# Midnite Mine Superfund Site
# 100 Percent Design

# Appendix G – Groundwater Controls

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Attachment G-2 Alluvial Flow Measurements

Attachment G-3 Calculation Brief – Extraction Trench Filter Compatibility Calculations

Attachment G-4 Geotechnical Investigation Report, Alluvial Groundwater Collection, Midnite Mine

## LIST OF ACRONYMS

| | |
|---|---|
| AGCS | Alluvial Groundwater Control System |
| ASTM | American Society for Testing and Materials |
| BMP | Best Management Practice |
| BODR | Basis of Design Report |
| CD | Consent Decree |
| Cm/s | Centimeters per Second |
| GCL | Geocomposite Clay Liner |
| gpm | gallons per minute |
| GSR | Green and Sustainable Remediation |
| EPA | U.S. Environmental Protection Agency |
| ft | Feet |
| HDPE | High-density Polyethylene |
| NEH | National Engineering Handbook |
| NRCS | Natural Resources Conservation Service |
| O&M | Operations and Maintenance |
| PCP | Pollution Control Pond |
| psi | pounds per square inch |
| RA | Remedial Action |
| RAO | Remedial Action Objective |
| RD | Remedial Design |
| Site | Midnite Mine Superfund Site |
| SB | soil bentonite |
| SLCB | slag-cement bentonite |
| SOW | Statement of Work |
| SWMP | Stormwater Management Plan |
| SWPPP | Stormwater Pollution Protection Plan |
| Tribe | Spokane Tribe of Indians |
| USBR | U.S. Bureau of Reclamation |
| USCOE | U.S. Army Corps of Engineers |
| WTP | Water Treatment Plant |

# G1.0 INTRODUCTION

This appendix to the *Midnite Mine Superfund Site Basis of Design Report* (BODR) presents the detailed design information of the groundwater controls for intercepting and collecting contaminated alluvial groundwater at the Midnite Mine Superfund Site (Site). Contaminated alluvial groundwater has been identified in the Western, Central, and Far East Seep Drainages and interim water management systems consisting of shallow wells and pump back systems have been installed in these three drainages to capture this groundwater. As part of the *Consent Decree Statement of Work* (CD SOW; EPA, 2011), a more robust Alluvial Groundwater Collection System (AGCS), consisting of a groundwater collection trench and a downgradient, low-permeability barrier will be installed in each of these drainages as part of the early stages of the Final Remedial Action (RA).

AGCSs will be installed in the Western, Central, and Far East Seep Drainages at the locations shown in Section 7 of the Drawings. Based upon comments received from EPA and the Tribe, the locations of the AGCSs in the Western Drainage and Central Drainage have been moved downstream from the locations previously shown in the Midnite Mine 60 Percent - Basis of Design Report (60% BODR, MWH, 2013). The groundwater controls are intended to intercept groundwater in the impacted shallow aquifer consisting of the shallow alluvium, residual soils, and underlying extremely weathered bedrock, then convey the groundwater for treatment at the Site water treatment plant (WTP). This design is based upon information from recent geotechnical investigations intended to provide site-specific subsurface information at each of the proposed AGCS locations, as well as from previous investigations of subsurface conditions in these drainages. A summary of the recent AGCS geotechnical investigations is included as Attachment G-4 to this appendix. The AGCS geotechnical investigations consisted of test hole drilling and sampling, as well as seismic refraction surveys at each of the proposed AGCS locations. The previous investigations are summarized in the *Draft data summary report from investigation of the alluvial aquifer south of the Midnite Mine* (SMI, 1997), the *Remedial Action Work Plan - Interim Mechanisms* (Tetra Tech, 2010a) and the *Storage Ponds Investigation Report* (MWH, 2012). These investigations indicate subsurface conditions at the proposed interception trench locations consist of alluvium overlying extremely weathered bedrock (i.e., the residual soil) that grade to less-weathered bedrock with depth. The alluvium and residual soils are generally relatively fine-grained with moderate permeability.

Groundwater controls proposed for each of these drainages will consist of an extraction trench installed immediately upslope of a low-permeability barrier wall. The extraction trench will be excavated through the alluvium, residual soils and extremely weathered paralithic bedrock to the point of hydraulic excavator refusal in competent bedrock. In the Far East Seep Drainage, the results of the seismic refraction survey performed along the AGCS alignment suggest that competent (Attachment G-4), unexcavatable bedrock may be deep in some areas. Although there is uncertainty associated with interpretation of excavatability from seismic refraction surveys, the point of excavator refusal may not be reached at a practical depth over parts of the AGCS. Large hydraulic excavator equipment with the ability to excavate to depths of 40 feet or more will be used to construct the AGCS. If areas along the proposed AGCS alignment are encountered where competent (unexcavatable) bedrock is deeper than the maximum reach of the excavator (assumed to be at least 40 feet), alternatives will be assessed for deepening the AGCS or modifying the location. Any location modification will be made in consultation with EPA.

The low-permeability barrier wall also will be installed to depths corresponding to excavator refusal in competent bedrock (or alternatives assessed as discussed above) immediately downgradient of the extraction trench to increase capture efficiency. If post-construction performance monitoring indicates significant bypass of alluvial groundwater either around, or under the low-permeability barrier wall, consideration will be given to permeation grouting of the barrier wall/bedrock contact as well as the bedrock underlying and adjacent to the barrier wall.

After excavation of waste piles, placement of these wastes in Pits 3 and 4, followed by capping of these upgradient areas, it is expected that the alluvial groundwater quality downgradient from these RA activity will gradually improve, and the Groundwater Controls described in this appendix will not be necessary. Once the groundwater quality in the alluvial groundwater system has improved to the point where they no longer exceed the maximum concentrations listed in Table 2-4 of the CD SOW, and after approval from EPA, the Groundwater Control systems will be abandoned. Abandonment shall include removal of all, or parts of, the collection systems and barrier walls as needed to return the flow regime in each drainage to a more natural state.

This remainder of this appendix contains the following information:

- Demonstration that the design will attain the Groundwater Control Performance Standards identified in the CD.

- Design calculations, assumptions, and parameters such as estimates of alluvial groundwater flow rates to be intercepted and conveyed to the WTP.
- Proposed locations of the groundwater controls.
- Sequencing for construction of the groundwater controls.
- Configurations, design details, and methods to be used during the construction of the: 1) groundwater barrier wall, 2) groundwater extraction trench, and 3) groundwater collection and conveyance systems.
- Materials management strategies, anticipated limits of excavations, and erosion and surface water controls.
- Instrumentation for monitoring of the performance of the Groundwater Controls.
- Green and Sustainable Remediation (GSR) considerations.

## G2.0 PERFORMANCE STANDARDS

The Performance Standards presented herein are defined in the SOW, 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 Remedial Design (RD), are summarized on Table 4-6 of the BODR. The general and specific Performance Standards related to Groundwater Controls are listed below.

## Table G-1 – Performance Standards Applicable to Groundwater Controls



| Performance Standard No. in CD SOW | Performance Standard | Comments |
|---|---|---|
| **2.3 General Standards Applicable to All Work Elements and Components of Work - Groundwater Controls** | | |
| 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. | Surface flows in the drainages are either ephemeral or intermittent, and construction will be scheduled during summer or early autumn to avoid impacting surface flows to the extent possible. Site preparation work will involve an open excavation perpendicular to the stream channels to a depth of at least two feet below the channel thalweg. Any shallow groundwater of surface flow intercepted in this excavation will be pumped to the Pollution Control Pond (PCP), from where it will be transferred to the WTP. |
| 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. | Construction of Groundwater Controls will occur during Phase 1 of RA construction activities and will be completed prior to sediment cleanup in drainages, thus avoiding recontamination of remediated areas. To the maximum extent possible, spoils from trench excavations will be hauled to the top of the South Waste Rock Pile along existing roads to avoid potential for contamination of previously uncontaminated areas. |
| 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 necessary to complete the Work. 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. | In accordance with the Master SWMP in Appendix O, a Construciton Stormwater Polution Protection Plan (SWPPP) will be prepared for this work and will include specific BMPs for sediment and stormwater control before, during, and after construction. |

**Table G-1 – Performance Standards Applicable to Groundwater Controls**

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| Performance Standard No. in CD SOW | Performance Standard | Comments |
|---|---|---|
| **2.4 Standards Applicable to Groundwater Control Work Components** | | |
| 2.4.3.3.2 I. | Contaminated groundwater in the alluvium and weathered bedrock that exceeds concentrations listed in Table 4-4 or which may result in concentrations in surface water downgradient greater than the concentrations listed in Table 4-3 shall be intercepted and collected. | Groundwater in the alluvium in the Western, Central, and Far Eastern Drainages has been identified as exceeding concentrations listed in Tables 4-3 and 4-4 and will be intercepted and collected as shown in the Section 7 Drawings. |
| 2.4.3.3.2 J. | This groundwater collection system shall be sited in locations to be determined during RD and shall consist of an interception trench excavated to competent bedrock, a designed drain backfill, a low permeability barrier on the down-gradient side of the drain backfill, and a collection sump and pump back system or other system approved by EPA. | The locations of the groundwater collection systems in the Western, Central, and Far Eastern Drainages are shown on Drawing 7-1 (in Volume II). |
| 2.4.3.3.2 K. | All water collected in the groundwater collection system shall be conveyed to the WTP for treatment. | Initially, water collected in the groundwater collection system will be conveyed to the WTP via the PCP. Once the PCP is decommissioned (in Phase 3), groundwater will be conveyed directly to the WTP Equalization Pond. |
| 2.4.3.3.2 L. | The groundwater collection system shall be constructed as early as practicable during the Work to provide effective capture of contaminated groundwater during up gradient construction and to accelerate the recovery of Blue Creek surface water and sediment quality. | The groundwater collection system will be constructed during Phase 1 of the RA construction. |
| 2.4.3.3.2 M. | The groundwater collection system shall continue to be operated until otherwise approved by EPA. | The groundwater collection systems have been designed for long-term operation, with maintenance systems including drain pipe cleanouts and easily accessible pump risers, to enhance long-term operation included in the designs. |

## G3.0 ENGINEERING DESIGN DRAWINGS

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

| Sheet Number | Description |
|---|---|
| 7-1 | Location of Alluvial Groundwater Controls |
| 7-2 | Western and Central Drainage Detailed Plan View |
| 7-3 | Western Drainage Section A |
| 7-4 | Western Drainage Section B |
| 7-5 | Western Drainage Section C |
| 7-6 | Central Drainage Section D |
| 7-7 | Central Drainage Barrier Wall |
| 7-8 | Central Drainage Extraction Trench |
| 7-9 | Far East Seep Drainage Detailed Plan View |
| 7-10 | Far East Seep Drainage Section G |
| 7-11 | Far East Seep Drainage Sections H and I |
| 7-12 | Groundwater Collection System Details |

## G4.0 LOCATION OF GROUNDWATER CONTROLS

Groundwater in the alluvium in the Western, Central, and Far East Seep Drainages has been identified as exceeding concentrations listed in Tables 4-3 and 4-4 of the BODR. As discussed above, alluvial pump back systems have been installed in these drainages as part of interim improvements to the water management system (Tetra Tech, 2010b). The AGCSs described in this appendix will replace those systems and will be located farther downstream in the Western, Central, and Far East Seep Drainages as shown on Drawings 7-1, 7-2, and 7-9 (in Volume II).

Based upon comments received from EPA and the Tribe, the locations of the AGCSs in the Western Drainage and Central Drainage have been moved downstream approximately 350 feet downstream and 710 feet respectively from the locations shown in the 60% BODR (MWH, 2013) in order to increase capture of potentially impacted alluvial groundwater in these downgradient areas. The location of the AGCS in the Far East Seep Drainage has not been moved.

## G5.0 CONSTRUCTION SEQUENCING

Installation of groundwater controls will occur during Phase 1 of construction and will be completed prior to sediment cleanup in the drainages, thus avoiding recontamination of remediated areas. Construction will be scheduled such that it occurs during summer or early

autumn to avoid impacting ephemeral/intermittent surface flows that occur in the drainages to the extent possible.

The sequence for construction of the groundwater collection systems within each of the drainages will be as follows:

1) BMP installations for sediment and stormwater controls immediately prior to commencement of construction.

2) Excavation of a level working platform in preparation for Extraction Trench and Barrier Wall construction. This excavation will be roughly perpendicular to the stream channel and will be excavated to a depth of approximately two feet below the stream channel thalweg or other lowest point in the existing ground surface along the valley cross section. It is anticipated that this level working platform will be approximately 30-feet wide and will extend into either valley wall until practical excavator refusal is reached. Ripping and/or blasting will not be performed as part of this work. Upon completion of the working platform excavation, a layer of stabilizing fill will be placed as needed to provide a stable working surface for construction equipment and to contain trench slurry.

3) Construction of the extraction trench will be completed as shown on Drawings 7-5, 7-8, and 7-11.

4) Dewatering pumps will be installed in the extraction trenches and temporary conveyance pipelines will be constructed to the existing PCP.

5) Commence with dewatering of the alluvial/shallow bedrock system.

6) Construction of the low-permeability barrier wall downgradient of the extraction trench as shown on Drawings 7-4, 7-7, and 7-11.

7) Backfill and grade working platform excavation in order to restore original grade in work area.

8) Install monitoring wells in each of the drainages to evaluate performance of the groundwater controls.

9) Install post-construction BMPs and revegetate disturbed areas in accordance with the Revegetation Plan contained in Appendix D (Attachment D-12).

10) Performance monitoring of the completed AGCSs will be performed as described in Section G9.0. If post-construction performance indicates significant bypass of alluvial groundwater either around, or under the low-permeability barrier wall, an investigation into the nature of the groundwater bypass will be performed and appropriate corrective measures will be implemented. The precise design of any corrective measures that might be required (e.g. permeation or jet grouting of the barrier wall/bedrock contact, permeation grouting of high-permeability bedrock underlying or adjacent to the barrier wall) cannot be defined at this time, and as such, the extent of these possible design changes are not shown on the drawings.

## G6.0 MATERIALS MANAGEMENT

Construction of the working platform will consist of excavating a level surface perpendicular to the stream channel at an elevation approximately two feet below the stream channel thalweg or other lowest point in the existing ground surface along the valley cross section. As discussed above, it is anticipated that this level working platform will be approximately 30-feet wide and will generally extend into either valley wall until practical excavator refusal is reached. As discussed in Section 1.0, seismic refraction survey results in the Far East Seep Drainage suggest that competent unexcavatable bedrock may be deep in some areas. Although there is some uncertainty associated with interpretation of excavatability from seismic refraction surveys, interpretations suggest excavator refusal may not be reached at a practical depth. The limits of excavatable rock shown on Sheet 7-11 are based on the seismic refraction results. These results suggest that excavations of more than 60 vertical feet and over 100 feet horizontally into the valley walls could be required to tie the working platform into unexcavatable bedrock in the Far East Seep Drainage. As a practical construction consideration, the sections shown on Sheet 7-11 limit excavations into the valley walls for working platform construction to a maximum depth of 30 feet. The working platform would then be benched at approximately 30 feet above the valley floor as shown on Section H on Sheet 7-11 in order to provide additional area for barrier wall construction. If these, or other conditions arise during construction that present construction difficulties that cannot be addressed in this proposed manner, other alternatives may be assessed including modifications to the proposed construction method or relocation of the alignment. Any modifications to the location or proposed methods of construction will be made in consultation with EPA.

Any shallow groundwater or surface flow intercepted at the working platform level will be pumped to the PCP and then transferred to the WTP. Shallow groundwater that will be removed during the installation of the extraction trenches and barrier walls is discussed in Section G7.0.

If spoils from site preparation excavations meet soil cleanup criteria, they will be stockpiled upgradient from the excavations and used for backfilling and final surface restoration. Spoils will not be stockpiled in the stream channels or other natural drainage pathways. If site preparation spoils do not meet soil cleanup criteria, they will be hauled to Pit 4 and incorporated into the mine waste backfill. Spoils from the extraction trench and barrier wall excavations will be hauled to a stockpile location on the South Waste Rock Pile and incorporated into the Pit 4 mine waste backfill.

# G7.0 EXTRACTION TRENCHES

Groundwater extraction trenches will be constructed in each of the drainages as shown on Drawings 7-5, 7-8, and 7-11. Construction will consist of trench excavation, installation of an in-trench dewatering system, backfilling with high-permeability backfill, installing trench cover, and final surface restoration. Each of these components is described in more detail in the following subsections.

## G7.1 Extraction Trench Excavation

Extraction trenches will be excavated from the working platform through the underlying alluvium and weathered bedrock materials to a depth where practical excavator refusal is reached, or in the case of the Far East Seep Drainage, to the limits of the working platform in the valley bottom as shown on Section I and Sheet 7-11. Ripping, blasting, drop-chisel excavation, or other methods of rock excavation that are likely to disturb the underlying formation and induce fracturing will not be performed as part of this work. The excavations will be continued into either valley wall as shown on the Drawings to the point where the working platform contact with the valley wall is reached. For design purposes the depth of excavator refusal was estimated based upon the results of seismic surveys and drill hole information obtained from recent AGCS geotechnical investigations (see Attachment G-4). Additional information was also obtained from summary reports from a previous investigation of alluvial aquifers south of the Midnite Mine (SMI, 1997) and from seismic refraction surveys and test hole drilling summarized in the *Storage Ponds Investigation Report* (MWH, 2012).

Although it is anticipated that extraction trenches will be excavated using biodegradable polymer slurry to support trench walls during construction, it is also possible that trench boxes or other shoring methods may be used.

## G7.2 Dewatering System

Flow rates expected in the extraction trenches were estimated and summarized in Attachment G-1 to this Appendix. These flow rates were estimated using data from the recent AGCS geotechnical investigation summarized in Attachment G-4 as well as previous investigations. These previous investigations are summarized in the *Remedial Action Work Plan - Interim Mechanisms (*Tetra Tech, 2010a) and the *Storage Ponds Investigation Report* (MWH, 2012).

These investigations found the alluvium in the drainages generally consists of silty or clayey sand with gravel, silty clay, and sand overlying decomposed quartz monzonite (Western and Central Drainages) or weathered/decomposed phyllite (Far Eastern Drainage). The decomposed quartz monzonite in the Western and Central Drainages generally is soil-like (residual soil), dense to very dense clayey sand, clayey sand with gravel, and sand with gravel that gradually transitioned to less weathered rock with depth. The decomposed phyllite in the Far East Drainage also is generally soil-like and classified as very dense silty sand, clayey sand, and sandy gravel with clay, and also gradually transitions with depth to less weathered rock.

The hydraulic conductivity of the alluvial and shallow bedrock system in the drainages was estimated using pumping test and slug test data from previous investigations (Tetra Tech, 2010a) to be 18 and 40 ft/day in the Western Drainage and 0.7 to 1.8 ft/day in the Central Drainage. Although no estimates were provided for the Far Eastern Drainage, they are assumed to be similar to the Western and Central Drainages (Tetra Tech, 2010a).

Based upon the hydraulic properties of the alluvium/shallow bedrock, and the extraction trench geometries shown on Drawings 7-5, 7-8, and 7-11, the estimated inflow rates to the extraction trenches ranged from approximately 0.1 gpm to 7 gpm under typical dry-season, base flow conditions (similar to when this construction is planned to occur) and from approximately 1 to 13 gpm during wet periods (refer to Attachment G-1). These flow estimates are consistent with flows measured at surface water monitoring stations WDAC and SW-12 in the Western and Central Drainages, respectively. These two stations are located downstream of the proposed collection systems in the Western and Central Drainages at points where shallow bedrock

forces alluvial groundwater flow to the surface. Discharge at these stations have been monitored continuously since 2010, and the resulting measurements are summarized in Attachment G-2 for comparison to these estimated (calculated) flows to the AGCSs in the Western and Central Drainages. Based upon both the groundwater flow estimates presented in Attachment G-1, and the current flow measurements summarized in Attachment G-2, it is assumed that in-flows to the AGCSs may range from 1 to 15 gpm depending on the time of year.

Groundwater will be collected in slotted drain pipe installed near the bottom of the trench as shown on Drawings 7-5, 7-8, and 7-11. A vertical pump riser will be connected to the drain pipe near the low-point of the extraction trench. Groundwater will be extracted from the trenches by pumping intermittently via submersible pumps and discharge pipes installed in each of the pump risers. Initially, groundwater from the extraction trenches will be conveyed to the PCP, and from there it will be conveyed to the storage ponds and WTP. Once the PCP is decommissioned (in Phase 3), groundwater will be conveyed directly to the WTP Equalization Pond.

The AGCSs shall continue to operate until otherwise approved by EPA. As such, the extraction trenches have been designed for long-term operation, with maintenance systems including drain pipe cleanouts and easily accessible pump risers to enhance long-term operation included in the designs as shown on the Drawings.

## G7.3 Extraction Trench Backfilling

The extraction trenches will be backfilled from the trench bottom to the elevation of the level working platform with drain sand. The drain sand will be placed using a tremmie pipe (or using similar method that will avoid trapping of trench slurry and other foreign materials within the backfill material) from the bottom of each trench upward. The drain sand will be selected such that it has sufficiently high permeability to provide efficient drainage, yet still provide filter compatibility with the finer alluvial sediments that have been encountered. Material meeting the gradational requirements for fine concrete aggregate (ASTM C33 or equivalent) will meet these requirements. This material will be sourced from an off-site supplier of concrete aggregate. The gradational characteristics of ASTM C33 fine aggregate are summarized in Table G-2.

**Table G-2 – Drain Sand Gradation Specification**

| Particle Size | | Coarse Range | Fine Range |
|---|---|---|---|
| | | Max | Max |
| Sieve Size | Size Opening [mm] | %Pass | %Pass |
| 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 |

Material with this specification has been tested and used extensively by the Natural Resources Conservation Service (NRCS) and others (USBR and USCOE) to provide filter-compatible backfill material for groundwater collection trenches excavated into fine-grained materials. The proposed ASTM C33 drain sand material was evaluated using procedures detailed in Part 633 of the National Engineering Handbook (NEH), Chapter 26 for evaluating sand and gravel materials in trench drains and has been found compatible with the site soils. The results of this evaluation are included as Attachment G-3.

Slots in the drain pipe described in the previous section also must be sized to be compatible with the selected backfill sand and prevent migration of sand into the dewatering system piping and pumps. Slot sizing calculations were also performed using NEH Chapter 26 guidelines, and are included in Attachment G-3. These calculations indicate that drain pipe with a 0.6 mm (No. 30) slot width will prevent migration of finer sand particles into the pipe.

In addition to gradational requirements, the drain sand backfill will not contain carbonates or other materials that may adversely react with the alluvial groundwater.

## G7.4 Final Grading and Surface Restoration

Upon completion of the dewatering system and trench backfill, the top of the extraction trench will be covered with a geocomposite clay liner (GCL) as shown on the Drawings to minimize the infiltration of surface water into the dewatering system. This GCL infiltration barrier will be covered with a minimum of 2 feet of compacted soil, the ground surface in the work area restored to its original contours, and areas of disturbance revegetated with native seed mix in accordance with project requirements.

# G8.0 BARRIER WALLS

Low-permeability barrier walls will be constructed immediately downgradient of the extraction trenches, as shown on Drawings 7-2, 7-3, 7-6, 7-9, and 7-10, in order to increase the capture efficiency of the AGCSs. Construction will consist of trench excavation and backfilling with low-permeability fill, installing trench cover, and final surface restoration. Each of these components is described in more detail in the following subsections.

## G8.1 Barrier Wall Excavation

The barrier wall will be excavated from the working platform through the underlying alluvium and weathered bedrock materials to a depth where practical excavator refusal is reached, or in areas where deep bedrock is encountered, as discussed in Section G1.0. Due to the likelihood that unexcavatable competent bedrock may occur at depths greater than 40 feet below the ground surface in the Far East Seep Drainage, it is anticipated that a multi-level working platform will be required for barrier wall construction at this location as shown on Section H of Drawing 7-11. The multi-level working platform is needed order to limit the amount of disturbance due to working platform excavation to a reasonable amount, and to accommodate barrier wall construction on the steep valley walls.

Ripping, blasting, drop-chisel excavation, or other methods of rock excavation that are likely to disturb the underlying formation and induce fracturing will not be performed as part of this work. The excavations will be continued into either valley wall as shown on the Drawings 7-4, 7-7, and 7-11 to the point where the working platform contact with the valley wall is reached.

Although it is anticipated that the barrier walls will be constructed as slag-cement bentonite (SLCB) slurry walls, it is possible that other methods (such as soil mixing) may be used. The SLCB will both provide trench support and serve as the final low-permeability backfill. Typical SLCB walls have moderate strength (typically 10 to 50 psi) and can achieve permeabilities of $5x10^{-7}$ cm/s ($3x10^{-4}$ ft/day) or less. Similar performance criteria are achievable with other methods such as soil mixing. Due to the restricted nature of the barrier wall sites, a more conventional soil-bentonite (SB) slurry wall method of construction is not considered a preferred option due to the need to haul excavation spoils to a remote mixing area (most likely on the South Waste Rock Pile). Once at the mixing area, mixing the spoils with bentonite and/or other additives, and back-hauling the treated spoils to the barrier wall sites for use as backfill would be required for construction of an SB wall.

Excavation spoils from the SLCB trench will be transported to a stockpile location on the top of the South Waste Rock Pile where they will be allowed to harden, and will then be incorporated into the Pit 4 mine waste backfill.

### G8.2 Final Grading and Surface Restoration

Upon completion of the barrier wall, the wall will be allowed to harden to the point where it will not be damaged by backfilling and then covered with a minimum of 2 feet of soil to prevent damage due to desiccation or erosion. The ground surface in the work area will then be restored to its original contours, and areas of disturbance revegetated in accordance with the Revegetation Plan contained in Appendix D (Attachment D-12).

## G9.0 PERFORMANCE MONITORING

A series of monitoring wells will be installed upgradient and downgradient of the AGCSs in each of the drainages to provide data needed to evaluate of the performance of the groundwater controls after construction. These proposed wells will be located as close as practical to the lowest points in the valley cross section, where alluvial groundwater will tend to be concentrated, as shown on Drawings 7-2 and 7-9.

In the Western Drainage, two upgradient wells and two downgradient wells will be drilled in the valley bottoms adjacent to the AGCS. Only one upgradient well is proposed for the Central Drainage as the numerous existing shallow wells upgradient of the groundwater control (e.g. PBC-01, PBC-02, and PBC-03) can be used to provide the necessary data in this area.

Likewise, only one upgradient well is proposed in the Far Eastern Drainage as the existing well MWED-05 will be used to provide additional upgradient water level information. In addition, a monitoring well will be placed within drain sand backfill near the low point of the trench, as shown on Drawings 7-5, 7-8, and 7-11 to allow for monitoring of water levels within the backfill.

Data from these wells will be used to evaluate the effectiveness of the AGCSs in controlling downgradient migration of impacted Site waters (see Table Q2-A-4 of the *Site-Wide Monitoring Quality Assurance Project Plan*, located in BODR Appendix Q2). If performance monitoring indicates significant bypass of alluvial groundwater either around, or under the low-permeability barrier wall (which is always a possibility, regardless of the depth of barrier excavation), consideration will be given to permeation grouting of the barrier wall/bedrock contact as well as the bedrock underlying and adjacent to the barrier wall.

# G10.0 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

GSR considerations for the Groundwater Controls included: 1) Constructions Materials (characteristics and manufacturing considerations), 2) Construction Methods, and 3) Low Impact/Sustainability measures undertaken during construction.

## G10.1 Construction Material Considerations

Piping in the groundwater extraction trenches will consist of HDPE. The use of HDPE as the pipeline material was in part selected for its GSR attributes. HDPE is less costly to transport and will require fewer truckloads over other pipe materials (e.g., metallic) because it weighs significantly less and smaller diameter pipes can be nested within larger pipes during transport. HDPE fused joints are less likely to leak than any other connection resulting in a more sustainable solution (lower likelihood of future repairs or contamination of surrounding materials). When installed permanently, HDPE yields a longer life expectancy because it does not rust or scour and is highly resistant to mineral tuberculation. HDPE also has a high chemical resistance yielding a superior piping material for this application with respect to environmental reliability as well as longevity of the material of construction.

## G10.2 Construction Methods

The selection of extraction trenches coupled with downgradient low-permeability barrier walls in the three drainages at the Site provides significant long-term sustainable benefits over drilling individual extraction wells along each alignment. The use of individual extraction wells to capture this groundwater would require significantly more infrastructure, sustained energy consumption, and O&M efforts. This was considered during the feasibility study for the Site (EPA, 2005), and as a result, extraction trenches coupled with downgradient low-permeability barrier walls are explicitly stated in the consent decree statement of work.

It is anticipated that the barrier walls will be constructed as SLCB slurry walls, although similar performance criteria are achievable with other methods of low-permeability barrier walls (e.g., soil-bentonite slurry wall). The use of a more conventional soil-bentonite slurry wall was not considered a preferred option due to the required hauling of excavated spoils to a remote mixing area. These spoils then would be mixed with bentonite and/or other additives and the resulting treated spoils hauled back to the barrier wall site for backfilling. The SLCB construction method

selected has significantly less material handling requirements and therefore would utilize less machine time and emit less greenhouse gases during implementation.

Ripping, blasting, drop-chisel excavation, or other methods of rock excavation would require significantly more energy consumption for equipment. The selected construction methods are simple, will result in facilities that will meet the performance objectives for removal of contaminated groundwater, and will have a lower impact on the surrounding ecosystem because the more intensive excavation methods are not necessary for this project.

### G10.3 Low Impact Development/Sustainability

Phasing of the installation of the groundwater controls system to occur prior to the sediment cleanup in the drainages provides less environmental/habitat impact as it avoids recontamination of previously remediated areas of the Site. Additionally, scheduling the construction of the groundwater controls system during the summer or early autumn (i.e., post spring runoff) minimizes the impact on the ephemeral/intermittent surface flow that occurs in the drainages.

After the RA is completed, an approved, native seed mix will be used for revegetation of the area. This native seed mix will provide habitat for the area wildlife.

## G11.0 REFERENCES

MWH Americas, Inc. (MWH), 2012. Midnite Mine Superfund Site, Storage Ponds Investigation Report - Revision 0, Prepared for Dawn Mining Company LLC, Newmont USA Ltd, March 22.

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U.S. Environmental Protection Agency (EPA), 2005. Midnite Mine Feasibility Study Report. Prepared for the U.S. EPA by URS Corporation. September.

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.

.

# Attachment G-1

# Calculation Brief – Extraction Trench Flow Estimates

# *ATTACHMENT G-1*

# *MIDNITE MINE REMEDIAL ACTION CALCULATION BRIEF FOR EXTRACTION TRENCH FLOW ESTIMATES*

| Revisioning | | | | | |
|---|---|---|---|---|---|
| **Rev.** | **Date** | **Description** | **By** | **Checked** | **Date** |
| *0* | *05-Nov-12* | *Initial Version* | *Tom Kelley* | *VKD* | *18-Nov-12* |
| *1* | *03-Dec-12* | *60% Design Submittal* | *Tom Kelley* | | |
| *2* | *24-Jul-14* | *90% Design Submittal* | *Tom Kelley* | *VKD* | |
| *3* | *15-Jul-15* | *100% Design Submittal* | *Tom Kelley* | *VKD* | *30-June-15* |

| Location and Format |
|---|
| *Electronic copies of these calculations are located in the project files system at:*<br><br>*\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\Groundwater Controls\90% BODR*<br><br>*The following calculations were generated using the following software:*<br><br>*Excel* |

# 1.0 BACKGROUND

This calculation brief presents estimates of the range of groundwater flow rates that may be intercepted by the Alluvial Groundwater Control Systems (AGCSs) at the Midnite Mine Superfund Site (Site). The AGCSs are intended to intercept impacted groundwater in the alluvial/shallow bedrock aquifers in the Western, Central and Far East Seep Drainages. The proposed Groundwater Control systems will be located near the southern perimeter of the fenced Mine Area and will consist of extraction trenches excavated roughly perpendicular to the valley bottom in each of the drainages. Based upon comments received from EPA and the Tribe, the locations of the Groundwater Control systems in the Western Drainage and Central Drainage were moved downstream approximately 350 feet downstream and 710 feet respectively from the locations shown in the Midnite Mine 60 Percent - Basis of Design Report (60% BODR, MWH, 2013) in order to increase capture of potentially impacted alluvial groundwater flowing from the upgradient area of the Site. The location of the AGCS in the Far East Seep Drainage has not been moved. A low-permeability barrier wall will be constructed immediately downgradient of each of the extraction trenches in order to enhance collection efficiency. Details of the proposed AGCSs for each of the three drainages are shown in Section 7 of the Drawings (MWH, 2015a).

The subsurface stratigraphy shown in Section 7 of the Drawings and used to update this calculation brief is based upon the results of the alluvial groundwater collection system geotechnical investigation (MWH, 2015b in Attachment G-4) that was completed in the fall of 2014 after the 90% Basis of Design Report had been finalized. Flow rates to the extraction trenches were estimated based upon the extraction trench geometries shown in Section 7 of the Drawings (MWH, 2015a) and data from previous investigations, as well as, the recent geotechnical investigation (MWH, 2015b).

The previous investigations (i.e., prior to the most recent 2014 work) are summarized in the *Remedial Action Work Plan - Interim Mechanisms (*Tetra Tech, 2010a) and the *Storage Ponds Investigation Report* (MWH, 2012). These investigations found the alluvium in the drainages generally consists of silty or clayey sand with gravel, silty clay, and sand overlying decomposed quartz monzonite (Western and Central Drainages) or weathered/decomposed phyllite (Far Eastern Drainage). The decomposed quartz monzonite in the Western and Central Drainages generally is soil-like (residual soil), dense to very dense clayey sand, clayey sand with gravel, and sand with gravel that gradually transitions to less -weathered rock with depth. The decomposed phyllite in the Far East Drainage also is generally soil-like at shallow depths and classified as very dense silty sand, clayey sand, and sandy gravel with clay, and again gradually transitions with depth to less-weathered rock. The 2014 geotechnical investigations generally confirmed these observations.

The proposed extraction trenches and barrier walls will be excavated through the alluvium and decomposed bedrock layers and into less-weathered bedrock to the point where hydraulic excavator refusal is reached, or to a maximum depth achievable by the excavation equipment is reached, whichever is less. Depths to excavator refusal and other subsurface stratigraphic information shown on the drawings relied heavily on the geotechnical investigation that was completed in 2014 specifically to obtain information for final design of the AGCSs. In the westerly portion of the Far East Seep Drainage, the estimated depths to unexcavatable hard rock were very deep, and a maximum excavation depth of 40 feet was assumed for the excavation equipment in the design drawings (see Sheet 7-11).

Hydraulic conductivity data from previous investigations are summarized in the *Remedial Action Work Plan - Interim Mechanisms (*Tetra Tech, 2010a). These data included hydraulic conductivity measurements from pumping tests and slug tests performed in the Western and Central Drainages and other alluvial areas at the site (SMI, 1997 and URS, 2002). Based on this testing, the hydraulic conductivity of the alluvial and shallow bedrock system in the drainages was estimated to be 18 and 40 ft/day in the Western Drainage and 0.7 to 1.8 ft/day in the Central Drainage. Hydraulic conductivity of alluvial materials in the Far Eastern Drainage was assumed to be similar to the Western and Central Drainages. This data was used in the design of alluvial pumpback wells systems that were constructed as part of interim water management system (Tetra Tech, 2010b). The *Storage Pond Investigation Report* (MWH, 2012) provides a summary of recent data from alluvial groundwater wells, including depths to alluvial groundwater in the vicinity of the extraction trenches that are summarized in Table 1.

**Table 1. Hydraulic Conductivity and Average Depth to Alluvial Groundwater**

| Location | Range of Hydraulic Conductivity (ft/day) | Average Depth to Groundwater |
|---|---|---|
| Western Drainage | 18 to 40 | 7 feet |
| Central Drainage | 0.7 to 1.8 | 8 feet |
| Far Eastern Drainage | 5 to 20 (assumed) | 16 feet |

# 2.0 DESCRIPTION OF ANALYSES

## 2.1 ONE-DIMENSIONAL (1-D) FLOW IN ALLUVIAL SYSTEM

The maximum flow that may potentially report to the AGCSs can be estimated based upon the flow in the alluvial system. Flow through in the alluvial groundwater system in vicinity of each of the AGCSs was calculated by assuming the alluvial system was prismatic, with a constant slope and uniform geometry in the downslope direction. In this case, the flow in the alluvial system can be calculated using the one-dimensional form of Darcy's law (Freeze and Cherry, 1979):

$$Q = -0.005194 * K * i * A$$

Where:

Q = Flow to the Extraction Trench (gpm)
*i* = the hydraulic gradient of the unconfined alluvial aquifer (equal to the channel bed slope in each drainage)
K = Hydraulic Conductivity (ft/day)
A = Cross-sectional area of the alluvial system below the groundwater table, measured normal to the direction of flow ($ft^2$).

The geometric parameters at each AGCS are summarized in Table 2. The cross-sectional areas shown in Table 2 were calculated based upon the depth at which groundwater was first encountered during drilling for the 2014 geotechnical investigation (the assumed normal flow condition). Cross-sectional areas under wet periods also were estimated assuming groundwater elevations 3 feet higher than the highest levels measured during the 2014 geotechnical investigation.

**Table 2. Extraction Trench Geometries**

| Location | A ($ft^2$) (Normal Flow Conditions) | A ($ft^2$) (Assumed Wet Periods) | *Valley Bottom Slope (i)* |
|---|---|---|---|
| Western Drainage | 532 | 1,067 | 0.06 |
| Central Drainage | 1,306 | 1,830 | 0.11 |
| Far Eastern Seep Drainage | 13 | 93 | 0.30 |

The results of the analyses of alluvial flows are summarized in Table 4 in Section 3.0.

## 2.2 CALCULATION OF TWO-DIMENSIONAL (2-D) FLOW TO TRENCH DRAIN

The rate of groundwater flow to the extraction trenches were also estimated using a closed-form solution for steady-state flow to a drain in an unconfined aquifer based upon the Dupuit-Forcheimer approximation for various assumed lengths of influence zones (McWhorter and Sunada, 1977). This solution assumes all flow toward the extraction trench is driven by the drawdown created by the extraction trench and does not account for the slope of the alluvial drainage (see following sketch). As such, it is likely that this solution will underestimate flows to the extraction trench at larger assumed influence zones and steeper bed slopes in the valley bottoms.

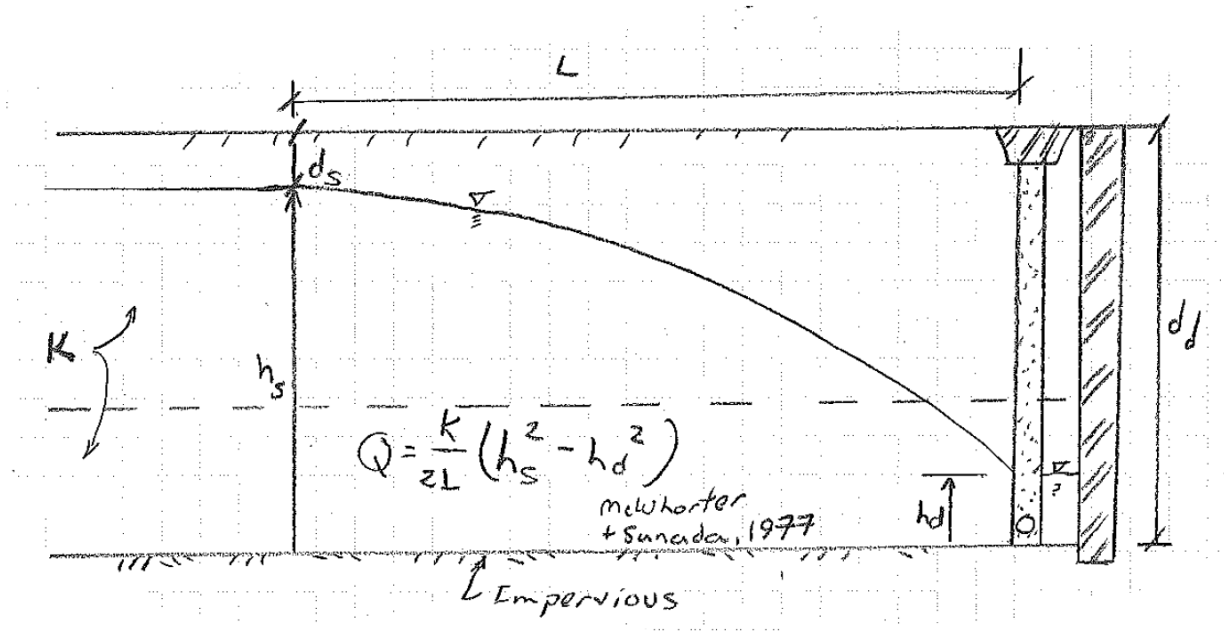
This two-dimensional closed-form solution is summarized below:

$$Q = 0.005194*B*K/2L\ (h_s^2 - h_d^2)$$

Where:

Q = Flow to the Extraction Trench (gpm)
K = Hydraulic Conductivity (ft/day)
$h_s$ = Hydraulic head in the alluvial system in areas beyond the zone of influence of the extraction trench, defined in terms of the bottom of the extraction trench (ft): ($h_s = d_d - d_s$)
- $d_d$ = depth of the extraction trench (ft)
- $d_s$ = depth to alluvial groundwater alluvial in areas beyond the zone of influence of the extraction trench (ft)

$h_d$ = Hydraulic head within the extraction trench (ft)
L = Length of zone of influence of the extraction trench (ft)
B = Trench Width in the out-of page plane (ft)




It is assumed that the extraction trenches will be dewatered using submersible pumps that are pumped intermittently, but that the average head within the extraction trench, $h_d$, will be approximately 3.5 feet.

In order to account for elevated alluvial groundwater levels that may occur during prolonged wet periods, and provide conservative (higher) estimates of potential inflow, the depth to alluvial groundwater, $d_s$, in areas beyond the zone of influence of the extraction trench was assumed to be 2 feet in the Western and Central Drainages, and 10 feet in the Far East Seep Drainage.

The average depth of each extraction trench was calculated based upon the cross sectional area and length of each extraction trench as shown on the drawings as follows:

$$D_{avg} = A_{xsec}/B$$

Where:

$D_{avg}$ = the average depth of the extraction trench below the groundwater static groundwater surface (ft)
$A_{xsec}$ = Cross Sectional Area of extraction trench below the static groundwater surface ($ft^2$)
B = as defined above

And $d_d$, the average depth of the extraction trench below the finished ground surface was calculated as:

$$d_d = D_{avg} + d_s \text{ (ft)}$$

A summary of geometric parameters for the proposed extraction trenches under normal flow and assumed wet period conditions are included as Table 3.

**Table 3. Extraction Trench Geometries**

| Location | $A_{xsec}$ ($ft^2$) | B (ft.) | $h_s$ (ft.) | $h_d$ |
|---|---|---|---|---|
| **Normal Flow Conditions** | | | | |
| Western Drainage | 532 | 167 | 3.2 | 0 |
| Central Drainage | 1,306 | 158 | 8.3 | 0 |
| Far Eastern Seep Drainage | 13 | 18 | 0.7 | 0 |
| **Assumed Wet Period Conditions** | | | | |
| Western Drainage | 1,067 | 189 | 5.6 | 0 |
| Central Drainage | 1,830 | 181 | 10.1 | 0 |
| Far Eastern Seep Drainage | 93 | 33 | 2.8 | 0 |

The results of the analyses of two-dimensional flow to trench drains in the three drainages are summarized in Table 5 through Table 7 in Section 3.0.

# 3.0 RESULTS

Estimated flows (Q) to each of the extraction trenches were calculated using the parameters and assumptions listed above for a range of 1) hydraulic conductivities 2) groundwater levels, and 3) influence zones (i.e., 40, 60, 80 and 100 feet), that reasonably could be expected in each trench. The results are summarized below for extraction trenches installed in each of the Midnite Mine drainages using 1-D (Table 4) and 2-D flow calculations.

**Table 4. Summary of 1-D Flow Calculations in Alluvial Systems**

| Location | Estimated Alluvial Flow (gpm) | |
|---|---|---|
| **Western Drainage** | Normal Flow Conditions | |
| | K = 18 ft/day | 3 |
| | K = 40 ft/day | 7 |
| | Assumed Wet Period Conditions | |
| | K = 18 ft/day | 6 |
| | K = 40 ft/day | 13 |
| **Central Drainage** | Normal Flow Conditions | |
| | K = 0.7 ft/day | 0.5 |
| | K = 1.8 ft/day | 1.3 |
| | Assumed Wet Period Conditions | |
| | K = 0.7 ft/day | 0.7 |
| | K = 1.8 ft/day | 1.9 |
| **Far East Seep Drainage** | Normal Flow Conditions | |
| | K = 5 ft/day | 0.1 |
| | K = 20 ft/day | 0.4 |
| | Assumed Wet Period Conditions | |
| | K = 5 ft/day | 1 |
| | K = 20 ft/day | 3 |

**Table 5. Summary of 2-D Flow Calculations for Western Drainage Extraction Trench**

| Range of Hydraulic Conductivities (ft./day) | Flow to Drain(Q - gpm) | | | |
|---|---|---|---|---|
| | (L = 40 ft.) | (L = 60 ft.) | (L = 80 ft.) | (L = 100 ft.) |
| Normal Flow Conditions | | | | |
| 18 | 2.0 | 1.3 | 1.0 | 0.8 |
| 40 | 4.4 | 2.9 | 2.2 | 1.8 |
| Assumed Wet Period Conditions | | | | |
| 18 | 7 | 5 | 4 | 3 |
| 40 | 16 | 10 | 8 | 6 |

**Table 6. Summary of 2-D Flow Calculations for Central Drainage Extraction Trench**

| Range of Hydraulic Conductivities (ft./day) | Flow to Drain(Q - gpm) | | | |
|---|---|---|---|---|
| | (L = 40 ft.) | (L = 60 ft.) | (L = 80 ft.) | (L = 100 ft.) |
| Normal Flow Conditions | | | | |
| 0.7 | 0.5 | 0.3 | 0.2 | 0.2 |
| 1.8 | 1.3 | 0.8 | 0.6 | 0.5 |
| Assumed Wet Period Conditions | | | | |
| 0.7 | 0.8 | 0.6 | 0.4 | 0.3 |
| 1.8 | 2.2 | 1.4 | 1.1 | 0.9 |

**Table 7. Summary of 2-D Flow Calculations for Far East Seep Drainage Extraction Trench**

| Range of Hydraulic Conductivity (ft./day) | Flow to Drain(Q - gpm) | | | |
|---|---|---|---|---|
| | (L = 40 ft.) | (L = 60 ft.) | (L = 80 ft.) | (L = 100 ft.) |
| Normal Flow Conditions | | | | |
| 5 | 0 | 0 | 0 | 0 |
| 20 | 0.01 | 0.01 | 0.01 | 0 |
| Assumed Wet Period Conditions | | | | |
| 5 | 0.09 | 0.06 | 0.0 | 0.0 |
| 20 | 0.3 | 0.2 | 0.2 | 0.1 |

The results from both approaches used for estimating flows to the alluvial groundwater collection systems provide relatively similar results for each of the three drainages. The two-dimensional flow analyses predicted lower flows in the Far East Seep Drainage, most likely due to the two-dimensional solution ignoring the contribution to the hydraulic gradient of the very-steeply sloped valley bottom. Based upon these results, the flow intercepted by each extraction trench is expected to range from 0.1 to 7 gpm under normal flow conditions, but could range from 1 to 13 gpm during very wet periods.

## 4.0 REFERENCES

Freeze, R.A. and J.A. Cherry, 1979. *Groundwater*, Prentice Hall, Inc., Upper Saddle River, New Jersey.

McWhorter, D.B. and D.K. Sunada, 1977. *Ground-Water Hydrology and Hydraulics*, Water Resources Publications, Littleton, Colorado.

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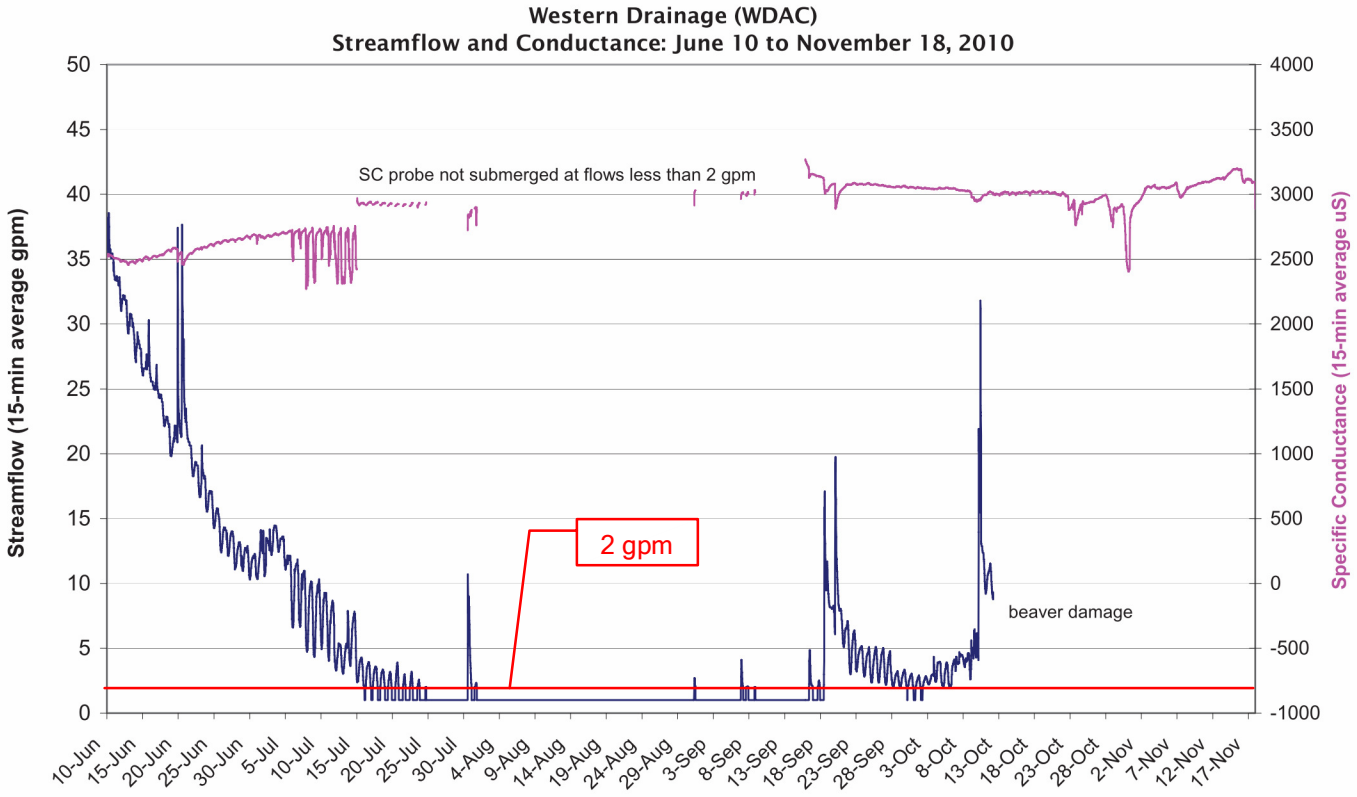
URS, 2002. Draft- Phase I Hydrologic Modeling for Midnite Mine RI/FS, Prepared for EPA Region 10, August.

# Attachment G-2

# Alluvial Flow Measurements

# WESTERN DRAINAGE ALLUVIAL FLOW MEASUREMENTS


Western Drainage (WDAC)
Streamflow and Conductance: June 10 to November 18, 2010
Streamflow (15-min average gpm)
Specific Conductance (15-min average uS)
SC probe not submerged at flows less than 2 gpm
2 gpm
beaver damage
50
45
40
35
30
25
20
15
10
5
0
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
10-Jun
15-Jun
20-Jun
25-Jun
30-Jun
5-Jul
10-Jul
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9-Aug
14-Aug
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3-Sep
8-Sep
13-Sep
18-Sep
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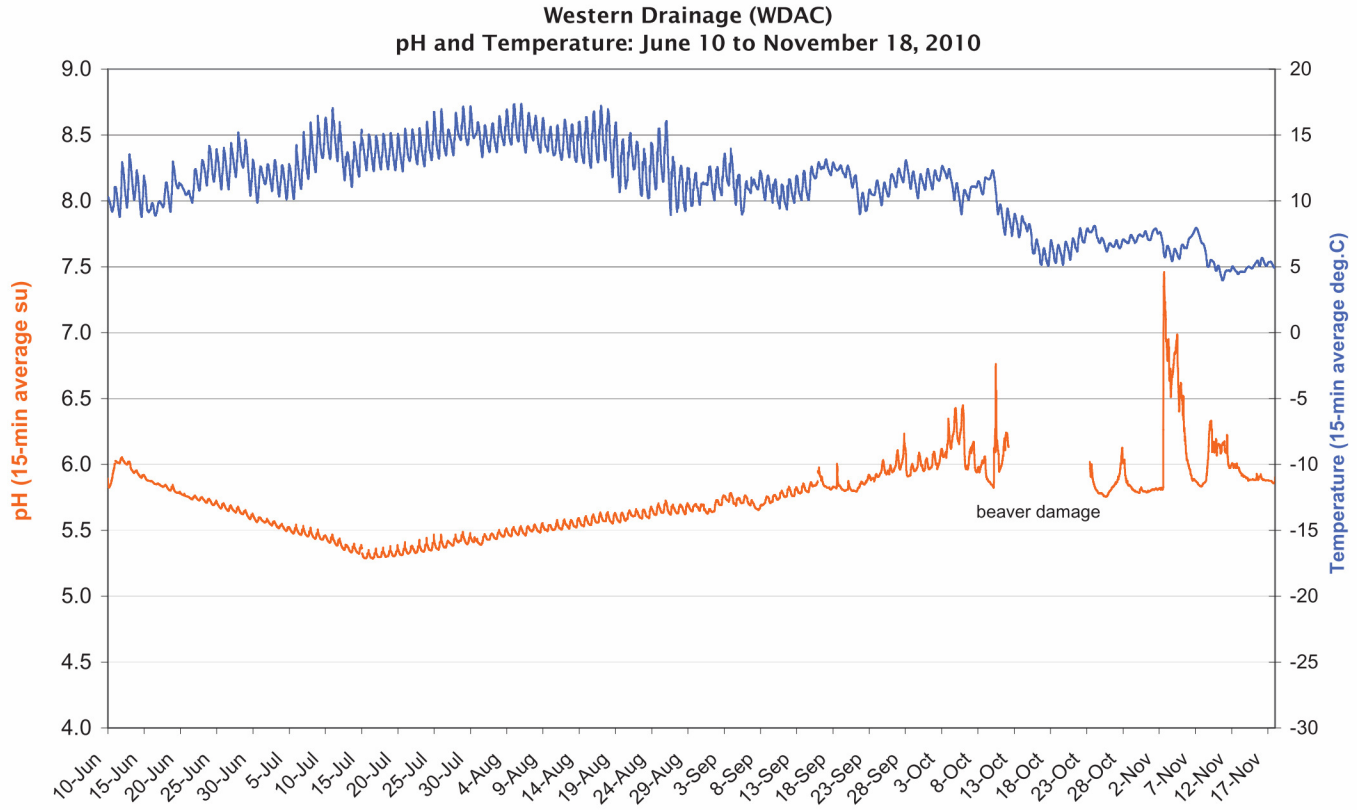
2-Nov
7-Nov
12-Nov
17-Nov


Western Drainage (WDAC)
pH and Temperature: June 10 to November 18, 2010
pH (15-min average su)
Temperature (15-min average deg.C)
beaver damage
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
20
15
10
5
0
-5
-10
-15
-20
-25
-30
10-Jun
15-Jun
20-Jun
25-Jun
30-Jun
5-Jul
10-Jul
15-Jul
20-Jul
25-Jul
30-Jul
4-Aug
9-Aug
14-Aug
19-Aug
24-Aug
29-Aug
3-Sep
8-Sep
13-Sep
18-Sep
23-Sep
28-Sep
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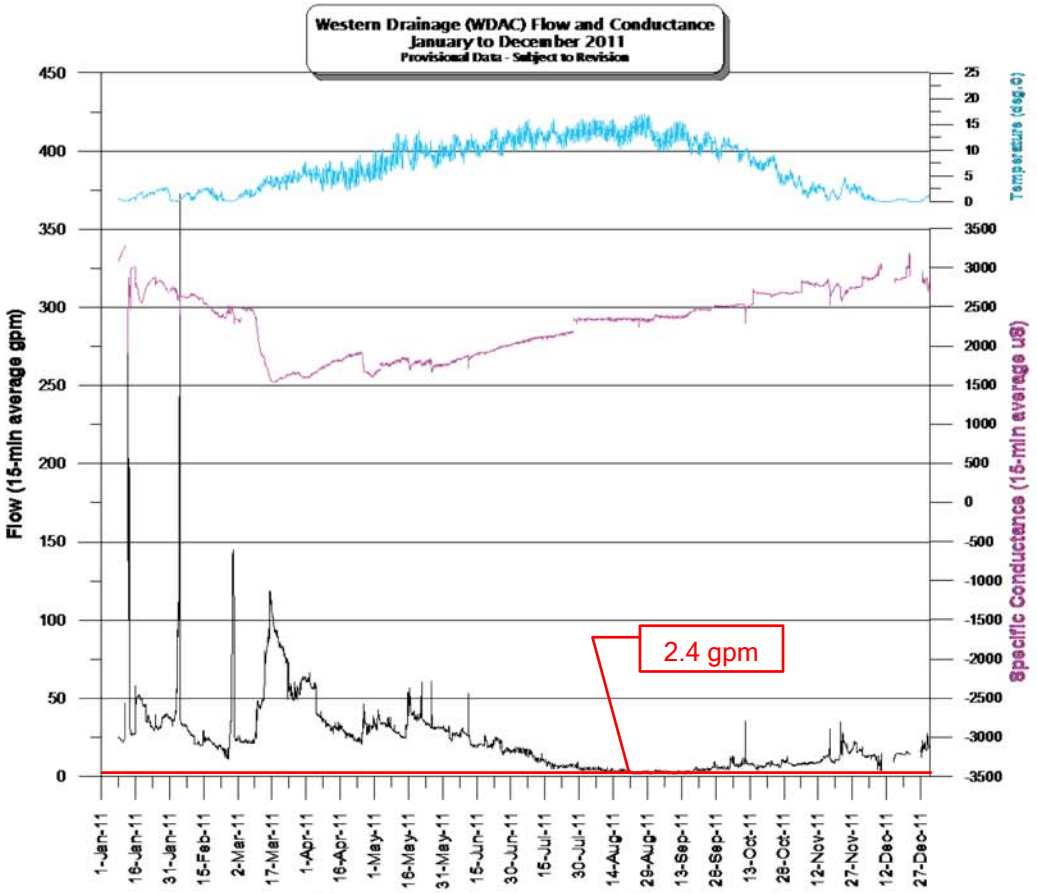
18-Oct
23-Oct
28-Oct
2-Nov
7-Nov
12-Nov
17-Nov

**Figure 5**


Western Drainage (WDAC) Flow and Conductance
January to December 2011
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
2.4 gpm
1-Jan-11
16-Jan-11
31-Jan-11
15-Feb-11
2-Mar-11
17-Mar-11
1-Apr-11
16-Apr-11
1-May-11
16-May-11
31-May-11
15-Jun-11
30-Jun-11
15-Jul-11
30-Jul-11
14-Aug-11
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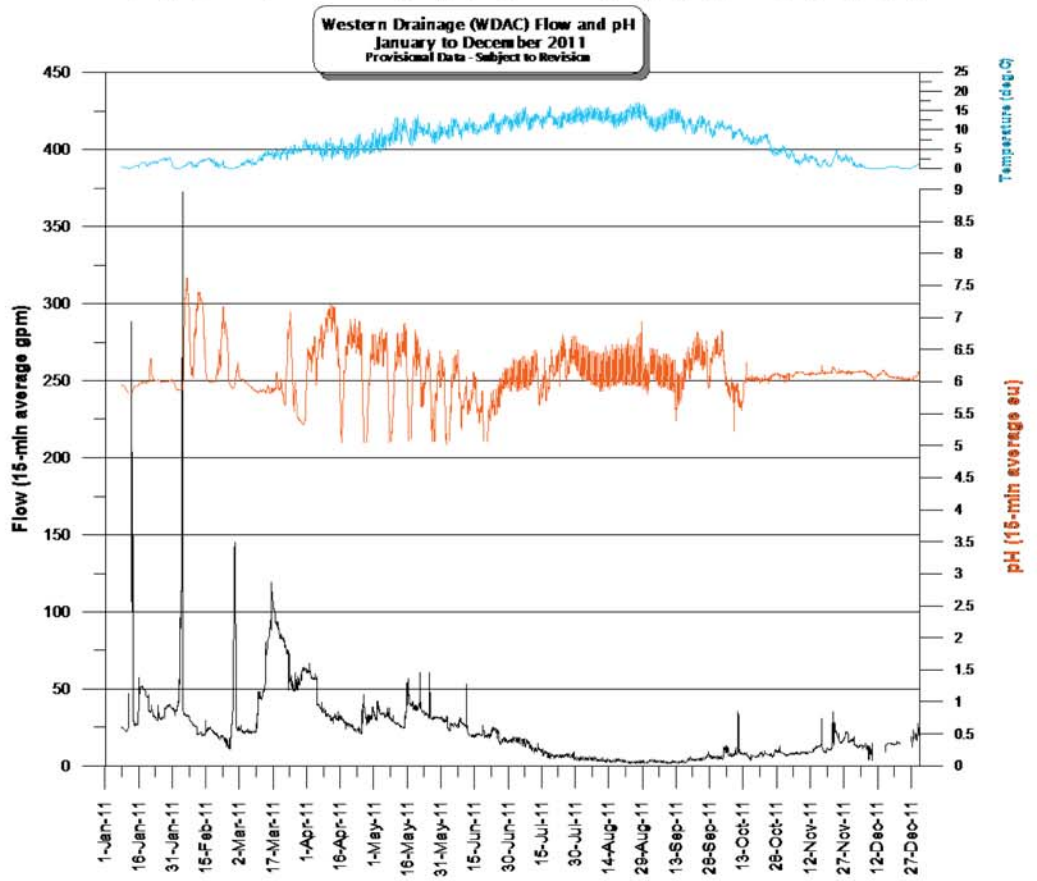
12-Dec-11
27-Dec-11


Western Drainage (WDAC) Flow and pH
January to December 2011
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
1-Jan-11
16-Jan-11
31-Jan-11
15-Feb-11
2-Mar-11
17-Mar-11
1-Apr-11
16-Apr-11
1-May-11
16-May-11
31-May-11
15-Jun-11
30-Jun-11
15-Jul-11
30-Jul-11
14-Aug-11
29-Aug-11
13-Sep-11
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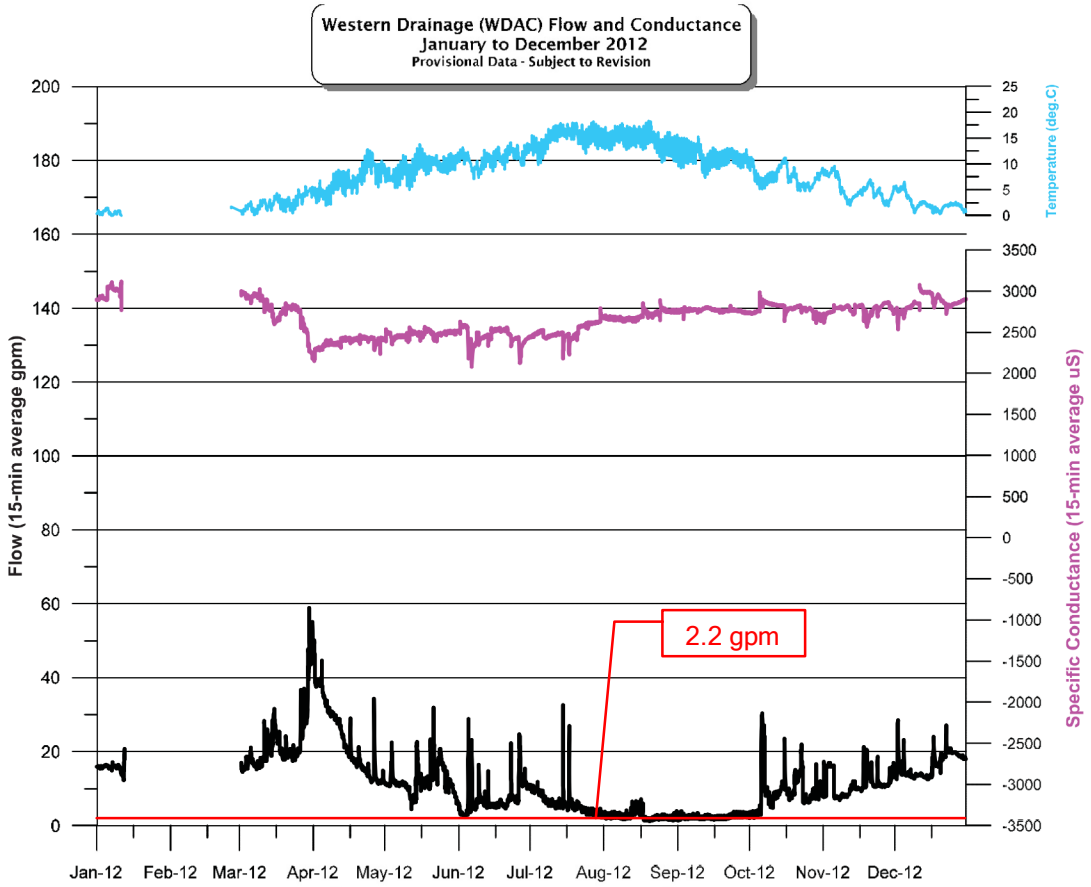
13-Oct-11
28-Oct-11
12-Nov-11
27-Nov-11
12-Dec-11
27-Dec-11

**Figure 4**


Western Drainage (WDAC) Flow and Conductance
January to December 2012
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
2.2 gpm
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12

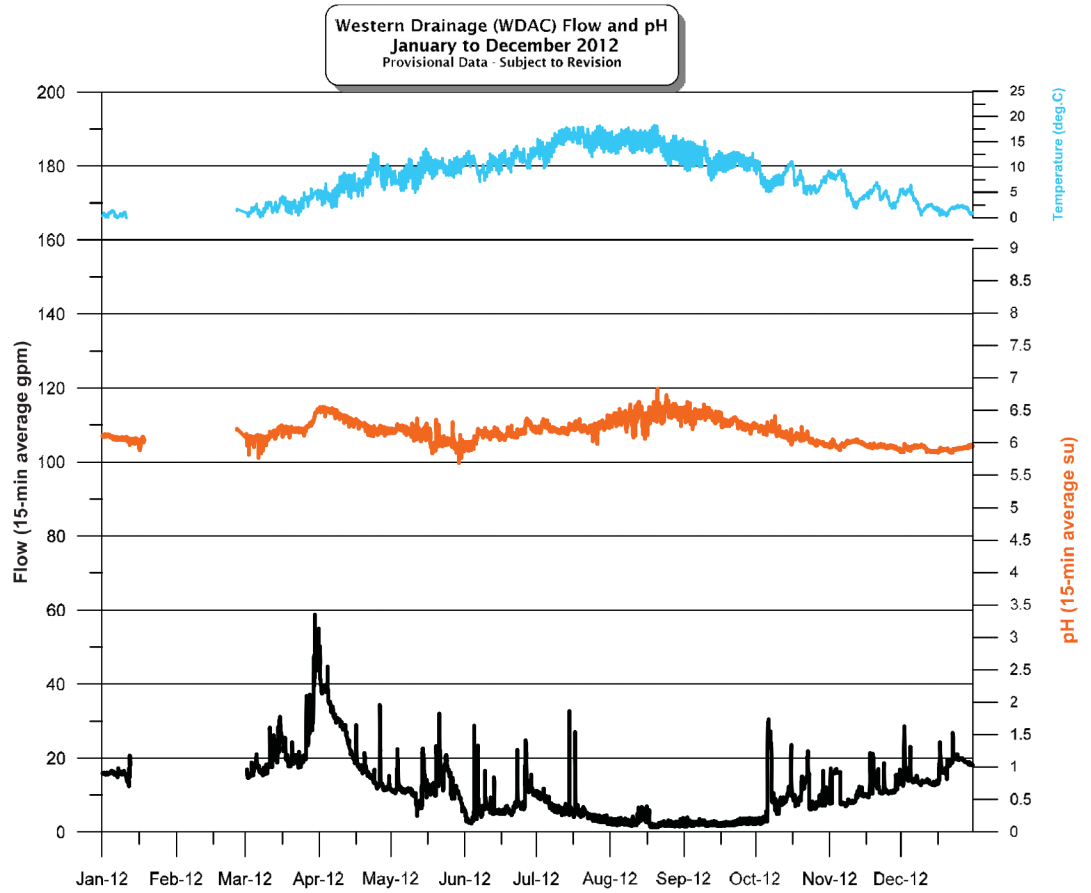
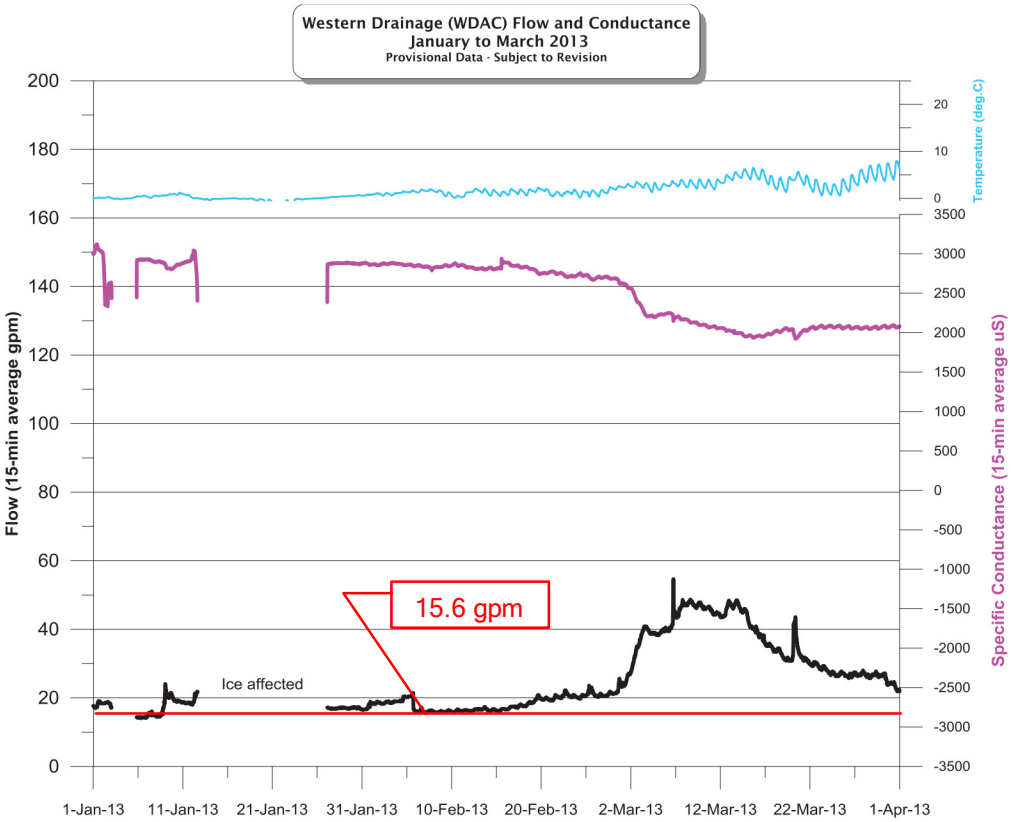

Western Drainage (WDAC) Flow and pH
January to December 2012
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12

**Figure 4**


Western Drainage (WDAC) Flow and Conductance
January to March 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
15.6 gpm
Ice affected
1-Jan-13
11-Jan-13
21-Jan-13
31-Jan-13
10-Feb-13
20-Feb-13
2-Mar-13
12-Mar-13
22-Mar-13
1-Apr-13

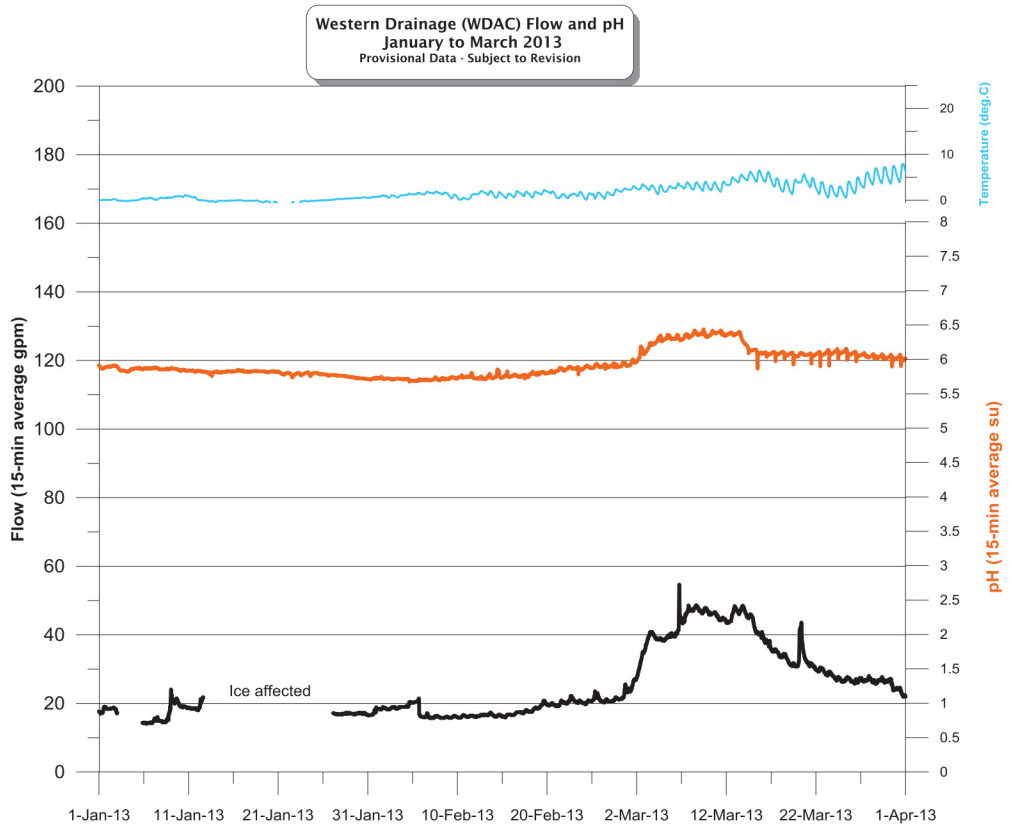

Western Drainage (WDAC) Flow and pH
January to March 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
Ice affected
1-Jan-13
11-Jan-13
21-Jan-13
31-Jan-13
10-Feb-13
20-Feb-13
2-Mar-13
12-Mar-13
22-Mar-13
1-Apr-13

**Figure 4**

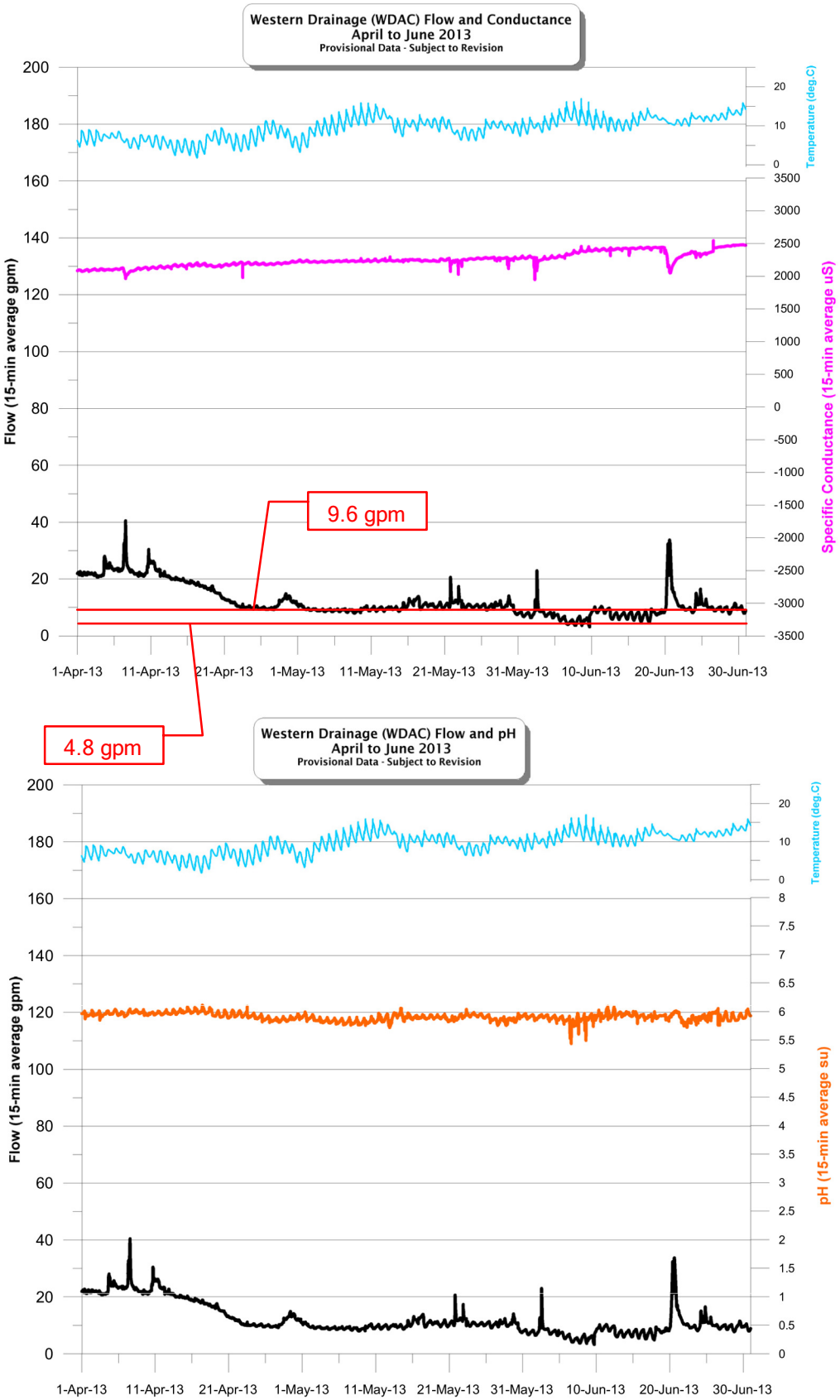
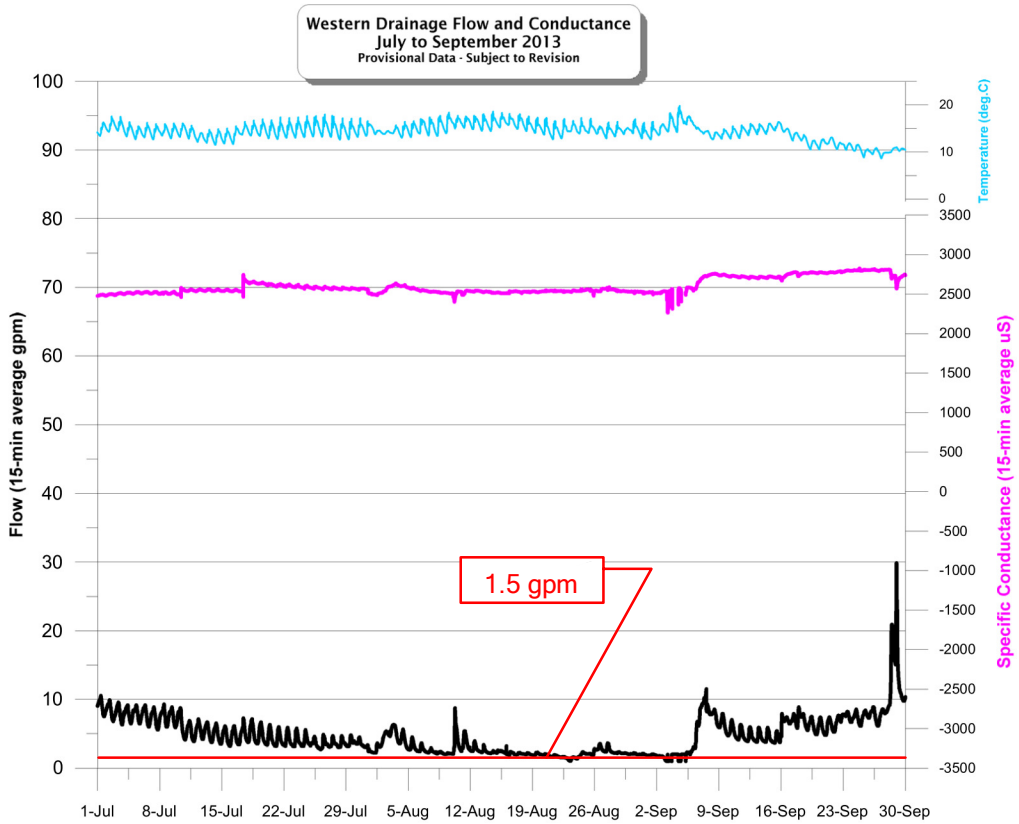

Western Drainage (WDAC) Flow and Conductance
April to June 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
9.6 gpm
4.8 gpm
1-Apr-13
11-Apr-13
21-Apr-13
1-May-13
11-May-13
21-May-13
31-May-13
10-Jun-13
20-Jun-13
30-Jun-13
Western Drainage (WDAC) Flow and pH
April to June 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)

**Figure 4**


Western Drainage Flow and Conductance
July to September 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
1.5 gpm
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep

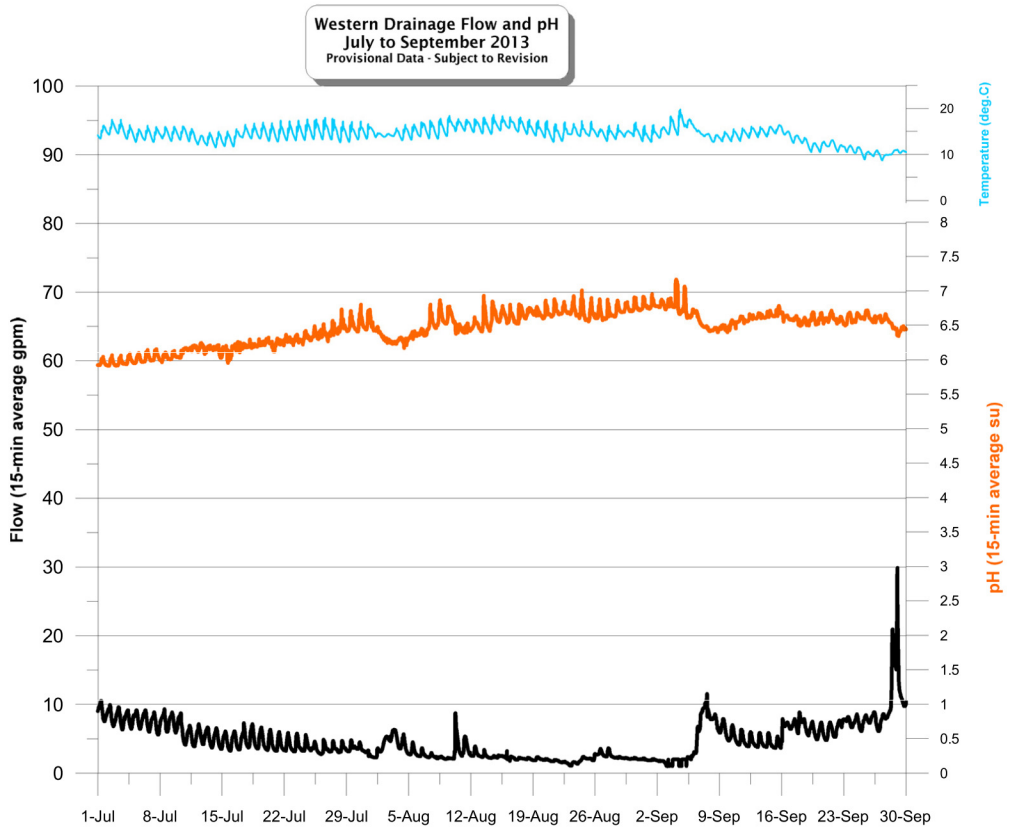
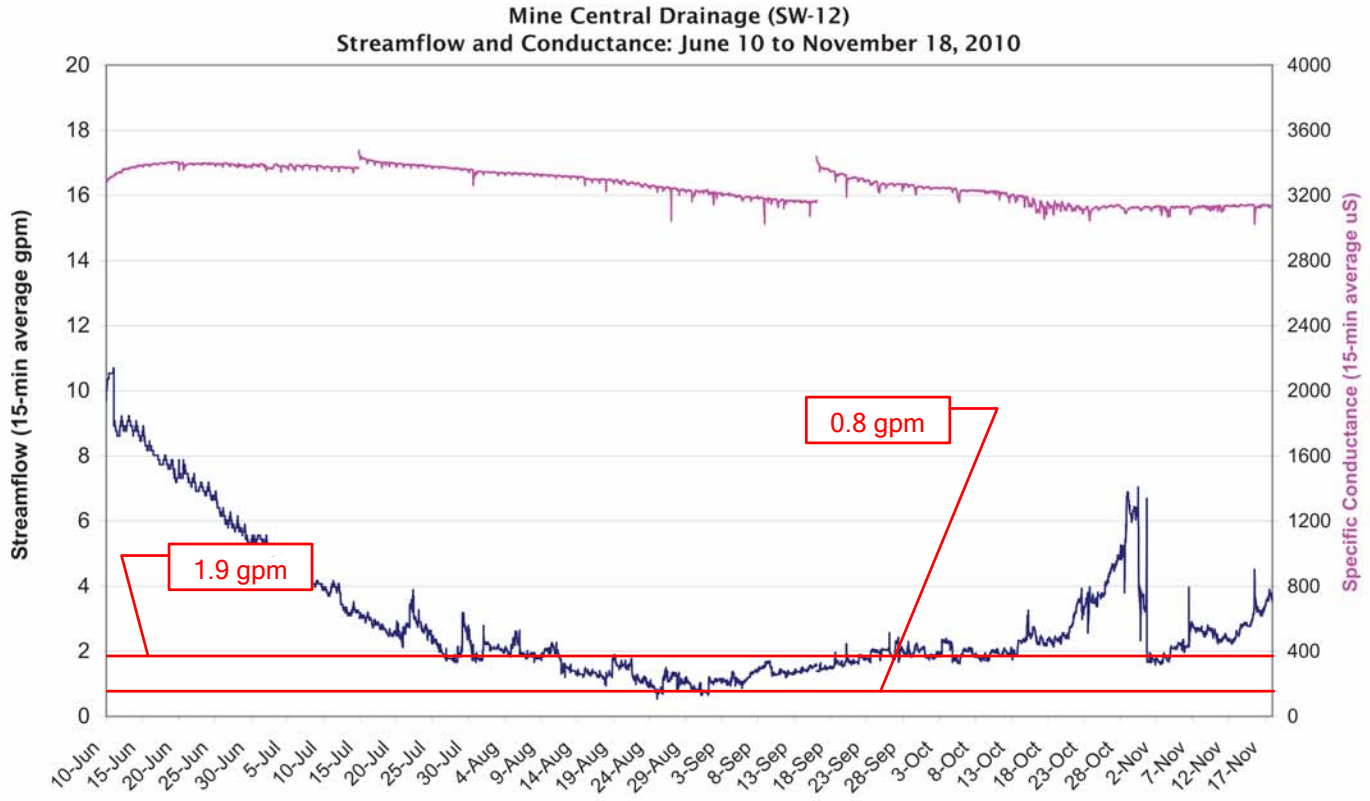

Western Drainage Flow and pH
July to September 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep

**Figure 4**

# CENTRAL DRAINAGE ALLUVIAL FLOW MEASUREMENTS


Mine Central Drainage (SW-12)
Streamflow and Conductance: June 10 to November 18, 2010
Streamflow (15-min average gpm)
Specific Conductance (15-min average uS)
1.9 gpm
0.8 gpm
20
18
16
14
12
10
8
6
4
2
0
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
10-Jun
15-Jun
20-Jun
25-Jun
30-Jun
5-Jul
10-Jul
15-Jul
20-Jul
25-Jul
30-Jul
4-Aug
9-Aug
14-Aug
19-Aug
24-Aug
29-Aug
3-Sep
8-Sep
13-Sep
18-Sep
23-Sep
28-Sep
3-Oct
8-Oct
13-Oct
18-Oct
23-Oct
28-Oct
2-Nov
7-Nov
12-Nov
17-Nov

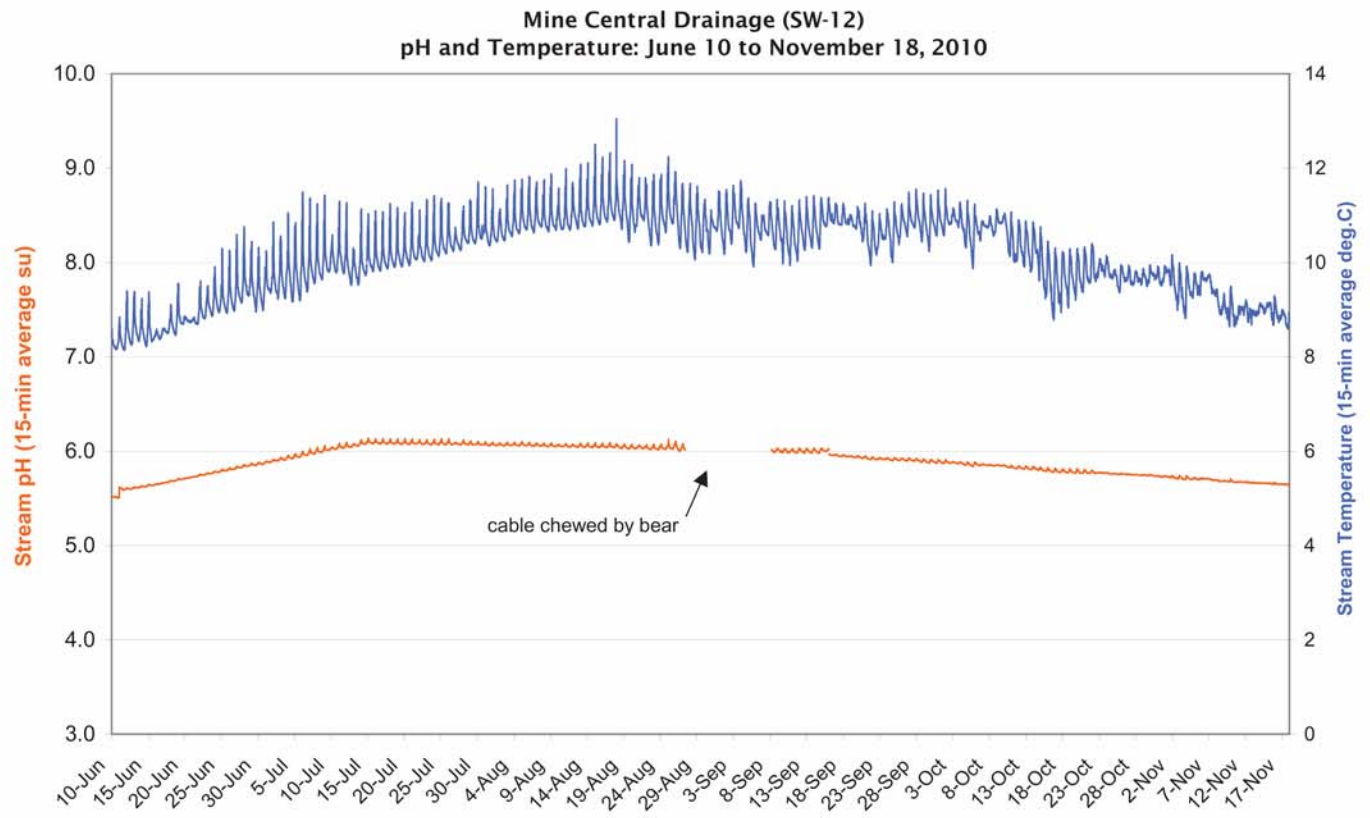

Mine Central Drainage (SW-12)
pH and Temperature: June 10 to November 18, 2010
Stream pH (15-min average su)
Stream Temperature (15-min average deg.C)
cable chewed by bear
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
14
12
10
8
6
4
2
0
10-Jun
15-Jun
20-Jun
25-Jun
30-Jun
5-Jul
10-Jul
15-Jul
20-Jul
25-Jul
30-Jul
4-Aug
9-Aug
14-Aug
19-Aug
24-Aug
29-Aug
3-Sep
8-Sep
13-Sep
18-Sep
23-Sep
28-Sep
3-Oct
8-Oct
13-Oct
18-Oct
23-Oct
28-Oct
2-Nov
7-Nov
12-Nov
17-Nov

**Figure 3**

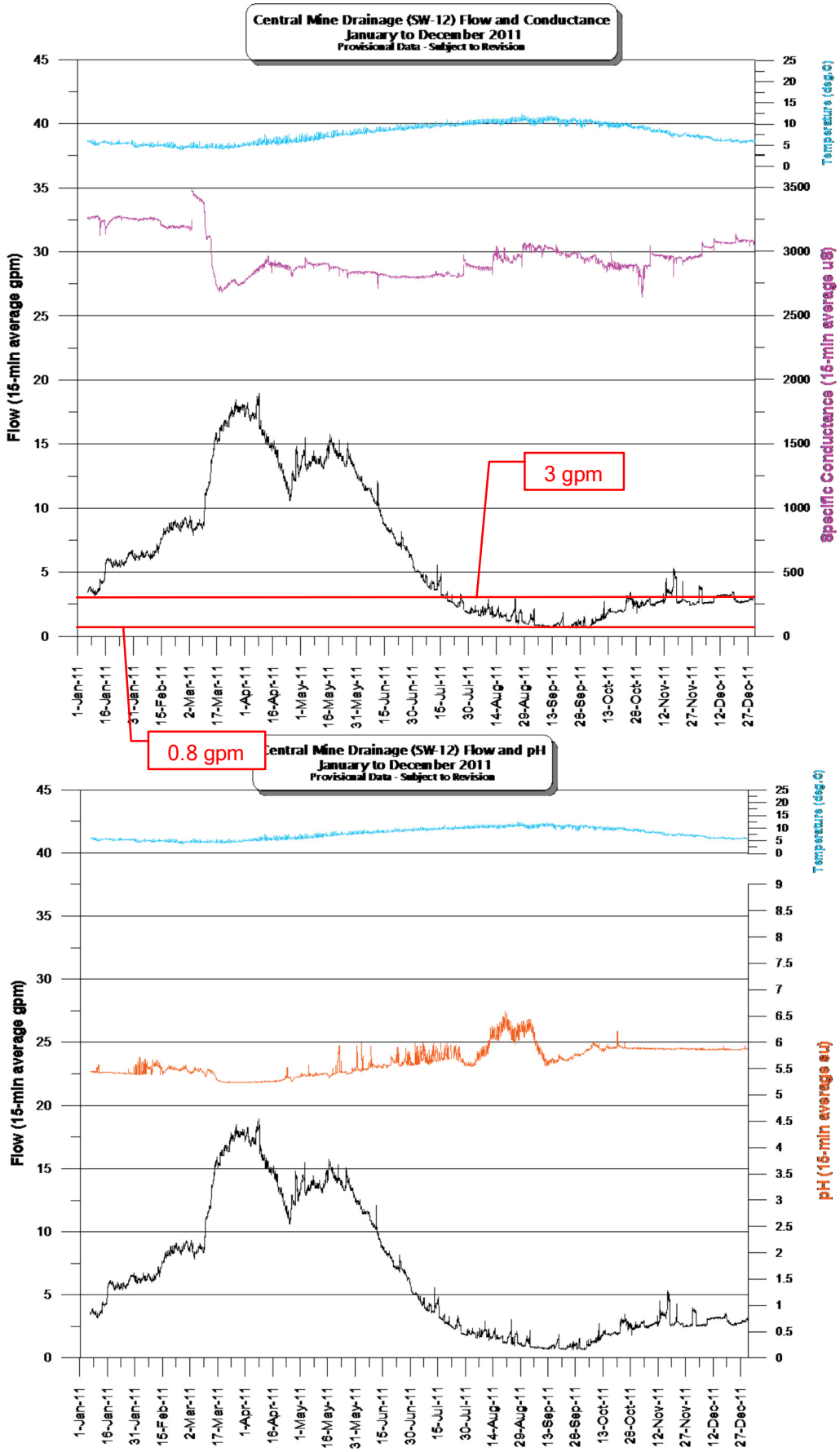

Central Mine Drainage (SW-12) Flow and Conductance
January to December 2011
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
3 gpm
0.8 gpm
Central Mine Drainage (SW-12) Flow and pH
January to December 2011
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
1-Jan-11
16-Jan-11
31-Jan-11
15-Feb-11
2-Mar-11
17-Mar-11
1-Apr-11
16-Apr-11
1-May-11
16-May-11
31-May-11
15-Jun-11
30-Jun-11
15-Jul-11
30-Jul-11
14-Aug-11
29-Aug-11
13-Sep-11
28-Sep-11
13-Oct-11
28-Oct-11
12-Nov-11
27-Nov-11
12-Dec-11
27-Dec-11

**Figure 2**

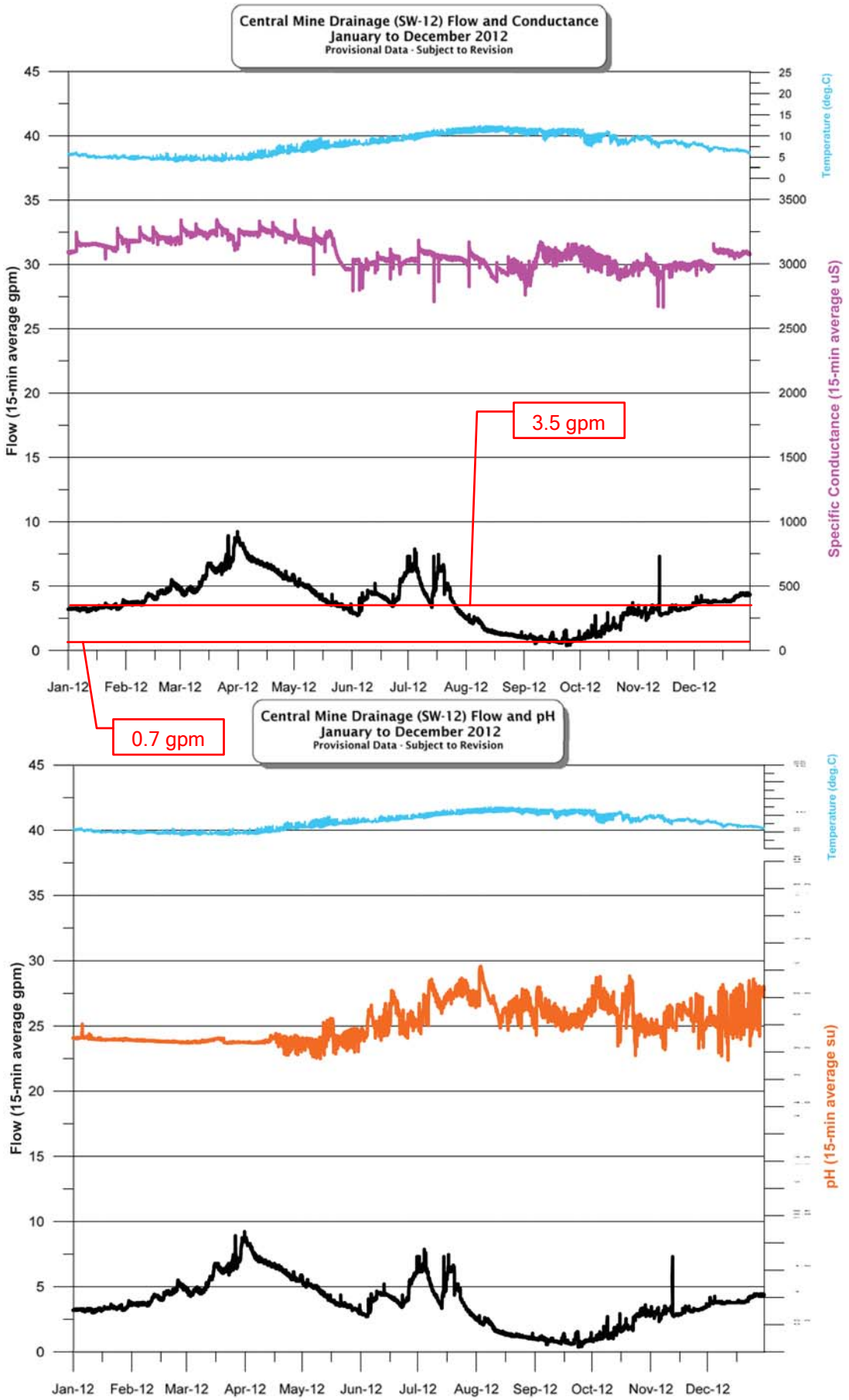
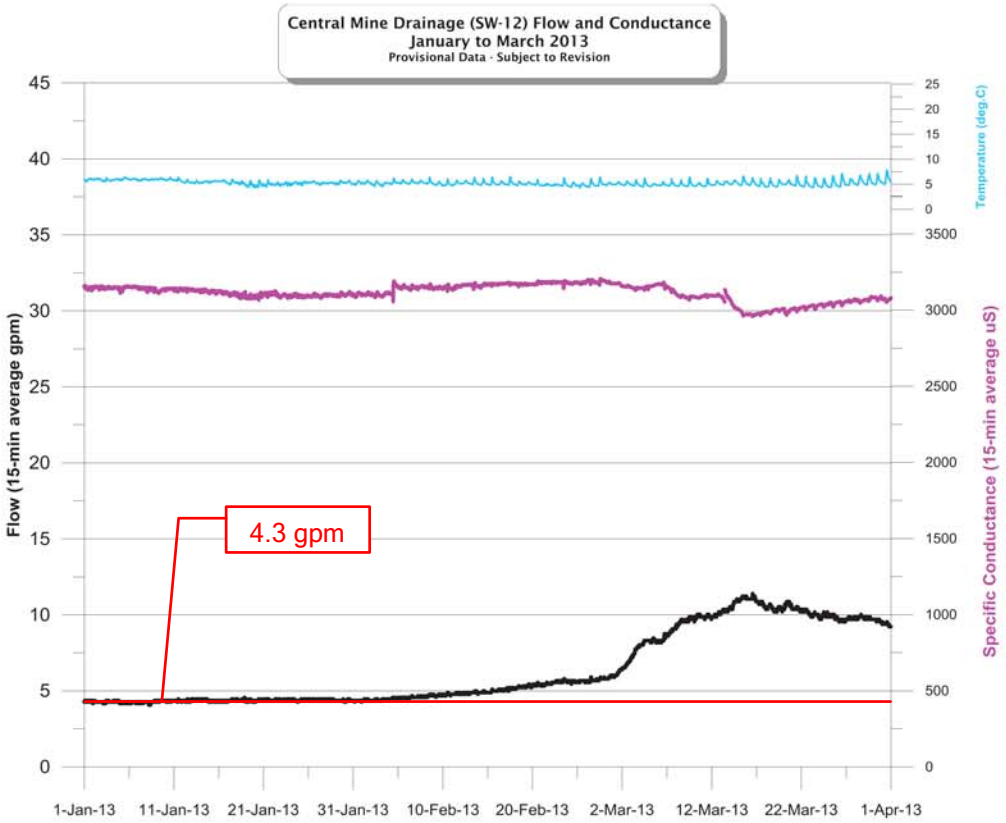

Central Mine Drainage (SW-12) Flow and Conductance
January to December 2012
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
3.5 gpm
0.7 gpm
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Central Mine Drainage (SW-12) Flow and pH
January to December 2012
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)

**Figure 2**


Central Mine Drainage (SW-12) Flow and Conductance
January to March 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
4.3 gpm
1-Jan-13
11-Jan-13
21-Jan-13
31-Jan-13
10-Feb-13
20-Feb-13
2-Mar-13
12-Mar-13
22-Mar-13
1-Apr-13

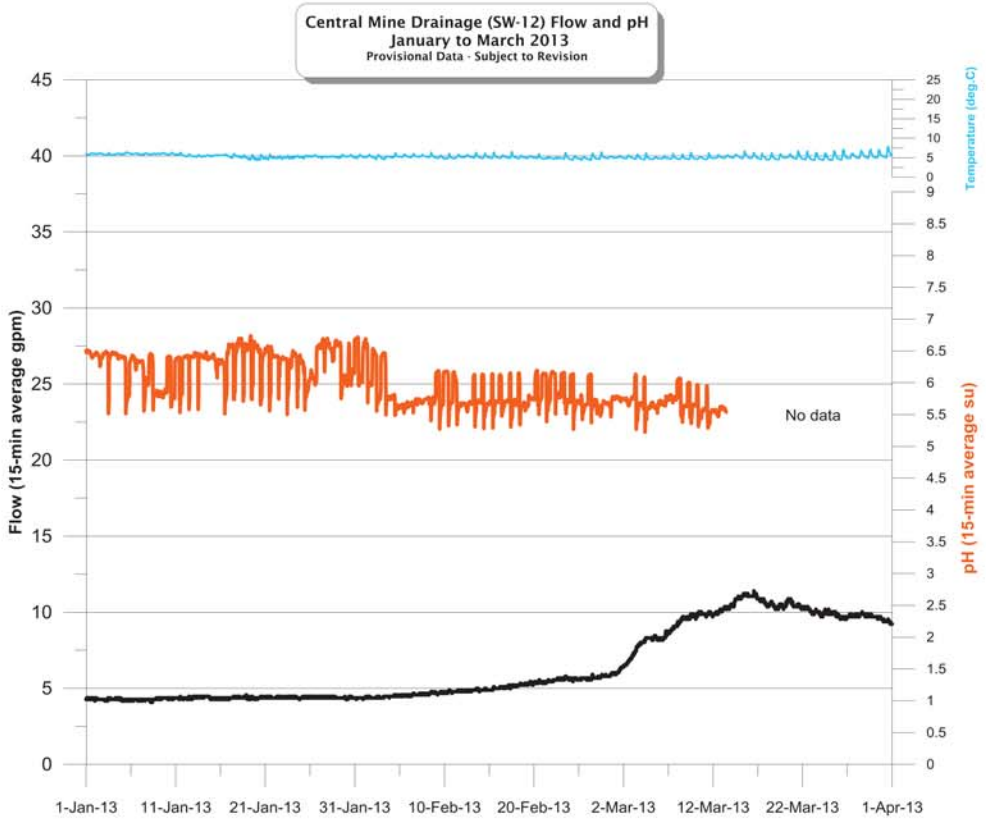

Central Mine Drainage (SW-12) Flow and pH
January to March 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
No data
1-Jan-13
11-Jan-13
21-Jan-13
31-Jan-13
10-Feb-13
20-Feb-13
2-Mar-13
12-Mar-13
22-Mar-13
1-Apr-13

**Figure 2**

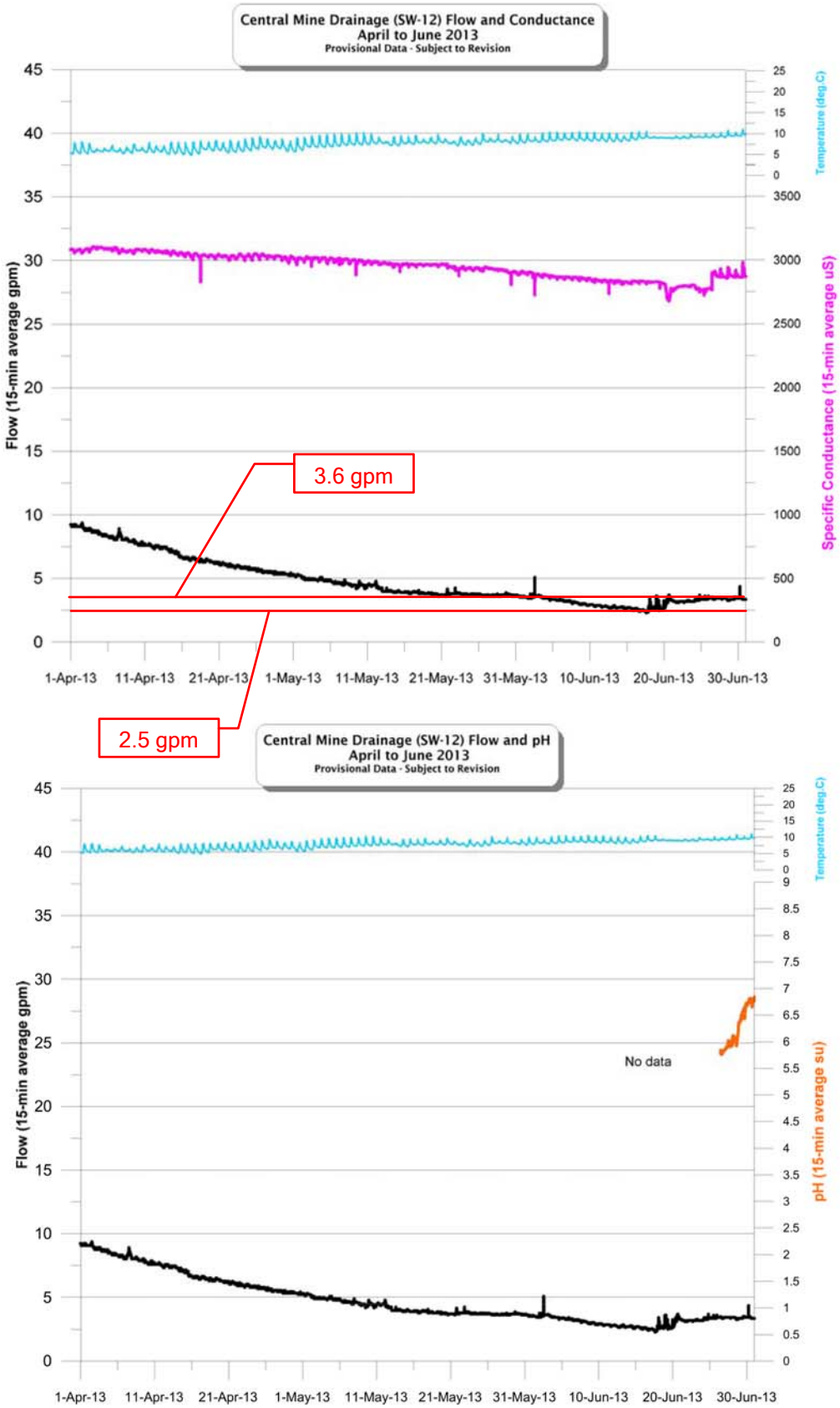
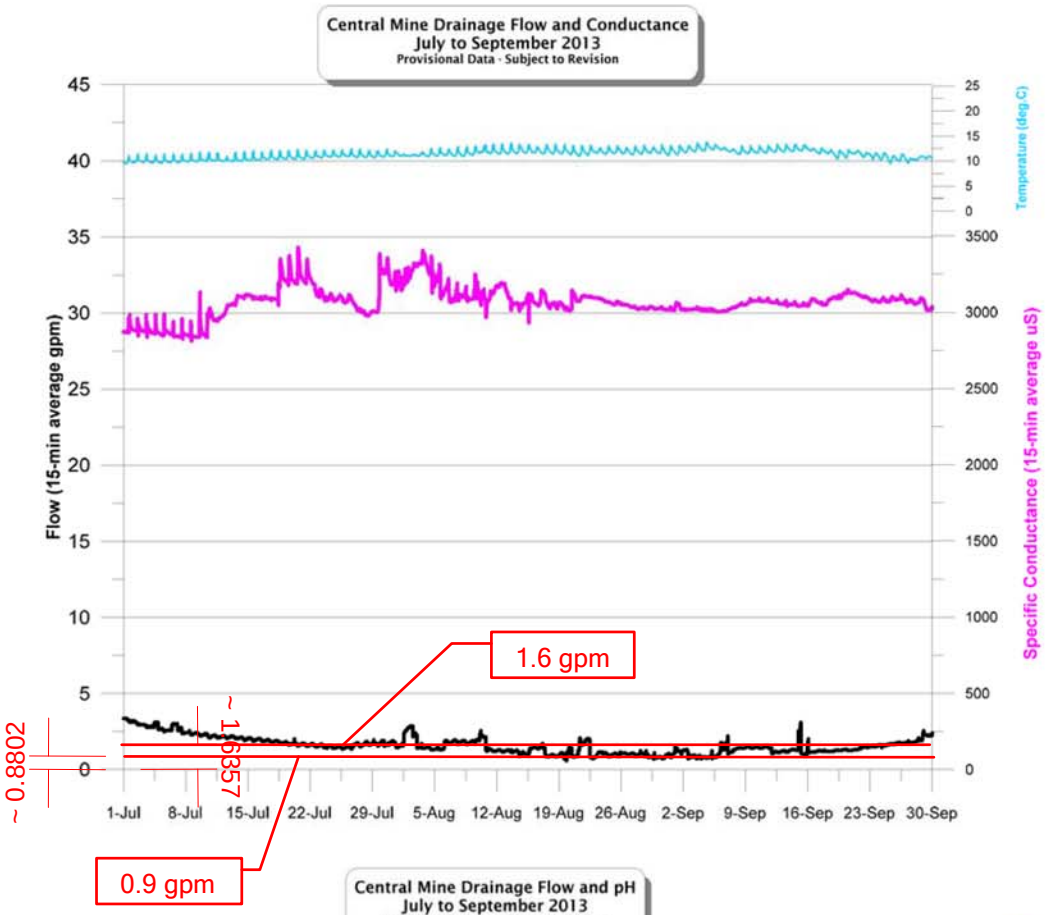

Central Mine Drainage (SW-12) Flow and Conductance
April to June 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
Specific Conductance (15-min average uS)
3.6 gpm
2.5 gpm
1-Apr-13
11-Apr-13
21-Apr-13
1-May-13
11-May-13
21-May-13
31-May-13
10-Jun-13
20-Jun-13
30-Jun-13
Central Mine Drainage (SW-12) Flow and pH
April to June 2013
Provisional Data - Subject to Revision
Flow (15-min average gpm)
Temperature (deg.C)
pH (15-min average su)
No data

**Figure 2**

**Figure 1**



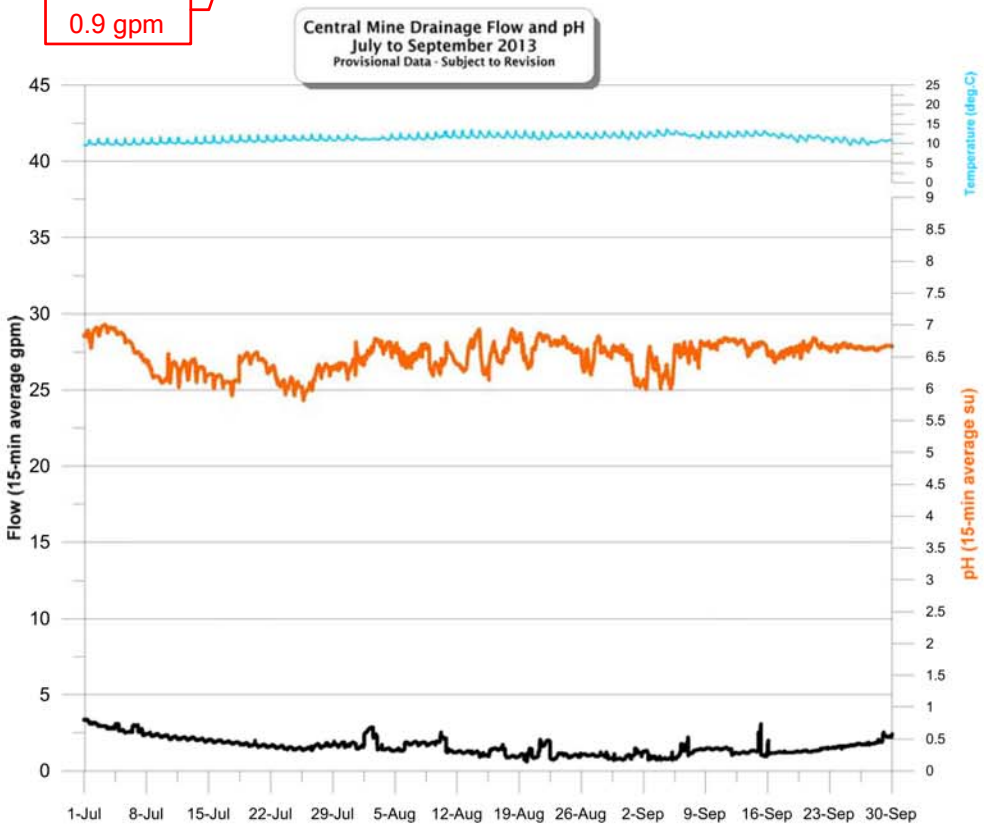




**Figure 2**

# Attachment G-3

# Calculation Brief – Extraction Trench Filter Compatibility Calculations

# *ATTACHMENT G-3*

# *MIDNITE MINE REMEDIAL ACTION*
# *Filter Calculations for Groundwater Collection Trenches*

| Revisioning | | | | | | |
|---|---|---|---|---|---|---|
| **Rev.** | **Date** | **Description** | **By** | **Checked** | **Date** | **Reviewed** |
| *0* | *4-Dec-13* | *60% Design* | *Chad Tomlinson* | *Tom Kelley* | *4-Dec-13* | *Tom Kelley* |
| | | | | | | |

## Location and Format

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

*\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical \Groundwater Collection Trenches*

*The following calculations were generated using the following software:*

*Microsoft Office Professional Plus 2010 (Microsoft Excel)*

## Supplement

*Supplement G-3.1 – Groundwater Collection Trench Backfill Gradation Calculations*

# 1.0 BACKGROUND

This calculation brief has been prepared to establish the gradation requirements for the groundwater collection trench backfill materials and confirm filter compatibility between the trench backfill and native alluvium (base soil). The groundwater collection trenches will be installed in the Western, Central and Far East Seep Drainages and will collect and convey intercepted groundwater for treatment at the Water Treatment Plant. It is expected that the groundwater collection trenches will be backfilled with drain sand conforming to gradational requirements of ASTM C33 Fine Aggregate (Fine Aggregate) and will be constructed with continuous trenching techniques with a biopolymer being used to provide trench support during excavation, placement of the collection pipe, and drain sand backfill.

## 1.1 METHODOLOGY

The design methodology used to develop the filter design for the dewatering sump was based on guidance provided in Chapter 26 – Gradation Design of Sand and Gravel Filters of the United States Department of Agriculture (USDA) Part 633 National Engineering Handbook (USDA, 1994). As the basis of the filter calculations, the native alluvium was considered as the base soil as this was typically finer textured, and thus more critical in terms of meeting filter compatibility criteria and preventing fines migration from the native soils. The gradation of native alluvium is provided in Calculation Set No. 1. Due to the percent passing a No. 200 sieve, the base soil was characterized as a Type 2 base soil as defined in Table 26-1 of Chapter 26 (USDA, 1994). The Fine Aggregate was evaluated for suitability as the backfill in terms of meeting both filtering and permeability criteria. The gradation of the ASTM C33 Fine Aggregate is presented in Table1.

**Table 1. 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 |

The filter calculations and gradation chart developed to confirm that the fine Aggregate satisfies filter and permeability criteria are presented in Calculation Set No. 1 and the results are summarized in Section 1.2.

The required slot size of the HDPE pipe to be placed in the collection trenches was also determined. Due to placement in a biopolymer slurry trench, placement of a single drainage media (as opposed to a multiple stage filter) is preferable. Therefore, the pipe slot size required

is based on the ASTM Fine Aggregate. Referring to Table 26-4 of Chapter 26 (USDA, 1994) for "non-critical drains where surging or gradient reversal is not anticipated", the perforation size must be less than or equal to $D_{85}$ of the Fine Aggregate (No.16 U.S Sieve Size).

### 1.2 RESULTS

Based on the calculations and rationale presented in Calculation Set No.1, the ASTM C33 Fine Aggregate was confirmed to meet both filter and permeability requirements. Although the $D_{60}$ of the Fine Aggregate is finer than determined by the filter calculations for the allowable finer range, this is considered acceptable by the NRCS guidelines. The $D_{60}$ specification is to prevent the use of very broadly graded soils (with flat gradation curves) which are prone to particle segregation by size during construction. More uniformly graded soils with steeper gradation curves than those indicated by the recommended limits are acceptable so long as they do conform to the finer particle range of the gradation specification.

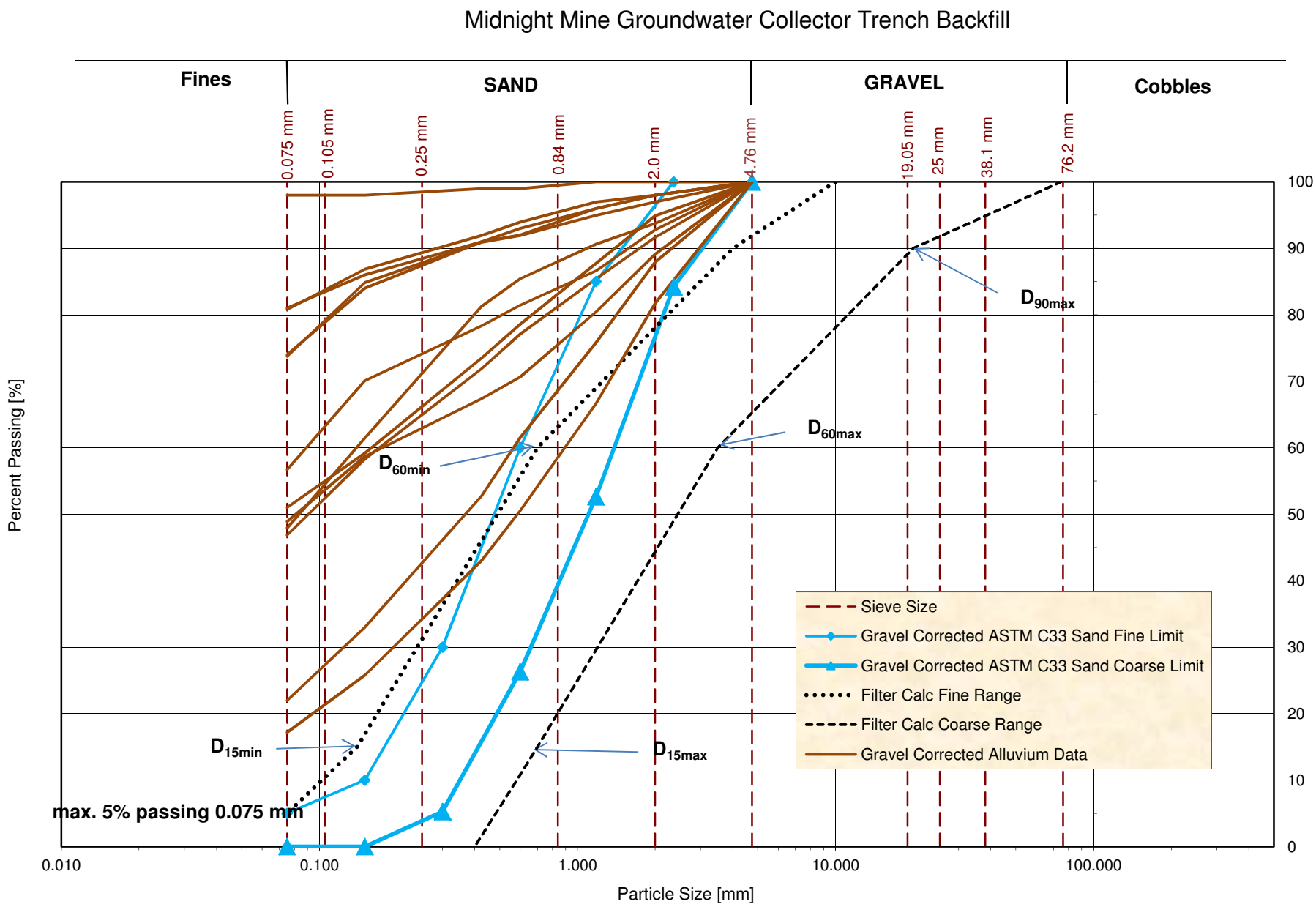
In order to achieve filter compatibility with the ASTM C33 fine aggregate, the extraction trench drain pipe will be specified to have a slot size of 0.6 mm corresponding to a No.30 U.S. Sieve Size.

## 2.0 REFERENCES

USDA, 1994. Chapter 26. Gradation Design of Sand and Gravel Filters. Part 633. National Engineering Handbook. National Resource Conservation Service. Washington D.C...

# Attachment G-3.1

# Groundwater Collection Trench Backfill Gradation Calculations


Midnight Mine Groundwater Collector Trench Backfill
Fines
SAND
GRAVEL
Cobbles
0.075 mm
0.105 mm
0.25 mm
0.84 mm
2.0 mm
4.76 mm
19.05 mm
25 mm
38.1 mm
76.2 mm
D90max
D60max
D60min
D15min
D15max
max. 5% passing 0.075 mm
Sieve Size
Gravel Corrected ASTM C33 Sand Fine Limit
Gravel Corrected ASTM C33 Sand Coarse Limit
Filter Calc Fine Range
Filter Calc Coarse Range
Gravel Corrected Alluvium Data
Percent Passing [%]
Particle Size [mm]
0.010
0.100
1.000
10.000
100.000
0
10
20
30
40
50
60
70
80
90
100

Client: Newmont Mining USA
Project: Midnite Mine
Description: Groundwater Collection Trench Backfill
Detail: Drain Gravel and Fine Aggregate Filter Design

Job No. 1011322
Date: 12/2/2013
Computed By: C. Tomlinson
Checked By: M. Davis

| Sieve Size | Size [mm] | %Pass |
|---|---|---|
| 3-inch | 76.2 | 0 |
| | 76.2 | 100 |
| | | |
| 1-1/2 inch | 38.1 | 0 |
| | 38.1 | 100 |
| | | |
| 1 | 25.4 | 0 |
| | 25.4 | 100 |
| | | |
| 3/4 inch | 19.05 | 0 |
| | 19.05 | 100 |
| | | |
| No.4 | 4.75 | 0 |
| | 4.75 | 100 |
| | | |
| No. 10 | 2 | 0 |
| | 2 | 100 |
| | | |
| No.20 | 0.84 | 0 |
| | 0.84 | 100 |
| | | |
| No.60 | 0.25 | 0 |
| | 0.25 | 100 |
| | | 0 |
| No. 140 | 0.105 | 0 |
| | 0.105 | 100 |
| | | |
| No. 200 | 0.075 | 0 |
| | 0.075 | 100 |

| ASTM C33 Fine Aggregate (Sand) | Filter per Design | | Coarse Range | Fine Range |
|---|---|---|---|---|
| | | | Max | Max |
| | Sieve Size | Size Opening [mm] | %Pass | %Pass |
| | 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 |

**Correction Factor = 100/Percent Passing No.4 Sieve**
**Correction Factor = 1.052632 1**

| Corrected Filter Gradation | | | Coarse | Fine |
|---|---|---|---|---|
| | Sieve Size | Sieve (mm) | % passing | % passing |
| | 3/8 inch | 9.5 | | |
| | No.4 | 4.75 | 100 | 100 |
| | No.8 | 2.36 | 84 | 100 |
| | No. 16 | 1.18 | 53 | 85 |
| | No. 30 | 0.6 | 26 | 60 |
| | No. 50 | 0.3 | 5 | 30 |
| | No. 100 | 0.15 | 0 | 10 |
| | No. 200 | 0.075 | 0 | 5 |

1000

Based on % passing #200 seive, predominantly type 2 soils with one curve classified as Type 1, use Type 2
Filter Calcs Note: Per USBR Design Manual pg 10, $D_{15f}/D_{85b}$ ratio for 2nd stage filter between 2 processed materials can be 9 (use 7)

$d_{85}$ = 0.15 mm Based upon curves of finer Type 2 materials
$D_{(15max)}$ 0.7 $9*d_{85base} \geq D_{15}$, but ≥ 0.7 mm Control Point 1
For Permeability $D_{15min} \geq 4xD_{15\ base\ before\ regarding}$
$D15_{min}$ 0.14 mm Control Point 2 Use $D_{15max}/5$ since finer curves do not extend to $D_{15}$ of native alluium
Check for Gap Grading $D_{15max}/D_{15min} \leq 5$
5 OK
Adjust $D_{15min}$ to maintain $D_{15max}/D_{15min}$ ratio of no more than 5
$D15_{min}$ 0.14 mm
To prevent broad range of particle sizes, Coefficient of Uniformity of 6 and ratio of max to min dia at all % passing values of 60 or less < 5
$D_{10max} = D_{15max} / 1.2$ = 0.583333333 mm
$D_{60max} = D_{10max} * 6$ = 3.50 mm Control Point 3
$D_{60min} = D_{60max} / 5$ = 0.70 mm Control Point 4
Determine minimum and maximum particle size ($D_5$ and $D_{100}$)
$D_5$ = greater than or equal to 0.075 mm Control Point 5
$D_{100}$ = 75 mm Control Point 6
To minimize segregation, need to define relationship between $D_{90max}$ and $D_{10min}$
$D_{10min} = D_{15min} / 1.2$ 0.116666667
Since $D_{10min}$ is 0.116667 mm then maximum $D_{90}$ for the filter is 20 mm per Table 26-6 Control Point 7

Connect Control Points 4,2 and 5 to form design for the fine side of the filter band. Connect Control Points 6,7,3 and 1 to form a partial design for the coarse side of the filter band

**Filter Design Criteria**

| | Name | Size (mm) | % Passing | Description |
|---|---|---|---|---|
| Fine | Control Point 8 | 10 | 100 | Extrapolated $D_{100min}$ |
| Fine | | 4 | 90 | Extrapolated $D_{90min}$ |
| Fine | Control Point 4 | 0.70 | 60 | $D_{60min}$ |
| Fine | Control Point 2 | 0.14 | 15 | $D_{15min}$ |
| Fine | Control Point 5 | 0.075 | 5 | $D_5$ |
| Coarse | Control Point 6 | 75 | 100 | $D_{100}$ |
| Coarse | Control Point 7 | 20 | 90 | $D_{90max}$ |
| Coarse | Control Point 3 | 3.5 | 60 | $D_{60max}$ |
| Coarse | Control Point 1 | 0.7 | 15 | $D_{15max}$ |
| Coarse | | 0.583333 | 10 | $D_{10max}$ |
| Coarse | | 0.4 | 0 | |

**Gradation of Base Soil (Native Alluvium)**

| U.S Standard Sieve Size | Size Opening [mm] | Percent Finer by Weight | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WD-B2, 2.5 - 5.5 | Adjusted WD-B2, 2.5 - 5.5 | CD-B2 2.5 - 4.0 | Adjusted CD-B2 2.5 - 4.0 | CD-B2 4.0 - 5.5 | Adjusted CD-B2 4.0 - 5.5 | CD-B2 10.0 - 11.5 | Adjusted CD-B2 10.0 - 11.5 | CD-B2 12.5 - 14.0 | Adjusted CD-B2 12.5 - 14.0 | CD-B2 15.0 - 16.5 | Adjusted CD-B2 15.0- 16.5 | CD-B2 17.5 - 19.0 | Adjusted CD-B2 17.5 - 19.0 | CD-B4 6.0 7.5 | Adjusted CD-B4 6.0 - 7.5 | CD-B4 11.5 - 13.0 | Adjusted CD-B4 11.5 - 13.0 | CD-B4 14.0 - 18.0 | Adjusted CD-B4 14.0 - 18.0 | ED-B1 17.5 - 19.0 | Adjusted ED-B1 17.5 - 19.0 | ED-B3 2.5 4.0 | Adjusted ED-B3 2.5 4.0 |
| 1/2 inch | 12.5 | 100 | | 100 | | | | 100 | | | | | | | | | | | | | | | | | |
| 3/8 inch | 9.5 | 100 | | 96 | | 100 | | 98 | | 100 | | 100 | | 100 | | 100 | | | | | | | | 100 | |
| No.4 | 4.75 | 93 | 100 | 91 | 100 | 96 | 100 | 96 | 100 | 99 | 100 | 97 | 100 | 92 | 100 | 99 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 98 | 100 |
| No.10 | 2 | 76 | 82 | 80 | 88 | 88 | 92 | 90 | 94 | 96 | 97 | 90 | 93 | 82 | 89 | 97 | 98 | 100 | 100 | 98 | 98 | 98 | 98 | 93 | 95 |
| No. 16 | 1.18 | 62 | 67 | 69 | 76 | 82 | 85 | 87 | 91 | 94 | 95 | 84 | 87 | 74 | 80 | 96 | 97 | 100 | 100 | 96 | 96 | 96 | 96 | 86 | 88 |
| No. 30 | 0.6 | 47 | 51 | 56 | 62 | 74 | 77 | 82 | 85 | 91 | 92 | 79 | 81 | 65 | 71 | 93 | 94 | 99 | 99 | 92 | 92 | 93 | 93 | 77 | 79 |
| No. 40 | 0.425 | 40 | 43 | 48 | 53 | 69 | 72 | 78 | 81 | 90 | 91 | 76 | 78 | 62 | 67 | 91 | 92 | 99 | 99 | 91 | 91 | 91 | 91 | 72 | 73 |
| No. 100 | 0.15 | 24 | 26 | 30 | 33 | 56 | 58 | 59 | 61 | 84 | 85 | 68 | 70 | 54 | 59 | 86 | 87 | 98 | 98 | 86 | 86 | 84 | 84 | 58 | 59 |
| No. 200 | 0.075 | 16 | 17 | 20 | 22 | 45 | 47 | 46 | 48 | 73 | 74 | 55 | 57 | 45 | 49 | 80 | 81 | 98 | 98 | 81 | 81 | 74 | 74 | 50 | 51 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Correction Factor =** | **100/Percent Passing No.4 Sieve** | | | | | | | | | | | | |
| **Correction Factor =** | | **1.075268817** | **1.098901099** | **1.041666667** | **1.041666667** | **1.010101** | **1.030928** | **1.086957** | **1.010101** | **1** | **1** | **1** | **1.020408** |

# Attachment G-4

# Geotechnical Investigation Report, Alluvial Groundwater Collection, Midnite Mine

# GEOTECHNICAL INVESTIGATION REPORT
# ALLUVIAL GROUNDWATER COLLECTION
# MIDNITE MINE

Revision 0
June 2015

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## ACRONYMS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| EPA | U.S. Environmental Protection Agency |
| ft | foot or feet |
| ft/sec | foot or feet per second |
| HSA | hollow-stem auger |
| MWH | MWH Americas, Inc. |
| Site | Midnite Mine Superfund Site |
| SPT | Standard Penetration Test |
| URS | URS Corporation |

# 1.0 INTRODUCTION

This report presents the results of the subsurface geotechnical investigation (Investigation) performed in 2014 to provide site-specific subsurface information for the design of the Alluvial Groundwater Collection System at the Midnite Mine Superfund Site (Site). The objective of the Investigation was to provide, through a drilling and geophysical program, site-specific geotechnical information to be used for the final design of the proposed alluvial groundwater collection systems in the drainages leading from the Site. The Investigation was performed in accordance with the *Alluvial Groundwater Collection System Geotechnical Investigation Work Plan* (Work Plan) dated June 27, 2014 (MWH, 2014a).

## 1.1 PROJECT BACKGROUND

The *Consent Decree Statement of Work for Midnite Mine* (EPA, 2011) requires the construction of alluvial groundwater collection systems to collect contaminated groundwater within the near-surface soil and shallow weathered bedrock at the Site. Water captured by this system will be conveyed to the Water Treatment Plant for treatment. Contaminated alluvial groundwater has been identified in the Western, Central, and Far East Seep Drainages. Groundwater collection systems have been proposed in each of these drainages as part of the Remedial Design presented in the 90% Basis of Design Report (MWH, 2014b). The proposed locations of the collection systems are shown on Figure 1. Each of the proposed alluvial groundwater interceptor systems will consist of an extraction trench installed immediately upgradient of a low-permeability barrier. The paired extraction trenches and low-permeability barriers will be constructed using the slurry trench method, or other suitable method selected by the construction contractor, through the alluvium, residual soils, and extremely weathered bedrock to the point of hydraulic excavator refusal in competent bedrock.

## 1.2 PURPOSE AND SCOPE OF INVESTIGATION

As discussed above, the purpose of the Investigation was to provide site-specific subsurface information at the locations of the proposed alluvial groundwater interceptor (collection) systems. The collection systems will be constructed by excavating along the proposed horizontal alignments shown on Figure 1 to the point of hydraulic excavator refusal in competent bedrock. The site-specific information needed for final design includes the estimated depth of excavatable materials and the stratigraphy of the materials, including the depth of saturated soils that will be encountered during installation of the collection systems. This information is necessary to estimate the final geometries of the proposed extraction trenches and low-permeability barriers, which will affect both material quantities and equipment needed for construction.

The scope of the Investigation included the drilling and geophysical data collection. Nine boreholes were drilled in the drainages (three boreholes each in the Western, Central, and Far East Seep Drainages) for collection of geotechnical samples/data. Seismic refraction surveys were conducted along four seismic lines (one seismic line each in the Western and Central Drainages, and two seismic lines in the Far East Seep Drainage). These borehole and seismic line locations are shown on Figures 2, 4 and 6. Data obtained during the field investigations were used to generate geologic sections for use in updating the design of the alluvial groundwater collection systems. The geologic sections show the interpreted stratigraphy in the

areas of the proposed alluvial groundwater collections systems, as well as the estimated limit of excavatable material.

## 2.0 SUBSURFACE EXPLORATION

Details of the drilling and geophysical programs are presented below.

### 2.1 GEOTECHNICAL DRILLING AND SAMPLING PROGRAM

A total of nine geotechnical boreholes were drilled on July 21-25, 2014 as part of this Investigation. Three boreholes each were drilled in the Western, Central, and Far East Seep Drainages at the locations shown on Figures 2, 4 and 6. The boreholes were drilled in lines perpendicular to the valley bottom as close to the alignments of the proposed low-permeability barriers as possible.

The boreholes were drilled by Budinger & Associates, Inc. of Spokane, Washington. An engineer from MWH observed the drilling and logged the boreholes. The drilling was performed by hollow-stem auger (HSA) drilling methods using a TEI HEM hydraulically-powered drill mounted to the arm of a Caterpillar 315C tracked excavator. The holes were drilled using hollow-stem augers with an inside diameter of 3.25 inches and an outside diameter of 6.5 inches.

Standard Penetration Test (SPT) measurements were performed every 2.5 feet of borehole depth by driving a standard split-barrel SPT sampler using an automatic hammer that delivers blows equivalent to a 140-pound weight falling 30 inches. SPT blow counts were recorded for each 0.5 feet of progress, as described in ASTM D1586 (ASTM International, 2011). After each SPT drive, the sampler was removed from the borehole and opened so that the material could be observed and photographs taken. Soil samples from the split-barrel SPT sampler were placed into plastic zip-top bags and stored in the locked storage container on-site for future reference as needed.

Soil samples collected during the SPT sampling were visually classified in general accordance with ASTM D2488 (ASTM International, 2009) to develop borehole logs. The borehole logs are provided in Appendix A, as well as photographs of the borehole locations (before and after drilling) and photographs of the SPT samples. At several borehole locations, groundwater was encountered during the drilling, and the depth at which groundwater was first encountered was recorded on the borehole log.

The boreholes were drilled until practical auger refusal in bedrock was reached. After the drilling, the open boreholes were abandoned by filling them with granular bentonite sealant. The borehole locations were recorded using a handheld GPS unit and were marked with stakes for a subsequent ground survey. Borehole locations were surveyed on July 29, 2014 by Benthin & Associates of Spokane, Washington in order to provide more accurate measurements of horizontal and vertical locations than could be obtained using the hand held GPS. The surveyor's report is provided in Appendix C. The surveyed coordinates and elevations are summarized in Table 1.

## 2.2 SEISMIC REFRACTION SURVEY PROGRAM

The geophysical investigation program was performed from July 14 through 18, 2014 and consisted of seismic refraction surveys along one seismic line in the Western Drainage (line WD-SL-14-01 on Figure 2), one seismic line in the Central Drainage (line CD-SL-14-01 on Figure 4), and two seismic lines in the Far East Seep Drainage (lines FESD-SL-14-01 and FESD-SL-14-02 on Figure 6). The seismic refraction surveys were conducted by Philip H. Duoos of Redmond, Washington. The report summarizing the geophysical information that was collected is provided in Appendix B and includes a detailed discussion of the field methods used to perform the surveys.

The seismic lines used in collection of the geophysical data were laid out in the field using a handheld GPS device. After the field work, the precise location of the seismic lines was surveyed by Benthin & Associates of Spokane, Washington on July 29, 2014. The results of this survey are included in the surveyor's report provided in Appendix C.

# 3.0 SUBSURFACE CONDITIONS

This section discusses the overall geology of the Site including the surficial soils and underlying bedrock. This section also summarizes the subsurface conditions in the Western Drainage, Central Drainage, and Far East Seep Drainage in the vicinity of the proposed alluvial groundwater collection systems. Table 1 provides a summary of the drilling program completed as part of this investigation and includes drilling depths, the depth to weathered bedrock, depth of first observed groundwater (if encountered), and depth of practical auger refusal.

Based on the results of the 2014 field investigations, as well as information from previous Site investigations, geologic sections were developed for the three drainage areas, as shown on Figures 3 (Western), 5 (Central) and 7 (Far East Seep). Information from previous Site investigations, including previous seismic surveys and borehole logs from previous drilling programs, was also used to develop the sections. A description of these previous investigations and their relevance to the design of the alluvial groundwater collection systems is provided in the Work Plan (MWH, 2014a).

## 3.1 OVERALL SITE GEOLOGY

The bedrock at the Site is generally composed of metamorphosed sedimentary (i.e., meta-sedimentary) rock of the Togo Formation with multiple quartz monzonite intrusions. The bedrock underlying the western portion of the Site, including the Western Drainage and Central Drainage, consists of variably-weathered quartz monzonite. The bedrock underlying the eastern portion of the Site, including the Far East Seep drainage area, consists of variably-weathered meta-sedimentary rock including phyllite, marble, calc-silicate hornfels, and quartzite. The degree and depth of bedrock weathering varies across the Site, and generally decreases with depth as would be expected. The bedrock material generally is overlain by unconsolidated surficial soils that have been deposited by stream and glacial activity, or are derived from in-place weathering of bedrock. In the Western Drainage, Central Drainage, and Far East Seep Drainage areas, the surficial deposits consist primarily of alluvium that has been deposited by intermittent running water (generally present in valley bottoms), colluvium derived principally by weathering and subsequent gravity transport (generally present on the side slopes), and

residual soils that are the result of in-place weathering of bedrock. A detailed discussion of the Site geology is presented in the Final Remedial Investigation Report (URS, 2005).

## 3.2 EXCAVATABILITY CRITERIA

As mentioned in Section 1.1, it is anticipated that the paired extraction trenches and low-permeability barriers will be constructed using the slurry trench method through the alluvium, residual soils, and extremely weathered bedrock to the point where hydraulic excavator refusal is reached in competent bedrock. It is assumed that the trenches will be excavated with a hydraulic excavator using a bucket fitted with rock teeth and ripping shanks. The depth to excavator refusal will depend on a number of factors including the type of bedrock, the degree of bedrock weathering, the nature of discontinuities in the bedrock (such as joints or bedding), the type and power of excavator, the dimensions and type of bucket, and the geometry of the excavator boom and stick.

For this evaluation, it is important to distinguish between excavatability criteria and the more commonly used ripability criteria, which are distinguished from each other as follows:

> Ripability criteria. Ripability criteria are often used to estimate depth at which point ripping to loosen rock-like material of material requiring blasting or other rock excavation techniques will be required for bulk excavation. Criteria developed by the US Army Corps of Engineers and presented in Caterpillar Performance Handbook (Caterpillar, 2015) are often used to estimate depths of ripability. Ripability criteria presented assume that ripping will be performed using a specific model dozer with a ripping tooth. For a D8 dozer equipped with a single-tooth ripper, working in igneous or metamorphic rocks similar to the bedrock at the Midnite Mine (i.e., a material with a compressive (p-wave) velocity (as measured during a seismic refraction survey) ranging from 6,000 to 8,000 ft/sec) is considered to be marginally rippable. For the purpose of this Investigation and ripability at this Site, subsurface materials/bedrock found to have a p-wave velocity less than 6,000 ft/sec during the seismic refraction surveys are considered rippable. Although this values is an estimate of ripability in near-surface material using a dozer with a single ripping tooth to aide in bulk excavation, it can be used to provide an estimate of the greatest depth that might be reached using a medium-sized hydraulic excavator (e.g. a Komatsu PC-800 excavator equipped with a long stick) for trench excavation.
>
> Excavatability Criteria. At locations where geotechnical borehole information is available, excavatability is evaluated based upon the SPT-based blow counts (N-Values). Depending on geologic conditions, depth of excavation, and type of equipment being used, the limit of excavatability during trench excavation is assumed to occur at the point where N-Values greater than 80 to 100 blows/ft are encountered. For the purposes of this Investigation, the depth at which SPT N-values exceeded 100 blows per foot was used to estimate the limit of excavatable material at geotechnical borehole locations.

Based upon these considerations, the occurrence of SPT N-values greater than 100 are used to estimate the limit of excavatability at borehole locations. Seismic P-wave velocities greater than 6,000 ft/sec. are used to differentiate between weathered and competent bedrock in the geologic sections shown on Figures 3, 5 and 7, and to provide an estimate of the lower bound of excavatability in locations where borehole information is not available.

## 3.3 WESTERN DRAINAGE

### 3.3.1 Drilling Observations

The Western Drainage borehole locations were installed along a line that generally is perpendicular to the stream course and along the axis of the low permeability barrier wall that is proposed in this drainage as shown on Figure 2. Borehole WD-14-01 was drilled on the east side slope of the drainage, approximately 10 vertical feet above the drainage bottom. WD-14-02 was drilled in the center of the drainage. WD-14-03 was drilled in the western portion of the drainage bottom, at the toe of the west side slope. Soil materials encountered in these borings generally consist of sandy clay, sand with clay, and clayey sand with varying amounts of gravel. Underlying the soil material, weathered quartz monzonite bedrock was encountered. At WD-14-02 and WD-14-03, located near the bottom of the drainage, weathered bedrock was encountered at a depth of 8.8 feet and 11.2 feet, respectively. At WD-14-01, which was located approximately 10 vertical feet above the drainage bottom, weathered bedrock was encountered at a depth of 18.1 feet. Once the weathered quartz monzonite material was encountered, the drilling resistance and blow counts increased until the point where the hollow stem auger could no longer effectively advance (i.e. practical HSA refusal was observed) in competent bedrock. Geologic sections in the Western Drainage area are shown on Figure 3.

Groundwater was encountered in all three boreholes. At WD-14-02 and WD-14-03, groundwater was encountered at a depth of 5.2 feet. At WD-14-01, groundwater was encountered at a depth of 19.2 feet. Once the groundwater was encountered in each borehole, the material was observed to be very moist to wet to the bottom of each borehole. The groundwater depths are shown on the geologic sections on Figure 3. The groundwater depths were measured during or immediately after the drilling and may not represent the actual water table.

### 3.3.2 Seismic Survey Results

A seismic refraction survey was conducted along one cross-valley survey line in the Western Drainage. The survey line was located as close to the alignment of the proposed low-permeability barrier as possible. This line is labeled WD-SL-14-01 on Figure 2. As shown on the sections in seismic survey report (Appendix B), the seismic survey identified unconsolidated soil with a p-wave seismic velocity ranging from 1,000 to 1,250 ft/sec overlying more consolidated material with a seismic velocity ranging from 2,400 to 3,200 ft/sec. Below this material, the seismic survey identified bedrock material with a much higher seismic velocity (12,200 to 12,900 ft/sec). The higher velocity material was encountered at depths ranging from 10.3 to 28.5 feet along the survey line and is interpreted to be competent, unweathered quartz monzonite bedrock that is not rippable.

### 3.3.3 Summary and Estimated Limit of Excavatable Material

In the Western Drainage, there is good agreement between the depth of SPT refusal (N values greater than 100) and the depth of the high-velocity competent bedrock observed in the seismic survey data as shown on the geologic sections on Figure 3. At all three boring locations, the depth of SPT refusal was within about 1.5 feet of the high velocity bedrock. Therefore, based on the criteria discussed in Section 3.2 above, the limit of excavatable material in this area is estimated to be along the top of the high velocity bedrock, as shown on Figure 3.

## 3.4 CENTRAL DRAINAGE

### 3.4.1 Drilling Observations

The Central Drainage borehole locations, similar to the other drainages, were installed along a line that is approximately perpendicular to the stream course and along the axis of the low permeability barrier wall proposed in this drainage as shown on Figure 4. Borehole CD-14-01 was drilled on the east side slope of the drainage, approximately 10 vertical feet above the drainage bottom. CD-14-02 was drilled near the center of the drainage. CD-14-03 was drilled slightly above the toe of the west side slope.

At CD-14-01, drilled on the east side slope, sand was observed to a depth of 8.0 feet, where weathered quartz monzonite bedrock was encountered. At CD-14-03, drilled on the west slide slope slightly above the drainage bottom, sandy clay was observed to a depth of 12.5 feet, where weathered quart monzonite was observed. Once the weathered bedrock was encountered, the blow counts increased until practical auger refusal was observed. Groundwater was not observed at CD-14-01 and CD-14-03.

At CD-14-02, in the center of the drainage, a very soft, wet soil consisting of sandy clay, clay with sand, and sand with clay with varying amounts of gravel was observed. The blow counts in this material were very low, with the SPT hammer falling under its own weight in many cases (SPT blow count of zero). At a depth of approximately 22 feet, weathered quart monzonite was observed, with practical auger refusal at a depth of 26.5 feet. Groundwater was measured in the open borehole at a depth of 6.0 feet, as shown on the geologic section on Figure 5. This water level was measured during the drilling and may not represent the actual water table.

### 3.4.2 Seismic Survey Results

A seismic refraction survey was conducted along one cross-valley survey line in the Central Drainage. The survey line was located as close to the alignment of the proposed low-permeability barrier as possible. This line is labeled as CD-SL-14-01 on Figure 4. As shown on the sections in seismic survey report (Appendix B), the seismic survey identified unconsolidated soil near the ground surface with a p-wave seismic velocity ranging from 1,100 to 1,400 ft/sec. In the eastern portion of the seismic line (along the eastern side slope of the drainage), the upper soil material was underlain by more consolidated material with a seismic velocity ranging from 2,800 to 3,200 ft/sec. In the area of the proposed low-permeability barrier (in the lower, central portion of the drainage), the upper soil was underlain by material with a seismic velocity ranging from 4,200 to 5,200 ft/sec. The higher seismic velocities measured in the lower, central portion of the drainage likely is due to the presence of groundwater in this area.

Below the surficial soils, the seismic survey identified bedrock material with a much higher seismic velocity (10,500 to 12,300 ft/sec). The higher velocity material was encountered at depths ranging from 16.1 to 26.2 feet along the survey line and is interpreted to be unweathered quartz monzonite bedrock that is not rippable.

### 3.4.3 Summary and Estimated Limit of Excavatable Material

In the Central Drainage, SPT refusal occurred above the high-velocity unrippable bedrock observed during the seismic survey, as shown on the geologic sections on Figure 5. At boring

CD-14-02 located in the center of the drainage, SPT refusal occurred about 1.5 feet above the unrippable bedrock. At borings CD-14-01 and CD-14-03, SPT refusal occurred about 8 feet and 5 feet above the high-velocity unrippable bedrock, respectively. The greater difference between excavatability limits (as estimated from SPT-blow counts) and ripability limits (estimated based upon p-wave velocity from the seismic survey) than was seen in the Western Drainage may be the result of a more gradual increase in bedrock hardness with depth in the Central Drainage. Based on the criteria discussed in Section 3.2 above, the depths of SPT refusal were used to estimate the limit of excavatable material in this area, as shown on Figure 5.

## 3.5 FAR EAST SEEP DRAINAGE

### 3.5.1 Drilling Observations

In the Far East Seep Drainage three borings were installed along a line that is approximately perpendicular to the stream course and along the axis of the low permeability barrier wall that is proposed in this drainage as shown on Figure 6. Borehole FESD-14-01 was drilled on the west side slope of the drainage, approximately 3 vertical feet above the drainage bottom. FESD-14-02 was drilled near the center of the drainage. Borehole FESD-14-03 was drilled slightly above the toe of the east side slope. At the boreholes near the side slopes (FESD-14-01 and FESD-14-03), sandy clay soil was observed to a depth of approximately 5 feet, where weathered meta-sedimentary bedrock was encountered. Some cobbles and boulder-sized rocks were observed on the ground surface. The weathered bedrock exhibited varying degrees of drilling resistance, and much of the weathered bedrock material retrieved from the SPT sampler could be broken down with minimal hand effort to clayey sand or sandy clay.

Practical auger refusal was observed at 35.0 feet and 31.0 feet at FESD-14-01 and FESD-14-03, respectively. No free groundwater water was observed at FESD-14-03 during the drilling. At FESD-14-01, no free water was observed in the augers, but the outside surfaces of all of the split-barrel samplers were wet below a depth of approximately 24 feet. Below this depth, the samples retrieved from the spilt-barrel were observed to alternate between very moist and wet. It is possible that the high clay content of the weathered bedrock material prevented the flow of groundwater into the open augers during the drilling of FESD-14-01, and/or localized zone(s) of perched water are present.

At FESD-14-02 drilled in the center of the drainage, clay with varying amounts of sand and gravel was observed to a depth of approximately 16 feet, where weathered meta-sedimentary bedrock was observed. Some cobbles and boulder-sized rocks were observed on the ground surface, and were noted by the driller during the drilling. The weathered bedrock was observed to be more competent in this area compared to the other two borings, and practical auger refusal was observed at a depth of 21.5 feet. Visible water was observed in the samples from a depth of approximately 15.5 to 16 feet, and from approximately 17.5 to 19 feet. These depth intervals may represent zones of perched water within the weathered bedrock material.

### 3.5.2 Seismic Survey Results

Seismic refraction surveys were conducted along two survey lines in the Far East Seep Drainage, as shown on Figure 6. Line FESD-SL-14-01 runs in a cross-valley direction, and line FESD-SL-14-02 runs down the center of the drainage. As shown on the sections in seismic survey report (Appendix B), the survey along line FESD-SL-14-01 identified unconsolidated soil

with a p-wave seismic velocity ranging from 1,050 to 1,300 ft/sec overlying more consolidated material with a seismic velocity ranging from 2,300 to 2,700 ft/sec. Below this surficial material, the seismic survey identified material with a much higher seismic velocity (11,500 to 13,000 ft/sec), as shown on the cross sections on Figure 7. This material is interpreted to be unweathered meta-sedimentary bedrock and was encountered at depths ranging from 19.1 feet near the center of the drainage to 49.3 feet at the southwest end of line FESD-SL-14-01.

The seismic survey along line FESD-SL-14-02 identified similar materials and p-wave velocities. Along seismic line FESD-SL-14-02, the high velocity bedrock was encountered at depths ranging from 18.2 to 28.9 feet.

### 3.5.3 Summary and Estimated Limit of Excavatable Material

The drilling conditions in the Far East Seep Drainage were more variable than the other two drainages, including the drilling resistance and the degree of weathering of the bedrock. At borehole FESD-14-01 located on the west side of the drainage, SPT refusal was observed about 3 feet below the top of the high-velocity bedrock material identified in the seismic survey. At borehole FESD-14-02 located in the center of the drainage, SPT refusal was observed about 3 feet above the top of the high-velocity bedrock. At borehole FESD-14-03 on the west side of the drainage, SPT refusal was observed about 1 foot below the top of the high-velocity bedrock. Based on these observations, it is expected that variable conditions will be encountered during excavation in this area. The limit of excavatable material is expected to be at the top of the high-velocity bedrock on the east and west sides of the drainage, and slightly above the high-velocity bedrock in the central part of the drainage, as shown on Figure 7. The depth of meta-sedimentary bedrock weathering (up to 49.3 feet) as identified by the seismic survey in the Far East Seep Drainage was significantly deeper than identified in the drainage immediately to the west (the East Seep Drainage), where less than 28 feet of highly-weather material was encountered during previous investigations (MWH, 2012).

## 4.0 SUMMARY

The geologic sections on Figures 3, 5 and 7 provide stratigraphic information that will be used to estimate the final geometries of the proposed extraction trenches and low-permeability barriers and to estimate material quantities and equipment needed for construction. This information includes the thickness of overburden soils, the thickness of weathered bedrock, and the depth to more competent bedrock. The geologic sections also show the depth at which groundwater was encountered at the time of drilling, if observed, as well as the estimated limit of excavatable materials. As in previous sections, the water levels encountered during drilling may not reflect actual groundwater levels at these locations.

The geologic sections are interpretive in nature and the information presented represents a best estimate based on the available data. The estimated limit of excavatable materials is based on the results of geotechnical test borings and geophysical seismic surveys, which identified relatively bedrock material with a high-seismic velocity underlying the overburden and weathered bedrock. As discussed in the seismic report in Appendix B, ideal geophysical method that was used has a general accuracy about +/-10 percent under good conditions. Therefore, the actual depth to competent bedrock should be expected to vary from that shown on the sections.

The actual depth to excavator refusal encountered during construction will depend on a number of factors including the type of bedrock, the degree of bedrock weathering, the nature of discontinuities in the bedrock (such as joints or bedding), the type and power of excavator, the type of bucket and ripping tines, and the length of excavator boom. It is expected that the depth to excavator refusal will vary from that shown on the sections. As a result, it is recommended that an excavator capable of excavating at least 10 feet below the greatest excavation depth shown in the final design be used for construction of the Alluvial Groundwater Collection Systems.

Good geometric constraint of the alluvial system was exhibited by the high-velocity bedrock contacts in both the Western and Central Drainages, as can be seen in the valley cross sections on Figure 3 and Figure 5. No such constraint was identified in the Far East Seep Drainage, where the contact with high-velocity bedrock appears to be dipping into the western slope of the drainage. The depth of weathered bedrock in this area is not consistent with observations made in the drainage immediately to the east (the Eastern Seep Drainage). Given the estimated depth to high-velocity bedrock in the Far East Seep Drainage, it may be difficult if not impractical to reach excavator refusal and tie the Alluvial Collection System into high-velocity bedrock in some areas.

## 5.0 REFERENCES

ASTM International, 2009. ASTM D2488-09a – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).*

ASTM International, 2011. ASTM D1586-11 – *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.*

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MWH Americas, Inc. (MWH), 2014a. *Alluvial Groundwater Collection System Geotechnical Investigation Work Plan, Revision 1.* Prepared for Dawn Mining Company LLC and Newmont USA Limited. June 27.

MWH Americas, Inc. (MWH), 2014b. *Midnite Mine Superfund Site 90 Percent Design, Basis of Design Report.* Prepared for Dawn Mining Company LLC and Newmont USA Limited. July 31.

URS Corporation (URS), 2005. *Midnite Mine Remedial Investigation Report.* Prepared for U.S. Environmental Protection Agency. September.

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.

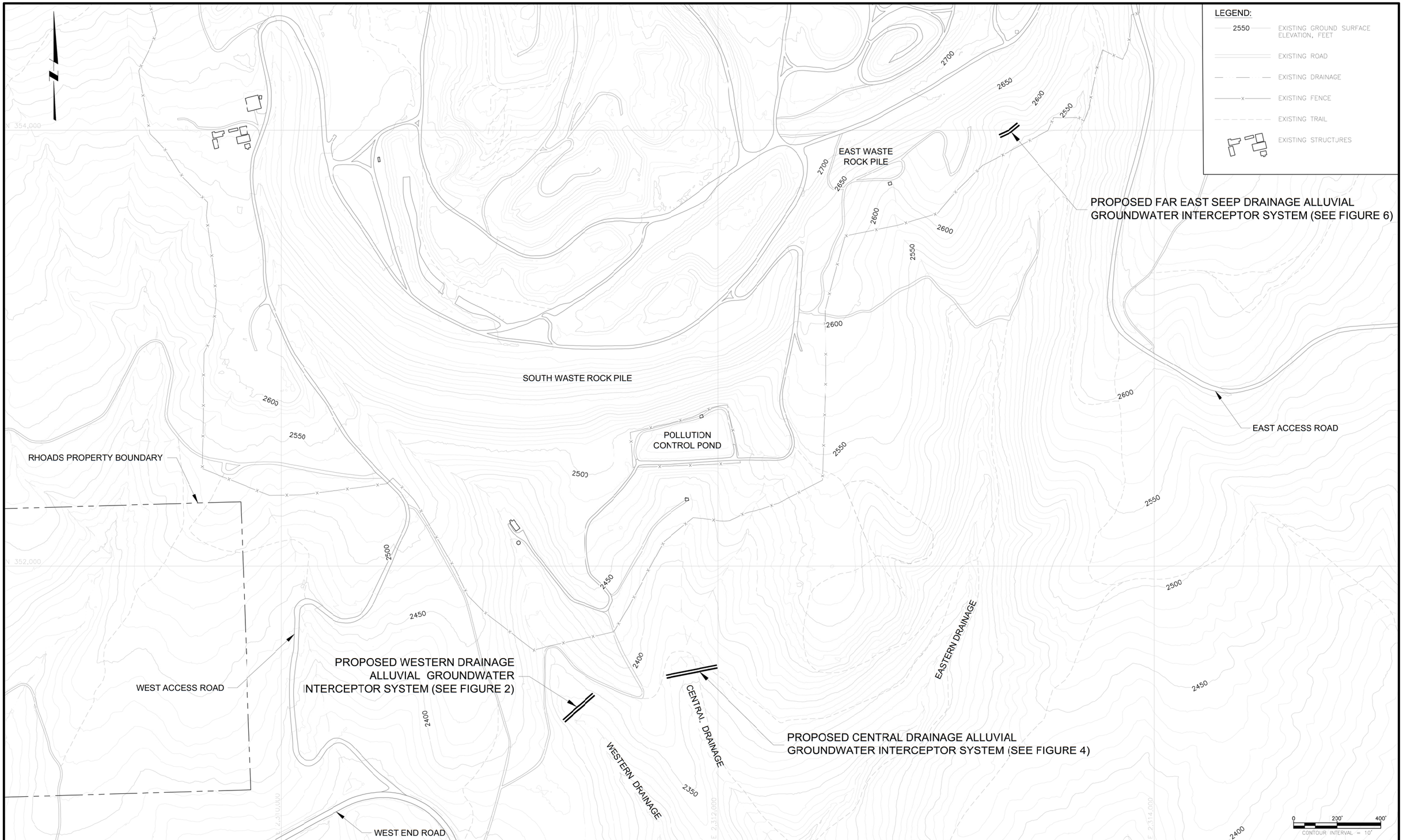
# TABLE

**Table 1. Summary of Borehole Information**

| Area | Borehole | Northing[1] (ft) | Easting[1] (ft) | Ground Surface Elevation[1] (ft) | Depth to Weathered Bedrock (ft) | Depth to Practical Auger Refusal (ft) | Depth to First Observed Groundwater (ft) |
|---|---|---|---|---|---|---|---|
| Western Drainage | WD-14-01 | 351390.6 | 2311413.3 | 2341.5 | 18.1 | 28.5 | 19.2 |
| | WD-14-02 | 351330.4 | 2311361.2 | 2330.1 | 8.8 | 14.5 | 5.2 |
| | WD-14-03 | 351301.0 | 2311325.0 | 2331.2 | 11.2 | 12.0 | 5.2 |
| Central Drainage | CD-14-01 | 351527.6 | 2311965.3 | 2363.1 | 8.0 | 20.5 | not observed |
| | CD-14-02 | 351518.0 | 2311855.6 | 2353.8 | 22.0 | 26.5 | 6.0 |
| | CD-14-03 | 351498.8 | 2311807.9 | 2354.3 | 12.5 | 15.4 | not observed |
| Far East Seep Drainage | FESD-14-01 | 353983.3 | 2313315.4 | 2563.1 | 12.0 | 35.0 | 24.0 |
| | FESD-14-02 | 353990.7 | 2313338.1 | 2559.9 | 16.0 | 21.5 | 15.5 |
| | FESD-14-03 | 354010.6 | 2313376.3 | 2561.2 | 5.3 | 31.0 | not observed |

Notes: (1) Coordinates are NAD 83 Washington State Plan, North Zone.

# FIGURES




DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE–NORTH, NAD 83/NAVD 88.

NEWMONT

| | |
|---|---|
| PROJECT LOCATION | WELLPINIT, WASHINGTON |
| PROJECT | MIDNITE MINE |
| TITLE | ALLUVIAL GROUNDWATER INTERCEPTOR SYSTEMS LOCATION MAP |
| FIGURE 1 | REVISION 1 |
| FILE NAME 1011322 LM | DATE AUG 2014 |

MWH

Z:\Project Files\Midnite\AutoCAD Files\Midnite Mine CAD Files\MWH\2015-MWH\From-MWH\2014-08-29 GW WORK PLAN\1011322 LM

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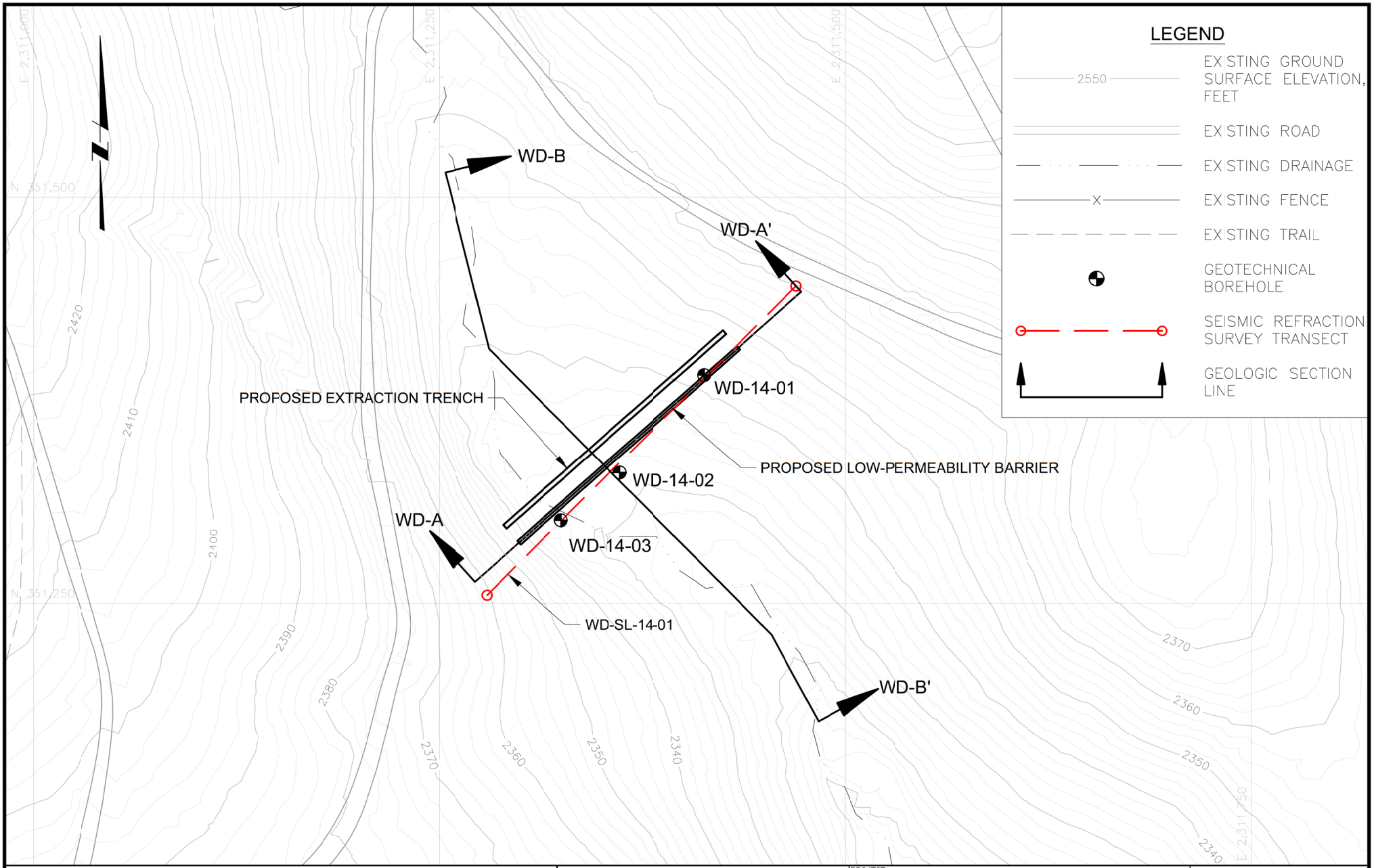



DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.

0 80' 160'

NEWMONT

PROJECT: MIDNITE MINE

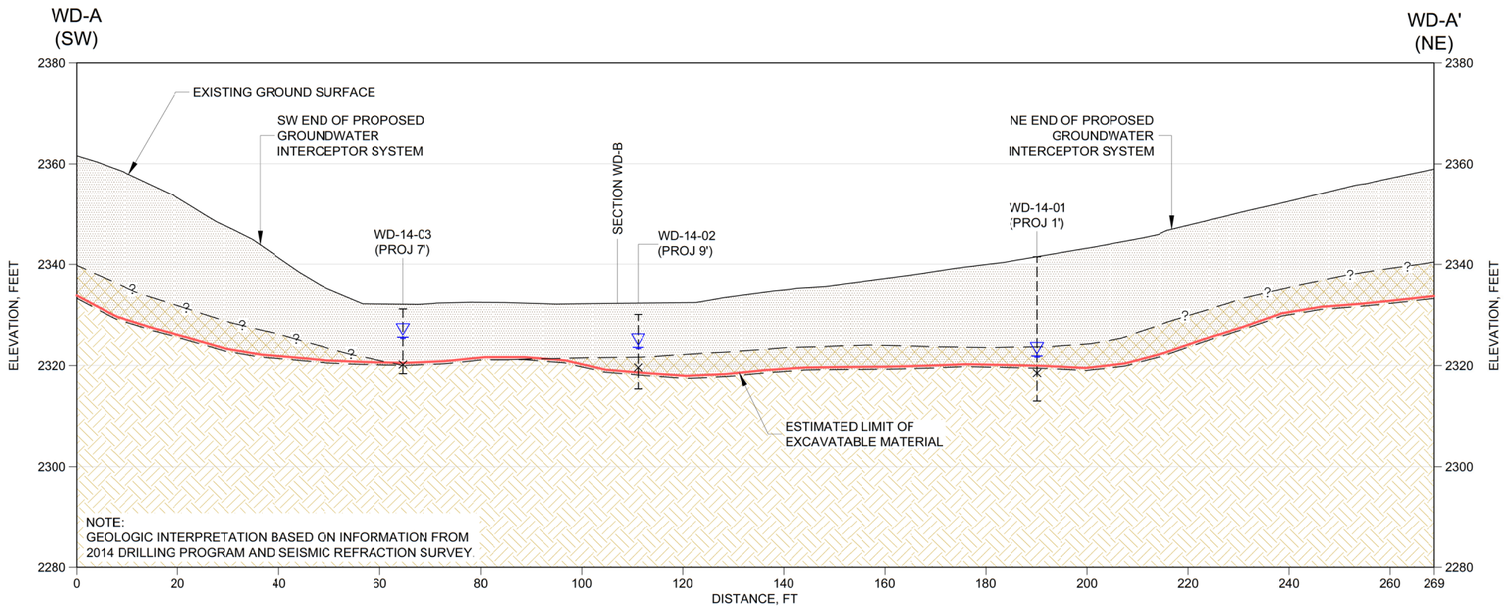
TITLE: WESTERN DRAINAGE ALLUVIAL GROUNDWATER INTERCEPTOR SYSTEM AREA

MWH

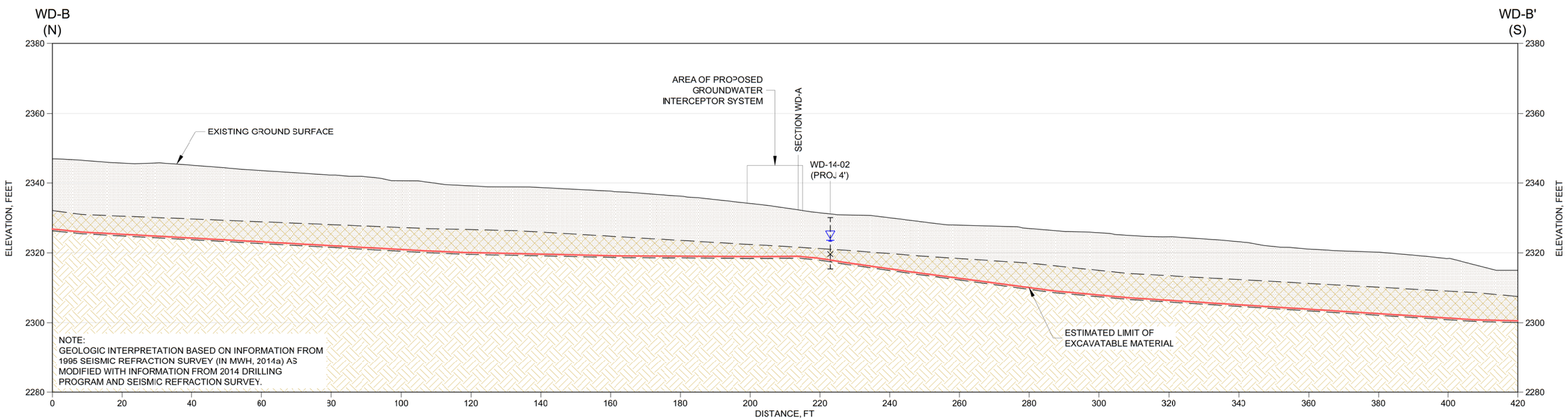
DATE: AUG 2014

FIGURE 2

FILE NAME: 1011322 AGWIS




GEOLOGIC SECTION WD-A
(LOOKING NW)




GEOLOGIC SECTION WD-B
(LOOKING NE)

## LEGEND

**OVERBURDEN**
UNCONSOLIDATED ALLUVIUM, COLLUVIUM, AND RESIDUAL SOIL WITH VARYING AMOUNTS OF SAND, GRAVEL AND FINES, CAN BE READILY DRILLED WITH HOLLOW STEM AUGER DRILL RIG

**WEATHERED QUARTZ MONZONITE**
VARIABLY WEATHERED, BREAKS DOWN TO A SAND/GRAVEL MIXTURE WITH VARYING PROPORTIONS OF SAND, GRAVEL AND FINES, GENERALLY DRILLABLE WITH HOLLOW STEM AUGER DRILL RIG

**QUARTZ MONZONITE**
RELATIVELY COMPETENT, GENERALLY NOT DRILLABLE WITH A HOLLOW-STEM AUGER DRILL RIG

EXISTING GROUND SURFACE

GEOLOGIC CONTACT
(DASHED WHERE APPROXIMATE, QUERIED WHERE UNCERTAIN)

**HOLLOW-STEM AUGER DRILL HOLE**

TOP OF HOLE

DEPTH OF FIRST OBSERVED GROUNDWATER DURING DRILLING. ACTUAL GROUNDWATER LEVELS MAY BE HIGHER OR LOWER THAN SHOWN

DEPTH OF SPT REFUSAL (N>100)

BOTTOM OF HOLE (PRACTICAL AUGER REFUSAL)

ESTIMATED LIMIT OF EXCAVATABLE MATERIAL

0 15' 30'

NEWMONT

| | |
|---|---|
| PROJECT LOCATION | WELLPINIT, WASHINGTON |
| PROJECT | MIDNITE MINE |
| TITLE | WESTERN DRAINAGE GEOLOGIC SECTIONS |
| FIGURE 3 | REVISION 0 |
| FILE NAME 1011322 AGWIS | DATE AUG 2014 |

MWH

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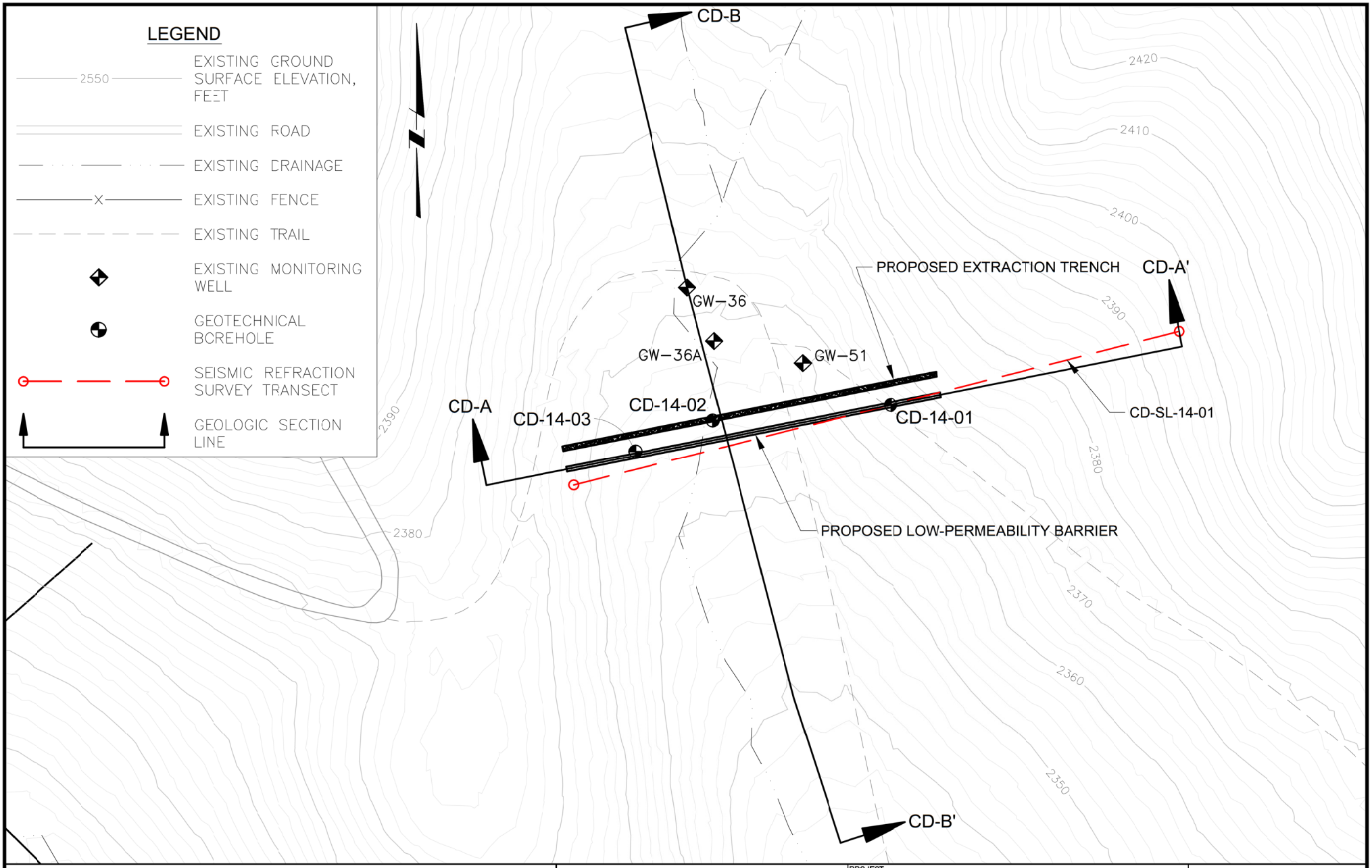



DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.

0 80' 160'

NEWMONT

PROJECT: MIDNITE MINE

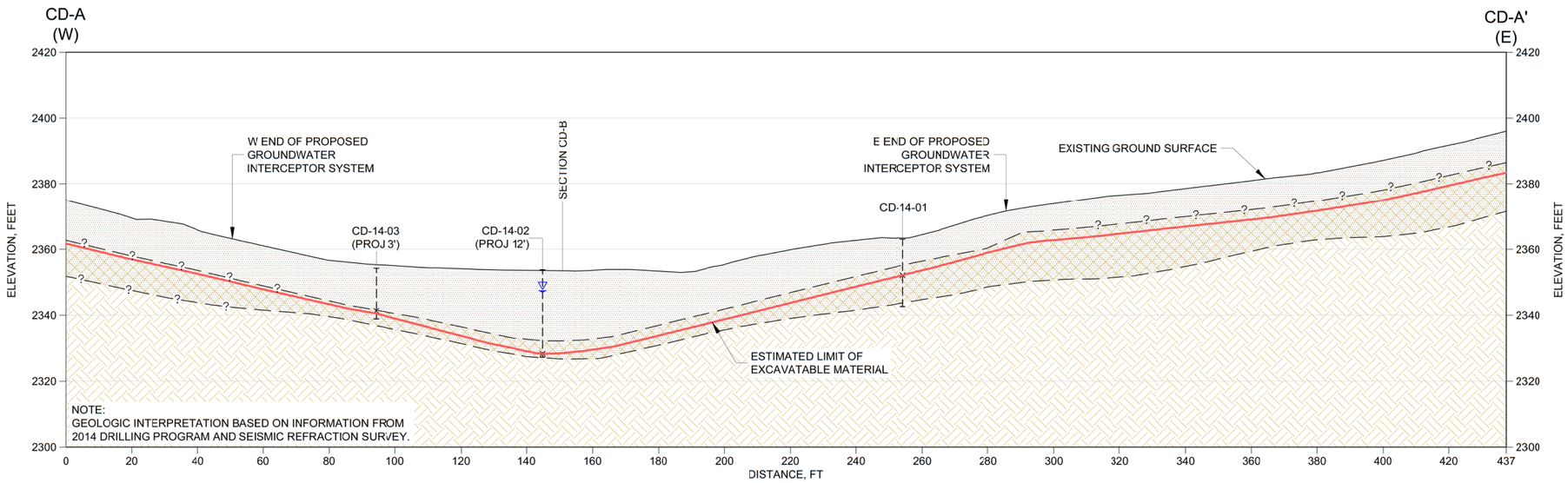
TITLE: CENTRAL DRAINAGE ALLUVIAL GROUNDWATER INTERCEPTOR SYSTEM AREA

MWH

DATE: AUG 2014

FIGURE 4

FILE NAME: 1011322 AGWIS




GEOLOGIC SECTION CD-A
(LOOKING NW)

## LEGEND

**OVERBURDEN**
UNCONSOLIDATED ALLUVIUM, COLLUVIUM, AND RESIDUAL SOIL WITH VARYING AMOUNTS OF SAND, GRAVEL AND FINES, CAN BE READILY DRILLED WITH HOLLOW STEM AUGER DRILL RIG

**WEATHERED QUARTZ MONZONITE**
VARIABLY WEATHERED, BREAKS DOWN TO A SAND/GRAVEL MIXTURE WITH VARYING PROPORTIONS OF SAND, GRAVEL AND FINES, GENERALLY DRILLABLE WITH HOLLOW STEM AUGER DRILL RIG

**QUARTZ MONZONITE**
RELATIVELY COMPETENT, GENERALLY NOT DRILLABLE WITH A HOLLOW-STEM AUGER DRILL RIG

EXISTING GROUND SURFACE

GEOLOGIC CONTACT
(DASHED WHERE APPROXIMATE, QUERIED WHERE UNCERTAIN)

**HOLLOW-STEM AUGER DRILL HOLE**

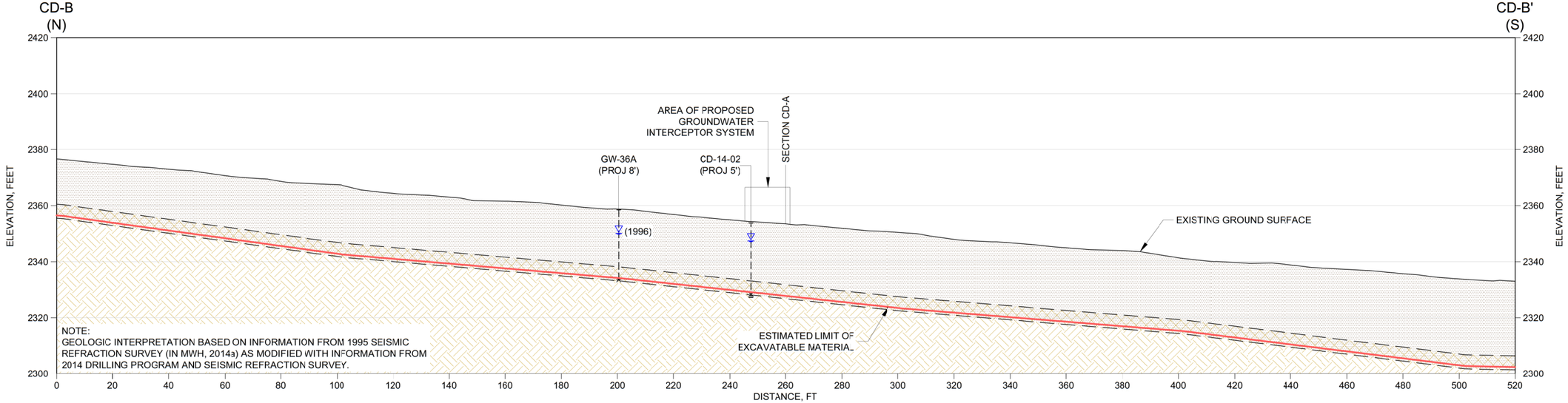
TOP OF HOLE

DEPTH OF FIRST OBSERVED GROUNDWATER DURING DRILLING. ACTUAL GROUNDWATER LEVELS MAY BE HIGHER OR LOWER THAN SHOWN

DEPTH OF SPT REFUSAL (N>100)

BOTTOM OF HOLE (PRACTICAL AUGER REFUSAL)

ESTIMATED LIMIT OF EXCAVATABLE MATERIAL




GEOLOGIC SECTION CD-B
(LOOKING NE)

0 20' 40'

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: CENTRAL DRAINAGE GEOLOGIC SECTIONS

MWH

FIGURE 5

REVISION 0

FILE NAME 1011322 AGWIS

DATE AUG 2014

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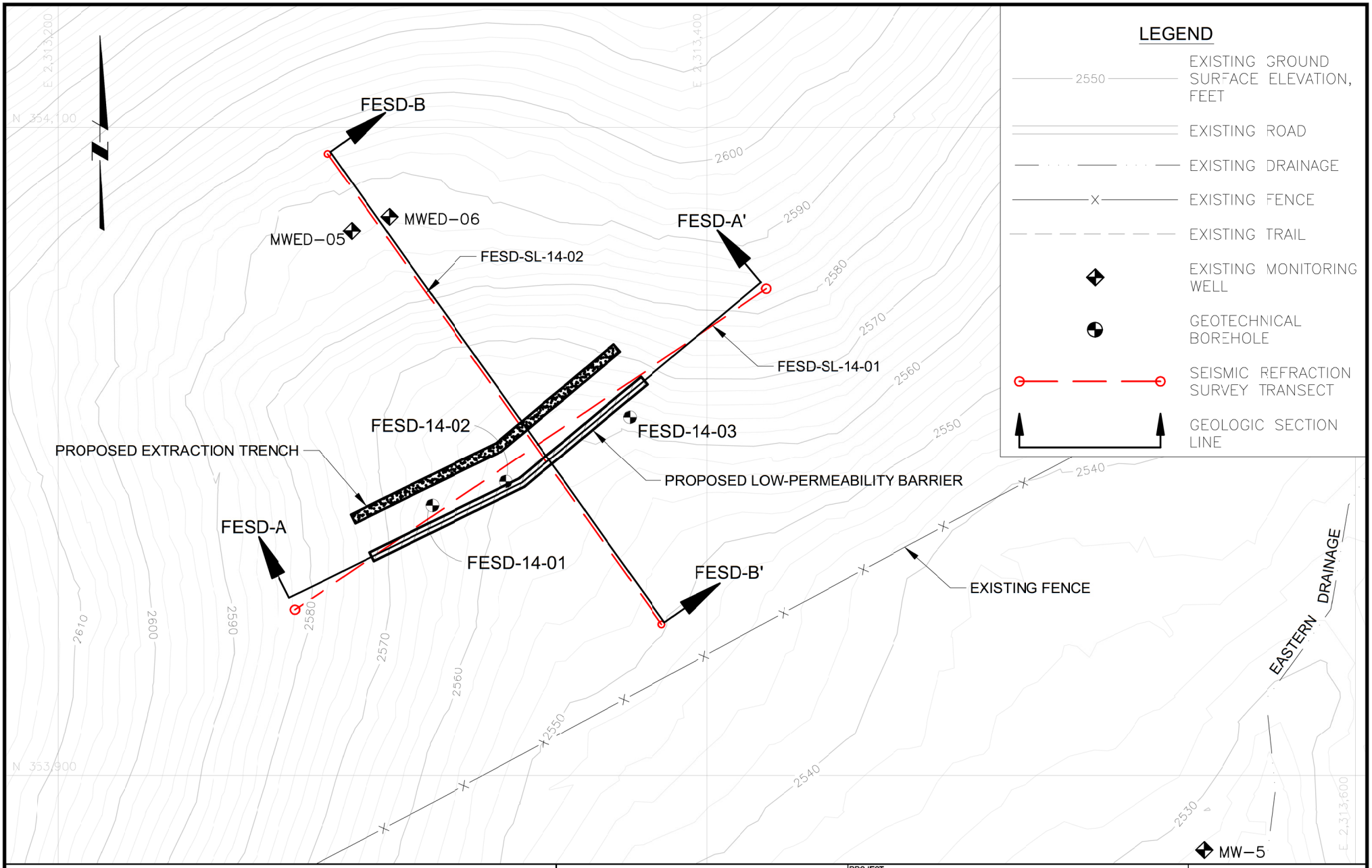



DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.

0 40' 80'

NEWMONT

PROJECT: MIDNITE MINE

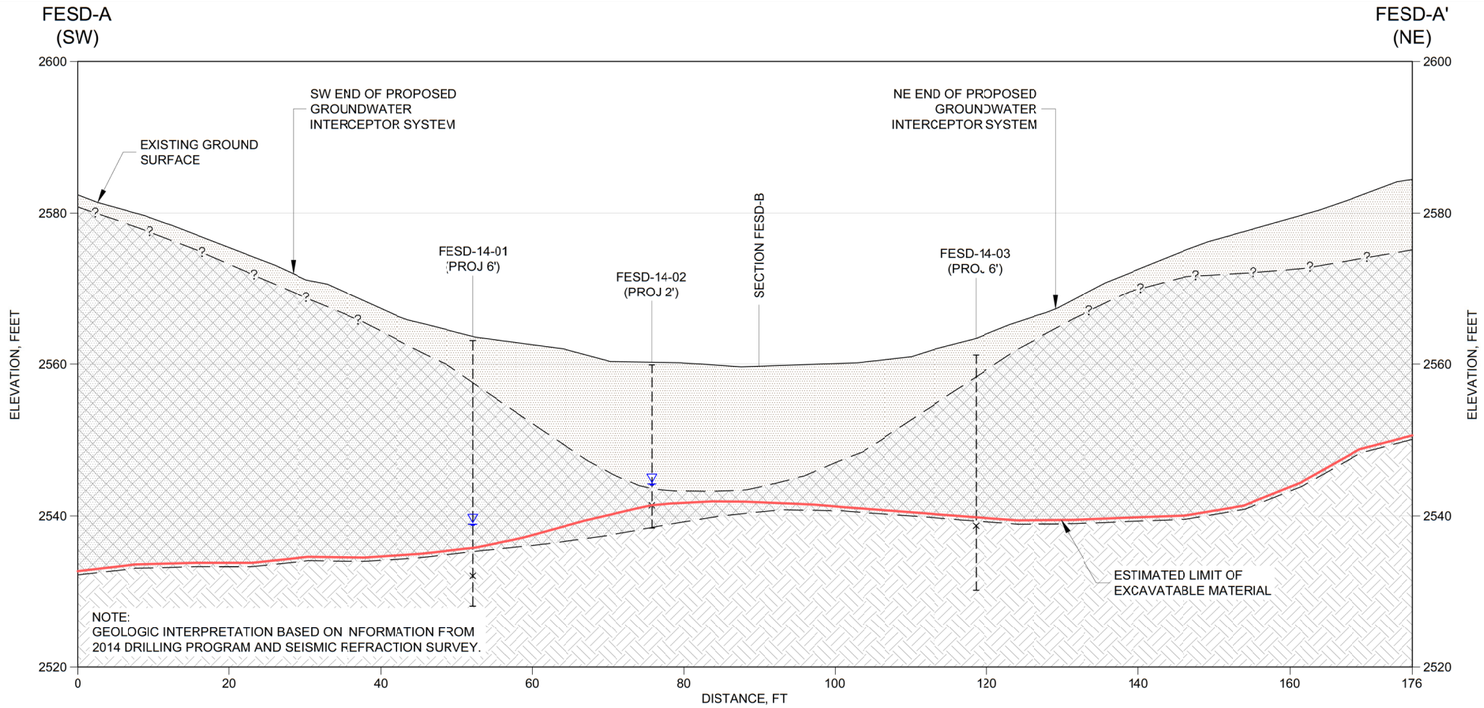
TITLE: FAR EAST SEEP DRAINAGE ALLUVIAL GROUNDWATER INTERCEPTOR SYSTEM AREA

MWH

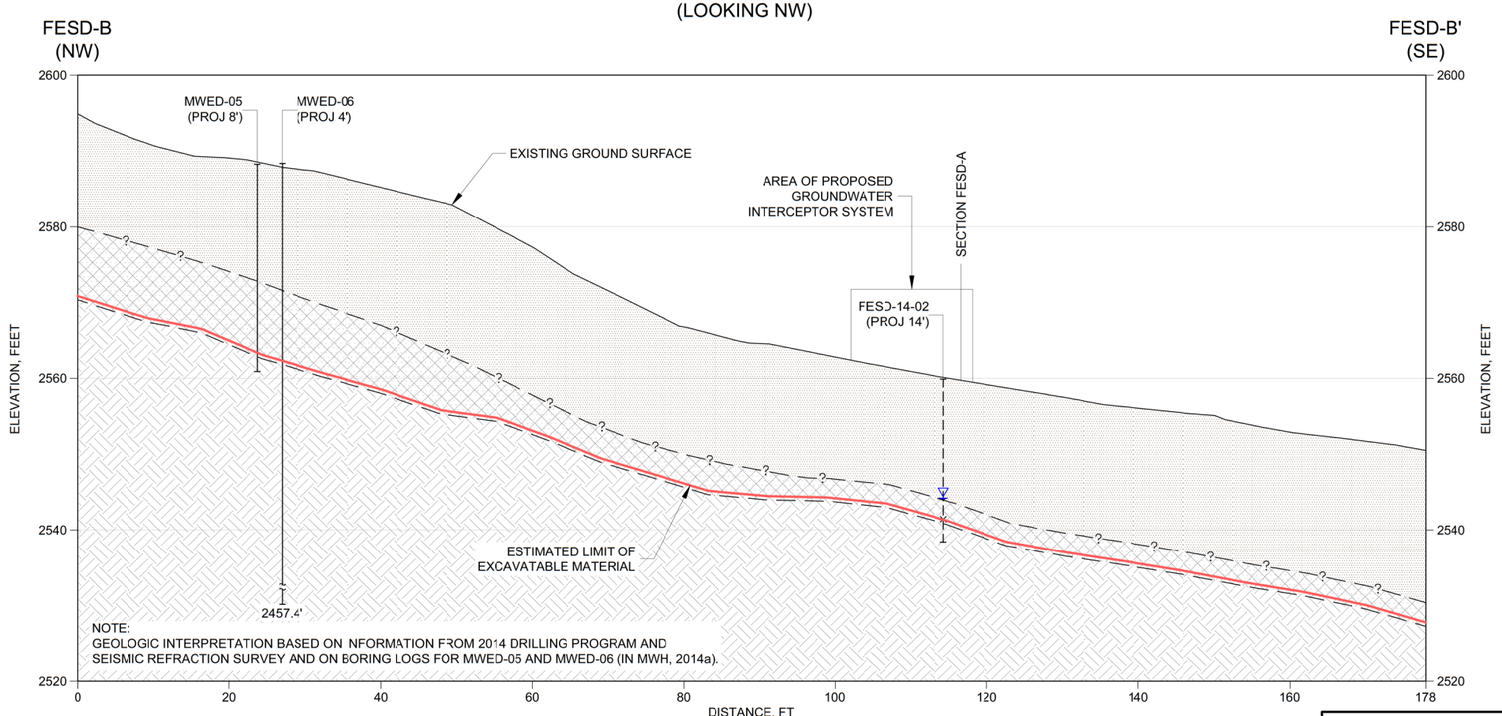
DATE: AUG 2014

FIGURE 6

FILE NAME: 1011322 AGWIS




GEOLOGIC SECTION FESD-A
(LOOKING NW)




GEOLOGIC SECTION FESD-B
(LOOKING NE)

## LEGEND

**OVERBURDEN**
UNCONSOLIDATED ALLUVIUM, COLLUVIUM, AND RESIDUAL SOIL WITH VARYING PROPORTIONS OF SAND, GRAVEL AND FINES, CAN BE READILY DRILLED WITH A HOLLOW STEM AUGER DRILL RIG

**WEATHERED META-SEDIMENTARY BEDROCK**
VARIABLY WEATHERED META-SEDIMENTARY ROCK OF THE TOGO FORMATION WHICH INCLUDES PHYLLITE, MARBLE, CALC-SILICATE HORNFELS AND QUARTZITE, GENERALLY BREAKS DOWN TO SAND TO CLAYEY SAND WITH VARYING PROPORTIONS OF SAND, GRAVEL AND FINES, GENERALLY DRILLABLE WITH A HOLLOW STEM AUGER DRILL RIG

**META-SEDIMENTARY BEDROCK**
RELATIVELY COMPETENT BEDROCK OF THE TOGO FORMATION, GENERALLY NOT DRILLABLE WITH A HOLLOW STEM AUGER DRILL RIG

EXISTING GROUND SURFACE

GEOLOGIC CONTACT
(DASHED WHERE APPROXIMATE, QUERIED WHERE UNCERTAIN)

**HOLLOW-STEM AUGER DRILL HOLE**

TOP OF HOLE

DEPTH OF FIRST OBSERVED GROUNDWATER DURING DRILLING. ACTUAL GROUNDWATER LEVELS MAY BE HIGHER OR LOWER THAN SHOWN

DEPTH OF SPT REFUSAL (N>100)

BOTTOM OF HOLE (PRACTICAL AUGER REFUSAL)

**AIR ROTARY DRILL HOLE**

TOP OF HOLE

BOTTOM OF HOLE

ESTIMATED LIMIT OF EXCAVATABLE MATERIAL

0 10' 20'

NEWMONT

| | |
|---|---|
| PROJECT LOCATION | WELLPINIT, WASHINGTON |
| PROJECT | MIDNITE MINE |
| TITLE | FAR EAST SEEP DRAINAGE GEOLOGIC SECTIONS |
| FIGURE 7 | REVISION 0 |
| FILE NAME 1011322 AGWIS | DATE AUG 2014 |

MWH

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# APPENDIX A

# BOREHOLE LOGS AND PHOTOGRAPHS

# WESTERN DRAINAGE

# BOREHOLE LOGS AND PHOTOGRAPHS

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. WD-14-01 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,390.6 | INCLIN./H: VERTICAL | START DATE: 7/21/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,413.3 | CASING DEPTH: N.A. | FINISH DATE: 7/22/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2341.5 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 28.5 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - 7.8') SANDY CLAY - Slightly moist, light yellowish brown, very stiff sandy clay, low plasticity, sand is very fine to fine-grained, sub-rounded, trace medium to coarse sand | |
| | | 2.5' | SS | 6 8 8 | 17" | | | |
| 5 | | 5' | SS | 8 9 8 | 18" | | | |
| | | 7.5' | SS | 6 10 11 | 18" | | (7.8-11.2') SAND WITH CLAY - Slightly moist, light yellowish brown, medium dense, very fine to fine sand with low plasticity clay, trace to few sub-angular coarse sand and gravel to 1/4" | |
| 10 | | 10' | SS | 6 8 11 | 18" | | | |
| | | 12.5' | SS | 6 6 4 | 18" | | (11.2 - 18.1') SAND WITH CLAY - Moist, yellowish brown medium dense, fine to coarse, angular to sub-rounded sand with low plasticity clay, few angular gravel to 1/4" size<br>(13.5') Becomes very moist | Increased drilling resistance @ 11.5' |
| 15 | | 15' | SS | 3 3 2 | 18" | | (15.7-16.3') Zone of very fine to fine sand (no coarse sand or gravel)<br>(16.3 - 18.1') Same as above (11.2-18.1) but more angular gravel (little) up to 3/4" size | More difficult drilling @ 17.0' |
| | | 17.5' | SS | 12 16 18 | 15" | | (18.1 - E.O.B.) WEATHERED QUARTZ MONZONITE - Very moist to wet, very dense, mottled orange and pale yellowish gray with black flecks, material disintegrates (with effort) to fine to coarse angular sand with trace to few fines and few to little angular gravel to ~ 3/4" size | $\nabla$ $H_2O$ @ 19.2' bgs @ 9:15<br>Sampler is wet (20' SS drive), and all SS samplers to E.O.B. |
| 20 | | 20' | SS | 14 22 30 | 14" | | | |
| | | 22.5' | SS | 39 50/4.5" | 11" | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

L:\Design-Drafting\Clients-1-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2014-08-08 GEOTECH LOGS\1011322 GEO LOGS

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. WD-14-01 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 2 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,390.6 | INCLIN./H: VERTICAL | START DATE: 7/21/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,413.3 | CASING DEPTH: N.A. | FINISH DATE: 7/22/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2341.5 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 28.5 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | 25' | SS | 31<br>50/5" | 11" | | | |
| | | 27.5' | SS | 50/2" | 2" | | | |
| | | | | | | | E.O.B. = 28.5'<br>Practical auger refusal at 10:30 a.m. Very slow, difficult drilling, rig lifting. | |
| 30 | | | | | | | | |
| 35 | | | | | | | | |
| 40 | | | | | | | | |
| 45 | | | | | | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

L:\Design-Drafting\Clients-1-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2014-08-08 GEOTECH LOGS\1011322 GEO LOGS

WD-14-01 Before Drilling
7/21/14

WD-14-01 SPT Sample at 2.5'
7/21/14

WD-14-01 SPT Sample at 5'
7/21/14

WD-14-01 SPT Sample at 7.5'
7/21/14

WD-14-01 SPT Sample at 10'
7/22/14

WD-14-01 SPT Sample at 12.5'
7/22/14

WD-14-01 SPT Sample at 15'
7/22/14

WD-14-01 SPT Sample at 17.5'
7/22/14

WD-14-01 SPT Sample at 20'
7/22/14

WD-14-01 Sample at 22.5'
7/22/14

WD-14-01 SPT Sample at 25'
7/22/14

WD-14-01 SPT Sample at 27.5'
7/22/14

WD-14-01 After Drilling
7/22/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. WD-14-02 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 1 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,330.4 | INCLIN./H: VERTICAL | START DATE: 7/21/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,361.2 | CASING DEPTH: N.A. | FINISH DATE: 7/21/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2330.1 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 14.7 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - 3.2') SANDY CLAY - Slightly moist, yellowish brown, soft, sandy low plasticity clay, sand is very fine to fine grained, trace sub-angular coarse sand and very fine gravel to 1/4" | |
| | | 2.5-3.2' 3.2-4' | SS | 4 10 10 | 18" | | | 2 samples retained |
| | | | | | | | (3.2-5.0') GRAVELLY SAND - Slightly moist, medium dense, yellowish brown, fine to coarse sub-angular to sub-rounded sand with some gravel (sub-angular to sub-rounded) to 1.5" or larger, trace fines | |
| 5 | | 5' | SS | 2 2 3 | 10" | | | ▽ $H_2O$ @ 5.2' bgs @ 15:55 in open hole |
| | | | | | | | (5.0 - 8.3') CLAYEY SAND WITH GRAVEL - Very moist to wet, loose to medium dense, yellowish brown, clayey fine to coarse sub-rounded to sub-angular sand with gravel (sub-angular) up to ~ 1" size | |
| | | 7.5' | SS | 4 3 10 | 17" | | | |
| | | | | | | | (8.3 - ~8.8') CLAY - Very moist to wet, firm, pale yellowish gray/brown, low plasticity clay, little fine to coarse sub-angular sand | @ 9' - slow drilling |
| 10 | | 10' | SS | 39 50/3" | 6" | | | |
| | | | | | | | (~8.8-E.O.B.) WEATHERED QUARTZ MONZONITE - Very moist to wet, mottled orange, yellowish gray and black, very dense, material breaks down to fine to coarse angular sand with few gravel to ~1/4", trace to few fines | |
| | | 12.5' | SS | 50/ 2.5" | 2" | | | |
| 15 | | - | SS | 50/ 2.5" | 2" | | E.O.B. = 14.7'<br>Practical auger refusal at 14.5'. Rig bouncing and grinding (about 30 min to drill from 12.5 to 14.5'). Drill to 14.5', drive sampler to 14.7'. | No sample retained from 14.5' SS drive |
| 20 | | | | | | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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WD-14-02 Before Drilling
7/21/14

WD-14-02 SPT Sample at 2.5'
7/21/14

WD-14-02 SPT Sample at 5'
7/21/14

WD-14-02 SPT Sample at 7.5'
7/21/14

WD-14-02 SPT Sample at 10'
7/21/14

WD-14-02 SPT Sample at 12.5'
7/21/14

WD-14-02 After Drilling
7/24/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. WD-14-03 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 1 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,301.0 | INCLIN./H: VERTICAL | START DATE: 7/21/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,325.0 | CASING DEPTH: N.A. | FINISH DATE: 7/21/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2331.2 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 12.8 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - 8.0') SANDY CLAY - Very moist, dark yellowish brown to brown, soft sandy low plasticity clay, sand is very fine to fine grained, trace sub-angular coarse sand to gravel to ~3/4" size | |
| | | 2.5' | SS | 0 0 2 | 10" | | | Few cuttings coming up - too soft |
| 5 | | | | | | | @ ~5' Becomes very moist to wet | ▽ $H_2O$ @ 5.2' bgs @ 12:43 |
| | | 5' | SS | 1 1 2 | 14" | | | |
| | | 7.5' | SS | 4 6 9 | 18" | | (8.0 - 11.2') CLAYEY SAND WITH GRAVEL - Wet, yellowish brown, medium dense, clayey fine to coarse sub-angular sand with gravel to ~1" size, more gravel with depth | @ 8' - rougher drilling |
| 10 | | 10' | SS | 6 19 50/5" | 14.5" | | | |
| | | 12' | SS | 39/ 50/ 3" | 10" | | (11.2' - E.O.B.) WEATHERED QUARTZ MONZONITE- Wet, mottled orange, pale yellowish gray and black, very dense, breaks down to fine to coarse angular sand with trace gravel to ~3/4", few fines | |
| 15 | | | | | | | E.O.B. = 12.8'<br>Practical auger refusal at 12.0' @ 12:35. Very slow and difficult advancement. Drill to 12.0', drive sampler to 12.8'. | |
| 20 | | | | | | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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WD-14-03 Before Drilling
7/21/14

WD-14-03 Auger Drilling
7/21/14

WD-14-03 SPT Sample at 2.5'
7/21/14

WD-14-03 SPT Sample at 5'
7/21/14

WD-14-03 SPT Sample at 7.5'
7/21/14

WD-14-03 SPT Sample at 10'
7/21/14

WD-14-03 SPT Sample at 12'
7/21/14

WD-14-03 Backfilling with Bentonite
7/21/14

WD-14-03 After Drilling
7/24/14

# CENTRAL DRAINAGE

# BOREHOLE LOGS AND PHOTOGRAPHS

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. CD-14-01 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 1 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,527.6 | INCLIN./H: VERTICAL | START DATE: 7/22/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,965.3 | CASING DEPTH: N.A. | FINISH DATE: 7/23/14 |
| DRILLER'S HELPER: PERRY, CHRIS AND JOE | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2363.1 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 20.5 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | 2.5' | SS | 5 4 4 | 17" | | (0 - ~8.0') SAND - Slightly moist, light yellowish brown, loose to medium dense, fine to coarse sub-angular sand, few low plasticity fines, few sub-angular gravel to ~1/2" size | |
| 5 | | 5' | SS | 5 6 6 | 15" | | | |
| | | 7.5' | SS | 5 10 13 | 13" | | (~8.0 - E.O.B.) WEATHERED QUARTZ MONZONITE - Slightly moist, pale yellowish gray, orange and black, breaks down easily to fine to coarse angular sand with trace gravel up to ~3/4" size, trace to few fines | |
| 10 | | 10' | SS | 25 43 50/6" | 18" | | | |
| | | 12.5' | SS | 50/ 5.5" | 8" | | | |
| 15 | | 15' | SS | 52/ 6" | 6" | | | |
| | | - | SS | 50/ 2" | 0" | | | |
| 20 | | - | SS | 50/ 2" | 0" | | E.O.B. = 20.5'<br>Practical auger refusal at 20.5'. No advancement after ~20 minutes of drilling. Water added with no improvement.<br><br>[No free water in the hole.] | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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CD-14-01 Before Drilling
7/22/14

CD-14-01 SPT Sample at 2.5'
7/22/14

CD-14-01 SPT Sample at 5'
7/22/14

CD-14-01 SPT Sample at 7.5'
7/22/14

CD-14-01 SPT Sample at 10'
7/22/14

CD-14-01 SPT Sample at 12.5'
7/22/14

CD-14-01 SPT Sample at 15'
7/23/14

CD-14-01 After Drilling
7/24/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. CD-14-02 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,518.0 | INCLIN./H: VERTICAL | START DATE: 7/22/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,855.6 | CASING DEPTH: N.A. | FINISH DATE: 7/22/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2353.8 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 26.5 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - ~12.5') SANDY CLAY - Very moist to ~5.5', then wet, dark yellowish brown, very soft, sandy low plasticity clay, very fine to fine sand, trace to few sub-angular coarse sand and gravel up to 3/4" size | |
| | | 2.5' | SS | 0 | 16" | | | |
| 5 | | 5' | SS | 1<br>2<br>2 | 18" | | | ▽ $H_2O$ @ 6.0' bgs @ 14:19 |
| | | 7.5' | SS | 1/18" | 18" | | @ 7.5' - 2" Zone of clayey fine to coarse sand | Sampler and sample wet (and every one to E.O.B.) |
| 10 | | 10' | SS | 0<br>3<br>1 | 18" | | (~11 - 11.5') Zone of sandy clay as above with no coarse sand or gravel | |
| | | 12.5' | SS | 0<br>0<br>1 | 18" | | (~12.5 - ~16') CLAY WITH SAND - Wet, very soft, gray, low plasticity clay with very fine to fine sand, trace coarse sand, sub-angular to sub-rounded, occasional 2-4" zones of fine to coarse sand with trace to few fines | |
| 15 | | 15' | SS | 0 | 18" | | | |
| | | 17.5' | SS | 0 | 18" | | (~16 - ~22') SAND WITH CLAY - Wet, very loose, gray, very fine to medium sand with few to little low plasticity fines, trace to few sub-angular coarse sand to gravel up to ~3/8" size | |
| 20 | | 20' | SS | 0 | 18" | | | |
| | | 22.5' | SS | 5<br>10<br>11 | 18" | | (~22' - E.O.B.) WEATHERED QUARTZ MONZONITE - Wet, very dense, yellowish green, orange and black, disintegrates to fine to coarse angular sand with trace to few fines and few angular gravel to ~1/4" size | Retained bottom 4" of sample |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. CD-14-02 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 2 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,518.0 | INCLIN./H: VERTICAL | START DATE: 7/22/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,855.6 | CASING DEPTH: N.A. | FINISH DATE: 7/22/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2353.8 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 26.5 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | 25' | SS | 17<br>50/<br>3.5" | 6" | | | |
| | | | | | | | E.O.B. = 26.5'<br>At 26.5', no auger advancement, rig lifting, practical auger refusal. | |
| 30 | | | | | | | | |
| 5 | | | | | | | | |
| 40 | | | | | | | | |
| 45 | | | | | | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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CD-14-02 Before Drilling
7/22/14

CD-14-02 SPT Sample at 2.5'
7/22/14

CD-14-02 SPT Sample at 5'
7/22/14

CD-14-02 SPT Sample at 7.5'
7/22/14

CD-14-02 SPT Sample at 10'
7/22/14

CD-14-02 SPT Sample at 12.5'
7/21/14

CD-14-02 SPT Sample at 15'
7/22/14

CD-14-02 SPT Sample at 17.5'
7/22/14

CD-14-02 SPT Sample at 20'
7/22/14

CD-14-02 SPT Sample at 22.5'
7/22/14

CD-14-02 SPT Sample at 25'
7/22/14

CD-14-02 After Drilling
7/24/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. CD-14-03 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 1 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 351,498.8 | INCLIN./H: VERTICAL | START DATE: 7/22/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,311,807.9 | CASING DEPTH: N.A. | FINISH DATE: 7/22/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2354.3 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 15.4 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - 12.5') SANDY CLAY - Slightly moist to ~7.5', moist to 12.5', medium stiff to stiff, sandy low plasticity clay, sand is very fine to fine-grained, trace to few sub-angular coarse sand and very fine gravel to ~1/4" size, occasional roots and organic material | |
| | | 2.5' | SS | 8 7 7 | 18" | | | |
| 5 | | 5' | SS | 5 2 3 | 18" | | | |
| | | 7.5' | SS | 3 4 6 | 18" | | (7.5 - 12.5') Same as above, but sand is coarser (fine to medium, sub-angular) with more coarse sand (few to little), trace gravel to ~1/4" | Poor recovery due to rock in sampler shoe |
| 10 | | 10' | SS | 10 13 9 | 7" | | | |
| | | 12.5' | SS | 33 50/ 2.5" | 9" | | (12.5 - E.O.B.) WEATHERED QUARTZ MONZONITE - Moist, very dense, mottled orange and pale yellowish gray with occasional black flecks, disintegrates easily to fine to coarse angular sand with trace to few fines and trace angular gravel to 3/4" | |
| 15 | | 15' | SS | 50/ 4.5" | 3" | | E.O.B. = 15.4'<br>Practical auger refusal @ 12:50. Auger is seizing and lifting rig. | |
| 20 | | | | | | | [No free water observed] | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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CD-14-03 Before Drilling
7/22/14

CD-14-03 SPT Sample at 2.5'
7/22/14

CD-14-03 SPT Sample at 5'
7/22/14

CD-14-03 SPT Sample at 7.5'
7/22/14

CD-14-03 SPT Sample at 10'
7/22/14

CD-14-03 SPT Sample at 12.5'
7/22/14

CD-14-03 SPT Sample at 15'
7/22/14

CD-14-03 After Drilling
7/22/14

# FAR EAST SEEP DRAINAGE

# BOREHOLE LOGS AND PHOTOGRAPHS

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. FESD-14-01 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 353,983.3 | INCLIN./H: VERTICAL | START DATE: 7/25/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,313,315.4 | CASING DEPTH: N.A. | FINISH DATE: 7/25/14 |
| DRILLER'S HELPER: PERRY AND JOE | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2563.1 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 35.0 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | - | SS | 11 20 25 | 2" | | (0 - ~5') SANDY CLAY - Slightly moist, medium stiff to stiff, dark yellowish brown, sandy low plasticity clay, sand is very fine to coarse, sub-rounded, abundant roots and organic debris, occasional gravel and cobble-sized material, a few boulders may also be present (some observed on ground surface) | Poor recovery from 2.5' SS drive due to rock in shoe |
| 5 | | 5' | SS | 11 18 43 | 18" | | (~5 - ~12') WEATHERED META-SEDIMENTARY BEDROCK (PHYLLITE?) - Slightly moist, very dense, mostly very dark greenish gray with abundant orange and yellow staining on fractures, breaks down with minimal hand effort to clayey very fine to fine sand with trace coarse sand | |
| | | 7.5' | SS | 24 21 28 | 16" | | | |
| 10 | | 10' | SS | 18 25 34 | 16" | | | |
| | | 12.5' | SS | 6 7 6 | 18" | | (~12-E.O.B.) VERY WEATHERED META-SEDIMENTARY BEDROCK (CALC-SILICATE?) - Moist, pale greenish yellow and gray with abundant brown and reddish orange staining and black flecks, breaks down with minimal hand effort to clayey very fine to fine sand with few coarse sand and gravel to ~3/4" size | ~12' Easier drilling |
| 15 | | 15' | SS | 3 5 5 | 18" | | | |
| | | 17.5' | SS | 4 11 7 | 15" | | (~17.5') Material becomes very moist. | ~17' Slightly harder drilling |
| 20 | | 20' | SS | 12 8 14 | 16" | | | |
| | | 22.5' | SS | 8 17 19 | 18" | | (~22.5') Some zones of nearly complete weathering to clay were observed, strong brown in color<br>(~24.0' - E.O.B.) Material alternates between very moist and wet. | Water observed in tip of sampler at ~24' |

NOTES:

- SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
- Hole backfilled with bentonite chip hole plug.
- Drilled an initial hole with auger refusal at 4' on a large boulder. Moved ~3' NE and drilled final hole.

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| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. FESD-14-01 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 2 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 353,983.3 | INCLIN./H: VERTICAL | START DATE: 7/25/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,313,315.4 | CASING DEPTH: N.A. | FINISH DATE: 7/25/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2563.1 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 35.0 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | 25' | SS | 8<br>12<br>10 | 18" | | | More difficult drilling @ ~25'<br>Sampler is wet (25' SS drive), sample is very moist |
| | | | | | | | | |
| | | - | SS | 5<br>6<br>5 | 0" | | | Sampler is wet (27.5' SS drive), no sample recovery |
| | | | | | | | | |
| 30 | | 30' | SS | 6<br>18<br>50/3" | 16" | | (~31.0 - E.O.B.) Rock is more competent, color is pale greenish gray with less reddish orange and brown staining. | Sampler and sample is wet (30' SS drive)<br>Much more difficult drilling @ ~31' |
| | | | | | | | | |
| | | 32.5' | SS | 50/5" | 5" | | | Sampler is wet (32.5' SS drive), sample is very moist to wet |
| 35 | | | | | | | E.O.B. = 35.0'<br>Practical auger refusal at 35.0'. Rig is grinding and lifting on very hard material with no advancement. | |
| 40 | | | | | | | | |
| 45 | | | | | | | [Note: No free water observed in open hole immediately after drilling. This could be due to high formation clay content and smearing of borehole walls, and/or the presence of zone(s) of perched water below ~24'.] | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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FESD-14-01 Before Drilling
7/24/14

FESD-14-01 SPT Sample at 5'
7/25/14

FESD-14-01 SPT Sample at 7.5'
7/25/14

FESD-14-01 SPT Sample at 10'
7/25/14

FESD-14-01 SPT Sample at 12.5'
7/25/14

FESD-14-01 SPT Sample at 15'
7/25/14

FESD-14-01 SPT Sample at 17.5'
7/25/14

FESD-14-01 SPT Sample at 20'
7/25/14

FESD-14-01 SPT Sample at 22.5'
7/25/14

FESD-14-01 SPT Sample at 25'
7/25/14

FESD-14-01 SPT Sample at 30'
7/25/14

FESD-14-01 SPT Sample at 32.5'
7/25/14

FESD-14-01 After Drilling
7/25/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. FESD-14-02 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 1 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 353,990.7 | INCLIN./H: VERTICAL | START DATE: 7/25/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,313,338.1 | CASING DEPTH: N.A. | FINISH DATE: 7/25/14 |
| DRILLER'S HELPER: PERRY AND JOE | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2,559.9 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 35.0 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - ~16') CLAY - Slightly moist, dark yellowish brown, stiff to very stiff, few very fine to fine sand, trace sub-rounded coarse sand, abundant roots and organic material, a few cobble-size rocks may be present (noted by driller) | |
| | | 2.5' | SS | 6 8 8 | 12" | | | |
| 5 | | 5' | SS | 6 7 7 | 15" | | (~4 - ~7.5') Slightly more coarse sand (few) and few sub-angular gravel to 1/2" | |
| | | 7.5' | SS | 5 5 7 | 13" | | (~7.5) Becomes moist, less coarse sand (trace to few), no gravel | |
| 10 | | 10' | SS | 2 3 3 | 18" | | (~10') Becomes very moist, medium stiff to stiff | |
| | | 12.5' | SS | 3 4 6 | 18" | | (~13.2 - ~16') Slightly more sub-angular to sub-rounded coarse sand (few), few sub-angular gravel to ~1/2" | ~14' More difficult drilling |
| 15 | | 15' | SS | 6 11 35 | 18" | | (~15.5 - 16') Visible water observed in sample | ~16' Very hard, slow drilling |
| | | 17.5' | SS | 47 39 50/2" | 15" | | (~16-E.O.B.) WEATHERED META-SEDIMENTARY BEDROCK - Very moist to ~17.5', wet from ~17.5' - ~19', moist to very moist below ~19', very hard, brittle, pale greenish gray to ~17', very dark greenish gray below ~17', brown and reddish orange staining on fracture surfaces throughout, some sandy clay present below ~17' | Sampler and sample is wet (17.5' SS drive) |
| 20 | | 20' | SS | 50/ 2.5" | 2.5" | | E.O.B. = 21.5'<br>Practical auger refusal at 21.5'. Rig is grinding and lifting with no advancement. | Sampler and sample is not wet (20' SS drive)<br><br>[Note: Water measured at 19.0' in open augers after 17.5' drive.] |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

L:\Design-Drafting\Clients-1-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2014-08-08 GEOTECH LOGS\1011322 GEO LOGS

FESD-14-02 Before Drilling
7/24/14

FESD-14-02 SPT Sample at 2.5'
7/25/14

FESD-14-02 SPT Sample at 5'
7/25/14

FESD-14-02 SPT Sample at 7.5'
7/25/14

FESD-14-02 SPT Sample at 10'
7/25/14

FESD-14-02 SPT Sample at 12.5'
7/25/14

FESD-14-02 SPT Sample at 15'
7/25/14

FESD-14-02 SPT Sample at 17.5'
7/25/14

FESD-14-02 SPT Sample at 20'
7/25/14

FESD-14-02 After Drilling
7/25/14

| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. FESD-14-03 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 1 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 354,010.6 | INCLIN./H: VERTICAL | START DATE: 7/24/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,313,376.3 | CASING DEPTH: N.A. | FINISH DATE: 7/25/14 |
| DRILLER'S HELPER: PERRY AND JOE | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2,561.2 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 31.0 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | (0 - ~5.3') SANDY CLAY - Slightly moist, medium stiff to stiff, dark yellowish brown, sandy, low plasticity clay, sand is very fine to coarse, sub-rounded, occasional cobble-sized material, abundant roots and organic debris | |
| | | - | SS | 7 10 11 | 0" | | | No recovery due to rock in tip of shoe. |
| 5 | | 5' | SS | 10 10 15 | 15" | | (~5.3 - ~7.5') WEATHERED META-SEDIMENTARY BEDROCK - Slightly moist, very hard and brittle, pale greenish gray with brown flecks, does not break down with hand effort | |
| | | 7.5' | SS | 6 9 9 | 13.5" | | (~7.5 - ~10') WEATHERED META-SEDIMENTARY BEDROCK - Moist, medium dense to dense, mostly pale greenish gray with some rusty orange and black flecks, breaks down with moderate hand effort to clayey very fine to medium sand with few to little angular to sub-angular coarse sand and gravel to ~1/2", some zones of more resistant material | |
| 10 | | - | SS | 13 20 24 | 0" | | | |
| | | 12.5' | SS | 31 36 50/4.5" | 12" | | (~10 - ~18.4') WEATHERED META-SEDIMENTARY BEDROCK - Moist, pale greenish gray, very hard and brittle, breaks down with great hand effort to very fine to fine sand with few fines | Much more difficult drilling @ 13.5' |
| 15 | | 15' | SS | 21 16 22 | 15" | | | Easier drilling @ 14.5' |
| | | 17.5' | SS | 10 16 13 | 18" | | (~18.4') Distinct color change at ~18.4' | |
| 20 | | 20' | SS | 8 10 13 | 16" | | (~18.4 - E.O.B.) WEATHERED META-SEDIMENTARY BEDROCK - Moist, medium dense, rusty reddish brown and black, breaks down easily to clayey sand/sandy clay, very low plasticity silt/ clay fines, sand is very fine to fine, trace to few angular coarse sand and gravel to ~3/4" | More difficult drilling @ ~21.5' |
| | | - | SS | 50/3" | 0" | | Material becomes increasingly dense and more resistant with depth. | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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| MWH | CLIENT: NEWMONT | SOIL BORING LOG | BOREHOLE No. FESD-14-03 |
|---|---|---|---|
| PROJ. No.: 1011322<br>PROJ. LOC.: WELLPINIT, WA | MIDNITE MINE - GEOTECH. INVESTIGATION, ALLUVIAL GW COLLECTION | | SHEET No. 2 of 2 |

| CONTRACTOR INFORMATION | DRILL RIG INFORMATION | | BOREHOLE INFORMATION | | |
|---|---|---|---|---|---|
| DRILLING COMPANY: BUDINGER AND ASSOC. | DRILLING RIG: TEI HEM | BIT TYPE: - | N. (FT): 354,010.6 | INCLIN./H: VERTICAL | START DATE: 7/24/14 |
| DRILLER: E. HAGEMAN | DRILLING METHOD: H.S.A. | AUGER I.D.: 3.25 IN. | E. (FT): 2,313,376.3 | CASING DEPTH: N.A. | FINISH DATE: 7/25/14 |
| DRILLER'S HELPER: PERRY AND CHRIS | HAMMER TYPE: AUTO. | AUGER O.D.: 6.5 IN. | ELEV (FT): 2,561.2 | AZIMUTH: N.A. | LOGGED BY: R SCHAUT |
| | HAMMER WT.: 140 LB. | CORE DIAM.: N/A | TOTAL DEPTH (FT): 31.0 | | |

| DEPTH (FT) | CORE RECOVERY | NUMBER | TYPE | BLOWS / 6" | RECOVERY | ADDITIONAL SAMPLES | DESCRIPTION | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | | 25' | SS | 16<br>39<br>50/3" | 12" | | | |
| | | | | | | | | |
| | | - | SS | 50/2" | 0" | | | |
| 30 | | - | SS | 50/2" | 0" | | | Much more difficult drilling @ 30.0' |
| | | | | | | | E.O.B. = 31.0'<br>Practical auger refusal @ 31.0'. Rig is grinding and lifting on very hard material with with no advancement | |
| 35 | | | | | | | [No free water observed.] | |
| 40 | | | | | | | | |
| 45 | | | | | | | | |

NOTES:
SS = 1.5" diameter split-spoon sampler. Bulk samples retained from sampler.
Hole backfilled with bentonite chip hole plug.

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FESD-14-03 Before Drilling
7/24/14

FESD-14-03 Setting Up Rig
7/24/14

FESD-14-03 SPT Sample at 5'
7/24/14

FESD-14-03 SPT Sample at 7.5'
7/24/14

FESD-14-03 SPT Sample at 12.5'
7/24/14

FESD-14-03 SPT Sample at 15'
7/24/14

FESD-14-03 SPT Sample at 17.5'
7/24/14

FESD-14-03 SPT Sample at 20'
7/24/14

FESD-14-03 SPT Sample at 25'
7/24/14

FESD-14-03 After Drilling
7/25/14

# APPENDIX B

# SEISMIC REFRACTION SURVEY REPORT

# SEISMIC REFRACTION SURVEY REPORT

## MIDNITE MINE - 2014 SURVEY
## STEVENS COUNTY, WASHINGTON

## ALLUVIAL GROUNDWATER COLLECTION SYSTEM
## GEOTECHNICAL INVESTIGATION

## FOR

## MWH AMERICAS, INC.
## FORT COLLINS, WASHINGTON

## SEPTEMBER 25, 2014

PHILIP H. DUOOS
GEOPHYSICAL CONSULTANT

Seismic Refraction Survey - 2014
Midnite Mine, Stevens Co., Washington
Alluvial Groundwater Collection System Geotechnical Investigation

Philip H. Duoos, Geophysical Consultant
September 25, 2014

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## CENTRAL DRAINAGE AREA FIGURES

MAP 2 (Central Drainage Area Map)
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## FAR EAST SEEP DRAINAGE AREA FIGURES

MAP 2 (Far East Seep Drainage Area Map)
PROFILE FESD-SL-14-01
PROFILE FESD-SL-14-02

September 25, 2014 Our Ref: 1130-14

Mr. Tom Kelley
MWH AMERICAS, INC.
3665 JFK Parkway
Building 1, Suite 200
Fort Collins, CO 80525

**REPORT:** Seismic Refraction Survey - 2014
Midnite Mine, Stevens Co., Washington
Alluvial Groundwater Collection System Geotechnical Investigation

Dear Mr. Kelley:

This letter report contains the results of the geophysical investigation that we performed at the Midnite Mine site during the period of July 14 – 18, 2014. The purpose of the investigation was to determine the depth to rock using seismic refraction methods to assist in your Alluvial Groundwater Collection System Geotechnical Investigation. Specifically, to help in the design of barrier walls and extraction trenches in three of the drainages south of the mine (Western Drainage, Central Drainage and Far East Seep Drainage.) A brief description of the seismic refraction method is provided in Attachment A.

## SEISMIC INVESTIGATION

### Field Methodology

The seismic lines were established in the field and referenced to the GPS endpoints that were provided by MWH, and marked in the field by MWH employee Emily Yeager. The seismic lines were extended beyond the GPS locations in most cases to ensure sufficient coverage of the alignment. Seismic line CD-SL-14-01 was extended much farther to the east than was required. All of the seismic lines were within 15 feet of the proposed alignments, which is within the 20-foot tolerance required in the scope of work.

We used 300-foot tapes to measure the locations of the geophones along each line and a Brunton compass to obtain the orientation. The lines were referenced to the proposed borings as well. Each geophone location was marked with a wire pin flag, and wood stakes (with orange flagging and blue flagging) mark the endpoints of each line and some intermediate points along each line. The pin flag colors and geophone spacings for each line are as follows:

Western Drainage, Line WD-SL-14-01, red flags, 8-ft spacing, 280 ft long.
Central Drainage, Line CD-SL-14-01, yellow flags, 11-ft spacing, 385 ft long.
Far East Seep Drainage, Line FESD-SL-14-01, orange flags, 8-ft spacing, 184 ft long.
Far East Seep Drainage, Line FESD-SL-14-02, yellow flags, 8-ft spacing, 184 ft long.

**Philip H. Duoos**
**PH/FAX: (425) 882-2634, CELL: (425) 765-6316**
**13503 NE 78th Place, Redmond, Washington, 98052**
**Email: geopyg@aol.com**

The locations of the seismic lines are shown on the Seismic Refraction Survey Maps (Maps 1, 2 and 3) which you provided. The geophone locations surveyed by Benthin & Associates are indicated by an "X" and the pin flag number for each geophone.

Most of the geophone pin flag locations were located by the surveyors which provided a very accurate surface profile and location. The drilling operations disturbed some of the geophone pin flags near the borings and they were not surveyed. The elevations of those locations are approximated using our hand-level data. The surveyors also did not locate our geophone pin flags to the east of the proposed barrier in the Central Drainage, so these elevations are based on our hand-level data. The hand-level data are estimated to be accurate within +/- 0.5 feet of the actual relative changes.

The seismic field investigation was performed using a signal enhancement digital seismograph to record the data using 14 Hz frequency geophones. A 35-pound slide-hammer source was used to generate the seismic wave, typically at 40 to 80 foot intervals along each seismic spread depending on the length of the line. Five to seven hammer shot locations were located along each line, with shots located off each end of the lines as well.

Field analysis of the data was done using manual calculations to determine that the seismic energy was refracting from bedrock, and to determine the required distance of the off-end shots so that the bedrock surface could be imaged properly. Preliminary modeling of some of the data was performed in the evening as a check on the field data.

The basic geologic units were identified based on the interpreted compressional wave velocities (in feet/second), the site-specific information (borings and wells), and results from other seismic surveys I have performed. Their probable classification is indicated on the following table. Please note that metamorphic and granitic bedrock with velocities greater than about 10,000 feet per second are typically not rippable using a D-10 Ripper (Caterpillar Performance Handbook, 1996.)

**Seismic Velocity Classification**

| LAYER SYMBOL | SEISMIC VELOCITY (feet per second) | PROBABLE CLASSIFICATION |
|---|---|---|
| O1 | 1,000 - 1,400 | Unconsolidated soil; loose overburden, fill and alluvium |
| O2 | 2,200 - 3,200 | More consolidated soil and overburden, colluvium, residual soils, highly weathered rock, moist and/or larger materials at higher velocities. |
| O3 | 4,200 - 5,200 | More consolidated overburden with larger material (gravel, cobbles, boulders), water-saturated in some cases, and/or weathered rock. |
| BX | 10,500 – 13,600 | High velocity bedrock, typically not rippable. |

**Seismic Interpretation Results**

Following each map are the seismic profiles for that drainage. The profiles show the geophone locations along the ground surface, the calculated depth points below each geophone, and the interpreted interfaces (dashed lines). The locations and results from nearby borings and intersecting seismic lines are also shown. Please note that the profiles are not to scale. The geophone spacing of 8 or 11 feet measured in the field is along the ground surface. The processing software takes the sloping ground into account and provides the shorter horizontal distance between each geophone.

The seismic velocity profiles are based on my interpretation of the data using a commercially available software package (SIP Win by Rimrock Geophysics). This software requires significant input from the user regarding velocity layer assignments. In addition, hand analysis of the data was also performed which provides a better estimate on the layer velocities than the computer model provides. These manually derived velocities were then used in the computer model. Additionally, hand-calculated depths using the manual data plots were used in numerous locations to confirm the computer modeling results.

These results were provided to you in digital format (Excel files) on September 19. The files include the seismic profiles as well as the data used to create the profiles. The data include the geophone number, horizontal spacing between geophones, ground surface elevation and the surveyor's information if available, and the velocity layer elevations and depths.

**Summary**

The use of the seismic refraction method at the three drainage areas provided a relatively rapid and detailed means of determining the subsurface conditions. The interpreted results correlate fairly well with the information in each drainage (borings and intersecting seismic lines), which seems to indicate that the interpretation models are fairly accurate. While the accuracy of the seismic interpretation depends on site-specific conditions, geophysical methods in general provide an accuracy of +/- 10% under good conditions. The data recorded from the site were typically of good quality due to the lack of wind noise and quiet conditions (no vehicle noise, etc.). Extreme changes in surface topography or inclination of subsurface interfaces will affect the accuracy.

As with any geophysical technique, these seismic results are interpretive in nature and represent the best estimate of subsurface conditions considering the limitations of the geophysical method employed. Only direct observations using borings or other means can ultimately characterize subsurface conditions, using the geophysical results as a guide. Review of this information by someone familiar with the geology of the area may also provide additional insight into the seismic results.

Please feel free to contact me if you have any questions or comments regarding this information, or if you require further assistance. I appreciated the opportunity to work with you on this project and look forward to providing you with geophysical services in the future.

Sincerely,

State of Washington
561
Licensed Geologist
Philip H. Duoos

Philip H. Duoos
Geophysical Consultant

**ATTACHMENT A**

# SEISMIC REFRACTION METHODOLOGY

## Overview

The seismic refraction method is used to evaluate numerous subsurface conditions; including depth to and strength (rippability) of rock, depth to water, and general subsurface stratigraphy.

The seismic refraction method uses an induced shock wave. As the shock wave propagates through the earth, it is affected by the materials through which it passes. Geophones placed on the ground surface record the ground motion caused by the resultant wave. A seismograph measures the time required for the resultant wave to arrive at each geophone. These geophones are located at selected distances from the wave source. Analysis of the data (travel times and distances) provides seismic velocities of subsurface material and depths to significant velocity interfaces.

Geologic conditions yielding higher seismic velocities include increased amounts of water, clay, cobbles, and rock fragments, greater compaction of overburden materials, and greater competency of rock. Several factors can affect the effectiveness of the seismic method including the proximity of cultural interferences (such as powerlines and traffic noise), surface conditions (such as loose soil), the size and depth of the target, and the seismic wave velocity contrast between stratigraphic units. Seismic velocities must increase with depth for a reliable interpretation of the data.

## Calculations

The description of the travel of seismic refraction waves through the earth uses the same equation that describes the refraction of light: Snell's Law. The following is a brief summary of the basic theory for a simple two-layer geologic model as discussed by Redpath (Redpath, 1973).

Snell's Law is stated as:

$$\frac{SIN\alpha}{SIN\beta} = \frac{V_1}{V_2}$$

and at the critical angle of incidence for a refracted seismic wave ($\beta$=90°), it becomes:

$$SIN\alpha = \frac{V_1}{V_2}$$

where $V_1$ and $V_2$ are the seismic wave velocities for the upper and lower layers, respectively.

The seismic refraction method measures the amount of time it takes the seismic energy to travel from the energy source to the geophones placed along the ground surface. The arrival time for the seismic wave at each geophone is plotted corresponding to the distance of the geophone from the energy source, creating a time-distance graph (Figure 1).

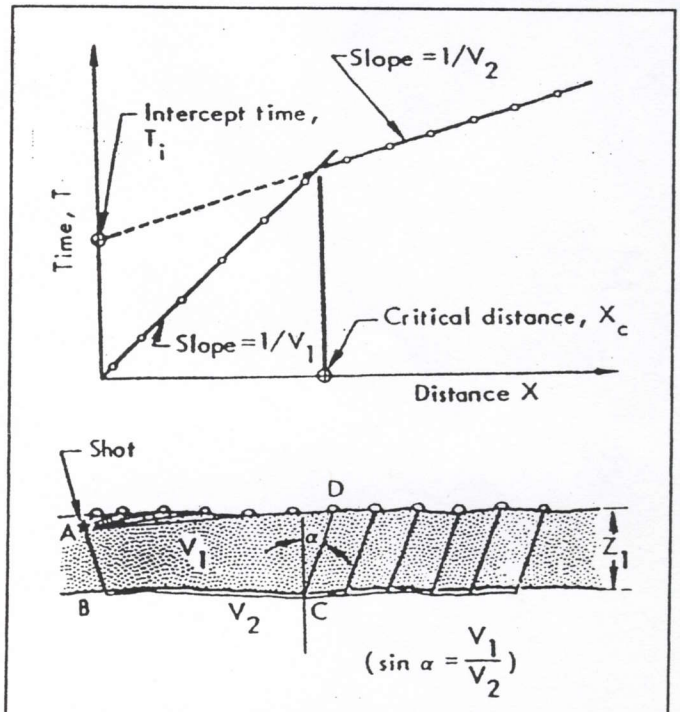


Figure 1: Two-layer geologic model and associated time-distance graph (Redpath, 1973).

The time required for the energy to reach the geophones near the source (direct wave arrivals) is based only on the seismic velocity of the energy traveling though the upper (low velocity) layer. At a certain distance from the source, called the critical distance, the first seismic waves to reach the

geophones will be those that have refracted from a deeper, higher velocity layer. Although these waves have traveled a greater distance than the direct waves, they have traveled at a greater velocity over most of their path, and thus arrive before the slower direct arrivals to the geophones farther from the source. Successively deeper layers with higher velocities affect the time-distance graph in a similar manner.

Using the time-distance graph, the velocities of the layers can be calculated (based on the slope of the arrival times), and the layer thicknesses can be calculated using the intercept times. The equation used in the time-intercept method to determine thicknesses is:

$$Z_1 = \frac{T_1 V_1}{2COS(SIN^{-1} V_1 / V_2)} + \frac{\text{SHOT DEPTH}}{2};$$

Figure 2 is a sketch of a multiple layer case and the corresponding time distance curve showing the intercept times.

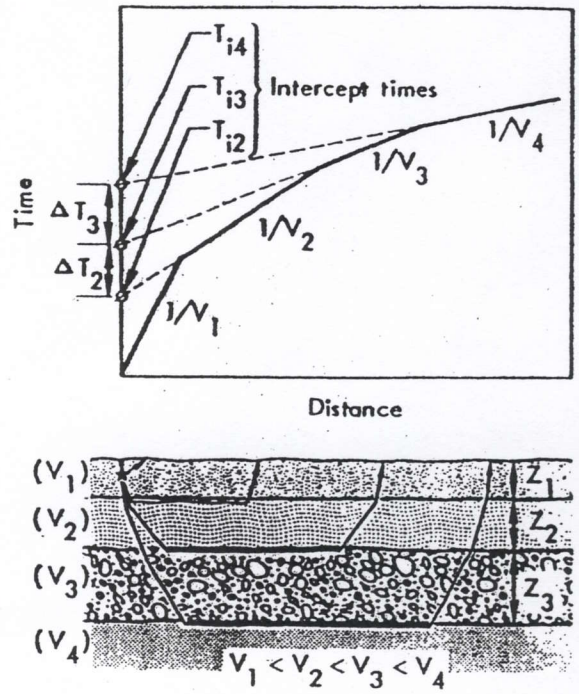


Figure 2: Multiple layer geologic model and associated time-distance graph (Redpath, 1973).

For more complex geologic models, as is usually observed, additional energy source locations are required at both ends of a seismic line as was done for this survey. The layer velocities are calculated using the data from all of the time-distance curves (delay-time method).

## Limitations

Two types of geologic conditions can cause a *hidden zone* problem. One type of hidden zone is a layer with a lower velocity than the layer above it. Energy approaching the layer at the critical angle will pass through the layer, and will not be refracted back to the surface until it encounters a deeper layer with a higher velocity, so no first arrivals are observed from the low-velocity layer. The presence of an unknown low-velocity layer will cause the calculated depths to be greater than the actual depths.

The other type of hidden zone is a layer with a greater velocity than the layer above it, but one that is too thin and/or does not have a large enough velocity contrast. The effect of a thin layer will cause the calculated depths to be shallower than the actual depths.

In areas with hidden zones, the amount of error can be determined based on direct observations (such as test pits or boreholes), and can be compensated for over the rest of the seismic lines.

References


Redpath, Bruce B. (1973). "Seismic Refraction Exploration for Engineering Site Investigations." *Tech. Report E-73-4*, U.S. Army Engineer Waterways Experiment Station Explosive Excavation Research Laboratory, Livermore, CA

# FIGURES

WESTERN DRAINAGE

CENTRAL DRAINAGE

FAR EAST SEEP DRAINAGE

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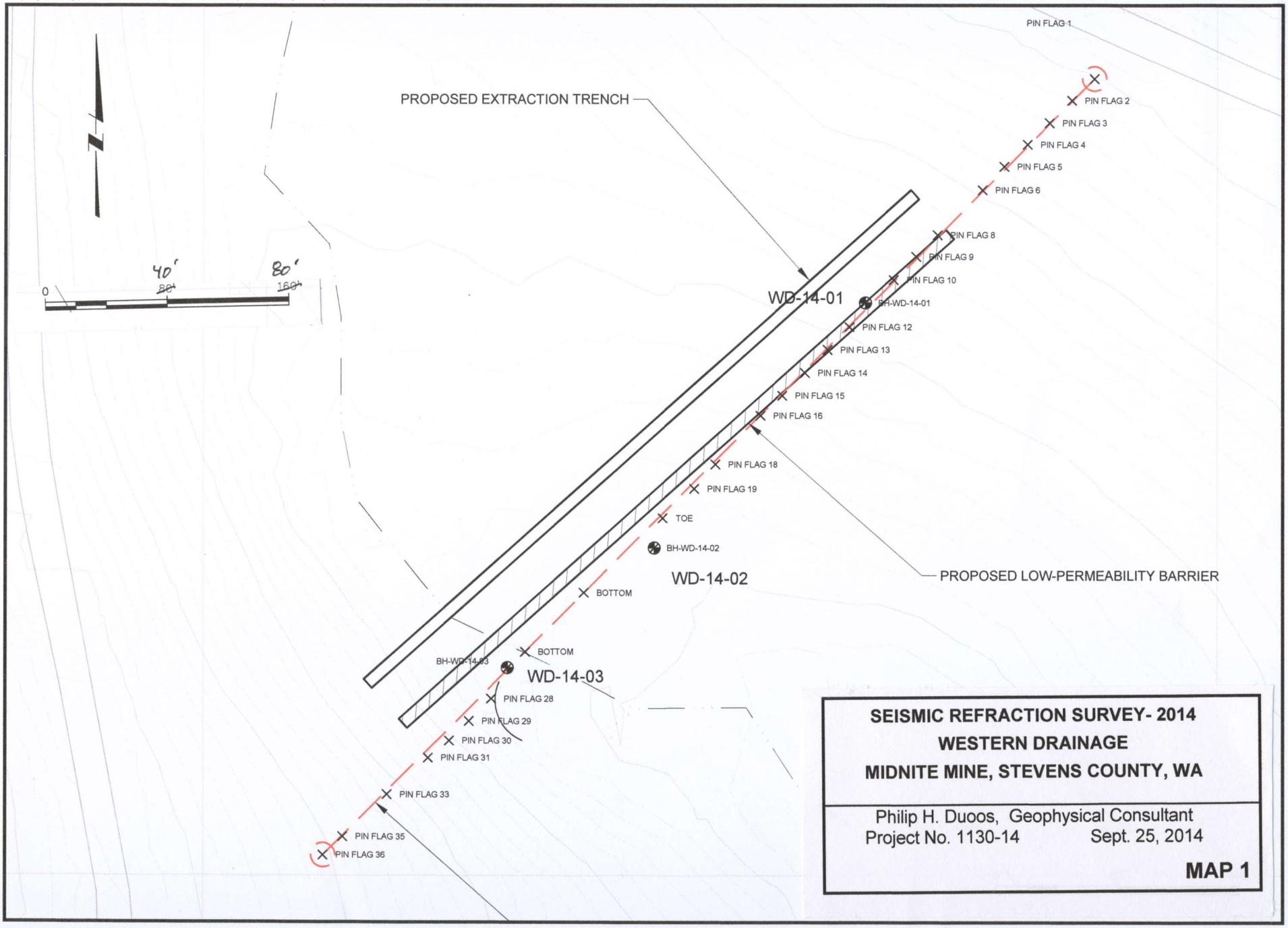
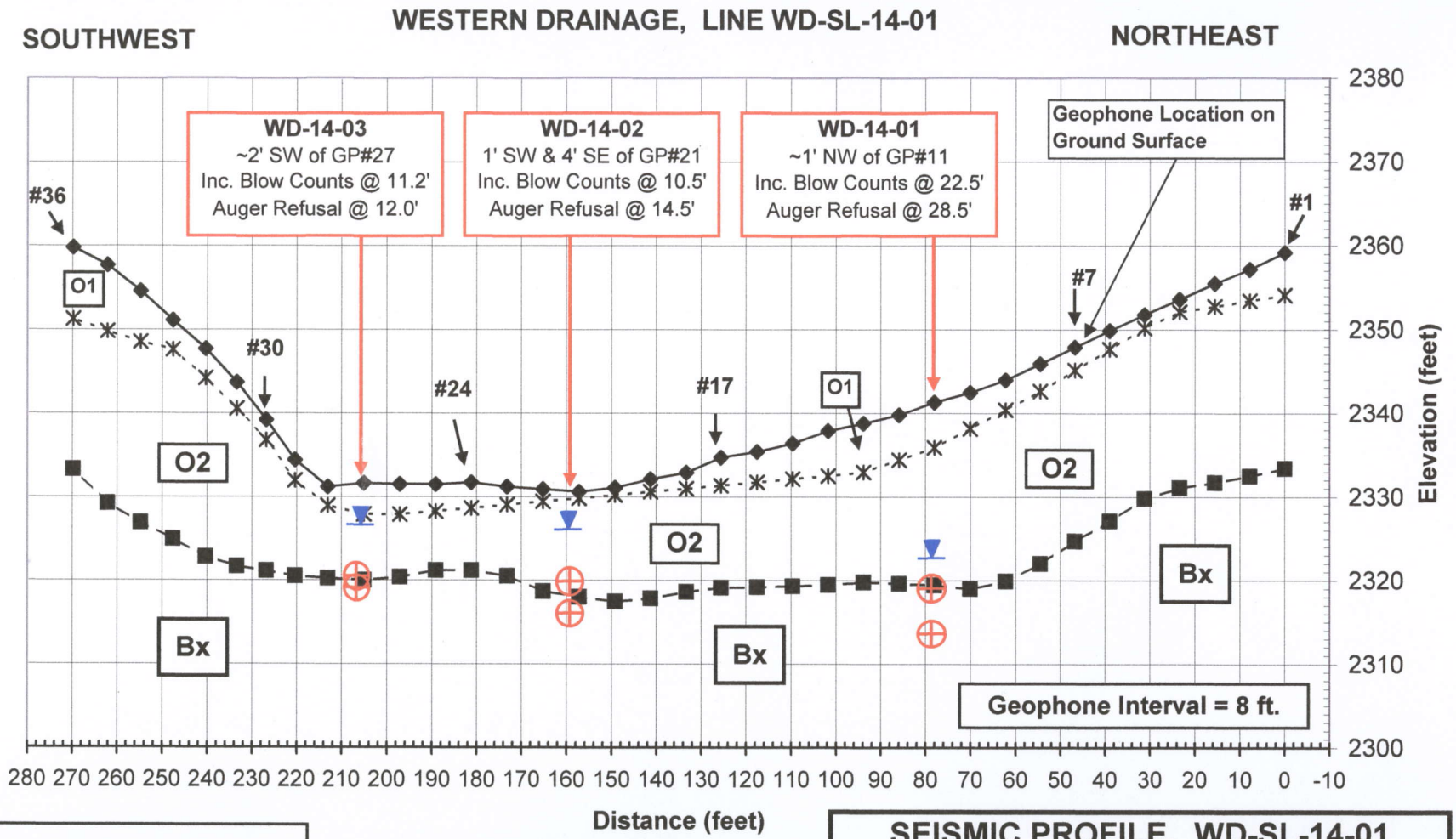



**SEISMIC REFRACTION SURVEY- 2014**
**WESTERN DRAINAGE**
**MIDNITE MINE, STEVENS COUNTY, WA**

Philip H. Duoos, Geophysical Consultant
Project No. 1130-14 Sept. 25, 2014

**MAP 1**




NOT TO SCALE

## Seismic Layer Velocities

| | | | | |
|---|---|---|---|---|
| O1: | 1,000 | - | 1,250 | fps |
| O2: | 2,400 | - | 3,200 | fps |
| O3: | Not Observed | | | |
| Bx: | 12,200 | - | 12,900 | fps |

Ground surface elevations for most of the geophone locations were provided by Benthin & Associates Surveyors. GP # 20-#27 flag locations were disturbed by drillers and not surveyed, along with a few other locations. These missing flag elevations are approximate (estimated within 0.5 feet) using hand level measurements.

## SEISMIC PROFILE, WD-SL-14-01

## MIDNITE MINE SEISMIC SURVEY
## WESTERN DRAINAGE

**For MWH Americas, Inc.**

Philip H. Duoos, Geophysical Consultant

PN 1130-14, September 25, 2014

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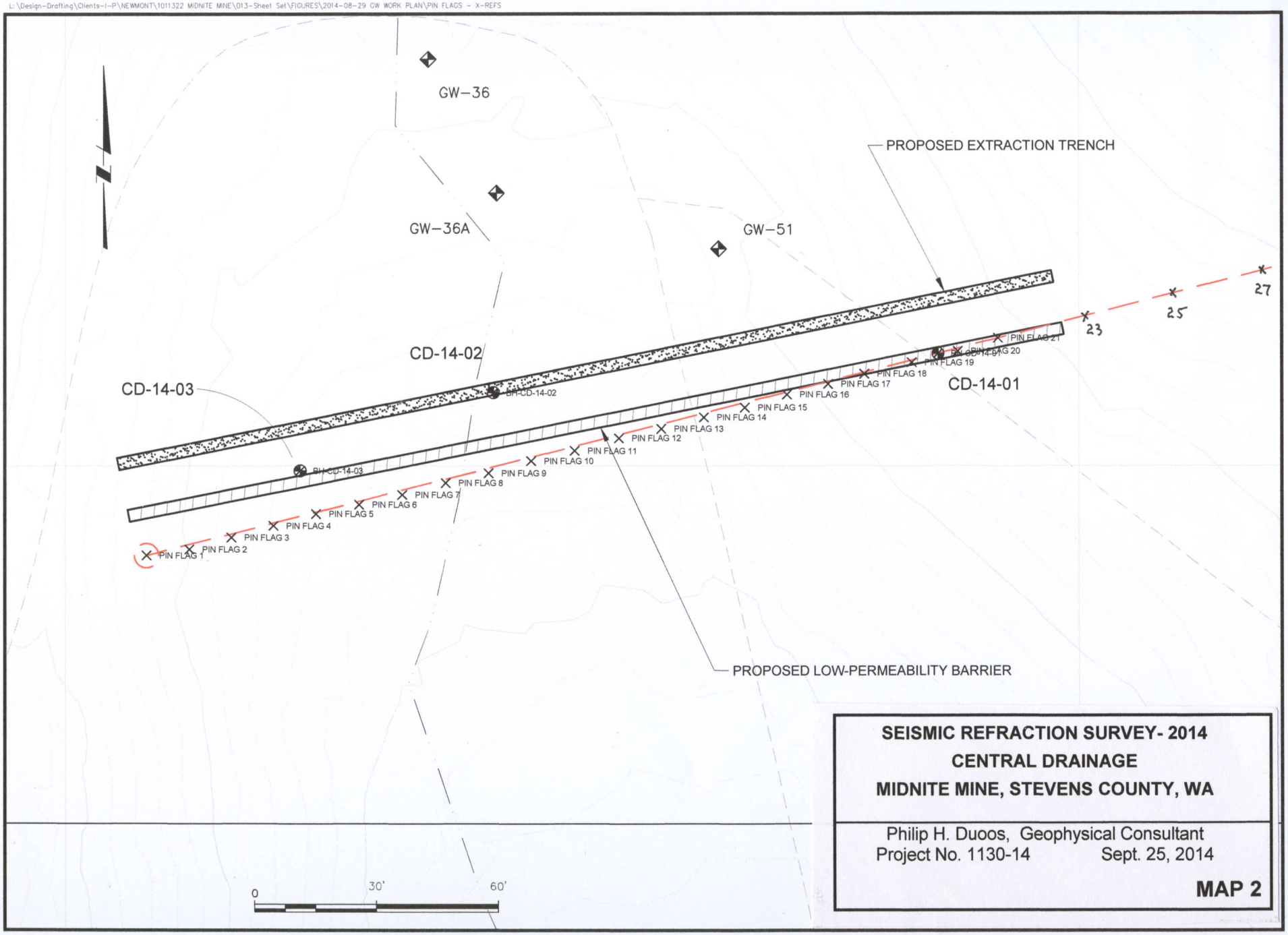



**SEISMIC REFRACTION SURVEY- 2014**

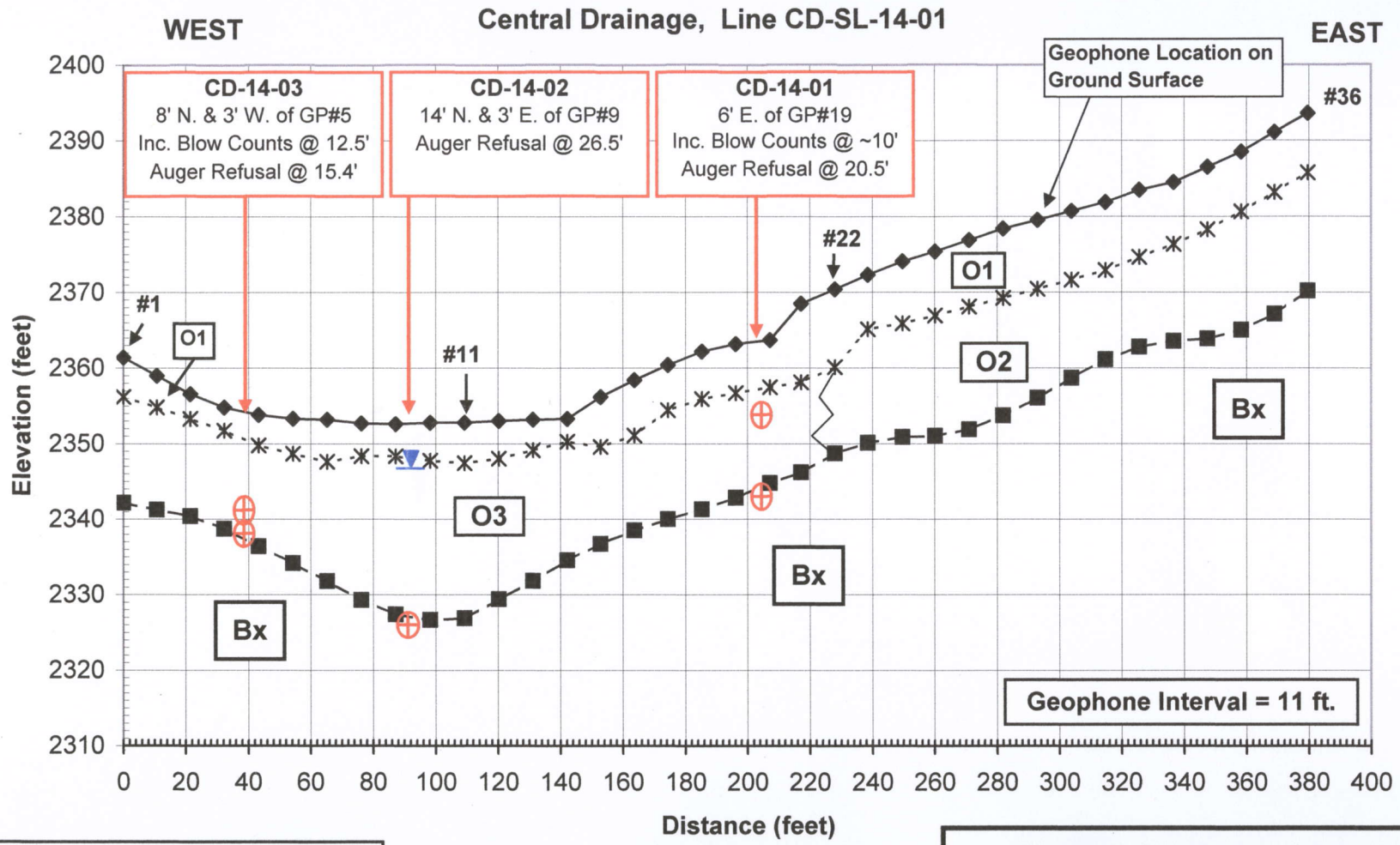
**CENTRAL DRAINAGE**

**MIDNITE MINE, STEVENS COUNTY, WA**

Philip H. Duoos, Geophysical Consultant

Project No. 1130-14 Sept. 25, 2014

**MAP 2**




NOT TO SCALE

## Seismic Layer Velocities

| | | | | |
|---|---|---|---|---|
| O1: | 1,100 | - | 1,400 | fps |
| O2: | 2,800 | - | 3,200 | fps |
| O3: | 4,200 | - | 5,200 | fps |
| Bx: | 10,500 | - | 12,300 | fps |

Ground surface elevations for GP #1 - #21 provided by Benthin & Associates Surveyors. GP #22 - #36 are approximate (estimated within 0.5 feet) using hand level measurements.

## SEISMIC PROFILE, CD-SL-14-01

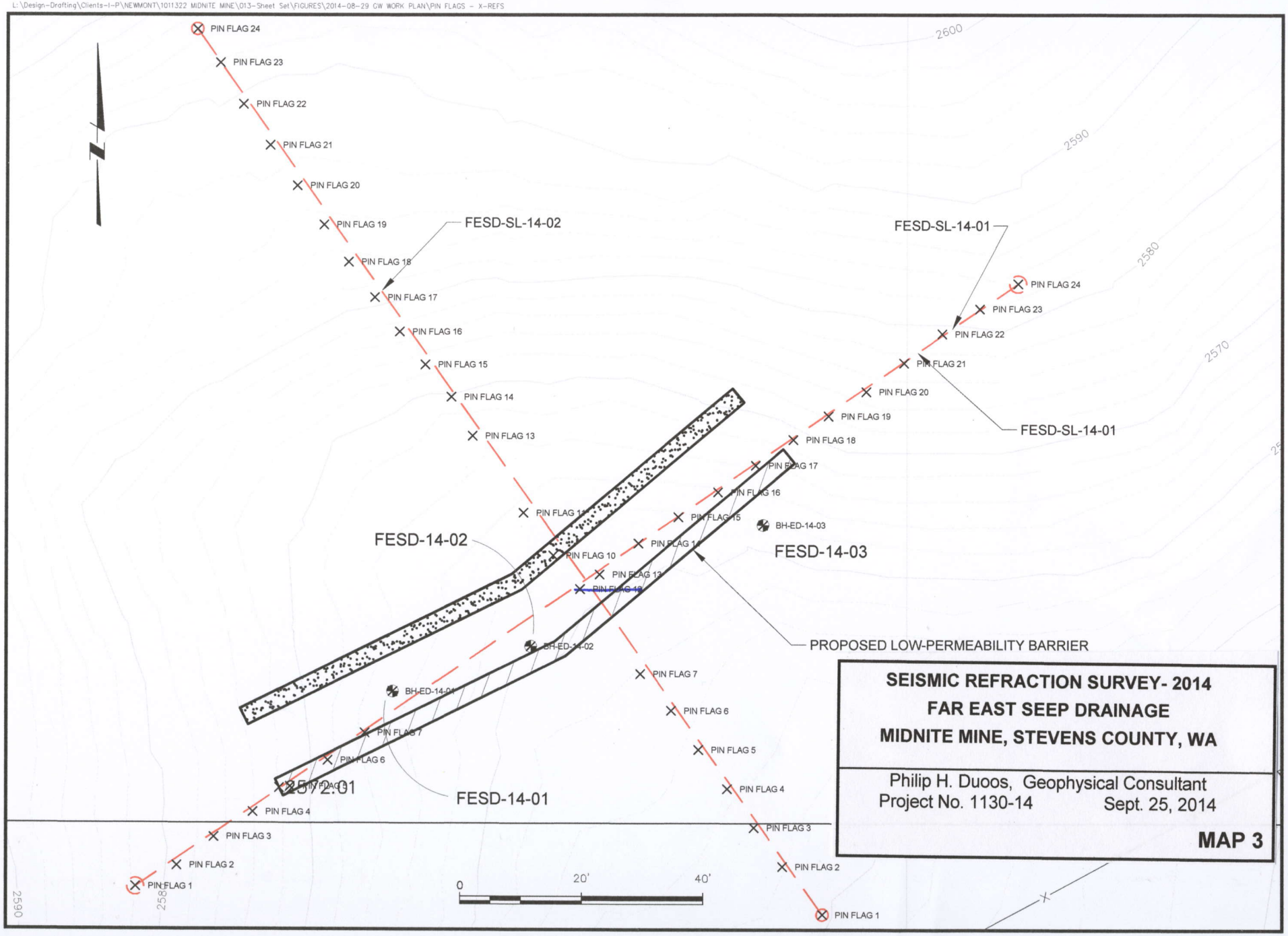
## MIDNITE MINE SEISMIC SURVEY
## CENTRAL DRAINAGE

**For MWH Americas, Inc.**

Philip H. Duoos, Geophysical Consultant

PN 1130-14, September 25, 2014

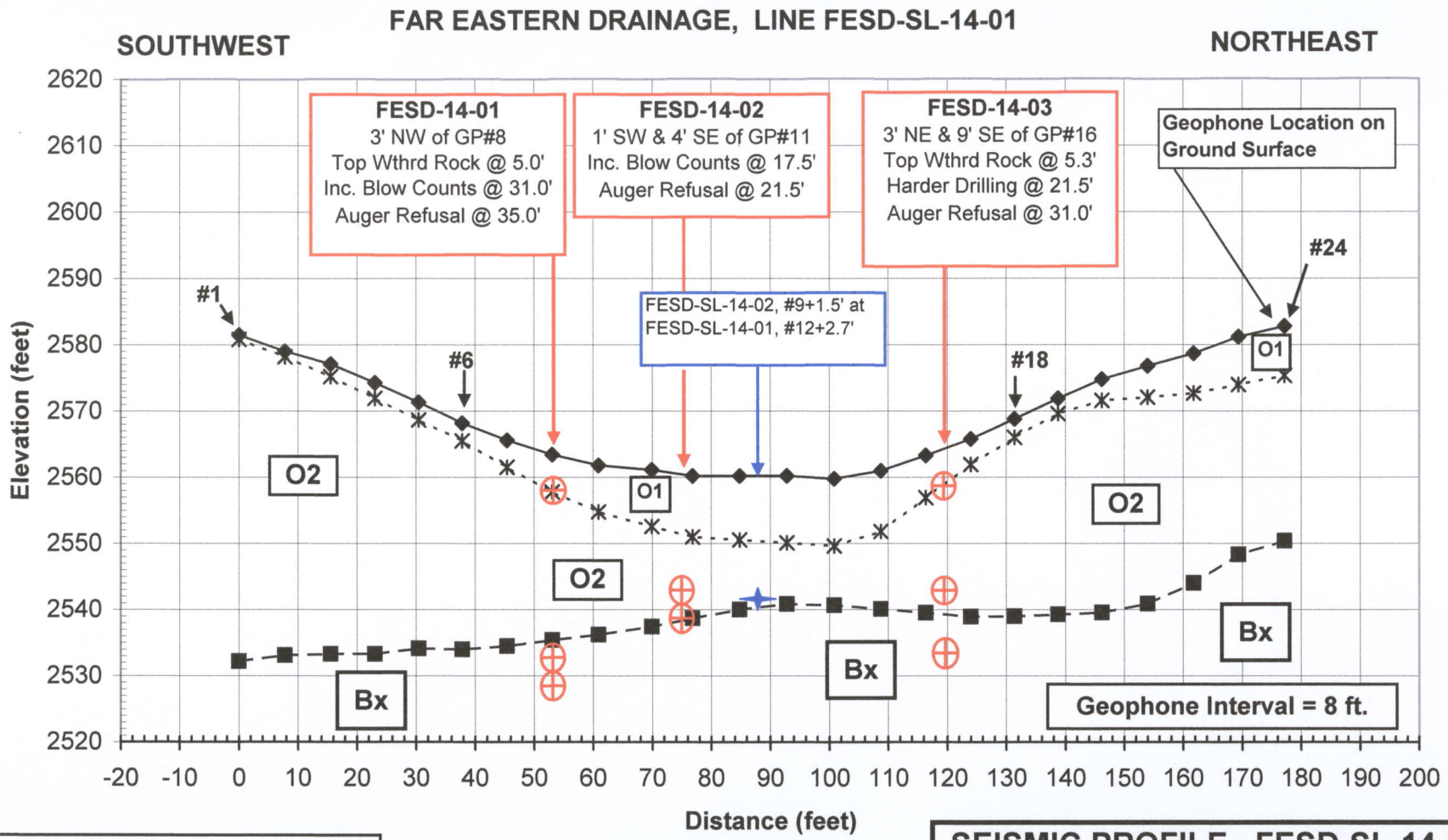
L:\Design-Drafting\Clients-I-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2014-08-29 GW WORK PLAN\PIN FLAGS - X-REFS




**SEISMIC REFRACTION SURVEY- 2014**
**FAR EAST SEEP DRAINAGE**
**MIDNITE MINE, STEVENS COUNTY, WA**

Philip H. Duoos, Geophysical Consultant
Project No. 1130-14 Sept. 25, 2014

**MAP 3**




## Seismic Layer Velocities

| | | | | |
|---|---|---|---|---|
| O1: | 1,050 | - | 1,300 | fps |
| O2: | 2,300 | - | 2,700 | fps |
| O3: | Not Observed | | | |
| Bx: | 11,500 | - | 13,000 | fps |

NOT TO SCALE

Ground surface elevations for most of the geophone locations were provided by Benthin & Associates Surveyors. GP #8- #12 flag locations were disturbed by drillers and not surveyed. These missing flag elevations are approximate (estimated within 0.5 feet) using hand level measurements.

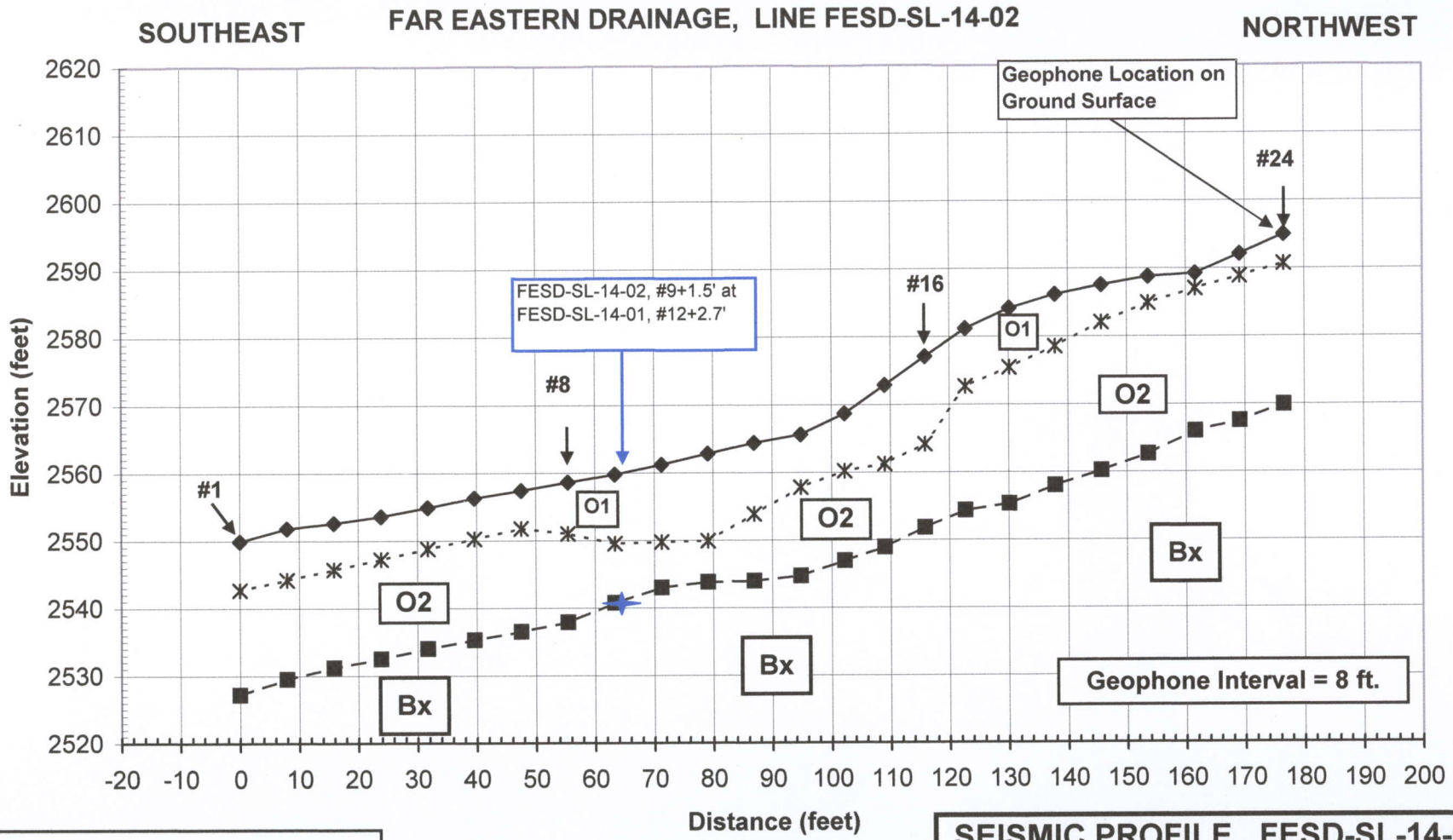
## SEISMIC PROFILE, FESD-SL-14-01

## MIDNITE MINE SEISMIC SURVEY
## FAR EASTERN DRAINAGE

**For MWH Americas, Inc.**

Philip H. Duoos, Geophysical Consultant

PN 1130-14, September 25, 2014




## Seismic Layer Velocities

| | | | |
|---|---|---|---|
| O1: | 1,000 | - | 1,200 fps |
| O2: | 2,200 | - | 2,700 fps |
| O3: | Not Observed | | |
| Bx: | 12,500 | - | 13,600 fps |

NOT TO SCALE

Ground surface elevations for most of the geophone locations were provided by Benthin & Associates Surveyors. GP #8- #9 flag locations were disturbed by drillers and not surveyed. These missing flag elevations are approximate (estimated within 0.5 feet) using hand level measurements.

## SEISMIC PROFILE, FESD-SL-14-02

## MIDNITE MINE SEISMIC SURVEY
## FAR EASTERN DRAINAGE

**For MWH Americas, Inc.**

Philip H. Duoos, Geophysical Consultant

PN 1130-14, September 25, 2014

# APPENDIX C

# SURVEYOR REPORT

WALTER O. DALE
PRESIDENT

# BENTHIN & ASSOCIATES

PROFESSIONAL LAND SURVEYING AND PLANNING
1004 NORTH ATLANTIC STREET • SPOKANE, WA. 99201-2209
(509) 325-4529 • (FAX) 325-4520 • SURVEY@GPS-SURVEYOR.COM

SCOTT A. DALE
SECRETARY

August 8, 2014

## MIDNITE MINE SEISMIC LINE REPORT FOR EAST, CENTRAL AND WEST DRAINAGE

The following is the final report for the locations and elevations of the seismic line pin flags and boreholes located within the East, Central and West Drainage Areas.

Coordinate system has been converted to NAD 83 (96) coordinates with NAVD 88 elevations.

Sincerely,

Walter O. Dale, PLS

WALTER O DALE
STATE OF WASHINGTON
29270
REGISTERED
PROFESSIONAL LAND SURVEYOR

# MIDNITE MINE SEISMIC LINE REPORT #2

## WEST DRAINAGE (WD-14-01)

COORDINATE SYSTEM IS NAD 83 (CORS 96) GROUND COORDINATES WITH NAVD 88 ELEVATIONS

| POINT NO. | NORTHING | EASTING | ELEVATION | DESCRIPTION |
|---|---|---|---|---|
| 610 | 351445.4 | 311469.8 | 2359.2 | PIN FLAG 1 |
| 681 | 351440.1 | 311464.2 | 2357.2 | PIN FLAG 2 |
| 682 | 351434.6 | 311458.7 | 2355.5 | PIN FLAG 3 |
| 683 | 351429.3 | 311453.3 | 2353.6 | PIN FLAG 4 |
| 684 | 351423.9 | 311447.6 | 2351.8 | PIN FLAG 5 |
| 685 | 351418.2 | 311442.2 | 2349.9 | PIN FLAG 6 |
| 686 | 351407.2 | 311431.1 | 2345.9 | PIN FLAG 8 |
| 687 | 351401.9 | 311425.8 | 2344.0 | PIN FLAG 9 |
| 688 | 351396.2 | 311420.3 | 2342.5 | PIN FLAG 10 |
| 689 | 351384.7 | 311409.4 | 2339.8 | PIN FLAG 12 |
| 690 | 351379.1 | 311404.0 | 2338.8 | PIN FLAG 13 |
| 691 | 351373.4 | 311398.4 | 2337.9 | PIN FLAG 14 |
| 692 | 351367.8 | 311392.8 | 2336.4 | PIN FLAG 15 |
| 693 | 351362.9 | 311387.4 | 2335.4 | PIN FLAG 16 |
| 694 | 351350.9 | 311376.3 | 2332.9 | PIN FLAG 18 |
| 695 | 351344.9 | 311371.1 | 2332.1 | PIN FLAG 19 |
| 699 | 351293.4 | 311321.0 | 2331.2 | PIN FLAG 28 |
| 700 | 351287.9 | 311315.5 | 2334.4 | PIN FLAG 29 |
| 701 | 351283.1 | 311310.6 | 2339.2 | PIN FLAG 30 |
| 702 | 351278.9 | 311305.4 | 2343.7 | PIN FLAG 31 |
| 703 | 351269.9 | 311295.3 | 2351.1 | PIN FLAG 33 |
| 704 | 351259.5 | 311284.4 | 2357.7 | PIN FLAG 35 |
| 612 | 351255.0 | 311279.5 | 2359.8 | PIN FLAG 36 |
| 697 | 351319.4 | 311343.8 | 2331.5 | BOTTOM |
| 698 | 351304.9 | 311329.4 | 2331.2 | BOTTOM |
| 696 | 351337.7 | 311363.3 | 2330.7 | TOE |
| | | | | |
| 705 | 351301.0 | 311325.0 | 2331.2 | BH-WD-14-03 |
| 706 | 351330.4 | 311361.2 | 2330.1 | BH-WD-14-02 |
| 707 | 351390.6 | 311413.3 | 2341.5 | BH-WD-14-01 |

NOTE: Coordinates on Siesmic Line Stakes are only certified to the nearest 0.1'

Elevations on Seismic Line Stakes are only certified to the nearest 0.1'

These coordinates are surface values with a 2,000,000 factor removed from Easting to differentiate from actual NAD 83 (CORS 96) Grid Coordinates.

# MIDNITE MINE SEISMIC LINE REPORT #2

## CENTRAL DRAINAGE (CD-14-01)

COORDINATE SYSTEM IS NAD 83 (CORS 96) GROUND COORDINATES WITH NAVD 88 ELEVATIONS

| POINT NO. | NORTHING | EASTING | ELEVATION | DESCRIPTION |
|---|---|---|---|---|
| 668 | 351478.0 | 311770.0 | 2361.4 | PIN FLAG 1 |
| 667 | 351479.5 | 311780.6 | 2359.0 | PIN FLAG 2 |
| 666 | 351482.4 | 311791.0 | 2356.6 | PIN FLAG 3 |
| 665 | 351485.3 | 311801.3 | 2354.8 | PIN FLAG 4 |
| 664 | 351488.2 | 311811.8 | 2353.8 | PIN FLAG 5 |
| 663 | 351490.5 | 311822.5 | 2353.3 | PIN FLAG 6 |
| 662 | 351492.9 | 311833.1 | 2353.2 | PIN FLAG 7 |
| 671 | 351495.8 | 311843.8 | 2352.7 | PIN FLAG 8 |
| 661 | 351498.2 | 311854.4 | 2352.6 | PIN FLAG 9 |
| 660 | 351501.2 | 311864.9 | 2352.8 | PIN FLAG 10 |
| 659 | 351503.7 | 311875.6 | 2352.8 | PIN FLAG 11 |
| 658 | 351506.8 | 311886.5 | 2353.0 | PIN FLAG 12 |
| 657 | 351509.1 | 311897.0 | 2353.2 | PIN FLAG 13 |
| 672 | 351511.9 | 311907.5 | 2353.3 | PIN FLAG 14 |
| 673 | 351514.3 | 311917.6 | 2356.2 | PIN FLAG 15 |
| 674 | 351517.5 | 311928.0 | 2358.4 | PIN FLAG 16 |
| 675 | 351520.1 | 311938.2 | 2360.4 | PIN FLAG 17 |
| 676 | 351522.6 | 311947.1 | 2362.2 | PIN FLAG 18 |
| 677 | 351525.4 | 311958.8 | 2363.2 | PIN FLAG 19 |
| 678 | 351528.2 | 311970.2 | 2363.7 | PIN FLAG 20 |
| 679 | 351531.4 | 311980.1 | 2368.5 | PIN FLAG 21 |
| | | | | |
| 680 | 351527.6 | 311965.3 | 2363.1 | BH-CD-14-01 |
| 670 | 351518.0 | 311855.6 | 2353.8 | BH-CD-14-02 |
| 669 | 351498.8 | 311807.9 | 2354.3 | BH-CD-14-03 |

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Elevations on Seismic Line Stakes are only certified to the nearest 0.1'

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# MIDNITE MINE SEISMIC LINE REPORT #2

## EAST DRAINAGE (ED-14-01)

COORDINATE SYSTEM IS NAD 83 (CORS 96) GROUND COORDINATES WITH NAVD 88 ELEVATIONS

| POINT NO. | NORTHING | EASTING | ELEVATION | DESCRIPTION |
|---|---|---|---|---|
| 634 | 353946.7 | 313386.1 | 2549.9 | PIN FLAG 1 |
| 633 | 353954.6 | 313379.5 | 2551.8 | PIN FLAG 2 |
| 632 | 353961.0 | 313374.8 | 2552.6 | PIN FLAG 3 |
| 631 | 353967.4 | 313370.4 | 2553.6 | PIN FLAG 4 |
| 630 | 353973.8 | 313365.7 | 2554.9 | PIN FLAG 5 |
| 629 | 353980.2 | 313361.2 | 2556.3 | PIN FLAG 6 |
| 628 | 353986.2 | 313356.1 | 2557.4 | PIN FLAG 7 |
| 627 | 354005.6 | 313341.8 | 2561.2 | PIN FLAG 10 |
| 626 | 354012.6 | 313336.9 | 2562.8 | PIN FLAG 11 |
| 604 | 354000.1 | 313346.2 | 2560.2 | PIN FLAG 12 |
| 625 | 354025.2 | 313328.5 | 2565.6 | PIN FLAG 13 |
| 624 | 354031.6 | 313325.0 | 2568.7 | PIN FLAG 14 |
| 623 | 354036.9 | 313320.7 | 2572.9 | PIN FLAG 15 |
| 622 | 354042.3 | 313316.5 | 2577.1 | PIN FLAG 16 |
| 621 | 354047.9 | 313312.4 | 2581.2 | PIN FLAG 17 |
| 620 | 354053.7 | 313308.1 | 2584.2 | PIN FLAG 18 |
| 619 | 354059.8 | 313304.0 | 2586.2 | PIN FLAG 19 |
| 618 | 354066.2 | 313299.6 | 2587.6 | PIN FLAG 20 |
| 617 | 354072.8 | 313295.1 | 2588.8 | PIN FLAG 21 |
| 616 | 354079.5 | 313290.7 | 2589.3 | PIN FLAG 22 |
| 615 | 354086.3 | 313286.9 | 2592.1 | PIN FLAG 23 |
| 606 | 354091.8 | 313283.1 | 2595.0 | PIN FLAG 24 |
| | | | | |

NOTE: Coordinates on Siesmic Line Stakes are only certified to the nearest 0.1'

Elevations on Seismic Line Stakes are only certified to the nearest 0.1'

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# MIDNITE MINE SEISMIC LINE REPORT #2

## EAST DRAINAGE (ED-14-02)

COORDINATE SYSTEM IS NAD 83 (CORS 96) GROUND COORDINATES WITH NAVD 88 ELEVATIONS

| POINT NO. | NORTHING | EASTING | ELEVATION | DESCRIPTION |
|---|---|---|---|---|
| 656 | 353951.2 | 313273.1 | 2581.5 | PIN FLAG 1 |
| 655 | 353954.7 | 313279.9 | 2579.0 | PIN FLAG 2 |
| 654 | 353959.4 | 313286.0 | 2577.1 | PIN FLAG 3 |
| 653 | 353963.5 | 313292.4 | 2574.3 | PIN FLAG 4 |
| 652 | 353967.7 | 313298.5 | 2571.3 | PIN FLAG 5 |
| 651 | 353972.0 | 313304.7 | 2568.2 | PIN FLAG 6 |
| 650 | 353976.5 | 313310.8 | 2565.6 | PIN FLAG 7 |
| 646 | 354002.5 | 313349.4 | 2560.2 | PIN FLAG 13 |
| 645 | 354007.6 | 313355.8 | 2559.8 | PIN FLAG 14 |
| 644 | 354011.9 | 313362.4 | 2561.0 | PIN FLAG 15 |
| 643 | 354016.0 | 313368.9 | 2563.3 | PIN FLAG 16 |
| 642 | 354020.4 | 313375.1 | 2565.8 | PIN FLAG 17 |
| 641 | 354024.6 | 313381.3 | 2568.8 | PIN FLAG 18 |
| 640 | 354028.5 | 313387.1 | 2571.9 | PIN FLAG 19 |
| 639 | 354032.5 | 313393.3 | 2574.8 | PIN FLAG 20 |
| 638 | 354037.2 | 313399.5 | 2576.8 | PIN FLAG 21 |
| 637 | 354042.0 | 313405.8 | 2578.7 | PIN FLAG 22 |
| 636 | 354046.1 | 313412.0 | 2581.2 | PIN FLAG 23 |
| 635 | 354050.2 | 313418.3 | 2582.8 | PIN FLAG 24 |
| | | | | |
| 649 | 353983.3 | 313315.4 | 2563.1 | BH-ED-14-01 |
| 648 | 353990.7 | 313338.1 | 2559.9 | BH-ED-14-02 |
| 647 | 354010.6 | 313376.3 | 2561.2 | BH-ED-14-03 |

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