Midnite Mine Superfund Site

10090 Percent Design

Appendix E – Water Management Ponds

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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

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LIST OF ACRONYMS

BMP	Best Management Practice
BODR	Basis of Design Report
CD	Consent Decree
EPA	U.S. Environmental Protection Agency
FOS	Factor of Safety
gpad	gallons per acre per day
gpm	gallons per minute
GSR	Green and Sustainable Remediation
HDPE	high density polyethylene
MA	Mine Area
Mgal	million gallons
NPDES	National Pollutant Discharge Elimination System
PCP	Pollution Control Pond
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
SOW	Statement of Work
SWMP	Stormwater Management Plan
SWRP	South Waste Rock Pile
WMS	Water Management System
WSDE	Washington State Department of Ecology
WTP	Water Treatment Plant

E.1.0 INTRODUCTION

This appendix to the *Midnite Mine Superfund Site Basis of Design Report* (BODR) presents the design information necessary for the temporary water management ponds. at the 90-percent design level. The Midnite Mine Superfund Site (the Site) remedial action (RA) requires consolidation of the mine wastes into Pit 3 and Pit 4 and isolation of the wastes from groundwater and surface water infiltration. Under the current water management system (WMS), Pits 3, Pit 4, and the Pollution Control Pond (PCP)4 are used to store mine-impacted surface and groundwater prior to water treatment and discharge from the Site (see Figure E-1). Temporary water management ponds (aka, storage ponds) will be needed during RA construction to control and store the impacted water when the pits and PCP are no longer available for water storage.

Proposed locations for these temporary storage ponds have been discussed with the Spokane Tribe and the EPA. During those discussions, the Tribe expressed its desire that the storage ponds be constructed within the existing fenced mine area (MA) boundary. This limits the number of suitable locations for these temporary water management ponds. This appendix describes the proposed sequence for construction, location, sizing, stability, and other considerations for the temporary water management ponds.

E1.1 BACKGROUND

The RA will be performed in three main phases as described in Appendix D, during which time mine impacted surface water and groundwater will be captured and stored pending treatment at the operating WTP. Estimates of the water storage requirements during each RA phase are presented in Attachment E-1 (Storage Pond Water Balance). As proposed, water storage will occur at fivethree different storage locations during the phased RA construction. These phases and locations are shown schematically on Figures E-2 through E-5, and include the existing Drawing 5-1 depicts the locations of Pit 3, the existing PCP, the new South Pond, and the new West Pond, and the new Water Treatment Plant (WTP) Ponds.

. The work associated with each phase of RA construction is described in detail in Appendix D and the effects of each phase of construction on storage requirements are discussed in Attachment E-1. A schematic of the existing water management system, including impacted

~~water storage facilities at the Site, is shown on Figure E-1.~~ During Phase 1 construction, mine wastes will be consolidated in Pit 4 and impacted water from the Site will be collected and stored in the PCP and Pit 3 as shown ~~in the schematic~~ on Figure E-2. The major~~There will be little~~ change to~~in~~ the current WMS during and upon completion of Phase 1 construction is that Pit 4 will no longer be used as a storage pond so that it can be backfilled with mine waste. The South Pond will be constructed during Phase 1 so that it is available to store water during Phase 2 as described below.~~.~~

Phase 2~~Backfilling of Pit 3~~ will commence with the backfilling of Pit 3, at which time ~~in Phase 2, and~~ Pit 3 will not~~no longer~~ be available for water storage. During Phase 2, impacted water will be stored in the PCP and in a new~~a~~ lined, temporary storage pond to be built~~located~~ immediately south of Pit 3 on the South Waste Rock Pile (i.e., the South Pond; see Figure E-3 and Drawing 5-1). Upon completion of Phase 2 the only significant volume of mine waste requiring excavation and consolidation will be that located in the Central Drainage portion of the South Waste Rock Pile in the vicinity of the South Pond and the ~~Pollution Control Pond (~~PCP. As a result,~~). At that point (Phase 3),~~ necessary water-storage volumes at the end of Phase 2 ~~volume~~ will be significantly reduced because much of the ~~water falling on the~~ Site surface water runoff~~in the form of rain and snow~~ can be shed from the remediated areas as clean water and discharged via local drainages to Blue Creek. The

~~During Phase 3, the South Pond will be dismantled and replaced by a smaller storage pond (i.e., the West Pond). The West Pond will be located in the Western Drainage in an area where waste has been removed during Phase 2 of the RA. The waste in the vicinity of the South Pond will be relocated to Pit 3. It is anticipated that the~~ West Pond will be constructed during Phase 2 after completion of cleanup of the upper and central portions the Western Drainage so that it is available to store water during Phase 3 as described below.~~where the West Pond will be located. During Phase 3, impacted water collected at the Site will be stored in the West Pond.~~

The South Pond will be removed at the start of Phase 3 so that the underlying and adjacent wastes can be excavated and backfilled in Pit 3, and mine-impacted water will be stored in the PCP and in a new smaller West Pond (see Figure E-4 and Drawing 5-1). The PCP and associated mine wastes underlying and in the vicinity will be removed near the end of Phase 3 and consolidated in Pit 3. At the end of Phase 3, all the mine-impacted water will be stored in the West Pond. .

Upon completion of Phase 3, all stormwater will be shed from the remediated areas as clean water, and the only mine-impacted water requiring storage prior to treatment will be from the Alluvial Groundwater Controls and from the dewatering wells installed in the consolidated wastes in Pit 3, Pit 4, and the Backfilled Pits Area (BPA). It is anticipated that these flowsUpon completion of Phase 3, it is anticipated that flows to the water management system will gradually decrease as steady-state base flow (groundwater inflow) levels are reached in the pit dewatering systems.. and from other site sources (e.g., the Alluvial Groundwater Collection Systems). The West Pond will remain operational until flows in the volumes of mine impacted water management system have reduced to the point where the equalization ponds at the new WTP are sufficientthere is no longer a need for temporary waterthis storage prior to treatmentfacility. Once flows have decreased to where the West Pond is no longer necessary, it will be decommissioned and any impacted sediments that may have accumulated within the West Pond and its liner system will be disposed of in a separate cell on top of the Pit 3 waste containment area as described in Appendix D.

The 90-Percent designs for the Phase 2 (South Pond) and Phase 3 (West Pond) are shown in Section 5 of the drawings contained in Volume II of this report, and are summarized in this appendix. Designs for the WTP equalization ponds are shown in Section 9 of the 60% design drawings. Section 9 drawings have not been progressed pastupdated for the 60% level90% design as the WTP design is on hold until the Midnite National Pollutant Discharge Elimination System (NPDES) permit is reissued.

The remainder of this appendix contains the following information:

- Demonstration that the design will attain the Performance Standards identified in the Consent Decree (CD) that are relevant to the storage ponds.
- Design calculations, assumptions, and parameters including:
    - Water balance calculations,- estimates of required storage capacities, and analysis of storage of construction water
    - Embankment stability analyses

- Pond configurations and capacities
- Calculation of pond liner anchorage requirements
- Emergency overflow spillway requirements

- Green and Sustainable Remediation (GSR) considerations

E2.0 PERFORMANCE STANDARDS

The Performance Standards presented herein are defined in the Consent Decree Statement of Work (CD SOW; EPA, 2011), and were developed to define attainment of the Remedial Action Objectives (RAOs) of the Selected Remedy. The performance standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. All of the Performance Standards for the Midnite Mine RA, as well as a summary of where or how they are addressed in the RD, are summarized on Table 4-6 of the BODR. The general and specific Performance Standards related to the Storage Ponds are listed below.

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Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments
2.3 General Standards Applicable to All Work Elements and Components of Work		
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 WTP 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.	The RA will be performed such that all water that potentially contacts mining wastes is captured and treated. 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 initially into Pit 3, and as construction progresses, into various storage ponds (described in this Appendix E) that will be constructed and ultimately to the WTP for treatment. Topography will be maintained throughout the RA construction activities such that clean water sheds away from the work areas, and mine-affected water is captured before it can discharge to the downstream drainages. These details are described in the following design appendices: Appendix D – Mine Waste Excavation and Containment describes how excavations will be performed in a manner to capture and contain potentially mine-affected surface water. Appendix E – Water Management Ponds describes how the pits and temporary surface water impoundments will be used to capture and store mine-affected water. Appendix F – Surface Water and Sediment Controls – provides the analysis and design of the surface water (SW) and sediment controls for post-closure conditions and for temporary channels installed during the RA construction phases. Appendix I – Water Treatment Plant describes how the mine-affected water will be treated and discharged. Appendix J – Influent and Effluent Pipelines describes how the mine affected water will be conveyed to the WTP and how the treated water will be conveyed to the discharge location.

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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	The majority of excavation activities are expected to occur above the water table. If groundwater is encountered or if stormwater accumulates in the excavations, the water will be contained and transferred to temporary surface water impoundments (as described in this Appendix E) and ultimately treated at the WTP. All sediments potentially contaminated by Site COCs will be captured and consolidated in the pits with the mining

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Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

Performance Standard No. in CD SOW	Performance Standard	Comments
2.3.18 B.iv	wetlands and surface water.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.	wastes.The majority of excavation activities are expected to occur above the water table. If groundwater is encountered or if stormwater accumulates in the excavations, the water will be contained and transferred to temporary surface water impoundments (as described in this Appendix E) and ultimately treated at the WTP. All sediments potentially contaminated by Site COCs will be captured and consolidated in the pits with the mining wastes. The surface water and sediment control structures to be constructed in the excavation areas are described in Appendix F. Sediment migration in the remediated areas will be managed in accordance with the Master SWMP (Appendix O).

2.3.24	All water requiring treatment shall be conveyed to and treated at the water treatment plant operating at the time of conveyance.	**Surface Water** – During the RA, surface water that contacts mine wastes will drain to the mine pits or temporary surface water impoundments (described in this Appendix E) that will store the mine-impacted water. The water in the impoundments will be conveyed to the operating WTP via conveyance channels and pipelines. The topography of the reclaimed areas will shed clean water away from any wastes that are pending excavation (i.e., during the phased RA construction activities), and away from the consolidated wastes (upon remedy complete). **Groundwater** – During the RA, groundwater discharging from seeps in the mine wastes will be captured and conveyed the temporary surface water impoundments (described in this Appendix E), and ultimately treated by the operating WTP. Groundwater that accumulates in the consolidated wastes in the pits and BPA will be captured by groundwater extraction wells, and treated at the WTP. These details are described in the following design appendices: Appendix D – Mine Waste Excavation and Containment describes how excavation of mine waste will occur such that potentially mine-impacted surface water is contained within the excavations and transferreddrains to the impoundments. Appendix E – Water Management Ponds describes how the mine pits and temporary impoundments will be used to capture and store potentially mine-impacted water. Appendix F – Surface Water and Sediment Controls describes the temporary and permanent structures that will convey surface water and control sediments. Appendix J - Influent and Effluent Pipelines describes how mine-affected water will be conveyed tofrom the storage ponds,impoundments and seeps to the operating WTP, and discharged from the WTP through the effluent pipeline to Lake Roosevelt.
2.4.2.3 B. Surface Water and Stormwater Management and Controls During Excavation		
2.4.2.3.2 B.v.	The Settling Defendants shall develop a monitoring program to ensure that the concentrations of	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 Appendix D – Mine

Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments

~~2.4.2.3 B. Surface Water and Stormwater Management and Controls During Excavation~~		
~~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 Appendix D – Mine~~ Waste Excavation and Containment, in this Appendix E – Water Management Ponds, ~~and~~ Appendix F – Surface Water and Sediment Controls. and Appendix J – Influent and Effluent Pipelines, 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.
2.4.2.4 A. Temporary Facilities during Construction Activities		
2.4.2.4.2 A.	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.	Design sections contained in this Appendix E (Water Management Ponds), Appendix F (Surface Water and Sediment Controls), Appendix J (Influent and Effluent Pipelines); and the associated design drawings in sections 5, 6, and 10 of Volume II describe/illustrate how surface water and impacted site water will be managed upon completion of each major phase of construction. Water will be transferred to the WTP as soon as practicable in order to maintain capacity in the impoundments for future storm events. In addition, 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 RAs.
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 (described in this Appendix E), and ultimately to the operating WTP. 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

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Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

Performance Standard No. in CD SOW	Performance Standard	Comments
~~.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 (described in this Appendix E), and ultimately to the operating WTP. 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 described in this Appendix E. Water from these ponds will be conveyed to the WTP for treatment.
2.4.3.3 Water Collection and Conveyance Work Component		
2.4.3.3.2 A.	All water requiring treatment, as described both above in this table and in this Component of Work, shall be collected and then conveyed to and treated at the WTP operating at the time of conveyance.	The temporary water management ponds described in this appendix will be used to store potentially mine-impacted water. This water will be conveyed to these impoundments and then to/from the operating WTP as described in Appendix J – Influent and Effluent Pipelines. ~~Surface water and groundwater requiring capture, containment, and conveyance to the WTP for treatment during the RA (and following the RA) are described in the text in Appendix D - Mine Waste Excavation and Containment, this Appendix E - Water Management Ponds, Appendix F - Surface Water and Sediment Controls, and Appendix G - Groundwater Controls. These appendices reference associated drawings in Volume II that pertain to collection and treatment of contaminated Site waters. Calculations in these sections are provided to facilitate proper sizing of the groundwater and surface water collection, storage, and treatment systems capacities. In addition, the OM&M Plan (Appendix P) describes comprehensive water management activities for the Site.~~
2.4.3.4 Water Storage and Treatment Work Component		

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2.4.3.4.2 B.	Water treatment shall minimize the need for water storage, as determined during RD.	Water storage ponds for attenuation of peak flows will be required during RA construction and for some period of time after construction while the hydrologic system equilibrates to the remediated configuration. Sizing of these temporary storage ponds are discussed in Attachment E-1 to this Appendix. The impacts of WTP flow capacity on the required water storage during construction are also discussed in Attachment E-1.

E3.0 DESIGN CRITERIA

E3.1 STORAGE CAPACITY CRITERIA

As part of the RA, a new WTP has been proposed with the ability to operate year--round at a maximum average daily rate of 500 gallons per minute (gpm).. Prior to the start of Phase 2 construction when mine-impacted Site water will be stored in the South Pond, either the new WTP will be operating, or the existing WTP will be winterized so that storage of water during a winter shutdown period will not be necessary. This will significantly reduce the peak volume of water stored at the Site from the levels currently reporting to the WMS. However, even with continuous operation of either the existing or the new WTP, some storage capacity will be required for Site water during RA construction when inflows temporarily exceed WTP capacity. In addition, it is necessary to provide storage for impacted waters collected during maintenance or unscheduled WTP shutdowns.

In order to provide a high degree of confidence that sufficient storage capacity exists to accommodate mine-impacted Site waters during RA construction activities, the water management ponds have been sized to accommodate:

1) The 100-year peak storage event. Based upon analysis of historical records, these peak storage events are associated with wet periods during winter and early springtime.

2) Storage that would be required if the WTP experienced a complete shutdown and was inoperable for six weeks during the peak storage event (Item #1 above).

The water balance calculations presented in Attachment E-1 discuss these design criteria and their implications for water storage requirements. The assumption of a catastrophic six-week shutdown period is considered to be an extreme event scenario. Although it is highly unlikely that this would occur during the 100-year peak storage period, this level of conservatism provides a high degree of confidence in the estimated storage volumes presented in this appendix.

E3.2 SLOPE STABILITY CRITERIA

In addition to meeting the performance standards listed in Section E.2, the South Pond will be designed in substantive compliance with criteria from the Washington State Department of Ecology (WSDE) Dam Safety Program to the extent that they are applicable to a synthetically-lined storage pond, which intermittently impounds water. Regulations governing jurisdictional dams are provided at: http://www.ecy.wa.gov/programs/wr/dams/Regulations.html. Engineering guidance for design and construction are outlined in guidance documents which are available for download at: http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html.

Under the WSDE Dam Safety Program rules, both the proposed South and West Ponds will be considered large, high-hazard structures. Both ponds, as currently designed, will have maximum embankment heights of 50 feet or more. Although no permanently -inhabited structures exist downstream, a release of the impounded water to downstream areas could result in significant economic and environmental damage. In addition, the CD SOW presents guidance on factors of safety for geotechnical stability.

Specifically, the required minimum factors of safety against slope failure presented in Table E-2 were used in the evaluation of slope stability analysis results discussed in Attachment E-2 and E-4.

Table E-2 – Design Criteria – Minimum Required Factors of Safety for Stability Analyses

Condition	Minimum Factor of Safety from Consent Decree	Minimum Factor of Safety based upon Dam Safety Guidelines	Minimum Factor of Safety Selected for Design
Static	1.3	1.5	1.5
Pseudostatic	1.0	1.0 to 1.1	1.1
Post-seismic Stability	N/A	1.0 to 1.1	1.1

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E3.3 ADDITIONAL DESIGN CRITERIA

Additional design criteria needed to substantially comply with requirements of the WSDE Dam Safety Program, including emergency overflow spillway capacity and freeboard requirements for flood routing during extreme precipitation events have been considered in design of the pond configurations and accounted for when making capacity calculations. In accordance with WSDE requirements, an emergency overflow spillway capable of passing water flows associated with the 10,000 year storm was considered in the design of the South and West Ponds. The intent is to provide assurance, in the extremely unlikely precipitation scenario which results in the ponds being overtopped, that the overflows occur in controlled locations such that a breach of the ponds within the impoundment will not occur and release stored water.

The emergency overflow spillway configurations shown for the South Pond and West Pond designin the 90-Percent Design drawings are open-channel-type spillways with 5-foot-deep trapezoidal sections and a 10-foot bottom width. The South Pond is an off-channel impoundment and will have a relatively small contributing area reporting to it during most of Phase 2 construction. Although the West Pond is situated in-channel in the Western Drainage, clean runoff from the Pit 4 cover and other upland areas will be diverted around the West Pond via the West Pond Diversion Channel and the West Pond Diversion Berm as shown on Drawing 6-4 and described in Appendix F. These upland diversions have been designed in accordance with criteria specified in the CD SOW such that they can convey storm flows associated with the 100-year storm event without suffering damage, and have the capacity to convey the 500-year storm event without overtopping. As a result, although the West Pond will be an in-channel impoundment, it also will have a relatively small contributing area under all but the most extreme storm events.

Since the West Pond emergency overflow spillway is designed for an extremely large storm event (approximately the 10,000 year storm), it was conservatively assumed that the clean water diversion channel and berm will not be functional and all upland water will report to the West Pond. Although the designed spillway dimensions are not needed to satisfy hydraulic requirements to pass design flows, WSDE also requires a minimum spillway depth of 5 feet to provide a minimum embankment freeboard of 5 feet above the spillway invert for a high-hazard dam. Likewise, a spillway bottom width of 10 feet is not required to pass design flows, but was selected based upon constructability considerations assuming the spillway excavation will be performed using a medium-sized (e.g. Caterpillar D-8 or D-9) dozer.

E4.0 ENGINEERING DESIGN DRAWINGS

The engineering design drawings are contained in Volume II of the BODR. The drawings related to Storage Ponds include:

Table E-3 –Design Drawings – Section 5, Water ManagementStorage Ponds

Sheet Number	Description
5-1	Storage Ponds General Layout
5-2	South Pond Grading Plan
5-3	South Pond Sump Plan
5-4	South Pond Sections
5-5	South Pond Emergency Spillway Grading Plan
5-6	South Pond Emergency Spillway Profile
5-7	West Pond Grading Plan
5-8	West Pond Sump Plan
5-9	West Pond Sections
5-10	West Pond Emergency Spillway Grading Plan
5-11	West Pond Emergency Spillway Profile
5-12	Typical Detail and Section (1 of 4)
5-13	Typical Detail and Section (2 of 4)
5-14	Typical Detail and Section (3 of 4)
5-15	Typical Detail and Section (4 of 4)
5-16	South Pond Details (1 of 4)
5-17	South Pond Details (2 of 4)
5-18	South Pond Details (3 of 4)
5-19	South Pond Details (4 of 4)
5-20	West Pond Details (1 of 3)
5-21	West Pond Details (2 of 3)
5-22	West Pond Details (3 of 3)

E5.0 STORAGE POND DESIGN CRITERIA AND FINDINGS

Below design criteria and findings for each of the proposed water management ponds are discussed. These discussions include the following elements:

- Pond Location
- Pond Storage Requirements
- Pond Configuration and Capacity
- Stability
- Construction Details
- Operational Considerations

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E5.1 SOUTH POND

The proposed location of the temporary South Pond is shown on Drawing 5-1 and Drawing 5-2. The South Pond will be used for water storage during the Phase 2 construction (possibly 5 years). The configuration of the South Pond is shown in plan view on Drawing 5-2 and sections are included on Drawing 5-4. Although seepage from this area is currently being collected in the Pollution Control Pond (PCP) (where it is collected, transferred to Pit 3, then pumped to the WTP for treatment), the South Pond will be constructed as a synthetically lined pond with double containment and leak detection. The liner system will significantly reduce the potential for increasing the saturation levels of the waste rock and foundation soils that could result in reduced embankment stability.

E5.1.1 South Pond Storage Requirements

The results of water balance analyses performed to estimate the storage required during the 5 years of Phase 2 of construction when the South Pond will be operational, are included in Attachment E-1. A schematic of the WMSwater management system, showing flow components considered in the Phase 2 water balance analyses is included as Figure E-3. With the exception that Pit 3 will no longer be available for water storage, the flow components are very similar to those shown on Figure E-2 for Phase 1. These flow components and the water balance analyses are discussed in greater detail in Attachment E-1. The water balance analyses indicate that approximately 59,100,000 gallons of pond volume is needed to provide storage during the 100-year wet period, assuming that the WTP is inoperable for six weeks during the peak pond inflow period. The water balance analyses also indicate that under normal operating conditions, the pond will contain very small volumes of water. If the plant is operational during the 100-year wet period, less than half of the South Pond capacity (23,400,000 gallons) wouldwill be utilized.

E5.1.2 South Pond Configuration and Capacity

The South Pond is shown on Drawings 5-1 through 5-6. The pond will be constructed by excavating waste rock from the SWRP to a crest elevation of 2,683 ft. The South Pond configuration includes an emergency overflow spillway on the east side of the pond as shown on Drawing 5-2. Assessment of the design storm used and estimation of design flows for the emergency overflow spillway design followed WSDE Dam Safety guidelines and are provided in

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Attachments E-8 and E9, respectively. The design calculations for the spillway are provided in Attachment E-10. The emergency overflow spillway is an open-channel--type spillway with an invert elevation at elevation 2,678 ft and a trapezoidal cross-section with a depth of 5 ft (as required by WSDE) and a bottom width of 10 ft as shown on Ddrawing 5-15.

The pond will include a divider berm in the pond bottom at elevation 2,636 ft that effectively forms two cells at low-water levels, allowing for maintenance of the pond while still maintaining the ability to operate in the other cell. The pond bottom in each cell will be sloped toward sumps areas, with sump bottoms located at elevation 2,619 ft and 2,620 ft for the east and west sumps, respectively. Figure E-6 depicts the stage-storage curve for the South Pond (shown on Drawings 5-1 thru 5-4) and illustrates that:

- The “maximum capacity” (defined by WSDE as the storage capacity at the embankment crest) for the configuration of the South Pond as designed is 80.3 million gallons (Mgal)..
- The available capacity at the spillway inlet level located 5 feet below the crest is 66.9 Mgal.
- The effective storage volume of the South Pond is 63.8 Mgal assuming that 3.1 Mgal of dead storage (corresponding to a pond elevation of 2,633 ft or a minimum pool depth of 14 feet) will be maintained in the pond bottom to accommodate variations in operational flows and to provide ballast to prevent liner lift-out during high wind events. Calculations were performed to estimate makeup water quantities needed to offset evaporation losses and maintain dead storage. These calculations indicate that estimated low flows from the WMSwater management system during Phase 2 of construction will be sufficient to maintain the water levels needed for dead storage in the South Pond. These calculations were submitted as an interim submittal to EPA on April 30, 2014 and are included as Attachment E-7.

Thus, the capacity of the current South Pond configuration shown in the figure is greater than needed to achieve the design criteria of 59.1 Mgal.

E5.1.3 South Pond Stability

The input parameters and procedures used for, and results of slope stability analyses are presented in detail in Attachment E-2. Safety--factor calculations against slope failure were made for deeper-seated failures that had the potential to break back to within 20 feet of the pond crest. Potential shallow failure surfaces, especially in the steeper portion of the lower SWRP slope would have lower factors of safety, but would not impact the South Pond at the proposed setback from the SWRP crest shown on Drawing 5-2. Post-earthquake analyses using post-seismic strength parameters to represent loose, saturated materials were performed for Cross -Section 1 in Attachment E-2 as this was the only location where a significant amount of this type of material exists at the waste rock foundation contact. The results of the stability analyses are summarized in Table E-4. These results show that the minimum factor--of--safety design criteria for slope stability presented in Table E-2 are met in all cases for the proposed South Pond configuration.

Table E-4 – South Pond Factors of Safety for Against Deep-Seated Slope Failures

	Factor of Safety (FOS)					
	Static 1.5 Minimum FOS		Pseudo-Static 1.1 Minimum FOS		Post-Earthquake 1.1 Minimum FOS	
Failure Surface	**Circular**	**Wedge**	**Circular**	**Wedge**	**Circular**	**Wedge**
Cross-Section 1	1.6	1.8	1.1	1.1	1.2	1.2
Cross-Section 2	1.5	1.8	1.2	1.4	n/a	n/a
Cross-Section 3	2.0	2.3	1.5	1.6	n/a	n/a

E5.1.4 South Pond Construction Details

Design details for the South Pond are included on Drawings 5-3 to 5-6 and 5-12 to 5-19. It is proposed that the South Pond be constructed immediately upslope from the PCP by excavating into the SWRP waste. Prior to excavation of the South Pond, existing Ore and Protore Piles 5 and 8 will be removed from the SWRP surface in the South Pond area and placed in Pit 4 as part of Phase 1 construction. After removal of the Protore in this area, additional excavation of SWRP material to depths of up to 70 feet will occur to create the pond. This will result in significant unloading of the waste rock and foundation soils in the South Pond area.

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The South Pond will be a double-lined with leak detection between the primary and secondary geomembranes. The primary liner will consist of a textured 60-mil high density polyethylene (HDPE) geomembrane overlying a synthetic geonet leak detection layer. The leak detection layer will overlie a secondary liner constructed of a second HDPE geomembrane liner. Drawing 5-12 depicts typical construction details for this liner system. In order to comply with WSDE Dam Safety guidelines, the South Pond will include and emergency overflow spillway configured as shown on Drawing 5-2. Calculations associated with the spillway design are included as Attachments E-9, E-10, and E-11.

As discussed in Sections E5.1.1 and E5.1.2, the South Pond will contain very little water beyond the 14 feet of water maintained for liner ballast in each cell for most years when the WTP is operating normally. Under these low-water operating conditions, wind uplift and anchor trench capacity can become a concern. In order to address this concern, evaluations were conducted of the anchor trench capacity for the anchor trench configuration shown on Drawing 5-12, and of potential wind uplift for both construction and low-water (dead-storage pool) conditions. The analysis of anchor trench capacity is summarized in Attachment E-5 and the wind uplift analysis is summarized in Attachment E-6.

These analyses indicate the proposed anchor trench design is more than adequate, and the proposed 60-mil HDPE primary (upper) geomembrane has adequate strength to withstand stresses induced by wind uplift. Although not accounted for in the design calculations, suction vents are included in the design as shown on Drawing 5-14 to reduce uplift stresses on the primary geomembrane liner due to wind-induced suction and/or high air temperatures developing in the leak detection layer. In addition, ballast in the form of sand-filled HDPE piping placed in the corners of the ponds is included in the design details to reduce the potential for uplift, curve reversal, and excessive flexure at these critical locations. Details for the in-pond ballasts are provided on Drawing 5-14. Due to the relatively short anticipated life of the South Pond (approximately 5 years), additional protection for the HDPE geomembrane systems is not warranted.

E5.1.5 South Pond Operational Considerations

The South Pond will be used for water storage during the 5-year Phase 2 construction period. During Phase 2, water from the South Pond will be transferred to the WTP, treated, and either

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discharged to Lake Roosevelt via the Blue Creek pipeline, or used for construction water as needed for construction as described in the Water Source Identification and Development Plan (Appendix T). Analyses were performed of potential scenarios for storing some portion of impacted water during the spring inflow season for later use as on-Ssite construction water during drier parts of the year. These analyses and their results are provided in Attachment E-1.

The results indicate that on-Ssite construction water during Phase 2 can be supplied by WTP effluent if sufficient impacted water from the spring meltoff is stored in the South Pond prior to beginning of the dry-season. Storage of impacted water for later treatment and use during the dry-season construction will not affect the required active storage capacity of the ponds since the water levels within the pond will be reduced to dead storage levels prior to the onset of the next late winter/early spring high flow period.

Action leakage rates through the primary liner for the South Pond during operation were proposed in an interim submittal to the EPA (MWH, 2014). A four-level system for action leakage rates and appropriate responses were proposed based upon a review of standards of practice as defined by existing state regulations across the United States regarding action leakage rates from surface impoundments, with particular emphasis placed on impoundments containing mine-impacted waters or constructed for groundwater protection. The four levels, based upon leakage rates measured in individual leak detection sumps, are:

- Level 1 Operating Leakage Rate (OLR) : <20 gallons per acre per day (gpad)
- Level 2 Increased Leakage Monitoring and Reporting (MR): >20 gpad, but <200 gpad
- Level 3- Leak Investigation and Action Plan (LIAP): >200 gpad, but <500 gpad and enhanced inspection of downstream slopes of embankments for signs of saturations or seepage.
- Level 4 Immediate Response Level (IRL): >500 gpad. Immediately implement enhanced inspection of downstream slopes of embankments for signs of saturation or seepage, determine the source of leakage, and prepare work plans and repair the pond, as needed.

Additional discussion and information regarding the operation, maintenance, and monitoring of the West Pond is provided in Appendix P.

E5.2 WEST POND

The location proposed West Pond is shown on Drawing 5-1 and Drawing 5-7. The West Pond will be used for water storage beginning in Phase 3 of the RA and remain operational until post-RA water management flows subside to the point where the equalization ponds adjacent to the new WTP provide sufficient storage for the overall WMS.~~water management system.~~ The configuration of the West Pond is shown in plan view on Drawing 5-7 and sections are shown on Drawing 5-9. The West Pond will be a doub~~a~~le-lined pond with leak detection as discussed above for the South Pond in Section E5.1.4. The West Pond will include and emergency overflow spillway configured as shown on Drawing 5-7 and designed in accordance with WSDE Dam Safety guidelines. Calculations associated with the spillway design are included as Attachments E-9, E-10, and E-11.

The~~A diversion channel, the~~ West Pond Diversion Channel~~,~~ will be constructed to route clean surface water flow from upstream areas in the Western Drainage around the east side of the West Pond and route it to the West Pond emergency spillway, as shown on Drawing 5-7. This diversion channel has been designed and sized to convey flows up to, and including those associated with the 500-year, 24-hour storm event and is described in Appendix F. The West Pond Diversion Berm also will be constructed uphill and to the north and west of the West Pond. This diversion berm will divert clean surface water flows to the south of the West Pond and into the lower Western Drainage. This berm is shown on Drawing 6-4 and described in Appendix F.

An emergency overflow spillway is included in the West Pond embankment at the left abutment (i.e. the contact of the embankment crest with the east slope of the Western Drainage).

E5.2.1 West Pond Storage Requirements

Water balance analyses were performed to estimate the storage required during the years when the West Pond is operational (assumed to be 10 to 15 years) and are described in detail in Attachment E-1. A schematic of the WMS~~water management system~~ at the start of Phase 3 construction, which represents the period of maximum flow to the West Pond, is shown on Figure E-4. A schematic of the WMS~~water management system~~ upon decommissioning of the West Pond is shown on Figure E-5. The flow components at these two stages are described in detail in Attachment E-1.

Operation of the West Pond is expected to be approximately 10 to 15 years. However, thereThere is a potential that the West Pond or some other water storage mechanism will be needed more than 15 years after completion of RA construction. The West Pond is designed to be in substantive compliance with WSDE Dam Safety Guidelines which were been developed for permanent water retention structures. As such, there is nothing inherent in the design that would limit the life span of the West Pond to 15 years if it is necessary to keep it in service for a longer period of time. Regardless, if it appears that flows are stabilizing at a rate greater than 50 gpm and the WTP equalization ponds will not be able to provide sufficient contingency storage, other longer-term storage measures will have to be considered.

The water balance analyses for the West Pond indicate that approximately 22,100,000 gallons of storage volume will be needed at the start of Phase 3 when the West Pond is needed and becomes operational. This volume includeswill allow for storage of inflow from the 100-year wet period assuming that the WTP is inoperable for six weeks during the peak pond inflow period. After the first few years of operation, when the remainder of the remaining mine waste in the Central Drainage has been removed, all and soil cleanup is completed, and additional stormwater can be shed clean from those remediated areas, the storage volume requirement of the West Pond will decrease. Under typical climate conditions and normal WTP operations, the West Pond will contain very small volumes of water.

E5.2.2 West Pond Configuration and Capacity

The West Pond is shown on Drawings 5-1, and 5-7 through 5-9. The pond will be constructed using an embankment of compacted fill consisting of native soils excavated from the impoundment footprint. The West Pond's embankment crest elevation is 2,660 ft. The design includes an emergency overflow spillway at the left abutment of the embankment as shown on Drawing 5-7. Assessment of the design storm used and estimation of design flows for the emergency spillway design followed WSDE Dam Safety guidelines and are provided in Attachments E-8 and E9, respectively. The design calculations for the spillway are provided in Attachment E-10. The emergency overflow spillway will be an open-channel--type spillway, with an invert elevation at elevation 2,655 feet, and a trapezoidal cross-section with a depth of 5 feet (as required by WSDE) and a bottom width of 10 feet as shown on drawing 5-15.

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The pond bottom will be sloped toward a sumps area, with sump bottom located at elevation 2,605 ft. Figure E-7 depicts the stage-storage curve for the West Pond (shown on Drawings 5-7 through 5-9) and illustrates that:

- The “maximum impoundment capacity” (defined by WSDE as the storage capacity at the embankment crest level) is 32.5 Mgal.
- The available capacity at the spillway inlet level located 5 feet below the crest is 25.4 Mgal.
- The effective storage volume of the West Pond is 24 MGal assuming that 1.4 MGal of dead storage (corresponding to a pond elevation of 2,619 ft, of a minimum pool depth of 14 feet) will be maintained in the pond to accommodate variations in operational flows and provide ballast against liner liftout during high-wind events. Calculations were performed to estimate makeup water quantities needed to offset evaporation losses and maintain dead storage. These calculations indicate that estimated low flows from the WMSwater management system during Phase 3 of construction will be sufficient to maintain the water levels needed for dead storage in the West Pond. These calculations were submitted as an interim submittal to EPA on April 30, 2014 and are included as Attachment E-7.

Thus, as depicted in Figure E-7 and the drawings referenced above, the capacity of the West Pond as designed is greater than needed to meet the design criteria of 22.1 MGal.

E5.2.3 West Pond Preliminary Stability

The input parameters and procedures used for, and results of slope stability analyses for the West Pond are presented in Attachment E-4. These analyses were based upon borehole information in the vicinity of the proposed West Pond site (which is currently buried under waste rock of the SWRP), and pre-minepremine topographic mapping. Safety--factor calculations against slope failure were made for deeper-seated failures that included the pond crest. Post-earthquake analyses using post-seismic strength parameters to represent loose, saturated materials were not performed for the West Pond. This is because any loose, saturated material that might exist within the embankment footprint will be removed and replaced with suitably moisture-conditioned compacted fill during construction.

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The results of the stability analyses are summarized in Table E-5. These results show that the minimum factor-‑of-‑safety design criteria for slope stability presented in Table E-2 are met in all cases for the proposed West Pond configuration. It is recommended that the assumptions made regarding foundation conditions and embankment and impoundment geometry be reevaluated as waste rock removal exposes the native ground surface during Phase 1 and the early stages of Phase 2 construction.

Table E-5 – West Pond Factors of Safety for Against Deep-Seated Slope Failures

	Factor of Safety (FOS)	
	Static	**Pseudostatic**
	(1.5 Minimum FOS)	**(1.1 Minimum FOS)**
Cross-Section 1	1.8	1.4
Cross Section 2	1.8	1.4

E5.2.4 West Pond Construction Details

Design details for the West Pond are included on Drawings 5-8 to 5-15, and 5-20 to 5-22. The West Pond will be constructed by excavating soils from the impoundment area immediately upstream of the West Pond and using them for construction of the West Pond embankment across the Western Drainage. Use of material from the upstream impoundment area as a borrow source will increase the West Pond capacity and reduce the required embankment height and volume.

The West Pond will be synthetically lined with two geomembranes and a leak-detection layer located between the primary and secondary geomembranes. The primary liner will consist of a 60-mil high density polyethylene (HDPE) geomembrane overlying a synthetic geonet leak detection layer. The leak detection layer will overlie a secondary 60-mil~~liner constructed of second~~ HDPE geomembrane liner. Drawing 5-12 depicts typical construction details for this liner system.

As discussed in Sections E5.2.1 and E5.2.2, the West Pond will contain very little water, beyond the minimum 14 feet of dead storage needed for liner ballast, when the WTP is operating normally. As with the South Pond, wind uplift and anchor trench capacity can become a concern under these low-water conditions. In order to address this concern, evaluations were

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made of anchor trench capacity for the anchor trench design shown on Drawing 5-12, and of potential wind uplift for both construction and low-water (dead-storage pool) conditions. These anchor trench analyses are summarized in Attachment E-5 and the wind uplift analyses summarized in Attachment E-6.

These analyses indicate the proposed anchor trench design is more than adequate, and the proposed 60-mil HDPE primary (upper) geomembrane has adequate strength to withstand stresses induced by wind uplift. Although not accounted for in the design calculations, suction vents have been included in the design as shown on Drawing 5-14 to reduce uplift stresses on the primary geomembrane liner due to wind-induced suction high air temperatures developing in the leak detection layer. In addition, ballast tubes in the form of sand-filled HDPE piping placed in the corners of the ponds is included in the design details to reduce the potential for wind uplift, curve reversal, and excessive flexure at these critical locations. Details of the in-pond ballast tubes are provided on Drawing 5-14. Due to the relatively short anticipated life of the West Pond (approximately 10 to 15 years), additional protection for the HDPE geomembrane systems is not warranted. If the West Pond is required to remain operational significantly longer than anticipated, replacement of the HDPE geomembrane liner system, or possibly even redesign and replacement of the entire West Pond may become necessary.

E5.2.5 West Pond Operational Considerations

The West Pond will be used for water storage during the Phase 3 construction and following the RA while the inflows of mine-affected water stabilize. The period of operation for the West Pond is assumed to be approximately 10 to 15 years. During Phase 3, water from the WestSouth Pond will be transferred to the WTP, treated, and either discharged to Lake Roosevelt via the Blue Creek pipeline, or used for construction water as needed for construction as described in Appendix T. Analyses were performed of potential scenarios for storing some portion of impacted water during the spring inflow season for later use as on-site construction water during drier parts of the year. These analyses and their results are provided in Attachment E-1.

The results indicate water captured by the WMS during the Phase 3 dry-season construction period will be sufficient to meet construction water needs, and additional storage prior to the onset of the dry season will not be needed during Phase 3.

Action leakage rates through the primary liner for the West Pond during operation were proposed in an interim submittal to the EPA (MWH, 2014). A four-level system for action leakage rates and appropriate responses were proposed based upon a review of standards of practice as defined by existing state regulations regarding allowable leakage rates from surface impoundments, with particular emphasis placed on impoundments containing mine-impacted waters or constructed for groundwater protection. The four levels, based upon leakage rates measured in individual leak detection sumps, are:

- Level 1 Operating Leakage Rate (OLR) : <20 gpad
- Level 2 Increased Leakage Monitoring and Reporting (MR): >20 gpad, but <200 gpad
- Level 3- Leak Investigation and Action Plan (LIAP): >200 gpad, but <500 gpad and enhanced inspection of downstream slopes of embankments for signs of saturations or seepage.
- Level 4 Immediate Response Level (IRL): >500 gpad. Immediately implement enhanced inspection of downstream slopes of embankments for signs of saturations or seepage, determine the source of leakage, and prepare work plans and repair the pond, as needed.

Additional discussion and information regarding the operation, maintenance, and monitoring of the West Pond is provided in Appendix P.

E6.0 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

Below are green and sustainable remediation (GSR) considerations for Appendix E – Water Management Pond. GSR considerations were evaluated for: 1) Construction Materials (characteristics and manufacturing considerations), 2) Construction Methods, and 3) Low Impact/Sustainability measures undertaken during construction.

E6.1 CONSTRUCTION MATERIAL CONSIDERATIONS

The ponds will be double-lineddual walled with a leak detection system. The primary liner material is a 60-mil HDPE geomembrane which is chemically compatible with the pond water and resistant to punctures and stress/strain conditions. These characteristics and the double-lineddual-walled design will help ensure the liners viability and protect the environment from release of impacted mine water.

Site grading for these temporary storage ponds will be minimized to the extent possible to reduce the required construction equipment operating time, greenhouse gas emissions, and fill material.

E6.2 CONSTRUCTION METHODS

The construction equipment used for the storage ponds will be appropriately sized to reduce fuel consumption and greenhouse gas emissions, and to minimize stormwater erosion during these activities. Dust suppression also will be conducted in the work areas and on the access roads to decrease visible dust related emissions.

The Stormwater 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 stormwater control. Aspects of these BMPs support the green and sustainable features of the RA by effectively:

- Minimizing the transport of potentially contaminated surface water and sediments from the MA
- Limiting damage to existing vegetation, wetlands, and surface water
- Diverting clean water around and away from the temporary storage ponds and remediation activities (by regrading and contouring the surface, using stormwater control BMPs, and temporary channels) thus preventing its potential contamination
- Segregating contaminated water from clean water to minimize the volume of stormwater requiring treatment at the WTP

All of these activities decrease the impacts of the RA construction on the surrounding environment and serve to limit short-term treatment of potentially contaminated stormwater.

The South Pond will be excavated into the mine wastes of the SWRP, and these materials are scheduledslated for backfilling into Pit 4. Because this material has to be moved for the RA, the only extra expenditure of resources is in placing and removing the liner when the pond is dismantled at the end of Phase 2 operations. This will save significant fuel and labor expenditures over excavation at an alternative unimpacted location where there would be environmental impacts. The West Pond will replace the South Pond and clean waters running off remediated areas (e.g., the newly constructed Pit 4 cover),, will be channeled around this pond so that the new WTP only has to treat impacted waters. Construction of the South and West Ponds then reduce greenhouse gas emissions by placing these storage areas within the mine area close to the sources of water, and by segregating clean from dirty water so the WTP operations can be reduced. These temporary on-site ponds also reduce the possible environment impacts of leaks when compared to an alternative offsite pond location that likely is unimpacted by the mine.

E6.3 LOW IMPACT DEVELOPMENT/SUSTAINABILITY

A thoughtful approach was taken to determine the volume required for each temporary pond. The storage ponds are a key component to the RA because they haveand help ensure the capacityability to abstoreb fluctuations in flow from maximum precipitation events, electrical disruptions that might render the WTP incapable of treatment, and/or major equipment malfunctions at the WTP inoperableexisting and new WTPs. Grading will be conducted and channels constructed to divert clean stormwater from entering the ponds and subsequently being treated at the WTP. 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 so that contaminated media do not leave the Site during construction. The Surface Water and Sediment Controls described in Appendix F will be used to shed clean water away from contaminated areas thereby reducing the volume of mine-impacted water requiring treatment. In addition, contaminated water will be retained in these doubale-lined temporary ponds within the contaminated areas, thereby preventing recontamination of remediated areas.

E.7.0 REFERENCES

U.S. Environmental Protection Agency (EPA), 2011. Consent Decree Statement of Work for the Remedial Action for the Midnite Mine Superfund Site, Spokane Indian Reservation, Washington. Civil Action No. CV-05-020-JLQ. United States of America, Plaintiff v. Dawn Mining Company, LLC and Newmont USA Limited, Defendants. August.

MWH Americas, Inc. (MWH), 2014. Technical Memorandum: Midnite Mine, Interim Submittal for 90% Design - Action leakage levels for Water Management Pond Primary Liners, Revision 0. Prepared for Worthington Miller Environmental and Newmont USA Limited. April 7.

Figures

Attachment E-1

Storage Pond Water Balance

Attachment E-2

South Pond Global Stability Analyses

Attachment E-3

South Storage Pond Liquefaction/Cyclic Softening Analysis

Attachment E-4

West Pond Global Stability Analysis

Attachment E-5

Liner System Anchor Trench Analysis

Attachment E-6

Liner System Wind Uplift Analysis

Attachment E-7

South and West Pond Dead Storage Evaporation Loss Analysis

Attachment E-8

Design Step Summary for the Midnite Water Management Ponds

Attachment E-9

Design Flow Estimates for Spillway Design

Attachment E-10

Spillway Designs

Attachment E-11 Water Management Ponds Freeboard Calculations