up water.

Cooling Tower Internal Conditions.

As stated, any one common set of specified internal cooling tower air and water parameters can be duplicated in all types of evaporative cooling towers. Therefore, the air and water conditions that do exist in a cooling tower are primarily dependent on performance criteria specified by the power plant designer, not on the type of cooling tower.

Typical water and air conditions in an evaporative cooling tower used in a large power plant application are as follows:

1. Incoming Air Temperature.

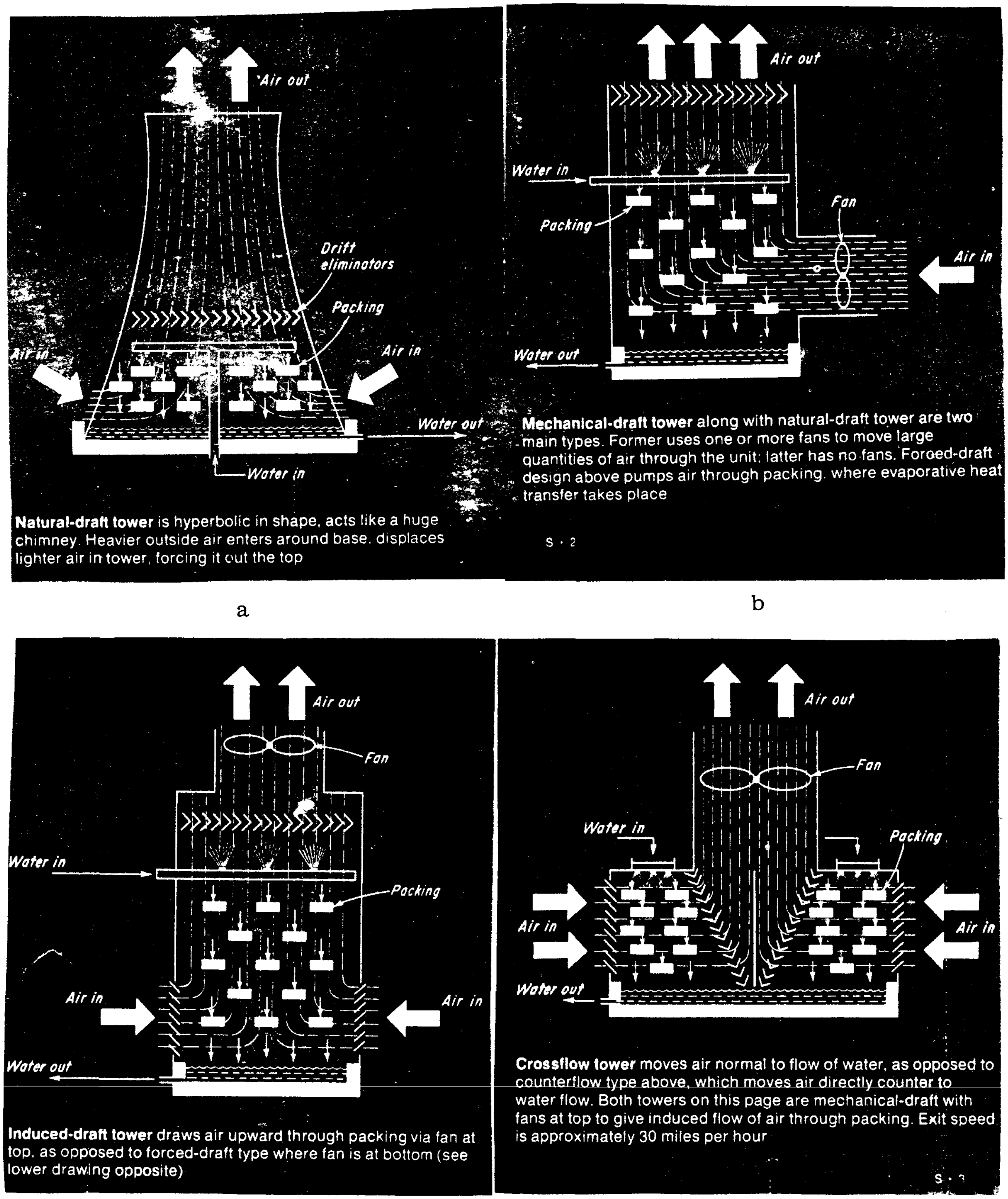
   The incoming air temperature is dependent on geographic location and time of year. Design conditions can range between 19° - 28°C WB (WB = wet bulb). The design condition is the wet bulb temperature which will not be exceeded more than 5-10 percent of the time.

   Toxins and pathogens will survive in these incoming temperatures. The most common temperatures used to incubate bacteria range from 20°C - 37°C.

2. Cooling Tower Plume Exit Temperature and Relative Humidity.

   The temperature of the plume exiting the cooling tower depends on the incoming air temperature and the temperature of the water entering the cooling tower. Values between 28° and 38°C are common, but higher exit temperatures do occur (43°C would not be abnormal). Under most conditions the plume exiting the tower is very near saturation (or 100 percent relative humidity). Therefore, the temperatures given arè dry bulb and wet bulb.

FIGURE 3
TYPICAL NATURAL AND MECHANICAL DRAFT COOLING TOWERS



Natural-draft tower is hyperbolic in shape, acts like a huge chimney. Heavier outside air enters around base, displaces lighter air in tower, forcing it out the top

a

Mechanical-draft tower along with natural-draft tower are two main types. Former uses one or more fans to move large quantities of air through the unit; latter has no fans. Forced-draft design above pumps air through packing, where evaporative heat transfer takes place

b

Induced-draft tower draws air upward through packing via fan at top, as opposed to forced-draft type where fan is at bottom (see lower drawing opposite)

c

Crossflow tower moves air normal to flow of water, as opposed to counterflow type above, which moves air directly counter to water flow. Both towers on this page are mechanical-draft with fans at top to give induced flow of air through packing. Exit speed is approximately 30 miles per hour

d

SOURCE: (ELLIOT, 1973)

Again these temperatures are within the optimal range of incubation temperatures. The most common temperature used to incubate total coliform bacteria is 35°C; and 45°C for fecal coliforms. The toxins with which we are concerned should remain stable.

3. Plume Exit Velocity.

   Mechanical draft towers emit drift at the rate of 35 ft/sec. Natural draft towers give off plumes at the approximate rate of 5 ft/sec. It is at these speeds that pathogens or toxins entrained in the drift will be emitted.

4. Cooling Tower Exit Water Temperature (cold water temperature).

   This temperature is in practice the same as the temperature of the water in the cooling tower basin. Since the design cooling range of most large towers is 11°C - 17°C, the cold water temperature is usually between 32°C - 38°C, a favorable range for most bacteria. This is not expected to affect chemical substances.

Relevant Power Plant Design Information.

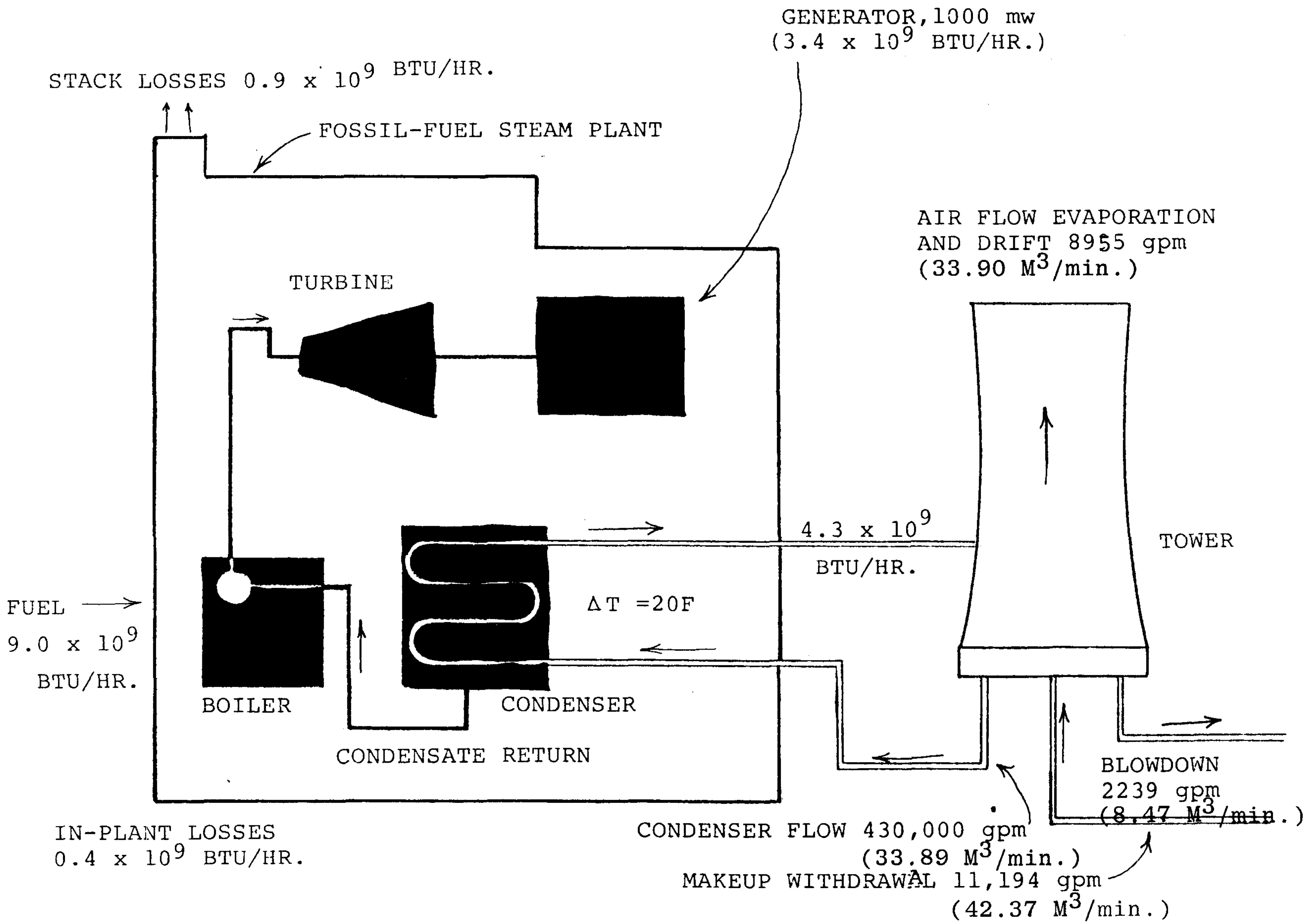
Simplified flow diagrams for typical 1000/MW fossil-fuel and nuclear power plants are given in Figures 4 and 5. The following concepts are pertinent to our discussion of tower design parameters.

1. The circulating water (i.e. the water flowing from the cooling tower to the condenser and back to the cooling tower) never comes in physical contact with the main steam from the turbine or the condensate return.

   Although temperatures do exist in a typical power plant which would thermally destroy pathogens, since the circulating water is not exposed to these conditions, any pathogens present, will not be destroyed by exposure to extreme heat.

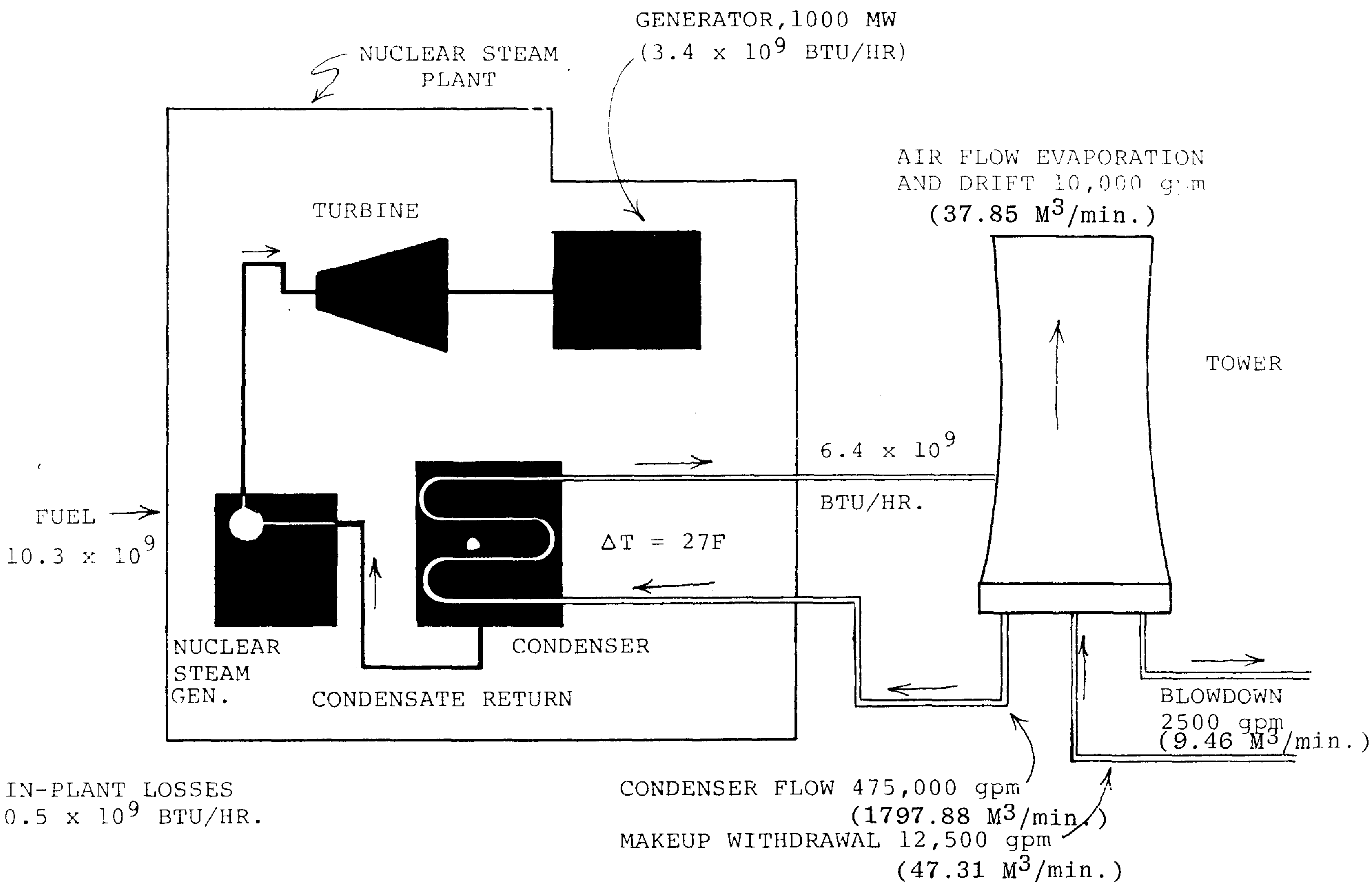
2. The time it takes for the circulating water to make one "round trip" (i.e., from the cooling tower basin to the condenser, back to and through the cooling tower) can vary between 2.5 minutes and approximately 2 hours. This is dependent on the size of the tower basin.

   If pathogens are capable of surviving, and toxins remain stable in water, whether they are exposed for two minutes or two hours should have no effect.



FOSSIL-FUEL STEAM ELECTRIC PLANT USING HYPERBOLIC TOWER HAS A HEAT BALANCE AS SHOWN FOR 1000-MW CAPACITY

FIGURE 4



NUCLEAR STEAM-ELECTRIC PLANT USING HYPERBOLIC TOWER HAS A HEAT BALANCE AS SHOWN FOR 1000-MW CAPACITY.

FIGURE 5

3. The amount of water released as drift is approximately 0.005 percent of the circulating water flow. In a modern cooling tower the drift rate can be as low as 0.001 percent. The amount of water released through evaporation is approximately 2.0 percent of the circulating water flow. The amount of water released as blowdown is approximately 0.5 percent of the circulating water flow. The amount of make-up water (i.e., water usually taken from a river, lake or ocean to replace the water losses given above is approximately 2.5 percent of the circulating water flow.

   These factors may be used in calculating the water loss through drift emission. If the concentrations of pathogens and toxins in the water are known then one can roughly calculate the quantity of these agents emitted in drift.

4. The time that the circulating water is actually circulating through the condenser is on the order of 10-20 seconds. The temperature of the saturated steam entering the condenser is typically about 103°C. The temperature of the condensate return is approximately 88°C - 93°C.

Chemical Treatment of Circulating Water.

A large range of treatment chemicals are available today to meet the four major categories of cooling water problems - corrosion, scale and deposits, fouling, and microbiological growth. Some of the major chemicals used in cooling tower circulating water treatment are identified in Table 9. These are among the candidates for consideration in this study.

The most commonly used chemical corrosion inhibitors are chromates, polyphosphates, zinc, molybdenum, ferro-cyanides, and organics. Chromic acid and its salts provide the base for the most popular and cost/effective corrosion inhibitors in use today. The chromates, considered anodic inhibitors, are often formulated with other inhibitors such as zinc, molybdenum and phosphates. The discharge of chromate, in its hexavalent state, is likely to be severely restricted as we proceed into an era of greater regulatory control and enforcement. The most commonly accepted effluent guideline limits plant chromate discharges to 0.05 mg/l as hexavalent chromium and total chromium to 1.0 mg/l and less in many individual situations.

At the present, chlorine is the most popular oxidizing agent used to control microbiological growth. Chlorine is usually batch fed; an average application might be 0.5 mg/l chlorine for one-half hour every four hours.

TABLE 9

COMMON WATER TREATMENT CHEMICALS

Chemical	Purpose	Concentration
Chlorine (usually batch fed)	microbiocide	1-2 ppm free chlorine for 2-4 hours
chromates	corrosion inhibitor	20-40 ppm
zinc	used in conjunction with chromate	2-3 ppm
Phosphates	corrosion inhibitor (substituted for chromates)	4-6 ppm as total phosphate
Polymers (e.g. poly acrylic acids)	silt dispersion	5-10 ppm
Phosphonates	scale control	5-10 ppm

The phosphonates represent a relatively new and extremely useful class of scale control agents. Several types of these compounds may be found in general cooling water scale control use. Among the most popular versions is an aminomethylene-phosphonate compound that employs the highly stable carbon to phosphorus bond.

Some of the commonly used scale inhibitors are polyphosphates, phosphonates, phosphate esters, polyacrylates, and sulfonated polystyrenes. In addition to being classified as corrosion inhibitors, the polyphosphates may also function as scale inhibitors at "threshold" levels. It is thought that polyphosphate is adsorbed on the growing face of calcite crystals, aborting normal growth patterns and reducing the hard scale normally associated with precipitating calcium carbonate.

Transport of Toxic Substances as a Function of Drift Characterization.

Cooling tower drift is defined as mechanically entrained water droplets which are generated inside the cooling tower and carried along with the air flowing through the tower and exhausted to the environment. (Chen *et al*. 1977) As defined, these water droplets have essentially the same chemical composition as the circulating water in the cooling tower. Therefore, toxic substances would retain the same concentrations in drift as in the circulating water.

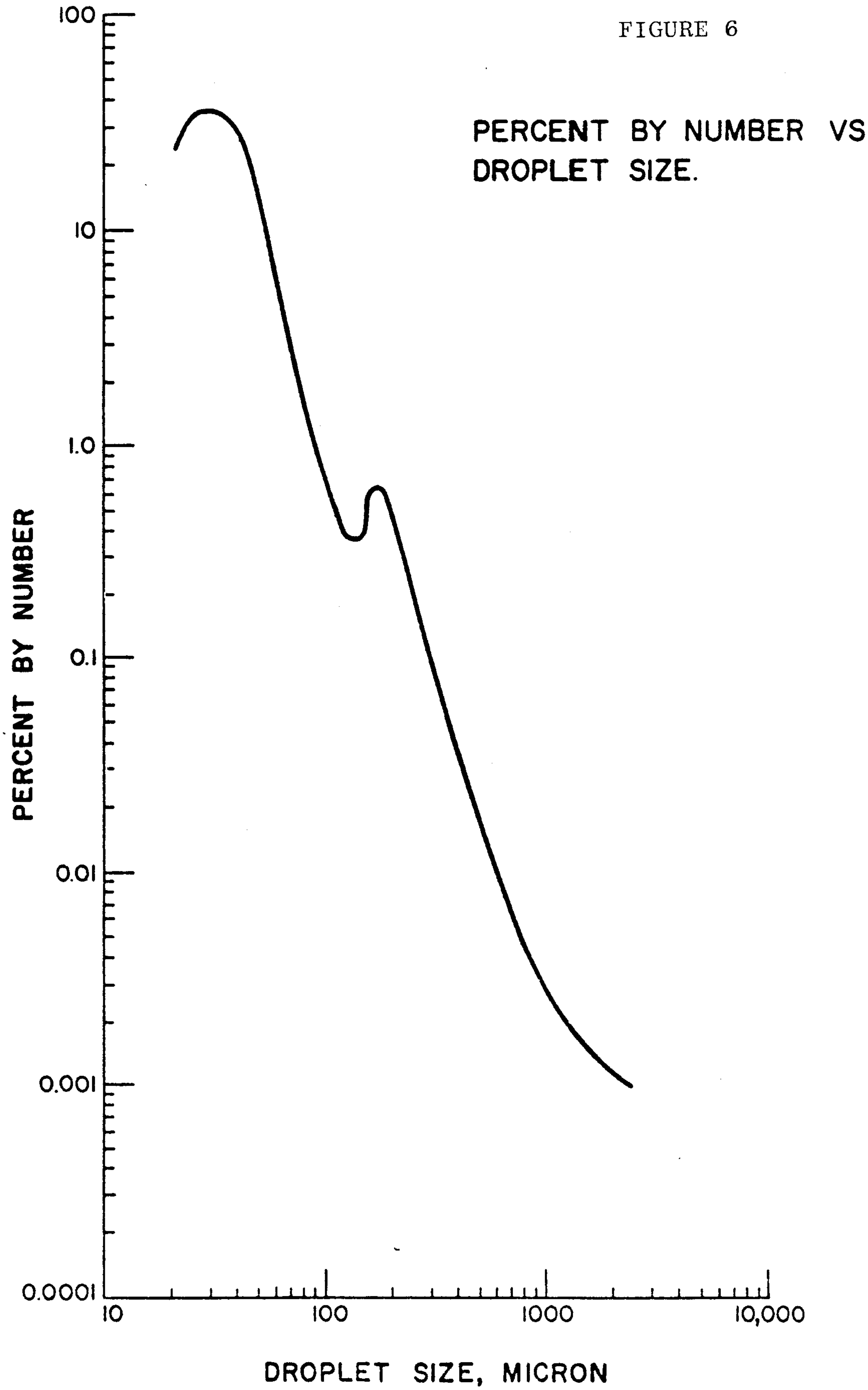
Most drift loss guarantees are quoted as a percent of the circulating water rate with a tacit implication that the drift impurity level is the same as that of the water circulated. We differentiate between drift and the liquid water added to the air due to condensation during the cooling of the tower plume since condensed water is "pure" water. Evaporated water is not objectionable from the standpoint of adding an impurity to the environment. However, the addition of moisture, contributing to a change in relative humidity, may be undesireable. In the evaluation of drift and its potential environmental hazard, we are ultimately interested in the total quantity of drift droplets discharged to the environment, their chemical impurities, and the subsequent behavior of this drift as it interacts with the environment.

To assess the environmental significance of drift it is necessary to establish the actual total drift emission rate from towers of the type found in industry today. The drift particle size and mass distributions must be determined before the dynamic and thermodynamic behavior of the drift as it interacts with the environment can be evaluated.

Particle Size and Mass Distribution.

Figure 6 presents the drift droplet size and mass distribution respectively at the stack discharge based on field tests. (Wistrom and Ovard, 1973). Note that these tests were run on towers where the total drift loss was measured at 0.001 percent of the circulating water rate and therefore, are representative of the current state of the art of drift eliminator designs.

FIGURE 6


PERCENT BY NUMBER VS
DROPLET SIZE.
PERCENT BY NUMBER
100
10
1.0
0.1
0.01
0.001
0.0001
10
100
1000
10,000
DROPLET SIZE, MICRON

KEY TO FIGURE 6

SIZE AND MASS DISTRIBUTION OF DRIFT PARTICLES

DROPLET DIAMETER (MICRON)	% OF SAMPLE BY NUMBER	% MASS BY DROPLET SIZE
22	24.0	0.43
29	36.0	1.49
44	26.0	3.76
58	6.3	2.09
65	4.0	1.86
87	1.4	1.56
108	0.67	1.43
120	0.43	1.26
132	0.28	1.09
144	0.26	1.32
174	0.65	5.81
300	0.11	5.04
450	0.027	4.17
600	0.011	4.01
750	0.0055	4.00
900	0.0033	4.03
1050	0,0024	4.57
1200	0.0019	5.46
1350	0.0016	6.80
2250	0.00095	17.99
2400	0.0010	21.83

Examination of these results reveals several important aspects of drift. First, it is noted that the exhaust drop size distribution is bimodal with peaks in the 35 micrometer and 200 micrometer size ranges respectively. In contrast, natural atmospheric aerosols exhibit a unimodal size distribution. This difference is not surprising when one considers that the air entrained drops in a cooling tower are both generated and removed by mechanical means within a few seconds. Secondly, whether bi-or uni-modally distributed the droplet sizes are capable of carrying two to thousands of particles or bacterium in each droplet.

Fall Velocity of Entrained Droplets

The terminal fall velocity of a drop is established when the aerodynamic drag force is equal to the weight of the drop. It has been shown that larger drops are not spherical, and in fact experience a marked flattening on their lower surface which materially affects fall velocity. The fall velocity drop size relationship is shown in Figures 7 & 8. Droplets smaller than 100 micrometers have fall velocities which are extremely low, indicating that weight of these small drops has a minor influence on their dynamic behavior. Thus, their path and position and that of entrained toxins and pathogens will be primarily governed by aerodynamic forces; most important of which are wind, buoyancy of the exhaust plume, and vertical eddies or turbulence in the atmosphere. Plume buoyancy and vertical atmospheric turbulence will tend to keep these small droplets in suspension for an extended period. The small droplets will essentially follow the plume path and their concentration at any point downwind will be governed by atmospheric dispersion. If the atmosphere is cold, the exhaust air is rapidly cooled and becomes super-saturated. The small drift droplets and entrained particles that remain entrained in the exhaust vapor act as condensation nuclei and tend to grow in size as long as this supersaturated condition remains.

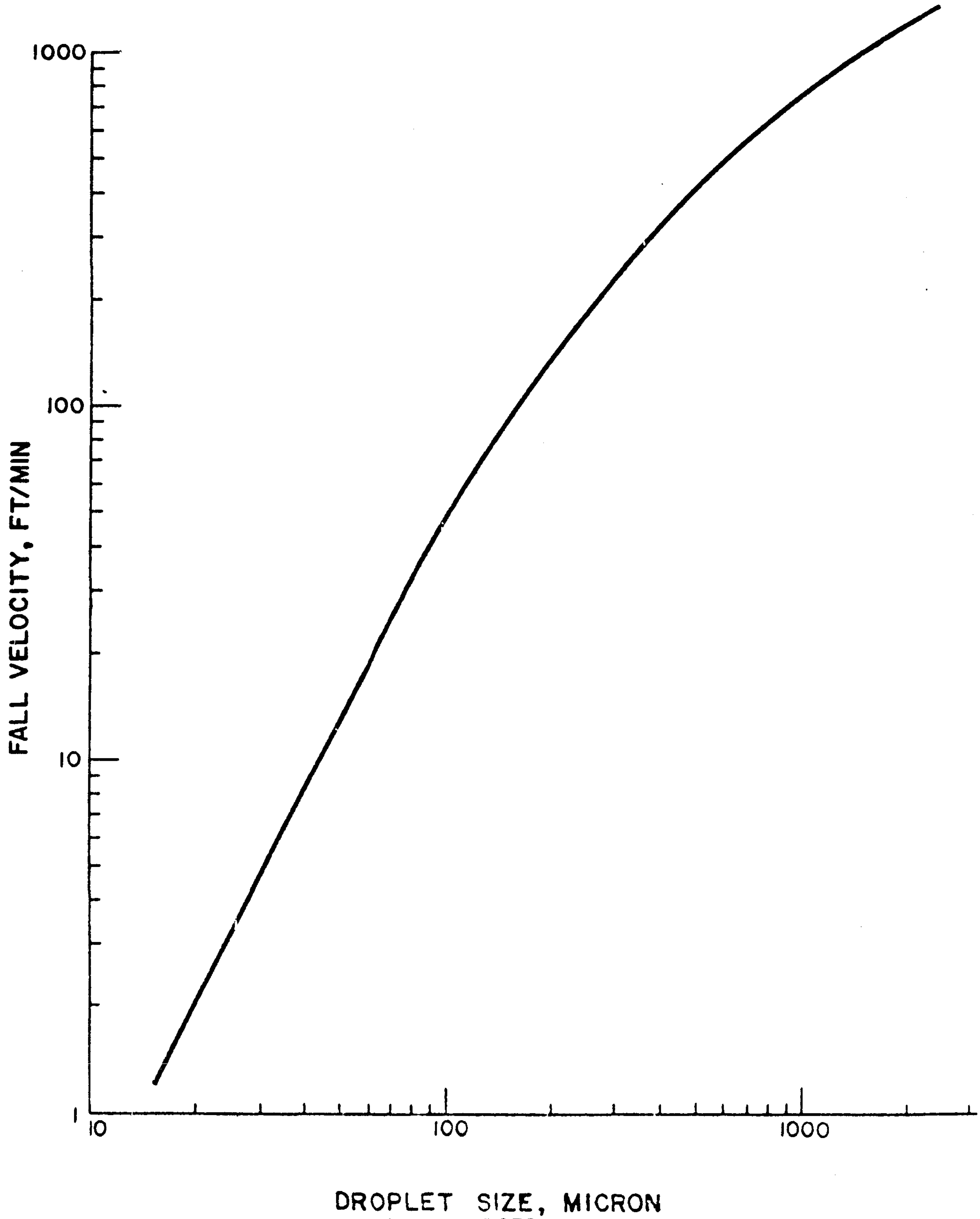
Figure 6 also shows that a few drops in the 1000-2400 micrometer range are present in the exhaust air. Even a casual field observation shows that water droplets in this size range are emitted from a cooling tower since they are clearly visible and easily detected. Field observations and drift size tests conducted directly behind the drift eliminators showed that most of these large droplets are generated in the tower plenum area where impinging drift and vapor condensation accumulates on structural members. Some of this collected moisture is eventually reentrained as larger droplets.

Drift Physics as a Function of Cooling Tower and Power Plant Design Conditions.

In an evaporative cooling tower, the water containing the

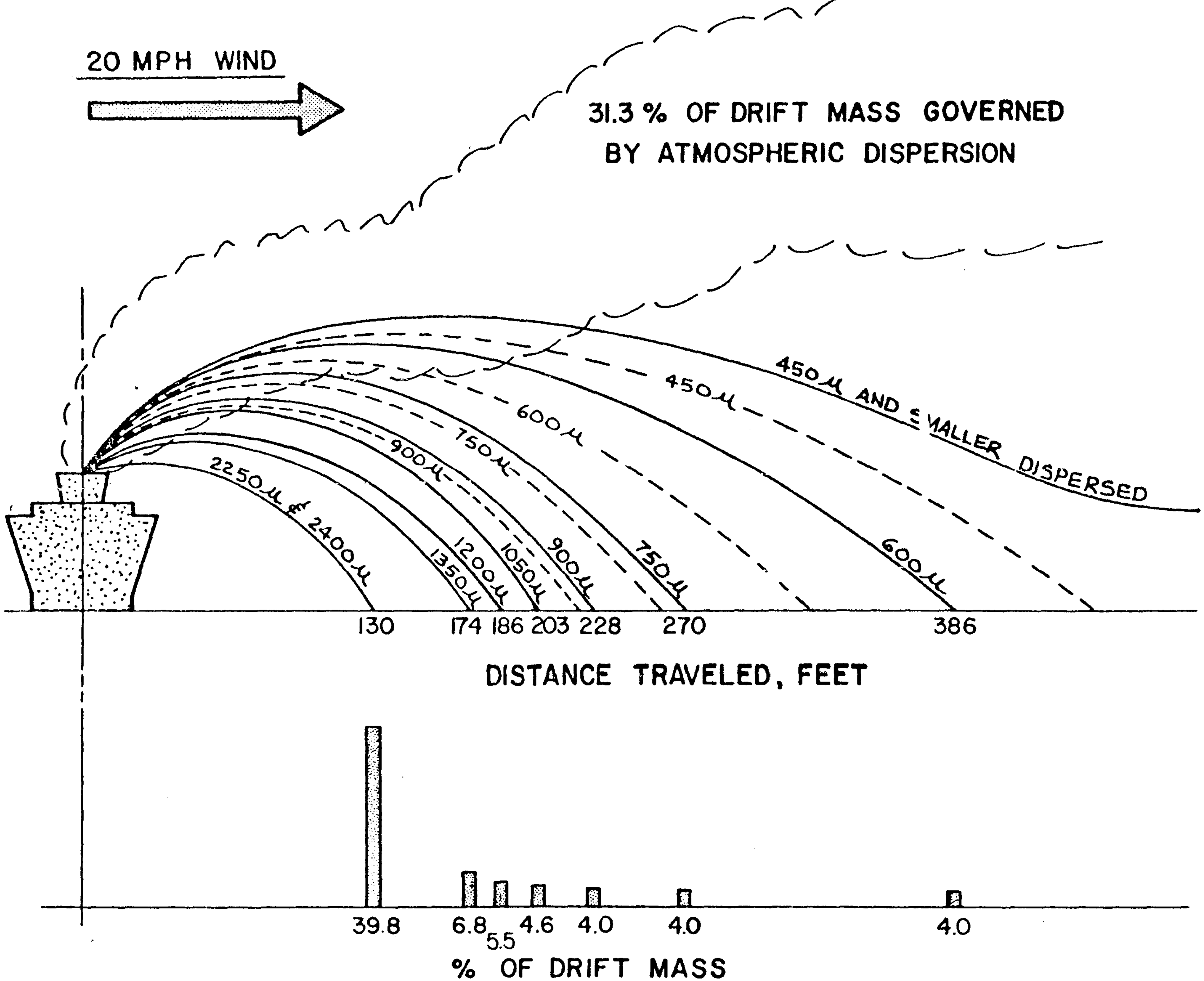
FIGURE 7

FALL VELOCITY OF WATER DROPS AS FUNCTION OF SIZE



SOURCE: Wistrom and Ovard, 1973

FIGURE 8



SOURCE: Wistrom and Ovard, 1973

waste heat comes in direct contact with the ambient air flowing through the tower. The various types of cooling towers are classified by the method used to create the air movement through them. In natural draft towers, air movement is induced by a large chimney utilizing the density difference between the air inside and outside the chimney. In a mechanical draft tower air is moved by fans; either the induced draft type (ID) that pulls air through the tower or the forced draft type (FD) that pushes air through the tower. Figure 3 (a-c) shows a typical natural draft tower and an induced draft and forced draft mechanical draft cooling tower.

Towers are further classified by the relative flow directions of the air and water in the tower. In a crossflow tower, the air flows perpendicular to the falling water (see Figure 3 (a)). In a counterflow tower the air flows vertically upward, counter to the falling water (see Figure 3 (b, c)).

However, the water and air conditions that exist in a cooling tower are dependent on the performance criteria specified by the design engineer, not on the type of tower or its air flow direction. Any one set of specified internal cooling tower water and air conditions can be duplicated in any of the types of cooling tower described above. The choice of cooling tower is usually made on the basis of economic and environmental considerations rather than on the basis of achieving certain design conditions.

The results presented here are considered typical for most drift eliminator designs. However, variations in the plenum environment and drift eliminator design will have a significant effect on the discharge drop size distribution. The older drift eliminator designs are characterized by the presence of more of the larger drops which appreciably increase the total drift loss and dispersion of a greater quantum of toxins and pathogens.

Figure 9 is a drift droplet size distribution after Chen, (1977) averaging 5 different sets of drift dots each for natural draft towers and mechanical draft towers. The only major difference between them is the maximum drop capable of being supported by the plume exit velocity.

Condensation Nuclei

Under ambient atmospheric conditions, natural cloud droplets are formed by the condensation of water vapor onto microscopic particles or condensation nuclei.

In the past, the actual size of these nuclei had only been determined by indirect methods. Recently electron microscopic measurements have been utilized. Presently, condensation nuclei are classified into three size groupings; Aitken, Large and

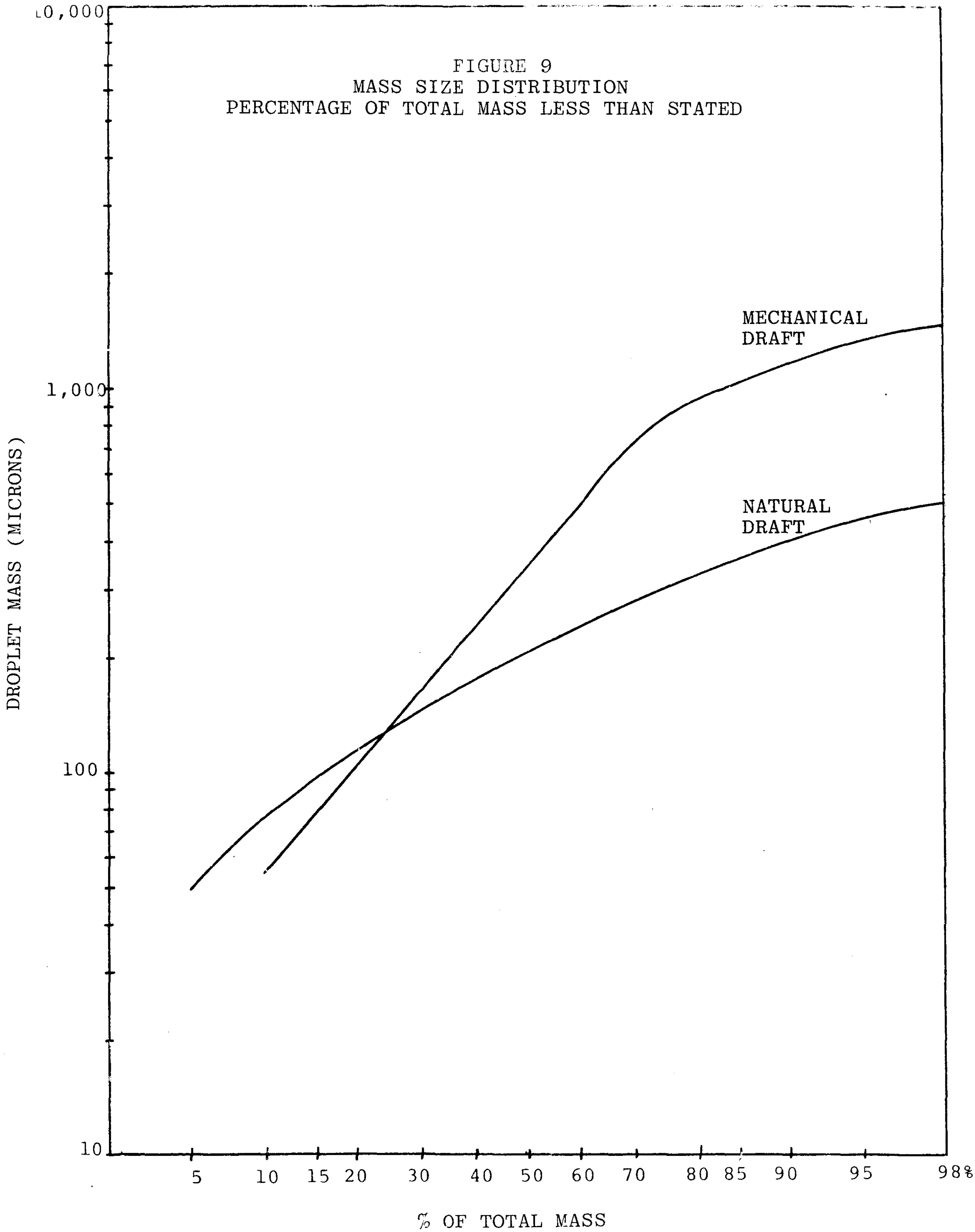


FIGURE 9
MASS SIZE DISTRIBUTION
PERCENTAGE OF TOTAL MASS LESS THAN STATED
MECHANICAL DRAFT
NATURAL DRAFT
DROPLET MASS (MICRONS)
10,000
1,000
100
10
5
10
15
20
30
40
50
60
70
80
85
90
95
98%
% OF TOTAL MASS

Giant. The size range for each of these classifications is found in Table 10.

Aitken nuclei are the most numerous type in aerosols. Their concentration exceeds that of large nuclei by 2.0 or 2.5 orders. The concentration of giant nuclei is insignificant, on the order of several nuclei per liter of air. The mass of individual nuclei varies between 10^{-15} and 10^{-11} g. Giant nuclei may have a mass as great as 10^{-8}g (see Table 10). Pathogenic and toxic particles, should they form condensation nuclei would constitute aitken nuclei.

Given an initial distribution of particles of every size, particles whose radius is $> 10^{-2}\mu$ become attached to larger particles due to Brownian motion. Those particles with radii greater than 20μ are sufficiently heavy to precipitate out. Both processes result in a distribution of particle size with fixed upper and lower limits. Between these upper and lower limits, the mass is distributed fairly evenly.

Condensation Nuclei Composition

The nature (chemical composition) of condensation nuclei is usually studied via the chemical and spectral analysis of samples of raindrops and cloud droplets. Analysis of rainwater shows the following average composition:

1 mg/l	CI^-
2 mg/l	NA+
3-5 mg/l	CA+
5-10 mg/l	$SO_4 2-$
5-15 mg/l	HCO_3^-

Maximum values in the analysis reached 10-15 times greater than these averages, and minimum values 10-20 times smaller. Other substances were also found in smaller amounts.

Impurities may be captured by raindrops during their fall. Analysis of water obtained from cloud droplets indicates the chemical composition of these nuclei. Analyses of aerosol particles collected in various atmospheric layers was carried out by Junge et. al. Chlorides were present in all samples varying between tenths of, and several mg/l.

The most common nuclei were found to contain compounds of chlorine, sulfur, nitrogen, carbon, magnesium, sodium and calcium. Sodium chloride is very frequently encountered in nuclei.

Various types of bacteria and viruses may act as condensation nuclei. A number of species have been determined to be active ice nuclei. They have been observed to initiate ice in supercooled water at -1.3°C in concentrations of up to 10^8 nuclei active at-5°C per cubic centimeter of culture. Species

TABLE 10

CHARACTERIZATION OF CONDENSATION NUCLEI

SIZE CLASSIFICATION	RADIUS (cm)	CONCENTRATION (cm^{-3})	MASS (g/M^3)
Aitken	$5X10^{-7}$ - $2X10^{-5}$	42500	17.
Large	$2X10^{-5}$ - $1X10^{-4}$	132	25.
Giant	$1X10^{-4}$ - $10X10^{-4}$	2.195	41.4
Giant distribution	$1X10^{-4}$ - $2X10^{-4}$	2.08	23
	$2X10^{-4}$ - $3X10^{-4}$	0.09	4.2
	$3X10^{-4}$ - $5X10^{-4}$	0.02	5.1
	$5X10^{-4}$ - $10X10^{-4}$	0.005	9.1

that have been specifically identified are *Pseudomonas syringae*, *Pseudomonas fluorescens* and *Erwinia herbicola*. Two other species have not been specifically identified although they have been shown to be active nuclei. Many other species have been tested for their ice nucleating ability, producing negative results.

Condensation and Drop Formation

The essential physics of condensation of water vapor onto acceptable nuclei includes surface tension characteristics, hygroscopic effects, the rate of diffusion of water vapor to the droplet and the rate of conduction of latent heat away from the droplet.

The most important factor involved in the formation of clouds is chilling of humid air, which can happen due to the following causes:

1. adiabatic expansion of air on vertical ascent,
2. turbulent transfer,
3. radiation (radiative chilling).

Cooling of air during adiabatic expansion involves a reduction in pressure. The main factor here is the movement of air into higher atmospheric layers. Average daily drops in atmospheric pressure (5-6 mb/day) chill each layer of air by 1-2° each day. Vertically ascending air, containing unsaturated water vapor, is cooled adiabatically by 1° for each 100 m of ascent.

When convection is well developed the air may rise by a height on the order of kilometers. This would result in a very strong cooling trend. Chilling of the air by turbulent transfer and mixing depends on the vertical distribution of temperature. In a stable stratification the upper portions of the layer in which turbulent transfer takes place will be cooled. If this cooling is accompanied by the transport of nearly saturated water vapor, its condensation may lead to the formation of stratus clouds.

Finally, the third cause of chilling is radiation. This process is manifested by the cooling of air layers containing a large amount of water vapor together with dust particles, condensation nuclei and smoke particles. It is also evident in nighttime chilling of the upper cloud boundary. Radiation often results in the appearance, and sometimes intensification, of the comparatively thin nighttime sub-inversion clouds.

In nature these processes act in combination. However, the prime factor in cloud formation remains the vertical movement of air.

The act of condensation begins, air is cooled and increases the relative humidity. Before the relative humidity reaches 100% (in terms of a plane surface of pure water), condensation begins on larger, more active nuclei. When the humidity approaches 100%, these have become full sized cloud droplets. Generally, the available water vapor is used by the larger nuclei and the smaller, less active nuclei remain unused. Therefore, the number of cloud droplets is greatly exceeded by the number of available nuclei.

An average active salt nucleus is 1 μ in diameter. When condensation occurs on such a particle, 1 second suffices for it to grow to the size of a small cloud droplet (10 μ). It will take about 500 seconds for the droplet to grow to a large cloud droplet (100 μ) and about 10,000 seconds (or 3 hours) for it to grow to the size of a small raindrop (1,000 μ, or 1mm). It would take several days for a large raindrop to form through condensation only. Thus it is seen that although the condensation process is capable of producing cloud droplets, it is far too slow to produce raindrops of the size actually observed. Therefore, there must be present some mechanism or combination of mechanisms that will cause cloud particles to join and form raindrops. Again, large magnitudes are involved. It will take about one million average cloud droplets to account for the water contained in a large raindrop. The mechanism for increasing the size of cloud droplets to raindrops is called accretion. Accretion occurs when a larger falling drop collides with other smaller droplets. These collisions critically depend on the position and radii of the two drops. Not all droplets that collide with the large drop adhere to it, however this coalescence increases rapidly in effectiveness as the drop size increases in size. This process is more significant than condensation in the ultimate formation of clouds.

Through all of these processes, condensation nuclei of pathogenic organisms and toxic substance particles, and aerosol droplets containing these may be incorporated into larger droplets and clouds. Under these conditions these particles and infectious agents may travel further, potentially governed by the weather patterns as well as local wind currents.

External Conditions Relevant to Drift Behavior

If atmospheric air is cold, the exhausted drift is rapidly cooled and becomes supersaturated. The small drift droplets remain entrained and act as condensation nuclei. As long as the supersaturated condition remains, they become enlarged due to condensation. Drift droplets affected by this phenomenon typically represent less than 12% of the total drift mass. Significant condensation occurs only during brief periods when a prolonged supersaturated plume conditon exists.

The relative humidity of the atmosphere, peripheral to the site of drift emission, may affect aerosol drift transport. In relatively dry areas, any substance or pathogen which is carried by aerosol drift, or constitutes the condensation nucleus of a droplet, will travel over further distances.

In dry areas the moisture in the aerosol or drift will evaporate rapidly. The particle or substance remaining will have a lower fall velocity than the initial droplet. Its transport will not be governed by air currents rather than by the drift itself. The ultimate deposition of these particles will resemble a Gaussian distribution.

In relatively damp areas organisms or substances carried by the aerosol or comprising the condensation nuclei will be transported shorter distances. The droplets will accrete moisture and due to the additional mass, the fall velocity increases. These droplets will fall out of the drift more rapidly, depositing the particles in a more immediate area.

The location and type of cooling device itself will affect local relative humidity. In dry areas, emitted drift will evaporate rapidly creating little if any change in the relative humidity. However, in damp areas, the air is less capable of absorbing this additional moisture. There may be an appreciable difference in the local relative humidity.

Natural draft towers are less likely to affect relative humidity at or near ground level than mechanical towers. Mechanical towers due to their lower height emit drift closer to ground level, and may produce an appreciable difference in the moisture content of the air.

This discussion on relative humidity will be particularly important in our subsequent analysis of direct effects on plants.

Ice-Crystal Process

In damp areas or when the atmosphere is near saturation, there may be problems from precipitation modification resulting from aerosol drift. One manifestation of this problem is the formation of ice crystals. Pathogenic or toxic particles may aid in this process, acting as nuclei.

Observation has shown that cloud droplets do not freeze until the temperature is far below the freezing point. Even as low as -30°C, perhaps one in a thousand droplets freeze. As the temperature approaches -40°C they freeze rapidly and at lower temperatures, clouds consist of crystals.

Liquid water that exists at temperatures below 0°C is said to be "supercooled". Observation has shown that freezing is initiated by a variety of impurities such as organisms or particles of chemical substances. The cloud droplets are exceptionally pure as compared with water on or in the ground.

Layers of cloud that contain a mixture of water droplets and ice crystals are unique because the saturation vapor pressure over ice is lower than over water. Although the difference is small, it is highly significant. In a cloud that consists of both droplets and crystals, the actual vapor pressure will be a compromise between the two saturation pressures. While the air is not quite saturated in respect to water, it is slightly super-saturated in respect ot ice. This, then, will cause water to evaporate from the droplets and vapor to condense on the ice particles. We have here a process which will cause a few cloud elements (those that consist of ice) to grow at the expense of the other elements.

As condensation is initiated on certain nuclei, freezing in undercooled clouds (between 0 and -40°C) is initiated by freezing nuclei, (a particle that will initiate the growth of an ice crystal out of a liquid water under these conditions). Minute ice particles are excellent freezing nuclei, and a number of other particles (natural or man-made) will also cause such growth.

Approximate estimates and observations show that for supersaturations of the order of 10-12% (assuming a concentration of about 100 per cubic meter) the ice crystals may grow within 4-5 minutes the mass of a crystal will equal that of a water droplet with a radius of about 100-200 μ. This rapid growth by sublimation is the reason why even thin (about 1 km thick) ice-crystal clouds with small velocities of rising air currents can produce precipitation bands. These sometimes reach the earth's surface in the form of fine, light snow or rain.

Substantially different conditions prevail when the ice particle occurs in the vicinity of water droplets, as is the case in mixed clouds. Conditions here are very favorable for sublimation growth, especially if there are many more supercooled droplets than crystals in the cloud. When relative humidity in the cloud decreases as a result of the sublimation of water vapor on ice particles, conditions of phase equilibrium over the droplets are disrupted. The latter start evaporating, thereby adding to the supply of moisture for crystal growth. Thus a special process of "transfer" (distillation) of water from supercooled droplets to crystals begins to operate.

In a supercooled droplet cloud rapid growth by distillation of vapor from droplets will set in as soon as ice particles with a radius of the order of 10^{-6} cm appear. As a result the crystals will be able to grow to large sizes until all the droplets evaporate. The initial excess of water vapor condenses upon the crystals and the cloud has been completely transformed into an ice-crystal cloud. Calculations show that the role of this process in the initial growth of ice particles occurring in a medium containing supercooled droplets is very great.

The initial stage of ice-crystal growth by sublimation takes place far more rapidly (10-20 times) than the condensational growth of water droplets. The point at which the process of accretion becomes dominant in the further growth of the ice crystals (r=50-60μ) is reached within a few minutes.

When considering the accretion of ice crystals it should be borne in mind that falling crystals have a greater capture surface than droplets for the same mass. At the same time, their fall velocity is lower than that of spherical particles. This accounts for the faster growth of non-spherical ice crystals by accretion and for the diversity of their shapes. It may roughly be estimated that ice particles grow 5-6 times more rapidly than droplets with the same mass.

Precipitation (Snow) From Cooling Tower Plumes.

During the winter of 1975-1976 significant environmental effects were observed from large natural-draft towers. They produced plumes persisting as far as 70 km in which the supercooled water droplets changed to ice crystals and produced light snowfall. Measurable accumulations of snow were observed on the ground. The falling snow restricted visibility to less than 1600 m close to the ground. From December 1975 through March 1976, this conversion of liquid droplets to ice crystals was observed ten times at several power plants. One of these incidents is described below.

During a period of clear weather on 18 January 1976, from 0755 to 1111 E.S.T., a flight test was conducted in the vicinity of a plant, located 25 km northwest of Charleston, West Virginia. This coal-fired plant has three hyperbolic cooling towers serving three generators totaling 2900 Mw. The weather was cold and clear with temperatures of -12°C near the surface, decreasing to -20°C at 1600 m above ground. The plumes from the three cooling towers merged and rose to form a typical liquid droplet cloud between 900 and 1600 m. The plumes mixed with the smokestack effluent at 400 m. The rise of the cooling tower plume stopped at the base of an elevated temperature inversion, also at 1600 m. The change from supercooled droplets to ice crystals began at 5 km and was complete 11 km downwind of the towers. This ice crystal cloud persisted aloft to a distance downwind of 43 km. Snow began descending from the base of the plume when the conversion from droplets to ice crystals started, and it first reached the ground at 13 km. Snowfall on the ground also continued to at least 43 km. The maximum accumulation of snow (very light fluffy snow) was 2.5 cm.

The ground measurements outside of the plume shadow indicated that the plume trajectory had changed from the initial conditions. The visibility in the clear air was greater than 15 km, but it was restricted to approximately 1600 m in the snow near the ground level, as it would be in a natural snowfall.

Snow from cooling tower plumes reached the ground only at considerable distances from the cooling tower (a minimum distance of 8 km was measured in one case).

In some of the tests, natural clouds were present and snow or snow showers came from them. This natural snow occurred before, during, or after the observations of snow from the cooling tower plumes. Snow was observed from the tower plumes, however, when it was not falling from natural clouds. Moreover, the conversion of the tower plumes from liquid drops to ice crystals sometimes induced a similar change in the natural clouds, creating an obvious "hole" in an otherwise unbroken cloud deck.

We cannot specify precisely the conditions required for induced snow. Observations to date have indicated that induced snow has been associated with low temperatures and with plumes diffusing in relatively stable conditions. The key parameters are air temperatures of -12°C or less and relatively stable diffusion conditions at plume height. The rate of water vapor emission from the towers must be critical also, since this is the source of the additional water vapor.

The artificial snowfall occurs when the atmosphere is cloudy and snow would be expected. In tests, natural snow often coincided with tower-induced snow or occurred soon afterward.

However, the observations made during the winter of 1975-1976 are not unique. A similar snowfall was observed at Oak Ridge, Tennessee, in 1960. The water vapor released from clusters of mechanical draft towers at the gaseous diffusion plant at Oak Ridge approximated that from a large power plant, and the weather conditions were similar to those which induced snow in the Charlestown observations. Agee has also described the artificial inducement of snowfall, but the incident he described appears to have been caused by a seeding effect of particles in supercooled fog.

The details of the Oak Ridge case are also presented here. The snow was intermittent and fairly light. Downwind from the cooling towers, snow began falling about 3 miles distant and continued to be deposited noticeably on the ground up to 5 miles. Some very light snow was reported as far as 10 miles from the towers late in the morning, but by noon all activity seemed to have ceased. The srow that was deposited 3 to 5 miles from the cooling towers was normal in appearance with some flakes up to 1/4-inch in size. The snow falling farther downwind was finer in structure and, in the sun, appeared almost crystalline in nature. Since there were no roads perpendicular to the direction of travel of the plume estimates of the lateral distance of snow deposit were not possible. The valley contour, however, suggested a possible width of approximately one mile.

The snow had been falling during the night, or at least prior to sunrise. Between 0800 and 0900 EST there were no clouds outside the affected area. In the area, the clouds ranged from scattered cumulus at 1,000 to 1,500 feet to low stratus (base less than 300 feet) as it snowed. Moisture from the cooling towers rose to an initial height of about 1,500 feet, then, as it progressed downwind, the resulting cloud decended, intermittently reducing visibility on the ground to less than 500 feet. A freezing nuclei detector operating at the time of the snowfall showed no increase of detectable nuclei.

Ground Level Drift Deposition

The drift deposition problem is a complicated one involving several interrelated processes: the dynamics and thermodynamics of drops in a rising plume, the point of which the drops break free from the plume, dispersal by atmospheric turbulence, and possible evaporation in the ambient atmosphere. To make deposition estimates, the source characteristics of the tower such as tower geometry, amount of water circulated, effluent speed, droplet emission spectra, drift rate, and salt concentration, must be known. Calculations must be made of the plume rise, which in part depends on the initial momentum and buoyancy flux and on the ambient atmospheric conditions. Droplet transport, which depends on meteorological conditions such as the atmospheric relative humidity, turbulence, temperature and its gradient, and wind velocity, must be estimated.

Thus, we see then an already difficult problem of modeling plume dispersion becomes considerably more complicated when we attempt to predict deposition of drift emitted with the plume. In addition, at the present time there is no reliable field data on drift deposition so that existing models cannot be evaluated as to their predictive capabilities. Chen and Hanna (1977) compared the results of ten different drift composition models. Typical natural cooling tower input conditions are given in Table 11. The individual results are given in Chen and Hanna (1977). The results of the ten models were averaged, producing the concentration factors in Table 12. By multiplying the concentration factor in Table 12 by the total mass emission rate of the substance of interest (Kg/month), the ground level concentration of the substance is determined. The concentration is that which would be determined by averaging the ten different model predictions using the input data of Table 11.

TABLE 11

MODEL INPUT PARAMETERS FOR CALCULATION OF TABLE 12

Plume initially saturated

Plume temperature at exit from tower, T_{po} = 305°K

Ambient temperature near exit from tower, T_{eo} = 275°K

Tower height = 100m

Tower exit diameter = 60m

Efflux velocity = 4.3 m/sec

Amount of circulating water = 499,338 gpm (1890 m^3/min.)

Drift rate = 2 X 10^{-5}

Water salinity = 3.45%

Wind speed = 4.3 m/sec.

Calculate salt deposition rate for a sector of 22.5°

Frequency of wind direction which blows toward the sector = 1

Ambient relative humidity = 70% (constant with height)

Isothermal ambient atmosphere (slightly stable atmosphere)

Drop size distribution:

Diameter interval	Mass mean diameter for interval (um)	Mass fraction
0-100	50	0.05
100-200	150	0.3
200-300	250	0.4
300-400	350	0.15
400-500	450	0.075
500-600	550	0.025

TABLE 12 TYPICAL* GROUND LEVEL DISTRIBUTION OF DRIFT PARTICLES FROM NATURAL DRAFT COOLING TOWERS

Downwind Distance (Km)	Area of 22½° Sector (Km^2)	Deposited** within Sector (Kg/month)	% of Total Deposition (%)	Concentration** within Sector (Kg/Km^2-month	Concentration*** Factor
.25 - .6	0.058	1246.	2.1	21483.	.3718
.6 - .8	0.055	810.	1.4	14727.	.2549
.8 -1.0	0.071	732.	1.2	10310.	.1784
1.0 - 1.5	0.254	2585.	4.3	10177.	.1761
1.5 - 2.0	0.344	2324.	3.9	6756.	.1169
2.0 - 4.0	2.356	6933.	11.7	2943.	.0509
4.0 - 10.0	16.493	17566.	29.6	1065.	.0184
10.0 - 30.0	157.081	21291.	35.8	135.	.0023
30.0 - 60.0	530.144	5023.	8.5	9.5	.0016
60.0-100.0	1256.638	870.	1.5	0.7	.0001
Total	1963.494	59380.	100.		

* Average of predicted deposition values of ten models, each using the input parameters of Table 1 (see ref. 1).

** Frequency of wind direction which blows toward sector = 1

*** Multiply the total mass emission (Kg/month) from the tower by the concentration factor to immediately determine the ground level concentration (Kg/Km^2) - month) within the distance interval.

A similar analysis was performed for the drift dispersion from a mechanical draft cooling tower. The input data is given in Table 13. The results, given in Table 14 are those predicted by one proprietary model. Therefore, the results are probably not as representative as those given for natural draft towers. A comparison of the results for natural and mechanical draft towers is given in Figure 10.

Aerobiology

The air as a route for the spread of infectious disease has been well documented in microbial and epidemiological literature. It is established, beyond any question, that droplet infection can spread epidemics although the transmission range is relatively short for respiratory diseases.

In recent years, much of the attention on the long range transmission of infectious organisms has been in the area of biological warfare. The information presented here was extracted from unclassified or declassified biological warfare documents, or derived from personal communications with or first hand experience of individuals involved in the subject. Some data, not singled out, had previously been classified or was extracted from classified sources and is now in the open literature, hence the open literature references.

The aerosolization of these wastes via wave action, or other agitation was clearly demonstrated by Claude Zobel (1946) and earlier. Additionally, it has been shown that the air travel and the subsequent dissipation of an aerosol from a given line source while approximating a function of an exponential decay pattern has nevertheless often retained its basic cloud structure and has in this form travelled hundreds of miles due to unique meteorological conditions. (U. S. Army 1966, and Report 219II) However, it must be recognized that due to the nature of the main sources of this data pool that some information has of necessity remained classified.

Data used in this section is from the following sources:

A. Fort Detrick, Maryland. A former United States Army installation dedicated to a variety of investigations dealing with many aspects of microbiological survival, metabolism, destruction and disease prevention.

B. Dugway Proving Grounds, Utah. A chemical warfare site still in existence, that has in the past been used for testing of biological and chemical agents in a variety of forms.

TABLE 13

MODEL INPUT PARAMETERS FOR CALCULATION OF TABLE 14

Cooling Tower Parameters

Cooling Tower Diameter (M)	16.6
Cooling Tower Height (M)	18.21
Plume Exit Velocity (m/sec)	9.35
Circulating Water Flow Rate	717900 gpm (2717.26 M^3/min)
Drift Rate (%)	.008
Plume Exit Temperature, dry bulb (^oK)	297.
Salt concentration (gm/cm^3)	.00135

Particle Diameter - Microns	% of Total Mass Drift
0 - 50	49%
50 - 100	20%
100 - 200	18%
200 - 300	7%
300 - 500	4%
500 & Larger	2%

Ambient Conditions

Wind speed (m/sec)	4.02
Temperature, dry bulb (^oK)	266.
Specific humidity (lbs moisture/lbs dry air)	.00158
Pasquill stability class	4
Frequency of wind direction which blows toward the sector	1

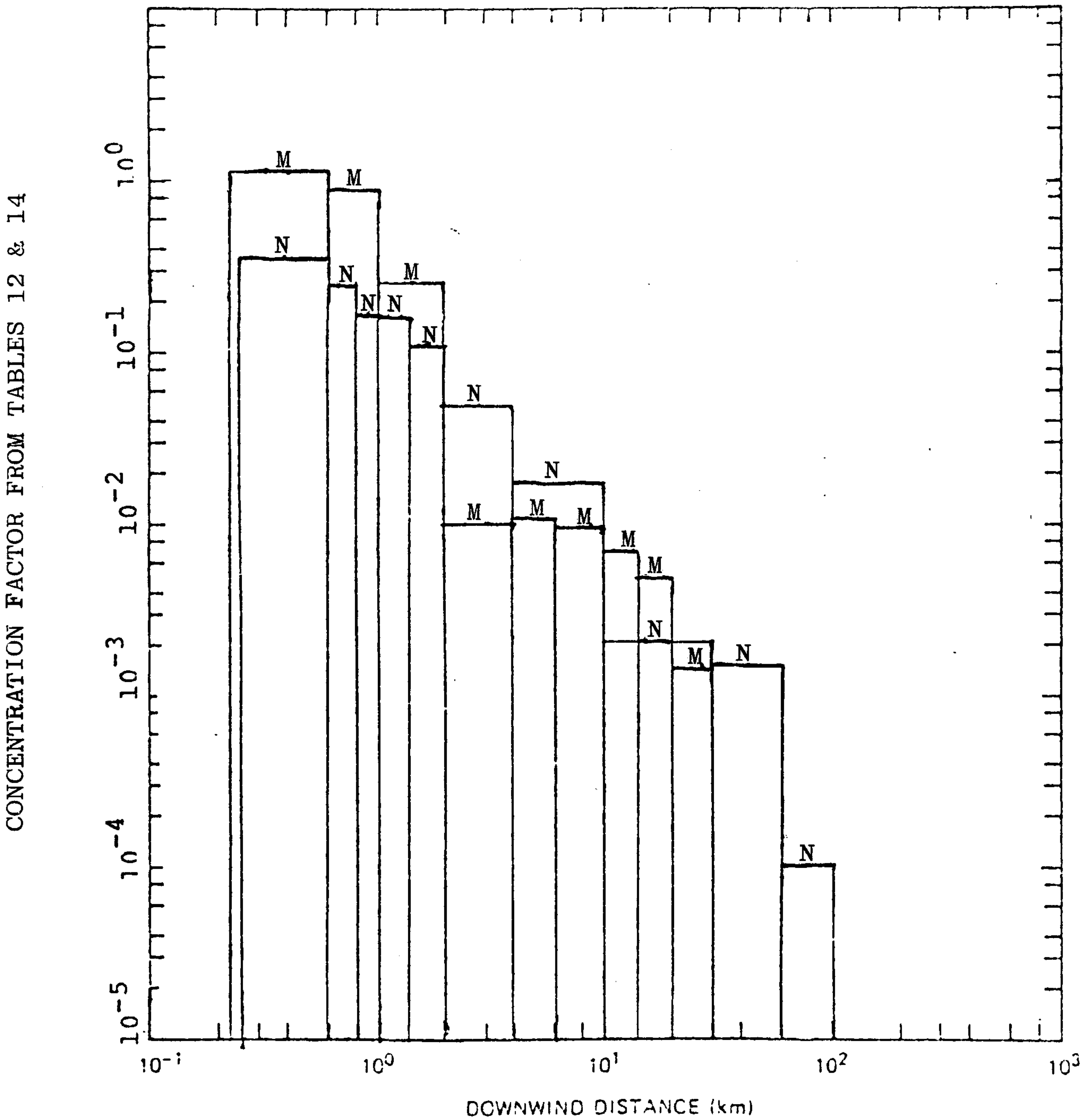
TABLE 14 EXAMPLE* OF GROUND LEVEL DISTRIBUTION OF DRIFT PARTICLES FROM A MECHANICAL DRAFT COOLING TOWER

Downwind Distance (Km)	Area of $22\frac{1}{2}^{o}$ Sector (Km^2)	Deposited** within Sector (Kg/month)	% of Total Deposition (%)	Concentration** within Sector (Kg/Km^2-month)	Concentration*** Factor
.22 - .6	.0612	938.	7.2	15328.	1.1928
.6 - 1.0	.1257	1450.	11.2	11534.	.8836
1.0 - 2.0	.5890	1981.	15.3	3363.	.2617
2.0 - 4.0	2.3562	306.	2.4	130.	.0101
4.0 - 6.0	3.9270	565.	4.4	144.	.0112
6.0 - 10.0	12.566	1570.	12.1	125.	.0097
10.0 - 15.0	24.544	2160.	16.7	88.	.0068
15.0 - 20.0	34.361	2130.	16.3	62.	.0048
20.0 - 30.0	98.174	1865.	14.4	19.	.0015
Total	176.7	12965.	100.		

* Calculated from predictions of combined trajectory - Gaussian drift dispersion model for a round mechanical draft cooling tower.

** Frequency of wind direction which blows toward sector = 1

*** Multiply the total mass emission (Kg/month) from the tower by the concentration factor to immediately determine the ground level concentration (Kg/Km^2-month) within the distance interval.



Calibration Factor vs. Downwind Distance For Examples of Natural (N) and Mechanical (M) Draft Cooling Tower Drift Deposition

FIGURE 10

The major mission was long range field testing in a relatively isolated part of the state.

C. Illinois Institute of Technology, Chicago, Illinois. Its research staff has contracts and grants from a large number of government and private sources. The research is variable and in some areas possibly classified.

D. Army Material Command, Washington, D.C. Involved with the logistics inherent in any aspect of the army mission.

E. Edgewood Arsenal, Edgewood, Maryland. At one time the research center for the study of gas, aerosol, and radiological and chemical properties, and the toxicity and protection from all forms of chemical agents.

F. United States Navy. Via direct or contracted efforts the USN was engaged in collaborative efforts with its sister services to investigate various aspects of biological warfare agents, dissemination, detection and protection.

G. Aberdeen Proving Grounds, Maryland. Primarily the army location for hardware testing.

H. Various contracts were in force at different times with organizations as diverse as Booz Allen Inc. and the University of Pennsylvania.

I. Foreign sources include the Canadian experimental station at Suffield, Canada and the British laboratories at Porton, England.

J. Wright Patterson Air Force Base, Ohio. Site of medical, physiological and toxicological testing in conjunction with the USAF mission. At one time it was involved in long range bacteriological tests from the point of view of detection and prevention of a microbiological attack.

The analysis within this task analyzes organisms in relation to attenuation due to dessication, solar radiation and ambient environmental conditions, and to protective chemical mechanisms. The organisms addressed in this task are listed in Table 15.

Results of Data Search

Serratia marcescens had been indicated as the causative agent in the deaths of individuals following a series of Biological Warfare (B.W.) tests. This occurred in two separate incidents, in 1950 near San Francisco and in 1952 near Fort McClellan, Alabama.

TABLE 15

ORGANISMS REVIEWED FOR AEROSOL SURVIVAL AND TRANSMISSABILITY

1. Rust spores
2. *Bacillus globigii*
3. *Pasteurella pestis*
4. *Pasteurella tularensis*
5. *Coccidioides immitis*
6. *Rickettsia burnetii*
7. *Serratia marcescens*
8. *Sarcina lutea*
9. Venezuelan equine encephalitis
10. *Vibrio cholerae*
11. Enterotoxin B
12. Simian virus
13. Toxic proteins
14. *Klebsiella pneumoniae*
15. *Escherichia coli*

lowered metabolic activity, permitting damaged cells to survive and even repair, lie dormant or even recuperate from the stress.

B. globiggi has also been used in field trials in the dried spore state, in a slurry and in liquid media. (U. S. Army, 1953).

Survial and Destruction

Levin (1966) has cataloged the persistence of a number of microorganisms in a spectrum of soils and climate. Tests of persistence and variability of persistence, have produced a variety of techniques designed to kill microorganisms. These range from extreme dry heat to the use of mustard gas on E. coli (U. S. Army 1965). Ultra violet light has of course been used against some organisms while other forms of radiation have permitted the ultimate recovery of the cell's capacity to produce DNA.

A study by Lighthart (1972) employed vegetative S. marcescens, Sarcina lutea and B. subtilis spores. The aerosols were challenged by varying humidities at 15^{o}C for 6 hours in a carbon monoxide environment that approximated a high urban concentration. The survivability varied from lethal to protected. For example, S. marcescens was killed off four to sevenfold at low (1-25%) RH. Above this at 90% RH, protections was provided. S. lutea varied from protection during the first hour to death during the next 5 hours, topping a seventy fold increase in the RH range of 0 to 75%. The spores of B. subtilis proved to be hardy in almost all environments.

Viruses and bacteria have been inactivated by ozone (Burleson, 1975) but the truly effective result depends on the water being free of almost all organic waste. River water would be a difficult treatment media by this method, due to the ozone demand of the organic material.

Viruses

Virus aerosol survival studies have lagged behind bacteria or plant spores due to the inherent problems of tracing, trapping and identification. As techniques have improved we have learned that some viruses persist in the airborne state in good numbers for 6 or more hours. Using vesicular stomatitis virus (VSV) Watkins et. al. (1965) studied temperature and humidity variables. He concluded that maximum stability occurred at 20% and 80% RH while minimal stability was to be found at 50% RH. Temperature increments from 50^{o}, 70^{o}, 80^{o} and 90^{o}F all increased the decay rate.

Harper (1961) studied vaccinia, influenza and V.E.E. at temperature ranges of 7-12^{o}C, 21-24^{o}C and 32-34^{o}C and concluded survival was inverse to temperature. Coxsackie A21 aerosols at 25^{o}C and 50 to 60% RH experience a 50% decay rate in the first few seconds of aerosolization.

The persistence inherent in many aerosols of virus origin, depends greatly on the initial concentration. A dry cloud containing virus matter exhibits a longer survival. The medium in which the virus is suspended in prior to, and during aerosolization influences the subsequent behavior. The content has been studied but not the mechanism. Inositol for example decreases the sensitivity of viruses to relative humidity, U.V. light and X-ray, thereby artificially prolonging the viability.

Survivability and inactivation of viruses in air was examined at Wright Patterson Air Force Base, Ohio with the following conclusions. (1974).

Adenoviruses, enteroviruses and Newcastle virus were most stable at room temperature and 50% relative humidity. Para influenza and respiratory syncitial viruses were inactivated rapidly as relative humidity shifted. The decrease in relative humidity decreased the survival rate of the adenoviruses and enteroviruses within 2 hours. At moderate (50%) or high (90%) relative humidity the survival rate varied from 7-24 hours. The para influenza, respiratory syncitial and New Castle viruses were inactivated rapidly at high and medium RH and to a lesser degree at low RH.

In the realm of survival, Lefler and Kott (1974) noted the survivability of polio virus Type I in dry sand for 77 days. Wellings extracted Coxsackie B_4, Polio Type II and I, Coxsackie Type A, (Wellings, 1975) Echo (Snow, 1955; Goetz, 1954; Erlich & Miller, 1968) from ground water. The significance of these findings lies in the appreciation of the ubiquity, and persistence of these microbiological entities with regard to survival.

Inactivation had been attempted by Jensen when he exposed aerosols of Coxsackie, influenza, sindbis, and vaccinia to ultra violet during passage through a tube. The kill percentage is expressed in Table 16. Therefore, one may conclude that by avoiding U.V., as in a dust cloud or debris environment, to some degree, the viability of the aforementioned viruses would be protected.

A number of studies were directed at the behavior of organic entities such as viral nucleic acid from Simian Virus 40 (SV40) (U. S. Army, 1956; Akers, 1972) virus protein and RNA of Encephalomyocarditis Virus (EMV) (DeJong et al, 1974), stability of toxic proteins (U. S. Army, 1965), enterotoxin B (U. S. Army, 1967).

The results concerning the survivability and persistence of these viruses varied greatly so that no general conclusion can be drawn.

For example:

SV40 persisted well at 21°C throughout a spectrum of relative humidities from 22 to 88%. At 32°C viability was practically gone within 60 minutes.

At relative humidities of 50% or less the EMV entity lost its viability, yet the RNA of the virus retained its infectivity.

The same illogicity persists with enterotoxin B and other proteins. However, as long as the substance retains its allergenic or toxic property the debilitating effects common to the entity can occur.

Mycotic Sources

Coccidioides immitus is distinctly hydrophobic when in its arthrospore stage (Levine, 1977). As such, it survives well within the wide ranging termperatures, relative humidity, dessication and even light energies of an infinite variety. Soil conditions that provide Na^+, Ca^{++}, SO_4^-, and Cl^- encourage the survival and growth of this fungus. Therefore, any organic mass able to provide these ions can in turn harbor this pathogen. Moisture enhances the mycelial growth. Dispersion by air is easily accomplished since the intact arthrospore is extremely persistent in air and in soil from which it can be wafted.

Rickettsia

Rickettsia burnetii is linked to Q fever. Aerosols of this agent have infected at distances of over ten miles from the point source (Tigertt, 1961).

Many of the effects of variables on microbiological survival in aerosols are tabulated in Table 17. The effects were arrived at during B.W. tests and research. Some of the variables examined include exposure to U.V. light, temperature and relative humidity.

TABLE 16

KILL PERCENTAGE OF VIRUSES EXPOSED TO ULTRA VIOLET RADIATION

100 ft.^{3}/min. flow		200 ft.^{3}/min. flow
99.9	coxsackie	97.5
99.9	influenza	99.9
99.9	sindbis	96.7
	vaccinia	99.9
96.8	adenovirus	91.3

TABLE 17

EVENTS INFLUENCING MICROBIOLOGICAL SURVIVAL

ORGANISM	TEMPERATURE °C	RELATIVE HUMIDITY	COMMENTS OR EFFECTS AND REFERENCES
Adenovirus			91.3% survival in an aerosol; exposed to U.V. light (Jensen, 1964).
	70°	50%	Stable at $22^{\circ}C$ (USDOA, 1974).
		50-90%	Decay directly proportioned to rise in relative humidity (U.S. Army, 1974).
Bacillus globigii	4°		Increased count of organism 100% survival (Leif and Hebert, 1977).
	ambient	ambient	Carried 12 mi. remained viable in field aerosol (U.S. Army, 1953).
Bacillus subtilis	ambient	ambient	Survived in all environments (Lighthart, 1972).
Coccidioides immitis	10°-45°	5-85%	Arthrospore survives well in all exposures (Levine, 1977).
Coxsackie A21	25°	50-60%	Immediate 50% decay (Jensen, 1964).
		100%	Found in ground water. Aerosol passed through U.V. light at rate of 200'/min.; 97.5% decay (Akers, 1972).
Coxsackie B4		100%	Found in ground water (Wellings, 1975).
Echo 1, 7, 11		100%	Found in ground water (Wellings, 1975).

TABLE 17

EVENTS INFLUENCING MICROBIOLOGICAL SURVIVAL

ORGANISM	TEMPERATURE °C	RELATIVE HUMIDITY	COMMENTS OR EFFECTS AND REFERENCES
Encephalomyo-caditis		50%	Virus loses viability (DeJong, 1974).
		50%	RNA retains infectibility.
Enterovirus	70°	50%	Stable at 22°C (U.S. Army, 1974).
		50-90%	Direct relationship between increase in relative humidity and survival.
Escherichia coli	24-30°	40-90%	Survives well; mustard gas affects growth (Dimmick, 1965 & U.S. Army, 1965).
Influenza	7-12° 21-24° 32-34°		Survival is inverse to rise in temperature (Harper, 1961).
			When aerosol was exposed to U.V.; 99% decay (Jensen, 1964).
Klebsiella pneumonia	ambient	ambient	Presence is key to poor environment (Seidler, 1975).
		<50%	Only 1% survival after 24 hours (Goldberg, 1977).
		>50%	Survival increased as relative humidity increased (Goldberg, 1977).
Newcastle virus	70°	50%	Stable at 22°C (U.S. Army, 1974).
		50-90%	Rapid deactivation of virus (U.S. Army, 1974).

TABLE 17

EVENTS INFLUENCING MICROBIOLOGICAL SURVIVAL

ORGANISM	TEMPERATURE °C	RELATIVE HUMIDITY	COMMENTS OR EFFECTS AND REFERENCES
Newcastle virus (Continued)		<50%	Increasing survival rate (U.S. Army, 1974).
Pasteurella Pestis		26-39%	Good survival rate (U.S. Army, 1965).
		61-87%	1 log death rate; actual 90% loss (U.S. Army, 1968).
Pasteurella tularensis	$-40-24^{\circ}$	>75%	Survives well (U.S. Army, 1964).
	$24-35^{\circ}$		Death rate increases linearly (Erlich, Miller, 1968).
	49°		Maximum kill temperature (Erlich, Miller, 1968).
Polio type I		0%	Survived for 77 days in sand (Leffler & KOH, 1974).
		100%	Found viable in ground water (Wellings, 1975).
Polio type II		100%	Found viable in ground water (Wellings, 1975).
Rickettsia burnetii			Proven to cause Q-fever 10 mi. from origin (Tigertt, 1961).
Sarcina lutea	15°	0-75%	Exposed to CO gas; survival varied (Lighthart, 1972).

TABLE 17

EVENTS INFLUENCING MICROBIOLOGICAL SURVIVAL

ORGANISM	TEMPERATURE °C	RELATIVE HUMIDITY	COMMENTS OR EFFECTS AND REFERENCES
Serrata marcescens		90%	Protected viability (Lighthart, 1972).
	-40-32°	20-80%	Increase in death over 32°
	-40-120°	20%	Decrease in relative humidity increased death rate (U.S. Army, 1968 and Dimmick, 1965).
	15°	1-25%	Survived for 6 hours while exposed to CO gas; then 4.7 fold death rate (Lightart, 1971).
		10%	Relative humidity not a factor in survival (Goetz, 1954).
Simian virus (SV)	21°	22-88%	Survived well (U.S. Army, 1965).
	32°	22-88%	Decayed within 1 hour (Akers, 1972).
Sindbis virus			96.7% survival when aerosol was exposed to U.V. light (Jensen, 1964).
Staphylococcus aureus	24-30°	<10%	Survives well (Dimmick, 1965).
Staphylococcus pullorum		15-80%	Survivability increases as relative humidity increases (Dimmick, 1965).
Streptococcus salivarius	24-30°	<10%	Survives well (Dimmick, 1965).

TABLE 17

EVENTS INFLUENCING MICROBIOLOGICAL SURVIVAL (5 of 5)

ORGANISM	TEMPERATURE °C	RELATIVE HUMIDITY	COMMENTS OR EFFECTS AND REFERENCES
Toxic Proteins	25-32°		Retains potency (U.S. Army, 1965)
Vaccinia	7-12° 21-24° 32-34°		Survival inverse to temperature (Harper, 1961).
			Aerosol exposed to U.V. light; 99% decay rate (Jensen, 1968).
V.S.V.	50°, 70°, 80°, 90°	20-80%	Increase in decay as temperature increases (Watkins, et. al.).
	7-12° 21-24° 32-34°		Survival inverse to temperature (Harper, 1961).

RESULTS OF TASK III - DIRECT EFFECTS

The potential direct effects of pathogenic organisms and toxic substances on plants, animals and humans were evaluated under this task. The study of conventional epidemiology and pathology concerns itself with the routes by which infection is acquired, considers the transmission of disease from man to man, that arising from contact with environmental sources, as well as the essential nature of the disease and especially the structural and functional changes caused by it. The potential of a given agent to cause disease in any given population, and the existence and pattern of any ensuing epidemic rests upon a number of variables, but particularly the following:

1. Portal of entry for the disease-causing agent.
2. Portal of exit.
3. Incubation period.
4. Gradient of infection.
5. Mode of spread.
6. Survival in nature.
7. Susceptibility of the population at risk.

Portal of Entry

Since the material released from the tower may be carried in a variety of physical forms and in particles of varying size, with different agents being present in differing quantities, three potential portals of entry must be considered:

Inhalation: Inhalation of airborne or droplet-carried organisms may create invasive disease at any site within the respiratory tract. Large particles and droplets are restricted by normal host defenses to deposition on the mucous membranes of the nose, mouth, pharynx, and upper tracheo-bronchial tree. In this instance, high concentrations of the infecting organism are usually required to produce disease, and the mechanism is usually direct contact. In contrast, smaller particles, 1-5 microns in size, will be inhaled into the distal portions of the respiratory tract, including the terminal bronchioles and alveoli, and these can cause disease with very small numbers of particles, occasionally estimated to be as few as a single particle. This is true "inhalation disease". For those few organisms studied, a balance exists between size of inhaled droplet and numbers of organisms required to transmit disease, making specific quantitative estimates of disease risk impossible, except for the few microorganisms well-studied in defined laboratory models of infection.

Contact: Particles of any size on exposed surfaces may cause disease in several specific areas. Whereas contact of even large numbers of most organisms on normal skin or surfaces is unlikely to cause disease, certain exposed surfaces may be much more susceptible, particularly the following:

1. Abnormal skin or surfaces (sites of burns, abrasions, or open wounds).
2. Mucuous membranes of respiratory tract.
3. Conjunctiva.

Ingestion: Food or water supplies contaminated by cooling-device drift can cause disease in any population ingesting such contaminated materials. In considering the possible role of cooling device drift, primary contamination of food and water supplies, as well as secondary contamination via infection of plants or animals lower down in the food chain must be considered. The risk of both primary and secondary contamination is particularly important for any population ingesting untreated food or unchlorinated water.

Portal of Exit

This is a relatively unimportant facet of this task, and is pertinent to the discussion of secondary propagation of disease through a community. Portals of exit are relevant by providing a means of infecting cooling tower makeup water in the first place. While organisms excreted predominantly by fecal or urinary routes of exit may find their way most readily into polluted river or ground water, virtually any organism in any tissue of any susceptible host, excreted by any route, such as respiratory tract discharges, could, under some natural circumstances, be found there. What is more important, therefore, is the ability of the organism to survive or multiply in such settings.

Incubation Period

This period between first contact of the host with the infecting organism and the development of clinical symptoms plays a major role in determining the shape of epidemic curves, and hence, in the development of appropriate forms of epidemiologic monitoring of the effects of cooling towers. However, consideration of incubation periods is not relevant to this preliminary discussion.

Gradient of Infection

This reflects the proportion of those infected who become symptomatically affected by the disease. It is important in determining the magnitude of an epidemic and in evaluating the public health significance. It is largely determined by the susceptibility of the population and the size of the infecting inoculum. This will become important in determining modes of epidemiologic monitoring, in which the search for asymptomatic infections may become required.

Mode of Spread

The conventional modes of transmission of epidemic disease are:

1. airborne
2. droplet
3. contact
4. food and/or water
5. vector.

Direct or indirect contact with cooling-device drift will involve all these modes of spread, with the possible exception of vector-borne disease. In the discussion of individual infectious agents that follows, droplet-borne diseases are considered under the respective portals of entry of either contact or inhalation disease depending on the anatomic site of impact of the offending agent and the route by which specific disease might be best acquired.

Survival in Nature

This concept is perhaps the most important in determining the risk from exposure to pathogens in cooling device drift. Survival of the microorganisms includes an analysis of what is present in the water sources used to cool the towers, survival of the initial "inoculum" in the highly unnatural thermal conditions of the tower, and in the aerosol produced. These last two considerations will be the most important factors in determining whether or not disease will ensue from the use of water polluted with any potential pathogen. This was of course, discussed within Task II.

Susceptibility of the Population at Risk

This may be the most difficult variable to define quantitatively, as it will differ for each organism and for each population group. For humans the demographic and medical variable that will need to be considered include the following:

1. Age distribution of the exposed population.
2. Racial distribution of the exposed population.
3. Sex distribution of the exposed population.
4. Presence of malnutrition or exposure to other factors that will affect host defense (e.g., malaria, produc-

ing reticuloendothelial system blockade, and thereby increasing susceptibility to Salmonella infection).
5. Prior experience or exposure to the pathogens and toxins involved.
6. Presence of immunologic deficiency states.

Variables to be considered for animals include these:

1. Age distribution of the exposed population.
2. Sex distribution of the exposed population.
3. Presence of malnutrition or other factors that will affect host defense (e.g., weather conditions, breeding cycles, migration and hibernation patterns).
4. Prior experience or exposure to the pathogens and toxins involved.
5. Presence of immunologic deficiency states.
6. Relative position in the trophic levels, and feeding pattern (e.g., herbivore, carnivore, omnivore).

The environmental and physical variables which predispose vegetation to infection or intoxication are more numerous and varied than those for humans and animals. The factors include:

1. Biological variables; including age, stage of development, species and variety of the exposed population.
2. Edaphic variables; soil conditions such as moisture and nutrition content.
3. Climatic factors; e.g. wind speed, temperature, relative humidity, light intensity and quality.
4. Presence of a second pollutant or toxin, which may modify the effect of the first.
5. Quantity of precipitation.
6. Factors of exposure including the concentration of the toxin, duration and frequency of exposure. (Continuous and intermittant exposures of the same dosage will produce significantly different effects).

General statements as to the relative risk of specific organisms or toxins can be found in Appendix B, Aerosol Drift Direct Effects Assessment Catalogue. Analysis of the actual effects on humans, animals and vegetation is included for each specific toxin or pathogen.

Finally it should be recognized that the risk of cooling device drift to a given population involves not only the direct transmission of disease and toxicity but also indirect transmission (to be discussed under Task IV), and transmission of allergens.

Allergens of many types can be considered, but are generally beyond the scope of this report, although several biologic agents can be so involved. Some, by their ubiquity and because the unique environmental situation of the cooling tower might potentiate their growth or transmission, might be particularly important, including:

A. Allergic broncho-pulmonary aspergillosis
B. Thermophilic actinomycetes.

Under these conditions, high concentrations of many other organisms, or antigenic fragments of organisms, might also become important. Among these is transmission of toxic substances which might alter the susceptibility of the population to other organisms, and resultant long-term effects of prolonged contact with unusual chemical or biologic materials.

One particular organism which could not be addressed fully within the format of the Aerosol Drift Direct Effects catalog is Mycobacterium tuberculosis. The general effect of this organism is tuberculosis, a chronic infectious disease. It is normally characterized by the formation of avascular nodules of inflamatory tissue.

The organism is carried and transmitted via aerosol formites while infection may occur through inhalation, ingestion or directly through skin. Inhalation is the most frequent means of infection. The route of entry of the infectious fomites may usually be inferred from the location of the characteristic lesions. Further transmission of the disease may occur from discharges from these areas.

There are three common varieties of this organism, var. hominus, var. bovis, var. avium. Each has a different pathogenicity. The bovine type is progressive and sometimes fatal in cattle. Manifestation in horses is progressive and usually associated with infection in cattle. The disease is also progressive in swine who are highly susceptible and in cats, who are usually infected from tuberculous milk. This type rarely affects sheep, goats, dogs, humans and does not affect birds.

The avian type affects all birds. Due to their lowered resistance to disease, disease occurs mostly in domestic or captivated, wild birds. This type produces chronic symptoms in swine and is progressive in sheep. It is the most common form to affect these animals. Rarely are goats, horses, cattle, dogs or cats affected by the avian variety.

Cattle, swine and cats are resistant to the var. hominus. This type doesn't affect horses, sheep, goats or most birds. Only psittacines are not resistant and their infection is usually associated with tuberculous owners. Dogs may also contract the disease from their owners and it manifests itself in the pulmonary form. Var. hominus is of course, the most common form to affect man.

When large animals contract tuberculosis, cattle normally develop lesions in the lungs and in the cephalic and thoracic lymph nodes. Swine develop lesions in the cephalic and abdominal lymph nodes, and it is sometimes fatal. In sheep and goats, the affected areas are the lungs and thoracic lymph nodes.

In smaller animals, dogs are affected in the thoracic organs and cats, initially in the abdominal organs and later in the lungs. Poultry develop the disease slowly. Initially there is intestinal ulceration and then necrosis and ulceration of the spleen and liver.

Wild animals rarely contract the disease except when associated with humanity, zoos or cattle raising areas. Wild birds commonly develop lesions in the spleen and liver. However, outward signs of infection are variable and may be non-existent. Outbreaks among wild animals involving more than one individual, are usually associated with man. Infection stems from exposure to either infected farm animals or sewage outfall.

Humans are quite susceptible to tuberculous infections but rarely manifest tuberculous disease. Generally the route of entry determines the site of primary lesions. Inhalation produces lesions in lungs and tracheobronchial lymph nodes; ingestion: mouth, tonsils, neck lymph nodes, intestine; skin: ulceration at specific site and regional lymph nodes. After a period of days the infecting organisms spread to all parts of the body.

Most of the tubercle bacilli do not find suitable sites for development. Some remain microscopic foci and may promote infection of bones, joints, lungs and other organs as much as ten years later. Disease due to reinfection usually becomes the chronic pulmonary form. This form is the prime cause for morbidity and mortality.

Man may be regarded as the sole carrier. Animal infection stems directly and indirectly from man, and any residual foci of infection in cattle are eliminated through mild pasteurization.

RESULTS OF TASK IV - INDIRECT EFFECTS

The effects of cooling device drift are not limited to direct reactions to and manifestation of disease from toxins and pathogens. The infection of plant and animal and human populations may either be secondarily transmitted or spread to other members of the community or may lead to interruption of human and animal food sources.

The potential of a given agent to indirectly or secondarily cause disease in any given population and the insuring patterns of infection or intoxification relies on the same variables as discussed under Task III.

1. Portal of entry for the disease-causing agent
2. Portal of exit
3. Incubation period
4. Gradient of infection
5. Mode of spread
6. Survival in nature
7. Susceptibility of the population at risk

Essentially all discussion contained in the previous section holds true and only the exceptions will be noted here.

Portal of Exit

Under this task, discussion of this facet takes on new importance. Organisms excreted from infected individuals, predominantly by fecal or urinary routes of exit and perhaps respiratory tract discharges, may find their way quite readily into polluted river or ground water. Virtually any organism in any tissue of any susceptible host, excreted by any route, could be found in water sources or areas of food cultivation. The ability of the organism or disease to survive, multiply or remain virulent in such settings, determines the potential for its transmission to successive individuals.

Mode of Spread

The five conventional modes listed in the previous task are valid considerations within this section as well. The difference lies in the role of vectors as means of transmission. Vector transmission by definition accounts for one living organism carrying a disease to another non-infectious individual. Vectors act in events such as insect bites (mosquitos transferring malaria); food chain transmission (infected plants; low order animals; herbivores; carnivores; and predators). Other instances include contact with open lesions on infected individuals.

Fomites too, play a major role in indirect effects from cooling towers. Ingestion of water contaminated with waste from infected individuals could spread disease. Plants may harbor pathogens on its edible parts or concentrate toxins in its leaves, fruits or roots, as in tuberous plants. Many small wild animals concentrate toxins in their fatty tissue, or may simply be infected with the disease itself. Inclusion of any of these in a food supply would further spread the infection or offending agent. Prior to pasteurization, milk from infected cows was the major cause of the spread of tuberculosis.

Concentration of people in close quarters, such as in schools, encourages person to person transmission. In recent years winter bouts of influenza have reached epidemic proportions and there have been renewed outbreaks of "childhood diseases" (rubella, chicken pox, measles). Rapid transmission would also occur between animals in farm and breeding settings.

Susceptibility of the Population at Risk

Susceptibility to an infection may increase when transmitted from one animal, plant or human to a like individual due to potentiation. Like individuals are susceptible to like organisms, varieties, even concentrations or innocula. As each individual becomes infected the innocula become more refined to meet the specifications necessary to infect subsequent individuals. Populations are therefore more susceptible to the agent being transmitted.

RESULTS OF TASK V - RECOMMENDATIONS

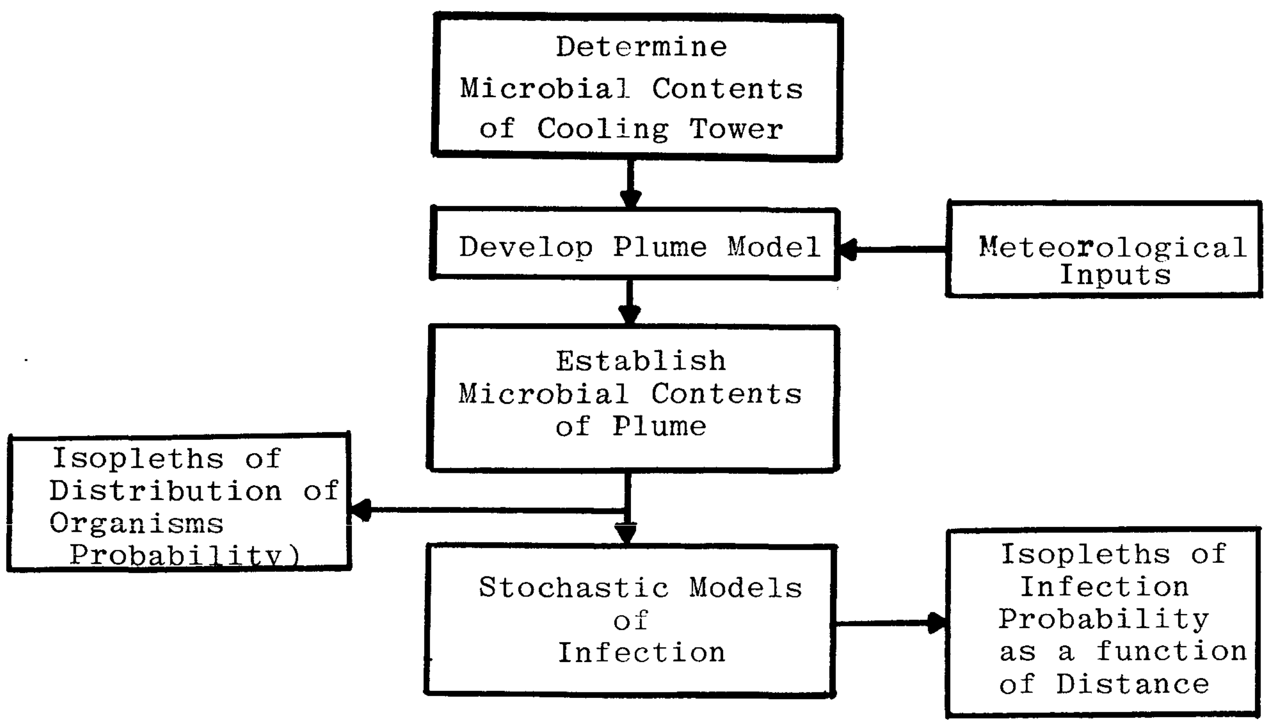
Discussion of the recommendations based on the results of this study, the results of Task V in the scope of the study, may be found in Section 3, Recommendations.

RESULTS OF TASK VI - COMPUTER SIMULATION

A. Introduction

The computer simulation is based on a combination of numerical and Monte Carlo modeling. Basically, the modeling is done in three serial parts for a cooling tower and associated ambient environment that are specified as input parameters. Part 1 developes the microbial environment in the cooling towers based on the data from the consultants. Part 2 develops and distributes the aerosols (micro-microbial environment) from the cooling tower into the environment. Part 3 calculates the microbial environment downwind from the cooling tower, evaluates the possibility of infections based on the results of Part 1 and 2, and prints out results. Figure 11 is a simplified flow chart for the simulation.

FIGURE 11
BASIC FLOW CHART



B. Development of Cooling Tower Microbial Environment

The consultants have developed a list of pathogenic organism that can occur in a polluted water source. This list was used as a basis to establish the microbial content of the cooling tower. To do this, a matrix was established listing each organism from the consultants list versus the following factors:

1. ability to produce disease (epidemiological significance)
2. survival in surface water
3. survival in treated effluent
4. survival in cooling device
5. survival in aerosols
6. integrity in fomites

For each factor a numerical value between 0 and 5 was assigned based on the consultants data. The definitions of these numerical constants are listed in Table 18. Table 19 shows the matrix and the numerical constants assigned for each category, for each organism considered. From the matrix a weighted product for each organism was found as follows:

$$W = \prod_{i=1} a_i f_i$$

Where W is the weighted product, a_i is the weighting factor (0 to 1) for the ith factor and f_i is the numerical constant from the matrix. As a practical initial matter, the weighting factors (a_i) were taken as unity, however, as more information becomes available and it is possible to refine the model, this should be changed. The products were grouped, that is, products with very similar numerical values were considered to be the same and normalized. From these normalized values a histogram was constructed and used as the distribution function for determining the probability that pathogens were present in the make-up water using Monte Carlo methods to evaluate the integral of the distribution function.

The number of organisms present in the make-up water (per unit volume) was modeled somewhat arbitrarily by using the probability from above as the mean of an exponential distribution limited to 10^6 maximum (personal conversation with Dr. H. Freudenthal). This was done by a modified Monte Carlo simulation. Thus, the number of pathogens entering the cooling tower per unit volume of make up water was established. This simulation, was further modulated by including only those results from the exponential distribution when a second selected uniform random variable exceeded the probability value found earlier.

TABLE 18

NUMERICAL CONSTANTS USED IN ESTIMATING PROBABLITIES

OCCURRENCE IN POLLUTED WATER SOURCE

(0) will not occur under any circumstances
(1) rarely occurs
(2) compromised - will occur only if concentration or frequency in surrounding environment significantly increases eg. epidemic, leak from toxic substance storage
(3) will occasionally occur
(4) will frequently occur
(5) will always occur
(x) unknown

SURVIVAL IN A PARTICULAR ENVIRONMENT (SURFACE WATER, TREATED EFFLUENT, COOLING DEVICE)

(0) will not survive under any circumstances
(1) rarely survives
(2) compromised - may survive in this environment only if conditions change eg. type of water treatment, presence of other toxins or pathogens
(3) will occasionally survive
(4) will frequently survive
(5) will always survive
(x) unknown

EPIDEMIOLOGICAL SIGNIFICANCE

(0) will never cause disease or direct effects
(1) rarely causes disease or direct effects
(2) compromised - host may contract the disease or become affected if its immune system has been weakened
(3) may cause non-transmittable effects or allergic responses
(4) usually causes disease
(5) always causes disease
(x) unknown

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in: surface water	Survival in: treated effluent	Survival in: cooling device	aeroso-lization	integrity in fomites
Absidia corymbifera	4	1	4	4	3	5	4
Absidia ramosa	4	1	4	4	3	5	4
Actinomyces israeli	2	3	4	3	3	4	4
Actinomyces keratolytica	2	1	4	1	4	4	4
Actinomyces naeslundii	1	3	4	1	1	3	3
Actinomyces odontolyticus	1	3	4	1	1	3	3
Actinomyces viscosus	1	3	4	1	1	3	3
Arachina propionica	1	3	4	1	1	3	3
Aspergillus spp.	4	4	4	4	4	5	5
Aspergillus flavus	3	3	4	4	3	5	5
Aspergillus nidulans	2	4	4	3	3	5	5
Aspergillus niveus	2	4	4	3	3	5	5
Aspergillus restrictus	2	4	4	3	3	5	5
Aspergillus terreus	2	4	4	3	3	5	5
Bacillus anthracis	4	1	1	1	1	5	5
Bacillus cereus	4	4	4	3	4	4	5
Bacillus subtilis	2	4	4	2	3	4	5
Bacteriodes fragilis	4	4	4	4	4	5	5
Bacteriodes melaninogenicus	4	4	4	4	4	5	5
Basidiobolus haptosporus	4	1	4	4	3	5	4
Blastomyces dermatitidis							
Bordetella parapertussis	1	1	1	0	1	4	4
Brucella abortus	4	1	1	1	1	5	5
Brucella canis	4	1	1	3	3	5	5
Brucella melitensis	4	1	1	3	3	5	5
Brucella suis	4	1	1	3	3	5	5
Candida albicans	2	3	4	3	3	5	5
Candida guillermondii	2	3	4	3	4	5	5

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in surface water	Survival in treated effluent	Survival in cooling device	aeroso-lization	integrity in fomites
Candida krusei	2	3	4	3	4	5	5
Candida parapsilosis	2	3	4	3	3	5	5
Candida pseudotropicalis	2	3	4	3	4	5	5
Candida stellatoidea	2	3	4	3	4	5	5
Candida tropicalis	2	3	4	3	4	5	5
Candida utilis	2	3	4	3	5	5	5
Candida viswanthii	2	3	4	3	5	5	5
Candida zeylatoides	2	3	4	3	5	5	5
Cladosporium bantianum	1	1	3	3	3	5	3
Cladosporium carrionii	1	1	3	3	3	5	3
Clostridium botulism	4	1	3	3	3	5	5
Clostridium perfingens	3	4	4	3	5	4	5
Cocciodioides immitis	4	3	3	3	3	5	5
Cocynebacterium spp.	2	4	4	3	3	4	5
Conidiobolus coronatus	1	1	4	4	3	5	4
Corynebacterium diptheriae	2	1	3	3	3	4	5
Corynebacterium ulcerans	2	1	3	3	3	3	5
Cryptococcus neoformans	2	1	4	3	3	4	5
Dermatophilus congolensis	2	3	4	3	3	4	5
Enterobacteriae	2	1	5	1	3	5	5
Enterococci	4	4	4	3	3	5	4
Escherichia coli	3	4	4	3	4	4	5
Fuscobacterium spp.	4	4	4	4	4	5	5
Geotrichium candidium	2	1	3	0	3	5	5
Haemophilus aegyptius	2	4	4	3	4	4	5
Haemophilus influenzae	2	1	1	0	1	4	4
Histoplasma capsulatum	4	4	4	4	4	5	5
Klebsialla pneumonia	4	4	4	4	4	4	4

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in surface water	Survival in treated effluent	Survival in cooling device	aeroso-lization	integrity in fomites
Listeria monocytogenes	2	1	4	1	1	5	4
Mucor spp.	2	1	4	1	1	5	4
Mucor pusillus	2	1	4	4	3	5	4
Mucor ramosissimus	2	1	4	4	3	5	4
Mycobacterium bovis	3	1	4	1	1	5	4
Mycobacterium chelonei	3	1	4	1	1	5	4
Mycobacterium fortuitum	3	1	4	1	1	5	4
Mycobacterium kansasii	3	1	4	1	1	5	4
Mycobacterium marinum	3	1	4	1	1	5	4
Mycobacterium scrofulaceum	3	1	4	1	1	5	4
Mycobacterium simiae	3	1	4	1	1	5	4
Mycobacterium tuberculosis	3	1	4	4	1	5	5
Mycobacterium ulcerans	3	1	4	1	1	5	4
Mycobacterium xenopi	3	1	4	1	1	5	4
Nocardia asteroides	2	1	4	1	1	4	5
Nocardia brasiliensis	2	1	4	1	1	4	5
Nocardia caviae							
Peptococcus spp.	4	4	4	4	4	5	5
Peptostreptococcus spp.	4	4	4	4	4	5	5
Phialophora dermatitidis	1	1	1	1	1	4	3
Phialophora gougerotii	1	1	1	1	1	4	3
Phialophora richardsiae	1	1	1	1	1	4	3
Phialophora spinifera	1	1	1	1	1	4	3
Phialophora verrucosa	1	1	1	1	1	4	3
Proteus mirabilis	4	4	4	1	4	4	5
Prototheca wickerhamii	1	1	4	1	1	0	0
Prototheca zopfi	2	1	4	1	1	0	0
Pseudomonas aeruginosa	2	1	4	1	1	4	4

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in surface water	Survival in treated effluent	Survival in cooling device	aeroso-lization	integrity in fomites
Pseudomonas mallei	4	1	3	3	3	4	5
Pseudomonas pseudomallei	4	1	4	3	3	3	4
Rhinocladiella compactum	1	1	1	1	1	5	3
Rhinocladiella perosoi	1	1	1	1	1	5	3
Rhizopus arrhizus	4	1	4	4	3	5	4
Rhizopus oryzae	3	1	4	4	3	5	4
Salmonella spp.	4	4	4	1	4	4	5
Salmonella typhi	4	4	4	3	4	4	5
Shigella spp.	4	4	4	1	4	4	5
Shigella boydii	4	4	4	1	4	4	3
Shigella dysenteriae	4	4	3	1	3	4	3
Shigella flexneri	4	4	3	1	3	4	3
Shigella sonnei	4	4	3	1	3	4	3
Sporothrix schenckii	2	3	4	1	1	4	4
Staphylococcus agalactiae	2	1	4	1	1	5	4
Staphylococcus aureus	4	4	4	4	4	5	5
Streptococcus spp.	2	1	1	0	1	4	4
Streptococcus agalactiae	2	1	1	0	1	4	4
Streptococcus faecalis	4	4	4	3	4	4	5
Streptococcus pneumoniae	2	4	4	1	3	4	5
Streptococcus pyogenes	2	1	4	1	1	5	4
Toruplopsis glabrata	2	1	4	1	1	5	4
Vibrio parahemolytica	4	4	4	1	5	4	5
Yersina enterocolitica	4	4	4	1	4	4	5
Yersina pestis	4	4	4	3	3	4	4
Yersina pseudotuberculosis	4	4	4	1	4	4	5
Zygomycetes	2	1	1	1	1	5	4

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in: surface water	Survival in: treated effluent	Survival in: cooling device	aeroso-lization	integrity in fomites
Acenapthene	3	3	4	4	4	1	4
Acetone	3	4	2	3	1	5	4
Acrolein	3	4	1	4	1	5	1
Acrylonitrile	4	4	4	4	1	5	1
Aldrin	4	4	4	4	4	1	4
Antimony	4	3	4	4	4	1	5
Arsenic	4	4	4	4	4	5	3
Asbestos	4	4	5	4	4	3	5
Benzene	3	4	4	5	1	5	4
Benzidene	4	4	4	4	4	1	2
Beryllium	4	4	4	4	4	1	2
Biphenyl (Diphenyl)	4	3	4	4	4	1	4
Cadmium	3	4	4	4	4	4	1
Carbon Tetrachloride	3	1	4	4	1	5	4
Chlordane	4	4	4	4	4	3	4
Chlorinated Benzenes	1	4	4	5	4	1	4
Chlorinated Ethanes	1	4	5	5	1	3	4
Chlorinated Napthalene	3	4	4	4	4	1	2
Chlorine	4	5	1	5	4	4	1
Chloroform	3	4	4	5	4	4	1
Clorophenol	3	1	1	2	4	3	4
Chromium	4	3	4	4	3	2	5
Copper	4	3	4	4	4	2	1
Cyanides	4	3	4	4	4	4	1
DDT & metabolites	4	4	5	5	4	3	4
Diabyl Ethers	4					1	1
Dichlorobenzenes	3	2	5	4	4	2	4
Dichlorobenzidine	3	3	4	4	4	1	4

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in surface water	Survival in treated effluent	Survival in cooling device	aeroso-lization	integrity in fomites
Dichloroethylene	3	4	4	4	4	1	1
Dichlorophenol	3	4	x	x	x	3	4
Dichloropropane, Dichloropropene	1	3	4	4	4	1	4
Dieldrin	4	4	5	4	4	3	4
2,4, Dimethyl Phenol	2	4	3	5	1	3	3
Dinitrotoluene	3	1	x	4	x	1	1
Diphenylhydrazinr	1	3	4	4	4	1	4
Endosulfan	3	x	4	4	4	1	2
Endrin & metabolites	4	4	5	4	4	3	4
Ethylbenzene	3	3	5	4	4	2	4
Haloether	x	x	x	5	1	1	4
Halomethanes	3	3	2	4	4	4	4
Heptachlor & metabolites	4	4	5	4	5	3	4
Hexachloro 1,3 Butadiene	3	3	4	4	4	x	x
Hexachlorocyclohexane (Lindane)	3	1	5	4	4	1	4
Isophorone	3	3	5	4	4	3	4
Lead	4	3	1	4	4	1	1
Mercury & compounds	4	4	2	4	4	4	2
Methyl Ethyl Ketone (Butanone)	3	3	1	1	2	3	4
Napthalene	4	3	5	4	5	5	1
Nickel & compounds	4	4	5	4	4	2	4
Nitrites	3	4	1	4	4	4	2
Nitrobenzene	4	4	2	1	4	3	4
Nitrophenol	1	4	3	4	2	3	x

TABLE 19

SUMMARY OF PATHOGEN/TOXIN PROBABILITIES

PATHOGEN/TOXIN	produce disease	occurrence	Survival in surface water	Survival in treated effluent	Survival in cooling device	aeroso-lization	integrity in fomites
Nitrosamines	3	x	1	x	5	5	4
PCB's	x	x	4	5	4	x	x
Pentachlorophenol	3	3	5	4	4	3	4
Phenol	5	4	1	5	3	4	3
Phthalate Esters	3	3	2	x	4	x	x
Secondary Amines	1	3	4	1	1	5	1
Selenium & compounds	3	4	1	5	4	3	1
Silver & compounds	1	x	4	4	4	2	1
Styrene	3	3	3	4	4	3	1
Tetrachloroethylene	3	4	3	5	4	x	x
Thallium & compounds	4	4	5	4	4	1	1
Toluene	3	4	3	3	3	3	4
Toxaphene	4	4	5	4	4	1	4
Vinyl Chloride	3	3	4	4	4	3	1
Zinc & compounds	4	4	2	2	4	1	x

The value of make up water was estimated as equal to the sum of the evaporation loss and the droplet losses. These losses were calculated on the basis of the cooling tower design parameters and/or the cooling tower operating condition. For the present model, blow-down was assumed to restore the initial (steady-state) operating condition of the cooling tower periodically with respect to salt and the pathogen concentration. The time between blow downs was calculated as:

$$T=(CONC-1.)\ TVOL/_{UMW}$$

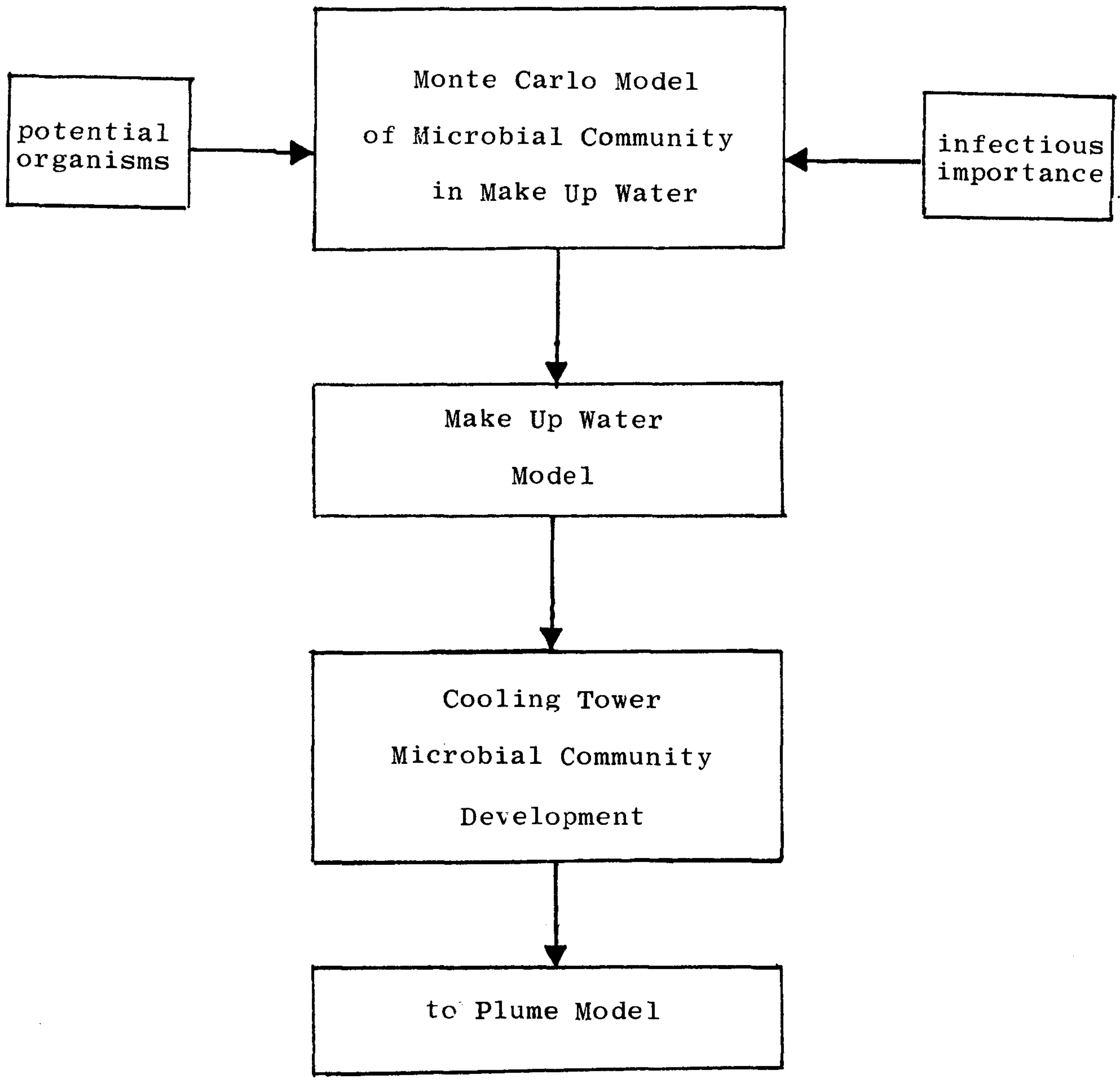
Where T is the time between blow downs, CONC is the maximum allowable concentration (input parameter), TVOL is the tower water value and UMW is the make up water input rates. The total average value of make up water taken in, then was calculated as:

$$BINVOL = UMW \times T/_{2}$$

where BINVOL is the total amount of water taken in between blow downs. This was multiplied by the number of organisms per unit volume derived earlier to establish the average microbial content of the cooling tower. As can be seen, the microbial content is then the average number of organisms taken in between blow downs diluted by the value of water carried by the tower. In the present model, no specific capability is included for growth or death of pathogenic organisms in the cooling tower. Their concentration is determined purely by input conditions and dilution factors. It is also assumed that the droplets are spherics and are homogeneous samples of the cooling tower microbial environment. Figure 12 shows a simplified flow chart of that portion of the simulation relating to the development of the microbial environment in the cooling tower.

FIGURE 12

MICROBIAL CONTENT OF COOLING TOWER



C. Aerosol Model - The Spatial Distribution of Organisms

The aerosol model that distributes the pathogens in the environment is based on the ORFAD Model (Oak Ridge fog and drift) (Wilson, 1975 & LaVerne 1977). The elements comprising the plume rise, the distribution of the aerosol droplet sizes and their physical distribution have been developed from this model. The model for this portion of the simulation takes cooling tower and environmental parameters (as inputs) and calculates the plume rise from the cooling tower and the plume environment. As in the ORFAD model, the aerosols are assumed to travel in ballistic trajectories set by the rise velocity of the plume centerline and the fall velocity of the droplet with respect to the plume centerline.

Plume rise is calculated as follows:

1. Determination of a buoyancy flux parameter (F)
2. Calculation of atmospheric stability (S)
3. Determination of the plume centerline (trajectory) (PR) based on F, S and wind conditions.

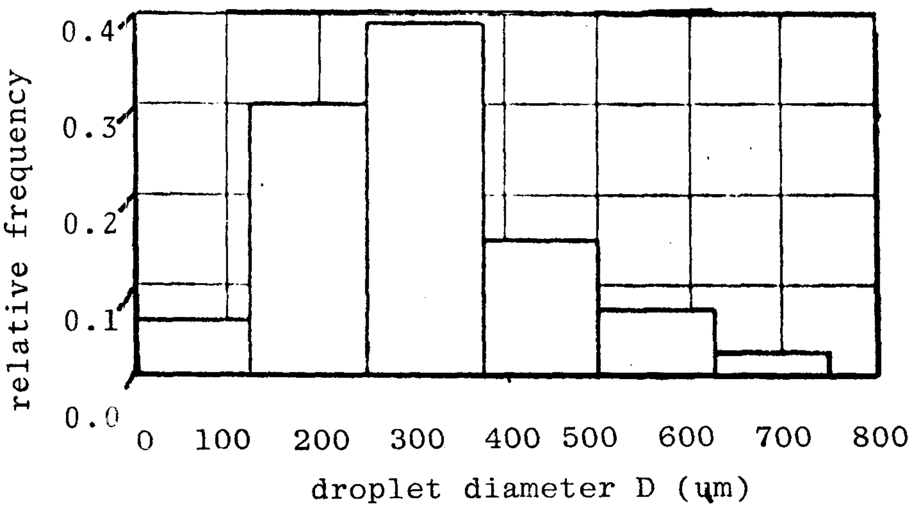
The flux buoyancy parameter (F) is that developed by Hanna (ref. 3). The atmospheric stability parameter is derived from the Pasquill stability class as determined from weather data (input parameters) that determine the atmospheric temperature gradient and the dry and wet bulk temperatures. Wind conditions (input parameters) are taken as 1 m/sec minimum, even for calm ground conditions since the wind velocity, generally is rarely less than this at typical tower heights. The plume is assumed to be disturbed over a 22.5^{o} angle downwind. Unlike ORFAD, this program computes for the downwind condition without regard to specific geographic direction. The day is broken into 4 hour segments starting at 0000 hours, and wind velocity, temperature (dry and wet bulb), stability and percent operating capacity of the plant are inputted for each time segment. Computations are done for each four hours and are summarized daily.

The aerosol drift deposition is based on ballistic ple as discussed by Laverne. This trajectory model assumes that all particles of a given original size (at the cooling tower) will fall to the ground at the same distance from the cooling tower for a given set of wind, stability and humidity conditions. This distance is such that the total trajectory is equal to the local plume height above the ground.

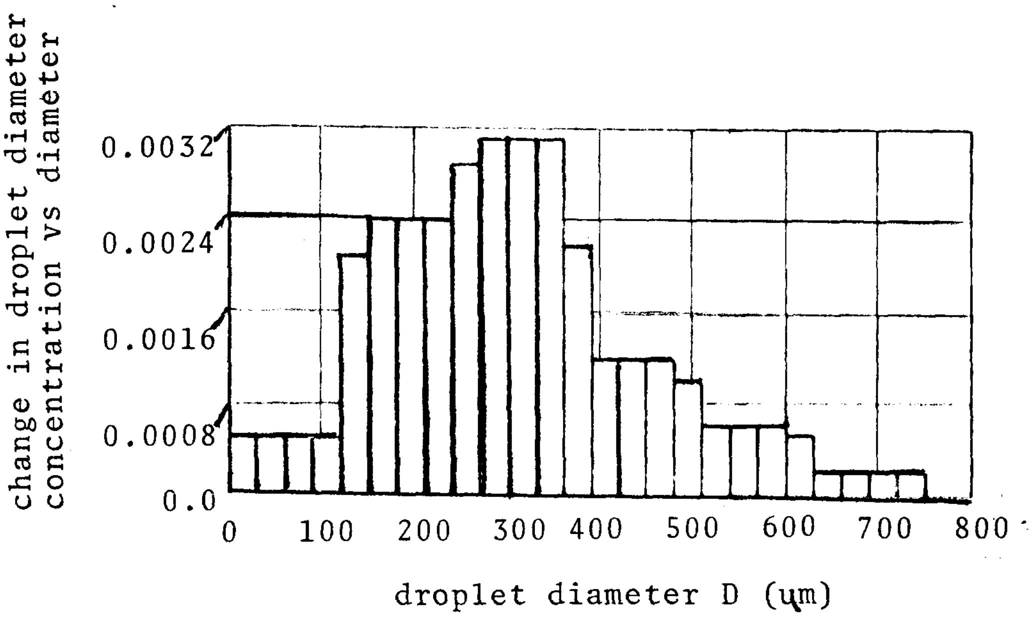
The distribution of aerosol particle sizes within the exit plume is shown in Figure 13(A). As in the ORFAD model, this distribution is recomputed in terms of the cumulative distribution function to obtain a refined droplet size distribution model (Figure 13 (B). Fall velocities are computed by using Stokes law for particles smaller than about 80 um and a relationship

FIGURE 13

DROPLET SIZE DISTRIBUTION



(A)

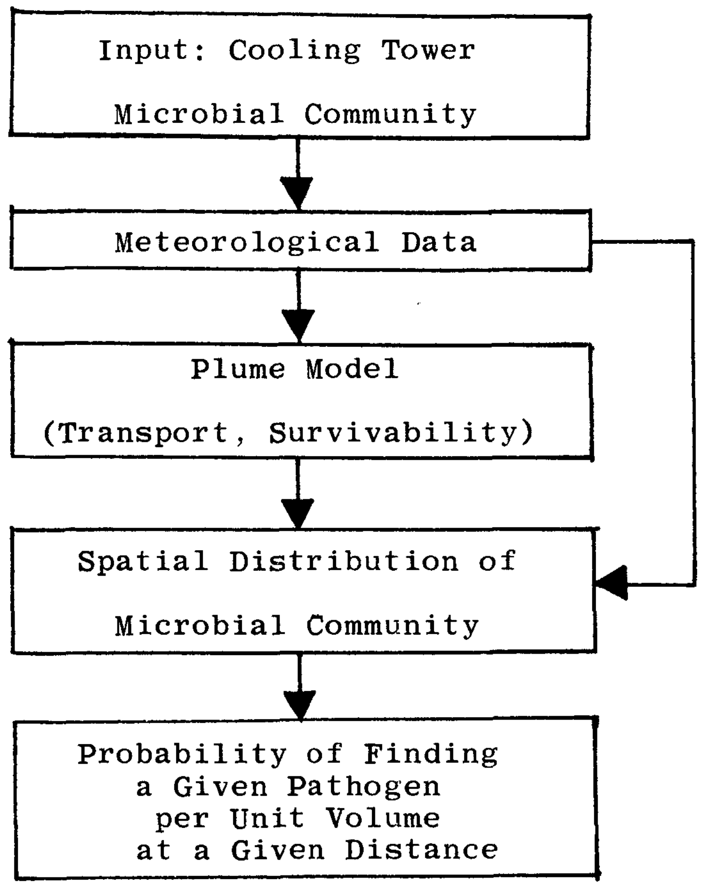


(B)

given in Letester (1966) for particles greater than about 80 μm. Particles in relative humidity environments greater than 76% are assumed not to evaporate, while particles in environments with less than 76% are assumed to evaporate, either to saturation (76%-50% R.H.) or dryness (R.H. 50%). Following the methods outlined in Laverne (1977), particles are distributed downwind in accordance with wind velocity, plume and weather condition. From these data, and the microbial input data from part 1 of the simulation, the total number of organisms impinged per unit area, per unit time, and present per unit volume (steady state), are easily calculated. The flow chart for this phase of the simulation is shown in Figure 14. It is assumed that the organisms that find their way into the aerosol will all survive if there is no evaporation (R. H. 76%) that 50% survive in the R. H. range of 76% to 50% and that 20% survive when the R. H. is 50%. These factors are further modified by 0.2 if there is direct sunlight (0800-0800) present or 0.5 with cloud cover. These factors are rather arbitrarily chosen and should be re-evaluated (perhaps dynamically simulated in further model developments. These results (organisms/M^3 and organisms/M^2) are tabulated for each four hour interval.

FIGURE 14

SPATIAL ORGANIZATION OF ORGANISMS



D. Estimation of Infection Probability

The previous elements of the simulation have established a potential microbial density for distances downwind from the cooling tower. It is now necessary to establish the extent to which these microbial densities are capable of producing infection. Two basic possibilities exist. In one case, inhalation of organisms can create an infection and in another, physical contact (touching or ingestion) will create an infection. In either case, a threshold level establishes a minimum below which nothing will happen. The estimation of this threshold is extremely difficult. Furthermore, the consequences of infection may vary from a general slight malaise to severe symptoms that require extensive care. The model developed here, does not consider the epidemiological affects of interaction between infected and non-infected individuals, but only considers the direct effect of the interaction between the microbial environment and the individual. Figure 15 is a simplified flow chart for Part 3 of the simulation.

The lifetime of deposited (or airborne) microbial particles has (again, rather arbitrarily) been taken to be 24 hours* on the average. The average ventilation value for a population is about 20,000 liters per day (Haup). Therefore, for the airborne organisms, the average number of organisms inhaled/day is calculated. A sticky problem is that of determining the number of organisms required to declare an infection. A randomly distributed variable, exponentially distributed with a mean of .1 X (3 X 10^6) was used to establish (in a Monte Carlo loop) the basis for estimating the number of organisms required to generate an infection. The same approach is used with respect to the number of particles injested with the assumption that an individual will ingest the microbial flora that falls on one square meter of surface in 24 hours. Results for 24 hours are obtained from the summation or averaging (as required) of the data accumulated for each four hours.

The above data is then used to generate infection probabilities, based on the number of times the infection threshold is pierced during the interval under consideration. This resultant is tabulated as the result for a particular simulation based on given input condition.

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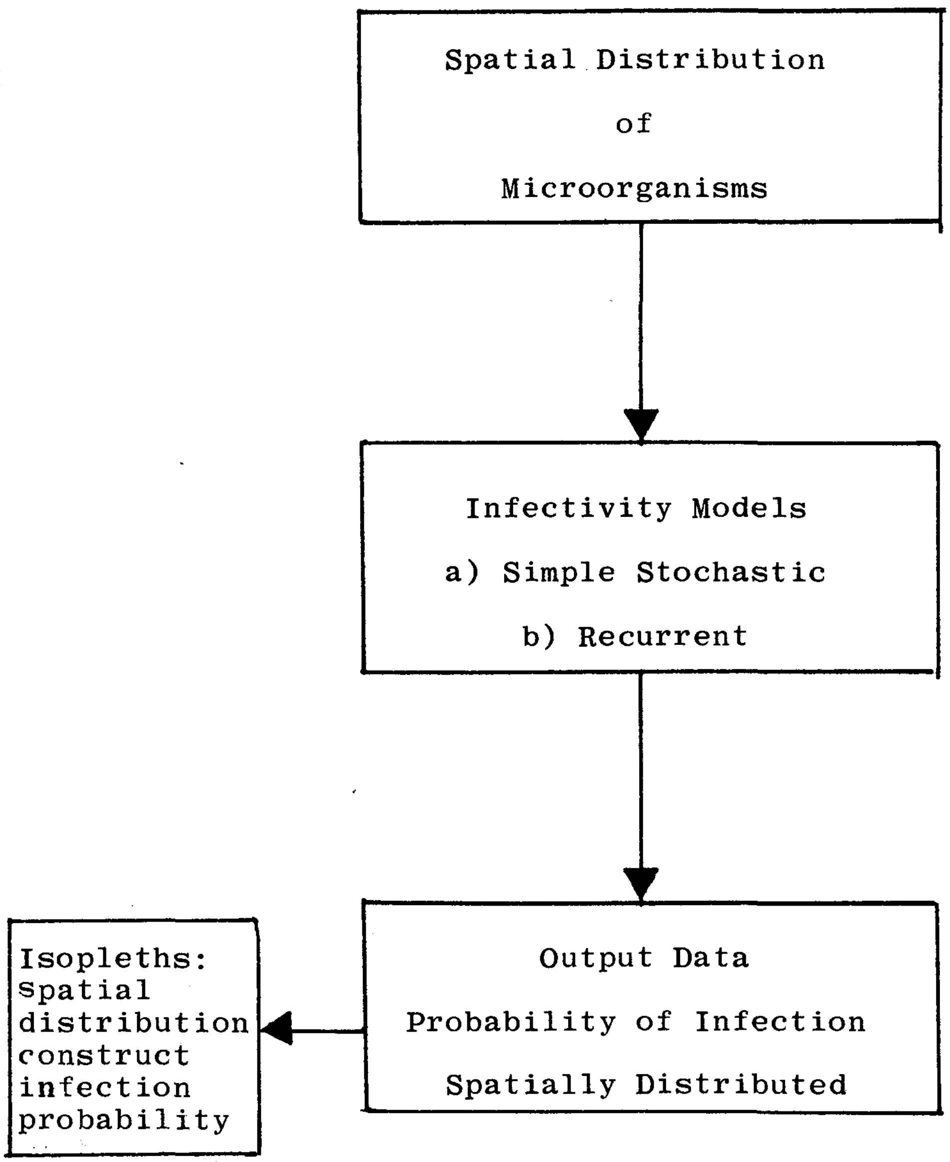
*It is recognized that many organisms remain viable for periods much longer than 24 hours, even years in some cases. However, it was assumed that the cooling tower, Figures 16-20, environment would not favor encystment or spore formation, and therefore, the cells would be susceptible to die-off due to uv, desiccation, etc. Twenty-four hours was picked as a working number for the purpose of modeling.

FIGURE 15

INFECTIVITY MODEL



E. Input Data Requirements

Table 20 lists the input data requirements and lists some typical values used in the simulations. These are printed for each simulation as part of the data file. Figure 16 shows a typical data file. Figures 17-21 shows the result of simulations under various conditions of cooling tower operation and environment.

Figure 17 simulates a typical summer day. Weather conditions represent the most significant difference in the simulations. Internal parameters on which the model is based, were previously discussed in Section 2. The fixed parameters were selected as typical for a large, natural draft tower. The day was divided into four (4) hour intervals as shown and the environmental parameters are varied as they might be for a summer day. The results of the simulation for each four hour interval are shown along with a summary of operating parameters for that interval. Also, listed for that interval are distance from the cooling tower, plume rise, the average number of organisms per cubic meter of air, the average number of organisms landing per square meter of surface area, all based on the output of the simulation. In addition, there is the Monte Carlo derived probability that the effluent will contain infectious organisms. Following the four hour listings are summaries for the 24 hour period detailing the number of organisms airborn per cubic meter, their incidence on surfaces per square meter, and the average 24 hour probability of effluent containing infectious organisms.

The second summary shows the results of exposure of a population to these infectious organisms with a maximum instantaneous susceptible population of 20%. The organisms are assumed to be ingested from both airborne particles and those picked up by contact with surfaces. This leads to the calculation of the average number of particles ingested assuming the population distributions described in the methodology. These averages are used in a simple infection model to derive the listing of the population fraction affected by the effluent.

The results support the concept that the potential for affecting a downwind population is present, unless measures are taken to control infectious organisms and toxins in the make-up water and the tower to suppress these effects. As pointed out in Section 2, many assumptions have been made because real data does not exist. These data, when available, could be used to considerably strengthen the model. However, even in its present form, the model clearly shows that if infectious organisms are present in the cooling tower environment, they will surely appear in the population downwind from the cooling tower.

Figures 18 and 19 represent the same operating parameters and environmental conditions. In Figure 18, 20% of the population is susceptible to infectious organisms and toxins. Figure 19 represents a worse case situation wherein 100% of the population is affected by transmitted pathogens and toxic particles. Figure 20 simulates conditions for a tower with a higher level of output, cooler environmental temperatures and a population which is 20% susceptible. Figure 21 represents a tower operating at 100% capacity with a 20% susceptible population.

TABLE 20
A TYPICAL INPUT PARAMETERS

PARAMETERS	UNITS	TYPICAL VALUES
Cooling tower height	ft	400
Tower inside diameter	ft	200
Temperature range (in tower)	^oF	25
Exit air velocity	ft/sec	0-50
Drift fraction	g/g	10^{-4} to 10^{-6}
Wind velocity	knots	50
Dry bulb temperature	^oF	-20 to +100
Wet bulb	^oF	-20 to +100
Pasquill Stability class	--	1 - 6

These data were inputted via a separated data file called FOR__.DAT. The program is now set to accept FOR28.DAT. These files are shown with each output run shown in Figure 6.

FIGURE 16

Typical Data File

```
TYPE (FILE) FOR26.DAT
450.,200.,5.E-5,12.,1.3,25.,1200.
50.,48.,10.,.8,4.
52.,45.,5.,.8,4.
60.,50.,20.,1.,5.
63.,50.,20.,1.,5.
58.,50.,5.,1.,4.
54.,50.,10.,1.,4.
3,5,7,9,13,223
@
```

FIGURE 17

***************COOLING TOWER FIXED PARAMETERS***************

TOWER HEIGHT (FEET)	450.00
TOWER DIAMETER (FEET)	250.00
HEAT LOSS (MEGACAL/SEC,MAX)	1000.00
TEMPERATURE RANGE (DEG F)	25.00
DRIFT FRACTION (G/G)	0.000050
CONCENTRATION RATIO (G/G)	1.30
EXIT VELOCITY (FT/SEC)	10.00

--COOLING TOWER ENVIRONMENTAL PARAMETERS--

TIME (HRS)	DRY BULB T	WET BULB T	WIND VEL.	OPER CAP	STABILITY
0- 400	70.00	65.00	5.00	.80	5.
400- 800	75.00	70.00	10.00	.90	4.
800-1200	80.00	72.00	8.00	1.00	5.
1200-1600	90.00	83.00	12.00	1.00	5.
1600-2000	80.00	75.00	9.00	1.00	5.
2000-2400	72.00	70.00	10.00	.90	5.

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 0- 400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.53
HEAT LOSS (MEGACAL/SEC)	800.00
DRY BULB TEMPERATURE (DEG F)	70.00
WET BULB TEMPERATURE (DEG F)	65.00
WIND VELOCITY (KNOTS)	5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	271.9	0.0	0.0
0.15	356.3	0.0	0.0
0.20	392.9	2403.1	4753.7
0.30	392.9	1443.5	2186.2
0.50	392.9	1254.4	1245.0
0.75	392.9	1689.0	1305.1
1.00	392.9	1085.7	630.1
1.50	392.9	1600.5	665.1
2.00	392.9	1100.6	378.0
2.50	392.9	802.7	223.3
3.00	392.9	539.6	118.6
4.00	392.9	340.0	57.2
5.00	392.9	240.6	29.7
7.00	392.9	149.5	12.8
9.00	392.9	116.2	10.0
10.00	392.9	20.2	1.1
12.00	392.9	16.8	0.9
15.00	392.9	13.5	0.7
20.00	392.9	6.9	0.2
25.00	392.9	5.5	0.2

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 400- 800HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.55	
HEAT LOSS (MEGACAL/SEC)		900.00
DRY BULB TEMPERATURE (DEG F)		75.00
WET BULB TEMPERATURE (DEG F)		70.00
WIND VELOCITY (KNOTS)		10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	136.4	0.0	0.0
0.15	178.7	144965.9	199142.1
0.20	216.5	38423.6	52783.1
0.30	283.7	11914.7	16367.4
0.50	398.8	3730.7	5125.0
0.75	522.6	1642.6	2256.5
1.00	633.0	945.4	1298.7
1.50	829.5	445.8	612.5
2.00	990.9	269.6	370.3
2.50	990.9	1636.7	1821.2
3.00	990.9	1276.9	1267.3
4.00	990.9	1973.4	1524.9
5.00	990.9	1370.0	795.1
7.00	990.9	2178.6	905.3
9.00	990.9	1556.4	534.5
10.00	990.9	1278.2	355.6
12.00	990.9	1065.2	296.3
15.00	990.9	687.6	151.1
20.00	990.9	433.2	72.9
25.00	990.9	306.3	37.9

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 800-1200HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .07
HEAT LOSS (MEGACAL/SEC) 1000.00
DRY BULB TEMPERATURE (DEG F) 80.00
WET BULB TEMPERATURE (DEG F) 72.00
WIND VELOCITY (KNOTS) 8.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	160.3	0.0	0.0
0.15	210.1	17714.7	0.0
0.20	254.5	4695.3	0.0
0.30	318.9	1456.0	0.0
0.50	318.9	4185.4	5749.6
0.75	318.9	2205.1	2188.6
1.00	318.9	3357.9	2594.7
1.50	318.9	1924.8	1117.1
2.00	318.9	2815.7	1392.5
2.50	318.9	2346.7	805.9
3.00	318.9	1955.6	671.6
4.00	318.9	1079.0	237.2
5.00	318.9	725.1	122.0
7.00	318.9	458.1	56.6
9.00	318.9	356.3	44.0
10.00	318.9	278.8	23.9
12.00	318.9	232.3	19.9
15.00	318.9	35.9	2.0
20.00	318.9	26.9	1.5
25.00	318.9	14.7	0.5

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1200-1600HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.16
HEAT LOSS (MEGACAL/SEC)	1000.00
DRY BULB TEMPERATURE (DEG F)	90.00
WET BULB TEMPERATURE (DEG F)	83.00
WIND VELOCITY (KNOTS)	12.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	110.4	0.0	0.0
0.15	144.7	34723.7	47700.6
0.20	175.3	9731.7	13368.5
0.30	229.7	3069.1	4216.1
0.50	289.6	1165.3	1600.7
0.75	289.6	3302.9	3675.2
1.00	289.6	4145.4	3644.5
1.50	289.6	2791.7	1879.1
2.00	289.6	1932.2	1121.4
2.50	289.6	3005.8	1486.5
3.00	289.6	2838.7	1179.6
4.00	289.6	1950.3	669.8
5.00	289.6	1421.7	395.5
7.00	289.6	688.2	115.8
9.00	289.6	535.3	90.1
10.00	289.6	426.2	52.7
12.00	289.6	355.2	43.9
15.00	289.6	247.2	21.2
20.00	289.6	35.8	2.0
25.00	289.6	28.6	1.6

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1600-2000HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.54
HEAT LOSS (MEGACAL/SEC)	1000.00
DRY BULB TEMPERATURE (DEG F)	80.00
WET BULB TEMPERATURE (DEG F)	75.00
WIND VELOCITY (KNOTS)	9.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	142.9	0.0	0.0
0.15	187.3	167370.7	207502.7
0.20	226.9	47063.3	58348.1
0.30	297.3	14858.2	18420.9
0.50	307.5	30438.8	33869.6
0.75	307.5	33611.3	29550.4
1.00	307.5	27496.8	21247.2
1.50	307.5	15536.7	9017.4
2.00	307.5	25613.6	10643.7
2.50	307.5	18759.0	6442.4
3.00	307.5	15632.5	5368.7
4.00	307.5	8613.3	1893.1
5.00	307.5	6890.6	1514.5
7.00	307.5	4135.8	696.0
9.00	307.5	2846.5	351.9
10.00	307.5	2229.6	191.4
12.00	307.5	1858.0	159.5
15.00	307.5	287.2	15.8
20.00	307.5	215.4	11.8
25.00	307.5	117.5	3.6

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 2000-2400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .21
HEAT LOSS (MEGACAL/SEC) 900.00
DRY BULB TEMPERATURE (DEG F) 72.00
WET BULB TEMPERATURE (DEG F) 70.00
WIND VELOCITY (KNOTS) 10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	135.7	0.0	0.0
0.15	177.9	742564.0	0.0
0.20	215.5	208802.9	0.0
0.30	282.3	65920.5	0.0
0.50	311.7	64452.4	184820.3
0.75	311.7	173105.7	330926.0
1.00	311.7	243932.9	349744.7
1.50	311.7	133611.9	127712.9
2.00	311.7	62840.0	45049.2
2.50	311.7	40217.6	23065.2
3.00	311.7	27928.9	13347.9
4.00	311.7	3567.1	1278.6
5.00	311.7	2282.9	654.6
7.00	311.7	963.1	197.3
9.00	311.7	1076.2	171.5
10.00	311.7	918.9	131.7
12.00	311.7	699.0	83.5
15.00	311.7	413.6	39.5
20.00	311.7	268.6	19.3
25.00	311.7	192.2	11.0

--------------- 24 HOUR TOTALS ---------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .34

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	0.0	0.0
0.15	1107339.0	454345.4
0.20	311119.8	129253.4
0.30	98662.0	41190.6
0.50	105227.0	232410.3
0.75	215556.6	369901.7
1.00	280964.0	379159.9
1.50	155911.4	141004.1
2.00	94571.7	58955.1
2.50	66768.6	33844.5
3.00	50172.2	21953.7
4.00	17523.1	5660.8
5.00	12931.0	3511.6
7.00	8573.2	1983.8
9.00	6487.0	1202.0
10.00	5151.9	756.5
12.00	4226.6	604.1
15.00	1685.0	230.4
20.00	986.8	107.6
25.00	664.9	54.7

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	0.0	0.000
0.15	1561684.4	18.135
0.20	440373.2	0.486
0.30	139852.6	1.223
0.50	337637.3	20.000
0.75	585458.3	9.244
1.00	660123.9	13.324
1.50	296915.5	18.221
2.00	153526.8	11.626
2.50	100613.1	10.064
3.00	72125.9	5.507
4.00	23183.9	0.486
5.00	16442.5	1.914
7.00	10557.1	0.318
9.00	7689.0	0.006
10.00	5908.4	0.000
12.00	4830.7	0.000
15.00	1915.4	0.000
20.00	1094.5	0.409
25.00	719.6	0.215

FIGURE 18

***************COOLING TOWER FIXED PARAMETERS***************

TOWER HEIGHT (FEET)	450.00
TOWER DIAMETER (FEET)	200.00
HEAT LOSS (MEGACAL/SEC,MAX)	750.00
TEMPERATURE RANGE (DEG F)	30.00
DRIFT FRACTION (G/G)	0.000050
CONCENTRATION RATIO (G/G)	1.40
EXIT VELOCITY (FT/SEC)	10.00

--COOLING TOWER OPERATING PARAMETERS--

TIME (HRS)	DRY BULB T	WET BULB T	WIND VEL.	OPER CAP	STABILITY
0- 400	72.00	68.00	5.00	1.00	3.
400- 800	70.00	66.00	2.00	1.00	2.
800-1200	72.00	67.00	3.00	.70	2.
1200-1600	75.00	71.00	5.00	1.00	3.
1600-2000	80.00	75.00	8.00	1.00	3.
2000-2400	77.00	74.00	5.00	1.00	4.

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 0- 400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.54
HEAT LOSS (MEGACAL/SEC)	750.00
DRY BULB TEMPERATURE (DEG F)	72.00
WET BULB TEMPERATURE (DEG F)	68.00
WIND VELOCITY (KNOTS)	5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	257.6	1157530.7	1753106.5
0.15	337.6	171767.8	260146.2
0.20	409.0	76052.8	115183.7
0.30	535.9	29332.3	44424.5
0.50	753.3	10220.6	15479.3
0.75	987.1	4696.3	7112.7
1.00	1195.8	2757.4	4176.2
1.50	1566.9	24301.0	33382.8
2.00	1788.3	15067.9	18680.9
2.50	1788.3	10665.2	10585.3
3.00	1788.3	16563.4	14562.2
4.00	1788.3	12922.4	8698.3
5.00	1788.3	18873.4	9333.6
7.00	1788.3	15355.8	6381.1
9.00	1788.3	10019.8	2787.3
10.00	1788.3	9017.8	2508.6
12.00	1788.3	6064.6	1333.0
15.00	1788.3	4074.8	685.7
20.00	1788.3	2700.9	333.9
25.00	1788.3	1877.2	161.2

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 400- 800HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .51
HEAT LOSS (MEGACAL/SEC) 750.00
DRY BULB TEMPERATURE (DEG F) 70.00
WET BULB TEMPERATURE (DEG F) 66.00
WIND VELOCITY (KNOTS) 2.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	653.5	418509.4	0.0
0.15	856.4	62103.3	0.0
0.20	1037.4	27497.2	0.0
0.30	1359.4	10605.2	0.0
0.50	1910.9	3695.3	0.0
0.75	2504.0	12797.4	23249.6
1.00	3033.4	2629.6	4777.4
1.50	3974.9	4516.2	6839.8
2.00	4589.6	5681.4	7804.6
2.50	4589.6	4086.2	4546.7
3.00	4589.6	6028.0	5299.7
4.00	4589.6	4735.4	3187.5
5.00	4589.6	3539.1	2054.1
7.00	4589.6	5657.6	2351.0
9.00	4589.6	3696.1	1028.2
10.00	4589.6	3326.5	925.4
12.00	4589.6	2237.4	491.8
15.00	4589.6	1503.2	253.0
20.00	4589.6	996.1	123.2
25.00	4589.6	692.1	59.4

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 800-1200HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .22
HEAT LOSS (MEGACAL/SEC) 525.00
DRY BULB TEMPERATURE (DEG F) 72.00
WET BULB TEMPERATURE (DEG F) 67.00
WIND VELOCITY (KNOTS) 3.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	418.6	182550.8	0.0
0.15	548.6	27089.0	0.0
0.20	664.6	11994.1	0.0
0.30	870.8	4625.9	0.0
0.50	1224.1	8503.4	16821.0
0.75	1604.1	4034.8	7330.1
1.00	1943.2	2357.0	3917.9
1.50	2546.3	1421.7	2153.2
2.00	2847.7	1748.1	2167.2
2.50	2847.7	1249.5	1240.1
3.00	2847.7	1947.8	1712.4
4.00	2847.7	1527.9	1028.5
5.00	2847.7	2239.0	1107.3
7.00	2847.7	1677.0	575.9
9.00	2847.7	1191.0	331.3
10.00	2847.7	1071.9	298.2
12.00	2847.7	720.9	158.5
15.00	2847.7	484.4	81.5
20.00	2847.7	321.0	39.7
25.00	2847.7	223.0	19.1

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1200-1600HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.33
HEAT LOSS (MEGACAL/SEC)	525.00
DRY BULB TEMPERATURE (DEG F)	75.00
WET BULB TEMPERATURE (DEG F)	71.00
WIND VELOCITY (KNOTS)	5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	245.7	230699.0	316915.1
0.15	321.9	37656.7	51729.6
0.20	390.0	16870.9	23175.8
0.30	511.0	6554.1	9003.4
0.50	718.4	2293.3	3150.3
0.75	941.3	1055.7	1450.2
1.00	1140.3	620.4	852.2
1.50	1494.3	298.6	410.2
2.00	1641.8	1629.6	1813.3
2.50	1641.8	2278.6	2003.3
3.00	1641.8	2111.1	1631.3
4.00	1641.8	1377.7	799.6
5.00	1641.8	2158.1	1067.2
7.00	1641.8	1613.0	554.0
9.00	1641.8	1145.0	318.5
10.00	1641.8	831.6	182.8
12.00	1641.8	693.0	152.3
15.00	1641.8	465.7	78.4
20.00	1641.8	308.7	38.2
25.00	1641.8	214.6	18.4

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1600-2000HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.54
HEAT LOSS (MEGACAL/SEC)	525.00
DRY BULB TEMPERATURE (DEG F)	80.00
WET BULB TEMPERATURE (DEG F)	75.00
WIND VELOCITY (KNOTS)	8.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	148.5	1462108.5	0.0
0.15	194.6	615833.1	763497.2
0.20	235.7	172227.6	213524.2
0.30	308.8	54280.5	67295.8
0.50	434.1	17112.9	21216.2
0.75	568.9	7553.8	9365.1
1.00	689.1	4352.6	5396.3
1.50	903.0	2055.0	2547.7
2.00	965.8	10592.2	11786.0
2.50	965.8	14689.5	12914.7
3.00	965.8	13568.4	10484.5
4.00	965.8	8817.5	5117.6
5.00	965.8	13793.2	6821.2
7.00	965.8	10293.2	3535.0
9.00	965.8	7304.5	2032.0
10.00	965.8	5304.7	1165.9
12.00	965.8	4420.6	971.6
15.00	965.8	2970.5	499.9
20.00	965.8	1969.5	243.5
25.00	965.8	1369.3	117.6

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 2000-2400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .11
HEAT LOSS (MEGACAL/SEC) 525.00
DRY BULB TEMPERATURE (DEG F) 77.00
WET BULB TEMPERATURE (DEG F) 74.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	240.7	52706921.0	0.0
0.15	315.4	22199903.0	0.0
0.20	382.1	6208559.4	0.0
0.30	500.7	1956733.1	0.0
0.50	703.9	1160041.0	3116082.4
0.75	922.3	1011519.6	2281934.3
1.00	1117.3	1120061.6	2243878.1
1.50	1464.1	547435.4	933247.5
2.00	1582.6	1343405.2	1844744.9
2.50	1582.6	1462743.0	1606894.3
3.00	1582.6	905710.1	829138.8
4.00	1582.6	477745.8	328016.9
5.00	1582.6	305757.3	167944.6
7.00	1582.6	155998.6	61204.3
9.00	1582.6	21427.3	6538.6
10.00	1582.6	17356.1	4766.6
12.00	1582.6	9966.6	2281.0
15.00	1582.6	6378.6	1167.9
20.00	1582.6	7138.4	980.2
25.00	1582.6	4223.7	464.0

-------------- 24 HOUR TOTALS --------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .38

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	56158319.0	2070021.5
0.15	23114353.0	1075373.0
0.20	6513201.9	351883.8
0.30	2062131.1	120723.7
0.50	1201866.5	3172749.3
0.75	1041657.6	2330441.9
1.00	1132778.7	2262998.0
1.50	580027.9	978581.2
2.00	1378124.3	1886996.8
2.50	1495712.0	1638184.5
3.00	945928.8	862828.9
4.00	507126.7	346848.4
5.00	346360.0	188328.0
7.00	190595.2	74601.3
9.00	44783.8	13035.9
10.00	36908.7	9847.5
12.00	24103.2	5388.1
15.00	15877.0	2766.3
20.00	13434.6	1758.7
25.00	8599.9	839.7

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	58228341.0	20.000
0.15	24189726.0	18.613
0.20	6865085.7	6.878
0.30	2182854.8	12.173
0.50	4374615.7	20.000
0.75	3372099.4	3.674
1.00	3395776.8	7.069
1.50	1558609.1	20.000
2.00	3265121.2	18.308
2.50	3133896.4	20.000
3.00	1808757.8	9.432
4.00	853975.1	6.754
5.00	534688.0	5.787
7.00	265196.5	14.795
9.00	57819.7	1.351
10.00	46756.2	1.133
12.00	29491.3	0.325
15.00	18643.3	0.112
20.00	15193.2	0.420
25.00	9439.6	0.312

FIGURE 19

***************COOLING TOWER FIXED PARAMETERS***************

TOWER HEIGHT (FEET)	450.00
TOWER DIAMETER (FEET)	200.00
HEAT LOSS (MEGACAL/SEC,MAX)	750.00
TEMPERATURE RANGE (DEG F)	30.00
DRIFT FRACTION (G/G)	0.000050
CONCENTRATION RATIO (G/G)	1.40
EXIT VELOCITY (FT/SEC)	10.00

--COOLING TOWER OPERATING PARAMETERS--

TIME (HRS)	DRY BULB T	WET BULB T	WIND VEL.	OPER CAP	STABILITY
0- 400	72.00	68.00	5.00	1.00	3.
400- 800	70.00	66.00	2.00	1.00	2.
800-1200	72.00	67.00	3.00	.70	2.
1200-1600	75.00	71.00	5.00	1.00	3.
1600-2000	80.00	75.00	8.00	1.00	3.
2000-2400	77.00	74.00	5.00	1.00	4.

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 0- 400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .54
HEAT LOSS (MEGACAL/SEC) 750.00
DRY BULB TEMPERATURE (DEG F) 72.00
WET BULB TEMPERATURE (DEG F) 68.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	257.6	1157530.7	1753106.5
0.15	337.6	171767.8	260146.2
0.20	409.0	76052.8	115183.7
0.30	535.9	29332.3	44424.5
0.50	753.3	10220.6	15479.3
0.75	987.1	4696.3	7112.7
1.00	1195.8	2757.4	4176.2
1.50	1566.9	24301.0	33382.8
2.00	1788.3	15067.9	18680.9
2.50	1788.3	10665.2	10585.3
3.00	1788.3	16563.4	14562.2
4.00	1788.3	12922.4	8698.3
5.00	1788.3	18873.4	9333.6
7.00	1788.3	15355.8	6381.1
9.00	1788.3	10019.8	2787.3
10.00	1788.3	9017.8	2508.6
12.00	1788.3	6064.6	1333.0
15.00	1788.3	4074.8	685.7
20.00	1788.3	2700.9	333.9
25.00	1788.3	1877.2	161.2

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 400- 800HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .51
HEAT LOSS (MEGACAL/SEC) 750.00
DRY BULB TEMPERATURE (DEG F) 70.00
WET BULB TEMPERATURE (DEG F) 66.00
WIND VELOCITY (KNOTS) 2.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	653.5	418509.4	0.0
0.15	856.4	62103.3	0.0
0.20	1037.4	27497.2	0.0
0.30	1359.4	10605.2	0.0
0.50	1910.9	3695.3	0.0
0.75	2504.0	12797.4	23249.6
1.00	3033.4	2629.6	4777.4
1.50	3974.9	4516.2	6839.8
2.00	4589.6	5681.4	7804.6
2.50	4589.6	4086.2	4546.7
3.00	4589.6	6028.0	5299.7
4.00	4589.6	4735.4	3187.5
5.00	4589.6	3539.1	2054.1
7.00	4589.6	5657.6	2351.0
9.00	4589.6	3696.1	1028.2
10.00	4589.6	3326.5	925.4
12.00	4589.6	2237.4	491.8
15.00	4589.6	1503.2	253.0
20.00	4589.6	996.1	123.2
25.00	4589.6	692.1	59.4

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 800-1200HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .22
HEAT LOSS (MEGACAL/SEC) 525.00
DRY BULB TEMPERATURE (DEG F) 72.00
WET BULB TEMPERATURE (DEG F) 67.00
WIND VELOCITY (KNOTS) 3.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	418.6	182550.8	0.0
0.15	548.6	27089.0	0.0
0.20	664.6	11994.1	0.0
0.30	870.8	4625.9	0.0
0.50	1224.1	8503.4	16821.0
0.75	1604.1	4034.8	7330.1
1.00	1943.2	2357.0	3917.9
1.50	2546.3	1421.7	2153.2
2.00	2847.7	1748.1	2167.2
2.50	2847.7	1249.5	1240.1
3.00	2847.7	1947.8	1712.4
4.00	2847.7	1527.9	1028.5
5.00	2847.7	2239.0	1107.3
7.00	2847.7	1677.0	575.9
9.00	2847.7	1191.0	331.3
10.00	2847.7	1071.9	298.2
12.00	2847.7	720.9	158.5
15.00	2847.7	484.4	81.5
20.00	2847.7	321.0	39.7
25.00	2847.7	223.0	19.1

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1200-1600HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .33
HEAT LOSS (MEGACAL/SEC) 525.00
DRY BULB TEMPERATURE (DEG F) 75.00
WET BULB TEMPERATURE (DEG F) 71.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	245.7	230699.0	316915.1
0.15	321.9	37656.7	51729.6
0.20	390.0	16870.9	23175.8
0.30	511.0	6554.1	9003.4
0.50	718.4	2293.3	3150.3
0.75	941.3	1055.7	1450.2
1.00	1140.3	620.4	852.2
1.50	1494.3	298.6	410.2
2.00	1641.8	1629.6	1813.3
2.50	1641.8	2278.6	2003.3
3.00	1641.8	2111.1	1631.3
4.00	1641.8	1377.7	799.6
5.00	1641.8	2158.1	1067.2
7.00	1641.8	1613.0	554.0
9.00	1641.8	1145.0	318.5
10.00	1641.8	831.6	182.8
12.00	1641.8	693.0	152.3
15.00	1641.8	465.7	78.4
20.00	1641.8	308.7	38.2
25.00	1641.8	214.6	18.4

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1600-2000HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.54
HEAT LOSS (MEGACAL/SEC)	525.00
DRY BULB TEMPERATURE (DEG F)	80.00
WET BULB TEMPERATURE (DEG F)	75.00
WIND VELOCITY (KNOTS)	8.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	148.5	1462108.5	0.0
0.15	194.6	615833.1	763497.2
0.20	235.7	172227.6	213524.2
0.30	308.8	54280.5	67295.8
0.50	434.1	17112.9	21216.2
0.75	568.9	7553.8	9365.1
1.00	689.1	4352.6	5396.3
1.50	903.0	2055.0	2547.7
2.00	965.8	10592.2	11786.0
2.50	965.8	14689.5	12914.7
3.00	965.8	13568.4	10484.5
4.00	965.8	8817.5	5117.6
5.00	965.8	13793.2	6821.2
7.00	965.8	10293.2	3535.0
9.00	965.8	7304.5	2032.0
10.00	965.8	5304.7	1165.9
12.00	965.8	4420.6	971.6
15.00	965.8	2970.5	499.9
20.00	965.8	1969.5	243.5
25.00	965.8	1369.3	117.6

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 2000-2400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.11
HEAT LOSS (MEGACAL/SEC)	525.00
DRY BULB TEMPERATURE (DEG F)	77.00
WET BULB TEMPERATURE (DEG F)	74.00
WIND VELOCITY (KNOTS)	5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	240.7	52706921.0	0.0
0.15	315.4	22199903.0	0.0
0.20	382.1	6208559.4	0.0
0.30	500.7	1956733.1	0.0
0.50	703.9	1160041.0	3116082.4
0.75	922.3	1011519.6	2281934.3
1.00	1117.3	1120061.6	2243878.1
1.50	1464.1	547435.4	933247.5
2.00	1582.6	1343405.2	1844744.9
2.50	1582.6	1462743.0	1606894.3
3.00	1582.6	905710.1	829138.8
4.00	1582.6	477745.8	328016.9
5.00	1582.6	305757.3	167944.6
7.00	1582.6	155998.6	61204.3
9.00	1582.6	21427.3	6538.6
10.00	1582.6	17356.1	4766.6
12.00	1582.6	9966.6	2281.0
15.00	1582.6	6378.6	1167.9
20.00	1582.6	7138.4	980.2
25.00	1582.6	4223.7	464.0

-------------- 24 HOUR TOTALS --------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .38

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	56158319.0	2070021.5
0.15	23114353.0	1075373.0
0.20	6513201.9	351883.8
0.30	2062131.1	120723.7
0.50	1201866.5	3172749.3
0.75	1041657.6	2330441.9
1.00	1132778.7	2262998.0
1.50	580027.9	978581.2
2.00	1378124.3	1886996.8
2.50	1495712.0	1638184.5
3.00	945928.8	862828.9
4.00	507126.7	346848.4
5.00	346360.0	188328.0
7.00	190595.2	74601.3
9.00	44783.8	13035.9
10.00	36908.7	9847.5
12.00	24103.2	5388.1
15.00	15877.0	2766.3
20.00	13434.6	1758.7
25.00	8599.9	839.7

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	58228341.0	100.000
0.15	24189726.0	93.064
0.20	6865085.7	34.390
0.30	2182854.8	60.866
0.50	4374615.7	100.000
0.75	3372099.4	18.371
1.00	3395776.8	35.344
1.50	1558609.1	100.000
2.00	3265121.2	91.542
2.50	3133896.4	100.000
3.00	1808757.8	47.158
4.00	853975.1	33.772
5.00	534688.0	28.933
7.00	265196.5	73.977
9.00	57819.7	6.753
10.00	46756.2	5.667
12.00	29491.3	1.625
15.00	18643.3	0.561
20.00	15193.2	2.101
25.00	9439.6	1.559

FIGURE 20

***************COOLING TOWER FIXED PARAMETERS***************

TOWER HEIGHT (FEET)	450.00
TOWER DIAMETER (FEET)	200.00
HEAT LOSS (MEGACAL/SEC,MAX)	1200.00
TEMPERATURE RANGE (DEG F)	25.00
DRIFT FRACTION (G/G)	0.000050
CONCENTRATION RATIO (G/G)	1.30
EXIT VELOCITY (FT/SEC)	12.00

--COOLING TOWER OPERATING PARAMETERS--

TIME (HRS)	DRY BULB T	WET BULB T	WIND VEL.	OPER CAP	STABILITY
0- 400	50.00	48.00	10.00	.80	4.
400- 800	52.00	45.00	5.00	.80	4.
800-1200	60.00	50.00	20.00	1.00	5.
1200-1600	63.00	50.00	20.00	1.00	5.
1600-2000	58.00	50.00	5.00	1.00	4.
2000-2400	54.00	50.00	10.00	1.00	4.

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 0- 400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .53
HEAT LOSS (MEGACAL/SEC) 960.00
DRY BULB TEMPERATURE (DEG F) 50.00
WET BULB TEMPERATURE (DEG F) 48.00
WIND VELOCITY (KNOTS) 10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	147.7	0.0	0.0
0.15	193.6	0.0	0.0
0.20	234.5	0.0	0.0
0.30	307.3	0.0	0.0
0.50	431.9	0.0	0.0
0.75	566.0	33588.6	100577.0
1.00	685.6	23065.9	60616.2
1.50	898.4	19152.6	42232.9
2.00	1088.4	21190.9	41473.5
2.50	1144.0	33167.7	54289.9
3.00	1144.0	62080.0	84678.8
4.00	1144.0	43036.0	44026.6
5.00	1144.0	24558.1	20098.8
7.00	1144.0	11749.6	6868.6
9.00	1144.0	7107.8	3231.7
10.00	1144.0	5757.3	2355.9
12.00	1144.0	907.8	309.6
15.00	1144.0	581.0	158.5
20.00	1144.0	270.2	55.3
25.00	1144.0	315.2	51.6

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 400- 800HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .44
HEAT LOSS (MEGACAL/SEC) 768.00
DRY BULB TEMPERATURE (DEG F) 52.00
WET BULB TEMPERATURE (DEG F) 45.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	287.4	0.0	0.0
0.15	376.6	0.0	0.0
0.20	456.3	0.0	0.0
0.30	597.9	0.0	0.0
0.50	840.4	0.0	0.0
0.75	1101.3	6755.1	0.0
1.00	1334.1	4638.8	0.0
1.50	1748.1	3851.8	0.0
2.00	2117.7	4261.7	0.0
2.50	2177.6	6670.4	0.0
3.00	2177.6	12485.0	0.0
4.00	2177.6	785.1	647.6
5.00	2177.6	1390.9	855.8
7.00	2177.6	896.2	441.4
9.00	2177.6	1466.0	562.2
10.00	2177.6	1240.0	414.3
12.00	2177.6	967.3	278.6
15.00	2177.6	1737.2	358.3
20.00	2177.6	1199.8	204.5
25.00	2177.6	877.3	121.1

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 800-1200HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .26
HEAT LOSS (MEGACAL/SEC) 768.00
DRY BULB TEMPERATURE (DEG F) 60.00
WET BULB TEMPERATURE (DEG F) 50.00
WIND VELOCITY (KNOTS) 20.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	67.4	0.0	0.0
0.15	88.3	0.0	0.0
0.20	107.0	0.0	0.0
0.30	140.2	2930.3	2642.1
0.50	197.1	504.6	455.0
0.75	243.9	212.0	191.2
1.00	243.9	159.0	143.4
1.50	243.9	484.0	363.8
2.00	243.9	703.4	479.6
2.50	243.9	507.8	280.4
3.00	243.9	401.2	197.6
4.00	243.9	565.1	246.6
5.00	243.9	476.8	159.3
7.00	243.9	319.4	92.0
9.00	243.9	560.2	115.5
10.00	243.9	504.2	104.0
12.00	243.9	387.9	66.1
15.00	243.9	284.4	39.3
20.00	243.9	172.7	18.8
25.00	243.9	116.4	9.7

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1200-1600HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .56
HEAT LOSS (MEGACAL/SEC) 768.00
DRY BULB TEMPERATURE (DEG F) 63.00
WET BULB TEMPERATURE (DEG F) 50.00
WIND VELOCITY (KNOTS) 20.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	66.1	0.0	0.0
0.15	86.6	12773.5	12540.5
0.20	104.9	4682.3	4596.9
0.30	137.5	1635.0	1605.2
0.50	193.3	540.3	530.4
0.75	239.6	262.3	257.5
1.00	239.6	196.7	193.1
1.50	239.6	687.9	567.5
2.00	239.6	1190.6	811.7
2.50	239.6	905.7	557.3
3.00	239.6	716.8	395.8
4.00	239.6	957.3	417.7
5.00	239.6	858.2	329.1
7.00	239.6	540.7	155.7
9.00	239.6	947.5	195.4
10.00	239.6	852.8	175.9
12.00	239.6	655.8	111.8
15.00	239.6	480.5	66.3
20.00	239.6	291.7	31.8
25.00	239.6	196.4	16.4

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1600-2000HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .29
HEAT LOSS (MEGACAL/SEC) 768.00
DRY BULB TEMPERATURE (DEG F) 58.00
WET BULB TEMPERATURE (DEG F) 50.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	278.8	0.0	0.0
0.15	365.4	15757.6	0.0
0.20	442.6	5776.2	0.0
0.30	580.0	2016.9	0.0
0.50	815.3	666.5	0.0
0.75	1068.3	323.5	0.0
1.00	1294.1	242.6	0.0
1.50	1695.8	848.7	0.0
2.00	2054.3	1468.7	0.0
2.50	2061.7	1117.3	0.0
3.00	2061.7	320.1	314.3
4.00	2061.7	263.3	197.9
5.00	2061.7	390.5	240.2
7.00	2061.7	472.4	206.1
9.00	2061.7	386.8	129.2
10.00	2061.7	348.1	116.3
12.00	2061.7	533.8	131.0
15.00	2061.7	487.7	100.6
20.00	2061.7	336.9	57.4
25.00	2061.7	246.3	34.0

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 2000-2400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .01
HEAT LOSS (MEGACAL/SEC) 768.00
DRY BULB TEMPERATURE (DEG F) 54.00
WET BULB TEMPERATURE (DEG F) 50.00
WIND VELOCITY (KNOTS) 10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	142.5	667715.0	1213064.7
0.15	186.8	93190.5	169303.0
0.20	226.2	40975.7	74442.2
0.30	296.5	15737.4	28590.8
0.50	416.7	5470.4	9938.3
0.75	546.1	2511.0	4561.9
1.00	661.5	1473.6	2677.2
1.50	866.9	6882.1	11439.3
2.00	1050.1	5025.6	7611.4
2.50	1072.7	7100.4	8803.0
3.00	1072.7	5563.2	6190.2
4.00	1072.7	8119.3	6273.9
5.00	1072.7	6069.6	4085.6
7.00	1072.7	7910.5	3912.1
9.00	1072.7	6439.5	2211.5
10.00	1072.7	5795.5	1990.3
12.00	1072.7	4408.2	1226.3
15.00	1072.7	2845.9	625.5
20.00	1072.7	1792.7	301.7
25.00	1072.7	1267.5	156.7

--------------- 24 HOUR TOTALS ---------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .35

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	667715.0	1213064.7
0.15	121721.7	181843.5
0.20	51434.2	79039.1
0.30	22319.7	32838.1
0.50	7181.8	10923.7
0.75	43652.5	105587.5
1.00	29776.7	63629.8
1.50	31907.0	54603.6
2.00	33841.0	50376.2
2.50	49469.3	63930.6
3.00	81566.3	91776.7
4.00	53726.0	51810.4
5.00	33744.1	25768.8
7.00	21888.9	11676.0
9.00	16907.8	6445.6
10.00	14498.0	5156.7
12.00	7860.7	2123.4
15.00	6416.7	1348.5
20.00	4064.0	669.5
25.00	3019.2	389.6

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	1880779.7	20.000
0.15	303565.1	5.182
0.20	130473.2	0.000
0.30	55157.8	1.640
0.50	18105.4	1.041
0.75	149240.0	7.946
1.00	93406.6	0.127
1.50	86510.6	1.380
2.00	84217.3	0.195
2.50	113399.9	1.183
3.00	173342.9	0.473
4.00	105536.4	5.531
5.00	59513.0	2.343
7.00	33564.9	1.877
9.00	23353.5	1.702
10.00	19654.7	1.159
12.00	9984.1	0.172
15.00	7765.2	0.344
20.00	4733.5	0.001
25.00	3408.7	0.789

FIGURE 21

***************COOLING TOWER FIXED PARAMETERS***************

TOWER HEIGHT (FEET)	450.00
TOWER DIAMETER (FEET)	200.00
HEAT LOSS (MEGACAL/SEC,MAX)	1200.00
TEMPERATURE RANGE (DEG F)	25.00
DRIFT FRACTION (G/G)	0.000100
CONCENTRATION RATIO (G/G)	1.40
EXIT VELOCITY (FT/SEC)	20.00

--COOLING TOWER OPERATING PARAMETERS--

TIME (HRS)	DRY BULB T	WET BULB T	WIND VEL.	OPER CAP	STABILITY
0- 400	55.00	52.00	20.00	1.00	5.
400- 800	55.00	51.00	25.00	1.00	5.
800-1200	60.00	55.00	10.00	1.00	3.
1200-1600	65.00	50.00	20.00	1.00	5.
1600-2000	63.00	61.00	5.00	1.00	6.
2000-2400	58.00	54.00	10.00	1.00	6.

COOLING TOWER AND ENVIRONMENTAL PARAMETERS   0- 400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .56
HEAT LOSS (MEGACAL/SEC) 1200.00
DRY BULB TEMPERATURE (DEG F) 55.00
WET BULB TEMPERATURE (DEG F) 52.00
WIND VELOCITY (KNOTS) 20.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	82.1	0.0	0.0
0.15	107.5	0.0	0.0
0.20	130.3	0.0	0.0
0.30	170.7	0.0	0.0
0.50	239.9	10434.8	14334.5
0.75	296.0	2174.1	2986.6
1.00	296.0	3504.0	3898.9
1.50	296.0	3857.4	3391.3
2.00	296.0	3152.4	2435.9
2.50	296.0	2319.1	1561.1
3.00	296.0	1778.7	1032.4
4.00	296.0	2589.1	1280.4
5.00	296.0	2344.2	974.1
7.00	296.0	1395.9	388.3
9.00	296.0	875.6	192.4
10.00	296.0	788.0	173.2
12.00	296.0	551.8	92.9
15.00	296.0	441.5	74.3
20.00	296.0	293.0	36.2
25.00	296.0	204.0	17.5

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 400- 800HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .55
HEAT LOSS (MEGACAL/SEC) 1200.00
DRY BULB TEMPERATURE (DEG F) 55.00
WET BULB TEMPERATURE (DEG F) 51.00
WIND VELOCITY (KNOTS) 25.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	65.6	0.0	0.0
0.15	86.0	0.0	0.0
0.20	104.2	451920.5	620810.7
0.30	136.5	96629.8	132741.9
0.50	191.8	26797.7	36812.4
0.75	251.4	11319.1	15549.2
1.00	274.6	7428.3	10204.4
1.50	274.6	24613.5	27387.7
2.00	274.6	16962.5	16835.5
2.50	274.6	27216.1	21030.3
3.00	274.6	20955.4	14105.5
4.00	274.6	14516.9	8425.5
5.00	274.6	22598.8	11175.9
7.00	274.6	16770.9	5759.6
9.00	274.6	11887.8	3306.9
10.00	274.6	10699.0	2976.2
12.00	274.6	7191.8	1580.7
15.00	274.6	4834.0	813.5
20.00	274.6	3207.3	396.5
25.00	274.6	2565.8	317.2

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 800-1200HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.55
HEAT LOSS (MEGACAL/SEC)	1200.00
DRY BULB TEMPERATURE (DEG F)	60.00
WET BULB TEMPERATURE (DEG F)	55.00
WIND VELOCITY (KNOTS)	10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	164.1	0.0	0.0
0.15	215.1	0.0	0.0
0.20	260.5	86868.0	0.0
0.30	341.4	18574.1	0.0
0.50	479.9	5151.0	0.0
0.75	628.8	2175.7	0.0
1.00	761.8	1427.9	0.0
1.50	998.2	2106.5	3827.0
2.00	1209.2	443.7	806.2
2.50	1382.8	865.1	1437.9
3.00	1382.8	1638.4	2250.7
4.00	1382.8	1030.9	1023.2
5.00	1382.8	1539.4	1353.4
7.00	1382.8	1069.4	620.7
9.00	1382.8	1630.3	806.3
10.00	1382.8	1672.1	694.8
12.00	1382.8	1281.0	439.9
15.00	1382.8	935.6	260.3
20.00	1382.8	566.3	124.5
25.00	1382.8	380.5	64.0

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1200-1600HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.04
HEAT LOSS (MEGACAL/SEC)	1200.00
DRY BULB TEMPERATURE (DEG F)	65.00
WET BULB TEMPERATURE (DEG F)	50.00
WIND VELOCITY (KNOTS)	20.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	76.9	126221.7	123919.0
0.15	100.7	34704.2	34071.1
0.20	122.0	17073.7	16762.2
0.30	159.9	7061.8	6933.0
0.50	224.7	2567.6	2520.8
0.75	279.0	1287.4	1263.9
1.00	279.0	965.5	947.9
1.50	279.0	643.7	632.0
2.00	279.0	2950.7	2434.2
2.50	279.0	5455.8	3719.6
3.00	279.0	4325.4	2661.4
4.00	279.0	2922.2	1439.4
5.00	279.0	4919.6	1886.7
7.00	279.0	3097.5	892.2
9.00	279.0	4741.9	1163.8
10.00	279.0	4881.4	1006.7
12.00	279.0	3751.9	639.5
15.00	279.0	2747.9	379.4
20.00	279.0	1667.2	181.9
25.00	279.0	1122.4	93.7

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 1600-2000HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .02
HEAT LOSS (MEGACAL/SEC) 1200.00
DRY BULB TEMPERATURE (DEG F) 63.00
WET BULB TEMPERATURE (DEG F) 61.00
WIND VELOCITY (KNOTS) 5.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	302.2	425005.7	0.0
0.15	321.0	116853.8	0.0
0.20	321.0	57489.4	0.0
0.30	321.0	921603.3	2247629.7
0.50	321.0	1649865.0	2414239.9
0.75	321.0	903697.7	881584.5
1.00	321.0	425025.1	310968.6
1.50	321.0	188900.0	92138.8
2.00	321.0	24126.3	8826.0
2.50	321.0	15440.8	4518.9
3.00	321.0	8866.7	2162.4
4.00	321.0	4987.5	912.3
5.00	321.0	6152.0	900.2
7.00	321.0	3071.0	321.0
9.00	321.0	2106.5	171.2
10.00	321.0	1798.6	131.6
12.00	321.0	1368.2	83.4
15.00	321.0	979.0	47.8
20.00	321.0	635.9	23.3
25.00	321.0	455.0	13.3

COOLING TOWER AND ENVIRONMENTAL PARAMETERS 2000-2400HRS

PROBABILITY OF EFFLUENT CONTAINING ORGANISMS	.53
HEAT LOSS (MEGACAL/SEC)	1200.00
DRY BULB TEMPERATURE (DEG F)	58.00
WET BULB TEMPERATURE (DEG F)	54.00
WIND VELOCITY (KNOTS)	10.00

DIST(MI)	PLUME RISE(M)	ORG/M3/4HRS	ORG/M2/4HRS
0.10	155.9	878180.6	1459709.3
0.15	204.3	133648.3	222149.8
0.20	247.4	59352.9	98656.2
0.30	261.9	34801.3	57846.7
0.50	261.9	196764.4	243944.4
0.75	261.9	109327.0	108508.1
1.00	261.9	163549.8	126377.5
1.50	261.9	92746.8	53829.8
2.00	261.9	135216.3	66869.6
2.50	261.9	122557.0	50928.5
3.00	261.9	93545.9	32126.4
4.00	261.9	63924.4	17782.4
5.00	261.9	41248.0	9066.1
7.00	261.9	24755.7	4165.9
9.00	261.9	17035.9	2106.2
10.00	261.9	13340.6	1145.4
12.00	261.9	11117.1	954.5
15.00	261.9	1717.9	94.4
20.00	261.9	1288.4	70.8
25.00	261.9	702.8	21.7

-------------- 24 HOUR TOTALS --------------

DAILY PROBABILITY OF EFFLUENT CONTAINING ORGANISMS .37

DIST(MI)	ORG/M3/DAY	ORG/M2/DAY
0.10	1429408.0	1583628.4
0.15	285206.3	256220.9
0.20	672704.5	736229.1
0.30	1078670.3	2445151.2
0.50	1891580.5	2711851.9
0.75	1029981.0	1009892.3
1.00	601900.6	452397.4
1.50	312868.0	181206.7
2.00	182851.9	98207.3
2.50	173853.9	83196.3
3.00	131110.6	54338.8
4.00	89971.1	30863.2
5.00	78802.0	25356.5
7.00	50160.4	12147.7
9.00	38278.0	7746.9
10.00	33179.6	6128.0
12.00	25262.0	3790.9
15.00	11655.8	1669.5
20.00	7658.1	833.2
25.00	5430.5	527.5

------------ SUMMARY OF RESULTS ---------------

DIST(MI)	AVG NO. PART. INGESTED/IND.	PERCENT AFFECTED BY EFFLUENT
0.10	3013036.4	20.000
0.15	541427.2	11.257
0.20	1408933.6	19.958
0.30	3523821.4	20.000
0.50	4603432.4	0.311
0.75	2039873.3	7.159
1.00	1054298.0	4.150
1.50	494074.6	7.704
2.00	281059.2	1.682
2.50	257050.1	15.002
3.00	185449.4	15.660
4.00	120834.3	1.400
5.00	104158.4	2.561
7.00	62308.1	6.319
9.00	46024.9	1.991
10.00	39307.6	3.284
12.00	29052.9	1.169
15.00	13325.3	2.601
20.00	8491.2	1.955
25.00	5958.0	0.000

F. Program History

Figure 22 is a listing of the simulation program. The program is written in Fortran IV for use with the DEC-20 system. Data is inputted via a data file (e.g. FOR 28. DAT) that contains the input data in free format.

FIGURE 22

```
@TYPE (FILE) PLUMOD.FOR
C       PROGRAM PLUMOD --A. UZZO-- 10/25/78
C       THIS PROGRAM SIMULATES THE PROBABILITY OF OCCURRENCE
C       THE DOWNWIND DISTRIBUTION AND POSSIBLE INFECTION IN
C       A POPULATION BY POTENTIALLY INFECTIOUS ORGANISMS FROM
C       COOLING TOWER DRIFT.  THE DISTRIBUTION AND POTENTIAL
C       EFFECTS OF THESE ORGANISMS ARE BASED ON DATA FROM
C       THIS REPORT.  THE DRIFT COMPUTATIONS ARE BASED ON THE
C       ORFAD MODEL AS DESCRIBED BY M. E. LAVERNE IN REPORT
C       ORNL/TM-5201 (OAK RIDGE NATIONAL LABORATORY).

        DIMENSION TBL(6,5),DIAM(7),R(1),XM(21),VI(25),VF(25,2)
        DIMENSION DF(25,2),CUMUL(25),DRFRAC(7),TGI(6),ISED(6)
        DIMENSION DRIFT(20),DR(20),IK(20),PRR(20),A(6),P(4),B(4)
        DIMENSION TOMS(20),TOMC(20),TOTC(20),TOTS(20)
        DIMENSION ARY(20),TOPP(20)

        DATA TGI/-.0263,-.0173,-.0146,-.01,.0046,.0263/
        DATA A/-7.9,5.03,-1.38E-7,11.3,8.13E-3,-3.49/
        DATA B/-9.1,-3.57,.88,.006/
        DATA DIAM/70.,175.,300.,425.,550.,700.,0./
        DATA DRFRAC/.06,.3,.39,.15,.07,.03,6./
        DATA G,PI,CUBRT,FTM/9.81,3.1416,.33333,.3048/
        DATA XM/.1,.15,.2,.3,.5,.75,1.,1.5,2,2.5,3.,
        14.,5.,7.,9.,10.,12.,15.,20.,25.,0./
        AB(Y)=255.37+.5555*Y
        OPEN(UNIT=7,ACCESS='SEQOUT',FILE='PLUM.DAT')
        LR=26

        PROBA=0.
        DO 8 I=1,20
        TOTS(I)=0.
        TOTC(I)=0.
8       CONTINUE

C       READ INPUT DATA AND WRITE FIXED DATA
        READ(LR,*)HTO,DIATO,FRACDR,EXSPDO,CONC,TMPR,HEATO
C       WRITE FIXED PARAMETERS
        WRITE(7,1000)
        WRITE(7,1003)HTO
        WRITE(7,1005)DIATO
        WRITE(7,1007)HEATO
        WRITE(7,1030)TMPR
        WRITE(7,1031)FRACDR
        WRITE(7,1032)CONC
        WRITE(7,1033)EXSPDO
        WRITE(7,1012)
        DO 5 I=1,6
        READ(LR,*)(TBL(I,J),J=1,5)
5       CONTINUE
        READ(LR,*)(ISED(I),I=1,6)
        LTIME=0
        NTIME=400
        WRITE(7,1034)
        WRITE(7,1035)
```

```
              MTIME=0
              KTIME=400
              DO 3 JK=1,6
              WRITE(7,1036)MTIME,KTIME,(TBL(JK,JL),JL=1,5)
              MTIME=MTIME+400
              KTIME=KTIME+400
      3       CONTINUE
              DO 800 NCY=1,6


              DBT=TBL(NCY,1)
              WBT=TBL(NCY,2)
              WINDO=TBL(NCY,3)
              PCAP=TBL(NCY,4)
              STAB=TBL(NCY,5)
              HEATO=HEATO*PCAP
              LSTAB=STAB

      C       CALCULATE TOWER PARAMETERS
              HT=HTO*FTM
              DIAT=DIATO*FTM
              EXSPD=EXSPDO*FTM
              WIND=WINDO*.514
              RAD=DIAT/2
              TAREA=PI*RAD*RAD
              EXVOL=EXSPD*TAREA
              CWFR=1.8E6*HEATO7)
              UMW=EVLOS+ARLOS
              APP=2.7
              FRACON=0.

      C       CALCULATE DILUTION FACTOR TIME--INPUT VOLUME
              TAU=(CONC-1.)*TVOL/UMW
              ATAU=TAU/2
              BINVOL=UMW*ATAU

      C       CALCULATE PROB. OF ORG PRESENT
              C=0.
              DO 30 I=1,2000
              Y=GGUBF(ISED(1))
              IF (Y-.064)10,11
      11      IF(Y-.1380)12,13
      13      IF(Y-.2686)14,15
      15      IF(Y-.3158)16,17
      17      IF(Y-.4444)18,19
      19      IF(Y-.4722)20,21
      21      IF(Y-.5833)22,23
      23      IF(Y-.6944)24,25
      25      IF(Y-.7963)26,27
      27      IF(Y-.9074)28,29
      10      Z=0.;GO TO 40
      12      Z=.1;GO TO 40
      14      Z=.2;GO TO 40
      16      Z=.3;GO TO 40
```

```
18      Z=.4;GO TO 40
20      Z=.5;GO TO 40
22      Z=.6;GO TO 40
24      Z=.8;GO TO 40
26      Z=.8;GO TO 40
28      Z=.9;GO TO 40
29      Z=1.
40      C=C+Z
30      CONTINUE
        PROB=C/2000.
        XY=ABS(GGNOF(ISED(3)))
        IF(XY.GT.1.)GO TO 2
        PROB=XY*PROB
2       PROBA=PROBA+PROB

C       CALCULATE INPUT PARAMETERS
        CTORG=0.
        NTRY=Y*20
        DO 210 I=1,NTRY

        CALL GGEXP(ISED(2),PROB,1,R(1))
        CNORG=R(1)*1.E5
        RV2=GGUBF(ISED(3))
        IF(RV2-PROB)200,205
200     CNORG=0.
205     CTNORG=CNORG+CTNORG
210     CONTINUE
     -SEE ORFAD MODEL
        DIAMAX=DIAM(IDRCL)*1.5-.5*DIAM(IDRCL-1)
        DIAM(IDRCL+1)=DIAMAX
        D=0.
        DD=DIAMAX/25.
        F=0.
        X1=0.
        X2=.5*(DIAM(1)+DIAM(2))
        K=1
        CONR=.01
        FAC=1.E-4*((1.+.7*CONR)*CONR/.3112)**CUBRT
        DO 240 J=1,25
        D=D+DD
        DIM=FAC*D
        VFJ2=3519.2*DIM*DIM
        VFJ1=.4963*VFJ2
        VIJ=D*D/33414.
        IF(D.GT.74.36)VIJ=.00445*(D-37.18)
        DFJ=7.415E-6*D**2.667
        DFJ1=DFJ*((VIJ-VFJ1)/(VIJ+VFJ1))
        DFJ2=DFJ*(VIJ-VFJ2)/(VIJ+VFJ2)
        VF(J,1)=VFJ1
        VF(J,2)=VFJ2
        VI(J)=VIJ
        DF(J,1)=DFJ1
```

```
      DF(J,2)=DFJ2
215   IF(D-X2)220,220,230
220   CUMUL(J)=F+DRFRAC(K)*(D-X1)/(X2-X1)
      GO TO 240
230   F=F+DR5,232
232   K=IDRCL
      F=F-DRFRAC(IDRCL)
235   X2=DIAMAX
      IF(J.LT.25)GO TO 215
      CUMUL(J)=1.
240   CONTINUE
      DO 250 J=1,24
250   CUMUL(26-J)=CUMUL(26-J)-CUMUL(25-J)

C     CALCULATE RELATIVE HUMIDITY
      TEO=AB(DBT)
      TEB=AB(WBT)
      JFLAG=0
      T=TEO
      GO TO 110
130   JFLAG=1
      T=TEB
110   CONTINUE
      IF(TEO.LT.273.16)GO TO 265
      Z=373.16/T
      P(1)=A(1)*(Z-1)
      P(2)=A(2)*ALOG10(Z)
      Z1=A(4)*(1.-1./Z)
      P(7)=A(7)*(10**Z1-1)
      Z1=A(6)*(Z-1)
      P(4)=A(5)*(10**Z1-1)

      GO TO 245
265   Z=273.16/T
      P(1)=B4))
245   SUM=0.
      DO 244 I=1,4
244   SUM=SUM+P(I)
      PVSF=14.696*10**SUM
      IF(JFLAG)120,120,140
120   PVSD=PVSF*2.063
      GO TO 130
140   PVSW=PVSF*2.036
      PV=PVSW-(7.67E-4*29.84*(DBT-WBT)*(1.+(WBT-32.)/1571.))
      RH=PV/PVSD
      IF(RH.LE.0.)RH=.01
      RHFAC=(1.-RH)**1.079
      IRH=2
      IF(RH.LT.0.5)IRH=1

C     CALCULATE TOWER EFFLUENT TEMPERATURE
      IF(WBT.LT.80)ENTAL=(WBT+4.31)/(7.92-.0248*WBT)
```

```
                IF(WBT.GE.80.)ENTAL=(WBT-13.85)/(2.77-.016*WBT)
                RAPP=TMPR*APP
                ENTAL=ENTAL+RAPP
                IF(ENTAL.GT.43.7)TS=(2.766*ENTAL+13.85)/(1.+.016*ENTAL)
                IF(ENTAL.LE.43.7)TS=(7.92*ENTAL-4.31)/(1.+.0248*ENTAL)
                TPO=AB(TS)
                DELQ1=EVLOS/(753130*EXVOL)
                DELQ=DELQ1*TPO
                U=WIND
                FC=0.
                DO 361 IX=1,20
2STAB)
                TEHT=TEO+TG*HT
                S=G*(TG+.01)/TEO
        300     CONTINUE
                FR=G*EXSPD*RAD*RAD*(1.-TEHT/TPO+DELQ*(.61+2545.*FC/TPO))
                IF(FR.GE.0.) GO TO 310
                TEHT=TPO
                GO TO 300
        310     CONTINUE
                IF(LSTAB.GT.4) GO TO 362
                F4=FR**.4
                H=AMIN1(HT,304.8)
                XS=2.16*F4*H**.6
                X=AMIN1(XME,3.*XS)
        320     CONTINUE
                H=1.6*(FR*X*X)**CUBRT/U
                PR=H
                GO TO 340
        330     CONTINUE
                PR=5.*SQRT((SQRT(FR/(S*SQRT(S)))))
        340     CONTINUE
                PRR(IX)=PR
                IF(PR.GT.0.) GO TO 350
                GO TO 361
         C       CALCULATE DRIFT AND DRIFT PARAMETERS
                K=25
                OR=0.
                OPR=0.
                OXME=0.
                INCR=1
                DO460 IX=1,20
                DRIFT(IX)=0.

                XME=XM(IX)*1609.3
                PR=PRR(IX)
                DPR=PR-OPR

        C       CALCULATE DRIFT
                DXME=XME-OXME
                OPR=PR
                OXME=XME
```

```
                IF(RH.LT.0.76) GO TO 410

      C         NO EVAPORATION
                VFALL=(HT+PR)*U/XME
                DIA=37.18+VFALL/.00445
                IF(VFALL.LT.0.1655) DIA=SQRT(73414.*VFALL)
                IDIA=DIA/DD+1.
                IK(IX)=IDIA
                IF(IDIA.GT.25)GO TO 491
                DVDR=(VFALL-U*DPR/DXME)/XME
                DDDR=DVDR/.0045
                IF(VFALL.LT.0.1665)DDDR=.5*DIA*DVDR/VFALL
                DCDD=CUMUL(IDIA)/DD
                GO TO 440

      C         EVAPORATION
      410       CONTINUE
                H=HT+PR
      420       RY=DF(K,IRH)/RHFAC
                IF(H.LT.RY) GO TO 450
                XR=U*(H-RY)29600          K=K-1
                OR=XR
                IF(K)491,491,420
      430       DCDD=CUMUL(K)
                IK(IX)=K
                IF(K.GE.25) GO TO 491
                VFALL=VF(K,IRH)
                DDDR=1./(XR-OR)
      440       CHI2=ARLOS*DDDR*DCDD*INCR*8./(XME*PI)
                DR(IX)=CHI2/VFALL
                DRIFT(IX)=CHI2
      491       CONTINUE
      460       CONTINUE
                IF(NCY.LE.2)AMOD=1.
                IF(NCY.GT.2 .AND. NCY.LT.6)AMOD=.2
                RANV=GGUBF(ISED(4))
                IF(RANV.LT.0.1)AMOD=.5
                IF(NCY.GT.5)AMOD=1
                IF(RH.GT.0.76)BMOD=1
                IF(RH.LE.0.76.AND.RH.GE.0.5)BMOD=.5
                IF(RH.LT.0.5)BMOD=.2
                DO 470 IY=1,20
                TUMS(IY)=DRIFT(IY)*CAORG*AMOD*14400.*BMOD
                TUMC(IY)=DR(IY)*CAORG*AMOD*14400.*BMOD
                TOTC(IY)=TOTC(IY)+TUMC(IY)
                TOTS(IY)=TOTS(IY)+TUMS(IY)
      470       CONTINUE
                WRITE(7,1012)
                WRITE(7,1001)LTIME,NTIME
                WRITE(7,1002)PROB
                WRITE(7,1006)HEATO
                WRITE(7,1008)DBT
                WRITE(7,1009)WBT
                WRITE(7,1010)WINDD
```

```
                WRITE(7,1011)


                WRITE(7,1016)
                DO 600 IR=1,20
      600       WRITE(7,1015)XM(IR),PRR(IR),TOMC(IR),TOMS(IR)
                LTIME=LTIME+400
                NTIME=LTIME+400
      800       CONTINUE
                PROBB=PROBA/6
      1001      FORMAT('1','     COOLINMS',F4.2)
      1003      FORMAT(1X,'TOWER HEIGHT (FEET)                   ',F10.2)
      1005      FORMAT(1X,'TOWER DIAMETER (FEET)                 ',F10.2)
      1006      FORMAT(1X,'HEAT LOSS (MEGACAL/SEC)               ',F10.2)
      1007      FORMAT(1X,'HEAT LOSS (MEGACAL/SEC,MAX)           ',F10.2)
      1008      FORMAT(1X,'DRY BULB TEMPERATURE (DEG F)          ',F10.2)
      1009      FORMAT(1X,'WET BULB TEMPERATURE (DEG F)          ',F10.2)
      1010      FORMAT(1X,'WIND VELOCITY (KNOTS)                 ',F10.2)
      1011      FORMAT(//)
      1000      FORMAT('1',//,'***************COOLING TOWER FIXED PAR
                1AMETERS***************'//)
      1015      FORMAT(2X,F7.2,10X,F8.1,5X,F12.1,5X,F12.1)
                WRITE(7,1012)
                WRITE(7,1018)
                WRITE(7,1020)PROBB
                WRITE(7,1019)
                DO 700 IM=1,20
      700       WRITE(7,1017)XM(IM),TOTC(IM),TOTS(IM)
      1012      FORMAT(////)
      1016      FORMAT(1X,'DIST(MI)',5X,'PLUME RISE(M)',6X,'ORG/M3/4HRS'
                1,6X,'ORG/M2/4HRS')
      1018      FORMAT('1',///,'---------------   24 HOUR TOTALS  --
                1-------------'/)
      1017      FORMAT(2X,F7.2,5X,F12.1,5X,F12.1)
      1019      FORMAT(1X,'DIST(MI)',7X,'ORG/M3/DAY',7X,'ORG/M2/DAY')
      1020      FORMAT(1X,'DAILY PROBABILITY OF EFFLUENT CONTAINING ORGA
                1NISMS',F4.2,/)
                DO 750 J=1,20
                TOPP(J)=20.*TOTC(J)+TOTS(J)
                PL=0.
                PK=0.
                DO 650 M=1,100
                CALL GGEXP(ISED(5),.1,1,R(1))
                DORG=3.E6*R(1)
                IF(TOPP(J).GT.DORG)PK=PK+1.
                PL=PL+1.
      650       CONTINUE
                AND=ABS(GGNOF(ISED(6)))
                ARY(J)=AND*PK*20./PL
                IF(ARY(J).GT.20.)ARY(J)=20.
      750       CONTINUE
                WRITE(7,1025)
                WRITE(7,1026)
```

```
              WRITE(7,1026)
              WRITE(7,1028)
              DO 770 N=1,20
              WRITE(7,1027)XM(N),TOFF(N),ARY(N)
      770     CONTINUE
      1025    FORMAT('1',///,'---------------     SUMMARY OF RESULTS
              1    ------------------')
      1026    FORMAT(1X,//,2X,'DIST(MI)',7X,'AVG NO. PART.',7X,'PERCEN
              1T AFFECTED')
      1028    FORMAT(19X,'INGESTED/IND.',10X,'BY EFFLUENT',/)
      1027    FORMAT(2X,F7.2,8X,F12.1,16X,F7.3)
      1030    FORMAT(1X,'TEMPERATURE RANGE (DEG F)          ',F10.2)
      1031    FORMAT(1X,'DRIFT FRACTION (G/G)               ',F10.6)
     ',F10.2)


      1034    FORMAT(12X,'--COOLING TOWER OPERATING PARAMETERS--')
      1035    FORMAT(1X,'TIME (HRS)'4X,'DRY BULB T',4X,'WET BULB T', 4X
              1,'WIND VEL.',4X,'OPER CAP',4X,'STABILITY')
      1036    FORMAT(1X,I4,'-',I4,2X,F10.2,4X,F10.2,4X,F9.2,7X,F4.2,
              16X,F4.0)
              END
@
```

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TECHNICAL REPORT DATA
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1. REPORT NO. EPA-600/7-79-251a	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Effects of Pathogenic and Toxic Materials Transported Via Cooling Device Drift-- Volume 1. Technical Report		5. REPORT DATE November 1979
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) H.D. Freudenthal, J.E. Rubinstein, and A. Uzzo		8. PERFORMING ORGANIZATION REPORT NO.
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15. SUPPLEMENTARY NOTES IERL-RTP project officer is Michael C. Osborne, Mail Drop 61, 919/541-2915.

16. ABSTRACT The report describes a mathematical model that predicts the percent of the population affected by a pathogen or toxic substance emitted in a cooling tower plume, and gives specific applications of the model. Eighty-five pathogens (or diseases) are cataloged as potentially occurring in U.S. waters, but there is insufficient data to predict the probability of occurrence or relate their occurrence to public health, population, or pollution. Sixty-five toxic substances are cataloged as potentially occurring in U.S. waters, but the actual number is probably many times the EPA-supplied list. Toxic concentrations to persons, animals, and plants are known for only a few of the chemicals: most toxic levels can be only inferred from animal studies. In the population as a whole, the epidemiological impact of a pathogen is a function of age, sex distribution, racial (genetic) distribution, general health and well-being, prior exposure, and immunological deficiency states. While cooling device drift may not be directly responsible for epidemics, it may potentiate the burden in an already weakened population, raising a segment of the population into the clinical state. The effect of toxic substances is difficult to evaluate because of inadequate data on humans. The effect is a function of concentration in susceptible tissue, and is much less dependent than pathogens on host resistance.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Water	Pollution Control	13B	07B
Cooling Towers	Epidemiology	Stationary Sources	13A,07A	
Drift	Mathematical Models		14B	12A
Plumes			21B	
Pathology			06E	
Toxicity			06T	

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APPENDIX C. EJSCREEN 2.1 REPORT

EJScreen Report (Version 2.1)

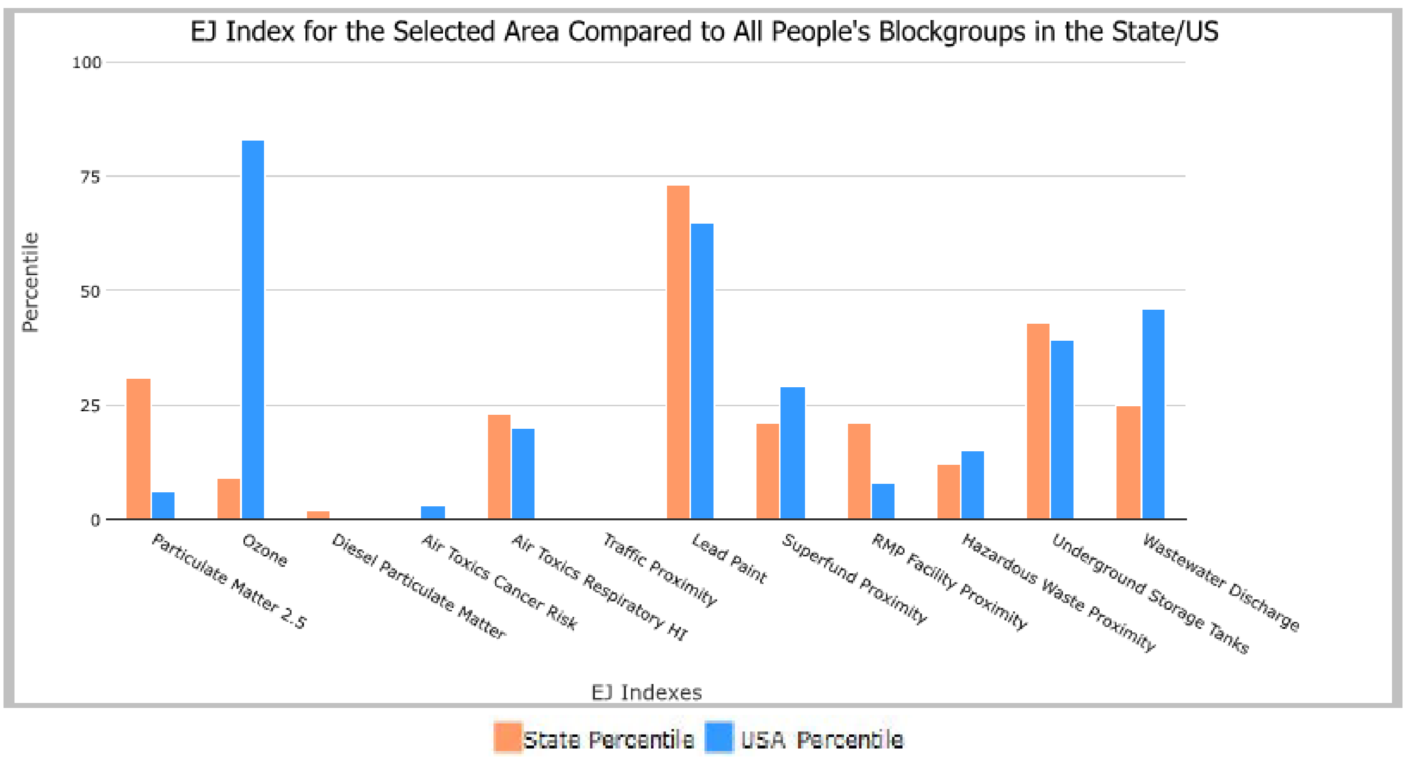
5 miles Ring Centered at 31.463991,-110.721450, ARIZONA, EPA Region 9

Approximate Population: 141

Input Area (sq. miles): 78.53

Hermosa Project - EJSCREEN 2.1

Selected Variables	State Percentile	USA Percentile
Environmental Justice Indexes		
EJ Index for Particulate Matter 2.5	31	6
EJ Index for Ozone	9	83
EJ Index for Diesel Particulate Matter*	2	0
EJ Index for Air Toxics Cancer Risk*	0	3
EJ Index for Air Toxics Respiratory HI*	23	20
EJ Index for Traffic Proximity	0	0
EJ Index for Lead Paint	73	65
EJ Index for Superfund Proximity	21	29
EJ Index for RMP Facility Proximity	21	8
EJ Index for Hazardous Waste Proximity	12	15
EJ Index for Underground Storage Tanks	43	39
EJ Index for Wastewater Discharge	25	46



This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

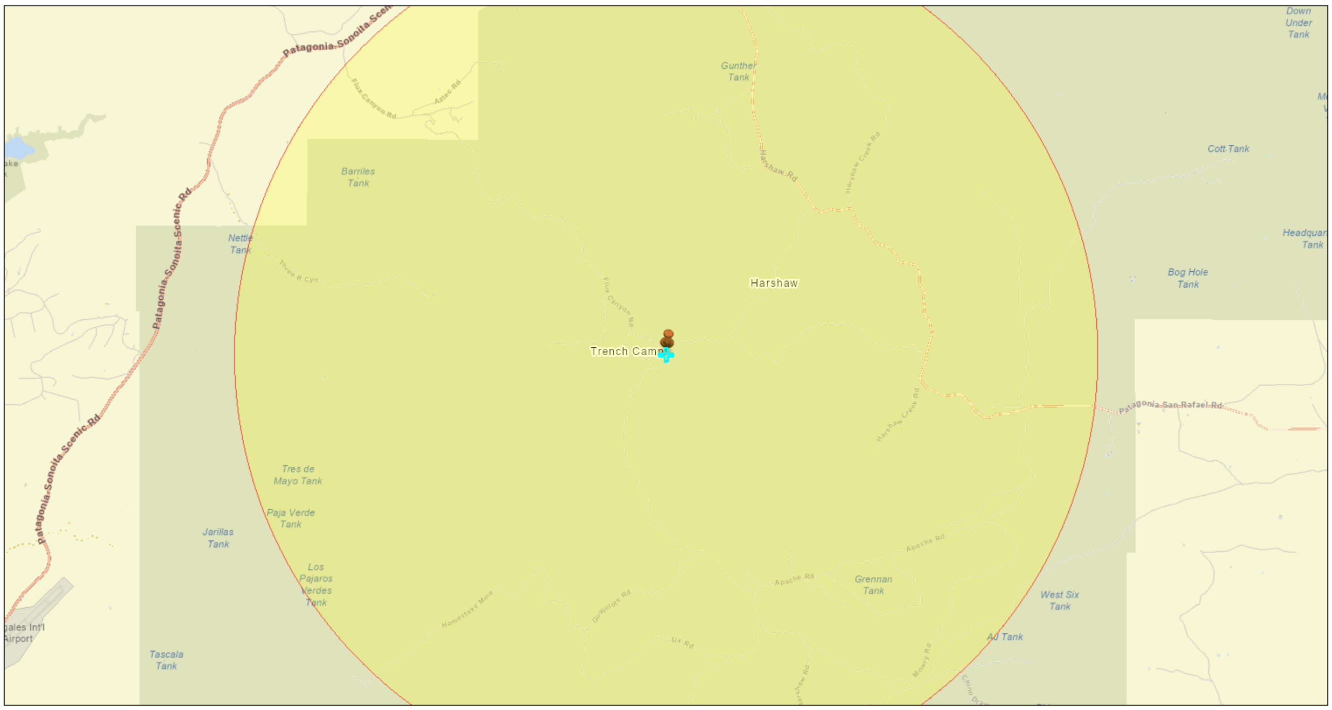
EJScreen Report (Version 2.1)

5 miles Ring Centered at 31.463991,-110.721450, ARIZONA, EPA Region 9

Approximate Population: 141

Input Area (sq. miles): 78.53

Hermosa Project - EJSCREEN 2.1



October 16, 2022

Hermosa Project - EJSCREEN 2.1

Search Result (point)

1:72,224

0 0.75 1.5 3 mi

0 1.25 2.5 5 km

CONANP, Esri, HERE, Garmin, Foursquare, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

Sites reporting to EPA	
Superfund NPL	0
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	0

EJScreen Report (Version 2.1)

5 miles Ring Centered at 31.463991,-110.721450, ARIZONA, EPA Region 9

Approximate Population: 141

Input Area (sq. miles): 78.53

Hermosa Project - EJSCREEN 2.1

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 (μg/m^3)	5.71	7.24	19	8.67	3
Ozone (ppb)	50	54.2	6	42.5	89
Diesel Particulate Matter* (μg/m^3)	0.0189	0.318	1	0.294	<50th
Air Toxics Cancer Risk* (lifetime risk per million)	11	32	7	28	<50th
Air Toxics Respiratory HI*	0.2	0.37	21	0.36	<50th
Traffic Proximity (daily traffic count/distance to road)	0.0025	570	0	760	0
Lead Paint (% Pre-1960 Housing)	0.24	0.08	87	0.27	52
Superfund Proximity (site count/km distance)	0.018	0.077	14	0.13	15
RMP Facility Proximity (facility count/km distance)	0.039	0.62	12	0.77	4
Hazardous Waste Proximity (facility count/km distance)	0.038	1.4	7	2.2	6
Underground Storage Tanks (count/km^2)	0.0036	1.7	30	3.9	0
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.00011	6.7	19	12	31
Socioeconomic Indicators					
Demographic Index	36%	38%	54	35%	60
People of Color	29%	46%	38	40%	50
Low Income	43%	33%	68	30%	72
Unemployment Rate	1%	6%	24	5%	24
Limited English Speaking Households	2%	4%	60	5%	63
Less Than High School Education	5%	12%	40	12%	36
Under Age 5	6%	6%	60	6%	59
Over Age 64	31%	18%	81	16%	90

*Diesel particular matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

For additional information, see: www.epa.gov/environmentaljustice