Midnite Mine Superfund Site

100~~90~~ Percent Design

Appendix D – Mine Waste Excavation and Containment

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Prepared for:

Dawn Mining Company
PO Box 250
Ford, Washington 990413

and

Newmont USA Limited
6363 South Fiddler's Green Circle
Greenwood Village, Colorado 80111

Prepared By:

MWH Americas, Inc.
2890 E. Cottonwood Parkway, Suite 300
Salt Lake City, UT 84121

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS

~~amsl~~	~~above mean sea level~~
ARD	acid rock drainage
ASTM	American Society for Testing and Materials
BODR	Basis of Design Report
BMP	Best Management Practice
BPA	Backfilled Pits Area
CD	Consent Decree
COC	constituents of concern
CRSP	Colorado Rockfall Simulation Program
CSWPPP	Contractor Stormwater Pollution Prevention Plan
CSZ	construction support zone
cy	cubic yard
DMC	Dawn Mining Company LLC
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference
GDL	geocomposite drainage layer
gpm	gallons per minute
GSR	Green and Sustainable Remediation
HASP	Health and Safety Plan
HDPE	high density polyethylene
HSWRP	Hillside Waste Rock Pile
LiDAR	Light Detection and Ranging
LLDPE	linear low-density polyethylene
MA	mined area
MAA	mine affected area
mg/L	milligrams per liter
Newmont	Newmont USA Limited
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission regulation
O&M	Operations and Maintenance
OM&M	Operations, Maintenance and Monitoring
pCi	picocuries
PCP	Pollution Control Pond
PVC	Polyvinyl Chloride
RA	Remedial Action

RAO	Remedial Action Objective
~~RAWP~~	~~Remedial Action Work Plan~~
RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
Site	Midnite Mine Superfund Site
SMP	Site-wide Monitoring Plan
SOW	statement~~scope~~ of work
SWMP	Stormwater Management Plan
SWRP	South Waste Rock Pile
TDS	total dissolved solids
Tribe	Spokane Tribe of Indians
USBOM	Bureau of Mines
WCA	Waste Containment Area
WTP	water treatment plant

D1.0 INTRODUCTION

This appendix to the Midnite Mine Superfund Site Basis of Design Report (BODR) presents the detailed design information for the Mine Waste Excavation and Containment components at the Midnite Mine Superfund Site (~~the~~ Site). Mine Wastes include above-grade mine wastes, contaminated soil and sediment, mine drainage sediments, and mine road materials.

Mine waste generally will be excavated, transported, and placed in the Waste Containment Areas (WCA) in a continuous operation, without stockpiling excavated material prior to placement in Pit 4 and Pit 3. As such, Mine Waste Excavation and Containment are considered to be a single task and both are illustrated in the same section in the design drawings (Section 4 of Volume II) and described in this appendix.

The configuration of the waste containment upon completion of the Remedial Action (RA)~~,~~ as shown on the Section 4~~.0~~ Drawings in Volume II of the BODR, reflect the maximum waste storage that could be realized using the existing pits for storage. The storage available, assuming this configuration, exceeds the range of current estimates of waste volumes at the Site as discussed in Section D4.0.

The proposed backfilling sequence consists of completing placement of waste within the Pit 4 to its final configuration, followed by placement of waste within the Pit 3. As such, the Pit 4 ~~Waste Containment Area (~~WCA~~)~~ shown on the Drawings in Section 4~~.0~~ is considered “fixed”, whereas the final Pit 3 configuration has room to be expanded or reduced and as a result, may “float” depending on the actual volume of waste encountered during cleanup. Backfilling Pit 4 prior to placing waste in Pit 3 provides the most flexibility with respect to allowing additional waste material if significant changes in volume are identified in the future. Because the Pit 3 WCA is larger, more flexibility in waste storage volume storage can be accommodated relative to the Pit 4 without significantly altering the design. In addition, lessons learned during backfilling of the smaller Pit 4 can be used to improve designs, operations and procedures for the larger Pit 3 backfilling effort. Regrading of the Backfilled Pits Area (BPA) and Area 5 (the area between Pit 3 and Pit 4) will be performed concurrently with backfilling of Pit 3. Although backfilling both pits simultaneously was initially considered, it was not deemed feasible given space limitations and water management considerations discussed in Appendix E – Water Management Ponds.

Mine waste excavation and placement within the WCA is divided into three phases:

- Phase 1 – Includes excavation and placement of mine wastes in Pit 4. Pit 4 will be dewatered and impacted Pit 4 water will be collected, conveyed and stored in Pit 3 during this Phase. Primary work objectives during Phase 1 include:

1) Preparation and construction of the site access road and construction support facilities described in Appendix B. ~~;~~ The construction support zone (CSZ) and water treatment plant (WTP) footprints will require soil cleanup prior to construction of these facilities. This cleanup will include demolition of existing structures within the CSZ. These activities are known as the Early Works.

2) Initial processing of drain materials from the Hillside Waste Rock Pile (HSWRP).

3) Excavation of the Pit 4 Overburden Pile, with placement of this and other mine waste in the upper Eastern Drainage in Pit 4.

4) Excavation and consolidation~~Consolidation~~ of Ore/Protore Piles within Pit 4.

5) Excavation of parts of the South Waste Rock Pile (SWRP) where the South Pond will be constructed and parts of the HSWRP, with consolidation of excavated materials in Pit 4.

6) Construction of the South Pond in the SWRP. The South Pond will be used to store water during the Phase 2 construction activities when Pit 3 is taken off-line to begin remediation.

~~6)~~7) Construction of the new ~~water treatment plant (~~WTP at the end of Phase 1~~)~~ prior to commencing with Phase 2 (providing the NPDES permitting approvals have been received and final design has been completed).

8) Capping and revegetating the final surface at Pit 4.

Phase 2 – Includes regrading the ~~Backfilled Pits Area (~~BPA~~)~~ and excavation and placement of mine wastes into Pit 3. ~~Initially,~~ Pit 3 will be dewatered and impacted water from the Site will be collected, conveyed, and stored in a lined, temporary storage pond located immediately south of Pit 3 on the SWRP~~South Waste Rock Pile~~ (i.e., the South Pond discussed in Appendix E). Primary ~~One primary objective of the Phase 2~~ work objectives during Phase 2 include:

1) Removal~~is to remove~~ all waste from, and meeting soil and sediment cleanup standards in the Western and Eastern Drainages so that surface water runoff in these drainage basins can be released to Blue Creek without retention and treatment at the WTP.

2) Regrading~~Phase 2 work will also include regrading of~~ Area 5 (located between Pit 3 and Pit 4).

3) Demolition of the existing WTP and associated facilities ~~will occur during Phase 2~~ provided the NPDES permitting is complete for the new facility, with placement of the demolition debris in Pit 3.

4) Construction of the West Pond; the West Pond will be used to store water during Phase 3 when the South Pond is taken off-line.

5) Demolition the other existing site facilities, with placement of the demolition debris in Pit 3.

- Capping and revegetating areas~~. Areas~~ where final grade has been established in the Pit 3 WCA, the BPA, and Area 5 ~~will be capped and revegetated~~ to the extent practical near the end of Phase 2. ~~It is anticipated that demolition of the other existing site facilities will occur during Phase 2.~~

Phase 3 – Includes excavation and placement of remaining mine wastes in Pit 3, capping of remaining uncovered areas in the Pit 3 waste containment area, and revegetation remaining disturbed areas. Upon completion of Phase 2 work, the only significant volume of mine waste requiring excavation and containment will be that located in the Central Drainage in the vicinity of the South Pond and Pollution Control Pond (PCP). ~~.~~ At that point, the South Pond can be decommissioned and replaced with a smaller retention pond in the Western Drainage (i.e., the West Pond) while Phase 3 of the remedial construction proceeds in the last remaining areas containing mine waste in the Central Drainage.

- ~~Phase 3 – Includes excavation and placement of remaining mine wastes in the upper portion of the Pit 3 waste containment area.~~ Demolition and/or removal of ~~any~~ temporary mobile and prefab support facilities in the CSZ and other areas of the Site will occur near the end of Phase ~~-~~3.

- ~~During Phase 3 impacted water collected at the Site will be stored in a lined, temporary storage pond located in the Western Drainage (West Pond).~~ Upon completion of Phase

3, it is anticipated that the only remaining material on Site requiring relocation and containment will be any impacted sediment that may have accumulated within the West Pond over its operational life and its liner system. The~~se~~ waste materials from the West Pond will be relocated to a separate waste containment cell located in the Contingency Storage Area in the upper portion of the Area 5/Pit 3 WCA as shown on Drawing 4-74~~72~~. The conceptual design for the Contingency Storage Area is shown on Drawing 4-97~~88~~. It is anticipated that the Contingency Storage Area would have capacity for at least 250,000 cubic yards of waste. The West Pond will not be decommissioned until flows at the Site have decreased to the point where the available storage in the equalization ponds at the new WTP can handle the storage requirements of the Site.

- **Contingent Action Wastes -** Waste materials may also include materials from outside the mined area (e.g., Blue Creek and D~~d~~elta sediments) that may need to be excavated as part of the Contingent Action. This material would be placed in additional cells constructed in the Contingency Storage Area which would be constructed on top of the an existing cover, and these wastes will be completely encapsulated with a separate underliner and drainage system beneath the waste, and a composite cover system over the waste as shown on Drawing 4-97~~88~~.

The remainder of this appendix contains ~~of~~ the following information in subsections and attachments:

- Demonstration that the design will attain the Mine Waste Excavation and Containment Performance Standards identified in the Consent Decree (CD, EPA, 2011) (~~in~~ Section D2.0).
- Calculations, assumptions, and parameters for the design such as waste material volume estimates, materials management strategies, anticipated limits of excavations, and erosion and surface water controls (provided in attachments to this appendix).
- Excavation and grading plans for the above-grade mine wastes, contaminated soil and sediment, mine drainage sediments, and mine road materials at key points during RA construction (provided in Section 4 of the D~~d~~rawings in Volume II).
- Strategy for managing surface water runoff in waste excavation areas. Details of surface water and sediment management at key points during the RA are included in Appendix F.

- Management of near-surface impacted groundwater in areas where it may impact surface water runoff quality.
- Considerations for Green and Sustainable Remediation (GSR) are in Section D13.0.
- Processes for verifying that cleanup levels have been achieved in the excavated areas are included in Appendix S.

D.1.1 DESIGN CHANGES

Final configuration of the WCA is shown on Drawings 4-17~~16~~, 4-46~~44~~, 4-55 and 4-74~~53 and72~~. This configuration differs somewhat from the conceptual design for the Selected Remedy as presented on Figure 12-1 of the Midnite Mine Record of Decision (ROD, EPA, 2006). These major differences are discussed below:

BPA/Pit 3 Continuous Cover Design. The WCA configuration shown on Figure 12-1 of the ROD shows the BPA and the Pit 3 WCA as two discrete waste containment areas, with a gap in the cover system between the BPA and the Pit 3 WCA. This gap results in a thin strip of uncovered area in a valley formed at the low point between the covered waste areas in Pit 3 and the BPA where meteoric water may infiltrate into either the BPA, Pit 3, or both. The conceptual design shown on Figure 12-1 of the ROD included a surface water/shallow groundwater interceptor trench that was included in the design as a means to try to collect water that may infiltrate in this uncovered area.

Rather than allowing this water to infiltrate, and then try to intercept or collect is afterwards, the design as presented in Drawing 4-55~~53~~ includes a continuous cover system between Pit 3 and the BPA, without this gap, and without the shallow surface water/groundwater interceptor trench. Continuous capping allows for interception and diversion of meteoric water from the BPA and Pit 3 WCA before it becomes groundwater and potentially contacts waste materials.

Elimination of Shallow Groundwater Interceptor Trench. The groundwater interception trench, located between the BPA and the Pit 3 WCA as shown on Figure 12-1 is superfluous given that a continuous cover system is being installed between the two areas to intercept and divert meteoric water before it becomes groundwater. In addition, the shallow interceptor system shown on Figure 12-1 lies almost on top of the topographic divide in the mine subwaste surface between areas draining to Pit 3 and areas draining to the BPA. Thus, although this trench could serve to intercept surface water if the WCA was shaped as shown in Section 12 of the ROD, it would be ineffective at collecting shallow groundwater since shallow groundwater flow has been shown to be topographically controlled (URS, 2002).

It also should also be noted that Figure 12-1 in the ROD was prepared using the pre-mine~~premine~~ topography, rather than the topography prepared by the U.S. Bureau of Mine (USBOM), which includes modifications to the topography resulting from the mining excavations at the Site that dramatically changed the pre-mined~~premined~~ topography. Evaluations of the USBOM topography, as well as evaluations of historic mining activity by Peters (1999), show that surficial materials and bedrock excavation occurred in this area to depths of 40 feet or more in the vicinity of the proposed surface water/groundwater interceptor trench, making it highly unlikely that any alluvium or alluvial groundwater will exist in this area after removal of mine waste.

Pit 4/Pit 3 Continuous Cover Design. Figure 12-1 in the ROD shows waste rock from Area 5 (the area between Pit 4 and Pit 3) being removed, leaving an approximately 10-acre area uncovered depression between Pit 3 and Pit 4 where surface water would be trapped and ponding would occur upgradient of Pit 3. Based upon the subwaste topography, it is clear that this area is the source of water for seeps expressing themselves in the north wall of Pit 3. Allowing ponding of surface water in this area will result in increased seepage into Pit 3 and should be avoided. As a result, the design presented in this BODR for the WCA (the Section 4 D~~d~~rawings) includes grading the waste rock to provide positive drainage away from Area 5, and capping the surface to form a continuous cover over the backfilled Pit 4, Area 5, and Pit 3 to prevent infiltration of meteoric water. Capping of Area 5 is expected to reduce or eliminate the seeps in the north wall of Pit 3.

Excavation of the Adit Pit and Pit 2 West. The excavation and waste containment plans presented in the 60% BODR, 90% BODR, and this 100~~90~~% BODR for the Adit Pit and Pit 2 West (the two small backfilled pits included as part of the BPA that are located in the Western Drainage) vary from that shown in the Preliminary (30%) BODR (MWH, 2012a). In the 30% BODR, the waste backfill in these two pits remained in place, with the waste surface graded to conform to the surrounding topography and capped to prevent infiltration of meteoric water. However, during the July 22, 2013 Technical Meeting held in Wellpinit, WA, EPA requested that the excavation and containment plan for these two pits be reevaluated and that additional consideration be given to removing the waste from the pits.

Upon additional consideration, it was determined that although removal of mine waste materials from these two pits would require excavation, transport, and consolidation of approximately 100,000 cubic yards of additional mine waste in the WCA, it does present a number of advantages. These include:

1. All waste material will be removed from the Western Drainage and consolidated in the Central Drainage. Removing all waste sources from the Western Drainage can be expected to reduce the potential for contaminant loading to groundwater in the Western Drainage while not measurably increasing the loading in the Central Drainage.
2. There is some indication that the Adit Pit was used as an ore load-out area during mining in the BPA (Peters, 1999). This suggests that some of the material in the partially backfilled Adit Pit may be higher activity material and possibly higher reactivity material that could be more effectively isolated within the Pit 3 backfill.
3. Although the groundwater well installed through the existing waste rock into the bottom of Pit 2 West (GW-52) West has always been dry, the mine waste subgrade topography indicates the pit bottom is not graded in a configuration that would be freely draining and has the potential to pond approximately 10-feet of water in the pit bottom. Excavation of all waste rock from Pit 2 West will allow for recontouring of the pit bottom to a configuration that will not have the potential to impound water in pit bottom. Although there is some potential for flushing of contaminants from the newly exposed pit walls in surface water runoff after excavation of the mine waste, should this occur it likely would only be for a relatively short period of time. In addition, it will be much easier to collect and treat this surface water runoff, if necessary for a short time, than if the impacted water occurred as groundwater (i.e., if the materials in Pit 2 West were left in place) over the long term.
4. Both the review of historical aerial photographs (Peters, 1999) and groundwater level measurements in the monitoring well installed in the Adit Pit (GW-55) indicate that groundwater has not been encountered in the Adit Pit either before or after backfilling. Thus, it appears that additional grading of the pit bottom will not be necessary to avoid ponding after removal of mine wastes. As was stated above for Pit 2 West, there is some potential for initial flushing of contaminants from the newly exposed pit walls in surface water runoff. If this does occur, it should be for a relatively short period of time and will be easily controlled.

5. If the waste was allowed to remain in the Adit Pit and Pit 2 West, the regraded waste surfaces would need to be very steep in order to conform to surrounding terrain. This would result in a very-steeply sloped composite cover system over both areas. The very-steeply ~~-~~sloped composite covers represent significant veneer slope stability and erosional stability challenges and would likely require long-term maintenance.
6. Although the removal of the mine waste from the Adit Pit and Pit 2 West was not explicitly discussed in the CD Statement of Work (SOW, EPA, 2011) (references are only made to regrading and capping the BPA waste in general), removal of waste from these two pits appears to conform more closely with the conceptual configuration of the WCA as shown in Figure 12-1 of the ROD (EPA, 2006).~~.~~

Based upon these positive outcomes, it was decided to remove the mine waste from the Adit Pit and Pit 2 West and consolidate them within the Pit 4 WCA during Phase1 of the RA. Final soil cleanup and verification of the Adit Pit and Pit 2 West will be completed in Phase 2 following cleanup of areas surrounding these pits. Wastes generated from final soil cleanup in these pits will be placed in Pit 3. This is presented in the Section 4 design D~~d~~rawings.

It also was requested by the Spokane Tribe of Indians (the Tribe) representatives that consideration be given to removing all waste material from the BPA and consolidating them within the Pit 3. EPA indicated this change would be considered a major change to the Selected Remedy and that data would be necessary to support this proposed change. EPA also explained that submittal and approval of an Explanation of Significant Difference (ESD) would be necessary before designs could be prepared for removal of all waste from the BPA. During the meeting it was agreed there is some merit to removal of all the backfilled pit waste; however, it was decided to not pursue this alternative any further given the amount of time that would be necessary to:

- Prepare the ESD and obtain technical and public consensus and approval,
- Alter or completely stop the ongoing Remedial Design (RD) process, and
- Ultimately the delay the Midnite Mine RA construction schedule.

D2.0 PERFORMANCE STANDARDS

The Performance Standards presented herein are defined in the Consent Decree Statement of Work, and were developed to define attainment of the Remedial Action Objectives (RAOs) of the Selected Remedy. The Performance Standards~~performance standards~~ include both general and specific standards applicable to the Selected Remedy work elements and associated work components. All of the Performance Standards, as well as a summary of where or how they are addressed in the ~~Remedial Design (~~RD,~~),~~ are summarized on Table 4-6 of the BODR. The Performance Standards applicable to the Mine Waste Excavation and Mine Waste Containment are listed in Tables D-1 and D-2 below. Performance Standards applicable to the remediation of the BPA are included as Table D-3. Since regrading of the BPA will be performed concurrently with Pit 3 backfilling during Phase 2 and the BPA surface cover will be contiguous with the Pit 3 surface cover, performance standards associated BPA remediation are addressed under Pit 3 waste consolidation performance standards, with the exception of performance standards for groundwater removal from the BPA.

Table D-1 — Performance Standards Applicable to Mine Waste Excavation

Page 1 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
2.3 General Standards Applicable to All Work Elements and Work Components		
2.3.15 E.	Removals and other excavations conducted as part of the construction activities shall be performed in a manner that allows for proper drainage from the excavated area. Drainage from Work Areas that may have come into contact with contaminants shall be captured and conveyed to the water treatment plant for treatment. No drainage from Work Areas that may have come into contact with contaminants shall be allowed to infiltrate or discharge to natural drainages where water treatment collection and conveyance controls are not in place and operating.	To the extent practical, mine waste excavations will be completed beginning at the upstream (northern) end of the Western, Central, and Far Eastern Drainages and continued in a downstream direction. Excavation areas will be graded in a manner that contains surface water runoff from excavation areas wholly within the excavation areas, from where it will either drain by gravity, or be pumped to the storage pond and ultimately the WTP for treatment. Additional details of excavation procedures to be used during mine waste removal are presented in Technical Specification Section 02205 – Mine Waste Excavation and Disposal.
2.3.15 H.	To the extent practicable, construction activities shall be conducted in a manner that does not result in the re-contamination of areas already remediated or contamination of areas that were previously uncontaminated. Any such re-contaminated or newly contaminated areas shall be addressed by the Settling Defendants in a manner that is subject to the review and approval of EPA.	The proposed phasing of construction activities will avoid the recontamination of remediated areas. Contamination of previously uncontaminated areas will be avoided to the maximum extent practical, and stockpiling of contaminated materials in uncontaminated areas will be avoided.~~ to the maximum extent practical.~~ If routing of construction traffic, or other operations that may potentially result in re-contamination of remediated areas or contamination of~~or~~ previously uncontaminated areas is unavoidable, these operations will be limited~~ to the extent practical~~, the EPA will be notified, and these areas will be addressed in a manner that is subject to the review and approval of the EPA. Requirements for the construction contractor to execute the work in a manner that does not result in the re-contamination of areas already remediated or contamination of areas that were previously uncontaminated is provided in Technical Specification Section 02205 – Mine Waste Excavation and Disposal.
2.3.18	Best Management Practices (BMPs) shall be used as specified below during all construction activities to minimize the transport of disturbed material by water, wind erosion or vehicles. The Settling Defendants shall develop a catalog of BMPs that shall be used at the Site and shall identify the primary activities requiring those BMPs. The BMP catalog shall be comprehensive and is subject to the review and approval of EPA. The minimum BMPs that must be contained in the BMP catalog are presented below. The Settling Defendants shall include these BMPs in the BMP catalog along with additional BMPs that may be	The Master SWMP included in Appendix O describes the over-arching framework for how stormwater and surface water will be managed to limit the release of sediment, pollutants, and deleterious debris to downstream areas during and following the RAs. The~~is~~ Master SWMP is the foundation document that provides the catalog of BMPs that will be applied to reduce the adverse impacts of stormwater. The RA Contractor~~The RAWPs that are prepared prior to each construction season~~ will be required to prepare a Construction Stormwater Pollution Prevention Plan (CSWPPP) that presents the~~include~~ stormwater management protocol and procedures that are specific to the phased construction activities. ~~-~~The RA

	necessary to complete the Work. A Storm ~~A Storm Water Management Plan (SWMP) shall be prepared which contains the BMP catalog and identifies BMPs and specific sediment control measures to be employed before, during, and after construction.~~	Contractor's CSWPPP~~RAWPs~~ will reference the~~is~~ Master SWMP for general stormwater management practices and will identify ~~the BMPs that are applicable to the scheduled construction activities.~~

Table D-1 — Performance Standards Applicable to Mine Waste Excavation

Page 2 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
	Water Management Plan (SWMP) shall be prepared which contains the BMP catalog and identifies BMPs and specific sediment control measures to be employed before, during, and after construction.	the BMPs that are applicable to the scheduled construction activities.
2.3.18. A	The Work shall be conducted in a manner that minimizes the generation of fugitive dust. If the application of water or other dust suppressants to Work Areas is used to control the generation and migration of fugitive dust, such application of dust suppressants shall comply with the following requirements:	It is anticipated that dust suppression will be required for this work and primarily will consist of dust suppressant watering. “Free” water will not be allowed to run off as a result of this activity. Dust suppressant additives may be added to permanent access roads or haul roads, subject to prior EPA approval. Technical specification Section 01560 – Temporary Environmental Controls~~(s) in Appendix K~~ describes dust suppression methods and procedures and will be subject to EPA review and approval.
2.3.18. A.i	Dust suppressants containing brine, or other materials that are harmful to surface water or vegetation shall not be used. Subject to EPA approval, water treated to meet the WTP discharge limits may be used for dust suppression in the Work Area, provided it will not result in releases to surface water or adversely affect worker health and safety.	See response top 2.3.18. A above. The design assumes that water from the WTP, which has elevated levels of TDS and sulfates, will be used for dust control in the Mine Area on contaminated materials. It is assumed that this water would not be used on areas that are outside of the Mine Area or have been cleaned up to applicable standards.
2.3.18. A.ii	Application of dust suppressants shall be performed in a manner that minimizes surface water runoff, over spray of chemical suppressants into surface water bodies, wetlands or other sensitive habitats, and/or generation of muddy conditions.	See response top 2.3.18. A above.
2.3.18. B	At a minimum, the following BMPs shall be used to minimize the transport of sediment from Work Areas:	BMPs to minimize sediment transport from the Work Area are~~will be~~ identified in the Master SWMP for this work. The Master SWMP is provided in Appendix O.
2.3.18 B.i	Staging areas, accumulation areas and other areas where Work is to be performed on exposed slopes shall be isolated with appropriate BMPs to minimize transport of potentially contaminated sediments from the Work Areas by surface water runoff.	The Master SWMP in Appendix O contains the BMP catalog, including BMPs to minimize the transport of sediments. As described in 2.3.15.E above, excavations will be conducted beginning with upstream areas within each drainage and working in a downstream direction, with the working excavation areas being shaped to retain surface water runoff. In areas where this is not possible, other BMPs will be utilized to minimize the transport of potentially contaminated sediments from the work areas by surface water runoff.
2.3.18 B.iii	Work that occurs within surface water bodies shall be performed in accordance with the requirements of the SWMP in the approved Remedial Action Work Plan to minimize sediment migration from the Work Area and mitigate damage to existing vegetation. All such Work shall be performed in a manner that limits harm to wetlands and surface water. In	The Master SWMP in Appendix O contains the BMP catalog, including BMPs to minimize the transport of sediments and to limit harm to wetlands and surface water during the RA. With a few specific exceptions (i.e., sediment cleanup within drainages) this work will not occur within surface water bodies. To the maximum extent practical, sediment cleanup within drainages will be conducted within drier parts of the

	~~In addition, the Work shall be performed in a manner that minimizes the release of sediments beyond the Work Area. BMPs shall be employed and refined as necessary to minimize the release of sediment.~~	~~year (summer and early autumn) to avoid unnecessary impacts to surface water bodies.~~

Table D-1 — Performance Standards Applicable to Mine Waste Excavation
Page 3 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
	addition, the Work shall be performed in a manner that minimizes the release of sediments beyond the Work Area. BMPs shall be employed and refined as necessary to minimize the release of sediment.	year (summer and early autumn) to avoid unnecessary impacts to surface water bodies.
2.3.18 B.iv	Any dewatering or diversion of surface water and groundwater shall be performed in a manner that minimizes the release of sediments to the extent practicable beyond the Work Area and limits harm to wetlands and surface water.	See response to 2.3.18 B.iii
2.4.2.3 Mine Waste Excavation Work Component		
A. Mine Waste Excavation		
2.4.2.3.2 A.i.	Above-Grade Mine Waste Excavation - Mine Wastes located above the premining topographic surface within the MA with the exception of mine wastes currently located in the Backfilled Pit Area (BPA) shall be excavated. All of the above materials located in the MA that exceed the cleanup levels identified in Table 4-1 shall be excavated for consolidation and containment in Pits 3 and 4.	Above-grade mine wastes located above the pre-mining topographic surface are shown on Drawing 4-1 and shall be excavated to the pre-mining topography as shown on Drawings 4-2, 4-24~~23~~, and 4-51~~49~~ and relocated in the Pit 3 and Pit 4 backfill areas. The Pit 3 and Pit 4 Mine Waste Containment Areas will be contiguous and continuously capped. As such, Area 5 between Pits 3 and Pit 4 will be regraded and capped in-place, as shown on Drawing 4-46~~44~~, as opposed to being excavated and placed in either Pit 3 or Pit 4.
2.4.2.3.2 A.ii.	Contaminated Soils and Sediments Excavation - Contaminated soils (impacted by roads or other areas of mine waste) and sediments located in the MA and MAA that exhibit contaminant concentrations above the cleanup levels in BODR Tables 4-1 and 4-2, shall be excavated for consolidation and containment in Pits 3 and 4.	Delineations of extents and volume estimates for contaminated soil cleanup within the MA and MAA are based on data and information provided in the *RI Report* (EPA, 2005) and *Mine Waste Investigations Report* (MGC, 2011a).The estimated cleanup limits shown in the Section 4 of the Drawings are based upon these delineations. As indicated on the Drawings, the actual extent of soil contamination and cleanup will be determined in the field using procedures defined in the "Analytical Support and Verification Plan for Remediation of Surface Materials and Sediments" is included in Appendix S.
2.4.2.3.2 A.iii.	Mine Drainage Sediments Excavation - Mine Drainage Sediments located in drainages downstream of the MA in the MAA have been impacted by the release of contaminated materials from the MA. Mine Drainage Sediments that exhibit contaminant concentrations above the cleanup levels presented in Table 4-2 shall be excavated for	See Response to 2.4.2.3.2 A.ii, above.

	consolidation and containment in Pits 3 and 4. The extent of contaminated sediments requiring removal in the mine drainages shall be determined during RD.	
2.4.2.3.2 A.iv	Road Materials Excavation – Mine wastes used for the construction of roads and any ~~soils and sediments below, adjacent to, and downstream of the roads that exceed the cleanup levels presented in BODR Table 4-2 shall be excavated for consolidation and containment in Pits 3 and 4. The extent of~~	See Response to 2.4.2.3.2 A.ii, above.

Table D-1 — Performance Standards Applicable to Mine Waste Excavation

Page 4 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
.	soils and sediments below, adjacent to, and downstream of the roads that exceed the cleanup levels presented in BODR Table 4-2 shall be excavated for consolidation and containment in Pits 3 and 4. The extent of~~.~~ contaminated materials requiring excavation shall be determined during RD	
2.4.2.3.2 A.v.	Soil/sediment sampling shall be conducted following removals to ensure that remaining soils and sediments meet cleanup levels identified in Tables 4-1 and 4-2. The sampling design and frequency shall be developed using methodology that conforms with EPA guidance for the development of sampling and analysis plans and quality assurance project plans.	See Response to 2.4.2.3.2 A.ii, above.
2.4.2.3.2 A.vi.	A layer of suitable soil or soil amendments, as determined during RD, shall be placed over areas cleared of mine waste. Such areas shall be graded and re-vegetated to minimize erosion and ARD formation and to channel water away from waste containment areas.	Areas cleared of mine waste will be graded to conform to the pre-mining topography as shown on Drawings 4-2, 4-24~~23~~, and 4-51~~49~~ to the extent practical. In areas cleared of mine waste where subsoil excavation and removal is required, one foot of clean soil from an approved borrow source or soil amendments will be placed to enhance revegetation and minimize erosion.
B. Surface Water and Stormwater Management and Controls During Excavation		
2.4.2.3.2 B.i.	During the excavation of contaminated materials, surface water and stormwater BMPs shall be applied to prevent, to the extent practicable, sediment transport and the contact of clean surface water and stormwater with contaminated materials.	Appendix F entitled “Surface Water and Sediment Controls” and Section 6 of the D~~d~~rawings in Volume II describe the Surface Water and Sediment Controls which will be used to shed clean water away from contaminated areas during various stages of the RA. The Master SWMP is contained in Appendix O and includes~~will contain~~ a BMP catalog. The SWMP defines the requirements for inspecting, maintaining, and repairing sedimentation controls and maintaining BMPs throughout construction.
2.4.2.3.2 B.ii.	To the extent practicable, clean water coming into contact with contaminated materials in the excavation areas that results in surface water concentrations exceeding the surface water cleanup levels identified in Table 4-3 shall be	To the extent practicable, the mine waste excavations will occur in a downhill direction, and be bermed and contoured such that such that all surface water that enters the excavations (and potentially contacts mine wastes) will be captured in the excavation. This

	collected and conveyed to the WTP for treatment.	water will either gravity drain or be pumped to the temporary storage impoundments pending treatment at the operating WTP. These details are included in Appendix D – Mine Waste Excavations and Containment and Appendix F – Surface Water and Sediment Controls.
2.4.2.3.2 B.iii.	Sediments captured by surface water and stormwater controls shall be contained and removed to an approved location designed to prevent redistribution of the sediments to the surrounding environment. The disposition of ~~the sediments shall be determined by sampling the sediments at a frequency and for analytes determined during RD.~~	Sediments will be captured during construction in a variety of temporary surface water and sediment controls structures discussed in Appendix F and BMPs identified in Appendix O (Master SWMP). The process for verifying Site COC concentrations in ~~sediments is included in the Analytical Support and Verification Plan for Remediation of Surface Materials and Sediments contained in Appendix S. Sediment determined to be contaminated (or assumed to be contaminated based on the location of the BMP) will~~

Table D-1 — Performance Standards Applicable to Mine Waste Excavation

Page 5 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
	the sediments shall be determined by sampling the sediments at a frequency and for analytes determined during RD.	sediments is included in the Analytical Support and Verification Plan for Remediation of Surface Materials and Sediments contained in Appendix S. Sediment determined to be contaminated (or assumed to be contaminated based on the location of the BMP) will be incorporated into the waste containment areas in Pits 3 and 4. Captured sediments that are determined to be clean may be incorporated into soil cover layers as part of remedial construction.
2.4.2.3.2 B.iv.	Surface water and stormwater controls and water collection and conveyance systems shall remain in place and be monitored for effectiveness until such a time as all contaminated materials requiring excavation have been removed for consolidation and containment in Pits 3 and 4.	The surface water and sediment controls (described in Appendix F), and water collection and conveyance systems (described in Appendix J) will be constructed, operated and removed according to a phased construction approach as described in Appendix A – General Design Information and in this Appendix D. These temporary structures and systems will remain in place until permanent structures/systems are built and water in the remediated areas can be shed to the natural drainages down gradient of the Site. The Operations Maintenance and Monitoring Plan (OM&M Plan) in Appendix P defines O&M requirements for the surface and stormwater controls during the RA activities. In addition, surface water down gradient of the Site will be monitored in accordance with the Site-Wide Monitoring Plan (SMP), contained in Appendix Q, to evaluate the effectiveness of these engineering controls during the RA.
2.4.2.3.2 B.v.	The Settling Defendants shall develop a monitoring program to ensure that the concentrations of contaminants in surface water leaving the MA are below those listed in Table 4-3. If concentrations are greater than those listed in Table 4-3, the water shall be collected and conveyed to the water treatment plant for treatment.	To the extent practicable, all surface water that contacts mining wastes within the MA will continue to be captured during the RA activities and conveyed to the operating WTP. These details are described in this Appendix D – Mine Waste Excavation and Containment, Appendix E – Water Management Ponds, and Appendix F – Surface Water and Sediment Controls. However, as noted in the ROD,

		achievement of the surface water cleanup levels down gradient of the MA will require a period for natural attenuation to occur after the remedy is completed. Therefore, the design does not include provisions to capture and treat surface water down gradient of the MA. The ~~Site-Wide Monitoring Plan (~~SMP~~)~~ in Appendix Q defines the monitoring program that will be implemented both during and following the RA to evaluate contaminant concentrations in surface water down gradient of the MA. The SMP defines the action levels that will be used during the RA to evaluate if mine-related contaminants are being released to surface water as a result of the RA activities. The SMP also describes how surface water will be monitored following the RA ~~for comparison with the cleanup levels listed on Table 4-3.~~

Table D-1 — Performance Standards Applicable to Mine Waste Excavation

Page 6 of 6

Performance Standard No. in CD SOW	Performance Standard	Comments
2.4.2.3.2 B.vi.	If, during the course of excavation, the surface water and stormwater BMPs in the BMP Catalog are found to be insufficient to address surface water and stormwater management issues, the Settling Defendants shall develop and implement new BMPs, subject to EPA review and approval.	for comparison with the cleanup levels listed on Table 4-3. As described in the Master SWMP included in Appendix O, the Project Engineer will perform periodic inspections and monitoring to confirm that the BMPs are adequate and functioning as intended, or to determine if additional BMPs are necessary. If necessary, the Project Engineer will immediately initiate actions to correct existing BMPs or develop and implement new BMPs.
C. Excavated Materials Staging/Stockpiling		
2.4.2.3.2 C. i.	If it is determined during design that staging of excavated materials prior to their consolidation and containment is necessary, a Staging/Temporary Stockpile Plan shall be developed and included in the RD.	A Staging/Temporary Stockpiling Plan is included as Appendix R. Generally, staging and stockpiling will not be necessary as most of mine waste material will be directly loaded and hauled to its final destination in the waste containment areas (see Technical Specification 02205 – Mine Waste Excavation and Disposal; Sections 3.3 and 3.4).~~.~~ The only material anticipated to require~~we anticipate~~ stockpiling prior to placement in the containment area are 1) the pit-bottom sediments, which will be stockpiled on the waste rock piles, 2) material from the topsoil stockpile at the WTP site, 3) excavation spoils from the construction of the groundwater control system, and 4) the drain rock that will be processed from the ~~Hillside Waste Rock Pile (~~HSWRP,~~),~~ which will occur in Area 5.
2.4.2.3.2 C. ii.	The Staging/Temporary Stockpile Plan shall include a list of BMPs that complies with applicable worker protection requirements. In addition, the BMPs shall ensure, to the extent practicable, that staged/stockpiled materials are isolated from contact with surface water and stormwater and that staging/stockpiling processes do not result in the generation of ARD and/or conditions that could lead to the migration of contaminants to the surrounding environment.	A Staging/Temporary Stockpiling Plan is provided in Appendix R. Temporary stockpiling of contaminated materials is designed to occur within existing mine waste areas (i.e., all runoff from the stockpiled materials will be captured and treated); therefore BMPs (other than those described in the Master SWMP) will not be needed. Engineering controls to capture stormwater and surface water in the mine waste areas are described in Appendix F (Surface W~~w~~ater and Sediment Controls) and are depicted in the Section 6 Drawings~~design drawings~~ included in Volume II. Applicable worker protection requirements for construction activities are included in Appendix L – RA Health and Safety Plan (HASP).

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 1 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
A. Temporary Facilities during Construction Activities		
2.4.2.4.2 A.i.	During performance of the Pits 3 and 4 Component of Work, temporary facilities, such as covers, runoff controls, temporary sumps, and water capture and removal systems, shall be provided, as determined in the SWMP and RD. Water requiring treatment shall be conveyed as soon as practicable to the WTP for storage and treatment.	Appendix F entitled “Surface Water and Sediment Controls” contains text, calculations and references Section 6 of the Drawings in Volume II. Appendix E entitled “Water Management Ponds” and references Section 5 of the Drawings in Volume II. These documents and drawings illustrate how surface water and impacted site water will be managed upon completion of each major phase of construction. The Master SWMP is contained in Appendix O. As required by the SOW in the CD, this SWMP will be updated on an annual basis, at a minimum, and will describe the intermediate phases and temporary facilities to be employed to capture and convey water to the WTP, as well as diversion of clean water around work areas, as construction progresses.
B. Groundwater Intrusion into Pits 3 and 4		
2.4.2.4.2 B.i.	Groundwater adjacent to each pit shall be collected and diverted away from the pits or blocked from flowing into the pits, as practicable, by methods determined during RD.	The primary mechanism proposed for diverting groundwater from the pits is to provide a continuous surface cover system over the majority of the contributing areas (to Pit 4, Pit 3, and the BPA) where surface infiltration provides a recharge source for groundwater reporting to the pits. This cap will extend beyond the pit crests and include areas that currently infiltrate and contribute to pit seepage (e.g., Area 5). Water from the surface cover system that historically has reported to the pits will be collected in the surface water diversions and routed around the pit areas.
2.4.2.4.2 B.ii.	To the degree practicable, clean groundwater shall be segregated from contaminated waters to minimize water volumes requiring treatment.	See response to 2.4.2.4.2 B.i. above. In addition, the construction specifications included as Appendix K (i.e., Section 02200 – Earthwork) require slush grouting of sections of perimeter collection channel that are excavated into bedrock and contain open fractures. The construction specifications also require shotcrete lining of high permeability weathered bedrock or other high permeability sections of perimeter channel excavations that cannot be treated by slush grouting.
2.4.2.4.2 B.iii.	To the degree practicable, groundwater entering the pits shall not contact reactive mine waste or waste capable of causing groundwater contamination.	An underdrain system constructed of non-reactive rock will be installed in the bottoms of Pits 3 and 4 to collect groundwater before it contacts reactive mine waste backfill in the pits, as shown in Section 4 of the Drawings in Volume II. The pit bottom drainage system will be separated from overlying reactive mine waste backfill by a synthetic geomembrane. In addition, a 20-foot thick layer of less reactive waste rock will be placed above the geomembrane to provide additional separation between pit

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 2 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
		groundwater and more reactive mine waste. The drain system will be extended up the pit walls, as shown on Drawings 4-15~~14~~ and 4-39~~37~~, in areas where pit wall seepage is occurring in order to intercept these seeps and convey them to the underdrain system before they contact reactive mine waste in the backfill. A separate Waste Rock Dewatering System will be installed above the geomembrane liner to collect water that infiltrates through the overlying waste rock and collects on the geomembrane liner.
2.4.2.4.2 B.iv.	Contaminated groundwater shall be captured and treated in the WTP.	This Appendix D - Mine Waste Excavation and Containment contains text, calculations, and references drawings in Volume II to describe/illustrate the contaminated groundwater pump-back system, which includes wells installed above and below the lower liner.
C. Surface Water Management - Pits 3 and 4		
2.4.2.4.2 C.i.	Surface water and stormwater management shall be conducted in accordance with the SWMP. Surface water and stormwater management BMPs shall be developed and constructed to divert clean surface water and stormwater away from the pits during construction. Surface water and stormwater that enters the pits shall be captured and conveyed to the WTP. Surface water and stormwater BMPs constructed shall remain in place and be monitored for effectiveness until consolidation and containment of excavated materials in the pits is completed and permanent surface water and stormwater management facilities are in place and functional.	Appendix F entitled “Surface Water and Sediment Controls” contains text, calculations and references drawings in Volume II that show how water will be captured and routed around construction activities at completion of the three major phases of construction. Per the SOW in the CD, the SWMP in Appendix O will be updated on an annual basis to reflect the most current construction status. The SWMP includes a BMP catalog, and will describe the temporary facilities to be employed to capture and convey impacted water to the WTP, and clean water around the work areas, at intermediate phases of construction.
2.4.2.4.2 C.ii.	Facilities shall be constructed to divert clean surface water away from the pits. The diversion facilities shall be designed using standard engineering techniques for capacity and erosional stability to convey the 100-year, 24 hour storm event in a stable manner and to withstand a 500-year, 24 hour storm event.	Clean surface water will be diverted away from the pits via a series of diversion channels and the grading of the final cover system. Appendix F (Stormwater and Surface Water Controls) includes the design information for the diversion channels and the phased stormwater controls are shown on the Section 6 Drawings~~design drawings~~ (located in Volume II). The conveyance capacity of these facilities has been designed for the 500-year, 24-hour storm event. Erosional stability of the cover system has been designed for the 100-year, 24-hour event as described in this Appendix D (Mine Waste Excavation and Containment). The construction specifications in Appendix K require slush grouting of sections of perimeter collection channel that are excavated into bedrock and contain open fractures.

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 3 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
		The construction specifications also require shotcrete lining of high permeability weathered bedrock or other high-permeability sections of perimeter channel excavations that cannot be treated by slush grouting
2.4.2.4.2 C.iii.	To the degree practicable, clean surface water shall be segregated from contaminated water to minimize water volumes requiring treatment.	The RA will be performed in phases such that surface water from remediated areas can be shed away from the active excavation areas as soon as practicable. Surface water will be segregated by site grading to manage and direct drainage, and using permanent and temporary drainage channels to divert clean surface water away from the active construction areas. Appendix D (Mine Waste Excavation and Containment) describes the phased excavation activities and the site topography at the end of each Phase is depicted on the Section 1 Drawings~~design drawings~~ (located in Volume II). Appendix F (Stormwater and Surface Water Controls) includes the design information for the diversion channels and the phased stormwater controls are shown on the Section 6 Drawings~~design drawings~~.
2.4.2.4.2 C.iv.	Contaminated surface water shall be captured and treated in the WTP.	Excavation activities will be performed such that drainage patterns are maintained to shed potentially contaminated surface water to diversion channels and temporary impoundments, and ultimately to the operating WTP. This Appendix D (Mine Waste Excavation and Containment) describes the excavation activities. Appendix F - Surface Water and Sediment Controls contains text, calculations, and references drawings in Volume II that show the temporary engineering controls (e.g., temporary drainage channels) that will be constructed to capture and convey contaminated water to the Water Management Ponds (Appendix E). Water from these ponds will be conveyed to the WTP for treatment.
D. Pits 3 and 4 Preparation and Mine Waste Excavation		
2.4.2.4.2 D.i.	Each pit shall be dewatered prior to any mine waste emplacement.	Pits 3 and 4 will be dewatered prior to construction activities as described in Sections 6.2 and 7.2 of this appendix and shown on the Remedial Action Schedule (Appendix X).
2.4.2.4.2 D.ii.	Water removed during such dewatering shall be conveyed to and treated at the WTP.	Water removed during dewatering of Pits 3 and 4 shall be conveyed to the WTP (either via the intermediate storage pond or directly to the WTP, depending on the WTP operating requirements) for treatment.
2.4.2.4.2 D.iii.	To the extent practicable, water shall be kept from accumulating in the pits during and after construction of the containment system. If water accumulates in the pits	The underdrain sump/dewatering system shown on Drawings 4-12, 4-15~~14~~, 4-37, 4-38~~36~~, and 4-39~~37~~ will be installed upon completion of pit-bottom grading and preparation and will remain operational

	during construction, the water shall be	through backfilling and completion of RA construction.

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 4 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
	collected and conveyed for treatment at the WTP.	Likewise, the mine waste dewatering system shown on Drawings 4-13, 4-16~~15~~, 4-40~~38~~, and 4-41~~39~~ will be installed upon completion of the geomembrane liner and will remain operational from that point forward. Duplicate dewatering risers, including pumps and piping are proposed to avoid shutdowns in the dewatering system due to maintenance or mechanical failure.
2.4.2.4.2 D.iv.	Existing sediments which have collected at the bottom of the pits shall be removed prior to preparation of the pit floors. Such removed sediments shall be staged for subsequent re-emplacement in the pits. The need and process for dewatering of the sediments and conveyance and treatment of water from the sediments shall be determined during RD.	Pit-bottom sediments shall be removed as described in Sections 6.3 and 7.3 of this appendix and stockpiled for replacement in the pits as described in an approved Staging/Temporary Stockpiling Plan. The Staging/Temporary Stockpiling Plan is included as Appendix R.
2.4.2.4.2 D.v.	As determined during RD, pit walls shall be prepared to ensure worker health and safety during construction.	Pit rockfall protection measures are described in Sections 6.1 and 7.1 of this appendix.
2.4.2.4.2 D.vi.	The pit surfaces shall be contoured to efficiently drain water entering the pits to low points located below the drainage layer. The need to perform additional excavation of the current pit bottoms to ensure gravity drainage to the low points shall be determined during RD.	Pit bottom surface preparation and grading is discussed in Sections 6.3 and 7.3 of this appendix, and shown on Drawings 4-12 and 4-37~~35~~. Pit 4 will require recontouring and excavation of a sump so that gravity flow in the pit bottom can be accomplished. Pit 3 will require some cleanup, but in general water in Pit 3 gravity flows to the last mined area (drop cut) which forms the low point of the pit.
E. Drainage Layer – Pits 3 and 4		
2.4.2.4.2 E.i.	A continuous drainage layer of non-reactive rock or other suitable material, approved by EPA, shall be constructed overlying the base of the pit and extending up the sides of each pit as necessary to intercept groundwater entering the pit.	Pit underdrain systems are described in Sections 6.4 and 7.4 of this appendix and shown on Drawings 4-12, 4-15~~14~~, 4-37, 4-38~~36~~, and 4-39~~37~~.
2.4.2.4.2 E.ii.	If during RD suitable material for the drainage layer can be found on site, EPA may approve the use of such materials, following consultation with the Tribe.	Results of investigations presented in the *Mine Waste Investigations Report* (MGC, 2011a) and the *Addendum to the Mine Waste Investigations Report* (WME, 2012) indicate that suitable material for the drainage layer can be processed from the HSWRP. It is anticipated that this material will be used for construction of the drainage layer.
2.4.2.4.2 E.iii.	The drainage layers shall extend vertically along the side walls of each pit to elevations determined during RD, to keep water entering the pits from contacting mine waste and to effectively channel water to the pit bottoms.	Locations of pit wall seeps were mapped as part of investigations for the *Geologic Investigations of Pits and Assessment of Pit Sediments Design Investigation Report* (MGC, 2011b) and the *Pit Seep Monitoring Report for Pit 3 and Pit 4* (Plumley and Assoc., 2012). These seeps are shown on Drawing 4-38~~36~~ and the drain configuration shown is

		designed to intercept these seeps and convey them to the pit-bottom sump without contacting reactive mine waste

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 5 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
		materials in the pit backfill.
2.4.2.4.2 E.iv.	The drainage layers shall be designed and constructed in a manner to provide efficient drainage of water along the sidewalls and bottoms of each pit.	See response to 2.4.2.4.2 E.iii, above.
2.4.2.4.2 E.v.	Water entering the pits and transported through the drainage layers shall be collected in a sump or sumps placed at the bottom of the pits. The water collection sump(s) shall be constructed in the lowest portion of the pit bottom and gravity drainage from the pit walls and pit bottom shall be used to direct water to the sump. The design of such sump(s) may require additional excavation into the pit bottom to ensure gravity drainage.	Pit bottom grading, drainage sumps, and drain placement are discussed in Sections 6.3, 6.4, 7.3, and 7.4 of this appendix and shown in Section 4 of the Drawings (Volume II).
2.4.2.4.2 E.vi.	The installation of the drainage layers along the pit walls and bottoms shall be coordinated with the emplacement of mine wastes into the pits and the sub-waste liners, described below.	The sequence for drain installation and waste placement are discussed in appendices D and X (RA Schedule), and shown on Section 4 of the Drawings.
2.4.2.4.2 E.vii.	Water levels in the sumps shall be maintained at elevations determined during RD which minimize hydraulic head, scaling, and fouling, and prevent water contact with the mine waste. Water collected in the sumps shall be conveyed by pumping or gravity for treatment at the WTP.	The anticipated range of operating water levels within the underdrain (pit bottom) and waste rock dewatering (overliner) sumps are shown on Drawings 4-79~~76~~ and 4-82~~79~~, respectively. The proposed range of water level fluctuations will ensure that the water level will remain within coarse drain rock of the sump backfill, thus avoiding water level fluctuations over the greater pit floor and liner surfaces, while avoiding drawing the water levels down to the elevation of the screened sections of dewatering risers. The pumping levels presented in the 100~~90~~% BODR are consistent with these water level requirements. The pumping levels are set below the bottoms of the pits (i.e., in the sumps) in order to maintain a groundwater flow direction from surrounding areas toward the pits, prevent contact~~preventcontact~~ of groundwater with the mine waste, and minimize the potential for scaling and fouling of the pit dewatering wells.
F. Sub-waste Liner – Pits 3 and 4		
2.4.2.4.2 F.i.	A sub-waste liner shall be constructed in each pit below and adjacent to the emplaced mine wastes in locations and to vertical elevations determined during remedial design.	Sub-waste liners will be placed between the drain systems and overlying mine waste in Pit 3 and Pit 4 as shown on Drawings 4-15~~14~~ and 4-41~~39~~.
2.4.2.4.2 F.ii.	The sub-waste liners shall be placed between the mine wastes and the	Sub-waste liners will be placed between the drain systems and overlying mine waste in Pit 3 and Pit 4

	drainage layers: additional materials shall be placed, as necessary, to protect the integrity of the sub-waste liners, as	as shown in Setion 4 of the Drawings. The liner section will include a geomembrane cushion (geofabric layer) under the geomembrane, and an

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 6 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
	determined during RD.	overliner cushion layer of fine-grained soil as discussed in Attachment D-1 to Appendix D. The plans to minimize fluctuations in water levels in an attempt to minimize scaling and fouling while preventing direct contact with the mine waste rock will be described in the OM&M Plan~~OMMP~~ for Water Management in Appendix P.
2.4.2.4.2 F.iii.	The sub-waste liners shall be constructed of a synthetic material determined during RD.	It is proposed that the sub-waste liner be constructed of High-Density Polyethylene geomembrane as discussed in Sections 6.5 and 7.6 of Appendix D.
2.4.2.4.2 F.iv.	The sub-waste liners shall be designed to effectively isolate the mine waste and minimize the passage of both water and mine waste particles between the adjacent drainage layers and the emplaced mine wastes.	See responses to 2.4.2.4.2 F.i, 2.4.2.4.2 F.ii, and 2.4.2.4.2 F.iii, above.
2.4.2.4.2 F.v.	The sub-waste liners shall be constructed in such a way as to transmit water collected on the liners to sump(s) located above the liner at its low point. The sumps shall be constructed in such a manner that water from the mine waste materials shall concentrate in the sump area using gravity drainage.	Proposed grading for the sub-waste liners are shown on Drawings 4-13 and 4-40~~38~~. This grading provides for gravity drainage of water on the liner surface toward sumps, which will be dewatered by pumping from waste rock dewatering risers located within the sumps.
G. Pits 3 and 4 Mine Waste Consolidation		
2.4.2.4.2 G.i.	All materials excavated as part of the Mine Waste Excavation Component of Work and existing sediments from the pit bottoms shall be consolidated in the pits.	Materials excavated during Mine Waste Excavation will be consolidated in the pits as described in Section D4.0 (Material Balance) of this appendix and shown in Section 4 of the Drawings.
2.4.2.4.2 G.ii.	Mine waste shall be emplaced in lifts above the sub-waste liner and any protective layer determined necessary during RD. Placement shall minimize settling.	It is proposed that Mine Waste be placed in 10-foot maximum horizontal loose lifts over the protective overliner cushion layer.
2.4.2.4.2 G.iii.	The emplacement of mine waste lifts shall be coordinated with the installation of the adjacent sub-waste liner and drainage layer along the pit walls and bottoms, as determined during RD.	Where required, drainage layer placement along the pit walls will occur concurrently with Mine Waste placement as shown on Drawing 4-90~~82~~.
2.4.2.4.2 G.iv.	Mine waste emplaced in the pits shall be compacted to design specifications during backfilling.	It is proposed that Mine Waste be placed by dumping from trucks and spreading in 10-foot maximum horizontal loose lifts as discussed in Sections D6.7, D7.8 and D8.1 of this appendix.
2.4.2.4.2 G.v.	Emplacement of mine waste in the pits shall ensure efficient drainage to sumps constructed above the sub-waste liner.	See responses to 2.4.2.4.2 G.ii and 2.4.2.4.2 G.iv above.

2.4.2.4.2 G.vi.	Water levels in the sumps above the sub-waste liner shall be maintained at an elevation determined during RD, which	See response to 2.4.2.4.2 E.vii above.

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 7 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
	minimizes hydraulic head, scaling, fouling and infiltration through the sub-waste liner.	
2.4.2.4.2 G.vii.	Water collected in such sumps shall be conveyed by pumping or gravity for treatment at the WTP.	A typical Waste Dewatering Sump Detail is shown on Drawing 4-82~~79~~. Water collected in these sumps will be pumped to the WTP through dewatering risers that will be raised concurrently with the rise of the waste backfill surface.
2.4.2.4.2 G.viii.	As determined during RD, the least reactive (ARD generating) mine waste materials shall be placed in portions of the pits below the surrounding groundwater level.	The first 20 feet of waste placed above the sub-waste liners will be lower-activity and low ARD potential waste as illustrated in Section 4 of the Drawings.
2.4.2.4.2 G.ix.	As determined during RD, materials with high radon-generating ability, such as ore and proto-ore, shall be placed in the pits so as to minimize radon flux at the top of the backfill and below the cover.	As shown in Section 4 of the Drawings, Ore, Protore, or other materials identified as having high radon-generating ability will be excluded from the 20 feet of waste immediately underlying the cover in the containment areas.
2.4.2.4.2 G.x.	The mine waste materials shall be mounded above the top elevation of each pit and sloped to support a cover and surface water management system designed to maximize runoff and minimize infiltration into the mine wastes, while preserving slope stability.	The top surfaces of the waste containment areas will be graded as shown in Section 4 of the Drawings to provide positive drainage of surface water from the cover surface. Erosional and slope stability calculations for the proposed cover surface are provided in Attachments D-5 and D-6 to this appendix.
H. Pits 3 and 4 Cover Construction		
2.4.2.4.2 H.i.	A cover made of geologic material and a synthetic liner shall be constructed over the emplaced mine waste in each pit in such a way as to permanently meet the ROD cleanup standards for soil and radon flux and to minimize the infiltration of water into the pits.	A cover system consisting of a synthetic linear low-density polyethylene (LLDPE) geomembrane overlain by a soil cover and 0.5 feet of growth media (soil cover or topsoil material, as shown on Drawing 4-83~~80~~). The soil cover thickness will be a minimum of 3 feet thick and will be obtained from the Rhoads Property Borrow area. On sloped areas steeper than 6.6:1 (horizontal:vertical) a geocomposite drainage layer (GDL) will be included between the geomembrane and soil cover layers in order to reduce the potential for positive pore pressure and cover instability at the geomembrane soil interface.
2.4.2.4.2 H.ii.	Cover specifications shall be determined during RD and shall ensure that the thickness of the geologic materials alone shall be sufficient to limit the radon flux rate to less than 20 pCi/m^2/sec as required in Section 8 of the ROD, in accordance with the Nuclear Regulatory Commission guidance document NUREG 1620 (NRC, 2000). Radon flux shall be	Radon flux calculations were performed for the selected cover borrow source and have been included as Attachment D-3 to this appendix.

	measured using standard NRC techniques presented in 40 CFR Part 61, Appendix B, Method 115 to ensure that the average radon flux from the cover	

Table D-2 — Performance Standards Applicable to Mine Waste Containment in Pits 3 and 4

Page 8 of 8

Performance Standard No. in CD SOW	Performance Standard	Comments
	remains less than 20 pCi/m2/sec.	
2.4.2.4.2 H.iii.	The cover shall be constructed in compacted lifts and include a synthetic liner of a material determined during design, to minimize infiltration of precipitation into the underlying mine wastes.	The soil cover system described in response to item 2.4.2.4.2 H.i has been proposed to meet this performance objective. The cover soil will be placed as described in Section D.10 of this appendix.
2.4.2.4.2 H.iv.	The cover shall be constructed to efficiently minimize infiltration of water, while preserving slope stability, minimizing erosion and biointrusion, and supporting vegetation. The cover shall be designed using standard engineering techniques and a factor of safety of 1.3 for static and 1.0 for dynamic slope stability. The cover shall be erosionally stable under the 100-year, 24-hour storm event.	The results of infiltration analyses of the cover system are included as Attachment D-4 to this appendix. Erosional and slope (veneer) stability calculations are included as Attachments D-6 and D-7 to this appendix, respectively.
2.4.2.4.2 H.v.	The cover shall overlay mounded mine waste and shall slope out to a surface water management system to maximize runoff and minimize infiltration into the mine wastes, while preserving slope stability.	See response to 2.4.2.4.2 G.x, above.
2.4.2.4.2 H.vi.	Once constructed, the cover shall be vegetated as determined during RD, in consultation with the Tribe, for purposes of evapotranspiration, ecological habitat, slope stability, and long-term effectiveness.	Infiltration calculations are presented in Attachment D-4 to this appendix. Vegetation parameters for infiltration analyses were selected based on proposed species provided in the Attachment D-12 (Revegetation Plan). Selection of species incorporated input from the Tribe as well as other factors as discussed in Attachment D-12.

Table D-3 — Performance Standards Applicable to Groundwater Removal from BPA

Page 1 of 3

Performance Standard No. in CD SOW	Performance Standard	Comments
A. Temporary Facilities During Construction Activities		
2.4.2.5 A.i.	During performance of the BPA Component of Work, temporary facilities, such as covers, runoff controls, temporary sumps, and water capture and removal systems, shall be provided, as determined in the SWMP and RD. Water requiring treatment shall be conveyed as soon as practicable to the WTP for storage and treatment.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 A.i above.
B. Groundwater Diversion - Backfilled Pit Area		
2.4.2.5 B.i.	Groundwater adjacent to the BPA shall be collected and diverted away or blocked from flowing into the BPA, as practicable, by methods determined during RD.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 B.i above.
2.4.2.5 B.ii.	To the degree practicable, clean ground water shall be segregated from contaminated ground water to minimize water volumes requiring treatment.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 B.ii above.
2.4.2.5 B.iii.	Contaminated groundwater shall be captured and treated in the WTP.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 B.iii above.
C. Surface Water - Backfilled Pit Area		
2.4.2.5 C.i.	Facilities shall be constructed to divert surface water away from the BPA. The diversion facilities shall be designed using standard engineering techniques for capacity and erosional stability to convey the 100-year, 24 hour storm event in a stable manner and to withstand a 500-year, 24 hour storm event.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 C.i above.
2.4.2.5 C.ii.	To the degree practicable, clean surface water shall be segregated from contaminated water to minimize water volumes requiring treatment.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 C.ii above.
2.4.2.5 C.iii.	Contaminated surface water shall be captured and treated in the WTP.	This work will be performed as part of the Phase 2 Pit 3 remediation. Refer to 2.4.2.4.2 C.iii above.
D. Groundwater Removal from Backfilled Pit Area		
2.4.2.5 D.i.	Water in the BPA shall be removed using wells or other methods approved by EPA during RD, to elevations determined during RD which minimize hydraulic head in the pit, scaling, and fouling.	The groundwater pump-back systems using extraction wells installed in the BPA are described in Section D7.5 of Appendix D entitled “Mine Waste Excavation and Containment”, and references drawings in Volume II to illustrate this contaminated groundwater pump-back system in the BPA. In general, wells currently on site that are effective at removing contaminated groundwater will be saved for continued use during the RA. Additional extraction wells may be installed and/or planned for installation in the BPA and conveyed to the WTP for treatment as described in this appendix.

Table D-3 — Performance Standards Applicable to Groundwater Removal from BPA
Page 2 of 3

Performance Standard No. in CD SOW	Performance Standard	Comments
2.4.2.5 D.ii.	Water removed from the BPA shall be conveyed to the WTP for treatment.	Water removed from the BPA will be conveyed to the WTP, either via the storage ponds or directly to the WTP, depending on WTP operating conditions at the time of removal.
E. Mine Waste Excavation and Consolidation		
2.4.2.5 E.i.	As approved during RD, mine waste materials shall be mounded above the top elevation of the BPA and sloped to support a cover and surface water management system designed to maximize runoff and minimize infiltration into the mine wastes, while preserving slope stability.	The elevation of the upper surface consisting of mine waste rock in the BPA will be greater than the current edge of the BPA as discussed in Appendix D and depicted on the drawings referenced in Volume II. This will allow the upper liner coming from Pit 3 to extend beyond this edge so that precipitation will run off the cover surface and be channeled away from the BPA. Cap slope stability also is discussed in Appendix D and there are calculations supporting the cover design including the slopes presented. Surface Water management designs are presented in Appendix F entitled “Surface Water and Sediment Controls”.
F. Cover Construction		
2.4.2.5 F.i.	A cover made of geologic material and a synthetic liner shall be constructed over the mounded mine waste in the BPA in such a way as to permanently meet the ROD cleanup standards for soil and radon flux and to minimize the infiltration of water into the pits.	Refer to 2.4.2.4.2 H.i. above
2.4.2.5 F.ii.	Cover specifications shall be determined during remedial design and shall ensure that the thickness of the geologic materials alone shall be sufficient to limit the radon flux rate to less than 20 pCi/m2/sec as required in Section 8 of the ROD, in accordance with the Nuclear Regulatory Commission guidance document NUREG 1620 (NRC 2000). Radon flux shall be measured using standard NRC techniques presented in 40 CFR Part 61, Appendix B, Method 115 to ensure that the average radon flux from the cover remains less than 20 pCi/m2/sec.	Refer to 2.4.2.4.2 H.ii. above.
2.4.2.5 F.iii.	The cover shall be constructed in compacted lifts and include a synthetic liner of a material determined during design, to minimize infiltration of precipitation into the underlying mine wastes.	Refer to 2.4.2.4.2 H.iii. above.
2.4.2.5 F.iv.	The cover shall be constructed to efficiently minimize infiltration of water, while preserving slope stability, minimizing erosion and biointrusion, and supporting vegetation. The cover shall be designed using standard engineering techniques and a factor of safety of	Refer to 2.4.2.4.2 H.iv. above.

Table D-3 — Performance Standards Applicable to Groundwater Removal from BPA
Page 3 of 3

Performance Standard No. in CD SOW	Performance Standard	Comments
	1.3 for static and 1.0 for dynamic slope stability. The cover shall be erosionally stable under the 100-year, 24-hour storm event.	
2.4.2.5 F.v.	The cover shall overlay mounded mine waste and shall slope out to a surface water management system to maximize runoff and minimize infiltration into the mine wastes, while preserving slope stability.	Refer to 2.4.2.5 E.i. above

As described above, the regra~~r~~ding and capping of BPA will be performed concurrently with Pit 3 backfilling during Phase 2 and the BPA surface cover will be contiguous with the Pit 3 surface cover. As such, performance standards applicable to regrading and capping of the BPA are addressed under Pit 3 waste consolidation performance standards.

D3.0 ENGINEERING DESIGN DRAWINGS

The engineering design drawings are contained in Volume 2 of the BODR. The drawings related to Mine Waste Excavation and Containment (Table D-4) are located in Section 4 and include:

Table D-4 — Mine Waste Excavation and Containment (Section 4) Drawing List

Page 1 of 3~~2~~

Sheet Number	Description
4-1	Mine Waste Location Map
4-2	Phase 1 - Waste Excavation and Pit 4 Backfill
4-3	Phase 1 – Hillside Waste Rock Pile Excavation Plan
4-4	Phase 1 – Pit 4 Overburden Pile Excavation Plan
4-5	Phase 1 – Stockpiles 1 and 2 Excavation Plan
4-6	Phase 1 – Stockpiles 3, 4, 5 and 8 Excavation Plan
4-7	Phase 1 - Stockpiles 6 and 7 Excavation Plan
4-8	Phase 1 – South Pond Bench Excavation Plan
4-9	Phase 1 – Western Drainage Waste Excavation Plan
4-10	Phase 1 – Pit 4 Cover Tie-In Grading Plan
4-11	Phase 1 – Pit 4 Cover Tie-In~~Ridge~~ Grading Point Table
4-12	Phase 1 – Pit 4 Bottom Excavation and Grading Plan
4-13	Phase 1 – Pit 4 Sub-Waste Liner Installation Plan
4-14	Phase 1 - Pit 4 Sub-Waste Liner Installation Grading Points
4-15~~14~~	Phase 1 – Pit 4 Sub-Waste Liner Installation Sections
4-16~~15~~	Phase 1 – Pit 4 Infiltration Collection System
4-17~~16~~	Phase 1 - Pit 4 Top of Cover Grading Plan
4-18~~17~~	Phase 1 – Pit 4 Top of Cover Ga~~r~~ding Point Table
4-19~~18~~	Phase 1 – Extent of Pit 4 Geocomposite Drainage Layer
4-20~~19~~	Phase 1 - Pit 4 Backfill Sections
4-21~~20~~	Phase 1 – Pit 4 North Subgrade Grading Plan
4-22~~21~~	Phase 1 – Pit 4 North Cover Grading Plan
4-23~~22~~	Phase 1 - Pit 4 North Sections
4-24~~23~~	Phase 2 – Waste Excavation and Pit 3 and BPA Backfill
4-25~~24~~	Phase 2 – Hillside Waste Rock Pile Excavation Plan
4-26~~25~~	Phase 2 – Western Drainage Excavation Plan
4-27~~26~~	Phase 2 – East Waste Rock Pile Excavation Plan
4-28~~27~~	Phase 2 – Pit 2 West Subgrade Grading Plan
4-29~~28~~	Phase 2 – Contaminated Soil and Sediment Location Plan
4-30~~29~~	Phase 2 – East Access Road Materials Excavation Plan
4-31~~30~~	Phase 2 – Western Drainage Sediments Excavation Plan
4-32~~31~~	Phase 2 – Eastern Drainage Sediments Excavation Plan
4-33~~32~~	Phase 2 – Internal Mine Roads Materials Excavation Plan
4-34~~33~~	Phase 2 – Pit 3 ~~and Area 5~~ Cover Tie-In Grading Plan
4-35~~34~~	Phase 2 – Pit 3 and Area 5 Cover Tie-In Grading Point Table
4-36	Phase 2 – Area 5 Cover Tie-In Grading Plan
4-37~~35~~	Phase 2 – Pit 3 Bottom Excavation and Grading Plan
4-38~~36~~	Phase 2 – Pit 3 Underdrain Dewatering Plan
4-39~~37~~	Phase 2 – Pit 3 Underdrain Dewatering Sections
4-40~~38~~	Phase 2 – Pit 3 Sub-Waste Liner Installation Plan
4-41~~39~~	Phase 2 – Pit 3 Sub-Waste Liner Installation Sections
4-42~~40~~	Phase 2 – Pit 3 and BPA Top of Cover Grading Plan
4-43~~41~~	Phase 2 – Pit 3 and BPA Top of Cover Grading Point Table
4-44~~42~~	Phase 2 – Pit 3 and BPA Backfill Sections (1 of 2)
4-45~~43~~	Phase 2 – Pit 3 and BPA Backfill Sections (2 of 2)
4-46~~44~~	Phase 2 – Area 5 Cover Grading Plan

~~4-45~~	~~Phase 2 – Area 5 Sections~~

Table D-4 — Mine Waste Excavation and Containment (Section 4) Drawing List
Page 2 of 3~~2~~

Sheet Number	Description
4-47	Phase 2 – Area 5 Sections
4-48~~46~~	Phase 2 – Pit 2 West Cover Grading Plan
4-49~~47~~	Phase 2 – Adit Pit Cover Grading Plan
4-50~~48~~	Phase 2 – Pit 2 West and Adit Pit Sections
4-51~~49~~	Phase 3 – Waste Excavation and Pit 3 and BPA Backfill
4-52~~50~~	Phase 3 – Central Drainage Excavation Plan
4-53~~51~~	Phase 3 – Contaminated Soil and Sediment Excavation
4-54~~52~~	Phase 3 – BPA Dewatering and Infiltration Collection Plan
4-55~~53~~	Phase 3 – Pit 3 and BPA Top of Cover Grading Plan
4-56~~54~~	Phase 3 – Pit 3 and BPA Top of Cover Grading Point Table
4-57~~55~~	Phase 3 – Pit 3 Toe Area Grading Plan
4-58~~56~~	Phase 3- Extent of Pit 3 and Area 5 Geocomposite Drainage Layer
4-59~~57~~	Phase 3 – Pit 3 and BPA Backfill Sections (1 of 2)
4-60~~58~~	Phase 3 – Pit 3 and BPA Backfill Sections (2 of 2)
4-61~~59~~	Permanent Maintenance Roads Key Map
4-62~~60~~	Pit 4 Maintenance Road Plan and Profile – Station 0+00 to 12+00
4-63~~61~~	Pit 4 Maintenance Road Plan and Profile – Station 12+00 to 24+00
4-64~~62~~	Pit 4 Maintenance Road Plan and Profile – Station 24+00 to 36+00
4-65~~63~~	Pit 4 Maintenance Road Plan and Profile – Station 36+00 to 48+00
4-66~~64~~	Pit 4 Maintenance Road Plan and Profile – Station 48+00 to 60+00
4-67~~65~~	Pit 4 Maintenance Road Plan and Profile – Station 60+00 to End~~70+00~~
4-68~~66~~	Pit 3 Maintenance Road Plan and Profile – Station 0+00 to End~~12+00~~
4-69~~67~~	BPA Maintenance Road Plan and Profile – Station 0+00 to 8+50
4-70~~68~~	BPA Maintenance Road Plan and Profile – Station 8+50 to 17+00
4-71~~69~~	BPA Maintenance Road Plan and Profile – Station 17+00 to End~~25+50~~
4-72~~70~~	Permanent Maintenance Roads Line and Curve Tables
4-73~~71~~	End of Phase 3 – Interim Fencing Plan
4-74~~72~~	Final Remediation Grading Plan
4-75~~73~~	Final Remediation – West Pond Regrading Plan
4-76	WCA Settlement Monitoring Points Plan
4-77~~74~~	Final Remediation – Permanent Access~~Boulder~~ Barrier Plan
4-78~~75~~	Revegetation Areas~~Plan~~
4-79~~76~~	Details and Typical Sections (1 of 20~~13~~)
4-80~~77~~	Details and Typical Sections (2 of 20~~13~~)
4-81~~78~~	Details and Typical Sections (3 of 20~~13~~)
4-82~~79~~	Details and Typical Sections (4 of 20~~13~~)
4-83~~80~~	Details and Typical Sections (5 of 20~~13~~)
4-84~~81~~	Details and Typical Sections (6 of 20~~13~~)
4-85~~82~~	Details and Typical Sections (7 of 20~~13~~)
4-86~~83~~	Details and Typical Sections (8 of 20~~13~~)
4-87~~84~~	Details and Typical Sections (9 of 20~~13~~)
4-88~~85~~	Details and Typical Sections (10 of 20~~13~~)
4-89~~86~~	Details and Typical Sections (11 of 20~~13~~)
4-90~~87~~	Details and Typical Sections (12 of 20~~13~~)

4-91~~88~~	Details and Typical Sections (13 of 20~~13~~)
4-92	Details and Typical Sections (14 of 20)

Table D-4 — Mine Waste Excavation and Containment (Section 4) Drawing List

Page 3 of 3

Sheet Number	Description
4-93	Details and Typical Sections (15 of 20)
4-94	Details and Typical Sections (16 of 20)
4-95	Details and Typical Sections (17 of 20)
4-96	Details and Typical Sections (18 of 20)
4-97	Details and Typical Sections (19 of 20)
4-98	Details and Typical Sections (20 of 20)

D4.0 MATERIAL BALANCE

The configuration of the WCA and major above grade waste excavation areas at the end of Phase 1, Phase 2, and Phase 3 are shown on Drawings 4-2, 4-24~~23~~, and 4-51~~49~~ respectively. The storage capacities of the WCA and estimated material excavation volumes are summarized in Table D-5 (Pit 4) and Table D-6 (Pit 3).

The Pit Waste Capacities shown in Tables D-5 and Table D-6 reflect the entire volume of the WCA exclusive of the soil cover volume. As noted in Section D1.0, the configuration of the WCA shown reflects the maximum waste storage. As can be seen in Table D-5 and D-6, the available disposal volume is greater than maximum anticipated volume of material requiring disposal.

Material volumes of above-grade excavations were calculated based upon topographic differences between the current ground surface (i.e., post mining) and the pre-mine ground surface in waste removal areas. Volumes estimates of Ore and Protore stockpiles, which are located on top of low-activity/reactivity waste surfaces, required the estimation of~~on~~ an intermediate, top of low-activity/reactivity waste rock surface. These intermediate surfaces were estimated based on drilling results presented in the *Mine Waste Investigations Report* (MGC, 2011a) and interpretations of the surrounding waste rock contours. Volume estimates for Contaminated Soil and Sediment, Mine Drainage Sediment, and Road Material excavations were obtained from the *Mine Waste Investigations Report*.

The majority of the high-activity/reactivity waste on Site will be placed in Pit 4. In order to assure there is sufficient capacity in the Pit 4 WCA to store this material, the storage capacity of the containment area, excluding zones that are: 1) within 20-feet of the underdrain, 2) within 20 feet of the surface cover, and 3) within 20 feet of the pit walls, was calculated and is listed as “Pit 4

High Activity/Reactivity Waste Capacity” in Table D-5. Prior to placement of high activity/reactivity waste in Pit 4, at least 20 feet of low activity/reactivity mine waste will be placed above the underdrain layer. It is anticipated that the sources of low-activity/reactivity mine waste placed above the drain layer in Pit 4 (prior to placement of any high activity/high reactivity waste) may include:

1) Rejected material from processing of the HSWRP~~Hillside Waste Rock Pile~~ placed as liner protection for the Subwaste Liner (3 feet thick)
2) Pit 4 Overburden Pile material (estimated to be approximately 440,000 cubic yards) and,
3) Other HSWRP~~Hillside Waste Rock Pile~~ reject material from initial drain material processing (total reject including overliner protection layer estimated to be 133,000 cubic yards).

The available volume of low-activity/reactivity mine waste from these sources is much greater than the estimated 140,000 cubic yards material needed to provide the proposed 20-foot thick minimum cover of low-activity/reactivity mine waste over the Pit 4 drainage layer.

Sources of low-activity/reactivity waste that will be placed above the drain layer in Pit 3 prior to placement of any high activity/ reactivity waste include:~~;~~

1) Drain rock processing rejects from HSWRP~~Hillside Waste Rock Pile~~ processing for drain material, and
2) The remainder of the unprocessed material from the HSWRP~~Hillside Waste Rock Pile~~.

The combined volume of low-activity/reactivity mine waste from these HSWRP~~Hillside Waste Rock Pile~~ materials is estimated to be approximately 1,550,000 cubic yards, which is much greater than the estimated 349,000 cubic yards material needed for the proposed 20-foot thick cover of low-activity/reactivity mine waste over the Pit 3 drainage layer. Thus, for both Pit 3 and Pit 4, the material available during early stages of backfilling, as identified in the RA Schedule presented in Appendix X, is more than sufficient to provide a low activity/reactivity layer at least 20 feet in thickness, prior to placement of higher activity/reactivity wastes.

Table D-5 — Phase 1 – Material Balance to Pit 4

Source of Mine Waste	**Volume (c.y.)**	
Low-Activity/Reactivity Waste Sources:		
Hillside Waste Rock Pile - Drain Gravel	95,700	
Pit 4 Subwaste Liner Bedding Layer	5.200	
Hillside Waste Rock Pile - Reject	133,000	
Pit 4 Overburden Pile	440,000	
Pit 4 Rockfall Debris and Grading Spoils	9,000	
South Pond Grading & Excavation	631,000	
West Access Road Cleanup	8,000	
Other South Waste Rock Pile Excavation	4,201,400	
Total Low-Activity/Reactivity Waste		**5,523,300**
High Activity/Reactivity Waste Sources:		
Protore Stockpile 1	127,000	
Protore Stockpile 2	60,000	
Ore Stockpile 3	34,200	
Ore Stockpile 4	379,000	
Ore & Protore Stockpile 5	79,900	
Ore & Protore Stockpile 6	185,000	
Ore Stockpile 7	78,600	
Lime Protore Stockpile 8	490,000	
Pit 4 Bottom Sediments	1,000	
Total High-Activity/Reactivity Wastes		**1,434,700**
Total Calculated Mine Waste Volume to Pit 4		**6,958,000**
Pit 4 High-Activity/Reactivity Waste Capacity		**3,549,000**
Total Pit 4 Waste~~/Reactivity~~ Capacity*		**6,958,000**

*Capacity calculated using bathymetric surface below the water levels in pits 3 and 4 and LiDAR topographic data presented in the *Survey Design Investigation Report* (Tetra Tech, 2010).

A shrinkage factor of 1.0 (no shrink or swell) was assumed between the excavated volume and in-place volume in the waste containment facilities when evaluating the available storage capacity. The estimated shrinkage factor is for end-of-construction conditions and includes settlement that occurs during the fill process, but does not include volume reductions that will occur due to long-term settlement (estimated in Attachment D-13). Although experience indicates that some shrinkage often occurs when regrading loose-dumped mine waste rock piles, a shrinkage factor of 1.0 is considered conservative, but reasonable in this case due to the age of the waste rock piles. This and other assumptions used to complete these initial~~preliminary~~ material balance calculations should be reviewed, and the calculations updated as additional information becomes available during ~~Remedial Action (~~RA~~)~~ construction.

Existing topsoil stockpiles located in the ~~construction support zone (~~CSZ,~~),~~ which includes the construction support facility and the WTP and equalization ponds, are shown on Drawings 2-1, 2-2, and 2-3. At present, these topsoil stockpiles have not been included in the Phase 1 material balance as material to be placed in Pit 4. These topsoil materials will be excavated and relocated as part of initial site preparation work. The Staging/Temporary Stockpiling Plan in Appendix R discusses where these materials may be stored during the RA depending on the results of sampling and analyses performed on these materials during the RA to determine if they meet soil cleanup criteria.

Preliminary testing performed on soils in the southern topsoil stockpile shown on Drawing 2-2 indicate these materials meet soil cleanup standards (MWH, 2013a). If further testing during the RA verifies that these soils, and any soils in the two smaller stockpiles shown on Drawing 2-3, meet soil cleanup standards, they will be used for clean soil cover during RA construction rather than being placed as mine waste in Pit 4 during Phase 1. If these materials do not meet soil cleanup standards, they will be temporarily stockpiled within existing mine waste areas. The Staging/Temporary Stockpiling Plan (Appendix R) describes where, and how, these materials will be temporarily stored during Phase 1 and then used either as cover material if clean, or backfilled into Pit 4 if concentrations are in excess of the cleanup limits.

Vegetation removed during site preparation will be disposed of as a thin layer in Pit 3. The volume of material is estimated to be approximately 20,000 cy based on tree counts conducted in May 2014. This material will be treated as low-activity/reactivity when placed within the WCA. Due to the small volume relative to the size of the WCA, differential settlement due to decomposition of this material over time is expected to be insignificant so long as the material is placed in a thin, relatively uniform layer over the WCA.

Table D-6 — Phases 2 and 3 Material Balance to Pit 3

Source of Mine Waste	Volume (c.y.)	
Low-Activity/Reactivity Waste Sources:		
Hillside Waste Rock Pile - Drain Gravel, Bottom	151,000	
Pit 3 Sub-Waste Liner Bedding Layer	14,700	
Hillside Waste Rock Pile - Drain Gravel, Slopes	210,000	
Hillside Waste Rock Pile - Reject & Unprocessed	1,551,000	
East Waste Rock Pile	1,132,000	
Eastern Drainage Sediments	30,000	
Pit 3 Rockfall Debris and Grading Spoils	31,700	
Western Drainage Sediments	80,000	
Western Drainage - Waste Rock & Sediments	4,381,600	
Impacted Foundation Sediments/Soils	995,000	
Access Road Materials	79,000	
Central Drainage Sediments	50,000	
Central Drainage - Remaining SWRP Materials	2,103,000	
Wood from Tree Removal	20,000	
Total Low-Activity/Reacitity Waste		**10,829,000**
High Activity/Reactivity Waste Sources:		
Pit 3 Bottom Sediments	3,300	
Adit Pit Waste	15,000	
PCP Soils	35,800	
Total High-Activity/Reactivity Waste		**54,100**
Total Calculated Mine Waste Volume to Pit 3		**10,883,100**
Total Pit 3 Waste Capacity*		**15,394,000**
Excess Capacity per Current Design		**4,510,900**

*Capacity calculated using bathymetric surface below the water surface in Pits 3 and 4 and LiDAR topographic data presented in the *Survey Design Investigation Report* (Tetra Tech, 2010).

The assumptions discussed above at arriving at this material balance will be reviewed as additional information becomes available and material balance calculations updated as needed. The CSZ~~Construction Support Zone~~ is shown on Drawing 2-13. The volume of material to be excavated during contaminated soil and sediment excavation during preparation of the Construction Support Facilities Zone (including sediments in isolated areas within the Whitetail Creek [referred to as the Far West Drainage in the RI/FS (URS, 2002)])~~])~~ will be determined during construction. It is expected to be a relatively small volume, and will be handled in the same manner as any contaminated topsoil stockpile~~Topsoil Stockpile~~ materials encountered.

The results of the materials balance calculations summarized in Tables D-5 and D-6 indicate there is sufficient capacity in the WCA to consolidate the estimated volumes of mine wastes from the Site. In addition, Pit 4 has sufficient capacity in the designated High Activity/Reactivity waste storage zone to consolidate all Ore and Protore Stockpiles on the Site. The calculated capacity for the Pit 3 backfill configuration reflects the maximum storage volume that can be achieved in this area. This configuration will be reviewed periodically during RA construction and the configuration modified as the waste volume estimates, as well as the estimated shrink/swell factor, become more refined.

D5.0 MINE WASTE EXCAVATIONS

The mine wastes that will be excavated for consolidation in the WCA include:

- Above-Grade Mine Wastes, which include wastes that are piled above the pre-mining topographic surface.
- Contaminated Soils and Sediments, which are materials located in the MA and mine affected~~mined~~ area (~~MA) and ~~MAA) that exhibit contaminant concentrations above the cleanup levels in BODR Tables 4-1 and 4-2. This includes sediments located in drainages downstream of the MA in the MAA, sediments in isolated locations in the Whitetail Creek (Far West) Drainage, and mine wastes used for the construction of roads and any soils and sediments below, adjacent to, and downstream of the roads that exceed the cleanup levels.

General excavation procedures that will be used for the excavation of all waste types are discussed in the following section, and excavation procedures specific to each of these waste types in subsequent sections.

D5.1 GENERAL EXCAVATION METHODS AND PROCEDURES

This section describes the general excavation procedures that are common to the various mine wastes.

~~•~~ Excavations will commence from higher to lower elevation (i.e., in a downhill direction), with a horizontal working excavation surface and an elevated surface at the downhill portion of the active excavation area to retain storm water within the excavation area.

- To the extent practicable, excavated materials will be directly loaded into haul trucks, transported, and placed within the WCA. Materials temporarily stockpiled will include:
    - Relocation of Existing Topsoil Stockpiles
    - Demolition Debris from Structures in the ~~Construction Support Zone (~~CSZ~~)~~
    - Phase I CSZ Soil Remediation Materials, including Whitetail Creek (Far West Drainage) soil cleanup materials
    - CSZ Grading Materials
    - ~~Hillside Waste Rock Pile (~~HSWRP~~)~~ Process Materials
    - Pit 4 – Bottom Cleanup and Grading
    - Groundwater Controls Systems Interceptor Trench Excavated Material
    - Pit 3 - Bottom Cleanup and Grading
- All temporarily stockpiled material will be handled in accordance with the Staging/Temporary Stockpiling Plan contained in Appendix R.
- Surface water and stormwater management will be in accordance with the *Stormwater Management Plan (SWMP)* included as Appendix O. The SWMP identifies the ~~Best Management Practices (~~BMPs~~)~~ that will be implemented to control surface water and minimize the transport of sediments during RA construction.
- Captured sediments that are confirmed to be below cleanup levels may be incorporated into constructed soil cover or revegetation soil layers. Captured sediments above cleanup levels will be consolidated with other mine wastes in the WCA.
- Maintenance and monitoring requirements for surface and stormwater controls are described in the *Operations Maintenance and Monitoring (OM&M) Plan* (Appendix P).
- Verification that excavated areas meet cleanup levels and additional contaminant delineation performed during the RA will be performed in accordance with the *Analytical Support and Verification Plan for Remediation of Surface Materials and Sediments* (Appendix S).

- The equipment and procedures for mine waste excavation is presented in the RA Work Plan. In general, mine waste excavation will be performed using standard excavating equipment and haul trucks.
- To the extent possible, excavation of sediments in the drainages will only occur during drier parts of the year (summer and early autumn) in order to avoid flowing water.
- Following removal of mine wastes but prior to final grading and installation of cover (i.e., completion of remediation), shallow test trenches will be excavated in areas where seeps are visible or are likely to contain shallow groundwater (i.e. valley bottoms or areas of wet ground). These shallow test trenches will be excavated to evaluate the possible existence of shallow groundwater that may interact with surface water after removal of mine waste and contaminated surface materials. If groundwater is observed in a test trench, samples will be collected and assessed relative to cleanup levels as discussed in Appendix O. If shallow groundwater is identified that does not meet cleanup standards, it will be collected and conveyed for treatment to minimize the co-mingling of contaminated water with clean water to the extent practicable.

  The precise details of shallow groundwater collection systems for as-yet unidentified areas where shallow groundwater may interact with surface water are not known at this time. These details will depend on the location and extent of these occurrences. Depending on the locations of the seeps, the water would be conveyed either by gravity, or be pumped to the water management pond or other impacted water collection point (e.g. the Western Drainage Seep pump back system).
- Areas cleared of above-grade mine waste and meeting soil cleanup criteria will be graded to conform to the pre-mining topography as shown on Drawing 4-74~~72~~, to the extent practical, covered, and revegetated as described in Section D11.0. In areas cleared of mine waste where the underlying native soils do not meet soil cleanup criteria, additional Contaminated Soils and Sediments Excavation will be performed as described in Section D5.3.

D5.2 Above-Grade Mine Waste Excavation

Above-grade mine wastes generally overlie the pre-mining topographic surface and are shown on Drawing 4-1. Above-Grade Mine Waste Excavation Plans have been prepared for the three key phases of construction as shown on Drawings 4-2, 4-24~~23~~, and 4-51~~49~~ and are discussed below. The above-grade wastes will be excavated to the native ground surface, which has been estimated based upon the pre-mining topography and will be verified visually in the field during excavation. The extents of contaminated soil cleanup below the above-grade mine waste will be determined during RA construction, and is not reflected in the finished grades shown on the Drawings.

Procedures for removal of contaminated soils beneath the above-grade mine wastes are described under “Contaminated Soils and Sediments Excavation,” Section D5.3 and estimated volumes for these materials are included as “Impacted Foundation Sediments/Soils” in the material balance presented in Section D4.0.

D5.2.1 Phase I Excavation

Excavated surfaces upon completion of Phase 1 construction are shown on Drawing 4-2. Primary above-grade excavations that will occur during this phase include:

1) Topsoil Stockpiles – Topsoil Stockpiles located in the CSZ are located in the southwestern corner of the Site as shown on Drawing 4-2. These Topsoil Stockpiles will be relocated by excavating to the native ground surface as part of initial Site preparation work and moved to temporary stockpile locations as discussed in Appendix R. The final ground surface shown is based upon the pre-mine topography in this area.

2) Pit 4 Overburden Pile – will be excavated to the native ground contact. The final ground surface shown is based upon the pre-mine topography in this area.

3) HSWRP – will be excavated as required to provide material needed to produce Pit 4 drain material. Excavation will occur starting from the eastern edge of the HSWRP and working in a westerly direction as shown on Drawing 4-3 in order to provide the needed drain material and clear HSWRP material from the final footprint of the Pit 4 WCA.

4) Ore/Protore Stockpiles - will be removed down to the “base of Protore surfaces” which were estimated as described in Section D4.0.

5) South Waste Rock Pile Waste material in the vicinity of the South Pond - will be excavated to provide a level bench at an elevation of approximately 26830~~0~~ ft.~~. amsl~~ as shown on Drawing 4-8~~9~~. The South Pond Excavation will be completed in waste rock to the final pond configuration and the surrounding waste rock surface graded to drain by gravity to the South Pond to the extent practical as shown on Drawing 4-8.

6) The uphill (northern) portion of the South Waste Rock Pile located in the Western Drainage - will be excavated to the native ground contact. The excavation will start from the uphill end of the South Waste Rock Pile and work in a downslope or downstream manner, removing all waste rock from the Western Drainage channel section as the excavation progresses. The excavated surface shown on the Drawing 4-9 in areas of the Western Drainage that have been cleared of waste rock reflect the pre-mine~~premine~~ topography. During excavation, the active waste rock excavation surface will be sloped to drain toward the north in order to prevent surface water runoff from the excavation as shown on Drawing 4-9.

7) Adit Pit and Pit 2 West – mine waste will be excavated to native ground contact. Final soil clean-up and verification in these areas will be completed in Phase 2. Final grading and backfilling of the Adit Pit and Pit 2 West is not practical during Phase 1 due to the extent of contaminated areas remaining around these pits. These remaining areas of contamination at the end of Phase 1 will pose a very significant risk for recontamination of the Adit Pit and Pit 2 West areas. Therefore, any associated soil cleanup and verification, final grading, and cover soil placement will not be completed until Phase 2 after cleanup of the areas adjacent to the Adit Pit and Pit 2 West has been completed. Any mine waste associated with soil cleanup in the Adit Pit and Pit 2 West will be placed in Pit 3. If water does accumulate in the two pits during the time period after removal of waste rock, but prior to final soil cleanup, grading, and cover soil placement, the pits may be dewatered by pumping to the water management system for treatment.

D5.2.2 Phase 2 Excavation

Excavated surfaces at the completion of Phase 2 construction are shown on Drawing 4-24~~23~~. Primary above-grade excavations that will occur during Phase 2 will include:

1) Completion of the excavation of the HSWRP to the native ground contact. The final ground surface shown on Drawing 4-25~~24~~ is based upon the pre-mine topography in this area.

2) Removal of all remaining Above-Grade Mine Waste from the Western Drainage. The final ground surface shown on Drawing 4-26~~25~~ is based upon the pre-mine topography in this area. Additional stormwater and sediment control structures required below the downstream toe of the waste rock upon completion of excavation and soil sediment

cleanup in the Western Drainage are discussed in Appendix F and shown on the Section 6 Drawings.

3) Removal of all Above-Grade Mine Waste in the East Waste Rock Pile located in the Eastern Drainage. The final ground surface shown on Drawing 4-27~~26~~ is based upon the pre-mine topography in this area. Additional storm water and sediment control structures required below the downstream toe of the waste rock upon completion of excavation and soil sediment cleanup in the Eastern Drainage are discussed in Appendix F and shown on the Section 6 Drawings.

4) Excavations associated with regrading and capping of Area 5 (between Pit 3 and Pit 4) once it is no longer needed for drain material processing and stockpiling. The final regraded surface of Area 5 is shown on Drawing 4-46~~44~~.

D5.2.3 Phase 3 Excavation

Drawing 4-51~~49~~ shows the excavated surfaces at the completion of Phase 3 construction. The primary Above-Grade Excavation that will occur during Phase 3 will consist of removing the South Pond and remaining South Waste Rock Pile from the Central Drainage downgradient of the Pit 3 WCA as shown on Drawing 4-52~~50~~. The final ground surface shown on Drawing 4-52~~50~~ is based upon the pre-mine topography in this area. Additional stormwater/sediment engineering controls (i.e., BMPs) as described in Appendix F and shown in Section 6 of the Drawings will be required below the toe of the South Waste Rock Pile during the final phase of excavation in the Central Drainage.

D5.3 CONTAMINATED SOILS AND SEDIMENTS EXCAVATION

Contaminated soils (impacted by roads or other areas of mine waste) and sediments are materials located in the MA and MAA that exhibit contaminant concentrations above the cleanup levels in BODR Tables 4-1 and 4-2. These materials include sediments located in drainages downstream of the MA in the MAA and sediments in localized areas within the Whitetail Creek (referred to as the Far West Drainage in the RI/FS). Contaminated soils and sediments may also include mine wastes used for the construction of roads and any soils and sediments below, adjacent to, and downstream of the roads that exceed the cleanup levels. These materials will be excavated for consolidation and containment in Pits 3 and 4.

Areas where contaminated soils and sediments have been identified or will be investigated during early phases of RA construction are shown on Drawings 2-1 through 2-4. Investigations of the extent contaminated soils and sediments, and volume estimates for contaminated soil cleanup within the MA and MAA are based on data and information provided in the *RI Report* (EPA, 2005), *Mine Waste Investigations Report* (MGC, 2011a), and the *White Tail Creek Sediment Evaluation – Phase 2 Data Transmittal Report* (WME~~MGC~~, 2014). In addition to those areas identified on the drawings, it is assumed that an average of 1-foot of contaminated soils and sediments exist under areas overlain by Above-Grade Mine Waste and will require excavation and relocation in the Pit 3 and Pit 4 WCA. The actual extent of soil contamination and cleanup will be determined during RA construction using procedures defined in the *Analytical Support and Verification Plan for Remediation of Surface Materials and Sediments* (Appendix S).

5.3.1 Phase 1 Soil/Sediment Removal

The Far-Western Drainage (White Tail Creek) was identified in the ROD as being potentially impacted. However, the FS (URS, 2002) assumed that no sediments would be removed from this area. Additional characterization of this drainage were performed during the fall of 2013 and summarized in the *White Tail Creek Sediment Evaluation Data Transmittal Report* (WME, 2014). The results of the sediment sampling indicated two locations in this area that will require cleanup of sediments. This work will be completed prior to Phase 1 and the approximate cleanup limits are shown on Drawing 2-4. Cleanup volumes are not significant (estimated to be approximately 5,000 cy).

The location of additional potentially ~~-~~contaminated sediments that may require cleanup during early stages of Phase 1 construction (Early Works) include the entire fenced area within the CSZ as shown on Drawings 2-1 and 2-13. Although Contaminated Soils and Sediments have not been identified in the area delineated on this drawing with the exception of the Whitetail Creek Investigation area lying outside of the perimeter fence (WME~~MWH~~, 2014), this area will be the site of the new WTP and Construction Support Facilities. As such, an evaluation of the potential for contamination and any necessary cleanup will occur as part of the initial RA construction. Contaminated material excavated from this area will be stockpiled as described in the *Staging and Stockpiling Plan* (Appendix R). Additional contaminated sediment cleanup during Phase 1 excavation will include the West Access Road, as shown on Drawings 2-1 and 2-4. The West Access Road is no longer used for Site access. Delineations of the extents of contaminated soils along the West Access Road are based on data and information provided in the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA.

5.3.2 Phase 2 Soil/Sediment Removal

The identified extents of contaminated soils and sediments that will be removed during Phase 2 construction are shown on Drawings 4-29~~28~~ through 4-33~~32~~. These areas of contamination include:

1) Western Drainage Sediments Excavation (Drawing 4-31~~30~~). The delineation of extents of contaminated sediment cleanup in the Western Drainage between the toe of the SWRP~~South Waste Rock Pile~~ and the confluence with the Eastern Drainage is shown on Drawing 4-31~~30~~ and was obtained from the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA. It is anticipated that this cleanup will occur immediately prior to completion of the cleanup of Above-Grade Waste and contaminated soils in the upper portion of the drainage. This will enable the release of storm water from the upper Western Drainage once cleanup is complete without remobilizing sediments located further downstream.

2) Eastern Drainage Sediments Excavation (Drawing 4-32~~31~~). The delineation of Eastern Drainage contaminated sediment cleanup in the Far East Drainage between the toe of the East Waste Rock Pile, and the confluence with the Eastern Drainage, and in the Eastern Drainage between the East Access Road and the confluence with the Western Drainage was obtained from the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA. It is anticipated that this cleanup will occur immediately prior to completion of the cleanup of Above-Grade Waste and contaminated soils in the East Waste Rock Pile area. This will enable the release of stormwater from the East Waste Rock Pile area upon completion of cleanup without remobilizing sediments located further downstream.

3) The East Access Road (Drawing 4-30~~29~~). This road currently provides access to the Site and existing WTP. A surface course of clean fill has been placed over the East Access Road in 2012 in order to reduce the potential for transport of contaminated sediments on vehicles travelling to and from the Site. It is anticipated that this road may continue to be used as a secondary access point during early phases of the RA, and that cleanup will not occur until later stages of Phase 2 construction. Delineation of extents of contaminated soils along the

East Access Road is based on data and information provided in the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA.

4) Internal Mine Roads (Drawing 4-33~~32~~). The Internal Mine Roads south of the PCP provide access to wells and pumps in the Western Drainage and to wells and the PCP pumpback system located in the Central Drainage. As such, the cleanup and or removal of these roads must be coordinated with water management activities and may not occur until later stages of Phase 2, or during Phase 3 of construction. Delineations of the extents of contaminated soils along the Internal Mine Roads are based on data and information provided in the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA.

5.3.3 Phase 3 Soil/Sediment Removal

The identified extents of contaminated sediments that will be removed during Phase 3 will include of cleanup of Central Drainage Sediments as shown on Drawing 4-53~~51~~. The delineation of Central Drainage contaminated sediment cleanup between the toe of the PCP and culvert crossing of the West End Road (Ford-Wellpinit Road) was obtained from the *Mine Waste Investigations Report* (MGC, 2011a). The actual extent of soil contamination and cleanup will be determined during RA. It is anticipated that this cleanup will occur immediately after completion of the cleanup of Above-Grade Waste and contaminated soils in the SWRP~~South Waste Rock Pile~~ and PCP area. Although not delineated during the mine waste investigation, it is anticipated that cleanup also will require dewatering and cleanup of soils in the pond area at inlet to the Ford-Wellpinit Road culvert crossing. This will enable the release of stormwater from the Central Drainage upon completion of cleanup without remobilizing sediments located further downstream. As discussed above, it is also possible that cleanup of the Internal Mine Roads will be delayed until this time so they can continue to provide access to PCP pumpback systems.

D6.0 PHASE 1 – PIT 4 WASTE CONTAINMENT

The sequence for backfilling of Pit 4 is discussed below, from the initial rockfall protection (D6.1) for worker safety to the final containment and capping of the pit (Section D6.9).

D6.1 PIT 4 ROCKFALL PROTECTION

In the fall of 2013, a Site visit and independent assessment of potential rockfall mitigation measures that could be implemented at the Site was performed by a specialist rockfall mitigation engineer/contractor. A recommended Rockfall Mitigation Plan has been developed by the specialist rockfall engineer/contractor based on this information and is included as Attachment D-11 to this Appendix.

Previous analyses of rockfall hazard and potential mitigation measures were performed for Pits 3 and 4 as part of the *Geologic Investigation of Pits and Assessment of Pit Sediments Design Investigation Report* (MGC, 2011b). The rockfall hazard analyses were made using the Colorado Rockfall Simulation Program (CRSP) (Jones, et al 2000) and incorporated assumed parameters based upon photographs and mapping of Site conditions available at the time. Updated rockfall simulations were performed as part of the Rockfall Mitigation Plan using CRSP, and incorporating the results of observations made while at the Site, as well as the results of rockfall monitoring that has been performed at the Site since 2011 (MWH, 2013b).

Conclusions made based upon the Site visit and updated rockfall hazard simulations included:

1. Physical and hydraulic scaling of the pit walls should be conducted to reduce the rockfall hazard prior to initiating work in the pits. Scaling should include removal, or identification and monitoring, of rockfall sources larger than 3-feet in size as appropriate.
2. The rockfall catch berm/ditch design (10-feet deep and 15-feet wide horizontally) and work sequence proposed should significantly reduce the risk of rockfall impacting the work areas during pit backfilling operations. The dimensions and construction sequence for maintaining the proposed rockfall berm/ditch is shown on Drawing 4-81~~78~~.
3. A portable rockfall barrier, or an approved alternative system should be used in areas where personnel need to work outside of construction equipment prior to construction of rockfall catch berms (i.e. during sump drilling/blasting, sump excavation, drainage system construction, and liner placement) or in areas where rockfall catch berms cannot be constructed due to Site space constraints. Preliminary sketches of the proposed portable rockfall barriers are included in Attachment D-11 to this appendix.
4. Although the Rockfall Hazard Monitoring Program has provided useful information relative to the rockfall hazard at the Site, continued monitoring is unlikely to provide additional information that would be useful in designing rockfall protection measures.

The recommendations in the Rockfall Mitigation Plan included as Attachment D-11 were made by the~~a~~ specialist rockfall mitigation engineer/contractor and provide the general guidelines that should be followed for rockfall protection to personnel working within the boundaries of the pits. The RA Contractor~~selected contractor~~ will be responsible for preparing a specific plan for rockfall mitigation that incorporates the listed rockfall mitigation and protection measures in Attachment D-11. This has been noted in the specifications. The specific rockfall mitigation plan will be subject to approval by Newmont/DMC and the EPA.

D6.2 PIT 4 DEWATERING

Pit 4 will be dewatered prior to commencement of pit bottom cleanup. Historically (WTP operating years 2001 through 2011), the peak accumulated water volume in Pit 4 has ranged from 9 million gallons to 25 million gallons, with an average peak storage of 15 million gallons. Based on these typical peak storage volumes, it is estimated that dewatering of Pit 4 will take approximately 20 days to complete. Water removed from Pit 4 during dewatering will be conveyed either directly to the WTP or to Pit 3 for intermediate storage prior to being conveyed to the WTP for treatment, depending on the WTP operating schedule at the time of dewatering.

D6.3 PIT 4 PIT BOTTOM CLEANUP AND GRADING

Sediments that have accumulated in the Bottom of Pit 4 were characterized as part of the field investigations performed for the *Geologic Investigations of Pits and Assessment of Pit Sediments Design Investigation Report* (MGC, 2011b). As part of those investigations, Pit 4 was dewatered to the point where approximately 0.5 acres of the pit bottom remained underwater. This allowed for the observation, measurement, and sampling of fine-grained sediments in the pit bottom. It was estimated that approximately 2,400 cubic yards of sediment had accumulated in the pit bottom. These sediments were found to be one to two feet thick in the pit bottom and thinner near the pit walls (0.1 to 0.3 feet thick). The sediments were noted to be predominantly saturated, silt-sized material with coarser material occurring around the margins of the pit floor. In addition to the materials investigated in the pit bottom, a significant amount of gravel to boulder-sized material are visible on the pit floor, both below and above the pool level. It is anticipated that additional coarse rock material will accumulate on the pit floor as a result of pit-slope rock scaling operations that will be performed to reduce rockfall hazard as described in Section D6.1.

The sediments and coarse rock material that has accumulated in the bottom of Pit 4 will be removed after completion of dewatering operations and prior to pit-bottom grading. Based upon the results of the pit sediments assessment (MGC, 2011b) it is anticipated that much of the material that has accumulated in the pit bottom can be removed using conventional earth-moving equipment (excavators, loader, and haul trucks). Prior to excavation, the material will be dried, either due to natural evaporation, or by adding drying agents if needed for very fine-grained, saturated sediments. These drying agents could include fine-grained waste rock or Site soils, imported fly ash (ASTM C618 Class C or Class F), or other materials and would be mixed with the pit-bottom sediments by bucket mixing using an excavator of front-end loader. At this time, the need for drying agents to stabilize/dewater the pit sediments is not anticipated. Should such a need be identified, any amendments will be subject to prior EPA and Tribe approval.

If it is determined that the amount of fine-grained sediments remaining after bulk cleanup using earth-moving equipment could be detrimental to the performance of the underdrain system, final cleanup by hydraulic-monitoring jetting of remaining sediments may be required. Hydraulic jetting would involve washing the remaining fine-grained materials using a high-pressure water jet to a low-point in the pit bottom where they could be collected using a slurry pump and conveyed to a dewatering area where they would be pumped into geotubes for dewatering.

Sediments and coarse rock material removed during pit-bottom cleanup operations will be stockpiled for replacement in Pit 4 as described in an approved Staging/Temporary Stockpiling Plan (Appendix R). Material removed during pit-bottom cleanup will not be placed in zones within the Pit 4 backfill that have been designated for low-activity/reactivity waste.

Upon completion of cleanup, the bottom of Pit 4 will be graded in preparation for placement of drain material as shown on Drawing 4-12. An underdrain sump will be excavated by drilling and blasting in the low area located in central portion of the pit bottom as shown on Drawing 4-12 and 4-79~~76~~. Generally, the pit is sloped to drain to this area in its current configuration. Areas where ponding may occur in the pit floor, or otherwise will not flow by gravity toward the underdrain sump will be reworked to the extent possible without ripping, drilling or blasting.

Due to the nature of the rock formation in the pit bottom, aggressive reworking of the pit floor (e.g. ripping or blasting) to remove smaller irregularities (i.e. less than 2 feet high) that result in areas of ponding is likely to result in irregular rock breakout and creation of other areas of ponding. As a result, grading the pit bottom to a perfectly smooth, free-draining surface is considered unrealistic, and is unnecessary given the inward hydraulic gradients toward the pit.

Instead, if areas of ponding are noted during the jetting operation and can be removed by scraping the pit floor with the toothed bucket of a hydraulic excavator, this will be performed. In addition, the required minimum thickness of drainage layer in the pit bottom (discussed in the following section) will be maintained as measured above any high point or “sills” in the pit bottom that obstruct flow and create ponding. Thus any areas of ponding will be shallow “dead pools” with very small volumes that form below the required minimum thickness of drainage layer and will not affect drain capacity. Material removed during grading and sump excavation will be stockpiled along with the coarse rock material removed during pit-bottom cleanup as described in the Staging/Temporary Stockpiling Plan (in Appendix R) and will be placed in Pit 4 during backfilling. Due to their in-situ proximity to mineralized areas, material removed during grading and sump excavation will not be placed in zones within the Pit 4 backfill that have been designated for low-activity/reactivity waste.

D6.4 PIT 4 UNDERDRAIN SYSTEM

An underdrain system constructed of crushed and screened, non-reactive rock from the Hillside Waste Rock dump will be installed in the bottom of Pit 4. This underdrain will collect groundwater before it contacts reactive mine waste backfill in the pit. A liner bedding layer will be placed over the underdrain prior to covering the underdrain system with a geomembrane liner (i.e., a sub-waste liner). The sub-waste liner is intended to isolate the underdrain from seepage through the overlying waste rock to the extent practical, a condition that is primarily a concern during construction. The configuration of the Pit 4 underdrain system is shown Drawings 4-13~~12~~ and 4-15~~13~~. The extent of the underdrain drain gravel and sub-waste liner are shown on Drawing 4-13.

In addition to the pit-bottom underdrain system, performance criteria 2.4.2.4.2 E.iii of the SOW in the CD stipulates that “*The drainage layers shall extend vertically along the side walls of each pit to elevations determined during RD, to keep water entering the pits from contacting mine waste and to effectively channel water to the pit bottoms.”* Locations of pit wall seeps were mapped during late summer of 2010 as part of investigations for the *Geologic Investigations of Pits and Assessment of Pit Sediments Design Investigation Report* (MGC, 2011b) and additional seep mapping was performed in the spring of 2012 to provide data during wetter portions of the year (Plumley and Assoc., 2012). As communicated, both in the summary report and in the approved work plan for the spring 2012 seep mapping (MWH, 2012b): “*The specific objectives of the additional pit wall seep monitoring were to verify seeps previously identified in* *the Geologic Report; and identify new seeps in the pit walls above the existing water level that might be evident in the spring. Data gathered from this additional monitoring is intended to help define the positioning of drains that will be included in the remedial design for interception of pit wall seeps.*" No signs of seepage were observed in Pit 4 during either of these investigations and as a result, the drain configuration shown on Drawing 4-12 does not include drainage layers extending up the pit walls in Pit 4.

The material proposed for the underdrain construction will be obtained by processing material from the HSWRP. Results of investigations presented in the *Mine Waste Investigations Report* (MGC, 2011a) and the *Addendum to the Mine Waste Investigations Report* (WME, 2012) indicate that processed by screening and crushing coarser fractions ~~of HSWRP material~~ will have suitable durability and geochemical characteristics for use in the underdrain layer. Gradation specifications have been developed for the underdrain materials for three distinct material drain materials; (1) sump drain rock, (2) drain gravel, and (3) liner bedding.

The sump drain rock material will be used as backfill in the underdrain sump as shown on Drawing 4-79~~76~~, and will be 2-inch to 6-inch sized material with no more than 3-percent by weight material finer than a #200 sieve. The drain rock is intended to have a very high permeability and large pore spaces to reduce the potential for plugging of the underdrain sump by the migration of fine-grained soils or accumulation of chemical precipitates.

The overlying drain gravel layer will cover the bottom and sump area of Pit 4 as shown on Drawings 4-12, 4-13, and 4-15~~14~~. The drain gravel layer will consist of medium to coarse gravel, and will have sufficiently high permeability to allow for gravity conveyance of groundwater and seepage water to the sump area without developing a significant saturated zone within the drain system. The gradation requirements for the drain gravel are developed in Attachment D-9, and summarized in Table D-7.

Table D-7 — Drain Gravel Gradation Requirements

U.S Standard Sieve Size	Opening Size (mm)	Percent Passing (%)	
		Maximum	Minimum
3-inch	76.2	100	100
1 1/2-inch	38.1	100	0
1-inch	25.4	90	0
3/4-inch	19.05	40	0
1/2 inch	12.7	20	0
3/8-inch	9.5	10	0
No. 4	4.76	5	0
No. 200	0.075	5	0

The estimated range of hydraulic conductivity for the drain gravel is $7x10^{-1}$ to $9x10^{0}$ cm/sec based on the gradation range listed in Table D-7. Calculations for estimated permeability of the drain gravel are presented in Attachment D-9.

The uppermost soil layer in the underdrain system will be a liner-bedding layer placed over the surface of the drain gravel as shown on the Sub-Waste Geomembrane Liner Detail on Drawing 4-81~~76~~. This bedding layer will reduce the potential for puncture of the overlying sub-waste geomembrane by coarse fragments within the drain gravel layer. The bedding layer will have a maximum particle size (D_{max}) of 1.5-inch or smaller and will meet filter (retention) compatibility requirements with the underlying drainage gravel layer. The gradation requirements for the bedding layer are developed in Attachment D-9 and summarized in Table D-8. Due to its coarse nature and low fines content, the bedding layer also will have a very high hydraulic conductivity, estimated to range between 0.3 and 1 cm/sec based on the specified gradation (see Attachment D-9).

Table D-8 — Liner Bedding Gradation Specifications(a)

U.S. Standard Sieve Size	Opening Size (mm)	Percent Passing (%)	
		Maximum	Minimum
1 1/2-inch	38.1	100	100
1-inch	25.4	100	90
3/4-inch	19.05	85	40
1/2 inch	12.7	40	10
3/8-inch	9.5	15	0
No. 4	4.76	5	0

Notes: [a/] Gradation based ASTM C33 No 56 Coarse Aggregate

The materials to be used in three layers within the underdrain system are designed to meet gradational stability (filter) criteria and prevent migration of the finer overlying materials into the underlying layers. Additional details of the liner bedding layer and the puncture resistance of the overlying geomembrane liner are included in Section D6.5 and Attachment D-1.

As currently configured, the underdrain system will have much greater flow capacity than is required to convey the groundwater flow rates measured in the Groundwater Investigations Design Investigation Report (MGC, 2011c). The drain gravel layer in the Pit 4 underdrain system as shown in the drawings with a 1) 5-foot minimum thickness, 2) h~~H~~ydraulic conductivity of 7x10^{-1} to 9x10^{0} cm/sec (1.38 to 17.7 ft/min), and 3) 5 percent minimum liner slope has the capacity to conduct between 2.6 and 33.1 gpm per foot of drain width to the underdrain sump. Given the total measured groundwater inflow rate of 13.5 gpm in Pit 4 (MGC, 2011c), the underdrain system as designed has sufficient capacity in each 0.4 ft to 5 ft-wide section of underdrain to convey the entire estimated Pit 4 inflow to the underdrain sump at the minimum specified drain thickness. Therefore, the drain system placed over the entire bottom of Pit 4, has much more hydraulic capacity than necessary to convey the anticipated flow. Also, as shown in Section C on Drawing 4-15~~14~~, the underdrain has a thickness considerably greater than the specified 5-foot minimum thickness at the critical location in the vicinity of the underdrain sump. Thus, the actual as-designed flow capacity will be much greater than required.

Underdrain Dewatering Design. To the extent practicable, water shall be kept from accumulating in Pit 4 during and after consolidation of waste within the pit. Water that accumulates in the underdrain sump during, and after construction, will be conveyed for treatment at the WTP by pumping through an underdrain sump dewatering system.

The underdrain sump dewatering system design is shown on Drawings 4-12, 4-15~~14~~, and 4-79~~76~~. Dewatering risers will be installed in the underdrain sump prior to placement of the sump drain rock. Backfill will be paced around the dewatering risers in a uniform manner using an~~d~~ excavator or similar placement technique (as opposed to pushing backfill around the risers using dozers) in order maintain a uniform horizontal stress distribution, and reduce lateral displacement of the risers during construction. The dewatering risers will be constructed from stainless-steel well casing, which will be extended during construction to remain above the backfill surface as waste is being placed in Pit 4. Stainless steel well casing was selected for the dewatering risers for its superior strength, which will allow it to withstand anticipated loadings from the waste backfill (relative to other corrosion-resistant pipe materials such as PVC and

HDPE). In addition, it will be much less susceptible to corrosion relative to other high-strength pipe materials.

The design for dewatering risers incorporate oversized friction sleeves that prevent backfill-settlement-induced dragdown forces from loading the riser pipes. The friction sleeves are constructed of high-strength carbon steel pipe of a larger inside diameter than the outside diameter of the riser casing. In addition, two layers of 60-mil smooth HDPE sheeting will be wrapped around the friction sleeve as shown on Detail 5~~4~~ of Drawing 4-80~~77~~ to provide an additional slip surface and further reduce drag down forces. Similar riser designs have been used successfully at a number of waste containment facilities where very high settlements were anticipated, including the Kettleman Hills hazardous and municipal waste facility in Kings County, California.

The underdrain sumps will be dewatered using submersible pumps installed within the drain risers casing after backfilling of the sump. The well-discharge pipes will be extended in coordination with the extension of well casings so as to remain above the backfill surface, and allow near continuous dewatering as waste is being placed in Pit 4.

Duplicate dewatering risers are proposed to avoid long shutdowns in the dewatering system due to maintenance or mechanical failure during the RA and post-RA. The underdrain configuration shown on the drawings provides approximately 1,100,000 gallons of storage (assuming an active porosity of 30 percent)~~%)~~ between the top of the sump and the lowest point in the overlying subwaste liner. This allows storage for approximately 58 days of groundwater inflow at the measured inflow rate of 13.5 gpm for Pit 4 without operating the underdrain dewatering system before the overlying bedding layer and liner system are at risk of becoming saturated.

Water Levels. The design range of operating water levels within the underdrain sumps is shown on Drawing 4-79~~76~~. The proposed range of water level fluctuations was selected to ensure that the water level will remain within coarse drain rock of the sump backfill, thus avoiding water level fluctuations over the greater pit floor and liner surfaces, while at the same time avoiding drawing the water levels down to the elevation of the screened sections of dewatering risers.

D6.5 PIT 4 SUB-WASTE LINER SYSTEM

Prior to placement of mine waste in Pit 4, a sub-waste liner will be installed over the underdrain system as shown on Drawings 4-13 and 4-15~~14~~. The intent of the sub-waste liner is to isolate the mine waste from the underdrain system to the extent practical and minimize the passage of both water and mine waste particles from the mine wastes into the underdrain system. The potential for migration of water and fines through the mine waste and into the underdrain will be greatest during mine waste placement, when the rates of infiltration of meteoric water will be greatest. Once the RA construction is complete, and the surface cover system is in place over the Pit 4 waste, the rates of water migration through the waste rock will diminish to low levels as discussed in Section D10.0

The liner subgrade (i.e. underdrain surface) will be shaped as shown on Drawing 4-13. The proposed grading for the sub-waste liner shown on Drawing 4-13 will provide for gravity drainage of water that collects on the liner surface toward a waste rock dewatering sump located at the low-point of the liner surface. Prior to liner installation, a geofabric cushion layer will be placed over the bedding layer of the underdrain system. The liner will be constructed of HDPE geomembrane as discussed in Section D9.0. Prior to placement of mine waste, an overliner protection layer will be placed over the geomembrane to protect it from damage from waste loading or construction equipment.

D6.6 PIT 4 WASTE ROCK DEWATERING SYSTEM

The proposed Pit 4 waste dewatering system is shown on Drawings 4-13, 4-15~~14~~, and 4-82~~79~~. The purpose of the waste rock dewatering system is to collect and convey water, primarily precipitation that during the backfilling operations collects on the sub-waste liner. This water will be conveyed from the sub-waste liner to a waste dewatering sump located on the low point of the liner, where it then will be pumped through dewatering risers to the WTP for treatment. It is anticipated that flow rates to the waste dewatering sump will be highest during construction and that once the surface cover system is in place over the Pit 4 waste, the rates of water migration through the waste rock will diminish to very low rates as discussed in Section D10.0.

Waste Dewatering System. Water that accumulates in the waste rock dewatering sump during, and after construction, will be pumped to the WTP through waste rock dewatering risers located in the sump. In order to increase hydraulic efficiency, the waste rock dewatering sump will be backfilled as shown on Drawing 4-82~~79~~ with drain gravel of similar specification to the drain gravel for the underdrain system discussed in Section D6.4. To provide separation and prevent fines migrations from the overlying mine waste into the drain gravel, a layer of ASTM C33 Fine Aggregate will be placed as a filter layer between the drain gravel and waste rock. In addition, the results of a filter-compatibility evaluation (Attachment D-10) indicate that an intermediate filter layer having a gradation consistent with ASTM C33 No.67 Coarse Aggregate will be needed between the drain gravel and the finer-grained (ASTM C33) waste filter sand. The required gradation of the drain gravel layer is summarized in Table D-7 above. The gradation requirements for the filter layers are developed in Attachment D-10 and summarized in Tables D-9 and D-10. These intermediate filter layers will most likely be sourced from an off-site borrow source.

Table D-9 — Filter Sand Layer (ASTM C33 Fine Aggregate) Particle Size Distribution

U.S. Standard Sieve Size	Opening Size (mm)	Percent Passing (%)	
		Maximum	Minimum
3/8 inch	9.5	100	100
No.4	4.75	95	100
No.8	2.36	80	100
No. 16	1.18	50	85
No. 30	0.6	25	60
No. 50	0.3	5	30
No. 100	0.15	0	10
No. 200	0.075	0	5

Table D-10 — Intermediate Filter (ASTM C33 No.67 Coarse Aggregate Gradation

U.S. Standard Sieve Size	Opening Size (mm)	Percent Passing (%)	
		Maximum	Minimum
1-inch	25.4	100	100
3/4-inch	19.05	100	90
1/2 inch	12.7	55	20
3/8-inch	9.5	10	0
No. 4	4.76	5	0

The Waste Rock Dewatering Risers~~subwaste dewatering risers~~ will be similar to the risers discussed for the Pit 4 underdrain dewatering system in Section D6.4. These risers will be extended periodically during construction to maintain a top elevation higher than the surrounding waste backfill surface. As with the underdrain system, the subwaste dewatering system will have duplicate dewatering risers to avoid shutdowns in the dewatering system due to maintenance or mechanical failure (i.e., a primary and a backup dewatering riser).

Water Levels. The design range of operating water levels within the ~~sub-~~waste rock~~liner~~ dewatering sumps is shown on Drawing 4-82~~76~~. The range of water level fluctuations will ensure that the water level will remain within the sump backfill, thus avoiding water level fluctuations within the mine waste, while avoiding drawing the water levels down to the elevation of the screened sections of dewatering risers in order to reduce the potential for scaling and plugging of the intake system.

As currently configured, the waste dewatering sump, with an estimated backfill hydraulic in the range of $7x10^{-1}$ to $9x10^{0}$ cm/sec and an effective sump radius of approximately 30 feet, will have much greater flow capacity than is required to convey the long-term infiltration rates estimated in the infiltration analyses summarized in Section D10.3.

Additional Infiltration Collection. Additional mine waste infiltration collectors will be installed on the hillside west of the Pit 4 crest as shown on Drawing 4-16~~15~~. The mine waste infiltration collectors will be French-drain style infiltration collectors installed in lined trenches as shown in detail on Drawing 4-82~~79~~. The purpose of these trenches is to collect water that may infiltrate through the mine waste at the native ground contact, and route it to the top of the sub-waste liner and waste dewatering system. This system is primarily intended to collect meteoric water that infiltrates through the waste rock during construction.

D6.7 PIT 4 MINE WASTE PLACEMENT

Once the sub-waste liner has been installed, Pit 4 will be ready to receive mine wastes from various sources at the Site. In general, Pit 4 will contain most of the high-activity/reactivity waste sources at the Site as shown in Table D-5.

The waste containment capacity of the configuration shown for Pit 4 is approximately 6.72 to 6.96 million cubic yards. The Pit 4 sections shown on Drawing 4-20~~19~~ delineate backfill zones where higher activity/reactivity wastes will be excluded. The material balance for Pit 4 is described in Detail in Section D4.0. The zone that can be used to contain higher activity/reactivity waste within Pit 4 has an estimated storage capacity of 3.5 million cubic yards, whereas the estimated volume of higher-activity/reactivity waste scheduled to be placed in Pit 4 is 1.43 million cubic yards. The material balance calculations indicate sufficient capacity exists for all waste scheduled for placement within Pit 4 as detailed in the material balance section.

As proposed, the waste placement sequencing in Pit 4 will be as follows:

1) Sump drain rock in underdrain sump (D6.4)
2) Underdrain gravel layer (D6.4)
3) Liner bedding (1.5” D_{max}) layer (D6.4)
4) Geofabric for liner cushion layer (D6.5)
5) Subwaste geomembrane liner(D6.5)
6) Overliner protection layer of fine-grained (1/4” D_{max} or finer) soil (D6.5)
7) Reject material from HSWRP

8) Pit 4 Overburden Pile material
9) Ore and Protore material
10) Sediments from cleanup of Pit 4 bottom
11) Pit 4 rockfall debris and pit-bottom grading spoils
12) South Pond grading and excavation spoils
13) Other SWRP~~South Waste Rock Pile~~ Excavation

These wastes will be hauled to Pit 4 in either mine haulage trucks or off-road dump trucks, dumped, and spread in horizontal lifts with maximum thickness of 10 feet. No additional compaction of the waste material is planned beyond that which results from spreading and incidental traffic over the waste surface by construction equipment.

The final configuration of the Pit 4 backfill upon completion of construction is shown on Drawings 4-17~~16~~ and 4-20~~19~~. The configurations shown on these drawings reflect final cover surface grading details including drainage benches, concave geomorphic design of intrabench slopes, etc.

Mine Waste Settlement. Settlement of the mine waste backfill in Pit 4 will result in deformation and strains in the final cover, as well as induce lateral displacement and drag-down forces on the underdrain and waste dewatering risers if not accommodated. Deformation analyses were performed~~ for the 90% design~~ to estimate the amount of settlement that can be expected in the mine waste both during and after construction. Evaluations also were made of the impact of the deformation on the cover system and underdrain dewatering risers. Description of the methods, assumptions, and material properties used in the analyses, as well as the results of the analyses are provided in Attachment D-13.

Two-dimensional (2D~~2-D~~) finite element analyses were performed along critical sections in Pit 4 to provide estimates of settlement for sections with significant variations in fill thickness over short horizontal distances. The 2D~~2-D~~ analyses were performed for initial settlement (occurring during construction) and long-term (post-cover construction) creep settlement. The lateral displacements of the underdrain and waste dewatering risers due to construction and long-term creep deformations of the mine waste also were estimated.

A summary of the settlement for the two critical sections analyzed for Pit 4 are provided in Table D-11. The creep settlement is based on estimates of the settlement that will occur within the first 50 years of completion of construction. The relationship of creep settlement with time initially shows a rapid rate of settlement immediately after completion of construction. The rate of settlement then slows considerably about 10 years after final placement.

Table D-11 — Maximum Calculated Settlements in Pit 4 Mine Waste

Section	End of Construction (ft)	50 years (Creep) (ft)	Total (ft)
Pit 4 – Section C	2.2	3.7	5.9
Pit 4 – Section D	2.8	4.5	7.3

The calculated in-section lateral displacements in the dewatering risers are presented in Table D-12. In addition, the total estimated horizontal displacement and deviation of the dewatering risers from vertical were calculated and the results are also summarized in Table D-12.

Table D-12 — Maximum Calculated Lateral Displacements at the Pit 4 Risers

Section	In-Section Displacement			Resultant Displacement			
	EOC (ft)	50 years (Creep) (ft)	Total (ft)	EOC (ft)	50 years (Creep) (ft)	Total (ft)	Deviation from Vertical
Pit 4 – Section C	0.10	0.31	0.4	0.42	0.42	1.3	0.4%
Pit 4 – Section D	0.41	0.82	1.2				

Estimates of three-dimensional (3D~~3-D~~) deformation for the cover system used the relationship developed in the 2D~~2-D~~ analysis between vertical creep settlement and the thickness of mine waste backfill. The maximum calculated geomembrane liner strains and differential settlements were estimated based upon the 3D~~3-D~~ distributions of settlement and are provided in Table D-13. The results the 3D~~3-D~~ deformations in the cover system also were used to evaluate the impact of long-term creep settlement along the relatively flat bench channels. Analyses of the Pit 4 cover and drainage bench designs prior to the 100% submittal indicates that post-settlement bed slopes along the drainage benches will exceed 0.5 percent at all locations, which exceeds the minimum slopes needed to convey stormwater from the WCA while providing sufficient freeboard against overtopping of drainage bench channels.

Table D-13 — Maximum Calculated Liner Strains and Differential Settlements for Pit 4 Cover

Max. Liner Strain (%)	Max. Differential Settlement (ft/ft)
0.42	0.021

The magnitude of the settlements listed in Table D-11 is considered reasonable for the evaluated loading conditions. Long-term maximum creep settlements of approximately 4.5 feet in Pit 4 are anticipated; however the differential settlement between adjacent points will be much lower. Overall, the estimated long-term creep settlements will not result in significant changes to the cover geometry or flow directions of precipitation on the cover due to the relatively steep grades of the as-designed cover surface.

The amounts of lateral displacement of the underdrain and waste dewatering riser pipes due to construction loadings, and from long-term creep settlement will result in deflections of the risers of approximately 0.4 percent. These deviations from vertical are not sufficient to adversely impact the functioning of the risers as the predicted deviations from vertical are relatively minor and occur in a uniform manner with fill height.

Lateral deformations and~~The estimated longitudinal~~ strains that may~~will~~ develop within the cover system~~geomembrane~~ due to long-term creep also were estimated from the results of the 2D finite-element modelling and summarized in Attachment D-13. The estimated lateral deformations were used to evaluate the potential for long-term creep to induced excessive strains on the cover geomembrane. The results indicated that strains induced by post-construction creep will be ~~differential settlement are~~ significantly less than the maximum strain the geomembrane is able to withstand.

The maximum tensile~~calculated longitudinal~~ strain developed in the geomembrane due to post-construction creep~~differential settlement~~ is estimated to be approximately two~~-and-a-half~~ orders of magnitude lower than the specified break strain for the LLDPE geomembrane. As such, the longitudinal strains induced in the geomembrane liner by creep settlement are considered acceptable and will not cause failure of the liner.

The estimated lateral deformations also were used to evaluate the potential for post-construction creep to cause excessive slippage between geomembrane layers in the non-welded cover geomembrane overlap at the drainage benches, which could result in development of a gap in the cover system geomembrane layer. The results of the evaluation indicate that, due to the flexible nature and relatively high interface shear strength of the textured LLDPE geomembrane material selected for cover construction, very little slippage (less than one inch) is expected at the non-welded overlaps at the drainage benches. Therefore, the proposed 5-foot overlap in these areas is considered sufficient.

D6.8 PIT 4 GLOBAL STABILITY

The results of global stability analyses of the final backfilled Pit 4 configuration are in Attachment D-5. The analyses are focused on global slope stability of potential failure surfaces located at moderate to large depths in the mine waste and foundation layers. The stability of the surficial cover system and potential for slope failures along cover interface elements are summarized in a separate attachment (Attachment D-7) and Section D10.5.

The proposed cover system will consist of a uniform soil layer overlying a geomembrane as shown on Drawing 4-83~~80~~. On steeper sloped areas of mine waste (greater than 15 percent), the cover system also will include a ~~geocomposite drainage layer (~~GDL~~)~~ between the soil and geomembrane layers to reduce potential pore water build up in the slope and increase slope stability. The extent of the GDL is shown on Drawing 4-19~~18~~. For the purposes of these global stability analyses, the soil cover was included, primarily to provide for a more complete accounting of weight forces, but localized, shallow failure surfaces within the cover layers were not considered in the global stability analyses. A 3-foot-thick cover soil layer was used in the analyses.

Criteria for minimum factors of safety for the stability of the final configurations for the mine WCA are specified in the CD SOW (EPA, 2011).~~.~~ These criteria include that a minimum factor of safety of 1.3 be maintained for static conditions and a minimum factor of safety of 1.0 be maintained under pseudo-static earthquake loading conditions. In addition, a post-earthquake analysis was made for the section selected since alluvial clays are thought to exist within the foundation. These clays likely are saturated and may experience strain-softening under earthquake loadings. In the post-earthquake analyses, the colluvium shear strength was modeled assuming (1) clay behavior, (2) sand behavior and (3) a conservative combination of sand-clay behavior. A minimum required factor of safety of 1.0 was selected as the design criteria for analysis of post-earthquake conditions.

Input parameters including section locations, sections geometries, material parameters, and seismic loading conditions are described in Attachment D-5. The results from the analyses of the backfilled Pit 4 containment area are summarized in Table D-14.

Table D-14 — Factors of Safety for Global Stability

Cross Section	Factor of Safety		
	Static	Pseudo-Static	Post-Earthquake
Design Criterion Minimum Factor of Safety	1.3	1.0	1.0
Pit 4 – Cross-Section 1	3.3	2.2	2.9 (clay behavior) 3.3 (sand behavior) 2.9 (sand-clay behavior)

These results indicate that the required minimum factors of safety for global stability are satisfied for the proposed final configuration at Pit 4 for the critical section that was analyzed.

D6.9 PIT 4 COVER SYSTEM

Typical surface cover details are shown on Drawings 4-83~~80~~ through 4-94~~86~~. The design criteria for the surface cover are common to all WCA. As such, the design calculations and details are described in Section D10. Specific design details for the tie-in of the Pit 4 surface cover into the Area 5 surface cover, to be completed later in Phase 2, is shown on Drawing 4-88~~83~~.

D7.0 PHASE 2 –PIT 3 WASTE CONTAINMENT AND BPA GRADING

Regrading of the BPA, regrading of Area 5, and initial waste containment~~Waste Containment~~ within Pit 3 will occur simultaneously and will result in a single contiguous, capped WCA. Therefore, with the exception of the groundwater dewatering systems in the BPA and Pit 3, all three work components are treated as a single entity. Below the construction activities follow a similar progression to those described in Section D6.0 and as a result, where construction elements and their designs are the same, the text below references previous discussions in Section D6.0.

D7.1 PIT 3 ROCKFALL PROTECTION

As discussed in Section D6.1, a Site visit and independent assessment of potential rockfall mitigation measures was performed by a specialist rockfall mitigation engineer/contractor. A recommended Rockfall Mitigation P~~p~~lan was developed by the specialist and is included as Attachment D-11 to this a~~A~~ppendix. The recommendations and conclusions for the designs for rockfall protection discussed for Pit 4 in Section D6.1 apply to Pit 3 as well.

D7.2 PIT 3 DEWATERING

Pit 3 will be dewatered prior to commencement of pit bottom cleanup. Peak accumulated water volumes in Pit 3 have historically ranged from 33 million gallons to 83 million gallons (WTP operating years 2001 through 2011), with an average peak storage of 58 million gallons. Based on these typical peak storage volumes, it is estimated that dewatering of Pit 3 could take approximately 80 days to complete. If necessary to meet the construction schedule, the Pit 3 dewatering time may be reduced considerably by drawing the water storage volume down in advance by extending the WTP operating schedule.

Water removed from Pit 3 during dewatering will be conveyed either directly to the WTP or to South Pond for intermediate storage prior to being conveyed to the WTP for treatment, depending on the WTP operating schedule at the time of dewatering.

D7.3 PIT 3 PIT BOTTOM CLEANUP AND GRADING

~~-~~Sediments that have accumulated in the Bottom of Pit 3 were characterized as part of the field investigations performed for the *Geologic Investigations of Pits and Assessment of Pit Sediments Design Investigation Report* (MGC, 2011b). As part of those investigations, Pit 3 was dewatered to the point where only the lowest point of the pit bottom~~,~~ near the drop cut along the western pit wall remained underwater. It was estimated that approximately 3,300 cubic yards of sediment cover the Pit 3 bottom, approximately 3-inches thick in the pit floor and a somewhat thicker layer around the perimeter of the pit floor. The sediments were noted to be predominantly saturated, silt-sized material with coarser material occurring around the margins of the pit floor. In addition to the fine-grained sediments in the pit bottom, some gravel to boulder-sized materials are located in isolated piles on the pit floor. It is anticipated that additional~~more~~ coarse rock material will accumulate on the pit floor as a result of pit-slope rock scaling operations. Cleanup operations will be similar to those described for Pit 4 in Section D6.3. The bottom of Pit 3 will be graded in preparation for placement of drain material as shown on Drawing 4-37~~35~~. An underdrain sump will be excavated by drilling and blasting in the low area located in northwestern portion of the pit bottom as shown on Drawing 4-37~~35~~ and 4-79~~76~~. Generally, the pit is sloped to drain to this area in its current configuration. As with Pit 4, areas where ponding may occur in the pit floor or otherwise will not flow by gravity toward the underdrain sump will be reworked to the extent possible without ripping, drilling or blasting.

Due to the nature of the rock formation in the pit bottom, aggressive reworking of the pit floor (e.g. ripping or blasting) to remove smaller irregularities (i.e. less than 2 feet high) that result in areas of ponding is likely to result in irregular rock breakout and creation of other areas of ponding. As a result, grading the pit bottom to a perfectly smooth, free-draining surface is considered unrealistic and unnecessary. Instead, if areas of ponding are noted during the jetting operation and can be removed by scraping the pit floor with the toothed bucket of a hydraulic excavator, this will be performed. In addition, the required minimum thickness of drainage layer in the pit bottom (discussed in the following section) will be maintained as measured above any high point or "sills" in the pit bottom that obstruct flow and create ponding. Thus any areas of ponding will be "dead pools" that form below the required minimum thickness of drainage layer and will not affect drain capacity.

Material removed during grading and sump excavation will be stockpiled along with the coarse rock material removed during pit-bottom cleanup as described in an approved Staging/Temporary Stockpiling Plan (~~in~~ Appendix R), and will be replaced in Pit 3 during backfilling. Due to their in-situ proximity to mineralized areas, material removed during grading and sump excavation will not be placed in zones within the Pit 3 backfill that have been designated for low-activity/reactivity waste.

D7.4 PIT 3 UNDERDRAIN SYSTEM

An underdrain system constructed of non-reactive rock will be installed in the bottoms of Pit 3 to collect groundwater before it contacts reactive mine waste backfill in the pits. The Pit 3 underdrain system will be similar to the Pit 4 underdrain system described in Section D6.4 and those details are not repeated in this section. The configuration of the Pit 3 underdrain system is shown Drawings 4-38~~36~~, 4-39~~37~~, 4-40~~38~~, and 4-41~~37~~. Performance criteria 2.4.2.4.2 E.iii of the SOW in the CD (EPA, 2011) stipulates that "The drainage layers shall extend vertically along the side walls of each pit to elevations determined during RD, to keep water entering the pits from contacting mine waste and to effectively channel water to the pit bottoms." Locations of pit wall seeps were mapped during late summer of 2010 as part of investigations for the Geologic Investigations of Pits and Assessment of Pit Sediments Design Investigation Report (MGC, 2011b) and additional seep mapping was performed in the spring of 2012 to provide data during wetter portions of the year (Plumley and Assoc., 2012). As communicated, both in the summary report and in the approved work plan for the spring 2012 seep mapping (MWH, 2012b): "*The specific objectives of the additional pit wall seep monitoring were to verify seeps previously* *identified in the Geologic Report; and identify new seeps in the pit walls above the existing water level that might be evident in the spring. Data gathered from this additional monitoring is intended to help define the positioning of drains that will be included in the remedial design for interception of pit wall seeps.*" The locations of seeps observed during these investigations are shown on Drawing 4-38~~36~~ and the slope drain configurations shown on this drawing are extended up the pit walls to intercept these seeps. At a minimum, the slope drains as shown extend a distance of 25 feet vertically above, and 50 feet horizontally beyond, the limits of these seep areas. In areas where mine waste will be placed directly against drain rock for the slope drains (see Drawings 4-38~~36~~ and 4-44~~42~~), only coarse-grained mine waste will be placed within 20-feet of the drain rock to protect from fines intrusion.

Details for the gradation requirements for the drain materials are developed in Attachment D-9 and summarized in Tables D-7 and D-8 in Section D6.4. As discussed in Section D6.4, the drain system has the capacity to conduct between 2.6 and 33.1 gallons per minute (gpm) per foot of drain width to the underdrain sump. Given the measured Pit 3 groundwater inflow rate ranged from 15.1 gpm to 19.9 gpm (MGC, 2011c), the underdrain system as designed has sufficient capacity in each 0.5 ft to 7.6 ft-wide section of underdrain to convey the entire estimated Pit 3 inflow to the underdrain sump at the minimum specified drain thickness. Therefore, the drain system placed over the bottom of Pit 3 will have much greater hydraulic capacity than the anticipated flows. The drain capacity on the pit slopes will be considerably higher due to the steeper gradients.

As shown in Section I~~O~~ on Drawing 4-39~~37~~, the underdrain as currently designed has a thickness considerably greater than the specified 5-foot minimum thickness at the critical location in the vicinity of the underdrain sump. Thus the actual as-designed capacity will be much greater. Based on these considerations, it can be concluded that the underdrain system, as currently configured, will have much greater flow capacity than is required to convey the measured groundwater flow rates reported in the *Groundwater Investigations Design Investigation Report (*MGC, 2011c).

As with Pit 4, water shall be kept from accumulating in Pit 3 during and after consolidation of mine waste within the pit to the extent practical. Water accumulating in the underdrain sump during, and after construction, will be conveyed for treatment at the WTP by pumping through an underdrain sump dewatering system. The underdrain sump will be dewatered using submersible pumps located in dewatering risers that connect the sumps to the ground surface.

Details of the dewatering riser design are described in Section D7.4. Similar to Pit 4, duplicate dewatering risers are proposed to avoid extended shutdowns in the dewatering system due to maintenance or mechanical failure during the RA and post-RA.

The underdrain configuration shown on the drawings provides approximately 370,000 gallons of storage (assuming an active porosity of 30 percent)~~%)~~ between the top of the sump and the lowest point in the overlying subwaste liner. This allows for approximately 15 days of storage within the underdrain system at an average estimated inflow rate of 17.5 gpm for Pit 3 without operating the underdrain dewatering system before the overlying bedding layer, liner system and waste rock are at risk of becoming saturated.

D7.5 BPA DEWATERING SYSTEM

The ~~Currently, the~~ two main backfilled pits in the BPA ~~are being dewatered as part of an ongoing BPA dewatering investigation~~ (i.e., the Boyd Pit and the smaller, upgradient Pit 2) were dewatered as part of a BPA dewatering investigation.~~).~~ The general location of these two pits are shown on Figure 1-3 in the BODR. Wells located in the two smaller pits associated with the BPA, the Adit Pit and Pit 2 currently are dry. The dewatering investigation was~~is being~~ conducted based on the approved work plan entitled, *Backfilled Pits Area Pumping Plan* (WME, 2013). This investigation provided~~is intended to provide~~ information regarding the configuration of dewatering wells and water levels to be maintained in the permanent BPA dewatering system. The two~~Two~~ existing dewatering wells, GW-54 (in the Boyd Pit) and GW-58 (in Pit 2) were~~are being~~ used for BPA dewatering, with~~ and~~ the groundwater from these wells ~~is~~ being piped to Pit 3 for storage prior to treatment. These are the same wells that were used in a previous BPA dewatering investigation performed in 1999 and 2000 (SMI, 2001, URS, 2002). The locations of GW-54 and GW-58 are shown on Drawing 4-54~~2~~.

The objectives of the investigation included:

1. Evaluating the operating condition of existing wells and equipment in Pit 2 and the Boyd Pit for use in initial dewatering of the BPA.
2. Initial dewatering in Pit 2 and the Boyd Pit to evaluate the effect of varying water levels and pumping schemes on groundwater water levels within the waste rock backfill and

surrounding bedrock to provide optimal water levels and dewatering well configurations for long-term dewatering of the BPA.

The initial phase of the BPA investigation consisted of testing the condition of Wells GW-54 and GW-58 and the associated piping and pumping systems to verify that they were operational and could be used for dewatering during the investigation program. This phase was completed in July 2013 and confirmed that the two dewatering wells and the associated equipment were functional. Pumping then commenced in GW-54, located in the larger, downgradient Boyd Pit in September 2013. Dewatering of the Boyd Pit was conducted in stages, with the groundwater level in the pit drawn down to predetermined levels and held at these lower level for a minimum of two weeks in order to measure inflow rate into the pit while maintaining a constant water level. Drawdown to the final stage within approximately 5 feet of the pit bottom was completed in late March 2014. Once the final drawdown stage in the Boyd Pit was attained, dewatering commenced in the smaller, upgradient Pit 2, while the pumping continued~~ing~~ in the Boyd Pit. Dewatering of Pit 2 also was conducted in steps and the final drawdown level was attained in late June 2014 (at approximately 3 feet above the pit bottom). In accordance with~~As indicated in~~ the approved Work Plan, ~~now that BPA~~ dewatering of the Boyd Pit and Pit 2~~has commenced, it~~ will be continued throughout the design process, the RA construction, and after construction.

The results of BPA dewatering have been presented in Data transmittal reports ~~from the BPA dewatering investigation have been~~ provided to EPA in Midnite Mine monthly reports beginning in August 2013 and are summarized in Attachment D-14.~~.~~ Generally, the results of BPA pumping confirm~~appear to be consistent with~~ the conceptual model of the Site hydrogeology presented in the *Backfilled Pits Area Pumping Plan* (WME, 2013). ~~Key components of the conceptual model include:~~

~~1. Evaluation of this post-mining topography (prior to backfilling) provides an indication of groundwater movement within the BPA. This post-mining topography indicates that Pit 2 was mined to a bottom elevation of approximately 2,734 feet above mean sea level (ft.-amsl), with the lowest point in the pit crest occurring along southerly edge of the pit at a ramp that leads south and downward toward the Boyd Pit. The conceptual model points out that if in-pit groundwater accumulates to an elevation of approximately 2,759 ft.-amsl, it begins to overtop at the low point along the southern edge of the pit crest and flow south down the ramp through the unconsolidated waste rock backfill and into the Boyd Pit.~~

~~2. The Boyd Pit's bottom elevation is approximately 2,654 ft.-amsl and the lowest point in the pit crest occurs along the southerly edge at an elevation of approximately 2,679. If the Boyd Pit groundwater accumulates to an elevation at, or above this low point, it overtops the pit crest and flows south through unconsolidated waste rock and alluvium to the southerly toe of the South Waste Rock Pile. It has been determined that subsurface flow from the BPA is contributing to the seeps in the vicinity of the PCP in the Central Drainage (Williams and Riley, 1996, SMI, 1999).~~

~~3. Previous investigations estimate groundwater inflow rates into Pit 2 and the Boyd Pit between 5 gpm and 7 gpm.~~

~~4.~~1. ~~Two smaller pits in the BPA (Pit 2 West and the Adit Pit) are located west of the topographic divide in the post-mining subgrade as shown on Drawing 4-2. As such, it is likely that they are part of the Western Drainage hydrologic basin as opposed to the BPA watershed in which Pit 2 and the Boyd Pit are located (i.e., the upper reaches of the Central Drainage).~~

The~~An initial evaluation of the preliminary results of the~~ BPA pumping investigation summary included as Attachment D-14 includes~~resulted in~~ the following conclusions~~observations~~:

1. The water levels ~~Mine waste backfill~~ in wells surrounding the Boyd Pit and Pit 2 indicate the pits act as~~appears to have a very high~~ hydraulic sinks when dewatered. In addition, water levels indicate Pit 2 acts as a hydraulic sink even without active pumping.
2. Long-term base inflow rates into the Boyd Pit and Pit 2 appear to be lower than previously estimated. The long-term late season (2014) inflow rates were ~~conductivity, with nearly identical water levels~~ measured to be approximately 2.5 gpm into the Boyd Pit, and the 2.0 gpm into Pit 2.
3. Pumping from the Pit 2 (GW-58)~~throughout~~ dewatering well did not significantly affect the direction of hydraulic gradients in the vicinity of Pit 2. Evaluation of paired deep and shallow wells in Pit 2 indicates flow from the deeper bedrock aquifer toward Pit 2 whether or not GW-58 was operational. This is likely due to the water-level control provided by the hydraulic connection to the Boyd Pit once a groundwater level above approximately 2,759 ft is reached in Pit 2.
4. There is connection between the groundwater levels measured in bedrock wells BOM-3M/BOM-3D and the dewatering of the Boyd Pit. However, additional pumping from Pit 2 did not have a noticeable effect on groundwater levels in BOM-3M/BOM-3D. Neither

pumping from the Boyd Pit, nor Pit 2 had a measureable effect on the shallow well BOM-3S.

5. Groundwater levels down gradient of the Boyd Pit at BOM-4 and GW-43 declined during the recent pumping campaign. Although it is possible this decline may be due to a decrease in the supply groundwater in the shallow buried alluvial channel down gradient of the Boyd Pit after the groundwater level in the pit dropped below the overflow elevation (2,679 ft); it may also be the result of normal seasonal variations. Additional pumping from Pit 2 during the later stages of the BPA dewatering program did not affect the rate of decline in groundwater levels at BOM-4 and GW-43.

1. Operation of the pumpback system during the testing period and the measured water chemistry at GW-54 and GW-58 indicate a potential for the formation of scale and potential fouling of the dewatering system (pumps and pipes). Therefore, routine maintenance of the dewatering system is recommended to ensure efficient operation.~~in monitoring well GW-56, which is located in the Boyd Pit approximately 200 feet south.~~

6. Based on the above observations and conclusions above, it appears that effective hydraulic control of the BPA groundwater system can be accomplished by pumping groundwater from the Boyd Pit only, and that pumping from Pit 2 can be discontinued. The volumetric rate of water capture when operating only the Boyd Pit pumping well (GW-54) at the later drawdown stages (6.6 gpm at elevation 2,662) was similar to the rate of capture when both the Boyd Pit and Pit 2 wells were operating, indicating little or no increase in capture efficiency by operating both well systems. This is consistent with the conceptual flow model based on BPA pre-backfill topography, which indicates water flowing from Pit 2 to the Boyd Pit.
7. It is recommended that an additional (redundant) dewatering well be installed in the Boyd Pit in the vicinity (within 25 feet) of the existing GW-54 dewatering well to provide a backup, and to limit the length of disruptions to operation of the dewatering system in the event of a catastrophic well failure.
8. The target operating water level range for the Boyd Pit dewatering system should be between 2,660 and 2,665 ft, which is sustainable as a groundwater level within this range was maintained for approximately 9 months during the BPA dewatering program in 2014.

9. It is estimated that the long-term, late-season dewatering rate (prior to capping of the BPA) will be approximately 4.5 gpm based upon the current combined flow rates from both the Boyd Pit and Pit 2. It is likely that the flow rates from the BPA dewatering system will decrease below this level once the area has been capped and isolated from infiltration of meteoric water above the BPA.

~~2. Over time pumping rates have decreased in the Boyd Pit while maintaining constant water levels. The constant-water-level pumping rate required at the first drawdown stage (elevation 2,679) in the Boyd Pit was approximately 7.3 gpm. A pumping rate of 6.6 gpm was needed to maintain a constant water level during the second drawdown stage at elevation 2,662.~~

~~3. It appears that a water level at, or below the level maintained during the second and final Boyd Pit drawdown stage (at approximately 2,662 ft) can be maintained in the Boyd Pit by pumping from GW-54.~~

~~4. The Mine waste backfill in the Pit 2 appears to have a lower hydraulic conductivity than the waste in the Boyd Pit because a relatively slow response has been observed in some wells (e.g. GW-53) that are within 50 feet of the Pit 2 pumping well (GW-58).~~

~~5. Pumping rates in Pit 2 necessary to maintain constant water levels have decreased over time similar to the Boyd Pit. The pumping rate required to maintain a constant water level in the GW-58 pumping well at the first drawdown stage (elevation 2,753 ft) in Pit 2 was approximately 4.4 gpm. At the second and final drawdown stage (elevation 2,743 ft) a pumping rate of approximately 3.2 gpm was needed to maintain a constant water level in the dewatering well.~~

~~6. A sharp decrease in inflow rate into the Boyd Pit was seen approximately 3 weeks after commencement of pumping from the upgradient Pit 2. Over time, the pumping rate from GW-54 in the Boyd Pit decreased from 6.6 gpm to approximately 4 gpm. Once the lowest drawdown stage was reached in the Pit 2 pumping well (GW-58), the combined pumping rates from both pits (7.2 gpm) was very similar to the pumping rates when only the Boyd Pit was being pumped (6.6 gpm to 7.3 gpm).~~

~~7.~~2. ~~With the exception of GW-57 in the Boyd Pit and BOM-12D in Pit 2, the bedrock wells in the BPA showed a slow response to pumping from the pits. With the exception BOM-3M and BOM-3D located in the ridge to the southwest of the Boyd Pit, all bedrock~~

~~wells in the vicinity of the two pits indicated hydraulic gradients toward the pits even before pumping commenced. Shortly after commencing pumping in the Boyd Pit, the hydraulic gradient in BOM-3M and BOM-3D indicated flow toward the Boyd Pit.~~

~~Preliminary conclusions drawn from the results of the BPA pumping investigation include that the conceptual model is correct in that once the groundwater level in Pit 2 reaches the level of the low point in southern perimeter of the pit, groundwater flows south along the buried access ramp from Pit 2 and into the Boyd Pit.~~

~~It appears that hydraulic control of the BPA can be provided by only dewatering from the Boyd Pit since very similar pumping rates were achieved when pumping from a single Boyd Pit dewatering well compared to when wells were pumped in both the Boyd Pit and Pit 2, As such, the current design of the permanent BPA dewatering design includes dewatering only from the Boyd Pit. It is recommended that the current BPA dewatering system continue to operate and be monitored prior to, and during Phase 1 and Phase 2 of RA construction in order to provide additional data concerning groundwater levels within and around the pits and hydraulic capture of individual dewatering wells. This additional data including potential seasonal variations should be used to further evaluate the concept of using a single dewatering well in Boyd Pit to provide hydraulic control for the BPA.~~

The ~~Based upon the preliminary results and conclusion from the BPA pumping investigation presented above, the~~ permanent dewatering system for the BPA will incorporate GW-54 in the Boyd Pit for continued use in the dewatering system. In addition, a second backup dewatering well will be installed in the Boyd Pit to provide redundancy in the permanent dewatering system. This second well will be of similar in design and construction, including:

1. Installation in a 10.5-inch nominal borehole, drilled across the waste/bedrock interface
2. 6-inch, Schedule 40 PVC well casing, with the lower 40 feet being screened ~~section~~ containing 0.020 inch milled slots.
3. Placement of 10-20 silica sand filter around the screened section to an elevation at least 10 feet above the top of well screen.
4. A~~Placing a~~ bentonite seal above the sand filter to the ground surface.

The backup well will be installed after completion of regrading of the BPA in the vicinity of GW-54 early in Phase 3 or RA construction. It is anticipated that the backup well will be installed within approximately 25~~30~~ feet of the GW-54 along the GW-54 access road as shown on Drawings 4-54 and 4-55~~52~~. It is also recommended that GW-58 be maintained as part of the permanent BPA monitoring~~dewatering~~ system to verify acceptable control of groundwater levels in Pit 2.

D7.6 PIT 3 SUB-WASTE LINER SYSTEM

Prior to placement of mine waste in Pit 3, a sub-waste liner will be installed over the underdrain system as shown on Drawings 4-40~~38~~ and 4-41~~39~~. The function of the sub-waste liner system is described in Section D6.5. Details of the proposed liner system are shown on Drawing 4-81~~78~~ and discussed in Section D6.5 and D9.0. The liner subgrade (i.e. underdrain surface) will be shaped as shown on Drawing 4-40~~38~~. The proposed grading for the sub-waste liner shown on Drawing 4-40~~38~~ will provide for gravity drainage of water that collects on the liner surface toward a waste dewatering sump located at the low-point of the liner surface. The waste dewatering sump will be dewatered by pumping from risers located within the sumps as discussed in Section D7.7.

D7.7 PIT 3 WASTE ROCK DEWATERING SYSTEM

The proposed Pit 3 waste rock dewatering system is shown on Drawings 4-40~~38~~, 4-44~~42~~, and 4-82~~79~~. The design and operation of the waste dewatering system is similar to that described for Pit 4 in Section D6.6 and those details are not repeated in this section. It is anticipated that flow rates to Pit 3 sub-waste dewatering sump will be highest during construction and that once the surface cover system is in place over the Pit 3 waste, the rates of water migration through the waste rock will diminish to very low levels as discussed in Section D10.0. As currently configured, the waste dewatering sump, with an estimated backfill hydraulic conductivity in the range of 7x10^{-1} to 9x10^{0} cm/sec and an effective sump radius of approximately 30 feet, will have much greater flow capacity than is required to convey the long-term infiltration rates estimated in the infiltration analyses summarized in Section D10.3.

D7.8 PHASE 2 PIT 3 MINE WASTE PLACEMENT/BPA REGRADING

Once the sub-waste liner has been installed in Pit 3, the pit and the BPA will be ready to receive mine wastes from various sources at the Site. In general, Pit 3 will contain most of the lower activity/reactivity waste sources at the Site listed in Table D-6. The configuration of Pit 3 as shown on the d~~D~~rawings, and the associated volumes listed in Table D-6 are for the maximized storage volume. As such, the waste storage capacity in the Pit 3/BPA WCA (15.4 million cy~~cubic yards~~) is much larger than the current waste volume estimate (11.1 million cy~~cubic yards~~), and the current configuration should be able to accommodate unanticipated wastes encountered during the final stages of the RA.

The configuration of the Pit 3 backfill upon completion of Phase 2 is shown on Drawings 4-42~~40~~, 4-44~~42~~ and 4-45~~43~~. As discussed in Section D7.0, regrading of the BPA, regrading of Area 5, and waste containment in Pit 3 will occur simultaneously and will result in a single contiguous, surface cover. Therefore, BPA regrading, Area 5 regrading, and Pit 3 backfilling are treated as a single work component.

The configurations shown on the drawings reflect surface grading details such as drainage benches, concave, geomorphic design of intrabench slopes, etc.

As proposed, the waste placement sequencing in Pit 3 during Phase 2 backfill operations will be as follows:

1) Sump drain rock in underdrain sump (D7.4)~~).~~
2) Underdrain gravel layer (D7.4)~~).~~
3) Sub-waste liner bedding (1.5” D_{max}) layer (D7.6)~~).~~
4) Geofabric for geomembrane cushion layer (D7.6)~~).~~
5) Synthetic geomembrane sub waste liner (D7.6)~~).~~
6) Fine-grained (1/4” D_{max} or finer) soil liner cushion layer (D7.6)~~).~~
7) Reject material from HSWRP~~.~~
8) Remainder of HSWRP material~~.~~
9) Pit 3 rockfall debris and pit-bottom grading spoils~~.~~
10) Sediments from cleanup of Pit 3 bottom~~.~~
11) Remainder of South Dump Material from the Western Drainage~~.~~
12) Contaminated soil cleanup from the Western Drainage~~.~~
13) Western Drainage Sediment Cleanup~~.~~
14) Existing WTP and other demolition debris
15) East Waste Rock Pile materials~~.~~
16) Contaminated soil cleanup from East Waste Rock Pile area~~.~~
17) Eastern and Far East Drainage Sediment Cleanup~~.~~
18) East Access Road Cleanup~~.~~
19) Other internal mine roads and contaminated soil cleanup~~.~~

These mine wastes will be hauled to Pit 3 in mine haul trucks or off-road dump trucks, dumped, and spread in horizontal lifts with maximum thickness of 10 feet. No additional compaction of the waste material is planned beyond that which results from spreading and incidental traffic over the waste surface by construction equipment.

D7.9 AREA 5 REGRADING

The area located between the uphill (northern) edge of Pit 3 and the downhill (southern) edge of Pit 4 is referred to as Area 5. This area is currently covered with waste rock with a relatively flat surface area that will be used for processing and stockpiling of drain rock material during Phases 1 and 2 of RA. Prior to mining, an alluvial channel cut through this area, sloping in a southerly direction, and into Pit 3. If waste rock were removed from this area to the pre-mine surface, as shown on Figure 12-1 of the ROD, an area of ponding with no surface drainage outlet would be formed immediately upstream of the Pit 3 WCA. This area of ponding would almost certainly result in seepage from into Pit 3. As a result, the plan for Area 5 is based upon grading this area to achieve a mounded, free-draining surface and covering it in a manner consistent with other waste areas (i.e. geomembrane cap and revegetated soil cover).

The configuration of the Area 5 surface upon completion of regrading is shown on Drawings 4-46~~44~~ and 4-47~~45~~. The surface cover will be tied into the Phase 3, Pit 3 cover and the Phase 1, Pit 4 cover as shown on Drawing 4-88~~83~~. The configurations shown on the drawings reflect surface grading details such as drainage benches, concave, geomorphic design of intrabench slopes, etc.

D7.10 PIT 3 PHASE 2 COVER SYSTEM

Upon completion of Phase 2 waste placement in Pit 3, a surface cover will be installed to the extent practical over those portions of the Pit 3 area where additional waste placement or regrading will not be occurring. This cover will serve to reduce the infiltration of meteoric water through the waste materials. As discussed in Section D7.8, the configuration of the Phase 2 Pit 3 backfill shown on Drawings 4-~~40, 4-~~42, 4-44, and 4-45~~43~~ reflects surface grading details such as drainage benches, concave, geomorphic design of intrabench slopes, etc. The cover design is described in Section D10.0. Specific design details for the tie-in of the Phase 2 - Pit 3 surface cover into the Pit 3 surface cover to be completed later in Phase 3, are shown on Drawing 4-92~~86~~.

D8.0 PHASE 3 –PIT 3 WASTE CONTAINMENT

D8.1 PHASE 3 PIT 3 MINE WASTE PLACEMENT

The configuration of the Pit 3 backfill upon completion of Phase 3 is shown on Drawings 4-55~~53~~, 4-59~~57~~ and 4-60~~58~~. The configurations shown on the drawings reflect surface grading details such as drainage benches, concave, geomorphic design of intrabench slopes, etc. The waste containment capacity of the configuration shown for Pit 3 at the end of Phase 3 is approximately 15,400,000 cubic yards.

As proposed, the waste placement sequencing in Pit 3 during Phase 3 backfilling will be as follows:

1) Debris from South Pond demolition.
2) Remainder of SWRP~~South Waste Rock Pile~~ material and PCP in Central Drainage.
3) Central Drainage soil and sediment cleanup.
4) Other contaminated soil cleanup.

These wastes will be hauled to Pit 3 in either mine haul trucks or off-road dump trucks, dumped, and spread in horizontal lifts with maximum thickness of 10 feet. No additional compaction of the waste material is planned beyond that which results from spreading and incidental traffic over the waste surface by construction equipment.

Mine Waste Settlement. As discussed in Section D6.7, settlement of the mine waste backfill results in deformation and strains in the final cover, as well as induces lateral displacement and drag-down forces on the underdrain and waste dewatering risers if not accommodated for in design and construction. Deformation analyses were performed for the Pit 3 mine waste ~~for the 90% design~~ using the same methods and assumptions presented in Section D6.7 for Pit 4.

A summary of the settlement for the two critical sections analyzed for Pit 3 are provided in Table D-15.

Table D-15 — Maximum Calculated Settlements in Pit 3 Mine Waste

Section	End of Construction (ft)	50 years (Creep) (ft)	Total (ft)
Pit 3 – Section A	4.6	6.4	11
Pit 3 – Section B	5.7	7.2	13

The calculated in-section lateral displacements in the underdrain and waste dewatering risers are provided in Table D-16. In addition, the total estimated horizontal displacement and deviation of the dewatering risers from vertical were calculated and the results are also summarized in Table D-16.

Table D-16 — Maximum Calculated Lateral Displacements at the Pit 3 Risers

Section	In-Section Displacement			Resultant Displacement			
	EOC (ft)	50 years (Creep) (ft)	Total (ft)	EOC (ft)	50 years (Creep) (ft)	Total (ft)	Deviation from Vertical
Pit 3 – Section A	0.96	1.7	2.7	0.97	1.9	2.8	0.6%
Pit 3 – Section B	0.13	0.78	0.9				

The maximum calculated geomembrane liner strains and differential settlements are provided in Table D-17. Analyses of the current (100% Design) Pit 3 cover and drainage bench design indicates that post-settlement bed slopes along the drainage benches will exceed 0.5 percent at all locations. This exceeds the minimum bed slope needed to convey stormwater from the WCA while providing sufficient freeboard against overtopping of drainage bench channels.

Table D-17 — Maximum Calculated Liner Strains and Differential Settlements for Pit 3 Cover

Max. Liner Strain (%)	Max. Differential Settlement (ft/ft)
0.33	0.027

The magnitude of the settlements listed in Table D-15 is considered reasonable for the evaluated loading conditions. Long-term maximum creep settlements of approximately 7.2 feet in Pit 3 are anticipated, however the differential settlement between adjacent points will be much lower. Overall, the estimated long-term creep settlements will not result in significant changes to the cover geometry or flow directions due to the relatively steep grades of the majority of the as-designed cover surface.

The amounts of lateral displacement of the underdrain and waste dewatering riser pipes due to construction loadings, and from long-term creep settlement will result in deflections of the risers of approximately 0.6 percent.~~%.~~ These deviations from vertical are not sufficient to adversely impact the ~~-~~functioning of the risers as the predicted deviations from vertical are relatively minor and occur in a uniform manner with fill height.

Lateral deformations and strains that may develop within the Pit 3 cover system due to long-term creep were estimated in a manner similar to that described for Pit 4 in Section 6.7 and are summarized in Attachment D-13. Like the Pit 4 analyses, analyses of lateral deformations and differential settlement indicate that deformations will not result in excessive strains developing within the cover geomembrane system, nor will they result in unacceptable slippage and separation at the non-welded overlaps at the drainage benches.~~The estimated longitudinal strains that will develop within the cover geomembrane due to long-term differential settlement are significantly less than the maximum strain the geomembrane is able to withstand. The maximum calculated longitudinal strain developed in the geomembrane due to differential settlement is two-and-a-half orders of magnitude lower than the specified break strain for the LLDPE geomembrane. As such, the longitudinal strains induced in the geomembrane liner by creep settlement are considered acceptable and will not cause failure of the liner.~~

D8.2 PIT 3 GLOBAL STABILITY

The results of global stability analyses of the final backfilled Pit 3 configuration are included in Attachments D-5. The global stability analyses are focused on potential failure surfaces located at moderate to large depths in the mine waste and foundation layers. The stability analyses of the surficial cover system and potential for slope failures along cover interface elements (veneer stability) are presented in a separate attachment (Attachment D-7) and summarized in Section D10.5.

The proposed cover system will consist of a uniform soil layer overlying a geomembrane as shown on Drawing 4-83~~80~~. On steeper sloped areas of mine waste (greater than 15 percent), the cover system will also include a ~~geocomposite drainage layer (~~GDL~~)~~ between the soil and geomembrane layers to reduce potential pore water build up in the slope and increase slope stability. For the purposes of these global stability analyses, the soil cover was included, primarily to provide for a more complete accounting of weight forces, but localized, shallow failure surfaces within the cover layers were not considered in the global stability analyses. A 3-foot-thick cover soil layer was used in the analyses.

Criteria for minimum factors of safety for the stability of the final configuration of the WCA are specific in the CD SOW (EPA, 2011).~~.~~ These criteria include that a minimum factor of safety of 1.3 be maintained for static conditions and a minimum factor of safety of 1.0 be maintained under pseudo-static earthquake loading conditions. In addition, a post-earthquake analysis was made for one section (Section 3) where it appears that alluvial clays may exist within the foundation. These clays likely are saturated and may experience strain-softening under earthquake loadings. In the post-earthquake analyses, the colluvium shear strength was modeled assuming: (1) clay behavior, (2) sand behavior and (3) a conservative combination of sand-clay behavior. A minimum required factor of safety of 1.0 was selected as the design criteria for analysis of post-earthquake conditions.

Input parameters including section locations, sections geometries, material parameters, and seismic loading conditions are described in Attachment D-5. The results from the analyses of the backfilled Pit 3 containment area are summarized in Table D-18.

Table D-18 — Factors of Safety for Global Stability

Cross Section	Factor of Safety		
	Static	Pseudo-Static	Post-Earthquake
Pit 3 – Cross-Section 2	2.9	2.0	-NA
Pit 3 – Cross-Section 3 (top of slope	3.0	2.1	3.0(clay behavior) 3.0 (sand behavior) 3.0 (sand-clay behavior)
Pit 3 – Cross-Section 3 (toe of slope)	2.3	2.0	2.6 (clay behavior) 1.7 (sand behavior) 1.6 (sand-clay behavior)

N/A – not applicable, as no alluvium clays are present in this section.

These results indicate that the required minimum factors of safety for global stability are satisfied for the proposed final configuration at Pit 3 at both critical section locations that were analyzed.

D8.3 PHASE 3 COVER SYSTEM

A surface cover will be placed over the remaining uncovered WCA upon completion of Phase 3 waste relocation and regrading activities. The configuration of the Phase 3 surfaces shown on Drawings 4-55~~53~~, 4-59~~57~~, and 4-60~~58~~ reflect surface grading details such as drainage benches, concave, geomorphic design of intrabench slopes, etc. Details of the cover design are presented in Section D10.0. Specific design details for the tie-in of the Phase 3 - Pit 3 surface cover into the Pit 3 surface cover that was completed in Phase 2, and the Pit 3 cover tie-in to the Area 5 cover area shown on Drawing 4-86.

D8.4 PHASE 3 DEWATERING SYSTEM

During Phase 3, French-drain style infiltration collectors will be installed at the toe of the waste backfill slopes in two locations as shown on Drawing 4-57~~55~~. The native ground surface at these two locations slopes toward the edge of the waste containment cover. The purpose of the infiltration collectors is to reduce the potential for head buildup beneath the liner at the waste/native ground contact in these two locations. Water in these collectors will drain by gravity to dewatering sumps located outside of the limits of waste containment cover. Water removed from the infiltration collectors will be conveyed to the WTP, either via the storage ponds or directly to the WTP, depending on WTP operating conditions at the time of removal.

D9.0 SUB-WASTE LINER/DEWATERING SYSTEM DESIGN

Sub-waste liners will overlie the drain rock in Pit 3 and Pit 4 as described in sections D6.5 and D7.6 and as shown on the d~~D~~rawings. The sub-waste liners in both pits have common design elements with common design considerations, which are summarized in this section.

The sub-waste liner will be placed over the underdrain and will serve to separate the overlying mine waste from the underdrain. The upper layer of the underdrain will consist of a minimum 1-foot thick layer of liner bedding material. The liner bedding material will consist of gravel processed from the HSWRP with a maximum particle size of 1.5 inches, and placed as the final lift on the surface of the drain rock to provide padding of the synthetic layers that follow. The required gradation for the liner bedding material is summarized on Table D-9 and the criteria used for development of this specification are summarized in Attachment D-9.

The proposed sub-waste~~subwaste~~ liner will consist of a:

1) Geofabric cushion layer placed over the liner bedding layer to provide additional puncture protection for the overlying geomembrane liner.
2) Geomembrane liner constructed from 80-mil HDPE geomembrane. HDPE was selected as the geomembrane material due to its resistance to degradation when exposed to a wide range of chemicals and durability under severe loading conditions.
3) Over-liner protection layer, consisting of a 3-foot minimum thickness of fine-grained material, with a maximum particle size of ¼ inches, in order to protect the geomembrane from damage due to waste loading or construction equipment.

Specific geomembrane design considerations including chemical compatibility of the selected geomembrane material with Site waters, and puncture resistance under anticipated waste loadings are discussed in the following sections.

D9.1 CHEMICAL COMPATABILITY CONSIDERATIONS

A review of the compatibility considerations between the HDPE geomembrane proposed for the sub-waste liner to chemical and radioactive degradation is summarized in Attachment D-2.

Water from two monitoring wells in the BPA (GW-54 and GW-58) are assumed to be representative of some of the most aggressive Site waters that might be in contact with the HDPE geomembrane liner and was therefore assumed in the evaluation.

Based on the results of water quality testing from the BPA wells, the primary constituents that may potentially have a detrimental effect on the proposed HDPE geomembrane are sulfuric acid and sulfates in the leachate solution. The values for these water quality parameters measured during design investigations in 2010 (MGC, 2011c) are:

- pH of approximately 3.5 to 4.0, and
- Sulfates concentrations of approximately 12,500 milligrams per liter (mg/L).

Available chemical resistance information for HDPE indicates that, at these concentrations, sulfuric acid and sulfates will not damage the liner. In addition, the HDPE geomembrane that has been proposed for the sub-waste liners will not be exposed to temperatures greater than about 20 degrees Celsius. Koerner (2005) lists HDPE as having “generally good resistance” to inorganic acids and salts at temperatures ranging from 38 to 70 degrees Celsius. Manufacturer’s literature notes that non-oxidizing acids and salts have little to no effect on an HDPE geomembrane (Poly-Flex, 2010). The literature also indicates that there is no mechanical or chemical degradation at sulfuric acid concentrations up to 50 percent and in high-sulfate solutions at temperatures ranging from 20 to 60 degrees Celsius (GSE, 2012). Based on review of available information, no measurable chemical degradation of the HDPE materials is expected for many hundreds of years.

Attachment D-2 cites a number of sources in the literature that document studies illustrating the compatibility of HDPE geomembrane liner material with acidic process solutions. Most of these studies are associated with municipal and industrial landfills; however, three studies that specifically address the compatibility of HDPE geomembranes with mine waste solutions containing low-pH mine water are discussed in Attachment D-2. All of these studies indicate that any chemical effects on the HDPE subwaste liner material properties would take many hundreds of years to occur.

Radioactive degradation of the 80 mil HDPE liner is not expected to be a concern based on S~~s~~ite-~~-~~specific~~-~~ gamma measurements that indicate upper bound radiation absorption for the geomembrane of 3000 rads over 1,000 years. This is significantly less than the 10^6 to 10^7 rads noted to be the lower bound for the start of polymer degradation. Additional discussion is provided in Attachment D-2.

D9.2 STRESS CONDITIONS/PUNCTURE PROTECTION

The sub-waste geomembrane liner protection requirements are evaluated in Attachment D-1. The potential for liner puncture and need for a geomembrane cushion layer are evaluated for liner bedding materials with angular particles and a maximum particle size (D_{max}) of 1.5 inches.

The results of the liner puncture design calculations are summarized in Table D-19. Table D-19 presents the required mass per unit area of geotextile cushioning for the maximum fill heights in Pit 3 and Pit 4 based upon the current detailed grading plan.

Table D-19 — Summary of Linear Puncture Protection Requirements

Location	Maximum Fill Height, Including Cover(ft.)	Geotextile Required for Puncture Protection
Pit 4	260	20 oz./s.y. NW GT
Pit 3	436	32 oz./s.y. NW GT

NW GT = nonwoven geotextile

The required protection for an 80-~~-~~mil HDPE geomembrane consists of a geotextile with a minimum unit density of 20 oz./yd^2 in Pit 4 to 32 oz./yd^2 in Pit 3 for a geomembrane overlying bedding material with a maximum particle size (D_{max}) of 1.5-inches. A geotextile cushion layer is not required when the geomembrane is in contact with fine-grained soil containing no material larger than ¼-inch in size such as the overliner protection layer.

D10.0 COVER SYSTEM DESIGN

Surface covers will be placed over Pit 4, Pit 3, the BPA, and Area 5 as described in Sections D6.9, D7.10, and D8.3, and as shown on the Section 4 Drawings in Volume II. The proposed cover system in all locations will consist of a:

1) Three-foot continuous soil cover layer without a separate topsoil or growth media layer based on an evaluation of Rhoads Borrow Area soil properties presented in the Revegetation Plan (Attachment D-12). These analyses indicate the Rhoads' soils will

provide a suitable plant growth media and no further amendment or additional topsoil is necessary.

2_ Geomembrane Layer. The geomembrane for the cover system will be 40 mil ~~linear low-density polyethylene (~~LLDPE~~)~~ with a textured top surface or similar.

3) ~~Geocomposite drainage layer (~~GDL~~)~~ on areas of mine waste that are sloped at steeper than a 15 percent grade. The GDL will be installed between the soil and geomembrane layers to reduce potential pore water build up in the slope to enhance slope stability.

LLDPE geomembrane material was selected for the surface cover system due to the flexibility of the material, which allows the material to undergo large strains without damage. This material was also selected based on the interface shear strength with the proposed cover borrow soil and with a GDL. The design details and calculations presented in this section are common for the entire WCA at the Site.

D10.1 COMPATIBILITY CONSIDERATIONS

A review of the compatibility of the LLDPE geomembrane proposed for the cover system to chemical and radioactive degradation is included in Attachment D-2.

Chemical compatibility for the cover geomembrane is less of a concern than for the liner system geomembrane. As noted in the *EPA (Draft) Technical Guidance For RCRA/CERCLA Final Covers* (EPA, 2004):~~:~~ **“***It is important that the requirements of a GM for a liner system not be confused with requirements for a cover system. In a typical liner system application, the GM is exposed to leachate and subjected to relatively high normal stresses. Replacement or repair of the GM after waste placement is not typically possible*.”~~” (EPA, 2004).~~

Leachate exposure for the cover geomembrane will be in the form of condensate on the bottom side of the geomembrane. The upper side of the geomembrane will have exposure to only meteoric water. The condensate that the cover geomembrane will be exposed to is expected to be much less aggressive than the leachate from the BPA described in Section D9.1.

Radioactive degradation of the LLDPE is not expected to be a concern based on site specific gamma measurements that indicate upper bound radiation absorption for the geomembrane of 3000 rads over 1,000 years. This is significantly less than the 10^6 to 10^7 rads noted to be the lower bound for the start of polymer degradation.

D10.2 RADON MODELING

Attachment D-3 summarizes the radon modeling that was performed as part of the surface cover design. The performance standard used for cover design is the U.S. Nuclear Regulatory Commission (NRC) average long-term radon emanation standard of 20 picocuries per square meter per second (pCi/m^2-sec). The proposed surface cover system consists of a uniform soil material overlying a geomembrane above mine waste with a relatively low activity concentration of radium-226. The geomembrane was not included in the analyses. Radon modeling was performed for the selected borrow source for the cover material (Rhoads Property Borrow Area).

The thickness of the reclamation cover needed to limit radon emanation from the backfilled pits was analyzed using the NRC RADON model (NRC, 1989). The model utilizes the one-dimensional radon diffusion equation, which uses the physical and radiological characteristics of the mine waste and overlying materials to calculate the rate of radon emanation through the cover. The model was used to calculate the cover thickness required to limit the radon emanation rate through the top of the cover to 20 pCi/m^2-s, following the guidance presented in NRC publications NUREG/CR-3533 (NRC, 1984) and Regulatory Guide 3.64 (NRC, 1989). The rate of emanation standard is applied to the average emanation over the entire surface of the backfilled pits.

Model input parameters, including soil and waste properties are discussed in detail in Attachment D-3. The results of radon modeling are shown on Table D-20. Included with these results is the thickness for the cover soil needed to reduce the rate of radon emanation to values below the limit of 20 pCi/m^2-s averaged over the entire WCA surface. The results also indicate that a cover thickness of 1.8 feet of Rhoads Property b~~B~~orrow material will be sufficient to limit radon emanation acceptable levels. However, it is recommended that a minimum cover thickness of 3.0 feet be used based upon slope stability, liner protection, and construction considerations.

Table D-20 — Summary of Radon Modeling Results

Model Parameters	Model Layer	
	Layer 1 **Mine Waste**	**Layer 2** **Cover**
Porosity	0.38	0.38
Specific Gravity	2.83	2.63
Dry Density (g/cc)	1.76	1.63
Radium-226 Activity Concentration (pCi/g)	32	0
Emanation Coefficient	0.35	0.35
Long-Term Moisture Content (%)	5.4	10.4
Calculated Radon Diffusion Coefficient (cm^2/sec)	0.0296	0.0142
Required Cover Thickness (cm)	----	53 (1.8 ft)

D10.3 INFILTRATION ANALYSIS

This section summarizes the results of analyses of infiltration through the cover system proposed for the Site. Details of the infiltration analyses are provided in Attachment D-4. These analyses were conducted to evaluate percolation (leakage) through the cover system under:

1) As-constructed conditions with the geomembrane intact
2) Long-term degraded conditions when the geomembrane has degraded and is no longer effective at limiting percolation.

For the as-constructed case, percolation through the cover system and into the underlying waste materials was assumed to occur through small defects in the geomembrane. For the infiltration analyses, the WCA cover was divided into three distinct areas depending on surface geometry and cover system components as listed in Attachment D-4.~~- .~~ Separate percolation calculations were made for each of these areas, and a composite, area-weighted percolation rate was calculated for the entire cover system.

In order to evaluate upper-~~-~~bound percolation conditions in the extreme long-term for degraded liner conditions, analyses were made assuming the geomembrane~~GM~~ and GDL no longer exist or have no effect on the hydraulics of the cover system and percolation would flow unimpeded through the bottom of the soil cover. As with the analyses of as-constructed conditions, the WCA cover was subdivided based upon surface drainage conditions as listed in Attachment D-4. The composite percolation rate through the cover system for the upper-~~-~~bound long-term degraded conditions was then calculated as the sum of the weighted area leakage rates.

Infiltration modelling was performed using one-dimensional numerical models to provide input for the cover leakage calculations. Runoff was incorporated in the 1D~~1-D~~ model for sloped surfaces by not allowing surface water to pond on the climate boundary (ground surface) if the 24-hour precipitation exceeded the 24-hour infiltration rates. The development of the numerical model is described below. Recommendations provided in NUREG/CR-7028 (Benson et al., 2011) and Albright et al. (2010) for modeling water balance covers were followed where applicable. Infiltration analyses were conducted using the computer program Vadose/W (Geo-Slope International, Ltd, 2012). Vadose/W is a finite-element-based program that can be used to model movement and distribution of pore water within porous material. Model input data including climate data, soil properties, and vegetation properties are presented in detail in Attachment D-4.

Infiltration simulations were performed for typical and wet period climate conditions. Typical conditions were represented by modeling one typical year, with analyses started using the initial conditions developed as described in Attachment D-4. Wet year conditions were analyzed based upon the third of three consecutive wet years following a typical year, and using initial conditions developed as described in Attachments D-4. The results are presented below.

The cumulative percolation through the cover for as-constructed conditions are presented in Table D-21. Sensitivity simulations included cases to evaluate the influence of cover thickness on calculated infiltration rates. The results show that the cover system as designed and under as-constructed conditions will reduce infiltration to 0.015 percent or less of annual precipitation under both typical and wet year climate conditions. As discussed in Attachment D-4, the majority of the percolation occurs in the relatively flat drainage bench areas where flow concentrations and surface ponding may occur. As a consequence, a secondary low-permeability barrier in the form of a GCL has been included in the design details for the drainage bench channel bottoms as shown on Drawing 4-85~~81~~.

Table D-21 — Infiltration Model Results for As-Constructed Conditions

Cover Thickness (ft)	Percolation through cover (mm/yr)		Percolation as Percent of Annual Precipitation (%)	
	Typical Year Climate Conditions	Wet Period Climate Conditions*	Typical Year Climate Conditions	Wet Period Climate Conditions*
2	0.030	0.109	0.006	0.017
3	0.016	0.097	0.003	0.015
6	0.052	0.168	0.011	0.026

*Results are for the final model year of three consecutive wet years following a typical climate year.

As an upper bound (i.e., worst case) estimate for percolation through the cover system under long-term conditions, the cover system was modeled assuming the geosynthetic layers will completely degrade and no longer have any effect on the hydraulic characteristics of the cover system (i.e. the effects of the geomembrane and GDL layers are completely ignored). The results for these analyses and summarized in Table D-22. The results show that a 3-foot cover system using Rhoads Property borrow soils (which is the designed thickness) will reduce infiltration to approximately 0.7 percent of annual precipitation under typical year, and approximately 2.3 percent of annual precipitation under wet year climate conditions.

Table D-22 — Infiltration Model Results for Long-Term Degraded Conditions

Cover Thickness (ft)	Percolation (mm/yr)		Percolation as Percent of Annual Precipitation (%)	
	Typical Year Climate Conditions	Wet Period Climate Conditions*	Typical Year Climate Conditions	Wet Period Climate Conditions*
2	5.90	16.41	1.25	2.51
3	3.09	15.17	0.66	2.32
6	2.00	14.19	0.42	2.17

*Results are for the final model year of three consecutive wet years following a typical climate year.

D10.4 EROSIONAL STABILITY

The results of erosional stability analyses for the cover system proposed for the RA Construction at the Midnite Mine are presented in this section. Details of the analysis procedures and input parameters are presented in Attachment D-6.

The most critical slopes for evaluating erosional stability are the steepest interbench slopes with the longest uninterrupted slope runs. The proposed side slope geometry for the cover slopes includes drainage benches at a 50-foot vertical spacing. The steepest intrabench slopes will be 3H:1V. The drainage benches will be shaped to provide a drainage channel on the bench surface and prevent over-crest runoff.

Erosional stability analyses were performed for the borrow source selected for cover material, the Rhoads Property Borrow Area. Material properties used in the analysis for these soils are included in Attachment D-6.

Erosional stability of the cover was evaluated for the 100-year, 24-hour storm event (EPA, 2011). The Rational Method as outlined in WDOE (2004) was used to calculate peak flows from the design storm.

The erosional stability of vegetated slopes was evaluated using the methods recommended in NRC (1990) and Johnson (2002). Temple et al. (1987) outlines procedures for grass-lined channel design. It is assumed that the soil covers will not be erosionally stable, and that repair and maintenance will be required if the design storm event occurs prior to vegetation being established on the soil cover. Therefore, the stresses were only evaluated for the condition where vegetation has been established. The erosional stability of the cover surfaces was evaluated by calculating a factor of safety against erosion due to the peak runoff from the 100-year, 24-hour storm event. The surfaces were evaluated for two conditions: 1) resistance of the vegetation, and 2) resistance of the cover system soil layer. The peak unit discharge flow was conservatively multiplied by a flow concentration factor of three.

Calculated factors of safety for erosional stability are presented in Table D-23. Calculated factors of safety less than 1.0 are an indication that a specific failure mode (either soil erosion or vegetation loss) can be expected during the design storm event. For the cover slopes, the calculated factors of safety show that for established vegetation conditions, slopes will be erosionally stable during peak discharge from the 100-year, 24-hour storm event.

Table D-23 — Factors of Safety for Erosion Protection of Cover

Interbench Slope	Description of Erosion Protection	Factor of Safety for Soil on Vegetated Slope	Factor of Safety for Vegetation
3H:1V	Vegetation and Top Soil	16.4	1.1

These analyses indicate that cover slopes constructed as vegetated slopes without rock for erosion protection will be erosionally stable once vegetation has been established. The calculated factors of safety for both soil erosion and vegetation loss are above 1.0.

Soil loss estimates from the surface covers for sheet flow were estimated for a 1,000-~~-~~year period using Version 2 of the Revised Universal Soil Loss Equation (RUSLE2) as summarized in Attachment D-6. The vegetation conditions assumed for the 1,000-~~-~~year time period varied from bare ground for the initial two years, to cool season grasses with poor stand for the remaining years. The parameters used in, and results of, the analyses are summarized in Table D-24. The results show that the expected surficial soil loss is not significant and is calculated to be less than one inch over the 1,000~~1000~~-year period analyzed.

Table D-24 — Summary of RUSLE2 Model Parameters and Results

Model Parameter	Value
Soil Texture	Sandy Loam
Climate	Stevens County, WA Annual Precip.18 – 20 inches
Cover Slope (%)	33
Cover Slope Length (ft)	171
Vegetation Conditions	
Initial two years	bare ground
2 to 1,000 years	cool season grasses (poor stand)
Soil loss for bare ground conditions with rough surface (tons/acre/year)	14.00
Soil loss for cool season grasses (poor stand) vegetation conditions (tons/acre/year)	0.12
Soil loss (inches/1,000 years)	**0.74**

D10.5 VENEER STABILITY

This section summarizes the results of slope stability (veneer) analyses that were conducted for the cover system that will be placed over the mine waste as part of the RA at the Site. This analysis is presented in Attachment D-7.

The cover system will consist of a uniform soil layer overlying a synthetic geomembrane. On steeply sloped areas (greater than 15 percent slopes), the cover system will also include a ~~geocomposite drainage layer (~~GDL~~)~~ between the soil and geomembrane layers. The GDL layer was added based on results of veneer stability analyses that indicated that stability is not satisfactory for steeper slopes if significant positive pore pressure develops above the geomembrane. The borrow source selected for the cover material, Rhoads Property Borrow Area, was evaluated.

Analyses were performed for: 1) drained conditions under static and pseudo-static loading, and (2) saturated conditions under static loading. For drained conditions, the GDL is assumed to have adequate capacity to preclude the development of positive pore pressures on the geomembrane liner and within the cover soil. The longest 3H:1V interbench cover slope was selected for evaluating the drained conditions. For saturated conditions, the slope angle resulting in a factor of safety of 1.3 was back calculated under static conditions assuming the cover soil is fully saturated. The back calculation of the slope angle for saturated conditions was used to estimate the slope angle at which the slope would become unstable if a GDL layer is not included and the soil cover becomes fully saturated.

The failure (sliding) surface is assumed to occur along the weakest interface, which corresponds to the surface with the lowest interface shear strength. Consequently, when a GDL is included in the cover system, the failure surface is assumed to occur along the GDL and geomembrane interface based upon the previous test results (MGC, 2011a) and experience on other projects that indicate the interface strengths for the mine soil-geosynthetic interfaces will be higher than for the GDL-geomembrane interface.

Analyses of stability in areas where a GDL is included in the cover system were used to back-calculate the minimum interface shear strength (as represented by an angle of interface friction and no adhesion) needed to meet project slope stability criteria. The results for required interface strength can then be used to evaluate the suitability of various geomembrane liner and GDL combinations in terms of required interface shear strength. The results of the analyses are presented in Table D-25. The project requirements for minimum factors of safety are 1.3 under static conditions and 1.0 under pseudo-static conditions as outlined in EPA (2011). For drained conditions, the minimum interface frictions angles needed to meet the project factor of safety requirements are 22.0° and 23.0° for static and pseudo-static conditions, respectively.

Table D-25 — Factors of Safety for Veneer Stability

Failure Surface	**Back-Calculated Minimum Required Interface Friction Angle**	
	Peak (used for static loading conditions, FS = 1.3)	**Post-Peak (used for pseudo-static loading conditions, FS = 1.0)**
GDL to Geomembrane Interface	22.0	23.0

For saturated conditions, the steepest slope that will still result in a factor of safety of 1.3 under static loading is approximately 9 degrees (16 percent). As a result, the cover system in areas steeper than 15 percent will include a GDL to prevent pore water buildup and increase slope stability. Top cover slopes which have flatter slopes (less than 15 percent) will not require a GDL except for the top cover slope of Pit 3 where there is a drainage swale and concentrated flows may occur. The extents of GDL coverage over the Pit 4 and Pit 3 WCA are shown on Drawings 4-19~~18~~ and 4-58~~53~~ respectively.

GDL/Geomembrane interface strength testing was conducted, using site specific soils as substrate and superstrate in the test setup, as part of the 60% design to measure interface strength parameters for the specific materials considered for construction. The results of the testing are summarized in Attachment D-7 and in Table D-26.

Table D-26 — Results for Measured Interface Friction Angles for Materials

Failure Surface	Friction Angle	
	Peak	Post-Peak
PVC/Single Fabric-Sided Geocomposite	18.3	16.3
PVC/Double Fabric-Sided Geocomposite	21.0	21.6
LLDPE/Single Fabric-Sided Geocomposite	18.5	15.9
LLDPE/Double Fabric-Sided Geocomposite	34.0	25.4

Based on the testing results, the interface friction angle for a LLDPE geomembrane/double fabric-sided drainage geocomposite does meet the minimum required interface friction angle to needed to satisfy veneer stability design criteria. Testing was also conducted for the interface between a 40 mil LLDPE Agru Super Gripnet Liner and geotextile. Although the test results indicate significant curvature in the failure envelop, which precludes simplified interpretation of interface strength using a friction angle, the test results indicate that a 40 ~~-~~mil LLDPE Agru Super Gripnet Liner/geotextile interface will meet the minimum shear strength requirements for veneer stability over the range of potential cover loadings. Additional discussion on the testing results is provided in Attachment D-7. Neither the PVC geomembrane tested with a single and double-fabric faced GDL nor the textured LLDPE geomembrane tested with a single-fabric-faced GDL met the interface strength criteria.

D10.6 REQUIRED GEOCOMPOSITE (GDL) CAPACITY

This section summarizes the seepage transmission capacity requirement for the ~~geocomposite drainage layer (~~GDL~~)~~ that is to be placed over steeper sloped surfaces of the cover system for the RA Construction at the Midnite Mine.

The design method used for estimating the acceptable transmissivity of a geocomposite drain is presented in Koerner (2005). This method was used in conjunction with the peak weekly percolation rate into the GDL at the base of the soil cover calculated as part of the infiltration analysis (Attachment D-4). The results present an upper bound value for the required GDL capacity. The peak weekly percolation rate calculated from the infiltration analysis is 29.73 millimeters/day. Two slope sections were evaluated and included: (1) the longest length for the steepest slope; and (2) the longest length for slopes steeper than 15 percent. As surface ponding is unlikely for either of these slope configurations, these GDL capacity analyses are considered to be conservative. Table D-27 lists the minimum recommended laboratory measured transmissivity values for the GDL.

Table D-27 — Summary of Recommended Minimum Laboratory Transmissivity Results

Slope	Gradient	Cover Loading (psf)	Recommended Minimum Laboratory Measured Transmissivity, θ_{ult} (m^2/s), for GDL
5.4H:1V	0.2	< 1000	9.3×10^{-4}
3H:1V	0.3	< 1000	3.4×10^{-4}

m^2/s = square meters per second; GDL = geocomposite drainage layer

D11.0 REVEGETATION OF DISTURBED AREAS

The revegetation approach for the Site during the RA is described in the Revegetation Plan provided as Attachment D-12. The Revegetation Plan includes:

- A description of the borrow source soil
- Where and where not additional soil will be necessary off the WCA
- Revegetation techniques in various disturbed area
- Appropriate seed mixtures and the use of shrub and tree seedlings
- Necessary inspections and maintenance, along with a weed management plan.

The Revegetation Plan divides the Site revegetation into four distinct areas based primarily on the slope angle that will be revegetated using different approaches. The areas described in the plan include the WCA, flat-lying disturbed areas, steeper areas that are greater than 3:1 (h:v) but flatter than 2:1 (h:v), areas steeper than 2:1 (h:v), and downstream drainages. Each area of these areas has distinct revegetation approaches related to soil layers, plant species, and mulching techniques that are recommended to establish self-sustaining native plant communities and meet the proposed land use goals of suitable wildlife habitat and traditional land uses.

D12.0 SURFACE WATER AND STORMWATER MANAGEMENT AND CONTROLS

The Mine Waste Excavation and Containment design provides for capture and treatment of mine-impacted surface water and stormwater, and for clean water to be shed away from contaminated areas. Appendix F and Section 6 of the drawings in Volume II describe the Surface Water and Sediment Controls, which will be used to shed clean water away from contaminated areas at the end of each of the three major phases of RA construction. The Master SWMP (included in Appendix O) identifies BMPs that will be applied to reduce the adverse impacts of stormwater and specific sediment control measures that will be employed before, during, and after construction for both sediment and stormwater control. The RA Contractor will be

~~As~~ required to prepare a CSWPPP that presents ~~by the SOW in~~ the stormwater management protocol and procedures that are specific to the phased construction activities. The RA Contractor's CSWPPP will reference the Master SWMP for general stormwater management practices and will identify the BMPs that are applicable to the scheduled construction activities. The CSWPPP~~CD, this SWMP~~ will be updated on an annual basis, at a minimum, and will describe the intermediate phases and temporary facilities to be employed in storm water and surface water management as construction progresses. With a few specific exceptions (e.g., sediment cleanup within drainages) ~~this work will not occur within surface water bodies.~~ To the maximum extent practical, sediment cleanup within drainages will be conducted within drier parts of the year (summer and early autumn) to avoid unnecessary impacts to surface water bodies.

To the extent practical, above-grade mine waste excavations and excavation of underlying contaminated soils will be conducted beginning with upstream areas within each drainage and working in a downstream direction, with the working excavation areas being shaped to retain surface water runoff. In areas where this is not possible, other BMPs will be utilized to minimize the transport of potentially contaminated sediments from the work areas by surface water runoff. ~~The SWMP at the 90% Design level is contained in Appendix O and contains a BMP catalog, including BMPs to control surface water and minimize the transport of sediments during construction.~~~~With a few specific exceptions (e.g., sediment cleanup within drainages)~~ work will not occur within surface water bodies. ~~To the maximum extent practical, sediment cleanup~~

~~within drainages will be conducted within drier parts of the year (summer and early autumn) to avoid unnecessary impacts to surface water bodies.~~

Mine-impacted~~The SWMP describes the procedures for characterization and disposal of~~ sediments captured in the ~~by surface water and~~ stormwater BMPs will be characterized and, if above sediment cleanup levels, consolidated with the mine wastes.~~.~~ Maintenance and monitoring requirements for surface and stormwater controls is described in the Operations Maintenance and Monitoring Plan (OM&M Plan~~OMMP~~) in Appendix P.

D13.0 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

The ~~Below are the green and sustainable remediation (~~GSR~~)~~ considerations for the~~Appendix D –~~ Mine Waste Excavation and Containment activities are presented below.~~.~~ GSR considerations were evaluated for: 1) Construction Materials (characteristics and manufacturing considerations), 2) Construction Methods, and 3) Low Impact/Sustainability measures undertaken during construction.

D13.1 CONSTRUCTION MATERIAL CONSIDERATIONS

The sub-waste liner and cover liner materials were carefully selected based on chemical compatibility and protection from punctures and stress/strain conditions. These characteristics will help ensure long-term viability and environmental protection.

The Rhoads Property Borrow Area soils were selected as the borrow source for the cover material because the fine-grained material: 1) promotes vegetation growth, 2) minimizes the final cover thickness based on radon emanation evaluations (which in turn reduces the number of truck loads to cover the Site), and 3) provides an erosionally stable cover material (which likely will require less long-term maintenance).

The most significant GSR opportunity regarding the cover material borrow source is limiting fuel consumption and greenhouse gas emissions associated with necessary truck haul distances. The Rhoads Property Borrow Area is located adjacent to the RA (where the covers will be installed). The proximity of the Rhoads Property Borrow Area significantly reduces the fuel required to transport the cover soils to the Site thereby significantly reducing the greenhouse gas emissions. The total number of truckloads necessary to cap the Site has been minimized by selecting the Rhoads Property Borrow Area soils versus other borrow sources that~~which~~ would likely require a thicker cover. Rhoads Property soil also provides a more favorable growth medium for plants and is less erosive than the other borrow sources evaluated, all of which support GSR principles.

D13.2 CONSTRUCTION METHODS

Mine waste will generally be excavated, transported, and placed in the mine WCA in the pits in a continuous operation, without stockpiling excavated material. Additionally, the excavation and hauling equipment used will be appropriately sized. These methods minimize the double handling of excavated materials, greenhouse gas emissions, fugitive dust generation, and erosion.

The proposed use of suitable material from the on-site HSWRP for the drainage layers underlying Pit 3 and Pit 4 prevents excavation and hauling of 515,000 cy of suitable material from an off-site borrow area. The benefits in reduced vehicle traffic, greenhouse gas emissions, fugitive dust generation, and erosion are substantial. The use of on-site materials also prevents habitat destruction at an off-site borrow location.

The proposed phasing of construction activities will avoid the recontamination of remediated areas. In addition, mine waste excavations will be completed beginning at the upstream end of the drainages and continue in a downstream direction thereby resulting in “clean” drainages. The added benefit of excavating in this manner is that any precipitation that falls during the work will be contained at the working face of the excavation and avoid contaminating downstream locations. Sediment cleanup within drainages will be conducted within the drier parts of the year to avoid unnecessary impacts to surface water bodies and wildlife.

Dust suppression will be utilized in the work areas~~area~~ and on the access roads to decrease visible dust related emissions. On-Site vehicle speeds will be restricted to accommodate safe roadway conditions based on roadway grade, roadway soil conditions, roadway congestion, and the need to limit air emissions caused by roadway fugitive dust. Dust suppressant water used for the construction and excavation activities likely will be taken from the WTP effluent, thus significantly reducing the need to import water to the Site from great distances. Dust suppressant additives likely will be used on semi-permanent access roads or haul roads, subject to prior EPA approval.

Construction workers will be instructed to avoid engine idling and using machinery with automatic idle-shutdown devices will be suggested. ~~On-site vehicle speeds likely will be limited~~

~~to 20 miles per hour to limit air emissions and fugitive dust.~~ Ultra-low sulfur diesel will be used in excavation and hauling equipment as well as support vehicles.

The ~~Storm Water Management Plan (~~SWMP (~~;~~ included in Appendix O) identifies ~~Best Management Practices (~~BMPs~~)~~ and specific sediment control measures that will be employed before, during, and after construction for both sediment and storm water control. The Surface Water and Sediment Controls will be used to shed clean water away from contaminated areas thereby reducing the volume of mine-impacted water requiring treatment and will contain contaminated water within the contaminated areas preventing recontamination of remediated areas.

D13.3 LOW IMPACT DEVELOPMENT/SUSTAINABILITY

A thoughtful approach was taken to optimize the route of the access roads from the excavation location to the disposal location to minimize Site disruption and vehicle mileage.

Maintaining a single point of entry/exit to the MA helps prevent re-contamination of areas already remediated or contamination of areas that were previously uncontaminated. This single point of entry/exit also minimizes the required support facilities and associated infrastructure.

Carpool locations in Wellpinit, Ford, and Spokane for worker transportation to and from the MA during excavation and construction activities will reduce traffic to and from the Site, fugitive dust generation, gasoline and diesel use, and greenhouse gas emissions.

Areas cleared of mine waste will be graded to conform to the pre-mining topography to restore the natural pre-existing landscape to the extent practical while meeting reuse goals. Mimicking rather than altering the Site’s natural setting will improve the cover’s long-term performance and protect local ecosystems.~~ecosystem services.~~ Revegetation efforts with an approved, native seed mix will commence promptly after excavation and construction activities are complete to restore habitat, improve infiltration, and reduce soil erosion.

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Attachment D-1

Liner Puncture Protection

Attachment D-2

Cover and Liner Geomembrane Compatibility

Attachment D-3

Cover Design, Radon Emanation Modeling

Attachment D-4

Cover Design, Infiltration Analyses

Attachment D-5

Global Stability Analysis

Attachment D-6

Erosional Stability Analyses

Attachment D-7

Cover System Veneer Slope Stability Analyses

Attachment D-8

Cover Design, Geocomposite Capacity Requirement

Attachment D-9

Filter and Hydraulic Conductivity Calculations for Pit 3 and Pit 4 Sub-Waste Liner Bedding and Drain Gravel

Attachment D-10

Filter Calculations for Pit 3 and Pit Waste Dewatering Sumps

Attachment D-11

Report from Rock Solids Solution – Midnite Mine Rockfall Mitigation Plan

Attachment D-12

Revegetation Plan

Attachment D-13

Cover Deformation Analysis

ATTACHMENT D-13

MIDNITE MINE REMEDIAL ACTION COVER DEFORMATION ANALYSIS

Revisioning

Rev.	Date	Description	By	Checked	Date	Reviewed
0	*9-Jul-2014*	*90% Design*	*Christine Weber and Brad Sick*	*P. Boodagh and Melanie Davis*	*18-Jul-2014*	*Tom Kelley*
1	*3-Jun-2014*	*100% Design*	*Christine Weber, Brad Sick, and Stephen Goodwin*	*Melanie Davis*	*11-Jun-2015*	*Tom Kelley*

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usden1s01\projects\NRII\Clients_I-P\Newmont\1011322 Midnite Mine\Technical\Calculations\Cover Settlement Analysis

\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\Remedial Action Cover Design\Cover Deformation

The following calculations were generated using the following software:

PLAXIS 2D
Microsoft Office Professional Plus 2010 (Microsoft Excel)

1.0 BACKGROUND AND PURPOSE

Stress-deformation analyses were performed to evaluate the potential cover settlement of the mine waste that will be placed in Pit 3 and Pit 4 as part of the Remedial Action (RA) at the Midnite Mine Superfund Site (the Site). The purpose of the analyses is to estimate the amount of settlement that the cover could potentially experience during construction and post-construction creep settlement of the mine waste in Pit 3 and Pit 4 (i.e., over an extended period of time). The horizontal (lateral) displacements of the pit dewatering sump risers, as well as the lateral displacements and strains in of the top cover geomembrane were also estimated.

Based on the calculated potential post-construction creep settlement, additional analyses were performed to evaluate changes~~:~~

- ~~The maximum strain on the cover geomembrane~~
- ~~Changes~~ in slope and potential drainage issues that may develop over time on the cover system drainage-bench channels

This attachment presents the methods, assumptions, and material properties used in these analyses, as well as the results and conclusions.

2.0 SETTLEMENT ANALYSIS

2.1 METHODS AND ASSUMPTION

The settlement analysis was performed using Plaxis 2D software (Plaxis, 2014). Plaxis 2D is a two-dimensional (2D) finite element program that is used to perform deformation analysis for various types of geotechnical applications. Plaxis 2D includes advanced constitutive models that allow for the simulation of non-linear, time-dependent, and anisotropic behavior of soils and/or rock.

The analysis was performed for initial (occurring during construction) settlement and long-term (post-cover-construction) settlement. The initial construction settlement is used to provide initial configuration and stress-state information for the analyses of post-construction settlement. The post-construction settlement provides an estimate of deformations that may occur in the cover system due to long-term creep. Deformation of the cover system may have impacts on the long-term performance of the cover system, particularly with respect to liner strain and drainage. The lateral displacements of the pit dewatering sump risers due to construction and long-term creep deformations of the backfill also were estimated. In addition, the lateral displacements of the top cover surface due to long-term creep deformations of the backfill were estimated along with the corresponding maximum lateral strain on the cover geomembrane.

2.2 LOADING STAGES

Seven loading stages were used for the analysis and are as follows:

- Initial Condition: The initial condition was the empty pit, with only gravity loading of the bedrock being considered in order to establish initial stress conditions.

- First Loading Stage: The first loading stage included the underdrain and the first layer of waste rock and only considered the displacements associated with gravity loading from these layers.
- Second Loading Stage: The second loading stage included the gravity loading of the second layer of waste rock, with additional displacements of the previous (first layer) of waste rock being modeled using the Hardening Soil constitutive model.
- Third and Fourth Loading Stages: The third and fourth loading stages were similar to the second loading stage, with deformations and stress distributions of previous loaded layers being modeled using the Hardening Soil constitutive model.
- Final Construction Stage: In the final construction stage, the placement of the waste rock in the pit is complete and all of the layers of waste rock are modeled using the Hardening Soil constitutive model.
- Post-Construction Stage: After construction loading is completed, a time-dependent settlement analysis performed to evaluate the settlement after 50 years. During this post-construction stage, the waste rock is modeled using the Soft Soil Creep constitutive model.

In the model, gravity loads associated with pit backfilling in Pit 3 and Pit 4 were applied in four stages, referred to as the First through Fourth Loading Stages above. For the First through Fourth Loading Stages, gravity loads were applied and analyzed in increments that represent sequential waste rock placement in thicknesses of 75 to 100 feet, depending on the section being analyzed.

Given the coarse nature of the waste rock, it was assumed that pore pressures do not develop during placement of the waste rock in the Pits and during the long-term creep phase of the analysis. Therefore, all materials were assigned drained/effective stress parameters.

2.3 CONSTITUTIVE MODELS

Four constitutive (stress-strain response) models were used in the analyses of cover settlement to represent the responses of the different materials under specific loading conditions: elastic, Mohr-Coulomb, Hardening Soil, and Soft Soil Creep. These models are described in detail in the Plaxis Material Models Manual (Plaxis, 2014). The general input parameters required for each constitutive model are provided in the following subsections.

2.3.1 Linear Elastic Model

The linear-elastic model is the simplest constitutive model in Plaxis and is based on Hooke's Law for isotropic linear elastic behavior. The linear elastic model requires a Young's Modulus (E) and Poisson's ratio (ν) as input.

The linear elastic constitutive model was used to calculate initial stresses due in the pit bedrock layers prior to backfilling.

2.3.2 Mohr-Coulomb Model

The Mohr-Coulomb model is a linear-elastic perfectly-plastic constitutive model. For stress states that fall within the fixed yield surface (i.e. do not exceed the material strength), the material stress-strain behavior is defined by a linear-elastic behavior and the strains are reversible. However, once the stress at a given point reaches the yield surface (i.e. the strength is exceeded), plastic flow occurs and irreversible strains occur. For the Mohr-Coulomb constitutive model, the yield surface is defined by a friction angle (ϕ) and cohesion (c) which are defined in the same manner as the failure envelop in traditional limit-equilibrium (e.g. slope stability) analyses. Since a linear elastic constitutive model is used to define the stress-strain response in the sub-yielding stress region, a Young's Modulus (E) and Poisson's ratio (ν) as described in Section 2.3.1 are also required as input.

The Mohr-Coulomb Constitutive Model was used to calculate stresses and strains in the bedrock and underdrain layers during backfill (construction) loading.

2.3.3 Hardening Soil Model

The Hardening Soil constitutive model is a more advanced constitutive model appropriate for many different types of soils. In the hardening soil constitutive model, when the soil is subjected to primary deviatoric (related to shear) loading, it shows a decreasing stiffness and simultaneously develops irreversible plastic strains (Plaxis, 2014). Unlike the Mohr-Coulomb model, the yield surface for the Hardening Soil model is not fixed in principal stress space, but can expand (harden) as plastic straining occurs. The Hardening Soil constitutive model is similar to the more familiar Duncan and Chang (1970) Hyperbolic model, but with some improvements that more accurately capture important aspects of the behavior of geologic materials during loading. These improvements include: 1) the Hardening Soil model uses the theory of plasticity rather than the theory of elasticity, 2) the Hardening Soil model includes soil dilatancy, and 3) the Hardening Soil model includes a yield cap (Plaxis, 2014).

The basic characteristics of the Hardening Soil model are (Plaxis, 2014):

- Stress dependent stiffness defined by a power law with an associated input parameter: m
- Plastic straining due to primary deviatoric loading – associated input parameter: the secant stiffness in a standard drained triaxial test (E_{50})
- Plastic straining due to primary compression – associated input parameter: the tangent stiffness for primary oedometer loading (E_{oed})
- Elastic unloading/reloading – associated input parameters: unloading/reloading stiffness (E_{ur}) and unloading/reloading Poisson's ratio (ν_{ur})
- Failure according to the Mohr-Coulomb failure criterion – associated input parameters: c, ϕ, and the angle of dilatancy (ψ).

The Hardening Soil Constitutive Model was used to calculate stresses and strains in the waste rock backfill during construction loading.

2.3.4 Soft Soil Creep Model

The Soft Soil Creep model was used to predict the long-term, post-construction time-dependent behavior of the waste rock under a nearly-constant state of stress. The basic characteristics of the model are (Plaxis, 2014):

- Stress-dependent stiffness (logarithmic compression behavior)
- Distinction between primary loading and unloading-reloading
- Secondary (time-dependent) compression

- Memory of pre-consolidation stress
- Failure behavior according to the Mohr-Coulomb criterion

The basic stiffness parameters for the Soft Soil Creep model include the modified swelling index (κ^*), modified compression index (λ^*), and modified creep index (μ^*). These values can be obtained from either an isotropic compression test or an oedometer test. The modified compression index is the slope of the normal consolidation line when the logarithm of stress is plotted as a function of strain. Similarly, the modified swelling index is the slope of the recompression line. The modified creep index can be estimated by plotting the long-term volumetric strain against the logarithm of time. Alternatively, the more traditional compression and recompression indices (C_c and C_r, respectively) can be entered into Plaxis, as well as the secondary compression index (C_α).

The Soft-Soil Creep Constitutive Model was used to long-term stresses and strains in the mine waste backfill layers after construction has been completed.

2.4 GEOMETRY

Two-dimensional sections of both Pit 3 and Pit 4 were evaluated for deformation, with two sections at critical locations analyzed for each pit. The locations of the sections used in the deformation analyses of Pit 3 and Pit 4 are shown on Figure 1 and Figure 2, respectively. Section A and Section B through Pit 3 are shown on Figure 3 and Section C and Section D at Pit 4 are shown on Figure 4. The sections are oriented to include the underdrain sump, and sump risers in each pit. The underdrain material was included in the model as a distinct material, however, the sump risers were not modelled as a separate material. The design of the well risers include the incorporation of friction sleeves and slip layers around the stainless steel well risers which will result in very little load transfer from the waste rock as it settles, to the steel riser pipes. In addition, the riser pipes will have a large amount of lateral flexibility. As such, the sump risers are not expected significantly influence the waste rock displacement patterns. The geometry used in modelling the sections in Plaxis is shown on Figure 5 through Figure 8.

The bedrock in the analysis (assigning the appropriate geologic units) was defined based on the engineering geology maps generated by geologic mapping performed as part of the Midnite Mine Pre-Design Investigations prepared by Miller Geotechnical Consultants (MGC, 2011).

2.5 MATERIAL PROPERTIES

The strength and deformation parameters for the materials used in the analysis were developed based on laboratory data, field test data, and previous experience with similar materials, as well as a one-dimensional calibration to rockfill settlement data from published literature sources as described in Section 4.1.1. The values selected and the basis of these values is provided in the following subsections. A summary of the material properties used in the analysis is provided in Table 1 and are discussed in detail in the following subsections.

Table 1. Summary of Material Properties

Material	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Poisson's Ratio	Young's Modulus (psf)	Rock Deformation Modulus (psf)
Waste Rock & Existing Waste	119	0	38	0.3	$8.01x10^5$	---
Bedrock - Quartz Monzonite	145	57,200	35.8	0.25	---	$3.12x10^7$
Bedrock - Schist/Phyllite	145	42,300	27.6	0.25	---	$3.83x10^7$
Bedrock - Calc-Silicate	145	78,900	32	0.25	---	$7.37x10^7$
Underdrain (Hillside Dump)	108	0	35	0.3	$8.01x10^5$	---

2.5.1 Waste Rock Backfill

The waste rock backfill that will be placed in the Pit 3 and Pit 4 currently is located in existing waste rock piles throughout the Site. Field and laboratory tests were performed in the South Spoils and Hillside Dump waste rock piles as part of an investigation performed by URS (URS 2002). The investigation included both excavation of test pits and drilling of test holes in each of the waste rock piles. In-situ density tests were performed in the test pits and samples of waste rock were obtained for gradation and other index property testing. Bulk samples (samples from the test pits with similar index properties) were used for triaxial shear testing.

It should be noted that it appears that only the gravel-sized (3-inch) and finer materials were included in the laboratory test specimens. A review of test pit logs from the 2002 investigation indicates that a significant percentage (in some cases greater than 50 percent) of the waste rock material was larger than 3 inches in size and was excluded from the test specimens. Due to the exclusion of a significant amount of coarser-grained material the compressibility and strength parameters estimated from these laboratory test results will be conservative and result in higher estimated settlements.

General Properties. The unit weight of the waste rock was estimated from the results of the in-situ density tests. The measured moist unit weight ranged from 95 pcf to 124 pcf, with an average value of approximately 119 pcf. The average value was selected for use in this analysis. These in-situ density tests did include coarser fractions of the waste rock that were excluded from the laboratory samples, and are considered representative of the whole waste rock density that will be achieved in the waste rock backfill.

The consolidated-undrained (CU) triaxial tests were performed on the bulk samples of waste rock compacted for 90 percent of the standard proctor maximum dry density at the natural moisture content. The CU tests resulted in a range of effective friction angles from about 33 to 44 degrees and a range of cohesion of 0 to 650 psf. A friction angle of 38 degrees with zero cohesion was used for the waste rock in stability analyses performed as part of the current design activities. This value is consistent with the laboratory data and was used in the settlement analysis in the Mohr-Coulomb model.

The Young's modulus, or elastic modulus, for the waste rock was estimated using both the laboratory data (triaxial stress-strain curves) and field data (SPT N-values) since both types of data were available and neither type of data was considered more accurate than the other. The average value of Young's Modulus obtained from the triaxial test data was approximately 1.78x10^6 psf. Correlations provided by Bowles (1996) and Schmertmann (1970) were used to estimate the Young's Modulus from SPT N-values collected in the field by URS (2002). The average $N_{1,60}$ value estimated from the SPTs performed in the waste rock is 26 and the 33rd percentile value is estimated at approximately 14. Both field and laboratory test values were used to estimate the Young's Modulus. The Young's Modulus values calculated from empirical correlations with SPTs range from 2.51x10^5 to 8.02x10^5 psf. A value of 3.6x10^5 psf was selected for the SPT-based estimate of Young's Modulus. The geometric mean of the laboratory-based and SPT-based estimates of Young's Modulus was used in the analysis and is 8.01x10^5 psf.

The Poisson's ratio for the waste rock was selected based on typical values for similar materials. Poisson's ratio typically ranges from 0.2 to 0.3 for cohesionless soils and from 0.3 to 0.4 for clayey soils. A value of 0.3 was used for the waste rock in the settlement analyses.

Properties for Constitutive Models. The input parameters for the Hardening Soil and Soft Soil Creep constitutive models, both of which were used for the waste rock in the settlement analysis, are discussed in in the following subsections. The values selected for the waste rock are summarized in Table 2 and are discussed in more detail below.

Table 2. Summary of Waste Rock Constitutive Model Input Parameters

Property	Value
Hardening Soil Model	
Secant Stiffness in standard drained triaxial test, E_{50}	1.15x10^6 psf
Tangent stiffness for primary oedometer loading, E_{oed}	1.08x10^6 psf
Unloading/reloading stiffness, E_{ur}	3.46x10^6 psf
Stress dependency, *m*	0.5
Dilatancy Angle	8 degrees
Soft Soil Creep Model	
C_c	0.08
C_r	0.008
C_α	0.003 – 0.006*

** Range of values considered in one-dimensional calibration model.*

Waste Rock - Hardening Soil Model. The secant stiffness in a standard drained triaxial test (E_{50}) was estimated using the triaxial test data for the waste rock. The secant stiffness was calculated from the stress-strain curves obtained from the triaxial tests based on the definition provided in the Plaxis Material Model Manual (Plaxis, 2014), which is shown graphically in Figure 9. The average E_{50} estimated from the nine CU triaxial tests performed on the waste rock from the South Spoils, which was used in the settlement analysis, is 1.33x10^6 psf. This estimated value is an undrained modulus. To estimate the drained modulus from the undrained modulus, the following equation was used:

$$E'_{50} = E_{50}\frac{2(1+\nu)}{3}$$

where:

E'_{50} – Drained secant stiffness
E_{50} – Undrained secant stiffness

ν – Poisson's Ratio

The estimated drained secant stiffness (E'_{50}) is approximately 1.15×10^6 psf. This is the value that was used in the settlement analysis.

The tangent stiffness for primary oedometer loading (E_{oed}) was calculated using the following equation:

$$E_{oed} = \frac{E(1-\nu)}{(1+\nu)(1-2\nu)}$$

where:

E – Young's Modulus
ν – Poisson's Ratio

The value of E_{oed} calculated using the above equation, a Young's Modulus of 8.01×10^5 psf, and a Poisson's ratio of 0.3 is 1.08×10^6 psf.

The unloading/reloading stiffness (E_{ur}) was estimated using the secant stiffness (E_{50}). As the triaxial testing did not include an unload/reload cycle, the default value in Plaxis of three times E_{50} (3.99×10^6 psf) was assumed for E_{ur} in the settlement analysis.

The exponent in the Hardening Soil constitutive model, *m*, represents the stiffness dependence on stress-level. As discussed in the Plaxis (2014), Janbu (1963) reported values of *m* around 0.5 for sands and silts. This value was assumed as a conservative estimate for the waste rock in the settlement analysis.

The Mohr-Coulomb parameters ϕ and c used in the Hardening Soil model are the same values as discussed in the General Properties section. The angle of dilatancy (ψ) was estimated based on information provided in Plaxis (2014). The value of ψ can be estimated for cohesionless soils with friction angles greater than 30 degrees as $\psi \approx \phi - 30°$. As the friction angle (ϕ) of 38 degrees is being used for the waste rock in the settlement analysis, the angle of dilatancy (ψ) is estimated to be 8 degrees.

Waste Rock - Soft Soil Creep Model. The compression index (C_c) for the waste rock was estimated based on previous experience with similar materials and void ratios. A C_c of 0.08 was used in the settlement analysis.

The recompression index, which is referred to as the swelling index in Plaxis (C_s), was estimated to be 10 percent~~%~~ of C_c, or 0.008.

The secondary compression index (C_α) was initially estimated using data from the consolidation phase of the triaxial testing. An average value of 0.003 was calculated from the consolidation vertical displacement versus time curves. A C_α value of 0.006 was obtained from previous experience for a similar material. A one-dimensional (1D) analysis was performed for the waste rock to calibrate the settlements obtained from Plaxis to measured rockfill settlements by changing the secondary compression index. This 1D calibration analysis is discussed in more detail in the Section 4.1.1.

The required Mohr-Coulomb input parameters for the Soft Soil Creep model are the same as those used for the Hardening Soil model.

2.5.2 Underdrain

As currently planned, the underdrain will be constructed from material processed from the Hillside Dump. The unit weight of the underdrain material was estimated from in-situ density tests performed in the test pits at the Hillside Dump (URS 2002). An average value of 108 psf was used in the settlement analysis. One set of triaxial tests was performed on material from the Hillside Dump, which resulted in a friction angle of about 35 degrees and a cohesion of 400 psf. A friction angle of 35 degrees with zero cohesion was used for the underdrain in the settlement analysis. The Young's Modulus for the underdrain material was assumed to be the same as for the waste rock material for the purposes of these analyses. The underdrain was modeled using the Mohr-Coulomb constitutive model.

2.5.3 Bedrock

As mentioned above, there are three main units of bedrock at Pit 3 and Pit 4: quartz monzonite, schist/phyllite, and calc-silicate. The rock strengths were estimated for each of the units, as discussed below.

The unit weight for all units of bedrock was estimated from laboratory density tests performed on rock cores obtained during a site investigation performed by as part of the Midnite Mine Storage Ponds Investigation (MWH, 2012). A conservative value of 145 pcf was selected for the bedrock. Also, a typical Poisson's ratio for rock of 0.25 was assumed for all bedrock units in Pit 3 and Pit 4.

The bedrock was modeled using the Mohr-Coulomb constitutive model. The input parameters for the Mohr-Coulomb model are provided below.

Bedrock - Quartz Monzonite. The friction angle, cohesion, and rock deformation modulus for quartz monzonite were estimated as part of the Midnite Mine Pre-Design Investigations (MGC 2011). These values were obtained using RocLab (RocScience, 2002) and the following estimated Hoek-Brown parameters: GSI = 37, UCS = 1000 ksf, m = 29, E_i = 240,000 ksf. The estimated friction angle and cohesion of 35.8 degrees and 57,200 psf, respectively. The estimated rock deformation modulus was 3.12×10^7 psf.

Bedrock - Schist/Phyllite. The strength properties for the schist/phyllite rock were also estimated as part of the Midnite Mine Pre-Design Investigations (MGC, 2011). The Hoek-Brown parameters used to estimate the strength and deformation properties were: GSI = 40, UCS = 1000 ksf, m = 10, E_i = 240,000 ksf. The estimated friction angle and cohesion based on the Hoek-Brown parameters, were 27.6 degrees and 42,300 psf, respectively. The rock deformation modulus was estimated to be about 3.83×10^7 psf.

Bedrock - Calc-Silicate. The strength and deformation properties for the calc-silicate rock were also estimated as part of the Midnite Mine Pre-Design Investigations (MGC, 2011). The Hoek-Brown parameters estimated for the calc-silicate are: GSI = 50, UCS = 1500 ksf, m = 12, E_i = 240,000 ksf. The estimated friction angle and cohesion were 32 degrees and 78,900 psf, respectively. The rock deformation modulus was estimated to be approximately 7.37×10^7 psf.

2.5.4 In-Place Waste Rock

In Section D at Pit 4, the waste rock will be placed over existing in-place waste rock in Area 5. In addition, in the toe Area of Pit 3~~Pit3~~ and in the Backfilled Pit Area (BPA) the existing waste rock will be left in place and regraded. The in-place waste rock was assumed to have the same material properties as the waste rock backfill and was assigned the same Hardening Soil constitutive model parameters. The existing waste was included in the initial stage gravity loading along with the bedrock (backfilling of Pit 4 has not begun).

3.0 ~~COVER STRAIN AND~~ DIFFERENTIAL SETTLEMENT

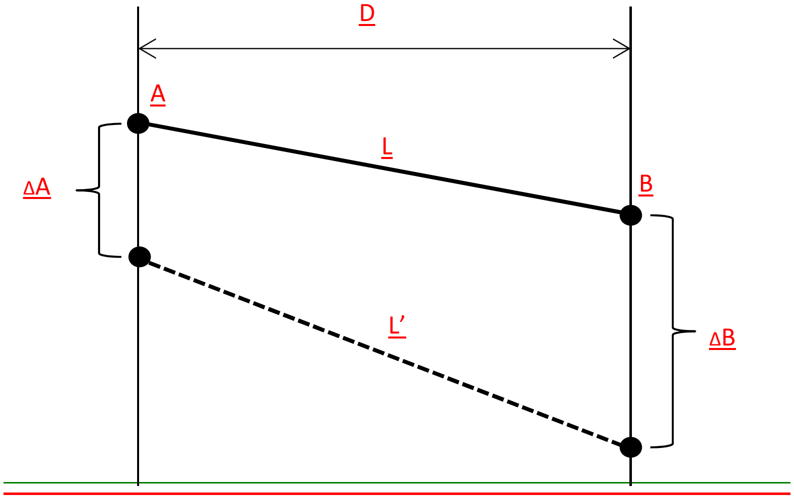
The results of the Plaxis long-term creep settlement analyses were used to calculate differential settlement in~~and~~ the ~~resulting strain in the LLDPE geomembrane in the~~ waste cover system. The initial construction settlement associated with backfill loading is expected to occur very rapidly and will be largely complete prior to final grading of the waste surface and construction of the cover system. Therefore, only the long-term, creep-related settlement was included in the differential settlement analysis.

Three-dimensional (3D) deformations in the~~and~~ cover systems were estimated from the results of the 2D settlement analysis using the relationship developed between the vertical creep settlement and the thickness of the waste fill material (shown in Figure 20). Computer-aided design (CAD) software was used to compare the as constructed (i.e., pre-creep) cover elevation surfaces to the existing grade surfaces in order to calculate thickness of waste fill material at each point across the two surfaces. The relationship between the vertical creep settlement and the thickness of the waste fill material was then used to create creep settlement surfaces for Pit 3 and Pit 4. The creep settlement surfaces were subtracted from the end-of-construction (i.e., pre-creep) surfaces to generate final settled cover surfaces~~strain analyses~~.

~~The strain in the cover system geomembrane induced by differential creep settlement was calculated at 50-foot horizontal intervals across each pit in order to determine the distribution of liner strains, the maximum liner strain, and the maximum differential settlement for each pit. In order to estimate settlement patterns and liner strain across the entire waste cover system, a relationship was developed between the creep settlement calculated at various points along the Plaxis analysis sections and the underlying thickness of the waste as discussed in Section 4.1.2. The resulting settlement vs fill thickness relationship was used to calculate the creep settlement at on a 50-foot by 50-foot grid spacing over the entire waste cover surface. The estimated creep settlements were used to calculate settlement-induced cover strain as described in the following paragraph. This resulted in the calculation of settlement and strain at approximately 1280 points on Pit 3 and 930 points on Pit 4. The creep settlement vs. fill thickness relationship was also used to evaluate the drainage bench profiles to identify where areas of ponding may develop due to long-term creep settlement.~~

~~In order to estimate cover settlement, the as-constructed (i.e., pre-creep) cover elevations and thickness of mine waste values were calculated at each grid point using design surface for final cover placement. Vertical settlement calculations, based upon the settlement vs. fill thickness relationship, were then performed between for each grid point and the points adjacent to it (i.e., points 50 feet to the north, east, south and west; and approximately 70.7 feet to points located~~

~~along the grid diagonals to the northeast, northwest, southeast, and southwest). The liner strain associated with differential creep settlement was then calculated between each set of points as follows:~~



~~$\varepsilon = \frac{L' - L}{L}$~~

~~ε = Strain (ft/ft)~~
~~L = Initial length of liner (ft)~~
~~L' = Length of liner after creep settlement (ft)~~

~~$L = \sqrt{(ElevA - ElevB)^2 + D^2}$~~

~~ElevA = Pre-creep cover elevation at point A (ft amsl)~~
~~ElevB = Pre-creep cover elevation at point B (ft amsl)~~
~~D = Level plane distance between point A and point B (either 50 ft or 70.7 ft)~~

~~$L' = \sqrt{[(ElevA - \Delta A) - (ElevB - \Delta B)]^2 + D^2}$~~

~~ΔA = Settlement at point A (ft) = Thickness of waste at point A (ft) * 0.015~~
~~ΔB = Settlement at point B (ft) = Thickness of waste at point B (ft) * 0.015~~

~~In a similar manner, the maximum differential settlement (i.e., the difference between ΔA and ΔB) was calculated between each point using the same array of points as for the cover geomembrane strain analysis.~~

Because the cover bench channels are designed to be constructed with fairly shallow slopes, post-creep elevation profiles were created for each bench channel in order to identify areas where ponding may occur due to slope reversal as a result of creep settlement. The post-settlement bench channel slopes were compared with the recommended minimum permissible design slope for bench channels provided in Appendix F (Supplement F-3.5). Post-settlement ground surface profiles were created using the final settled cover surfaces.~~as described in Section 4.1.3.~~

4.0 RESULTS

4.1 SETTLEMENT ANALYSIS

4.1.1 1D Calibration Analysis

As mentioned previously, a one-dimensional analysis was performed for the waste rock to calibrate the settlements obtained from Plaxis to measured rockfill settlements presented in the literature by varying the secondary compression index. The measured settlements for rockfill dams are reported by Oldecop and Alonso (2007). The settlement results obtained from the Plaxis calibration runs are presented, along with the measured waste rock settlements, on Figure 10.

For the one-dimensional calibration model, a 300-ft tall column (representing Pit 4) and a 400-foot tall column (representing Pit 3) of waste rock material were generated in Plaxis. The waste rock was first loaded by gravity and assigned the Hardening Soil model with the associated material properties. The waste rock material was then assigned the Soft Soil Creep model and allowed to deform over a period of 30 years (the period of time shown in Figure 1 of Oldecop and Alonso). The percent settlement (settlement divided by the height of the column and multiplied by 100) was plotted versus time and compared with the datasets presented in Figure 1 in Oldecop and Alonso (2007). The results of the 1D calibration runs are shown in Figure 10.

The calibration analysis was performed for a range of values of the secondary compression index values, C_α. The initial analysis was performed assuming a C_α of 0.006. Additional analyses were performed assuming C_α values of 0.004 and 0.003. A C_α of 0.004 provided results similar to the Rivera de Gata and Beliche Dams and was considered a conservative estimate of the secondary compression index, as the value provides settlements on the higher end of values measured for rockfill dams. A C_α value of 0.004 was used in the subsequent 2D cover settlement analyses.

4.1.2 2D Deformation~~Settlement~~ Analysis

The 2D deformation~~settlement~~ analysis was performed for four sections (two for Pit 3 and two for Pit 4) for construction and post-construction conditions (i.e. Figures 3 and 4 for Pits 3 and 4, respectively). Vertical settlement~~The displacement~~ contours for the end of construction (EOC) and post-construction (Creep) are shown in Figure 11 through Figure 18. A summary of the settlement~~displacements~~, shown in the contours for the two stages (EOC and Creep), is provided in Table 3.

Table 3. Summary of Maximum Calculated Settlements in Waste Rock

Section	End of Construction (ft)	50 years (Creep) (ft)	Total (ft)
Pit 3 - A	4.6	6.4	11

Pit 3 - B	5.7	7.2	13
Pit 4 - C	2.2	3.7	5.9
Pit 4 - D	2.8	4.5	7.3

The Creep settlements are relevant for estimating deformations in the cover system over time. The relationship between calculated creep settlements and time are shown for each section in Figure 19. As can be seen on Figure 19, creep settlement initially occurs at a rapid rate, and although creep settlement continues indefinitely, the rate slows considerably after about 10 years. As a result, subsequent estimates of long-term creep settlement have been based on the settlement that occurs within the first 50 years of completion of construction.

In order to estimate the settlement~~three-dimensional deformation~~ patterns across the cover systems from the results of the analyses of the 2D sections, a relationship was developed between the vertical creep settlement and the thickness of the waste fill material at ten locations, with varying fill thicknesses, in each 2D section analyzed. The results of the 2D analyses were used to develop the relationship between creep settlement and fill thickness shown in Figure 20. As shown in Figure 20, there is a linear trend (represented by the line on the drawing) to the relationship between creep settlement and fill thickness, and a linear regression was used to develop a best fit line. The equation of the line then was used to estimate cover settlement at other off-section locations within each backfilled pit.

In addition to estimating the vertical settlements~~deformations~~ that would affect the cover system, the 2D settlement analysis was used to estimate the lateral displacements at the sump risers both during construction due to backfill loading and after construction. The estimated distribution of the lateral displacements at the location of the sump risers is shown for each section in Figure 21 through Figure 28. A summary of the maximum lateral displacements for each section at the sump risers is provided in Table 4. In addition, the total estimated horizontal displacement for the sump risers in each pit was calculated as the resultant of the estimated displacements vectors from the two approximately ~~-~~perpendicular analysis sections in each pit, as well as the resulting deviation from vertical are also summarized in Table 4.

Table 4. Summary of Maximum Calculated Lateral Displacements at the Sump Risers

	In-Section Displacement			Resultant Displacement			
Section	**EOC (ft)**	**50 years (Creep) (ft)**	**Total (ft)**	**EOC (ft)**	**50 years (Creep) (ft)**	**Total (ft)**	**Deviation from Vertical**
Pit 3 - A	0.96	1.7	2.7	0.97	1.9	2.8	0.6%
Pit 3 - B	0.13	0.78	0.9				
Pit 4 - C	0.10	0.31	0.4	0.42	0.42	1.3	0.4%
Pit 4 - D	0.41	0.82	1.2				

The lateral displacements of the top cover surface due to long-term creep deformations were also estimated based on the 2D deformation analyses. The results were used to evaluate potential effects of lateral displacements on the cover geomembrane, and the non-welded cover geomembrane overlap at the drainage benches. The average lateral displacements and associated lateral strains were calculated at approximately 100-ft intervals along the sections that were analyzed as part of the 2D deformation analysis as shown on Figures 29 and 30. Calculation sheets are provided in Supplement D-13.1. Note that negative strains indicate compression along a particular 100-foot section, which is not of consequence in terms of either geomembrane yielding or loss of geomembrane continuity at non-welded geomembrane overlaps. Positive (tensile) strains have potential consequences in terms of geomembrane yielding and loss of overlap continuity, and were used for evaluation of the effects of creep deformation on cover performance.

The maximum potential geomembrane extension along off-section (i.e. not located along 2d deformation analysis sections) locations was conservatively estimated using the maximum average lateral tensile strain calculated for any 100-ft spacing along an interbench slope (1.06 percent) multiplied by a representative maximum interbench slope length (approximately 250 feet). The locations of the maximum average lateral strain and representative interbench slope length are indicated on Figure 29. Although a higher strain (1.96) was calculated at on location farther to the east of the location selected, it did not occur along a cover slope as can be seen on Figure 29, and was not considered relevant to the analyses of non-welded cover overlap areas.

Using the estimated maximum lateral down-slope strain of 1.06 percent, the calculated maximum lateral extension along the 250-foot slope length is approximately 2.7 feet. This maximum lateral extension will result in both stretching (tensile straining) of the cover system LLDPE geomembrane as well as sliding of the geomembrane along the non-welded geomembrane overlap at the drainage benches. This sliding will occur over that portion of the free end of the geomembrane in the overlap area that does not have sufficient embedment to resist the tensile forces imparted by the lateral extension. The length of the free end of the geomembrane that may be subject to sliding can be calculated based on the required development length needed to resist the tensile forces imparted on the geomembrane by the creep-related lateral extension. The maximum tensile forces that may be developed in the geomembrane can be calculated as:

$$T = \sigma_t A$$

Where:

T = maximum imparted tensile force within the geomembrane
σ_t = imparted tensile force within the geomembrane
A = Cross sectional area of geomembrane = 0.48 in^2/ft for 40-mill LLDPE
$\sigma_t = E\varepsilon_t$
E = Modulus of LLDPE geomembrane = 60,000 psi (typical, 2 percent strain)
ε_t = maximum tensile Strain = 0.0106

Based upon the above considerations, the maximum tensile force imparted on the geomembrane due to creep deformations is expected to be approximately 305 lbs/ft. Likewise, the required development length needed at the free end to resist movement can be calculated based on the interface shear resistance on the top and bottom surfaces of the geomembrane as:

$$R = \sigma_v \tan\delta_U + \sigma_v \tan\delta_L$$

Where:

σ_v = vertical stress due to soil cover loading = d*γ_s
d = thickness of soil cover = 3 ft nominal, actually somewhat thicker at outer edge of drainage benches
γ_s = unit weight of soil cover = 110 pcf as described in Attachment D-7
So:
σ_v = 330 psf
δ_U = frictional resistance along upper geomembrane/soil cover interface = 22.7 degrees as described in Attachment D-7.
δ_L = frictional resistance along lower geomembrane/GDL interface = 25.4 degrees as described in Attachment D-7.

Which results in a calculated pullout resistance of R = 330tan(22.7) + 330tan(25.4) = 295 psf. The required geomembrane development length required to resist the tensile force imparted by the creep-related extension can then be calculated as:

$$L_d = T/R = 305\ (\text{lb/ft}) / 295\ (\text{psf}) = 1.03\ \text{ft.}$$

Thus, it can be concluded that only the first one foot of LLDPE geomembrane nearest the free end of the overlap will potentially be subjected to slippage along the overlap, whereas the majority of the geomembrane along the 250-long slope can be expected to experience stretching. The actual amount of slippage along the one-foot portion of geomembrane at the free end is expected to be less than one inch. Thus, the proposed 5-foot non-welded geomembrane overlap at each drainage bench is expected to be more than sufficient to avoid separating due to post-construction, creep-related deformations.

The synthetic geomembrane proposed for use in the cover system is specified as 40-mil GSE UltraFlex Textured LLDPE Geomembrane or equivalent.
The maximum percent elongation at break for this material is 250 percent. The maximum calculated average lateral strain (based on an approximately 100-ft spacing) developed in the geomembrane due to lateral displacement (1.96 percent in a cross-slope direction) is two-and-a-half orders of magnitude lower than this specified break strain. Thus the proposed LLDPE geomembrane is expected to have sufficient flexibility to accommodate post-construction, creep-related deformations.

4.1.3 Three-Dimensional (3D) Settlement Analysis

3D deformations in the cover systems were estimated as described in Section 3 using the relationship developed as described in Section 4.1.2 between the vertical creep settlement and the thickness of the waste fill material. Creep settlement contours created using this relationship are presented in Figures 31~~29~~ through Figure 34~~32~~. The creep settlement contours were subtracted from the end-of-construction (i.e., pre-creep) contours to create final settled cover contours, as presented in Figures 35~~33~~ and 36~~34~~ for Pit 3 and Pit 4, respectively.

4.2 ~~COVER STRAIN AND~~ DIFFERENTIAL SETTLEMENT

Post-creep settlement~~strain~~ of the cover ~~geomembrane~~ was calculated ~~on a 50-ft grid spacing~~ over the entire waste containment area cover~~. Eight longitudinal strain calculations were performed for each point on the grid (corresponding to displacements between that grid point and each of the surrounding grid points) and the maximum longitudinal strain was selected and assigned to each point. The maximum longitudinal strain at each point then was used to create isopachs showing the distribution of strains across the geomembrane liner for the Pit 3 and Pit 4 cover system, as presented in Figures 35 and 36, respectively. A summary of the maximum calculated geomembrane liner strains and differential settlements for each pit is provided in Table 5.~~

~~Table 5. Summary of Maximum Calculated Liner Strains and Differential Settlements~~

~~Pit~~	~~Max. Liner Strain (%)~~	~~Max. Differential Settlement (ft/ft)~~
~~Pit 3~~	~~0.33~~	~~0.027~~
~~Pit 4~~	~~0.42~~	~~0.021~~

~~A 40 mil linear low-density polyethelene (LLDPE) is proposed for the cover geomembrane and is specified as the GSE UltraFlex Textured Geomembrane or equivalent. The maximum percent elongation at break for this material is 250 percent.~~ as described in Section 3.0. ~~The maximum calculated strain developed in the geomembrane due to differential settlement (0.42 %) is two-and-a-half orders of magnitude lower than this specified break strain.~~

Based on the estimated final settled cover contours, profiles were created along the flow line of each drainage bench channel on the cover system in order to identify areas of potential ponding that may develop with long-term creep settlement. Plan views of bench channel profile lines are presented on Figure 37 and Figure 43~~38~~ for Pit 3 and Pit 4, respectively. Profiles for each bench channel are presented on Figures 38 through 42~~Figure 39 and 40~~ for Pit 3 and on Figures 44 through 47 for Pit 4. All bench channels maintain a down-gradient slope greater than 0.5 percent after~~41 and 42 for Pit 4. Two areas were identified where~~ long-term creep settlement. This slope is greater than the minimum permissible design slope of 0.4 percent for the bench channels (see Supplement F-3.5 of Appendix F, Calculation Brief Addendum, WCA ~~may result in slope reversal and areas of ponding on Pit 3 (near STA 8+00 on Pit 3~~ Bench Channel Design Update).~~B, and STA 17+50 on Pit 3 Bench Channel E). In addition, one area on Pit 4 (near STA 4+50 on Pit 4 Bench Channel E) was identified where slope reversal may occur due to long-term creep settlement.~~

5.0 CONCLUSIONS

The results of settlement analysis presented herein were used to evaluate the design of the cover system and the potential for lateral displacement of the sump risers due to backfill loading and long-term creep. The magnitude of the settlements is considered reasonable for the evaluated loading conditions. The use of a relationship to estimate the vertical settlement based on fill thickness represents an estimation of the three-dimensional behavior of the waste rock in the backfilled mine pits, but cannot fully account for the actual three-dimensional effects that may occur during and after construction. Generally, these three-dimensional effects are expected to result in slightly lower maximum settlements than would occur under two dimensional conditions due to out-of-plane effects of the relatively rigid pit walls.

Long-term maximum creep settlements of approximately 7.2 feet in Pit 3 and 4.5 feet in Pit 4 are anticipated, however the differential settlement between adjacent points will be much lower. Overall, the estimated long-term creep settlements will not result in significant changes to the cover geometry or flow directions due to the relatively steep grades of the majority of the as-designed cover surface.

~~The estimated longitudinal strains that will develop within the cover geomembrane due to long-term differential settlement are significantly less than the maximum strain the geomembrane is able to withstand. The maximum calculated longitudinal strain developed in the geomembrane due to differential settlement is two-and-a-half orders of magnitude lower than the specified break strain for the LLDPE geomembrane. As such, the longitudinal strains induced in the geomembrane liner by creep settlement are considered acceptable and will not cause failure of the liner.~~

The evaluation of estimated long-term creep settlement along bench channels indicates that all bench channels will maintain ~~there is~~ a down-gradient slope greater than the minimum permissible design slope of 0.4 percent after settlement. Though ~~potential for~~ ponded areas ~~in a few isolated areas where design-slopes~~ are not expected, the~~very flat. The~~ drainage benches will be monitored as described in the long-term OM&M plan and will be regraded as necessary if long-term creep settlement leads to conditions where drainage is not occurring as designed.

The amounts of lateral displacement of the sump riser pipes due to construction loadings, and from long-term creep settlement were also estimated. It is estimated that total lateral displacements due to both construction loading and long-term creep will result in deflections of the sump risers between 0.4 percent~~%~~ (at Pit 4) and 0.6 percent~~%~~ (at Pit 3). These deviations from vertical are not sufficient to represent problems for the functioning of the dewatering risers as the predicted deviations from vertical are relatively minor and occur in a uniform manner with fill height.

The lateral extensions of the cover geomembrane between drainage benches due to long-term creep deformation of the backfill is estimated to be a maximum average of 2.7 feet. Due to the flexibility and interface frictional resistance of the textured LLDPE geomembrane proposed for the cover system, the vast majority of the geomembrane will experience stretching, rather than interface sliding due to the predicted lateral extensions. Only the outermost free edge of the non-welded geomembrane overlap at each drainage bench is expected to experience interface slippage, with the actual displacement along the interface expected to be less than one inch. Thus, the design overlap of 5 feet is more than sufficient to maintain geomembrane continuity.

The estimated tensile strains that will develop within the cover geomembrane due to long-term differential settlement are significantly less than the maximum strain the geomembrane is able to withstand. The maximum calculated longitudinal strain developed in the geomembrane due to differential settlement is two-and-a-half orders of magnitude lower than the specified break strain for the LLDPE geomembrane. As such, the longitudinal strains induced in the geomembrane liner by creep settlement are considered acceptable and will not cause failure of the liner.

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FIGURES

Supplement D-13.1

Cover Geomembrane Lateral Displacement Calculations

Attachment D-14

BOYD PIT AND PIT 2 DEWATERING