APPENDIX C
PRE-EARLY RESPONSE ACTION, VOLATILE ORGANIC COMPOUNDS IN SOIL GAS, BROADWAY NORTH LANDFILL
REMEDIAL INVESTIGATION REPORT
GROUNDWATER OPERABLE UNIT

Arizona Department of Environmental Quality

Broadway-Pantano Water Quality Assurance Revolving Fund Site

June 1, 2012

BROADWAY NORTH LANDFILL -- PRE-EARLY RESPONSE ACTION, VOLATILE ORGANIC COMPOUNDS IN SOIL GAS

The majority of the soil gas data - and, in particularly, the most recent investigations performed at the Broadway North Landfill (BNL) - indicate that releases of volatile organic compounds (VOCs) have occurred at the BNL, and the deep vadose zone soil gas data support the determination that the BNL is the source of the groundwater contamination emanating from underneath the BNL.

- Thirteen soil gas investigations within the Site (initially for LFG migration studies, and later for remedial investigations, as well) have been completed by eight different consultants since 1980. The following have pertinence related to shallow or deep soil gas sampling within landfilled areas. The bulleted list below indicates (1) the consultant which performed the work, (2) the client for whom the work was performed, in parentheses, and (3) the year the in which the work was performed:
- GRC Consultants, Inc. (Cienega Corporation), 1985
- Tracer Research Corporation (Woodward Consultants), 1988
- Arizona Department of Environmental Quality (United States Environmental Protection Agency, Region IX), 1995
- Camp Dresser & McKee (City of Tucson), 1998
- Hydro Geo Chem, Inc (City of Tucson), 2000

<u>GRC Consultants, Inc. (Cienega Corporation), 1985</u>

In June 1985, GRC (1985) installed four shallow soil gas monitoring wells in the central and western portions of the BNL (Figure C-1). Each well (Wells #1 through #4) was installed to a depth of 10 feet below ground surface (bgs) and screened from 5 to 10 feet bgs. The report does not specify if the wells were screened in refuse or native soil, or if soil samples were collected for laboratory analysis. Soil gas samples were collected from three of the wells (Wells 1, 3, and 4) on June 29, 1985; and they were analyzed for VOCs utilizing United States Environmental Protection Agency (USEPA) Method 624. Tetrachloroethene (PCE) was detected in two of the soil gas samples (Well #1 and #3), while trichloroethene (TCE) was detected in one of the soil gas samples (Well #3). Additional VOCs detected in the soil gas samples collected from the wells included: methylene chloride; acetone; trans-1,2-dichloroethene (DCE); chloroform; methyl ethyl ketone; cis-1,2-DCE; benzene; 2-hexanone; toluene; ethylbenzene; m-xylene; and o,p-xylene. This appears to be the earliest investigation to report the presence of VOCs in soil gas at the BNL. Laboratory results for PCE and TCE are presented in Table C-1 and on Figure C-1.

<u>Tracer Research Corporation (Woodward Consultants), 1988</u>

Woodward-Clyde Consultants (WCC) subcontracted Tracer (1988) to conduct a shallow soil gas survey over the BNL. Soil gas sampling locations were spaced on an approximate 400-foot center grid pattern, as shown on Figure C-2. Soil gas samples were collected at depths ranging from 2.5 to 6 feet bgs in December 1988. The soil gas samples were analyzed for PCE, TCE, and 1,1,1-trichloroethane. Methane (CH_4) concentrations were

measured using a flame ionization detector (FID). Laboratory results for PCE and TCE are listed on Table C-1 and shown on Figure C-2. Tracer noted that the highest concentrations of PCE and TCE in soil gas were located in sample points along the eastern boundary of the BNL (SG-17 and SG-29) and at the northern end of the landfill (SG-36 and SG-40). The maximum concentration of PCE in soil gas (1.0 microgram per liter-vapor, µg/L-v) was detected in the sample collected from SG-30, located on the west side of the BNL, north of the 5th Street Extension. The maximum concentrations of CH_4 occurred in the central and northern portions of the BNL.

Arizona Department of Environmental Quality (USEPA, Region IX), 1995

In February 1995, ADEQ (1995) conducted a Preliminary Assessment/Site Investigation at the BNL. A portion of the investigation included advancing and collecting soil gas samples from hydraulically driven probes (GeoProbes®) at 16 locations on the BNL. Background samples were collected at two locations outside the known limits of the landfill. Soil gas samples were collected at depths ranging from 8.5 to 19 feet bgs. Laboratory results for PCE and TCE in soil gas are presented in Table C-1 and on Figure C-3. Due to the elevated laboratory method reporting limit (MRL) of 2 µg/L-v, only one soil gas sample (from BNL-16 at 8.5 feet bgs) contained a detectable concentration of PCE.

Camp Dresser & Mckee (City of Tucson), 1998

From 1996 to 1998, Camp Dresser & McKee (CDM) conducted field investigations, which were presented in CDM's BNL Landfill Operable Unit Remedial Report for the City of Tucson and Pima County (CDM, 1998). These extensive investigations followed a phased approach to include sampling and laboratory analysis of: (1) soil gas from existing, temporary, and newly installed monitoring probes; (2) subsurface soil; and (3) groundwater from existing and newly installed groundwater monitor wells.

During June and July, 1996, CDM (1998) collected 81 soil gas samples from 64 sampling locations (SG-1 through SG-64; Figure C-4). Soil gas samples were collected at depths of 10 and 20 feet bgs and analyzed for VOCs using an on-site laboratory. Analytical results for PCE and TCE are listed in Table C-1 and shown on Figure C-4. In general, higher concentrations of VOCs were identified in several sampling areas (SG-2, SG-22, SG-23, SG-48, and SG-39) across the BNL . The results from this phase of the investigation were used to determine the placement of soil borings for the next phase of the investigation conducted by CDM.

In July and early August 1996, CDM installed 13 shallow soil gas monitor probes (GP-1 through GP-13) using hydraulic push techniques. CDM also advanced five soil borings (B-1 through B-5) to 61.5 feet bgs and one soil boring (B-6) to 100 feet bgs utilizing a hollow-stem auger drill rig. The shallow monitor probes (GP-Series) and soil boring (B-Series) locations were chosen using the results of the shallow soil gas survey (Figure C-5). These GP-series probes are still in place at the BNL, screened at depths ranging from 8.5 feet to 20 feet bgs. Soil borings B-3, B-5, and B-6 also were completed as either single or nested soil monitor probes. Nested monitor probes in borings B-3 and B-6 were screened from 24 to 29 and 55 to 60 feet bgs, respectively. Monitor probe B-5 was screened from 28 to 38 feet bgs. Soil gas samples were collected from three shallow monitor probes (GP-1, GP-4, GP-8) and two deep (55 to 60 feet bgs) monitor probes (B-3 and B-6) for laboratory analysis. Soil gas

analytical results for PCE and TCE concentrations are shown on Figure C-5 and included in Table C-1.

In October 1996, CDM installed three deep nested monitor probes (DP-1, DP-2, and DP-3) at the Site (Figure C-6). Soil samples were not collected for laboratory analysis while drilling soil borings DP-1, DP-2, and DP-3. However, 13 soil gas samples were collected during drilling for laboratory analysis using a SimulProbe™ device. Laboratory analytical results for PCE and TCE concentrations in soil gas are presented in Table C-1 and shown on Figure C-6. Soil gas samples collected using the SimulProbe™ device indicate laboratory detectable concentrations of PCE and TCE are present to a minimum depth of at least 195 feet bgs in all of the monitor probe locations. Soil boring DP-1 was completed as four nested monitor probes, with screened intervals of 45 to 50, 120 to 125, 145 to 150, and 188 to 193 feet bgs. Soil borings DP-2 and DP-3 were completed as four nested vapor monitor probes, each with screened intervals of 45 to 50, 95 to 100, 145 to 150, and 188 to 193 feet bgs, respectively.

Between December 1996 and February 1997, CDM installed three groundwater monitoring wells with four nested soil gas monitor probes along the western side of the BNL. Groundwater and soil gas samples were collected from the newly installed wells and probes. Soil gas samples also were collected from several vapor sampling probes at DP-1, DP-2, and DP-3. The groundwater monitor wells (designated MW-1, MW-2, and MW-3 by CDM; re-designated by COT as WR-273A, WR-274A, and WR-275A, respectively) were installed to total depths ranging from 347 to 360 feet bgs. Wells WR-273A, WR-274A, and WR-275A were screened from 298 to 338, 306 to 346, and 317 to 357 feet bgs, respectively. The nested soil gas monitoring probes were screened at 45 to 50, 130 to 135, 215 to 220, and 295 to 300 feet bgs in wells WR-273A and WR-275A. Soil gas monitoring probes in well WR-274A were screened at 45 to 50, 95 to 100, 215 to 220, and 295 to 300 feet bgs. The locations of the monitor wells with nested soil gas monitoring probes are shown on Figure C-7. CDM (1998) collected soil gas samples for laboratory analysis from the sampling probes at WR-273A, WR-274A, WR-275A, DP-1, DP-2, and DP-3 in February 1997. Laboratory results for PCE and TCE concentrations in soil gas are presented in Table C-1 and on Figure C-7.

Hydro Geo Chem, Inc. (City of Tucson), 2000

During January and February 2000, Hydro Geo Chem (HGC) installed six soil vapor extraction (SVE) wells (R-070A through R-075A) and two air injection (AI) wells (R-068A and R-069B) at the BNL (HGC, 2001). The wells were installed as part of the Early Response Action (ERA) implemented at the BNL by City of Tucson and Pima County. The remedial well locations are shown on Figure C-8. The SVE wells were constructed with a screened interval for vapor extraction extending from approximately 157 to 228 feet bgs, plus two nested soil gas monitoring probes screened from 45 to 50 feet bgs and 95 to 100 feet bgs, respectively. The AI wells were constructed with an injection screen interval from approximately 240 to 368 feet bgs, plus four nested soil gas monitoring probes screened from approximately 44 to 52, 95 to 100, 144 to 150, and 195 to 200 feet bgs. In April and May 2000, HGC collected soil gas samples from: (1) the monitoring probes and extraction intervals in the SVE wells; (2) the monitoring probes and injection intervals in the AI wells; (3) the nested soil gas monitoring probes in groundwater monitor wells WR-273A, WR-274A, and WR-275A; and (4) the nested soil gas monitoring probes DP-1, DP-2, and DP-3.

Laboratory results for PCE and TCE in soil gas are presented in Table C-1 and on Figure C-8.

LIST OF ATTACHMENTS

TABLES

Table C-1 Historical Soil Gas Sampling Results, Broadway North Landfill, Remedial Investigation Report, Broadway-Pantano WQARF Site, Tucson, Arizona.

FIGURES

Figure C-1 Soil Gas Sampling Results from 1985 Investigation by GRC, Broadway North Landfill
Figure C-2 Soil Gas Sampling Results from 1988 Investigation by Tracer, Broadway North Landfill
Figure C-3 Soil Gas Sampling Results from 1995 Investigation by ADEQ, Broadway North Landfill
Figure C-4 Soil Gas Sampling Results from June/July 1996 Investigation by CDM, Broadway North Landfill
Figure C-5 Soil Gas Sampling Results from GP & B Series Probes in August 1996 by CDM, Broadway North Landfill
Figure C-6 Soil Gas Sampling Results from DP Series Probe Installation in October 1996 by CDM, Broadway North Landfill
Figure C-7 Soil Gas Sampling Results from Deep Probes in February 1997 by CDM, Broadway North Landfill
Figure C-8 Soil Gas Sampling Results Prior to SVE/AI Start-up, Broadway North Landfill

REFERENCES

Arizona Department of Environmental Quality, 1995. Preliminary Assessment/Site Inspection, Broadway North Landfill. June 30, 1995.

Camp Dresser & McKee, 1998. Remedial Investigation Report, Broadway North Landfill, Tucson, Arizona. March, 1998.

GRC Consultants, Inc., 1985. Landfill Soil Gas Results, Broadway Landfill, Gateway Center Development, Tucson, Arizona. September 24, 1985.

Hydro Geo Chem, 2001. Semi-Annual Full Scale Soil Vapor Extraction/Air Injection System Performance Report II, Broadway North Landfill, Tucson, Arizona. October 23, 2001.

Tracer Research Corporation, 1988. Shallow Soil Gas Investigation at the Gateway Landfill, Tucson, Arizona. December, 1988.

TABLE C-1
HISTORICAL SOIL GAS SAMPLING RESULTS, BROADWAY NORTH LANDFILL
REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
Well 1	6/29/1985	5 - 10	0.102	<0.01	Y	1
Well 3	6/29/1985	5 - 10	10.6	16.7	Y	1
Well 4	6/29/1985	5 - 10	<0.02	<0.01	Y	1
SG-01	12/7/1988	4.5	0.007	<0.0003	Y	2
SG-02	12/7/1988	6.0	0.01	<0.0003	Y	2
SG-03	12/7/1988	5.0	0.03	<0.0003	Y	2
SG-04	12/7/1988	5.0	0.005	<0.0003	Y	2
SG-05	12/7/1988	6.0	0.06	<0.0003	Y	2
SG-06	12/7/1988	6.0	0.03	0.008	Y	2
SG-07	12/7/1988	6.0	0.04	0.002	Y	2
SG-08	12/7/1988	6.0	0.03	0.01	Y	2
SG-09	12/7/1988	6.0	0.004	0.002	N	2
SG-10	12/5/1988	6.0	<0.00006	<0.0002	N	2
SG-11	12/7/1988	6.0	0.02	<0.0003	Y	2
SG-12	12/7/1988	6.0	0.02	0.02	Y	2
SG-13	12/7/1988	4.0	0.006	0.003	Y	2
SG-14	12/7/1988	4.0	0.004	0.002	Y	2
SG-15	12/5/1988	4.0	0.0005	<0.0002	Y	2
SG-16	12/7/1988	5.0	0.02	0.04	Y	2
SG-17	12/7/1988	6.0	0.6	1	Y	2
SG-18	12/6/1988	6.0	<0.00005	<0.0002	N	2
SG-19	12/6/1988	6.0	0.02	0.04	Y	2
SG-20	12/6/1988	6.0	0.02	0.08	Y	2
SG-21	12/5/1988	4.0	0.0008	0.002	N	2
SG-22	12/6/1988	6.0	0.004	0.002	N	2
SG-23	12/6/1988	6.0	0.008	0.002	Y	2
SG-24	12/6/1988	2.5	0.01	0.004	Y	2
SG-25	12/6/1988	6.0	0.0006	<0.0002	Y	2
SG-26	12/6/1988	6.0	0.002	0.008	Y	2
SG-27	12/6/1988	6.0	0.02	<0.0002	N	2
SG-28	12/6/1988	6.0	0.02	0.0004	Y	2
SG-29	12/7/1988	6.0	0.2	0.5	N	2
SG-30	12/6/1988	5.0	1.0	<0.02	N	2
SG-31	12/6/1988	4.0	0.007	<0.0002	Y	2
SG-32	12/5/1988	3.0	0.02	0.003	N	2
SG-33	12/6/1988	6.0	0.04	<0.0002	Y	2
SG-34	12/7/1988	3.0	0.08	<0.0003	Y	2
SG-35	12/7/1988	6.0	0.1	<0.0003	Y	2
SG-36	12/6/1988	6.0	0.2	0.6	N	2
SG-37	12/7/1988	5.0	0.1	<0.0003	Y	2
SG-38	12/7/1988	6.0	0.008	0.02	N	2
SG-39	12/6/1988	6.0	0.004	0.008	N	2
SG-40	12/7/1988	6.0	0.4	0.8	N	2

TABLE C-1
HISTORICAL SOIL GAS SAMPLING RESULTS, BROADWAY NORTH LANDFILL
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BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
SG-1	7/1990	5.0	0.02	0.001	Y	3
SG-2	7/1990	5.0	0.08	0.0005	Y	3
SG-3	7/1990	5.0	0.2	<0.00005	Y	3
SG-4	7/1990	5.0	0.1	<0.00005	Y	3
SG-5	7/1990	5.0	0.2	<0.00005	Y	3
SG-6	7/1990	3.0	0.04	<0.00005	Y	3
SG-7	7/1990	4.0	0.04	<0.00005	Y	3
SG-8	7/1990	4.0	0.04	<0.00005	Y	3
01SV	2/1995	8.5	<2.0	<2.0	N	4
01DV	2/1995	18.5	<2.0	<2.0	Y	4
02SV	2/1995	8.5	<2.0	<2.0	Y	4
02DV	2/1995	18.5	<2.0	<2.0	Y	4
03SV	2/1995	8.5	<2.0	<2.0	Y	4
03ASV	2/1995	8.5	<2.0	<2.0	Y	4
04SV	2/1995	8.5	<2.0	<2.0	N	4
04DV	2/1995	18.5	<2.0	<2.0	N	4
05SV	2/1995	8.5	<2.0	<2.0	Y	4
05DV	2/1995	18.5	<2.0	<2.0	Y	4
05ADV	2/1995	18.5	<2.0	<2.0	Y	4
06SV	2/1995	8.5	<2.0	<2.0	Y	4
06DV	2/1995	18.5	<2.0	<2.0	N	4
07SV	2/1995	8.5	<2.0	<2.0	Y	4
09SV	2/1995	8.5	<2.0	<2.0	N	4
09DV	2/1995	18.5	<2.0	<2.0	N	4
10SV	2/1995	8.5	<2.0	<2.0	Y	4
10DV	2/1995	18.5	<2.0	<2.0	Y	4
11SV	2/1995	8.5	<2.0	<2.0	Y	4
11DV	2/1995	18.5	<2.0	<2.0	Y	4
11ASV	2/1995	10.0	<2.0	<2.0	Y	4
11ADV	2/1995	19.5	<2.0	<2.0	N	4
12SV	2/1995	8.5	<2.0	<2.0	N	4
12DV	2/1995	18.5	<2.0	<2.0	N	4
13SV	2/1995	8.5	<2.0	<2.0	Y	4
13DV	2/1995	18.5	<2.0	<2.0	Y	4
14SV	2/1995	8.5	<2.0	<2.0	Y	4
14DV	2/1995	18.5	<2.0	<2.0	Y	4
15SV	2/1995	8.5	<2.0	<2.0	Y	4
15DV	2/1995	18.5	<2.0	<2.0	Y	4
16SV	2/1995	8.5	2.6	<2.0	Y	4
16DV	2/1995	18.5	<2.0	<2.0	Y	4
17SV	2/1995	9.0	<2.0	<2.0	Y	4
17DV	2/1995	19.0	<2.0	<2.0	Y	4

TABLE C-1
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REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
SG-1	6/28/1996	10	<1.0	<1.0	Y	5
SG-1	6/28/1996	20	1.3	<1.0	Y	5
SG-2	6/28/1996	10	3.6	<1.0	Y	5
SG-2	6/28/1996	20	<1.0	<1.0	Y	5
SG-3	6/28/1996	10	<1.0	<1.0	N	5
SG-3	6/28/1996	20	<1.0	<1.0	N	5
SG-4	7/2/1996	10	1.5	<1.0	Y	5
SG-5	7/2/1996	20	1.7	1.5	Y	5
SG-6	7/2/1996	20	2.3	<1	N	5
SG-7	7/2/1996	20	2.6	1.0	Y	5
SG-8	6/28/1996	10	<1.0	<1.0	N	5
SG-8	6/28/1996	20	<1.0	<1.0	Y	5
SG-9	6/28/1996	10	<1.0	<1.0	Y	5
SG-9	6/28/1996	20	<1.0	<1.0	Y	5
SG-10	7/2/1996	20	1.6	<1.0	Y	5
SG-11	7/2/1996	20	1.4	<1.0	Y	5
SG-12	7/2/1996	20	1.6	<1.0	Y	5
SG-13	7/2/1996	20	2.1	<1.0	Y	5
SG-14	7/2/1996	20	2.4	1.2	Y	5
SG-15	6/28/1996	10	<1.0	<1.0	Y	5
SG-15	6/28/1996	20	<1.0	<1.0	Y	5
SG-16	6/28/1996	10	<1.0	<1.0	Y	5
SG-16	6/28/1996	20	<1.0	<1.0	Y	5
SG-17	6/28/1996	10	1.2	<1.0	Y	5
SG-17	6/28/1996	20	<1.0	<1.0	Y	5
SG-18	7/2/1996	20	1.2	<1.0	Y	5
SG-19	7/2/1996	20	1.3	<1.0	Y	5
SG-20	7/2/1996	20	2.3	2.6	Y	5
SG-21	7/2/1996	20	2.4	1.4	Y	5
SG-22	7/2/1996	20	6.2	1.0	Y	5
SG-23	6/28/1996	10	2.2	1.3	Y	5
SG-23	6/28/1996	20	5.6	1.5	Y	5
SG-24	7/2/1996	20	2.0	<1.0	N	5
SG-25	7/2/1996	20	<1.0	<1.0	N	5
SG-26	7/2/1996	20	2.2	<1.0	N	5
SG-27	7/3/1996	20	2.1	<1.0	Y	5
SG-28	7/3/1996	20	2.1	<1.0	N	5
SG-29	6/28/1996	10	<1.0	<1.0	Y	5
SG-29	6/28/1996	20	<1.0	<1.0	Y	5
SG-30	6/27/1996	10	<1.0	<1.0	N	5
SG-30	6/27/1996	20	<1.0	<1.0	N	5
SG-31	6/27/1996	10	<1.0	<1.0	N	5
SG-31	6/27/1996	20	<1.0	<1.0	N	5
SG-32	6/27/1996	10	3.6	1.1	Y	5

TABLE C-1
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REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
SG-32	6/27/1996	20	4.8	1.1	Y	5
SG-33	6/27/1996	10	<1.0	<1.0	Y	5
SG-33	6/27/1996	20	<1.0	<1.0	Y	5
SG-34	6/27/1996	10	<1.0	<1.0	N	5
SG-34	6/27/1996	20	<1.0	<1.0	N	5
SG-35	6/27/1996	10	<1.0	<1.0	N	5
SG-35	6/27/1996	20	<1.0	<1.0	N	5
SG-36	7/2/1996	20	1.5	<1.0	Y	5
SG-37	7/2/1996	20	1.5	1.0	Y	5
SG-38	7/8/1996	20	<1.0	2.1	Y	5
SG-39	7/8/1996	20	6.4	16	Y	5
SG-40	7/8/1996	20	<1.0	<1.0	Y	5
SG-41	7/8/1996	20	<1.0	<1.0	Y	5
SG-42	7/8/1996	20	2.0	1.0	Y	5
SG-43	7/8/1996	20	<1.0	<1.0	Y	5
SG-44	7/8/1996	20	<1.0	<1.0	Y	5
SG-45	7/8/1996	20	<1.0	<1.0	Y	5
SG-46	7/8/1996	20	<1.0	<1.0	Y	5
SG-47	7/8/1996	20	<1.0	<1.0	N	5
SG-48	7/9/1996	20	7.1	2.3	Y	5
SG-49	7/9/1996	20	1.8	<1.0	N	5
SG-50	7/9/1996	20	1.8	<1.0	N	5
SG-51	7/9/1996	20	2.1	1.1	Y	5
SG-52	7/9/1996	20	2.0	1.0	Y	5
SG-53	7/9/1996	20	2.1	1.1	Y	5
SG-54	7/9/1996	20	2.1	<1.0	N	5
SG-55	7/9/1996	20	2.5	1.2	Y	5
SG-56	7/9/1996	20	2.7	<1.0	Y	5
SG-56	7/9/1996	28	2.5	<1.0	N	5
SG-57	7/9/1996	20	2.9	<1.0	Y	5
SG-58	7/9/1996	20	2.3	1.0	Y	5
SG-59	7/9/1996	20	2.7	1.9	Y	5
SG-60	7/9/1996	20	2.5	1.4	Y	5
SG-61	7/9/1996	20	2.7	1.3	Y	5
SG-62	7/9/1996	20	2.5	2.9	Y	5
SG-63	7/9/1996	20	2.2	1.0	Y	5
SG-64	7/9/1996	20	2.8	1.3	Y	5
B3-02	8/1996	55-60	<5.0	12	Y	5
B6-01	8/1996	55-60	<5.0	<5.0	N	5
GP-01	8/1996	9-19	<5.0	<5.0	N	5
GP-04	8/1996	10-20	<5.0	<5.0	N	5
GP-08	8/1996	15-20	<5.0	<5.0	N	5

TABLE C-1
HISTORICAL SOIL GAS SAMPLING RESULTS, BROADWAY NORTH LANDFILL
REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
DP-1	10/8/1996	45	12	<5.0	N	5
DP-1	10/8/1996	95	16	<5.0	N	5
DP-1	10/9/1996	140	<5.0	<5.0	N	5
DP-1	10/10/1996	195	<5.0	<5.0	N	5
DP-1A	10/16/1996	195	45	<5.0	N	5
DP-2	10/11/1996	45	<5.0	<5.0	Y	5
DP-2	10/11/1996	95	<5.0	<5.0	Y	5
DP-2	10/11/1996	145	16	9.8	Y	5
DP-2	10/11/1996	193	38	13	Y	5
DP-3	10/18/1996	45	7.8	<5.0	Y	5
DP-3	10/18/1996	95	22	7.8	Y	5
DP-3	10/18/1996	145	43	16	Y	5
DP-3	10/18/1996	194	43	14	Y	5
DP-1-50	2/1997	45-50	11	<5.0	N	5
DP-1-125	2/1997	120-125	20	<5.0	N	5
DP-1-150	2/1997	145-150	29	<5.0	Y	5
DP-1-193	2/1997	188-193	38	<5.0	Y	5
DP-2-50	2/1997	45-50	<5.0	<5.0	Y	5
DP-2-100	2/1997	95-100	12	6.8	Y	5
DP-2-150	2/1997	145-150	17	9.7	Y	5
DP-2-193	2/1997	188-193	33	12	Y	5
DP-3-50	2/1997	45-50	33	11	Y	5
DP-3-100	2/1997	95-100	32	11	Y	5
DP-3-150	2/1997	145-150	36	13	Y	5
DP-3-193	2/1997	188-193	33	12	Y	5
MW-1-50	2/1997	45-50	14	<5.0	Y	5
MW-1-135	2/1997	130-135	5	<5.0	Y	5
MW-1-220	2/1997	215-220	15	<5.0	N	5
MW-1-300	2/1997	295-300	<5.0	<5.0	N	5
MW-2-50	2/1997	45-50	<5.0	<5.0	N	5
MW-2-100	2/1997	95-100	<5.0	<5.0	N	5
MW-2-300	2/1997	295-300	<5.0	<5.0	N	5
SG-2-220	2/1997	215-220	<5.0	<5.0	N	5
MW-3-50	2/1997	45-50	9.8	<5.0	Y	5
MW-3-135	2/1997	130-135	11	<5.0	N	5
MW-3-220	2/1997	215-220	16	5.3	N	5
MW-3-300	2/1997	295-300	<5.0	<5.0	N	5
R-070A-50	4/24/2000	45-50	42	42	Y	6
R-070A-100	4/24/2000	95-100	54	45	Y	6
R-070A-WH	4/24/2000	156-225	160	34	Y	6
R-071A-50	4/25/2000	45-50	0.71	<0.21	Y	6
R-071A-100	4/25/2000	95-100	<0.13	<0.21	Y	6

TABLE C-1
HISTORICAL SOIL GAS SAMPLING RESULTS, BROADWAY NORTH LANDFILL
REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
R-071A-WH	4/25/2000	158-228	0.96	0.21	Y	6
R-072A-50	4/25/2000	45-50	<0.13	<0.21	Y	6
R-072A-100	4/25/2000	95-100	0.50	<0.21	Y	6
R-072A-WH	4/25/2000	157-227	0.38	0.22	Y	6
R-073A-50	4/24/2000	45-50	44	5.2	Y	6
R-073A-100	4/24/2000	95-100	39	5.6	Y	6
R-073A-WH	4/24/2000	158-228	53	9.4	Y	6
R-074A-50	4/28/2000	45-50	<0.13	<0.21	Y	6
R-074A-100	4/28/2000	95-100	3.3	0.31	Y	6
R-074A-191	4/28/2000	157-226	24	8.8	Y	6
R-075A-50	4/28/2000	45-50	0.16	<0.21	Y	6
R-075A-100	4/28/2000	95-100	<0.3	<0.45	N	6
R-075A-WH	4/28/2000	157-225	22	5.1	Y	6
R-68A-50	4/25/2000	47-52	27	5.5	Y	6
R-68A-100	4/25/2000	95-100	21	4.4	Y	6
R-68A-150	4/25/2000	144-149	25	1.8	Y	6
R-68A-200	4/25/2000	195-200	47	4.8	Y	6
R-68A-WH	4/25/2000	240-320	44	15	Y	6
R-69B-50	3/30/2000	44-49	<0.13	3.2	Y	6
R-69B-100	3/30/2000	95-100	3.4	3.7	Y	6
R-69B-150	3/30/2000	145-150	17	8.8	Y	6
R-69B-200	3/30/2000	195-200	<0.3	<0.2	Y	6
R-69B-WH	3/30/2000	257-320	54	9.4	Y	6
DP-1-50	4/25/2000	45-50	33	4.6	Y	6
DP-1-125	4/25/2000	120-125	38	<0.21	Y	6
DP-1-150	4/25/2000	145-150	89	3.1	Y	6
DP-1-195	4/25/2000	188-193	64	2.1	Y	6
DP-2-50	4/26/2000	45-50	0.34	0.88	Y	6
DP-2-100	4/26/2000	95-100	<0.13	7.0	Y	6
DP-2-150	4/26/2000	145-150	26	11	Y	6
DP-2-195	4/26/2000	188-193	61	19	Y	6
DP-3-50	4/25/2000	45-50	50	23	Y	6
DP-3-100	4/25/2000	95-100	89	25	Y	6
DP-3-150	4/25/2000	145-150	96	23	Y	6
DP-3-190	4/25/2000	188-193	96	<0.21	Y	6
WR-273A-50	5/2/2000	45-50	45	0.45	Y	6
WR-273A-130	5/2/2000	130-135	45	0.45	Y	6
WR-273A-200	5/2/2000	215-220	63	0.94	Y	6
WR-273A-300	5/2/2000	295-300	70	3.0	Y	6
WR-274A-50	5/2/2000	45-50	1.3	1.9	Y	6
WR-274A-100	5/2/2000	95-100	0.81	2.4	Y	6
WR-274A-220	5/2/2000	215-220	3.5	4.3	Y	6
WR-274A-300	5/2/2000	295-300	9.6	5.0	Y	6

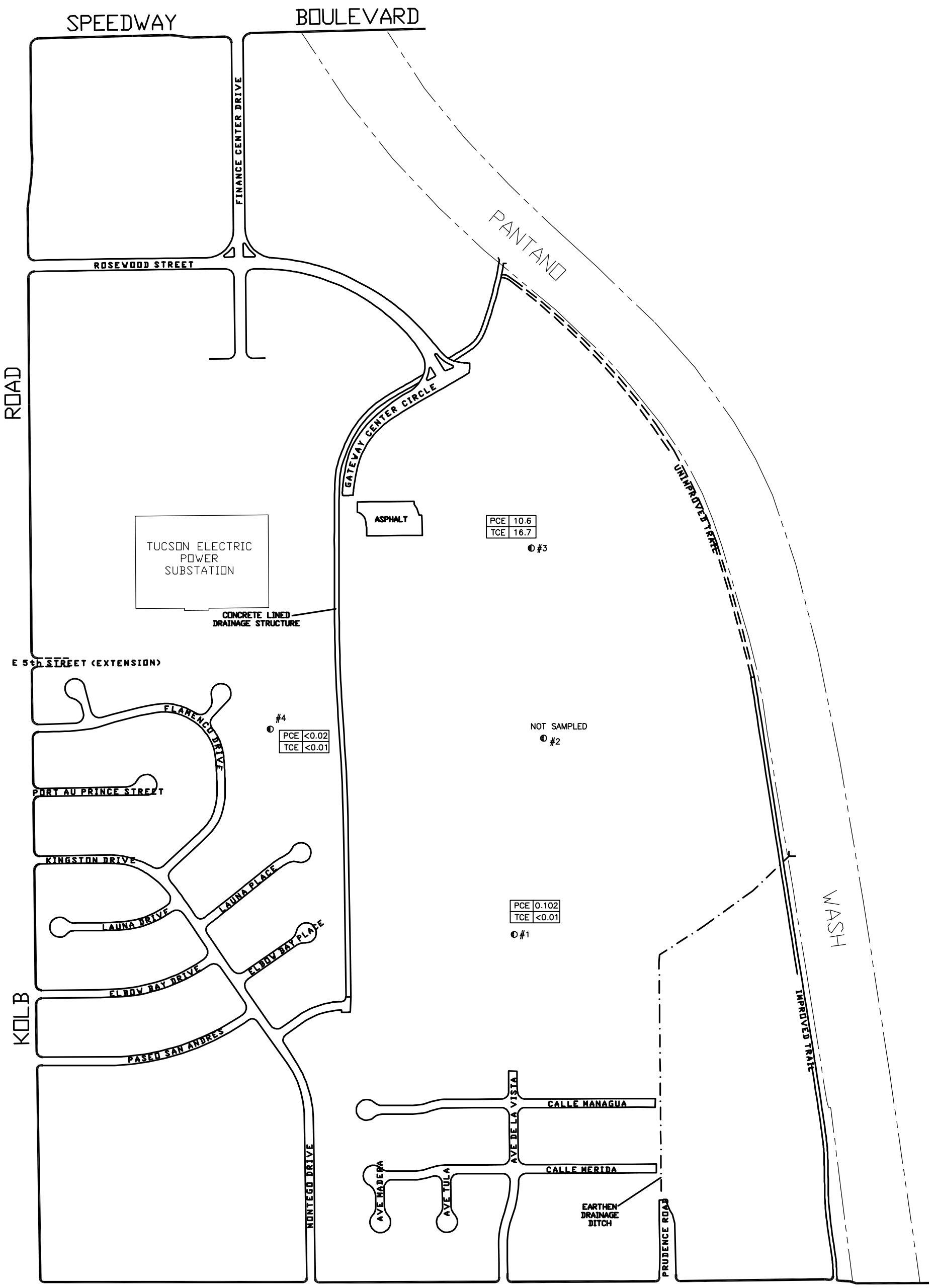
TABLE C-1
HISTORICAL SOIL GAS SAMPLING RESULTS, BROADWAY NORTH LANDFILL
REMEDIAL INVESTIGATION REPORT
BROADWAY-PANTANO WQARF SITE
TUCSON, ARIZONA

Sampling Point ID	Date	Sample Depth (feet bgs)	PCE (µg/L-v)	TCE (µg/L-v)	Other VOCs Detected? (Y/N)	Reference
WR-275A-50	5/2/2000	45-50	5.8	5.8	Y	6
WR-275A-130	5/2/2000	130-135	34	8.2	Y	6
WR-275A-220	5/2/2000	215-220	35	8.8	Y	6
WR-275A-300	5/2/2000	295-300	55	12	Y	6

Notes: bgs = Below ground surface
PCE = Tetrachloroethene
TCE = Trichloroethene
VOC = Volatile organic compounds
µg/L-v = Micrograms per liter-vapor

References:

1 GRC Consultants, Inc., 1985. Landfill Soil Gas Results, Broadway Landfill, Gateway Center Development, Tucson, Arizona. September 24.
2 Tracer Research Corporation, 1988. Shallow Soil Gas Investigation at the Gateway Landfill, Tucson, Arizona. December.
3 Woodward-Clyde Consultants, 1990. Report for Phase II Environmental Site Assessment and Soil Gas Survey, Broadway and Prudence Site, Tucson, Arizona. July 27.
4. Arizona Department of Environmental Quality, 1995. Preliminary Assessment/Site Inspection, Broadway North Landfill, Broadway & Kolb Roads Tucson, Arizona 85710, Pima County. June 30.
5 Camp Dresser & McKee, 1998. Remedial Investigation Report, Broadway North Landfill, Tucson, Arizona. March.
6 Hydro Geo Chem, Inc., 2001. Full Scale Soil Vapor Extraction/Air Injection System Performance Report, Broadway North Landfill, Tucson, Arizona. March 16.



LEGEND

◐ #1 PROBE LOCATION

PCE <0.01	CONCENTRATION OF TETRACHLOROETHENE IN MICROGRAMS PER LITER
TCE 0.102	CONCENTRATION OF TRICHLOROETHENE IN MICROGRAMS PER LITER

NOTE: SCREENED INTERVAL FROM 5 TO 10 FEET BELOW GROUND LEVEL.

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SOIL GAS SAMPLING RESULTS FROM 1985 INVESTIGATION BY GRC BROADWAY NORTH LANDFILL

FIGURE: **C-1**

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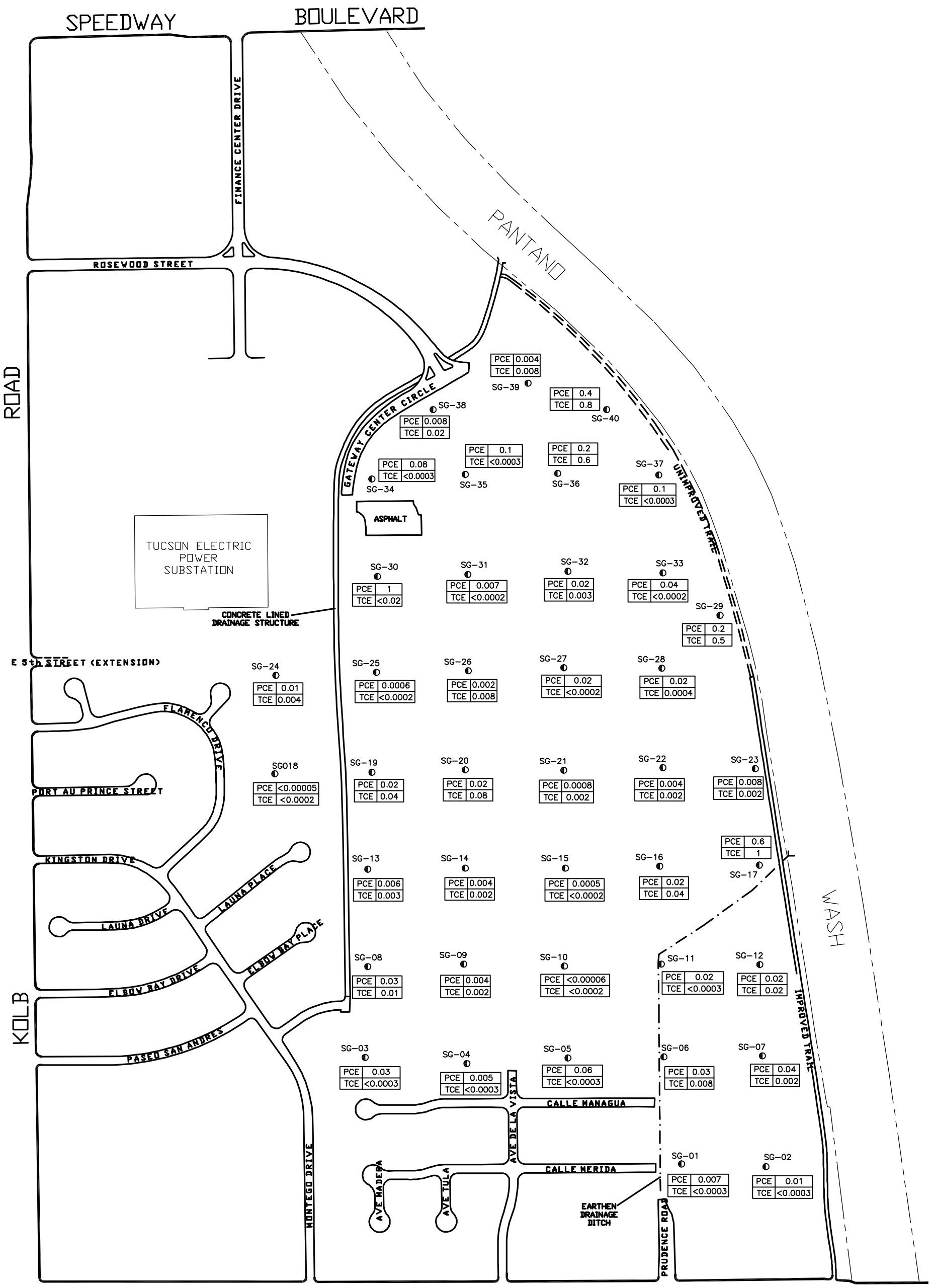

LEGEND

#1 SHALLOW (2.5 TO 6 FEET BELOW GROUND LEVEL) TEMPORARY PROBE LOCATION

PCE	<0.01
TCE	0.102

CONCENTRATION OF TETRACHLOROETHENE IN MICROGRAMS PER LITER
CONCENTRATION OF TRICHLOROETHENE IN MICROGRAMS PER LITER

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SOIL GAS SAMPLING RESULTS FROM 1988 INVESTIGATION BY TRACER BROADWAY NORTH LANDFILL

FIGURE: **C-2**

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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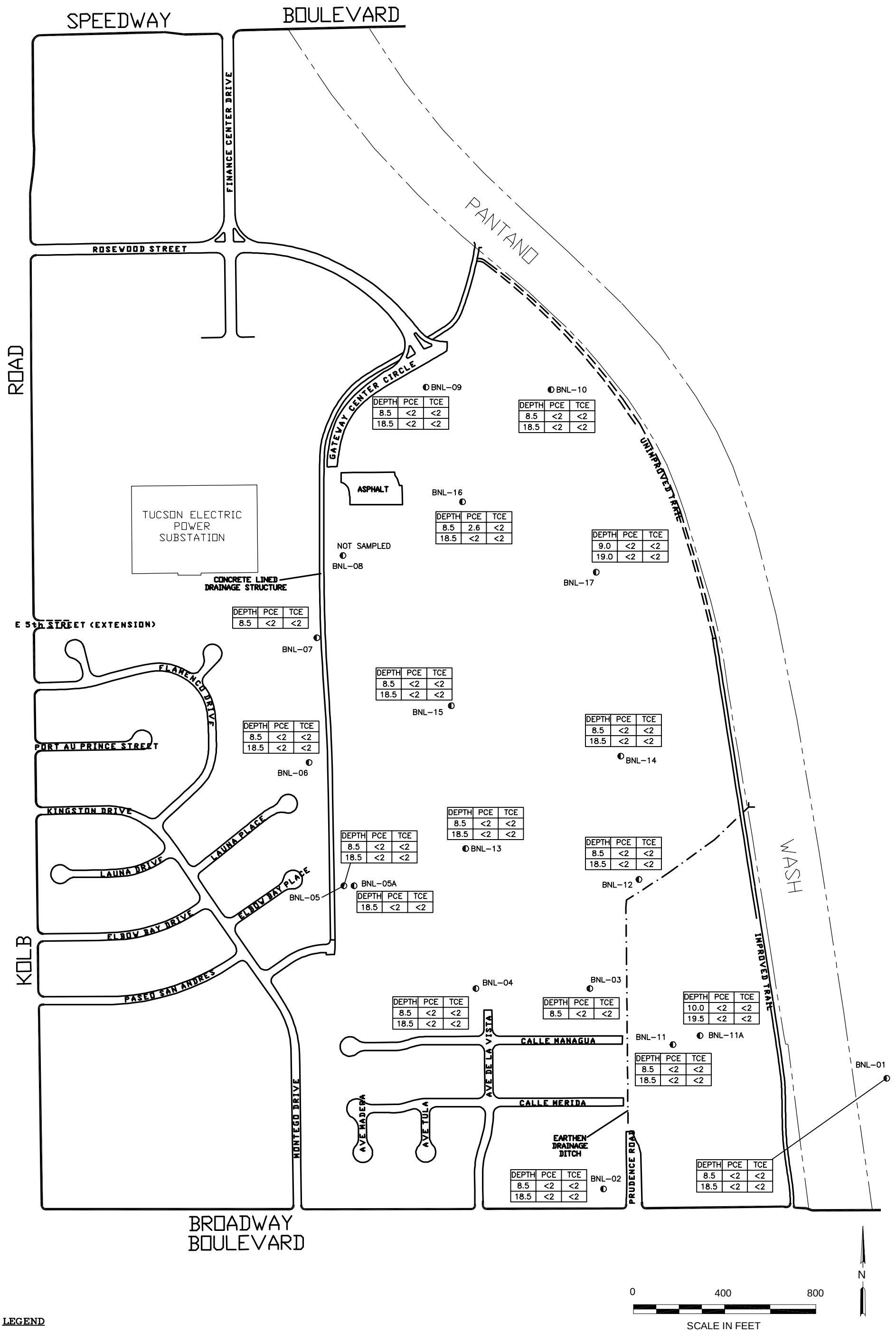

LEGEND

○ #1 SOIL GAS SAMPLING POINT

DEPTH	PCE	TCE
8.5	<2	<2
18.5	<2	<2

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

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WQARF SITE
LANDFILL OPERABLE UNIT
TUCSON, ARIZONA

SOIL GAS SAMPLING RESULTS FROM 1995 INVESTIGATION BY ADEQ BROADWAY NORTH LANDFILL

FIGURE: **C-3**

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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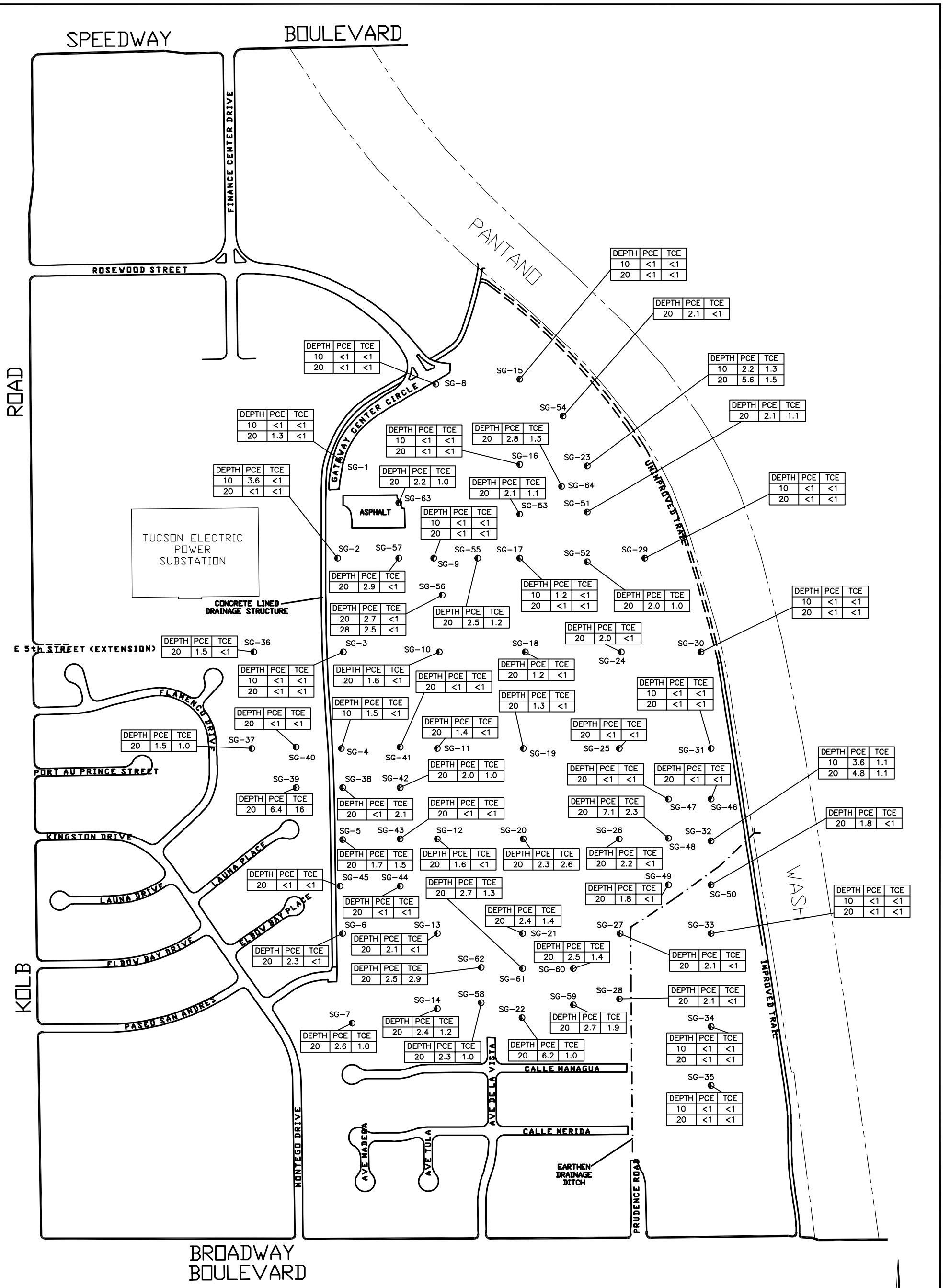

LEGEND

◐ SG-1 TEMPORARY PROBE LOCATION

DEPTH	PCE	TCE
10	1.8	<1
20	6.2	1.0

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

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LANDFILL OPERABLE UNIT
TUCSON, ARIZONA

SOIL GAS SAMPLING
RESULTS FROM JUNE/JULY 1996
INVESTIGATION BY CDM
BROADWAY NORTH LANDFILL

FIGURE:
C-4

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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SPEEDWAY

BOULEVARD

FINANCE CENTER DRIVE

ROSEWOOD STREET

PANTANO

ROAD

GATEWAY CENTER CIRCLE

UNIMPROVED TRAIL

GP-9

ASPHALT

B-6

DEPTH	PCE	TCE
60	<5.0	<5.0

B-5

GP-8

DEPTH	PCE	TCE
20	<5.0	<5.0

TUCSON ELECTRIC POWER SUBSTATION

CONCRETE LINED DRAINAGE STRUCTURE

E 5th STREET (EXTENSION)

FLAMENCO DRIVE

GP-12

GP-6

B-3

GP-5

DEPTH	PCE	TCE
60	<5.0	12

GP-11

PORT AU PRINCE STREET

KINGSTON DRIVE

LAUNA PLACE

GP-10

GP-13

GP-2

LAUNA DRIVE

ELBOW BAY PLACE

ELBOW BAY DRIVE

KOLB

PASEO SAN ANDRES

GP-7

B-4

B-2

GP-4

DEPTH	PCE	TCE
20	<5.0	<5.0

GP-3

WASH

IMPROVED TRAIL

GP-1

B-1

DEPTH	PCE	TCE
19	<5.0	<5.0

CALLE MANAGUA

AVE DE LA VISTA

CALLE MERIDA

AVE MADERA

AVE TULA

EARTHEN DRAINAGE DITCH

PRUDENCE ROAD

MONTEGO DRIVE

BROADWAY BOULEVARD

N

0 400 800

SCALE IN FEET

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LEGEND

- SOIL BORING LOCATION
- PROBE LOCATION

DEPTH	PCE	TCE
20	<5.0	<5.0

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

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**SOIL GAS SAMPLING
RESULTS FROM GP & B SERIES
PROBES IN AUGUST 1996 BY CDM
BROADWAY NORTH LANDFILL**

FIGURE:
C-5

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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SPEEDWAY

BOULEVARD

FINANCE CENTER DRIVE

ROSEWOOD STREET

ROAD

PANTANO

GATEWAY CENTER CIRCLE

IMPROVED TRAIL

ASPHALT

DP-2

DEPTH	PCE	TCE
45	<5.0	<5.0
95	<5.0	<5.0
145	16	9.8
193	38	13

TUCSON ELECTRIC
POWER
SUBSTATION

CONCRETE LINED
DRAINAGE STRUCTURE

E 5th STREET (EXTENSION)

FLAMENCO DRIVE

PORT AU PRINCE STREET

KINGSTON DRIVE

LAUNA PLACE

LAUNA DRIVE

ELBOW BAY PLACE

ELBOW BAY DRIVE

KOLB

PASEO SAN ANDRES

DP-3

DEPTH	PCE	TCE
45	7.8	<5.0
95	22	7.8
145	43	16
194	43	14

WASH

DP-1

DEPTH	PCE	TCE
45	12	<5.0
95	16	<5.0
140	<5.0	<5.0
195	45	<5.0

AVE DE LA VISTA

CALLE MANAGUA

CALLE MERIDA

AVE MADERA

AVE TULA

MONTEGO DRIVE

EARTHEN
DRAINAGE
DITCH

PRUDENCE ROAD

BROADWAY
BOULEVARD

N

0 400 800

SCALE IN FEET

LEGEND

◐ DP-1 NESTED PROBE LOCATION

DEPTH	PCE	TCE
20	<5.0	<5.0

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

NOTE: SOIL GAS SAMPLES COLLECTED DURING DRILLING USING A SIMULPROBE.

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SOIL GAS SAMPLING RESULTS FROM DP SERIES PROBE INSTALLATION IN OCTOBER 1996 BY CDM BROADWAY NORTH LANDFILL

FIGURE: **C-6**

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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SPEEDWAY

BOULEVARD

FINANCE CENTER DRIVE

ROSEWOOD STREET

PANTANO

ROAD

GATEWAY CENTER CIRCLE

UNIMPROVED TRAIL

ASPHALT

TUCSON ELECTRIC POWER SUBSTATION

WR-273A

DEPTH	PCE	TCE
50	14	<5.0
135	5	<5.0
220	15	<5.0
300	<5.0	<5.0

CONCRETE LINED DRAINAGE STRUCTURE

DP-2

DEPTH	PCE	TCE
50	<5.0	<5.0
100	12	6.8
150	17	9.7
193	33	12

E 5th STREET (EXTENSION)

FLAMENCO DRIVE

WR-274A

DEPTH	PCE	TCE
50	<5.0	<5.0
100	<5.0	<5.0
220	<5.0	<5.0
300	<5.0	<5.0

PORT AU PRINCE STREET

KINGSTON DRIVE

LAUNA PLACE

LAUNA DRIVE

ELBOW BAY PLACE

ELBOW BAY DRIVE

DP-3

DEPTH	PCE	TCE
50	33	11
100	32	11
150	36	13
193	33	12

WR-275A

DEPTH	PCE	TCE
50	9.8	<5.0
135	11	<5.0
220	16	5.3
300	<5.0	<5.0

KOLB

PASEO SAN ANDRES

DP-1

DEPTH	PCE	TCE
50	11	<5.0
125	20	<5.0
150	29	<5.0
193	38	<5.0

WASH

IMPROVED TRAIL

AVE DE LA VISTA

CALLE MANAGUA

CALLE MERIDA

AVE MADERA

AVE TULA

MONTEGO DRIVE

EARTHEN DRAINAGE DITCH

PRUDENCE ROAD

BROADWAY BOULEVARD

N

0 400 800

SCALE IN FEET

LEGEND

◐ DP-1 NESTED PROBE LOCATION

⊕ WR-275A COT MONITOR WELL (WITH NESTED PROBES)

DEPTH	PCE	TCE
20	<5.0	<5.0

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

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**SOIL GAS SAMPLING
RESULTS FROM DEEP PROBES
IN FEBRUARY 1997 BY CDM
BROADWAY NORTH LANDFILL**

FIGURE:
C-7

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
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SPEEDWAY

BOULEVARD

FINANCE CENTER DRIVE

ROSEWOOD STREET

ROAD

PANTANO

GATEWAY CENTER CIRCLE

UNIMPROVED TRAIL

DEPTH	PCE	TCE
45–50	<0.13	<0.21
95–100	3.3	0.31
157–226	24	8.8

DEPTH	PCE	TCE
45–50	0.16	<0.21
95–100	<0.3	<0.45
157–225	22	5.1

R–075A
4/28/00

DEPTH	PCE	TCE
45–50	45	0.45
130–135	45	0.45
215–220	63	0.94
295–300	70	3

4/28/00
R–074A

ASPHALT

4/26/00
DP–2

DEPTH	PCE	TCE
45–50	0.34	0.88
95–100	<0.3	7
145–150	26	11
188–193	61	19

TUCSON ELECTRIC
POWER
SUBSTATION

WR–273A
5/2/00

CONCRETE LINED
DRAINAGE STRUCTURE

R–069B
3/30/00

DEPTH	PCE	TCE
44–49	<0.13	3.2
95–100	3.4	3.7
145–150	17	8.8
195–200	<0.3	<0.2
257–320	54	9.4

E 5th STREET (EXTENSION)

DEPTH	PCE	TCE
45–50	1.3	1.9
95–100	0.81	2.4
215–220	3.5	4.3
295–300	9.6	5

WR–274A
5/2/00

DEPTH	PCE	TCE
45–50	42	42
95–100	54	45
156–225	160	34

4/24/00
R–070A

DEPTH	PCE	TCE
45–50	0.71	<0.21
95–100	<0.13	<0.21
158–228	0.96	0.21

R–071A
4/25/00

FLAMENCO DRIVE

PORT AU PRINCE STREET

KINGSTON DRIVE

LAUNA PLACE

LAUNA DRIVE

ELBOW BAY PLACE

ELBOW BAY DRIVE

PASEO SAN ANDRES

KOLB

DEPTH	PCE	TCE
45–50	50	23
95–100	89	25
145–150	96	23
188–193	96	<0.21

DP–3
4/25/00

R–068A
4/25/00

DEPTH	PCE	TCE
47–52	27	5.5
95–100	21	4.4
144–149	25	1.8
195–200	47	4.8
240–320	44	15

5/2/00
WR–275A

DEPTH	PCE	TCE
45–50	5.8	5.8
130–135	34	8.2
215–220	35	8.8
295–300	55	12

R–073A
4/24/00

DEPTH	PCE	TCE
45–50	44	5.2
95–100	39	5.6
158–228	53	9.4

DP–1
4/25/00

DEPTH	PCE	TCE
45–50	33	4.6
120–125	38	<0.21
145–150	89	3.1
188–193	64	2.1

R–072A
4/25/00

DEPTH	PCE	TCE
45–50	<0.13	<0.21
95–100	0.50	<0.21
157–227	0.38	0.22

WASH

IMPROVED TRAIL

CALLE MANAGUA

AVE DE LA VISTA

CALLE MERIDA

AVE MADERA

AVE TULA

MONTEGO DRIVE

EARTHEN
DRAINAGE
DITCH

PRUDENCE ROAD

BROADWAY
BOULEVARD

LEGEND

DP–1	NESTED PROBE LOCATION
R–073A	VAPOR EXTRACTION WELL (WITH NESTED PROBES)
R–068A	AIR INJECTION WELL (WITH NESTED PROBES)
WR–275A	COT MONITOR WELL (WITH NESTED PROBES)

DEPTH	PCE	TCE
20	<5.0	<5.0

DEPTH IN FEET BELOW GROUND LEVEL
RESULTS IN MICROGRAMS PER LITER
PCE – TETRACHLOROETHENE
TCE – TRICHLOROETHENE

NOTE: SAMPLE COLLECTION DATE AS NOTED AT LOCATION OF SAMPLING PORTS.

N

0 400 800

SCALE IN FEET

Stantec
8211 S. 48th Street
Phoenix, Arizona 85044
PHONE:(602) 438-2200 FAX:(602) 431-9562

FOR:
BROADWAY-PANTANO
WQARF SITE
LANDFILL OPERABLE UNIT
TUCSON, ARIZONA

SOIL GAS SAMPLING RESULTS PRIOR TO SVE/AI START UP BROADWAY NORTH LANDFILL

FIGURE: **C-8**

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
18OT.20401.07	MDR	TAK	CRP	DECEMBER 2006