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APPENDIX E

FEASIBILITY STUDY FOR METALS IN DROSS MATERIAL

Broadway Pantano Water Quality Assurance Revolving Fund Site
Tucson, Arizona

Submitted to:

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
A.A.C.	Arizona Administrative Code
A.R.S.	Arizona Revised Statute
ADEQ	Arizona Department of Environmental Quality
BNL	Broadway North Landfill
COC(s)	contaminant(s) of concern
CSM	conceptual site model
DEUR	Declaration of Environmental Use Restriction
EC(s)	engineering control(s)
ft	feet
FS	Feasibility Study
GPL	Groundwater Protection Level
IC(s)	institutional control(s)
LOU	Landfill Operable Unit
M	million
NR-SRL	Non-Residential Soil Remediation Level
PCB(s)	polychlorinated biphenyl(s)
PRAP	Proposed Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RO	remedial objective
R-SRL	Residential Soil Remediation Level
Site	Broadway Pantano Water Quality Assurance Revolving Fund Site
SRL	soil remediation level
TCLP	Toxicity Characteristic Leaching Procedure
WQARF	Water Quality Assurance Revolving Fund

1.0 INTRODUCTION

This appendix to the Broadway Pantano Water Quality Assurance Revolving Fund (WQARF) Site (the "Site") Feasibility Study (FS) Report was prepared to document the FS process for Metals in Dross Material located at the southern part of Broadway North Landfill (BNL). The contaminants present in the dross material are confined to a limited portion of the Site Landfill Operable Unit (LOU) and are distinct from volatile organic compound contamination, which is the source of impacts in the Site Groundwater Operable Unit (GOU). On this basis, the FS process for the dross material is addressed independently herein to simplify FS Report organization. The selected remedy developed for the dross material in this appendix is hereby incorporated into the remedy identified in the FS Report.

2.0 DROSS MATERIAL BACKGROUND

As identified in the body of the Site FS Report, a molten metal waste referred to as dross material was disposed of in the southern portion of the BNL (**Figure E2-1**) at some time in the past and has been characterized as containing high concentrations of metals. This section presents a description of the dross material and provides a summary of waste characterization activities. A brief history of Site activities related to the dross material is also presented. General Site history and land/water usage information are described in the body of the Site FS Report.

Unless otherwise noted, information presented in this section is abstracted from the LOU Remedial Investigation (RI) Report (Clear Creek, 2015).

2.1 Waste Description

The dross material present at the Site is a molten metal waste product of unknown origin. Aplomado (2000) describes the waste as a green and white mottled layer present in the southern most waste cell of BNL where construction debris was disposed.

Characterization of the waste was principally conducted during efforts to redevelop BNL in the 1990s. Based on the results of waste sampling, the dross material contained detectable concentrations of arsenic, barium, cadmium, chromium, lead, mercury, silver, trichloroethene, and the polychlorinated biphenyls (PCBs) 1254 and 1260 (Aplomado, 2000)[1]. Total concentrations of metals in the dross material were generally two to three orders of magnitude greater than concentrations in background samples collected from native soil (Aplomado, 2000). The contaminants of concern (COCs) in the dross material are metals and include arsenic, lead and cadmium based on a comparison of metals concentrations in the dross material to Arizona Residential Soil Remediation Levels (R-SRLs). Arsenic and lead concentrations also exceed Non-Residential Soil Remediation Levels (NR-SRLs). Cadmium, chromium and lead were identified as COCs in the LOU RI on the basis that these compounds exceed minimum Arizona Groundwater Protection Levels (GPLs) used to evaluate the potential for a contaminant to impact groundwater.

[1] Trichloroethene and PCBs 1254 and 1260 were detected in the dross material at concentrations that are less than applicable R-SRLs; these compounds are not COCs.

Samples of the dross material were also evaluated using the Toxicity Characteristic Leaching Procedure (TCLP). Cadmium and lead were found at concentrations in the leachate that exceed the regulatory level for the toxicity characteristic of hazardous waste (Aplomado, 2000).

2.1.1 Current Nature and Extent of Site Contamination

As depicted in **Figure E2-1**, the dross material disposal area can be divided into two sub regions. In the northern region (0.94 acres) located within the perimeter fence line of BNL, the dross material is covered with soil (see **Section 2.1.3)**. The southern region of the dross material disposal area (0.98 acres) underlies the Broadway Star Shopping Center building and a paved parking lot. The waste in the dross material disposal area varies in thickness from a few inches to a few feet (ft) and can be intermixed with construction and demolition debris (Aplomado, 2000).

2.1.2 Waste History

In the 1990s, Home Depot began assessing the BNL property located north of the Broadway Star Shopping Center as a future store location. Environmental Site Assessment activities and geotechnical investigations revealed the presence of landfill debris and dross material at the Site. Following completion of characterization activities in December 2000, Home Depot placed soil cover over dross material present in the northern region to improve site conditions and minimize the potential for human exposure to the waste. Since Home Depot did not own the property, the cover material was not intended to be a permanent, engineered cap (in the early 2000s, Home Depot also erected a temporary fence around the dross site.)

Based on the identification of waste beneath the area where they planned to construct a building, Home Depot wrote a letter to the Arizona Department of Environmental Quality (ADEQ) identifying possible options for remediation of the site. ADEQ responded that they must submit a closure plan for review and approval before they could build. On this basis, four remedial alternatives for the dross area were evaluated by Aplomado (2000):

1. Excavate, load, and transport the materials to an off-site disposal facility.
2. Excavate and treat the materials using soil stabilization, then transport to an offsite disposal facility.
3. Excavate and treat the materials using soil stabilization, then dispose on-site.
4. Cap the materials in place using soil and geosynthetic clay liner.

A risk evaluation determined that each of the four options offered overall protection for human health and the environment. Capping was determined to be the most cost-effective and implementable alternative while providing a moderate to high level of long-term and short-term protectiveness.

Ultimately, Home Depot did not construct a store at the property and the parcel currently remains undeveloped. To prevent exposure of the Metals in Dross Material to potential receptors, a secure fenced area with warning signs was installed by ADEQ (**Figure E2-1**). Semiannual to annual inspections of this waste management area are conducted by ADEQ to maintain the implemented

engineering controls (ECs) (soil cover and security fencing) and protect human health and the environment.

2.2 Conceptual Site Model

The conceptual site model (CSM) described in this Appendix supplements the CSM presented in the FS Report.

2.2.1 Environmental Setting

The dross material disposal area straddles an undeveloped region of BNL and the Broadway Star Shopping Center (**Figure E2-1**). The undeveloped portion of the dross material disposal area is covered with native vegetation and there is a potential for localized low lying areas where surface water ponding and erosion could occur.

2.2.2 Contaminant Fate and Transport

The following bulleted list summarizes the likely mechanisms responsible for the fate and transport of metals in dross material to potential receptors:

- Although details regarding placement of the dross material at BNL are unknown, the waste appears to have been disposed of in the vicinity of the construction debris cell at some point during the period of waste disposal activities (from circa 1953 to 1972).
- With the potential exception of Broadway Star Plaza development and waste characterization activities conducted to support redevelopment of the property north of Broadway Star Plaza, the dross material has likely remained undisturbed since placement.
- Metals present in dross material that was covered with either soil or development are anticipated to be relatively stable. Since the dross disposal area is part of a construction debris disposal cell (3.5 acres), metals mobilization resulting from exposure of the dross material to landfill leachate is not probable and is expected to be further limited by low surface water infiltration rates at the Site.
- If not appropriately managed, exposed dross material at the surface could be mobilized by erosion and transported to environmental or human receptors.

2.2.3 Risk Evaluation Summary

Most of the information used to assess risks posed by the dross material was collected in the mid to late 1990s during investigations conducted to support redevelopment of the property. The risk implications of these investigations are documented in the LOU RI Report (Clear Creek, 2015), summarized in **Figure E2-2,** and discussed by environmental medium below:

Waste. The dross contains arsenic, lead, and cadmium at concentrations that exceed soil remediation levels (SRLs). SRLs are risk-based criteria developed to evaluate human exposure to impacted material. There are SRLs for residential and non-residential (e.g., commercial) exposure scenarios. The concentrations of arsenic, lead and cadmium exceed residential thresholds. The concentrations of arsenic and lead also exceed non-residential thresholds. The

dross is currently covered with soil placed in 2000 by a prospective property developer. The soil cover and a security fence constructed around most of the dross material disposal area extent that is not covered by Broadway Star Plaza (**Figure E2-1**) currently serve as ECs that limit risks associated with direct exposure to the dross by outdoor site users and trespassers. These controls require routine inspection and maintenance to remain effective. Recent inspections of the portion of dross material disposal area that is not covered by Broadway Star Plaza have indicated the presence of small amounts of dross at the landfill surface.

Soil. Based on soil sampling conducted around the dross area security fence line in April 2003, shallow (up to 6 inches below surface) soils collected around the outside perimeter of the dross site do not contain metals at concentrations that exceed SRLs (SECOR, 2004). These results indicate that the risk from soil contamination located outside the security fence line was within risk management thresholds when the samples were collected. Soil erosion and soil movement due to burrowing animals have the potential to complete the exposure pathway in the future if soils containing higher levels of dross are exposed and no measures are taken to ensure the dross material remains covered.

Groundwater. Since cadmium, chromium and lead have been detected in the dross material at concentrations that exceed GPLs, these metals were retained as COCs in the LOU RI Report. Lead and cadmium are naturally-occurring metals that have been reported at low frequencies in Site groundwater samples at concentrations that exceed Arizona Aquifer Water Quality Standards; however, these metals (and other dross material COCs) were not prevalent in groundwater downgradient of the dross area (i.e., at BP-9 or WR-177A) suggesting the material does not serve as a significant source of current groundwater contamination. It is notable that these wells may not be optimally located to evaluate impacts from dross material at the site. BP-9 is located hydraulically downgradient of a portion of the dross area that is covered by paving and the Broadway Star Plaza (**Figure E2-1**), which would be expected to mitigate surface water infiltration through the dross material. WR-177A is located more than 1,500 ft downgradient of the dross area. If surface water infiltration has mobilized metals present in the dross material (particularly where the dross material is not covered by the Broadway Star Plaza), groundwater could be impacted in the future.

3.0 DELINEATION AND DESCRIPTION OF REMEDIATION AREA

Site remedial objectives (ROs) for land and groundwater use are presented in the FS Report. In summary, applicable ROs are for land use and include requirements to protect current and future residential and non-residential users of the Site against possible exposure to hazardous substances within or on BNL.

Since the dross material remains at the Site and metals associated with this waste have the potential to impact soil, groundwater and Site receptors at present and/or in the future if not properly managed, the extent of area subject to ROs based on risk is defined by the known extent of dross material at the Site (see **Figure E2-1**).

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL MEASURES

This section identifies remedy selection criteria, screens applicable remedial measures and presents retained remedial measures for Metals in Dross Material present at the Site. “Remedial measures are remediation technologies or methodologies, and are screened based on anticipated removal or reduction of contaminants at the site and the ability to achieve the ROs. Selected remedial measures will be assembled with selected strategies to develop the reference remedy and alternative remedies” (ADEQ, 2015).

4.1 Remedy Selection Criteria

Arizona Revised Statutes (A.R.S.) 49-282.06 states that the following factors must be considered in the selection of remedial actions:

- Population, environment, and welfare concerns at risk.
- Routes of exposure.
- Amount, concentration, hazardous properties, environmental fate (such as the ability to bioaccumulate, persistence, and probability of reaching the waters of the state), and the form of the substance present.
- Physical factors affecting human and environmental exposure, such as hydrogeology, climate, and the extent of previous and expected migration.
- The extent to which the amount of water available for beneficial use will be preserved by a particular type of remedial action.
- The technical practicality, necessity, and cost-effectiveness of alternative remedial actions applicable to a site.
- The availability of other appropriate federal or state remedial action and enforcement mechanisms, including funding sources established under the Comprehensive Environmental Response, Compensation, and Liability Act, to respond to the release.

4.2 Basis for Identification of Applicable Remedial Measures

The basis for identifying applicable remedial measures for Metals in Dross Material is summarized below:

- The southern portion of the dross disposal area has been capped with the Broadway Star Shopping Center building and pavement (**Figure E2-1**). Unless this development is demolished or intrusive site work is performed in the southern portion of the dross material disposal area, the risk posed by the dross material is controlled.
- Dross material in the northern portion of the dross material disposal area (**Figure E2-1**) was covered with soil in 2000 but this implemented remedial measure was not an engineered soil cap and not intended to be permanent. Over time, dross material has become exposed at the surface in regions of this area that are both inside and outside of an existing security fence installed by ADEQ to control access to the dross material. The

soil cover offers no protection from infiltrating surface water and concentrations of select metals present in the dross material exceed GPLs.

4.3 Identification of Remedial Measures

Based principally on the previous evaluation conducted for the site (Aplomado, 2000), remedial measures applicable to Metals in Dross Material are:

- Institutional Controls (ICs)
- ECs
- Inspections
- Excavation with on-site encapsulation
- Excavation with off-site disposal

4.4 Screening of Remedial Measures

Remedial measures are typically screened based on the anticipated ability of the measure to address site ROs and reduce contaminant concentration, mass or toxicity. In this FS, screening criteria used to assess how well the ROs will be addressed by remedial measures were as follows:

- Effectiveness – may include compatibility with current and reasonably foreseeable land use, COC treatment effectiveness, and the ability to meet regulatory requirements.
- Implementability – may include constructability, operations and maintenance requirements, and generation and management of waste products.
- Health and safety considerations as they apply to the mechanics of the measure.
- Flexibility and/or expandability of the mechanics of the measure.
- Cost.

Table E3-1 evaluates the remedial measures presented in Section 4.3 against these criteria and identifies those retained. Further discussion of remedial measure screening is provided below.

Institutional Controls. ICs are non-engineered instruments that include administrative or legal controls to limit exposure of contaminants to site receptors and/or protect the integrity of the remedy (e.g., ECs). Examples of applicable ICs include a Declaration of Environmental Use Restriction (DEUR) and zoning restrictions for land use.

*ICs are retained. DEURs would be needed to: control development of parcels where dross material is anticipated to remain (i.e., Pima County parcel numbers 133-23-110C and 133-23-1570; see **Figure E2-1**), identify requirements for intrusive site work in areas where dross material exists, and require appropriate management and inspection of any implemented ECs. This measure would need to be implemented with other remedial measures to adequately address Site ROs.*

Engineering Controls (Security Fencing). A security fence around the perimeter of the dross material would be an EC intended to minimize the hazard to human health with a separation barrier. This remedial measure would leave the dross material in place and restrict human access through the use of a security fence and notification signs.

Fencing is retained. This remedial measure is highly implementable and cost effective, although it may not be control contaminant exposure if vandalized or inadequately maintained. ADEQ installed perimeter fencing and warning signs around most of the dross disposal area covered with soil to reduce dross material exposure to the public. Periodic inspections by ADEQ and its contractors indicate that burrowing animals are uncovering dross material at the surface, the perimeter fencing is being damaged by unauthorized trespassers, and small amounts of dross material are becoming exposed beyond the defined boundaries of the fenced area.

Engineering Controls (Capping). A cap constructed over the dross material would be an EC intended to create a barrier and interrupt the exposure pathway to human and environmental receptors. Development (i.e., the Broadway Star Plaza) in the southern portion of the dross disposal area and soil cover placed in the northern portion of the dross disposal area are existing capping ECs implemented at the site. A new engineered cap in the northern portion of the dross disposal area would address exposed dross material at the surface and could be designed with low permeability materials to limit precipitation/surface water infiltrating through the cap and reduce potential COC mobilization to groundwater. Engineered caps can be constructed using soil in conjunction with a low permeability clay/geo-synthetic clay liner or a structural surface composed of concrete or asphalt that can be used where continued access to the site by vehicles or heavy equipment is desired.

Capping is retained. Capping has already been implemented in the southern portion of the dross disposal area (the building and asphalt parking lot constitute a "development cap") and use of this measure to address exposed dross in the northern portion of the dross material disposal area is likely to be a cost effective measure to adequately control contact with and limit exposure to hazardous contaminants found in the dross material.

Inspections. Periodic inspections of the Site would be conducted to verify implemented ICs and ECs are working as intended.

Inspections are retained but must be implemented with ICs and/or ECs in order to control exposure and meet ROs.

Excavation with On-site Encapsulation. The intent of this remedial measure is to excavate contaminated soil and place it in an engineered Corrective Action Management Unit constructed on-site. The dross disposal area would then be backfilled with clean soil from an approved borrow source to match surrounding elevations.

Excavation with On-Site Encapsulation of contamination is not retained on the basis that excavation of the dross material would unnecessarily expose environmental and human receptors to contaminants present in the dross material during excavation, transport and replacement. Further, the hazardous nature of the dross material would require extensive

permitting and regulatory approval to construct a new management unit on-site. However, this remedial measure would meet ROs and could promote redevelopment of the parcel where dross material is present.

Excavation with Off-site Disposal. This remedial measure requires earthwork to dig up and remove contaminated soil. The contaminated soil would be characterized and disposed of off-site in accordance with local, state, and federal regulations. The Site would then be backfilled with clean soil from an approved borrow source to match surrounding elevations.

*Based on the high cost associated with the excavation of approximately 18,000 cubic yards of dross material estimated to present at the Site with disposal of the waste at a Resource Conservation and Recovery Act (RCRA) Subtitle C facility (*Aplomado, 2000)*, excavation with off-site disposal is not retained for further evaluation. However, this remedial measure would meet ROs and could promote redevelopment of the parcel where dross material is present.*

4.5 Retained Remedial Measures

On the basis of screening documented in the foregoing sections, measures retained for potential implementation at the Site are:

- ICs
- ECs (security fencing and capping)
- Inspections

5.0 DEVELOPMENT OF THE REFERENCE REMEDY AND ALTERNATE REMEDIES

Using the retained remedial measures developed in Section 4.0, a Reference Remedy has been developed along with a less aggressive and more aggressive remedial alternative for comparison. The Reference Remedy and the alternative remedies must consist of remedial measures and corresponding remedial strategies capable of meeting all ROs for the Site. Remedies may incorporate more than one remedial strategy or include contingent remedial strategies to address reasonable uncertainties regarding the achievement of ROs, including uncertain time frames for implementation. Remedial strategies identified in Arizona Administrative Code (A.A.C.) R18-16-407(E) and (F) and a brief discussion of applicability to Metals in Dross Material follows:

- Plume remediation – this strategy is used to achieve water quality standards for COCs in waters of the state throughout the Site. *Plume remediation is not applicable to Metals in Dross Material because there are no current groundwater impacts associated with this source of contamination.*
- Physical containment – this strategy contains contaminants within definite boundaries. *Security fencing and capping use this strategy to limit exposure of contamination to environmental and human receptors and achieve ROs. ICs are a remedial measure that increase the effectiveness of this strategy.*
- Controlled migration – this strategy controls the direction or rate of migration but not necessarily contains the migration of contaminants. *Controlled migration is not applicable to Metals in Dross Material because there are no current groundwater impacts associated*

with this source of contamination.

- Source control – this strategy eliminates or mitigates a continuing source of contamination. C*apping can use this strategy to mitigate the potential mobilization of contamination from the dross material and achieve ROs.*
- Monitoring – this strategy is used to observe and evaluate contamination at the site through the collection of data. *Inspections are a monitoring strategy that increase the effectiveness of the physical containment strategy.*
- No action – this strategy consists of no action at the Site. *This strategy is not applicable to Metals in Dross Material because the waste is present at the surface of the disposal area and additional action is required to address current and future exposure risk.*

The following sections identify remedial measures and strategies used to develop the Reference, Less Aggressive, and More Aggressive Remedies. The remedial measures and strategies are defined by their ability to achieve ROs and maintain consistency with applicable land use plans. A description of the design, installation, inspection and maintenance of the remedies is also presented.

5.1 Reference Remedy

The Reference Remedy must be developed based on the best engineering, geological and hydrological standards of practice. Source control must also be incorporated into the reference remedy.

5.1.1 Remedial Measures and Strategies

The Reference Remedy for Metals in Dross Material combines the remedial measures of ICs, ECs and inspections which use the remedial strategies of physical containment, source control and monitoring to achieve ROs. Further description of the remedy is as follows:

- ICs – A DEUR needs to be placed on the parcels where dross material is present to control development, identify requirements for intrusive site work in areas where dross material exists and require appropriate inspection and maintenance of implemented ECs.
- ECs – A new engineered soil cap would be constructed over the extent of dross material present in the northern portion of the dross material disposal area currently covered by soil (**Figure E5-1**). Perimeter fencing (with warning signs) would be constructed around the soil cap. The purpose of fencing would be to prevent entry of humans into the capped area to protect cap integrity and thus help prevent human exposure to site contaminants. The building and parking area of Broadway Star Plaza would be incorporated into the remedy as an existing development cap over dross material in the southern portion of the dross material disposal area.
- Inspections – Inspections would be conducted to evaluate whether the soil cap, perimeter fencing around the soil cap, and development cap continue to limit contaminant exposure to Site receptors. Inspections would be required by the DEUR at a defined frequency.

5.1.1.1 Achievement of Remedial Objectives

The Reference Remedy would achieve ROs for land use by restricting environmental and human exposure to the dross material with capping and fencing ECs and ICs for intrusive site work. ICs would also be put in place to make certain that the ECs remain effective for as long as the dross material remains at the site and would require inspections to ensure that the ECs are properly maintained.

5.1.1.2 Consistency with Land Use Plans

The current use of the dross material disposal area is partly “no use” (undeveloped) and partly commercial use, but possible future uses allowable under existing zoning include office, commercial recreation, commercial service, commercial general, residential (including single-family residential), research and development, and a golf course (Clear Creek, 2015). A DEUR implemented as part of the remedy would include some restriction on the type of future development that could occur in the dross disposal area (e.g., no single-family residences) to ensure that ECs are maintained and reduce the likelihood of humans experiencing unacceptable exposure to the metals in the waste. In the future, with a DEUR modification, the property owner could replace the fencing and soil cap with an appropriate development cap (e.g., buildings, parking lot).

5.1.2 Design and Installation

The design of the new soil cap would be based on RCRA Subtitle D design guidelines and consist of site preparation (i.e., clearing, grubbing, and grading) and installation of a low permeability clay layer overlain by an erosion control layer covering the extent of the northern dross material disposal area surface (see **Figure E5-1**). The cap material would be sourced from clean, engineered soils and would be installed to an appropriate compaction density to limit permeability and promote structural integrity. Following construction, the cap would be hydroseeded with a drought tolerant seed mix to limit erosion. This cap would mitigate the migration of contaminants from the dross material due to disturbances such as weather and animals tracking through or burrowing in the waste. The capped area would be surrounded by a 6-ft chain-link perimeter fence with signage to limit human access to the soil capped area. The fencing would have an access gate and would be secured with a padlock.

5.1.3 Inspection and Maintenance

An inspection and maintenance plan for the new soil cap, fencing/warning signs and existing development cap would be prepared to ensure that the soil cap and fencing controls are working as intended and that requirements for intrusive site work are documented and available to site workers. Inspections would be conducted on an annual basis and include observations of the integrity of the soil/development caps and fencing, general repairs on an as needed basis, and preparation of a report detailing the activities performed during the year. Scheduled soil cap maintenance would be conducted at an estimated frequency of every ten years and consist of clearing and grading of the cap, reinstallation of an erosion control layer of soil to the cap, and hydroseeding to return the cap to near newly-constructed condition.

5.2 Less Aggressive Remedy

5.2.1 Remedial Measures and Strategies

The Less Aggressive Remedy for Metals in Dross Material combines the remedial measures of ICs, ECs and inspections which use the remedial strategies of physical containment and monitoring to achieve ROs. Further description of the remedy is as follows:

- ICs – *Same as Reference Remedy* – A DEUR needs to be placed on the parcels where dross material is present to control development, identify requirements for intrusive site work in areas where dross material exists and require appropriate inspection and maintenance of implemented ECs.
- ECs – New perimeter fencing (with warning signs) would be constructed around the extent of dross material present in the northern portion of the dross material disposal area currently covered by soil (**Figure E5-2**). The purpose of the fencing would be to prevent entry of humans into the dross site area. The building and parking area of Broadway Star Plaza would be incorporated into the remedy as an existing development cap over dross material in the southern portion of the dross material disposal area.
- Inspections – *Same as Reference Remedy* – Inspections would be conducted to evaluate whether the perimeter fencing around the dross material disposal area and development cap continue to limit contaminant exposure to Site receptors. Inspections would be required by the DEUR at a defined frequency.

5.2.1.1 Achievement of Remedial Objectives

The Less Aggressive Remedy would achieve ROs for land use by restricting human exposure to the dross material with a fencing EC (dross material currently present at the surface would remain), incorporating the Broadway Star Plaza development cap into the remedy and requiring an IC for intrusive site work. ICs would also be put in place to make certain that the ECs remain effective for as long as the dross material remains at the site and would require inspections to ensure that the ECs are properly maintained.

5.2.1.2 Consistency with Land Use Plans

The current use of the dross material disposal area is partly “no use” (undeveloped) and partly commercial use, but possible future uses allowable under existing zoning include office, commercial recreation, commercial service, commercial general, residential (including single-family residential), research and development, and a golf course (Clear Creek, 2015). A DEUR implemented as part of the remedy would include some restriction on the type of future development that could occur in the dross disposal area (e.g., no single-family residences) to ensure that ECs are maintained and reduce the likelihood of humans experiencing unacceptable exposure to the metals in the waste. In the future, with a DEUR modification, the property owner could replace the fencing with an appropriate development cap (e.g., buildings, parking lot).

5.2.2 Design and Installation

The dross material disposal area currently covered with soil would be surrounded by a 6-ft chain-link perimeter fence with signage to limit human access to the soil capped area (**Figure E5-2**). The fencing would have an access gate and would be secured with a padlock.

5.2.3 Inspection and Maintenance

An inspection and maintenance plan for the fencing/warning signs, soil cover and existing development cap would be prepared to ensure that the fencing controls are working as intended and that requirements for intrusive site work are documented and available to site workers. Inspections would be conducted on an annual basis and include observations of the integrity of the fencing, general repairs to the fencing on an as needed basis, regrading/addition of supplemental soil cover if required, and preparation of a report detailing the activities performed during the year.

5.3 More Aggressive Remedy

5.3.1 Remedial Measures and Strategies

The More Aggressive Remedy for Metals in Dross Material combines the remedial measures of ICs, ECs and inspections which use the remedial strategies of physical containment, source control and monitoring to achieve ROs. Further description of the remedy is as follows:

- ICs – *Same as Reference Remedy* – A DEUR needs to be placed on the parcels where dross material is present to control development, identify requirements for intrusive site work in areas where dross material exists and require appropriate inspection and maintenance of implemented ECs.
- ECs – An asphalt cap would be constructed over the extent of dross material present in the northern portion of the dross material disposal area currently covered by soil (**Figure E5-3**). The building and asphalt-covered parking area of Broadway Star Plaza would be incorporated into the remedy as an existing development cap over dross material in the southern portion of the dross material disposal area.
- Inspections – *Same as Reference Remedy* – Inspections would be conducted to evaluate whether the asphalt cap and development cap continue to limit contaminant exposure to Site receptors. Inspections would be required by the DEUR at a defined frequency.

5.3.1.1 Achievement of Remedial Objectives

The More Aggressive Remedy would achieve ROs for land use by restricting environmental and human exposure to the dross material with capping ECs and ICs for intrusive site work. ICs would also be put in place to make certain that the ECs remain effective for as long as the dross material remains at the site and would require inspections to ensure that the ECs are properly maintained.

5.3.1.2 Consistency with Land Use Plans

The current use of the dross material disposal area is partly “no use” (undeveloped) and partly commercial use, but possible future uses allowable under existing zoning include office, commercial recreation, commercial service, commercial general, residential (including single-family residential), research and development, and a golf course (Clear Creek, 2015). A DEUR implemented as part of the remedy would include some restriction on the type of future development that could occur in the dross disposal area (e.g., no single-family residences) to ensure that ECs are maintained and reduce the likelihood of humans experiencing unacceptable exposure to the metals in the waste. In the future, with a DEUR modification, the property owner could replace the asphalt cap with an appropriate development cap (buildings, parking lot).

5.3.2 Design and Installation

The design of the asphalt cap would consist of site preparation (i.e., clearing, grubbing, and grading) and installation of a gravel sub-base, an asphalt base layer and an asphalt wear course layer covering the extent of the northern dross material disposal area surface (**Figure E5-3**). The cap would mitigate the migration of contaminants from the dross material due to disturbances such as weather and animals tracking through or burrowing in the waste. The cap would also prevent large vegetation growth in the capped area which can affect cap integrity.

5.3.3 Inspection and Maintenance

An inspection and maintenance plan for the asphalt cap and existing development cap would be prepared to ensure that the caps are working as intended and that requirements for intrusive site work are documented and available to site workers. Inspections would be conducted on an annual basis and include observations of the integrity of the asphalt/development caps and preparation of a report detailing the activities performed during the year. Scheduled asphalt cap maintenance would be conducted at an estimated frequency of every 8 to 15 years (depending on use) and consist of resurfacing the asphalt wear course layer. Annual general repairs are not anticipated between cap maintenance events because of the likely integrity of asphalt.

6.0 DETAILED EVALUATION AND COMPARISON OF THE REMEDIES

6.1 Comparison Criteria

Based on the preceding demonstration that the remedial alternatives are capable of achieving the ROs and are generally consistent with land use plans for the parcels where the dross material is present, this section presents a comparative evaluation of the Reference Remedy and the alternative remedies based on practicability, risk, cost and benefit in accordance with A.A.C. R18-16-407(H) as the primary criteria. An overview of these evaluation criteria is as follows:

- Practicability: Feasibility, short and long term effectiveness, and reliability.
- Risk: Overall protectiveness of public health and aquatic and terrestrial biota under reasonably foreseeable use scenarios and end uses of water.
- Cost: Expenses and losses including capital, operating, maintenance, and life cycle costs.

- Benefit: Value of the remedy in terms of lowered risk, reduced concentrations or volume of contamination, decreased liability, aesthetics, enhancement of future uses, and improvements to local economies.

6.2 Detailed Evaluation of Remedies

An evaluation of the remedial alternatives using the criteria of practicability, risk, cost and benefit is summarized in **Table E6-1**. The sections below further describe how each remedial alternative performs against the criteria.

6.2.1 Reference Remedy

6.2.1.1 Practicability

The Reference Remedy is moderately feasible and implementable due to the conventional design and construction of the new soil cap and fencing. With proper inspections and maintenance of the ECs, the remedy should be generally effective in restricting contact with the dross material over a foreseeable land use period of 30 years. Routine maintenance of the fence would likely be required on an annual basis and soil cap maintenance could be required every ten years. Creating a barrier with a soil cap, development cap and perimeter fence is a reliable way of achieving physical containment of COCs when the contamination is stable.

6.2.1.2 Risk

There is moderate risk associated with the Reference Remedy's protectiveness of human health and terrestrial biota because the contamination remains in place and implemented controls must be properly maintained to be effective for the duration that the contamination remains on-site. The remedy minimizes this risk with institutional controls that would control future development, require management of intrusive site work, and require proper inspection and maintenance of implemented controls. However, the fence is susceptible to being vandalized and the soil cap is susceptible to damage so inspection and maintenance would be critical to long-term management of risks due to contact with the dross material.

6.2.1.3 Cost

The total capital cost for the design and construction of the Reference Remedy is estimated to be $324,000. Per ADEQ direction, costs to maintain/comply with DEURs, inspect infrastructure, and maintain engineering controls were not included in the FS evaluation of costs. A breakdown of capital costs is presented in **Table E6-2**.

6.2.1.4 Benefit

The benefit of the Reference Remedy is the exclusion of most potential receptors (i.e., trespassers) from contact with the dross material. Use of low permeability capping materials would further mitigate the mobilization of metals from the dross material to groundwater.

6.2.2 Less Aggressive Remedy

6.2.2.1 Practicability

The Less Aggressive Remedy is highly feasible because it uses existing implemented controls (soil cover) and a new fence to control contact with the dross material. The installation of a perimeter fence is highly implementable because of the ease of design and construction of this control. This remedy would not be effective if exposed dross at the surface results in a complete physical contact-based or airborne pathway over the foreseeable land use of 30 years (which is difficult to predict). Perimeter fencing is not a reliable way of achieving physical containment of the contamination since the fence is susceptible to being vandalized and dross material is exposed at the surface. Fence maintenance would likely be required on an annual basis.

6.2.2.2 Risk

There is considerable risk associate with the Less Aggressive Remedy's protectiveness of human health and terrestrial biota because the contamination remains in place, exposed at the surface (to a limited yet unquantified extent), and implemented controls must be properly maintained to be effective for the duration that the contamination remains on-site. The remedy minimizes this risk with institutional controls that would limit future development, require management of intrusive site work, and require proper inspection and maintenance of implemented controls. However, the fence will likely be vandalized in the future based on past experience at the site and weather and animals could allow the migration of contaminated materials outside of the fenced area increasing risk of contact with the dross material.

6.2.2.3 Cost

The capital cost for the design and construction of the Less Aggressive Remedy is estimated to be $64,000. Per ADEQ direction, costs to maintain/comply with DEURs, inspect infrastructure, and maintain engineering controls were not included in the FS evaluation of costs. A breakdown of capital costs is presented in **Table E6-3**.

6.2.2.4 Benefit

The benefit of the Less Aggressive Remedy is that it has the potential to decrease contact between most potential receptors (i.e., trespassers) and the hazardous dross material.

6.2.3 More Aggressive Remedy

6.2.3.1 Practicability

The More Aggressive Remedy is moderately feasible and implementable due to the conventional design and construction of the asphalt cap. With proper inspections and maintenance of the ECs, the remedy should be generally effective in restricting contact with the dross material over a foreseeable land use period of 30 years. Use of an asphalt cap is a highly reliable way of achieving physical containment of the contamination of COCs since the cap would prevent the growth of vegetation that could compromise the cap and it would be easy to inspect. Depending on use,

the asphalt cover could require maintenance every 8 to 15 years to replace the wear course layer of the cover.

6.2.3.2 Risk

There is moderate risk associated with the More Aggressive Remedy's protectiveness of human health and terrestrial biota because the contamination remains in place and implemented controls must be properly maintained to be effective for the duration that the contamination remains on-site. The remedy minimizes this risk with institutional controls that would require management of intrusive site work and require proper inspection and maintenance of implemented controls. An asphalt cap is highly resistant to damage which would reduce the risk of contact with contaminated materials relative to other ECs (i.e., fencing alone or fencing with a soil cap).

6.2.3.3 Cost

The capital cost for the design and construction of the More Aggressive Remedy is estimated to be $262,000. Per ADEQ direction, costs to maintain/comply with DEURs, inspect infrastructure, and maintain engineering controls were not included in the FS evaluation of costs. A breakdown of capital costs is presented in **Table E6-4**.

6.2.3.4 Benefit

The benefit of the More Aggressive Remedy is the exclusion of potential receptors (i.e., trespassers) from contact with the dross material with fewer restrictions on land use since fencing would not be required. The asphalt surface could also be beneficially used, if needed. Use of low permeability capping materials would further mitigate the mobilization of metals from the dross material to groundwater.

6.3 Comparison of Remedies

6.3.1 Practicability

All of the evaluated remedy alternatives are practicable. They are each feasible in terms of design and construction. The Less Aggressive Remedy is the least effective and the least reliable because, although human contact with contamination is mitigated by fencing (if properly maintained), dross material remains exposed within the fenced management area. The Reference Remedy is more effective and reliable than the Less Aggressive Remedy but is also subject to whether associated controls (i.e., fencing and capping) are properly maintained. The More Aggressive Remedy is the most effective and reliable alternative because it includes more robust containment of the contaminated materials. The asphalt cap does require maintenance but it is less susceptible to damage due to unforeseen conditions (e.g. significant rain events, wildlife burrowing) than the soil cap. It is also easier to inspect than a soil cap. Asphalt cap resurfacing maintenance would be based on traffic usage; for high traffic usage, maintenance would likely be required every 8 years (the soil cap would need to be maintained every 10 years). For low traffic usage, the maintenance frequency for an asphalt cap could be reduced to resurfacing every 10 to 15 years.

6.3.2 Risk

All of the evaluated remedy alternatives have some risk to the protectiveness of human health and terrestrial biota because the contamination remains in place. The risk is minimized by the physical containment barrier that separates the contamination from receptors. The more extensive the physical containment barrier is, the less risk there is of exposure to receptors. The Less Aggressive Remedy provides separation from contamination but the dross material remains exposed to the environment. The Reference Remedy provides cover and separation which would greatly reduce exposure risks, provided ECs are maintained. The ability of the capping approach implemented in the More Aggressive Remedy to limit risk would also be subject to whether ECs are maintained; however, the asphalt cap is anticipated to wear better and be inspected easier than a soil cap.

6.3.3 Cost

Capital costs for the evaluated remedies range from $64,000 for the Less Aggressive Remedy to $324,000 for the Reference Remedy. At $262,000, the estimated capital cost for the More Aggressive Remedy is lower than the Reference Remedy but generally comparable.

6.3.4 Benefit

All of the evaluated remedial alternatives provide the benefit of exclusion of potential receptors from contact with the hazardous dross material which achieves ROs for land use. The More Aggressive remedy is the only alternative that does not restrict human access to the area at the surface. All three alternatives allow for the possibility of being replaced by a development cap (building, parking lot) in the future.

Presently a DEUR is in development for the parcel containing the northern part of the dross site. This DEUR is based on existing undeveloped conditions. Construction of a “development cap” in the future would require that the DEUR be modified and approved by ADEQ.

6.4 Uncertainties

The most significant uncertainties impacting the comparison of remedies presented in **Section 6.3** are:

- *The extent of the dross material disposal area relies solely on sampling and visual observations conducted during efforts to redevelop the BNL property in the 1990s which are documented by Aplomado (2000)*. During implementation of the proposed remedy, additional dross material could be exposed that was not identified and this may result in cost increases as the limits of the remedy would need to be expanded. To better control this uncertainty prior to development of the Proposed Remedial Action Plan (PRAP), soil borings could be advanced around the perimeter of the dross area to refine the extent of this material and regions where dross is present at the surface could be investigated through excavation to evaluate whether the dross has been deposited or exposed via erosion.

- *The amount of dross material exposed at the surface is not well defined.* The risk posed by this material has been addressed by conservatively assuming that applicable exposure pathways could be completed to Site receptors if ECs are not maintained.
- *The dross material disposal area is comingled with the construction debris cell of the landfill which may settle over time.* Widespread settling is not indicated at this time. However, if settlement issues are noted during construction of the cap, additional measures may be required to stabilize (e.g., compact) the subsurface below the cap which may increase costs. To better address this uncertainty prior to preparation of the PRAP, a technical assessment of existing settlement in the region could be conducted using inspection and topographic survey techniques.
- *The information used to assess potential impacts of the dross material on groundwater includes GPLs and reliance on water quality information from wells that may not be optimally located (i.e., BP-9 and WR-177A).* The risk posed by this material is difficult to predict and has been addressed by conservatively assuming that applicable exposure pathways could be completed to Site receptors in the future if surface water infiltration is not mitigated.
- *The topography of the dross material disposal area is currently not defined.* Significant grading required to construct a level asphalt cap would increase costs. A topographic survey of the area conducted prior to preparation of the PRAP could address this uncertainty and provide the basis for future design.

7.0 PROPOSED REMEDY

7.1 Process and Reason for Selection

The More Aggressive Remedy is the proposed remedy for the Site. This remedy was selected based on the comparison of the practicability, risk, cost and benefit of the remedy alternatives discussed in **Section 6.0**. The More Aggressive Remedy was selected because it provides superior effectiveness, risk control, and benefit when compared to the other evaluated remedies. The More Aggressive Remedy was assessed as comparable in capital expenditure to the Reference Remedy.

7.2 Achievement of Remedial Objectives

As discussed in Section 5.3.1.1, the More Aggressive Remedy achieves ROs for land use through source control, physical containment, and monitoring. Implemented ICs, ECs, and inspections would protect Site receptors from exposure to Metals in the Dross Material by restricting environmental and human exposure to the dross material. To ensure the continued integrity of the ECs (and thus continued achievement of the ROs), DEURs should be placed on Pima County parcel numbers 133-23-1570 and 133-23-110C. As of the finalization of this FS report, a DEUR was in process for parcel number 133-23-1570.

7.3 Achievement of Remedial Action Criteria Pursuant to A.R.S. 49-282.06

The More Aggressive Remedy is proposed as the final remedy for Metals in Dross Material present at the Site. This remedy would achieve the remedial action criteria detailed in A.R.S. 49-282.06 by:

- Assuring the protection of public health and welfare of the environment by providing physical containment and source control of hazardous materials to prevent contact with Site receptors.
- Limiting the mobilization of metals present in the dross material to groundwater so that public and private production wells downgradient of the Site can provide potable water to their respective end users.
- Providing necessary containment of metals in dross material with a reasonable, cost-effective and technically feasible remedial strategy.
- Providing a potentially beneficial use of the land.

7.4 Consistency with Current and Future Land and Water Use

As discussed in Section 5.3.1.2, the More Aggressive Remedy is consistent with the current use of the properties where dross material is present. A DEUR implemented as part of the remedy would include some restriction on the type of future development that could occur in the dross disposal area to ensure that ECs are maintained and reduce the likelihood of humans experiencing unacceptable exposure to the metals in the waste. In the future, with a DEUR modification, the property owner could replace the asphalt cap with an appropriate development cap (buildings, parking lot).

8.0 REFERENCES

Aplomado, 2000. *Risk Evaluation of Remedial Alternatives*, Broadway Store Re-Location, Broadway Boulevard & Prudence Road, Tucson Arizona. December 11, 2000.

Arizona Department of Environmental Quality (ADEQ), 2015. *Feasibility Study Work Plan Broadway Pantano WQARF Registry Site, Tucson Arizona*. April 30, 2015.

Clear Creek Associates (Clear Creek), 2015. *Final Remedial Investigation Report*, Broadway-Pantano WQARF Site, Landfill Operable Unit, Tucson, Arizona. Prepared for ADEQ. February 27, 2015.

SECOR, 2004. *Technical Memorandum: Summary of Surface Soil Sampling Conducted at the Closed Broadway North Landfill, Broadway Pantano WQARF Site*. October 5, 2004.

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TABLES

Table E3-1
Screening of Dross Material Remedial Measures

Measure	Description	Effectiveness	Implementability	Health and Safety Considerations	Flexibility/ Expandability	Cost	Retained	Comments
Institutional Controls	Restrictions on land use; requirement for protection from dross material for intrusive site work; requirement for maintenance of engineering controls.	Medium	High	Low	High	Low	✓	Must be combined with other measures to meet ROs.
Engineering Controls	Minimizes exposure to dross material with use of a separation barrier.	Medium	High	Low	High	Medium	✓	Must be combined with other measures to meet ROs.
Inspections	Long term monitoring used to ensure institutional and/or engineering controls are maintained.	Low	High	Low	High	Low	✓	Must be combined with other measures to meet ROs.
Excavation with On-Site Encapsulation	Relocates dross material to an appropriate location on-site in an engineered management unit.	Medium	Low	Medium	Medium	High	No	Must be combined with other measures to meet ROs.
Excavation with Off-Site Disposal	Removes dross material from the site and disposes it off-site in accordance with the regulations.	High	Moderate	Medium	High	High	No	Would meet ROs based on the quantity and concentrations of contamination.

Notes:

ROs - remedial objectives

WQARF - Water Quality Assurance Revolving Fund

Table E6-1
Comparison of Remedial Alternatives

Remedial Alternative	Incorporated Remedial Strategies per A.A.C. R18-16-407(F)	Remedial Strategy	Technology Process Options	Practicability[1]	Risk[2]	Cost[3]	Benefit[4]
Reference Remedy *Soil Cap, Perimeter Fence, Development Cap (existing), Institutional Controls and Inspections*	2,4,5	● Source Control ● Physical Containment ● Monitoring	● Physical Surface Protection ● Boundary Protection	● Moderately implementable ● Moderately feasible ● Moderately effective/reliable with proper maintenance ● More maintenance likely required than Most Aggressive Remedy	● Moderate risk (contamination remains on-site but is controlled) ● Less risk of exposure to trespassers and residents than the Less Aggressive Remedy	$324K	● Exclusion of receptors from contact with dross (decreases liability) ● Mitigation of metals mobilization through use of low permeability capping materials
Less Aggressive Remedy *Perimeter Fence, Development Cap (existing), Institutional Controls and Inspections*	2,5	● Physical Containment ● Monitoring	● Boundary Protection	● Highly implementable ● Highly feasible ● Not effective if exposed dross at surface results in a complete physical contact or airborne exposure pathway ● Not reliable if fencing is vandalized ● Frequent maintenance	● Higher risk if the fence is vandalized ● If dross is/becomes exposed, there is a potential contact risk to trespassers and potential airborne risk to residents	$64K	● Decreases receptor contact with dross
More Aggressive Remedy *Asphalt Cap, Development Cap (existing), Institutional Controls and Inspections*	2,4,5	● Source Control ● Physical Containment ● Monitoring	● Physical Surface Protection	● Moderately implementable ● Moderately feasible ● More effective than Reference or Less Aggressive Remedies ● Highly reliable in controlling contaminant exposure ● Maintenance requirements will be dependent on use	● Moderate risk (contamination remains on-site but is controlled) ● Less risk of exposure to trespassers and residents than the Less Aggressive Remedy	$262K	● Exclusion of receptors from contact with dross (decreases liability) ● Mitigation of metals mobilization through use of low permeability capping materials ● Potentially beneficial land use

Notes:

A.C.C. - Arizona Administrative Code

K - Thousand

[1] Practicability: feasibility, short-term effectiveness, long-term effectiveness, reliability

[2] Risk: Overall protection of human health and environment

[3] Cost: Per Arizona Department of Environmental Quality direction, this criterion only includes capital costs for the dross material feasibility study evaluation

[4] Benefit: e.g. Lowered risk to human health and environment, reduction in COC concentration and/or volume, decreased liability, public acceptance, aesthetics, preservation of existing uses, enhancement of future uses, and improvement to local economy

Remedial Strategies per A.A.C. R18-16-407(F):

1. Plume remediation is a strategy to achieve water quality standards for contaminants of concern in waters of the state throughout the site.
2. Physical containment is a strategy to contain contaminants within definite boundaries.
3. Controlled migration is a strategy to control the direction or rate of migration but not necessarily to contain migration of contaminants.
4. Source control is a strategy to eliminate or mitigate a continuing source of contamination.
5. Monitoring is a strategy to observe and evaluate the contamination at the site through the collection of data.
6. No action is a strategy that consists of no action at a site.

Table E6-2
Reference Remedy Capital Costs

Item	Estimated Unit Cost	Estimated Quantity	Units	Total Estimated Cost
Soil Cap				
Clearing and Grubbing	$ 325	1.1	Ac	$ 400
Grading	$ 5,300	1	Ea	$ 5,300
Soil	$ 20	5,000	L.C.Y.	$ 100,000
Hauling	$ 10	5,000	L.C.Y.	$ 50,000
General Fill	$ 5	5,000	L.C.Y.	$ 25,000
Compaction	$ 0.50	5,000	E.C.Y.	$ 2,500
Hydroseeding	$ 0.75	5,300	S.Y.	$ 4,000
Fencing				
Fencing	$ 46	1,000	L.F.	$ 46,000
			Construction Subtotal	*$ 233,200*
Construction Markup				
Survey		2%	of Construction Subtotal	$ 4,700
QA/QC		4%	of Construction Subtotal	$ 9,300
Mobilization		8%	of Construction Subtotal	$ 18,700
General Conditions		10%	of Construction Subtotal	$ 23,300
			Construction Total	$ 289,200
Engineering		6%	of Construction Total	$ 17,400
Construction Management		6%	of Construction Total	$ 17,400
			Total	**$ 324,000**

Notes:

- Costs are presented in 2016 US Dollars ($US 2016) rounded to the nearest $100; the total is rounded to the nearest $1,000.
- The estimated unit costs presented are for planning purposed only, at the feasibility study level (-30% to +50%).
- The remedial approach and associated costs summarized here will be refined during the design and construction contracting phase.

% - percent
Ac - acres
Ea - each
E.C.Y - embankment cubic yards
GPM - gallons per minute
L.C.Y - loose cubic yards
L.F. - linear feet
S.Y. - square yards

Table E6-3
Less Aggressive Remedy Capital Costs

Item	Estimated Unit Cost	Estimated Quantity	Units	Total Estimated Cost
Fencing				
Fencing	$ 46	1,000	L.F.	$ 46,000
			Construction Subtotal	*$ 46,000*
Construction Markup				
Survey		2%	of Construction Subtotal	$ 900
QA/QC		4%	of Construction Subtotal	$ 1,800
Mobilization		8%	of Construction Subtotal	$ 3,700
General Conditions		10%	of Construction Subtotal	$ 4,600
			Construction Total	$ 57,000
Engineering		6%	of Construction Total	$ 3,400
Construction Management		6%	of Construction Total	$ 3,400
			Total	**$ 64,000**

Notes:

- Costs are presented in 2016 US Dollars ($US 2016) rounded to the nearest $100; the total is rounded to the nearest $1,000.
- The estimated unit costs presented are for planning purposed only, at the feasibility study level (-30% to +50%).
- The remedial approach and associated costs summarized here will be refined during the design and construction contracting phase.

% - percent

L.F. - linear feet

Table E6-4
More Aggressive Remedy Capital Costs

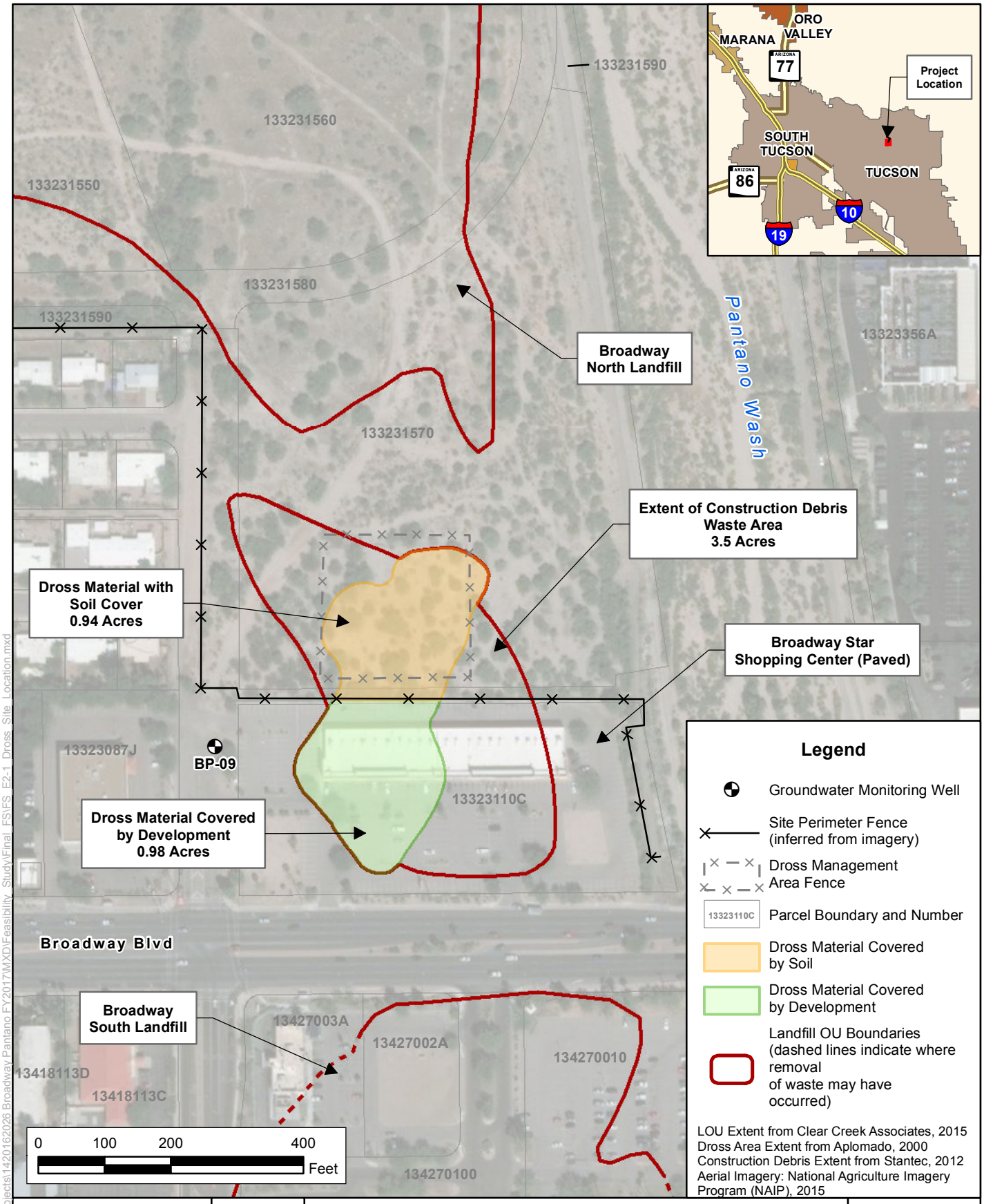
Item	Estimated Unit Cost	Estimated Quantity	Units	Total Estimated Cost
Asphalt Cap				
Clearing and Grubbing	$ 325	1.4	Ac	$ 500
Compaction	$ 0.50	1,400	E.C.Y.	$ 700
Soil	$ 20	1,400	L.C.Y.	$ 28,000
Grading	$ 5,300	1	Ea	$ 5,300
Plant-Mix Asphalt Paving	$ 21	6,600	S.Y.	$ 138,600
Hauling	$ 11	1,400	L.C.Y.	$ 15,400
			Construction Subtotal	*$ 188,500*
Construction Markup				
Survey		2%	of Construction Subtotal	$ 3,800
QA/QC		4%	of Construction Subtotal	$ 7,500
Mobilization		8%	of Construction Subtotal	$ 15,100
General Conditions		10%	of Construction Subtotal	$ 18,900
			Construction Total	$ 233,800
Engineering		6%	of Construction Total	$ 14,000
Construction Management		6%	of Construction Total	$ 14,000
			Total	**$ 262,000**

Notes:

- Costs are presented in 2016 US Dollars ($US 2016) rounded to the nearest $100; the total is rounded to the nearest $1,000.
- The estimated unit costs presented are for planning purposed only, at the feasibility study level (-30% to +50%).
- The remedial approach and associated costs summarized here will be refined during the design and construction contracting phase.

% - percent
Ac - acres
Ea - each
E.C.Y - embankment cubic yards
L.C.Y - loose cubic yards
S.Y. - square yard

FIGURES



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PM:	NC
Date:	6/15/2017
Scale:	1" = 200'

N

Feasibility Study
Broadway Pantano WQARF Site
Tucson, Arizona

Metals in Dross Material
Site Location Map

FIGURE
E2-1

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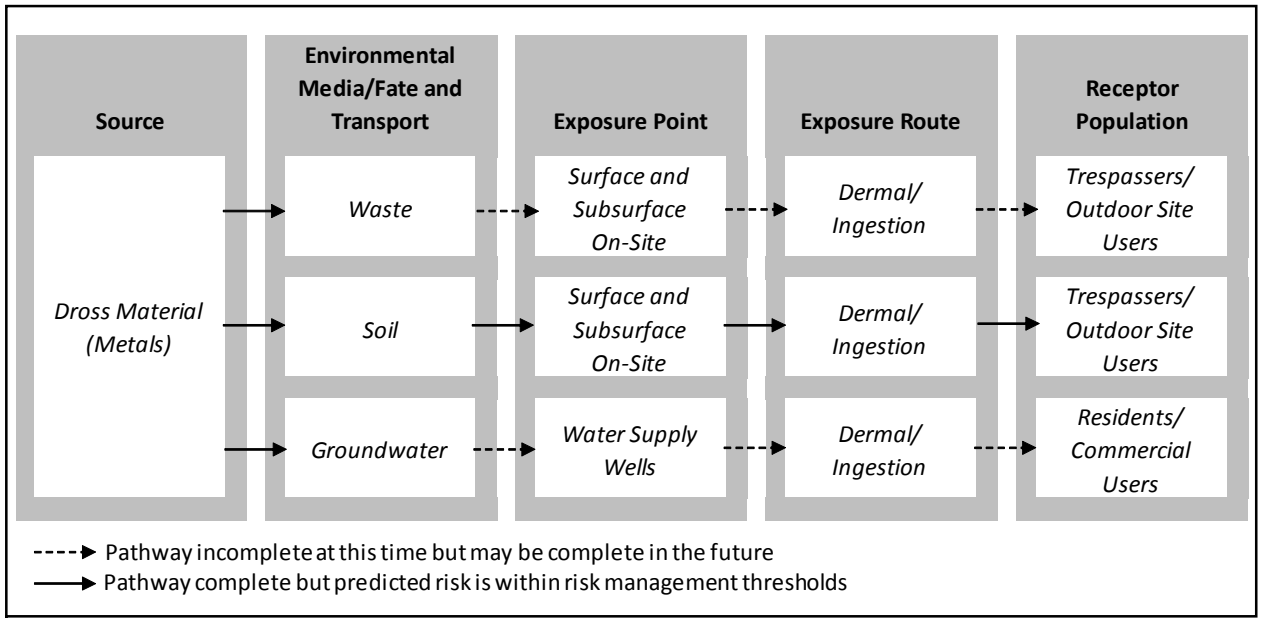
Path: X:\Projects\2016 Projects\142016026 Broadway Pantano FY2017\MXD\Feasibility_Study\Final_FS\FS_E2-1_Dross_Site_Location.mxd

Metals in Dross Material



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PM:	NC
Date:	6/12/2017
Scale:	NA

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Feasibility Study
Broadway Pantano WQARF Site
Tucson, Arizona

Exposure Pathway Summary

FIGURE **E2-2**

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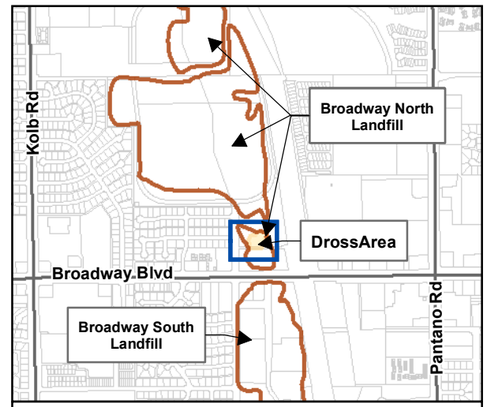

Area of Detail

Legend

- Perimeter Fencing
- Dross Material Covered by Soil
- Soil Cap

Dross Area Extent from Aplomado, 2000
Aerial Imagery: ESRI, 2010

0 25 50
Feet

N

Feasibility Study
Broadway Pantano WQARF Site
Tucson, Arizona

Metals in Dross Materials Reference Remedy

FIGURE		
E5-1	Job No.:	14-2016-2026
	PM:	NC
	Date:	5/19/2017
	Scale:	1"= 50'

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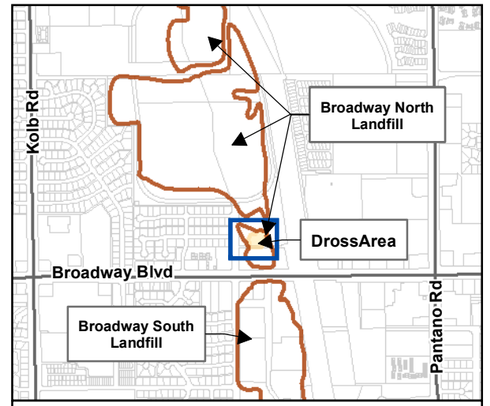

Area of Detail

Legend

- Perimeter Fencing
- Dross Material Covered by Soil

Dross Area Extent from Aplomado, 2000
Aerial Imagery: ESRI, 2010

0 25 50
Feet

N

Feasibility Study
Broadway Pantano WQARF Site
Tucson, Arizona

Metals in Dross Materials
Less Aggressive Remedy

FIGURE		
E5-2	Job No.:	14-2016-2026
	PM:	NC
	Date:	5/19/2017
	Scale:	1"= 50'

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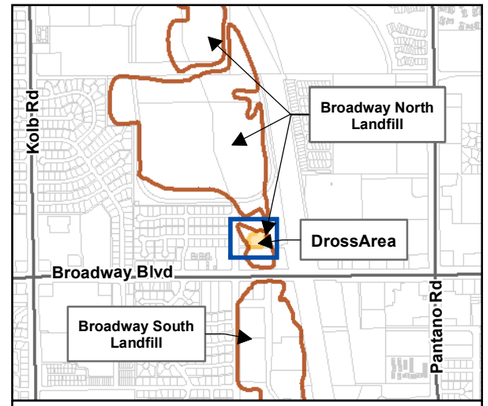

Area of Detail

Legend

- Dross Material Covered by Soil
- Asphalt Cap

Dross Area Extent from Aplomado, 2000
Aerial Imagery: ESRI, 2010

0 25 50
Feet

N

Feasibility Study
Broadway Pantano WQARF Site
Tucson, Arizona

Metals in Dross Materials
More Aggressive Remedy

FIGURE		
E5-3	Job No.:	14-2016-2026
	PM:	NC
	Date:	5/19/2017
	Scale:	1"= 50'

amec foster wheeler