Appendix 3-G

Summary of Waste Rock Facility Design Documents

MURRAY RIVER COAL PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

Appendix 3-G

Summary of Waste Rock Facility Design Documents

1. Excerpt (Chapter 6) from Bulk Sample Technical Assessment Report (October 2011)
2. Excerpt (Response 3) from Comment-Responses to Bulk Sample Technical Assessment Report (January 2012)
3. Stability Assessment of Waste Rock Facility with Geomembrane Liner (September 2012)
4. Soil Liquefaction Evaluation (October 2012)

HD Mining International Ltd.

MURRAY RIVER BULK SAMPLE
Waste Discharge Permit Application
Technical Assessment Report

Rescan™ Environmental Services Ltd.
Rescan Building, Sixth Floor - 1111 West Hastings Street
Vancouver, BC Canada V6E 2J3
Tel: (604) 689-9460 Fax: (604) 687-4277

October 2011

6. Waste Management

6. Waste Management

6.1 DEVELOPMENT SCHEDULE

Mine development will occur sequentially over a three year period. Table 6.1-1 outlines the preliminary schedule and although the schedule will need to be moved forward in time, the table does indicate the relative time frames needed to complete the Project.

Table 6.1-1. Preliminary Construction Schedule

		2011					2012												2013			
Activity	**Months**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1Q**	**2Q**	**3Q**	**4Q**
Surface Construction	3	■	■	■																		
Decline Construction	9				■	■	■	■	■	■	■	■	■									
Shaft Construction	8				■	■	■	■	■	■	■	■										
Preparing for Mining	1												■									
Bulk Sample Mining	4													■	■	■	■					
Reclamation (if needed)																				■	■	

The Decline and Shaft construction are based on an average advance rate of 20 feet (6.1 m) per day that includes an allowance for mobilization, surface till tunnelling, and demobilization. The production phase of the Bulk Sample mining is based on an average of 1,000 tonnes per day.

6.2 WASTE ROCK MANAGEMENT

The Ministry of Energy and Mines guidelines (1998) for the prevention and reduction of ML/ARD include the following management strategies in order of preference:

- Avoidance: total or partial reduction of excavation, disturbance or exposure of ML/ARD generating materials.
- Underwater Storage: this is generally the most effective method of preventing ARD and reducing ML. An important consideration of this strategy is rapid disposal to minimize significant weathering prior to submergence under water. The prevention of exposure of waste materials to atmospheric oxygen minimizes material weathering and the production of secondary weathering products such as sulphate, acidity (lower pH), and metals.
- Waste Segregation: Segregation of potentially acid generating materials from not-potentially acid generating materials is the most common applied segregation. However, this can also be applied to significant ML versus low or negligible ML as well. Typically ARD and significant ML materials are placed under water in an impoundment or in a stockpile with liner or other adequate means of containment and capture of runoff and seepage.
- Blending and Covers: This strategy is considered less than reliable than underwater storage. Blending is generally applicable where there are sources of neutralization potential such as carbonate minerals in limestone are blended with ARD generating materials to neutralize ARD in-situ on a micro- and meso-scale. Covers are designed and/or constructed to minimize atmospheric oxygen ingress and thereby slowing the material weathering rates. In most cases, covers have demonstrated to reduce/slow weathering rates and thereby reduce secondary

weathering product concentrations (loadings) in runoff and seepage. However, this may also result in significantly longer timeframes before weathering is complete.

- Chemical Treatment: Generally considered a mitigation strategy of last resort. It also generally applies to materials that are strongly acid generating and/or metal leaching where treatment is the only feasible means of preventing off-site impacts and other prevention/mitigation methods are not feasible.

6.2.1 Waste Rock Facility

With the primary concern being mitigation of potentially acid producing waste rock material and metals leaching from the waste rock, Rescan was tasked to provide additional design and operational information for the proposed Waste Rock Facility associated with mining operations under the Bulk Sample Permit. The Waste Rock Facility is located southeast of the Man and Materials Shaft as depicted on Figure 2.1-1. As waste material is excavated from the Conveyor Belt Decline and the Man and Materials Shaft, it will be transported, via surface haulage equipment, to the Waste Rock Facility. Development of the shaft and decline are expected to take 6-9 months. The primary mitigation steps which are described in more detail in the following narrative include:

- Encapsulation of PAG material to prevent contact with air and water;
- Placement of waste rock on engineered (graded/compacted/drainage) impermeable liners;
- Compaction of material, both PAG and Non-PAG, as it is placed and spread across the Waste Rock Facility;
- Constructing a waste rock footprint that is large enough to contain the mined waste rock as well as material that must be temporarily stockpiled due to mining sequence constraints, sampling and monitoring requirements, or because of delays;
- Perimeter ditches around the Waste Rock Facility and Coal Stockpile footprint designed to collect contact water and route it to the Sediment/Treatment Ponds; and
- Monitoring program concurrent with mining operations to ensure that PAG material is identified and encapsulated.

Construction of the Conveyor Belt Decline and the Man and Materials Shaft to design depth will require mining through four stratigraphic formations two of which are known to be PAG formations. Overburden, in the form of unconsolidated glacial till, will also be excavated. Table 6.2-1 provides a summary of the material balance and the thickness of each formation that will be encountered. The Hasler Formation and the Hulcross Formation are PAG and HD will construct the waste rock facility so that material from the PAG formations will be encapsulated within Non-PAG waste rock minimizing the material's exposure to air and water. All material characterized as Uncertain, will be considered PAG.

As a result of further testing on the iron carbonate units within the Boulder Creek formation, approximately 20% of the test results were identified as PAG. Since the Boulder Creek Formation is primarily a conglomerate and it is not easy to visually distinguish between PAG and Non-PAG material within the formation, it will be assumed that 20% of the total volume of the Boulder Creek Formation will be PAG, or approximately 3700 m^3 representing approximately 54 meters of advance in the decline and shaft. Since it will not be possible to distinguish between PAG and Non-PAG, HD will commit to concurrent ABA and Shake Flask Extraction testing for the entire minable thickness of the Boulder Creek Formation. That which is identified as PAG will be segregated and encapsulated within the Waste Rock Facility. Non-PAG Boulder Creek material will be used as part of the cover system.

Table 6.2-1. Estimated Volumes by Formation for Decline and Shaft (LCM – Loose Cubic Metres)

Formation	Conveyor Belt Decline		Man and Materials Shaft		Total Waste Mine Site	
	meters	LCM	meters	LCM	meters	LCM
Overburden (Non-PAG)	63	24,251	7	54,486	70	78,737
Hasler - (PAG)	**915**	**32,180**	**158**	**18,135**	**1073**	**50,315**
Boulder Creek (Non-PAG)	130	4,502	93	10,227	223	14,729
Boulder Creek (PAG)	**30**	**1,125**	**24**	**2,557**	**54**	**3,682**
Hulcross (PAG)	**83**	**2,919**	**73**	**7,976**	**156**	**10,895**
Gates(Non-PAG)	413	15,119	157	19,563	570	34,682
Gates D and E Coal Seams (PAG)	**54**	**1,305**	**15**	**1,177**	**69**	**2,482**
Total	1,688	81,401	527	114,121	2215	195,522

Source: Norwest Corporation/Rescan Environmental

The Gates Formation contains several thin layers of non-economic coal seams. The D and E coal seams, representing approximately 2,482 m^3 representing approximately 69 meters of advance in the decline and shaft, will be mined through to reach the targeted F coal seam. The D and E coal seams will not be analyzed, but will be considered PAG material. It will be segregated and placed within the encapsulation layer.

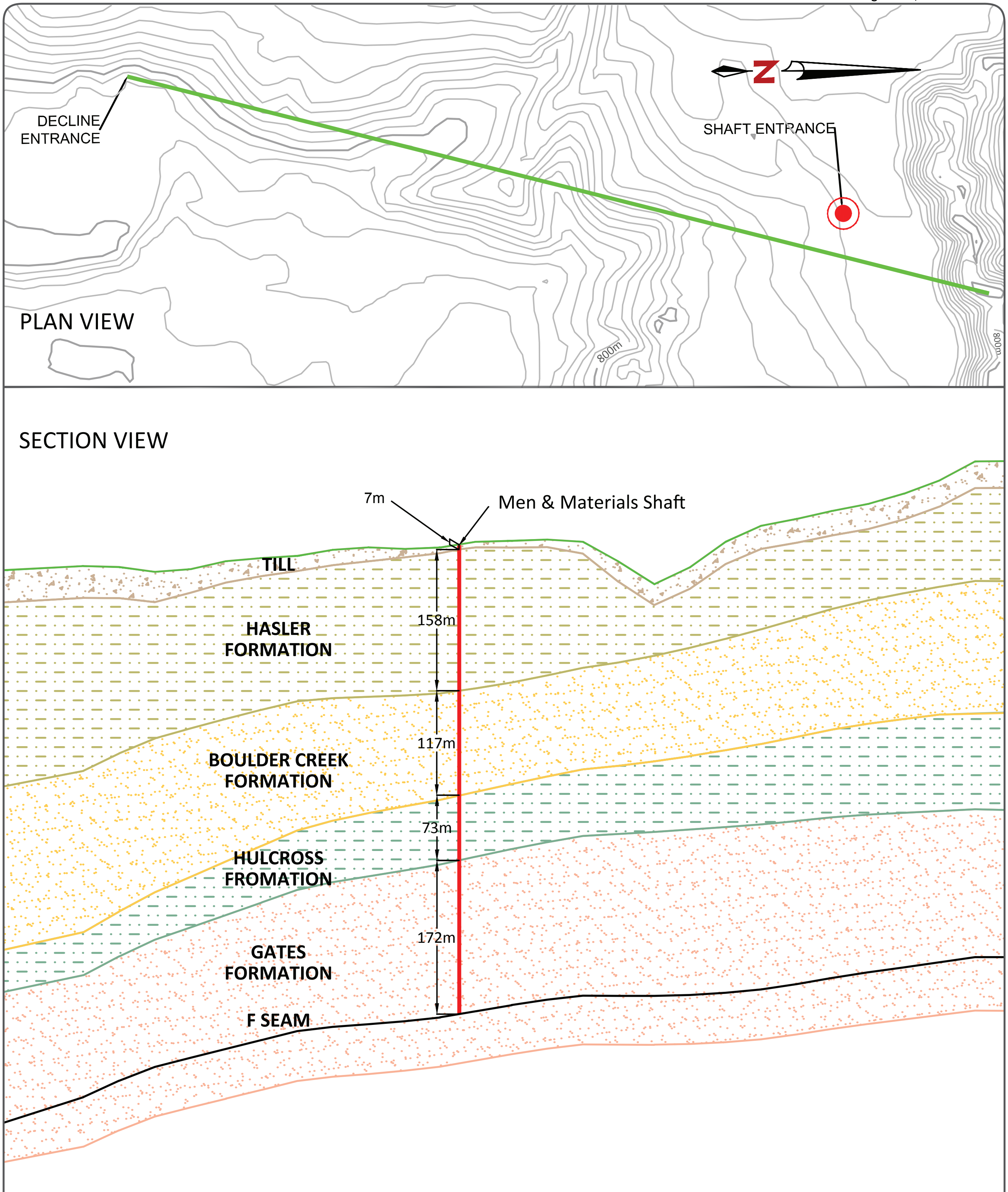
The dimensions of the proposed Waste Rock Facility will be approximately 300 m by 200 m or 6.0 ha. The “toe” of the waste material slope will approach no closer to the edge of the prepared subgrade area than 25 meters making the effective area of the facility to be approximately 275 m by 175 m, or 4.8 ha. The ultimate height of the facility will depend on the amount of compaction that is achieved but the height should not extend more than 9-10 meters. Since most of the waste rock is composed of silty/sandy material with high clay content, permeability rates as low as 10^{-7} cm/s can be achieved utilizing accepted engineering and construction methods for compaction.

Because of the stratigraphy and the mining sequence and the need to collect and analyze samples, a temporary stockpile area will be required to contain Non-PAG material and at times, PAG material. The footprint of the waste rock facility will be of sufficient area to accommodate both the waste rock from the mine as well as temporary PAG and non-PAG stockpiles. Additionally, the Coal Stockpile footprint area, at the Conveyor Decline site, will be cleared, graded, and compacted so that PAG and non-PAG material from the decline can be temporarily stockpiled at this facility. Figures 6.2-1 and 6.2-2 depict the stratigraphic formations that will be mined.

6.2.2 Clearing, Grubbing and Soil Salvage

The Waste Rock Facility footprint is located in a forested area and HD will need to apply for a Use Permit from the Ministry of Forest and Lands. HD will contract with a local logging company to remove merchantable timber and to log off any remaining timber. Unusable timber, slash, and vegetative debris will be cleared and pushed into piles along the perimeter of the footprint and either burned or possibly stockpiled to create micro-habitats for wildlife during future reclamation.

PROJECT # 791-004 ILLUSTRATION # a32791w August 17, 2011



LEGEND

TILL	7m LENGTH	527m
HASLER FORMATION	158m LENGTH	
BOULDER CREEK FORMATION	117m LENGTH	
HULCROSS FORMATION	73m LENGTH	
GATES FORMATION	172m LENGTH	

HORIZONTAL SCALE = VERTICAL SCALE

0 50 100 150 200

METERS

Source: Norwest Corporation

hd Mining

MURRAY RIVER PROJECT

Men and Materials Shaft Cross-section

Figure 6.2-1

Rescan Engineers & Scientists

PROJECT # 0791-004 ILLUSTRATION # a32792w August 17, 2011

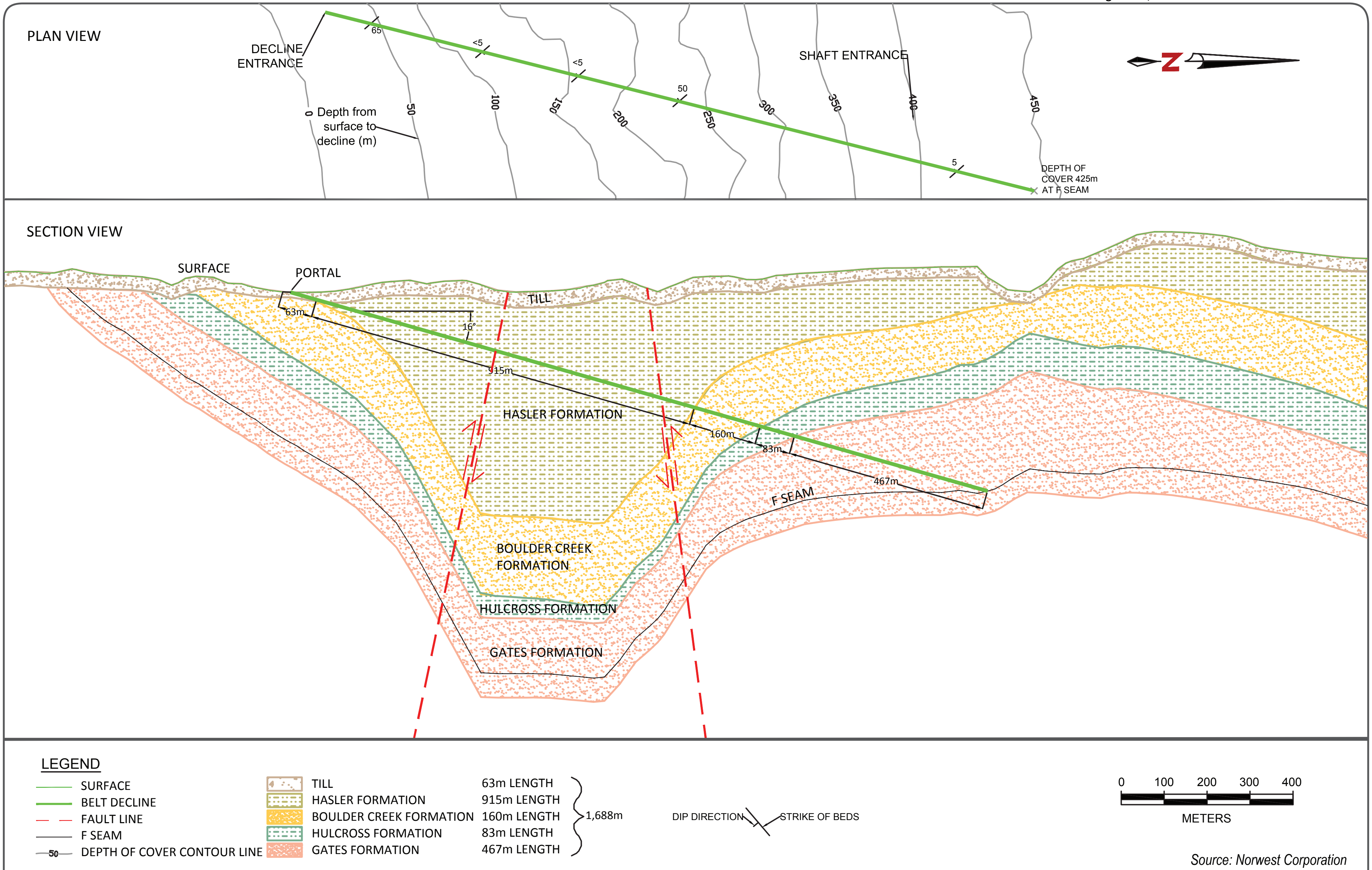


Figure 6.2-2

HD Mining

MURRAY RIVER PROJECT

Belt Decline Cross-section

Figure 6.2-2

Rescan Engineers & Scientists

The topsoil (A and B soil horizons) will be salvaged from the waste rock facility footprint area and stockpiled, along with topsoil from the footprint of all the other surface facilities including the shaft and decline areas, sediment ponds, ditch corridors, coal stockpile area, magazines, and any new roads. The vertical extent of the horizons varies across the waste rock facility footprint area but salvage will be maximized to the extent possible. It is anticipated that soil can be salvaged to a possible depth of approximately 50 cm meaning that an approximate volume of 26,000 m^3 of topsoil will be salvaged from the waste rock footprint. Soil salvage will include roots, small woody debris and plant fragments. In some cases, plant roots, living plant fragments and seeds contained in the soil's seed bank will regenerate once the soils are applied to the reclamation site and will assist with revegetation efforts. Stumps and other small woody debris will be placed along the perimeter of the cleared footprint area to be used to create substrate diversity during future reclamation. Appendix 9.4-1 contains guidelines for clearing, grubbing, and soil salvage.

The topsoil stockpiles will remain for the Bulk Sample project but once the decline and shaft development is completed (6-8 months) topsoil will be used as a final reclamation cover for the waste rock facility and other areas that can be reclaimed at that time. For that interim period, the topsoil stockpiles will be seeded with a fast growing interim seed mix (fall rye and a mixed cover of annuals and perennial grasses and legumes). Erosion control blankets (GEOCOIR® matting or coconut fibre blanket) will be installed on the stockpile to prevent erosion until the seed mix has germinated and grown. The topsoil stockpile will also be monitored for invasive weeds.

6.2.3 Subgrade Preparation

The footprint of the Waste Rock Facility will be graded and contoured. The contoured footprint will then be compacted to provide ground stability and to create an impermeable base. The native surface materials, composed of unconsolidated glacial till, has a high percentage of fines (silt and clay), so a relatively high degree of compaction can be achieved (~ 10^{-7} cm/s). For a detailed geotechnical discussion of the subgrade materials beneath the Waste Rock Facility, other areas within the Project site, and for areas of usable construction materials (clay, durable rock), please refer to the geotechnical discussion in Section 7.0

After the contouring and compaction work is completed, a nominal 0.5 meter layer of clean gravel (~20,000 m^3) will be placed on the contoured and compacted subgrade. The gravel will allow any water inherent in the waste rock and the minimal amount of water that would infiltrate into and through the waste rock to drain towards the collection ditches and then to the Sediment/Treatment pond. After placement of the drainage layer, 1.0 meter of till material (~40,000 m^3) will be placed over the subgrade. This material will be compacted and will serve as part of the impermeable base below the encapsulated PAG material.

The Coal Stockpile at the decline site will also be prepared with a compacted subgrade and perimeter ditching to serve as a temporary stockpile for material mined from the Decline. This material will remain at the Coal Stockpile only as long as it takes to transport it to the Waste Rock Facility utilizing surface haulage equipment. Should there be delays moving the material, the Coal Stockpile will serve as an adequate temporary storage facility should it be required.

6.2.4 Waste Rock Facility Construction and Sequencing

The waste rock facility will be constructed from the ground up (as opposed to angle-of-repose construction) in a series of compacted one-half to one meter lifts. The overall side slopes of the facility will be 3h:1v.

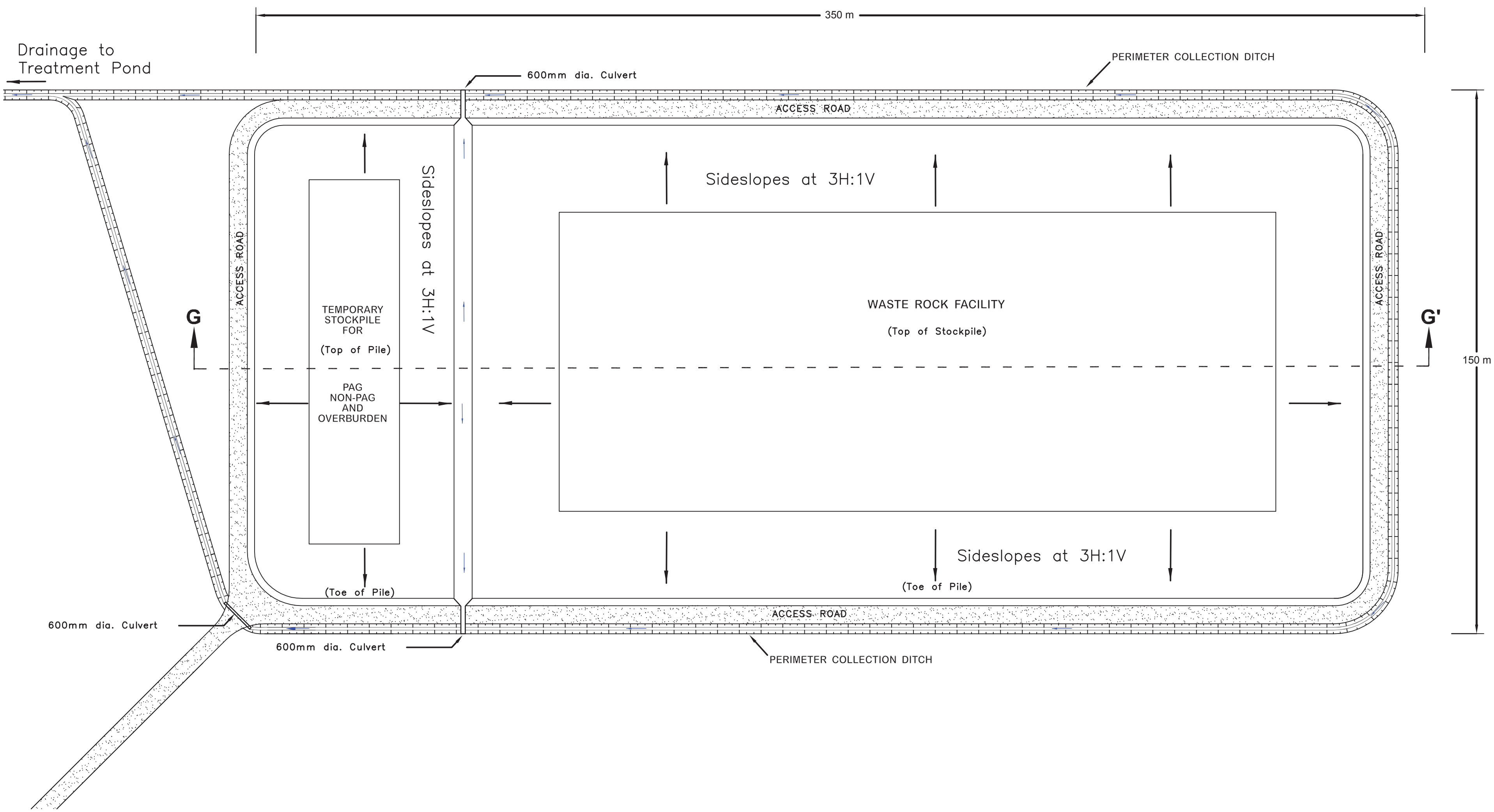
The construction sequence is summarized as follows in the order each formation will be mined:

- **Glacial Till:** There will be an estimated 79,000 m^3 of glacial till excavated from the decline and shaft workings that will be utilized as the base of the Waste Rock Facility. Only 40,000 m^3 will be required for the base. A 1.0 meter thick layer of till will be spread and compacted on the prepared subgrade. The remaining till material will be stockpiled to be used as a final cover for the waste rock and possibly for other construction purposes.
- **Hasler Formation:** There will be an estimated 50,300 m^3 of waste rock from the Hasler Formation that has been identified as PAG. This material will be placed directly onto the compacted base material and spread out in 0.5 to 1.0 meter lifts, then compacted. The material will be offset from the edge of the base material by a minimum of 10 meters.
- **Boulder Creek Formation:** There will be an estimated 18,400 m^3 of material from the Boulder Creek Formation. The Boulder Creek material is comprised predominantly of Non-PAG material; however, there is an estimated 3700 m^3 that is considered PAG that will be encapsulated. All of the Boulder Creek material will be temporarily stockpiled until the Hulcross Formation is mined through and encapsulated. In addition, all Boulder Creek material will be tested for ABA and Shake Flask Extraction and material identified as PAG will be transported to the Waste Rock Facility to be encapsulated along with the Hulcross material. Non-PAG material will be stockpiled for later use as a cover. All Boulder Creek material will be compacted.
- **Hulcross Formation:** There will be an estimated 10,900 m^3 of material from the Hulcross Formation that has been identified as PAG. This material can be directly spread and compacted within the encapsulation layer.
- **Gates Formation:** There will be an estimated 34,700 m^3 of material from the Gates Formation that is Non-PAG; however, the Gates Formation contains two thin non-economic coal seams labelled D and E. For the purpose of this Bulk Sample permit, the D and E coal seams, totalling 2500 m^3, will be considered PAG and will be placed and compacted within the encapsulation layer. Some Non-PAG Gates material may need to be stockpiled temporarily until the coal seams are mined through and encapsulated.

The temporarily stockpiled Non-PAG Boulder Creek and Non-PAG Gates material will be placed, spread, and compacted over the PAG material forming a Non-PAG cover that will be 1.0-2.0 meters thick. The remaining glacial till will then be placed over the Gates and Boulder Creek material followed by a nominal thickness of 25 cm of topsoil as the final cover. Figure 6.2-3 depicts the plan view of the completed Waste Rock Facility and Figure 6.2-4 depicts a cross-sectional view of the completed Waste Rock Facility. A materials balance indicates that there will be approximately 2 times the amount of Non-PAG as PAG meaning that there is an adequate volume of Non-PAG material to ensure that PAG material is effectively encapsulated.

6.2.5 PAG Monitoring Program

HD will commit to conducting programmatic ABA monitoring that will be concurrent with mining. As material is mined and transported to the surface, representative samples will be collected and analysed for ABA and for any oxidized material, a Shake Flask Extraction will be conducted. Formations targeted for testing will be the entire sequence of the Boulder Creek Formation and the transition zones between formations. From previous drilling data, HD has a precise record indicating depth to each formation and the thickness of each formation.



hd Mining

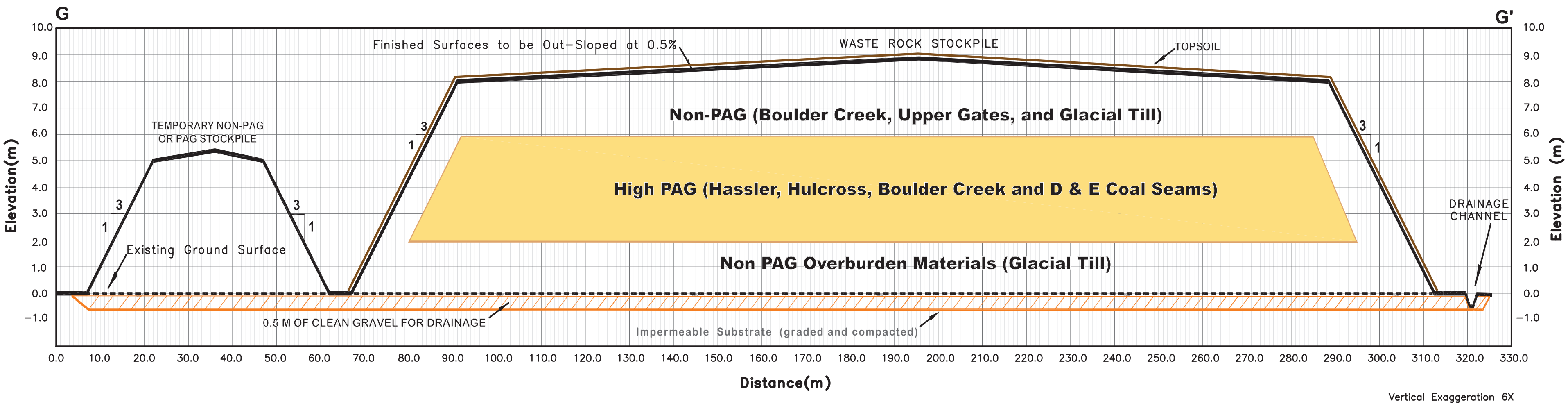
MURRAY RIVER PROJECT

Bulk Sample Site Layout of Waste Rock Facility - Plan View

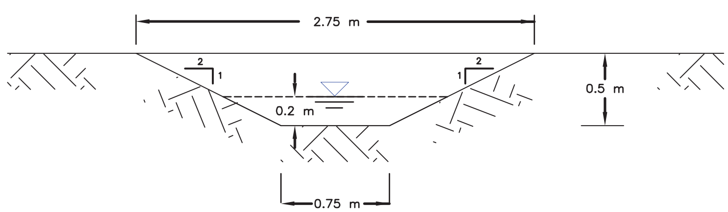
Figure 6.2-3

Rescan Engineers & Scientists

Longitudinal Profile



Detail of Perimeter Collection Channel



Planning Notes:

1. Site to be cleared, grubbed and re-graded (where necessary) prior to construction. Topsoil salvage to be completed.
2. Identified high PAG Waste to be encapsulated by Non-PAG, and Overburden Materials.
3. The entire rock storage area to be lined with an impermeable base layer of suitable native, clay-based materials or engineered liner system.
4. Waste Rock Facility to be constructed at 3 H : 1 V sideslopes.
5. All Rock Waste Materials to be placed in lifts that are to be less than 0.5 to 1.0 m in depth. Each lift of rock waste materials to be dynamically compacted with a sheepsfoot compactor.
6. Perimeter collection channels to have a gradient of approximately 1.0% to ensure efficient conveyance of surface water runoff to water treatment pond.

hd Mining | MURRAY RIVER PROJECT

Cross-section View of Waste Rock Facility

Figure 6.2-4

Rescan Engineers & Scientists

Since mining progress (tonnage and footage) is tracked very closely and recorded, it will be relatively easy knowing where the mining face is in relation to the formations, formation changes, and the intervals that require sampling. The following summarizes the sampling scheme to be implemented:

- **Surface to the top of the Hasler Formation:** Samples will be collected in the glacial till starting at a point 2.0 meters from the top of the Hasler Formation.
- **Bottom of the Hasler Formation to the top of the Boulder Creek Formation:** Samples will be collected starting at a point 2.0 meters from the top of the Boulder Creek Formation.
- **Boulder Creek Formation:** All Boulder Creek material will be temporarily stockpiled and sampled.
- **Bottom of the Boulder Creek Formation to the top of the Gates Formation:** The first 2.0 meters of the Gates Formation will be sampled and tested.
- **Partings (coal-waste mixture):** It is not anticipated that any waste material will be encountered once the F-Seam is reached and full-scale coal production begins, but if any partings are encountered during production, it will all be considered PAG material. It is assumed that once coal production begins, the Waste Rock Facility will be reclaimed so the parting material will be spread and compacted on unused portions of the Waste Rock Facility footprint then covered with an layer of compacted Non-PAG material (glacial till).

HD will commit to having adequate supervision and trained personnel, either HD employees or contractors, to ensure that the mining plan and sequencing is followed and that all PAG material and suspected PAG material is segregated, stockpiled in a designated location, sampled for ABA and Shake Flask Extraction, and finally placed in the Waste Rock Facility as either PAG or Non-PAG material after analytical results are known. No PAG material will remain uncovered longer than it takes to receive analytical results but since the material will be stored on an impermeable liner, exposure will be greatly mitigated. All material to be tested will be transported to the designated temporary stockpile area at the Waste Rock Facility.

Because of safety reasons, samples will not be collected at the mining face, but instead will be collected after the material has been dumped by the haul trucks at the Waste Rock Facility. Samples will be random 5-point composite grab samples. A log will be kept to track the mined footage, volumes, rock type, disposition of material in the temporary stockpile area, sample analytical results, and final disposition of sampled material in the Waste Rock Facility.

In formulating the Waste Management Plan, certain assumptions have been made:

- The Coal Stockpile, located near the Conveyor Decline, will be used as a temporary stockpile area for waste material. As such, the area will be constructed like the Waste Rock Facility and will have an impermeable subgrade. Since coal production will not begin until the shaft and decline development work has been completed, the Coal Stockpile Area will be a suitable location to stockpile material before it is transferred to the Waste Rock Facility.
- It is assumed that the shaft excavation and the decline excavation will occur concurrently and within the time frame proposed by HD in the Notice of Work. However, if the mining schedules and production rates change or there are other mining or weather related delays, there will be adequate space within the Waste Rock Facility footprint and/or the Coal Stockpile footprint to stockpile both PAG and Non-PAG material.
- It is assumed that waste material, both PAG and Non-PAG, will not be directly transported to the Waste Rock Facility from the decline using underground haulage equipment. Waste material from

the decline will be stockpiled temporarily at the Coal Stockpile until surface haulage equipment can transport it to the Waste Rock Facility. All mined material, depending on the mining sequence and pending determination of whether it is PAG or Non-PAG, will either be directly encapsulated or stockpiled temporarily in the temporary stockpile area within the Waste Rock Facility footprint.

HD Mining International Ltd.

MURRAY RIVER BULK SAMPLE
Waste Discharge Permit Application Technical Assessment Report and Notice of Work Addendum:
Comments and Responses

Rescan™ Environmental Services Ltd.
Rescan Building, Sixth Floor - 1111 West Hastings Street
Vancouver, BC Canada V6E 2J3
Tel: (604) 689-9460 Fax: (604) 687-4277

January 2012

The leachate, pending monitoring results, will be discharged to the Sediment Pond for further TSS treatment or discharged directly to M20 Creek if discharge standards are met. If metal concentrations are elevated, the leachate will be transported off-site for treatment and disposal.

It should be noted that during excavation of the Decline and the Shaft, PAG material will be temporarily exposed to air and water. It is anticipated that ARD reactivity will not be an issue as the exposure time will be short and both the Decline and Shaft will be lined with concrete further limiting the exposure of PAG material.

COMMENT 3

The waste rock management strategy presented in Section 6 of the TAR proposes to segregate rock identified as PAG and encapsulate this material with non-PAG waste rock to prevent contact with air and water. As stated at the November 16, 2011 meeting, MEM has a number of concerns with this proposal related to both conceptual plans that are presented and details of implementation of this plan operationally (Question 18 from the September 17, 2011 email).

a. Overall, there is a concern that the encapsulation plan will not be capable of preventing air and water from interacting with the PAG waste rock. This presents an environmental and financial liability as there could be a future requirement for treatment if weathering products from the PAG materials are released from the dump.

b. The cover system is the critical component to effective encapsulation of PAG waste. There is no cover design presented to indicate how the proposed cover will prevent water infiltration. Currently the TAR states that overburden and non-PAG Boulder Creek will be compacted to create an impermeable cover. There are examples of other site in British Columbia (e.g. Equity Silver) where an engineered till cover system has proven ineffective for preventing water infiltration. The Boulder Creek Formation is a combination of sandstone, conglomerate, shale and mudstone. It is not clear that compaction of this rock would produce an effective impermeable layer. The overburden may be better suited for this and sequencing of the cover material requires further consideration.

c. MEM strongly recommends consideration of a geosynthetic cover for this waste rock dump.

d. Cover design specifications are required prior to permitting.

e. An appropriate reclamation plan for the waste rock dump is required and must include a maintenance schedule. Note that the integrity of some cover systems is compromised by tree growth (e.g. the design as currently proposed will not be able to support tree growth as this would affect the integrity of the cover).

f. Section 6.2.3 describes subgrade preparation. Details should be provided to describe design for contouring of subgrade to ensure the waste rock dump may be constructed in a manner that prevents water from ponding beneath the dump.

g. The design indicates that the base of the dump will be a 0.5 m layer of gravel to allow drainage under the dump and also drainage of water through the dump. On top of the gravel is a 1 m thick compacted till layer intended to act as an impermeable base for the PAG material. How will this impermeable till layer be designed to avoid a perched water table in the PAG rock? What design parameters are used to ensure adequate compaction of the till? Does the gravel layer under the compacted till present any geotechnical issues if water is moving through this layer?

h. There is a discrepancy between dimensions quoted in the text of the TAR (page 6-3) and those shown on the plan view schematic (Figure 6.2-3). Please correct this in the detailed designs.

i. MEM strongly recommends that consideration be given to the ability to move waste rock into the underground if this project proceeds to full-scale mine development in the future.

RESPONSE 3

The above comments are addressed in the following sections. Initial site preparation, foundation preparation, cover design, and drainage control and treatment for the WFR are discussed. A surface reclamation and mine closure plan is presented in the response to Comment #8.

Construction elements for the WRF consist of logging, clearing and grubbing, salvaging topsoil and till for later reclamation and grading the surface so that any water (leachate or precipitation) infiltrating through the WRF will be directed to collection ditches along the perimeter of the WRF. Site preparation, along with the WRF foundation liner system, will prevent water infiltrating through the soil column and into any near-surface groundwater. Figure 1 depicts a plan view of the WRF including the temporary stockpile area, a lined leachate collection pond, and the perimeter ditch system. As discussed in the TAR, storm water diversion ditches and other erosion control BMPs will be constructed and installed around the WRF footprint area to prevent soil loss from the footprint area.

Site Preparation

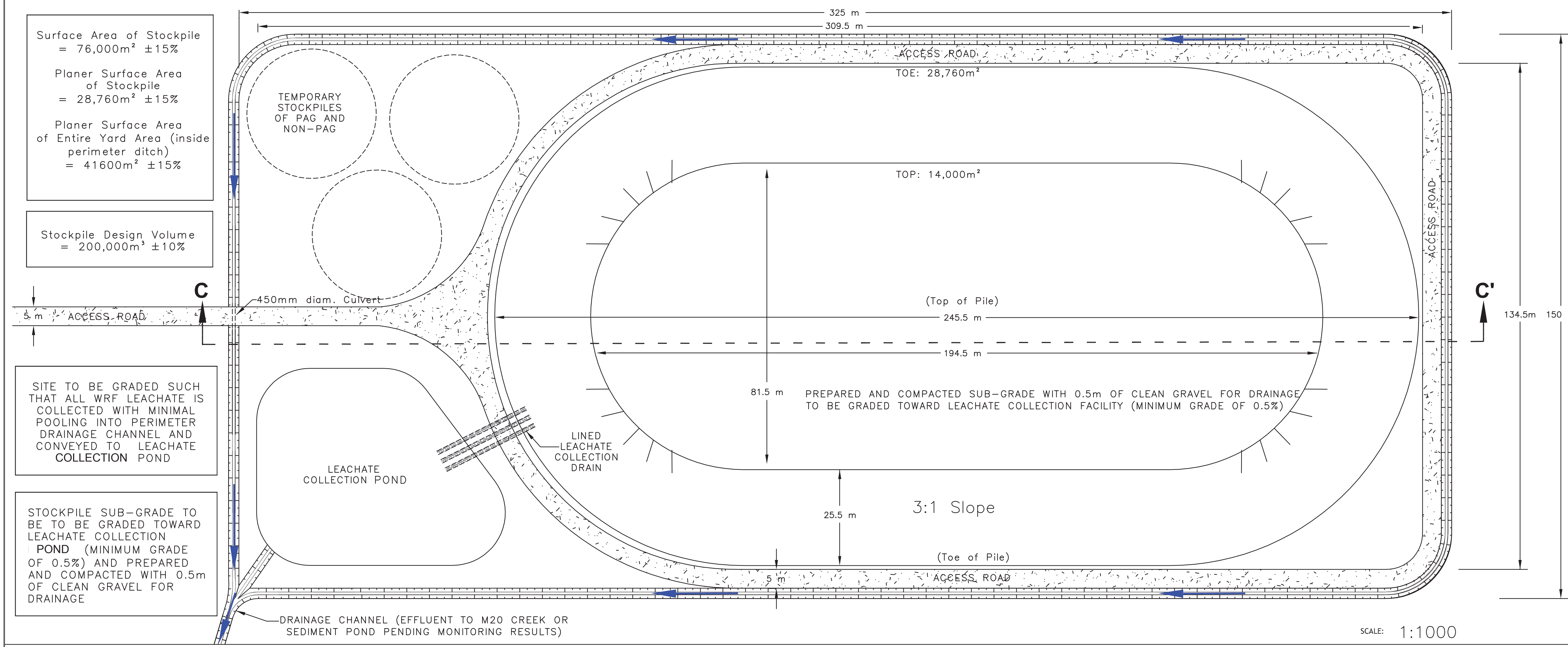
Clearing and grubbing entails the removal of all timber and vegetative material from the WRF footprint area (approximately 325 m X 150 m). Unusable timber, slash, and vegetative debris will be cleared and pushed into stockpiles along the perimeter of the footprint to be used to create micro-habitats for wildlife during future reclamation. The topsoil (A and B soil horizons) will be salvaged from WRF footprint area and stockpiled. It is estimated that up to 50 cm or 26,000 m^3 of topsoil can be salvaged from the WRF footprint. Living plant fragments and seeds contained in the soil's seed bank will regenerate once the soils are applied to the reclamation site and will assist with re-vegetation efforts. Stumps, unusable timber, and other small woody debris will be placed along the perimeter of the cleared footprint area to be used to create substrate diversity during future reclamation. Any loose surface till will also be salvaged and stockpiled for later use. The WRF footprint will be graded and contoured (nominal 1% slopes) so that any drainage of water from beneath the waste rock and foundation liner system will report to the perimeter collection ditches.

Once contouring is complete, the native material will be compacted. Accepted industry standards for compaction will be followed. Through soil sampling and laboratory testing, HD will determine the optimum compaction density (ASTM D1557 - Proctor Density) and moisture content for the native material. HD will also conduct an investigation, both on-site and off-site, to determine a source of usable clay material.

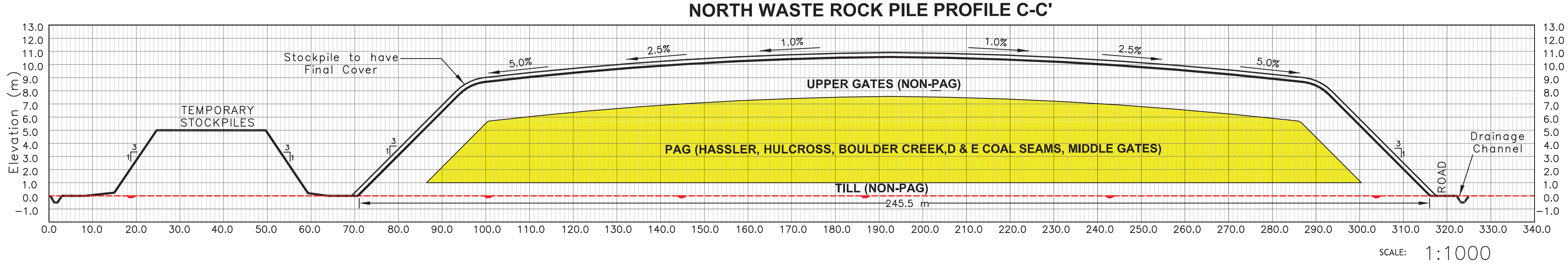
Foundation Preparation

The foundation liner system will consist of a 30 cm compacted clay layer as the primary barrier layer. It is anticipated that an off-site source of suitable clay can be located for the clay liner; however, as much on-site native material will be used as possible. HD will identify and utilize both on-site and off-site clay sources as needed. Should a suitable source of clay material not be found, HD will install, in lieu of the 30 cm compacted clay layer, a Geosynthetic liner – either a Geosynthetic Clay Liner (GCL) or a HDPE liner. Installation Guidelines for both liner systems are included as part of Appendix A.

Overlying the 30 cm of compacted clay layer will be 0.5 m of clean gravel. The gravel layer will direct any leachate away from the clay liner and to the perimeter ditches. The gravel will also serve as a cushion for the clay liner. The gravel will be comprised of hard and durable material with no construction or geotechnical related issues.



NORTH WASTE ROCK PILE PROFILE C-C'



HD Mining | MURRAY RIVER PROJECT | Rescan Engineers & Scientists

Figure 1

Murray River Bulk Sample Site Conceptual Layout of North Waste Rock Stockpile during Operations

Overlying the gravel layer will be a 0.5 m layer of compacted till. The compacted till will serve to cushion and protect the underlying clay and gravel drainage layer as well as provide a stable base for the placement of the PAG material. Overlying the till layer will be the compacted PAG material that will be placed as described in Section 6.0 of the TAR. All materials will be compacted in accordance with accepted industry standards. Figure 2 graphically depicts the foundation liner system.

Engineered Cover

An engineered cover system will be installed over the WRF to minimize infiltration of water (precipitation/snowmelt) into the underlying waste rock. Once placement of the compacted waste rock material is completed, a 30 cm thick layer of till will be placed over the waste rock and compacted (Figure 2). A 30 cm compacted clay layer will then be placed on the till material to form a near impermeable barrier. Once the 30 cm compacted clay layer has been placed, a 50 cm thick layer of till, slightly compacted in the lower 25 cm, will be placed. The upper non-compacted 25 cm will provide a suitable zone for water storage and rooting for the vegetation. The till will be covered with a 25 cm thick layer of topsoil that will be seeded with a rapidly establishing vegetative cover of native grasses and legumes to reduce the potential of surface erosion. The topsoil will contain seeds and organic material native to the site. The 75 cm cover will be sufficient to support grasses and shrubs and as the vegetation grows and spreads, the more evapo-transpiration will occur helping to minimize the amount of water that could infiltrate into the WRF.

If there is insufficient clay material to utilize as part of the cover liner system, a 40 mil (1.5 mm) thick HPDE liner or a GCL will be installed in lieu of the 30 cm of compacted clay. The WRF will have a nominal 5% slope to ensure positive drainage off the WRF and to ensure that surface ponding does not occur. The slopes of the of the WRF will be maintained at a 3H:1V further promoting surface runoff and reducing downward movement of precipitation into the WRF.

Table 2 provides precipitation data for the area around the Project site. The Denison Plant site is approximately 7.5 km east of the Project site and Tumbler Ridge is approximately 12.5 km northeast of the site. Based on the data from these stations, mean annual precipitation at the Project site averages approximately 580 mm with 35% falling as snow between late September and early May (Table 2). Snowmelt will generally occur in May. That is, approximately 205 mm could be available as snowmelt. However, it is expected that when snowmelt occurs, the melted snow will generally runoff the WRF as the ground will be frozen.

Adhering to Construction QA/QC guidelines for installing clay or HDPE liners is essential. Successful installation of these types of liners is very dependent on weather conditions, both in terms of temperature and moisture. Table 2 indicates that April and May have the most favourable conditions for construction; however, weather conditions must be monitored on a daily basis. HD Mining will hire qualified earth moving contractors to construct the WFR as well as qualified contractors to install the clay or geosynthetic liner systems. Construction of the WRF will adhere to accepted industry standards for subgrade preparation, material compaction, and installation of liner systems. Construction QA/QC documents are included in Appendix A.

Drainage Control and WRF Water Management

As described in Sections 6.0 and 7.0 of the TAR, a lined ditch system will be constructed around the perimeter of the WRF. The projected small quantities of leachate from the WRF and any surface run-off water from the footprint will be collected and routed to a lined (clay or geosynthetic liner) leachate collection pond located within the WRF footprint. Water reporting to the collection pond will be sampled and analyzed for metals and TSS. Pending monitoring results, the leachate will be discharged to the Sediment Pond if TSS levels are elevated or discharged directly to M20 Creek if discharge standards are met. If metal concentrations are elevated, the leachate will be transported off-site for treatment and disposal.

PROJECT # 791-004 ILLUSTRATION # a34233w December 13, 2011

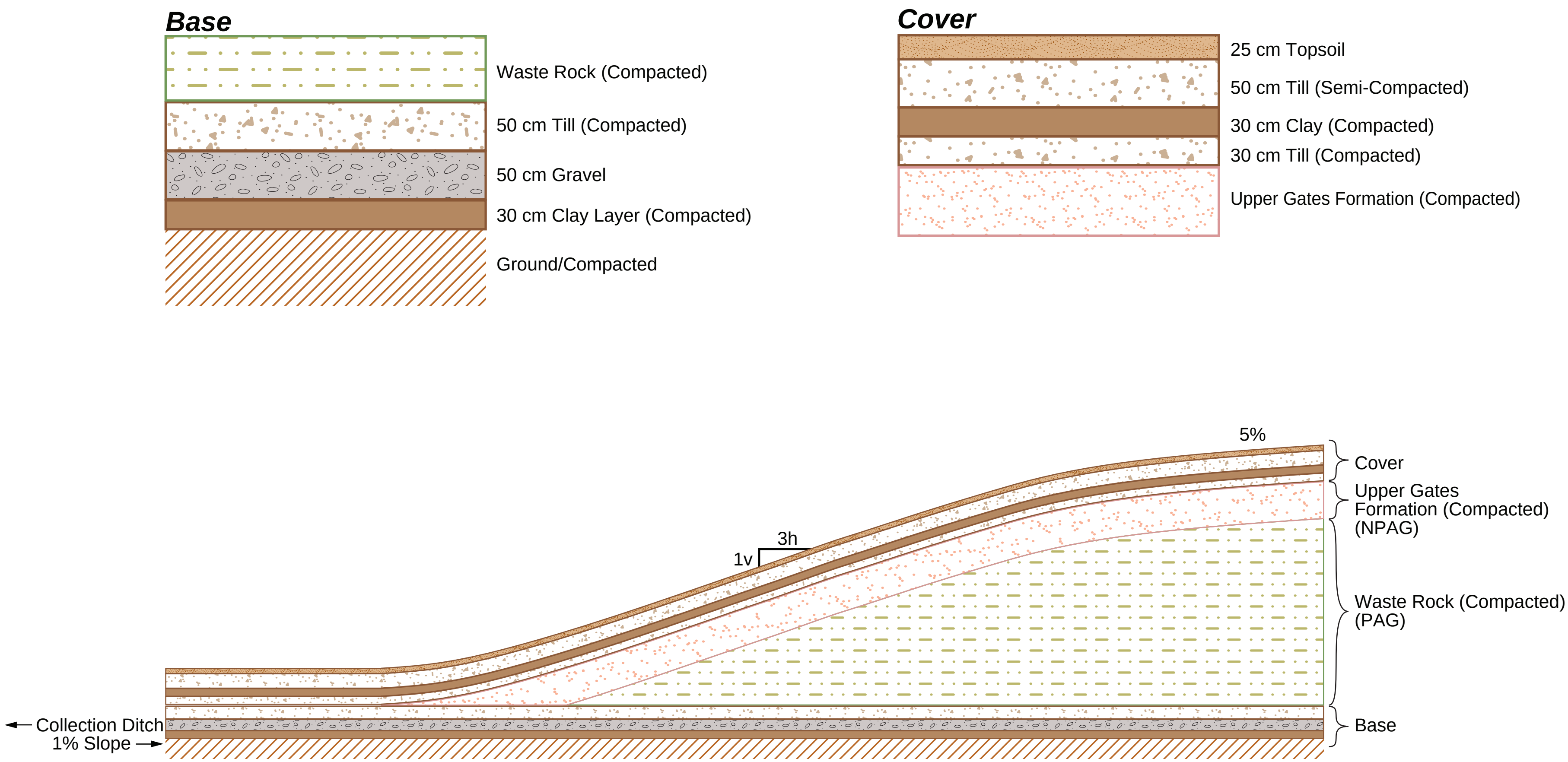


Figure 2

MURRAY RIVER PROJECT

Cross-section View of Waste Rock Facility

Figure 2

Table 2. Precipitation Data for Denison and Tumbler Ridge Sites

	Denison Plant Site Average Accumulated			Tumbler Ridge Average Accumulated		
Month	Rain (mm)	Snow (cm)	Precipitation (mm)	Rain (mm)	Snow (cm)	Precipitation (mm)
1	5	37	41	2	35	37
2	3	24	26	1	24	25
3	3	34	35	3	32	35
4	17	13	30	12	10	21
5	27	4	31	27	3	30
6	83	0	83	73	0	73
7	88	0	88	77	0	77
8	52	0	52	56	0	56
9	52	2	54	36	2	38
10	30	20	49	13	13	26
11	5	47	52	5	36	41
12	3	31	33	3	25	27

It is anticipated that the amount of leachate infiltrating through the WRF will be minimal and intermittent and when the cover system is in place, the amount of leachate reporting to the collection pond will approach zero. In order to monitor infiltration into and through the WRF, HD Mining will install piezometers (vibrating wire or standpipe) in the completed WRF. The piezometers, set at different depths within the waste pile, will allow HD to monitor the effectiveness of the cover system (post-reclamation) by measuring water levels within the stack (if any) and to determine if any residual water is perched above the foundation clay liner. A description of a vibrating wire piezometer is included in Appendix A.

The WRF leachate collection pond, as in the case of the larger Sediment Pond, will be constructed and operational prior to the construction of the WRF. In this way, leachate from the WRF can be collected and managed as the WRF is under construction when PAG material will be temporarily exposed.

The site-specific water quality monitoring plan as discussed in Section 9.0 of the TAR has been amended to include monitoring from the proposed WRF leachate collection pond. Although design details need to be formulated based on estimated leachate flows from the WRF, it is expected that the small quantity of leachate from the WRF will be intermittent and finite. The system will be of adequate size to hold the leachate water until analytical results are received and final disposition of the leachate can be determined. Table 3 is the revised Water Quality Monitoring Plan.

Although Comment #8 states the requirement that HD provide a Reclamation and Closure Plan for the Bulk Sample Project as a contingency in case full-scale long-term mining will not occur, it is clear that HD is committed to long-term mining at their Murray River Project and is prepared for the Environmental Assessment process. HD is aware that underground backfilling of waste material is an option that will be presented during the Environmental Assessment process. HD will analyze and evaluate the underground backfill option in terms of feasibility and cost in preparation for the Environmental Assessment.

Table 3. Water Quality Sampling Frequency, Duration and Analytical Parameters

Location	Monitoring Installations	Sampling Frequency	Sampling Duration	Parameters To Be Monitored
WRF (downgradient)	Four to 6 wells approximately 6 m to 10 m deep	Quarterly during operations and biannually thereafter	During operations and 3-5 years post-closure	pH, alkalinity, hardness, major/minor anions and cations, nutrients, and dissolved metals
Sediment Ponds	End of Pipe or grab sample at spillway; Turbidity from pond	Weekly; Daily turbidity	During operations	flow, pH, TSS, major/minor cations and anions, turbidity, nutrients, and total metals
WRF Leachate Pond	End of Pipe or grab sample from collection pond	As needed	During operations and 3-5 years post-closure	TSS, pH, total metals
WRF	3-4 Piezometers	Weekly	3-5 years post-closure	Water level

COMMENT 4

Section 6 notes that all materials characterized as uncertain will be considered PAG (page 6-2). In the geochemistry section, the uncertain classification is defined as samples with SNPR values between 1 and 2. Table 6.2-1 indicates that all Hasler, Hulcross and Gates D and E coal seams will be PAG. It also indicates that 20% of the Boulder Creek Formation is assumed to be PAG (note that section 5 states Boulder Creek is 25% PAG).

a. Section 5 notes that 25% of the Middle Gates Formation is assumed to be PAG. Is this the same material as the Gates D and E coal seam or is this different rock? If it is different rock, why will it not be managed the same way as the Boulder Creek PAG waste rock?

b. Section 6 indicates a commitment to segregate PAG and non-PAG rock and defines rock with an SNPR<2 as PAG. It has been made clear that all Hasler and Hulcross waste rock is defined as PAG. It has also been made clear that sampling of the Boulder Creek Formation will be required to segregate the PAG from non-PAG. Will sampling be completed for all other units to enable segregation and appropriate handling of materials with an SNPR<2? Clarification is required. (see also question 11 of the September 17, 2011 email)

c. How will sampling and segregation be completed operationally? There was discussion about this at the meeting on November 16th. This is an important part of the waste management plan as it is presented in the TAR. Operational details are required, if segregation is not operationally practical, are there other options available? Thought needs to be given to what test procedures will be used, where analyses will be completed and turn-around times for data. An operational waste rock management plan is required to be submitted to MEM before this bulk sample can be permitted. (see also question 12 of the September 17, 2011 email)

d. During planning and sequencing of waste rock dump construction, measures should be in place to minimize the requirement for temporary stockpiles that leave PAG rock exposed for extended periods of time.

RESPONSE 4

a) The Middle Gates Formation is assumed to be 25% PAG (PAG defined as SNPR < 2). Additionally, the D and E coal seams are also considered PAG. All Middle Gates material will be sampled and tested for ABA in accordance with the PAG Monitoring Plan (Response #6) with the exception of

GeoEngineering Ltd.

Sustainable and Thorough Solutions

Vancouver, BC
Tel: 604-737-4794
info@GeoEngineeringLtd.com

MEMORANDUM

TO: Bob Askin, PGeo, PEng, Rescan Environmental Services Ltd.

FROM: Ali Ameli, PE, PEng

PROJECT: Murray River Coal Project

PROJECT No: 12 – 27 (Rev 2)

DATE: September 21, 2012

SUBJECT: Waste Rock Facility Stability Assessment – Use of Geomembrane Instead of Clay Liner

PROJECT OVERVIEW

It is planned to store the waste rock produced during the bulk sample process in an area of approximately 150 m x 300 m at the North Mine Site. The waste rock area should have stable slopes and be designed to contain the potential acid generating rockfill materials.

A comprehensive study (Reference 1) was carried out by Rescan (RES), which assumed the use of clay liners at the base and in the final engineered cover in design of the waste rock facility.

With the reported scarcity of clay sources in the vicinity of the project area, Geo Engineering Ltd. (GEL) was retained by RES to extend the design of waste rockfill facility, using alternative geosynthetic membranes. GEL's study is therefore supplementary to the original RES design, and this memorandum should be read in conjunction with Reference 1.

We understand the waste rock, produced by the excavation of the overburden and bedrock, consists of angular rock fragments ranging in size from boulders to sand and silt size particles. The rockfill pile will have a total height of up to 10 m with a perimeter drop slope of 3H:1V.

ANALYSIS

GEL conducted an independent slope stability (limit equilibrium) analysis based on overall configurations given in the original design. A detailed view of the stockpile base is shown in Appendix A.

The original assessment (Reference 1) was carried out using Morgenstern-Price method. Bishop method that has also been allowed for the analysis of circular surfaces (Reference 2) was adopted by GEL for the current analysis. GSLOPE software was used. The analysis was further checked by Janbu's simplified method and lower factor of safety values were recorded. Nevertheless, the difference in factor of safety obtained by various methods has been found to be within 5% of each other, which would have insignificant impacts on the range of factors of safety obtained in this study.

The soil parameters for the GEL slope stability analysis were chosen based on the field tests data, reported in GDR (Reference 3). The reports reviewed did not indicate groundwater level (except a minor perched water) at the site. The recent groundwater data in the monitoring wells obtained from

RES for the North Mine Site indicated a groundwater depth of more than 3.3 m from the surface (Reference 4). GEL analysis for slope stability under static and pseudo-static conditions was based on the assumption that the groundwater level would be at the ground surface raising up to 2 m above the membrane within the waste rock stockpile. This situation would mimic a flood condition at the site and produce conservative values for the factors of safety.

The results of stability analysis during construction (Short Term) and after placement of the engineered cover (Long Term) are shown in Table 1. Similar to the June 2012 assessment, the target minimum design factors of safety suggested by BC Mine and Waste Rock Pile Research Committee (Reference 5) were adopted as presented in Table 1 below.

Table 1: Minimum Factor of Safety for Slope Stability

Graphic Results	Stability Condition	Calculated Minimum Factor of Safety	Suggested Minimum Factor of Safety
Stability of Surface			
Fig. 1	Short Term (during construction)	2.1	1.0
Fig. 2	Long-Term (reclamation – abandonment)	1.8	1.1
Deep-Seated Stability			
Fig. 3	Short Term (static)	1.9	1.1 – 1.3
Figs. 4 and 5	Long-Term (static)	1.8 and 2.0	1.3
Figs. 6 and 7	Seismic (Pseudo-Static)	1.3 and 1.4	1.0

CONCLUSIONS

- When geomembranes are used instead of clay liners, the calculated factors of safety remain higher than the specified target values under static and pseudo-static conditions (Table 1).
- The groundwater is assumed to be at the ground surface, which resembles a temporary flood condition. The calculated factors of safety are thus conservative values for the factor of safety during the service life of the project.
- Till materials are known to have low water conductivity. The till materials above the gravel, noted in the original RES design, must be selected from materials that have adequate permeability to facilitate drainage of water in the waste rock into the gravel layer.

FINAL REMARKS

There is the potential for the medium-dense sand layer (indicated with a limited extent in one of the boreholes in the vicinity of the project) to liquefy in a seismic condition, if saturated. Such an occurrence might compromise the foundation stability in the proposed waste rock area. The scope of this report does not include a detailed study to assess the possible consequences of a potential liquefaction incident on the foundation soil and the enclosing membrane.

The study in this memorandum was conducted based on a literature review of the information supplied to GEL in References 1, 3 and 4. GEL scope of work did not include the assessment of the accuracy and adequacy of geotechnical engineering data obtained by others.

REFERENCES

1. Murray River Coal Bulk Sample Project. Waste Rock Facility Stability Assessment, Rescan, June 29, 2012.

2. Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Landslide Hazards in California. ASCE Organized Committee, Published by SCEC, 2002.

3. Geotechnical Data Report for Surface Facilities. Murray River Coal Project, Tumbler Ridge, BC. Golder Associates, Dec 2011 (85 pages).

4. Murray River North Site Groundwater Level Readings. Email from Rescan Environmental Services Ltd. Sep 18, 2012.

5. British Columbia Mine Waste Rock Pile Research Committee, Interim Guidelines, Investigation and Design Manual, May 1991.

For and on the Behalf of

Geo Engineering Ltd.

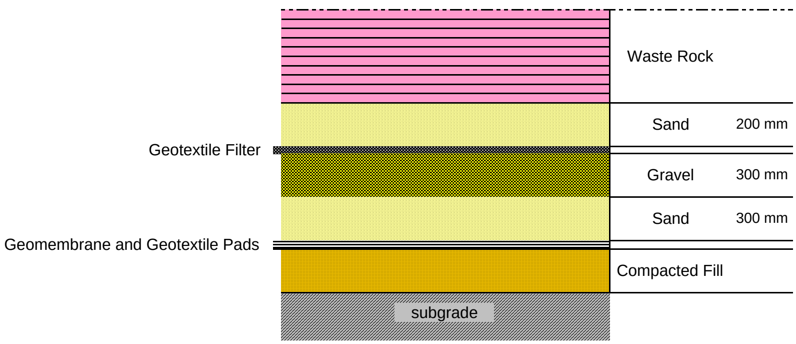
21/09/2012

Ali Ameli, PE, PEng

Attached: Appendix A and Figs 1 to 7

APPENDIX A

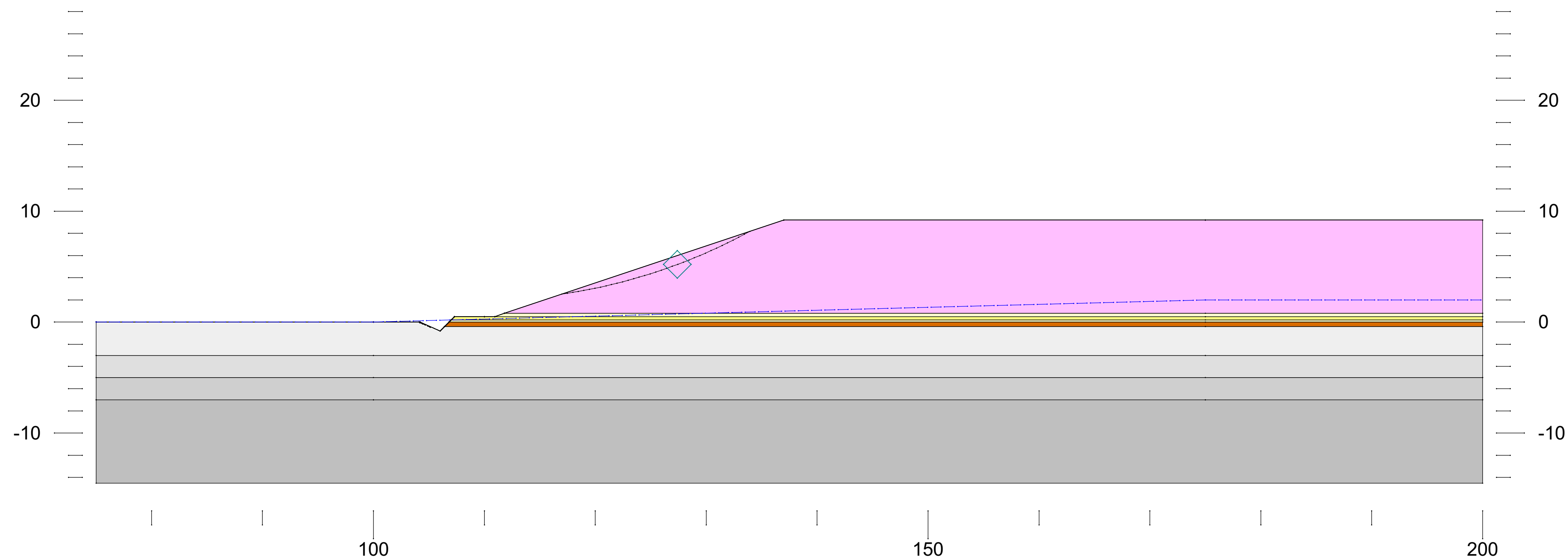
Detail of Stockpile Base Preparation



	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	32	1
Fill	19	0	34	1
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

F = 2.130

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes



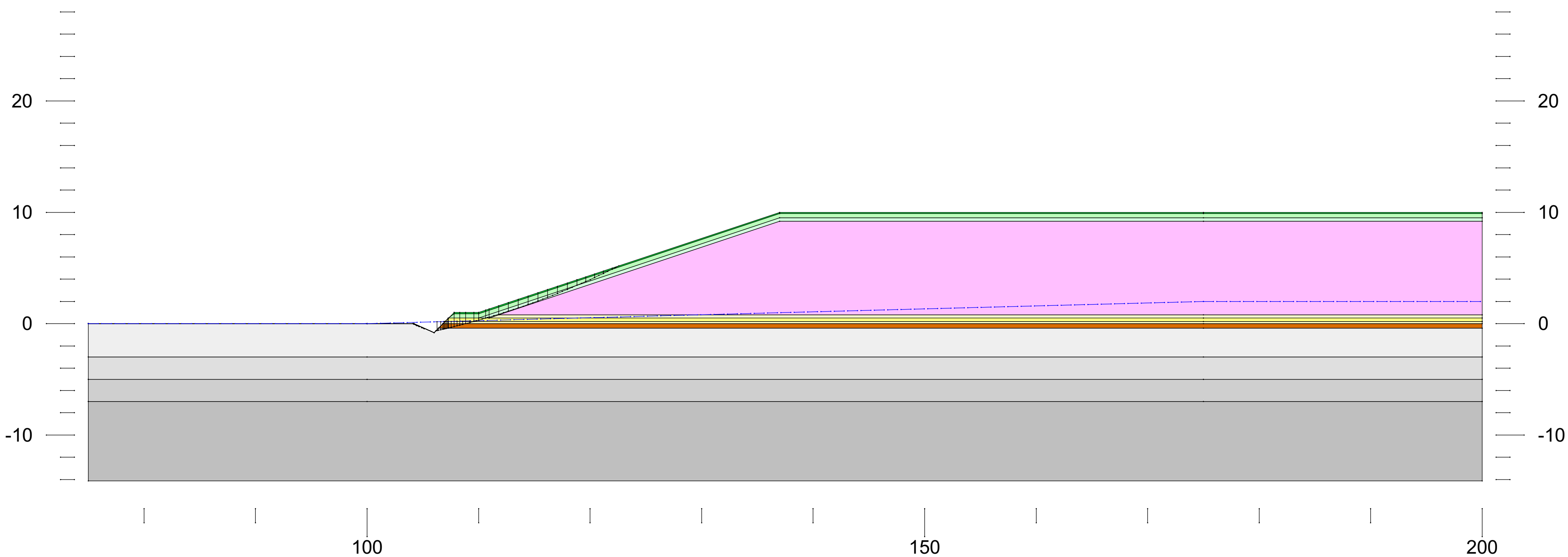
9/17/2012 7:08:38 PM E:\New folder (2)\finals\12-27 (109.7, 52.6) - shallow static (short term).gsl Geo Engineering Ltd. - Vancouver BC F = 2.130

Fig. 1

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	32	1
Fill	19	0	34	1
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

F = 1.835

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes

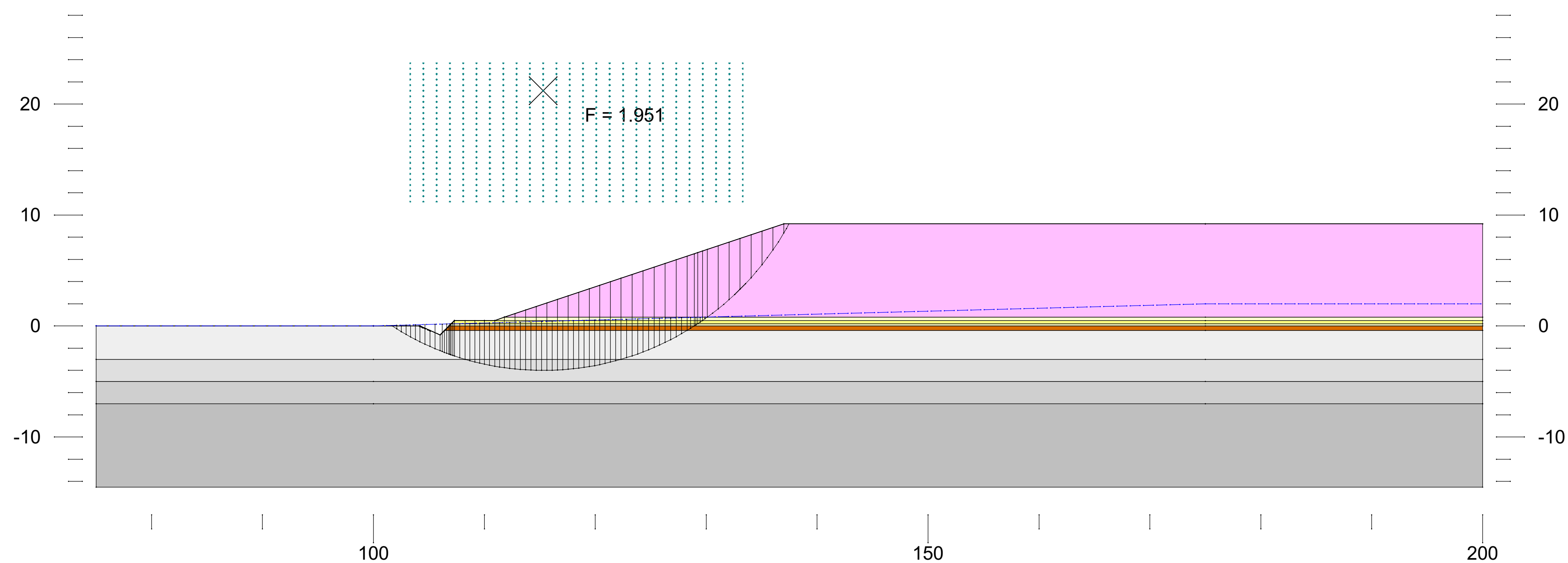


9/19/2012 11:48:06 PM E:\New folder (2)\finals\12-27 (91, 68) - shallow static bishop 1.834.gsl Geo Engineering Ltd. - Vancouver BC F = 1.835

Fig. 2

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	32	1
Fill	19	0	34	1
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes

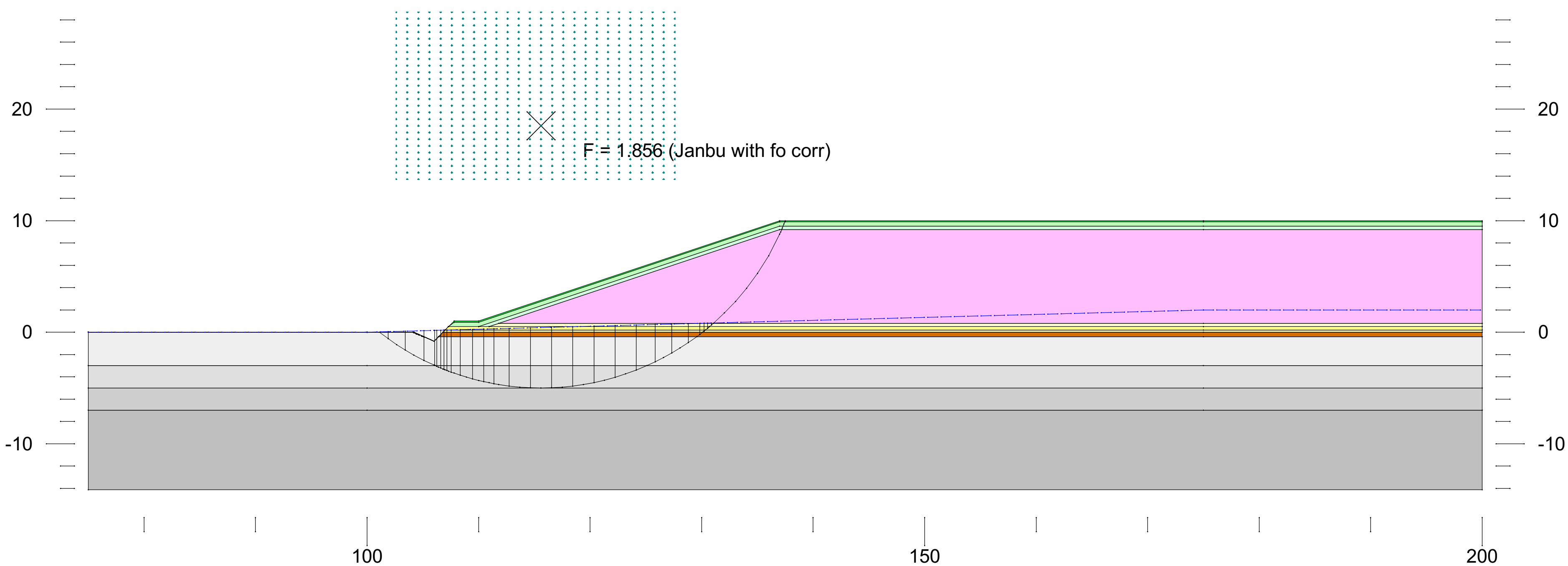


9/19/2012 11:52:35 PM E:\New folder (2)\finals\12-27 (115.3, 21.2) - deep no cover static (short term).gsl Geo Engineering Ltd. - Vancouver BC F = 1.951

Fig. 3

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	32	1
Fill	19	0	34	1
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes

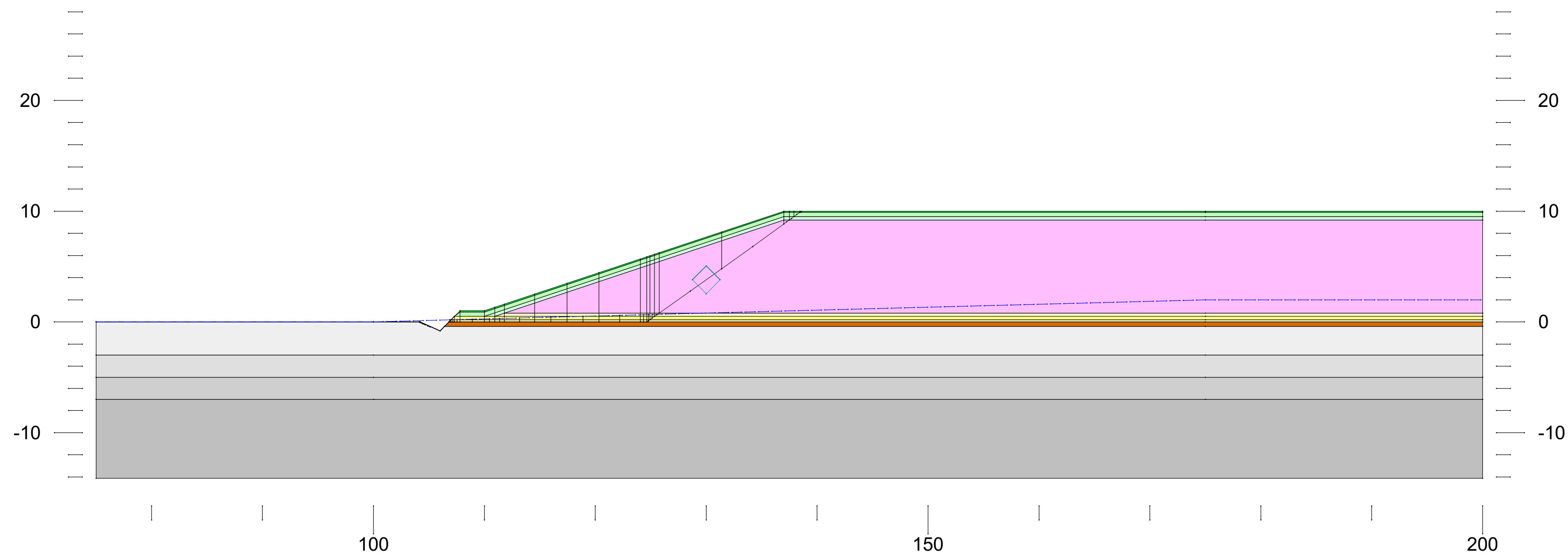


9/20/2012 12:04:45 AM E:\New folder (2)\finals\12-27 (115.6, 18.5) - deep static janbu.gsl Geo Engineering Ltd. - Vancouver BC F = 1.856 (Janbu with fo corr)

Fig. 4

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	30	1
Fill	(Infinitely Strong)			
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes



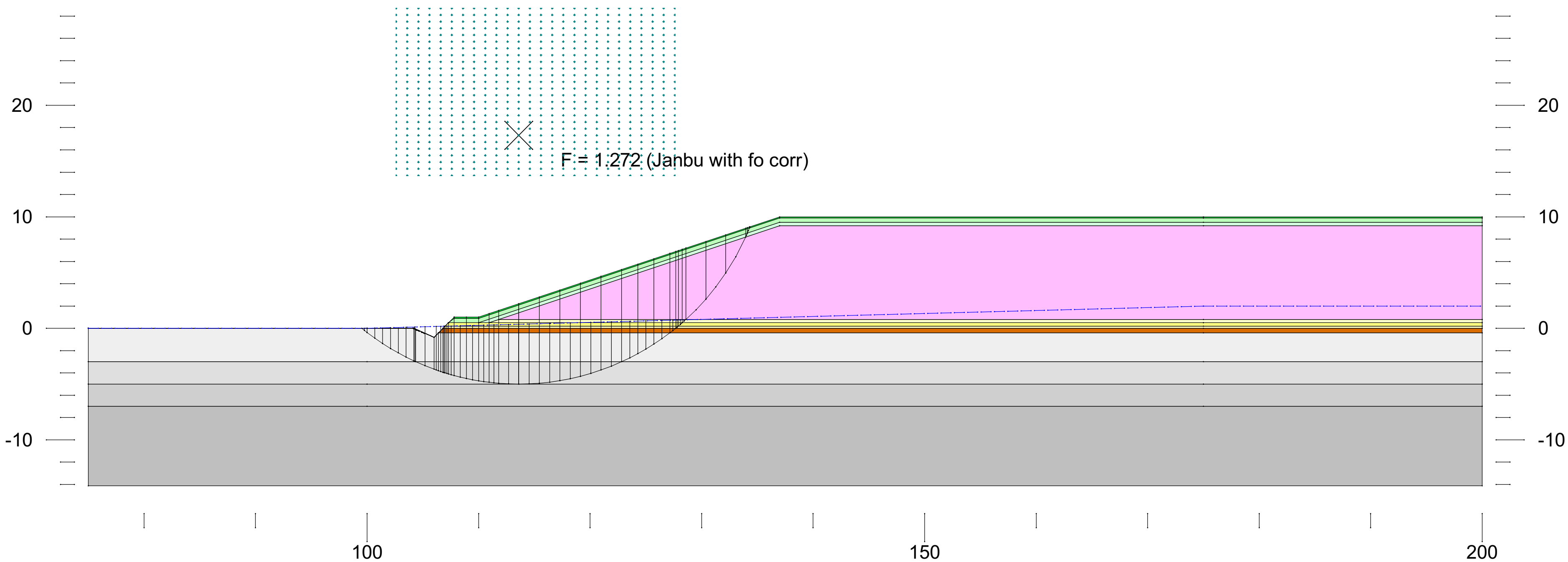
9/21/2012 10:32:02 AM E:\New folder (2)\finals\12-27 (-435,796) - partial sliding on membrane with phi=30.gsl Geo Engineering Ltd. - Vancouver BC F = 2.054

Fig. 5

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	32	1
Fill	19	0	34	1
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

Seismic coefficient = 0.123

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes



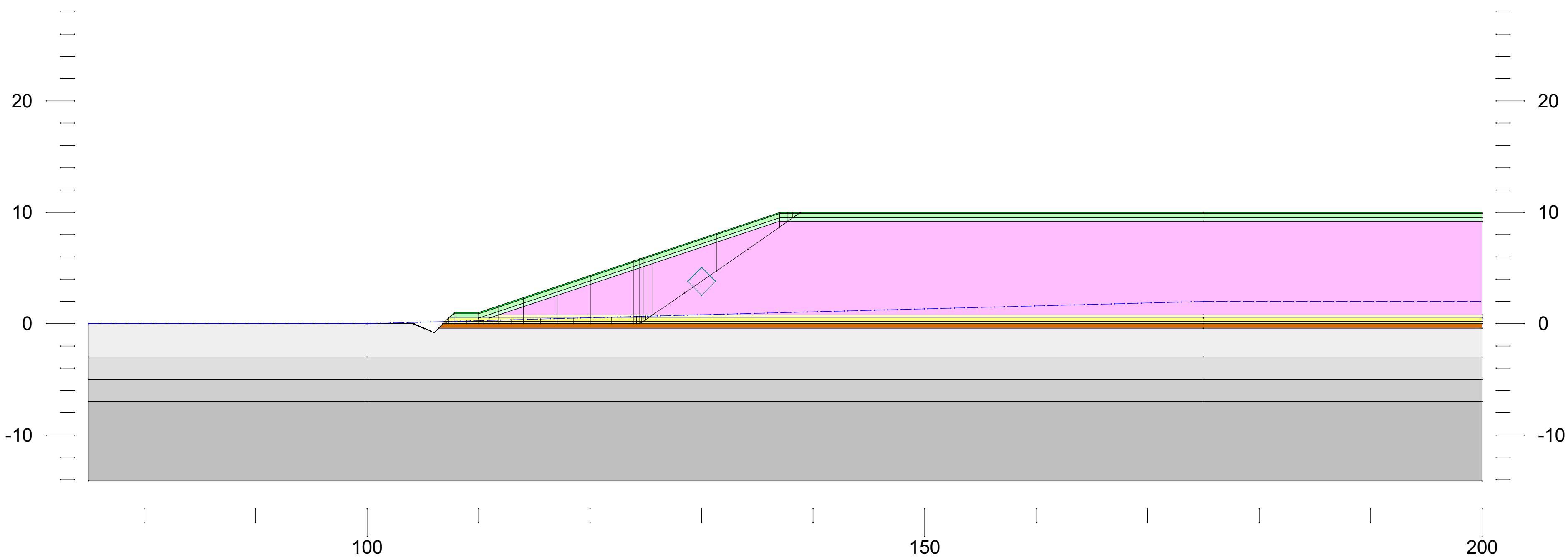
9/21/2012 10:47:44 AM E:\New folder (2)\finals\12-27 (113.6,17.3) - deep seismic.gsl Geo Engineering Ltd. - Vancouver BC F = 1.272 (Janbu with fo corr)

Fig. 6

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Till	18	2	32	0
Till	18.5	0	32	0
Till	19	0	33	0
Waste Rock	21	0	35	1
Sand	19.5	0	33	1
Gravel	19.5	0	34	1
Sand	18.5	0	30	1
Fill	(Infinitely Strong)			
Sand + Gravel some s	19	0	33	1
Alluvium	18	0	31	1
Alluvium	19.5	0	34.5	1
Silty Sand some grav	21	0	40	1

Seismic coefficient = 0.123

Geo Engineering Ltd. - Vancouver BC
12-27
Murray River Coal Project - Waste Rock Facility
Sep 17, 2012
Stability Assessment
Design Modification - Use of Geo Membranes



9/21/2012 10:36:32 AM E:\New folder (2)\finals\12-27 (-450,844) - partial sliding on membrane with phi=30 EQ.gsl Geo Engineering Ltd. - Vancouver BC F = 1.429

Fig. 7

MURRAY RIVER COAL PROJECT

SOIL LIQUEFACTION EVALUATION (WASTE ROCK FACILITY)

4			
3			
2			
1	October 3, 2012	Signed and Sealed	A Ameli
0	September 29, 2012	Issued for Discussion	A. Ameli
Rev.	**Date**	**Subject of Revision**	**Author**

1 INTRODUCTION

It is planned to store the waste rock produced during the bulk sample process in an area of approximately 150 m x 300 m at the North Mine Site. The rockfill pile will have a total height of up to 10 m with a perimeter drop slope of 3H:1V. The stability of the waste rock facility slopes was assessed by Geo Engineering Ltd. (GEL) using geomembranes instead of clay liners to contain the acid generating rockfill materials in the facility (Reference 1). It was concluded that the calculated factors of safety remained higher than the specified target values under static and pseudo-static conditions.

According to the site investigation data, in some portions of the site, the waste rock facility foundation contains a layer of medium to coarse sand with little silt exhibiting relatively small SPT blow counts. Such materials, if saturated, would have the potential to liquefy in a seismic event, causing displacements in the foundation soils. If liquefaction occurs, the stability of rockfill slopes and the integrity of the enclosing membrane will be compromised.

This memo evaluates the liquefaction resistance of foundation soils using the simplified procedure to complete the waste rock facility assessment (Reference 1) under seismic conditions. The assessment was carried out for the soil profile encountered in test hole TH09, which is located close to the southwest portion of the waste rock facility.

2 SEISMIC SITE RESPONSE PARAMETRS

Seismic design of the rockfill stockpile will be based on and in conformance with the 2010 National Building Code of Canada (NBCC). The 2010 NBCC defines the design earthquake as one with ground motion parameters having a 2% probability of exceedance in 50 years (i.e., a 1:2,475 year return period earthquake event). The ground motion parameters are shown in Appendix A. Seismic site response parameters were then obtained for the assumed site “Class D”.

3 GEOTECHNICAL PARAMETERS

3.1 General

The site-specific soil information used for the liquefaction triggering assessment was obtained from an excerpts of the Geotechnical Data Report (GDR) submitted to GEL (References 2 and 3). Key input soil parameters required for the analysis include the standard penetration test data, percentage of fines in granular materials and groundwater readings.

3.2 Soil Profiles and Properties

Liquefaction assessment was carried out for the soil profile encountered in test hole TH09. The test hole incorporates medium to coarse sand and gravel with some silt containing rounded cobbles exhibiting a SPT value of 28. This layer is underlain by medium to coarse sand with little silt to silty sand and trace to little fine gravel (alluvial) exhibiting an SPT value of 12. The alluvium is, in turn, underlain by a deposit of silty sand with some gravel (till) showing an SPT value of 68. The till materials are underlain by bedrock at about 8 m, where the borehole terminates. The specific test hole utilized to generate the soil profile was selected due to low SPT blow counts that could extend from a depth of 2 m to 5.3 m.

The subsurface conditions in the TH09 test hole appear to be similar to those obtained in MWH17 to MWH19 shallow wells that were drilled in the eastern portion of the site at a later date (Reference 4). However, TH08 test hole drilled approximately in the center of the waste rock footprint (References 2 and 5) did not show liquefiable soils.

3.3 Fine Contents in Granular Materials

The fines content of the soil was determined based on SPT samples collected during the geotechnical investigation. The grain size distribution curve for a sample within the suspected liquefiable soil indicates a fines content of 8%. Samples (Reference 3) in similar soil stratum, e.g. within depth intervals of 3.80 m to 7.5 m in TH10 indicate fines content of approximately 6%. A fines content of 7% was assumed for the current liquefaction triggering assessment.

3.4 Groundwater

The GDR (Reference 2) did not include piezometer data in the zone of the proposed waste rock facility. Shallow wells MW-H17 to MW-H19 in and around the waste rock facility were installed at a later stage by the RES Hydrogeology Group. The spot measurements reported by RES in the shallow wells indicated a minimum groundwater depth of 3.3 m below the ground elevation (4). For the liquefaction triggering assessment, a groundwater depth of 3 m is assumed.

4 CALCULATIONS

The shear stresses induced in the soil by earthquake loading are termed Cyclic Stress Ratios (CSRs). The CSR values for the sand layer were computed by the following formula, using the simplified method for the 1:2,475 year return period design earthquake, to evaluate the soil liquefaction potential from a standard penetration test.

$$CSR = 0.65\ (a_{max}/g)\ (\sigma_v/\sigma'_v)\ r_d$$

where:

a_{max} = peak horizontal acceleration at the ground surface generated by the earthquake
g = acceleration of gravity
σ_v = total vertical overburden stress
σ'_v = effective vertical overburden stress
r_d = stress reduction coefficient

Soil liquefaction induced by seismic loading conditions is determined by comparing the Cyclic Resistance Ratio (CRR) of the soil at a depth to the CSR (the driving force) at the same depth. Though there is some uncertainty associated with determination of the CRR and CSR values, it is typically considered that soil liquefaction will occur at depths where the CSR values exceed the CRR values (i.e. FS = CRR/CSR < 1). Determination of the site-specific CRR values requires correction for the ground surface slope (k_α), the effective overburden stress (k_σ), and the design earthquake magnitude (k_M) as follows:

$$CRR = CRR_1 \times k_\alpha \times k_\sigma \times k_M$$

Determination of the site-specific correction factors (i.e., k_α, k_σ and k_M) was based on the relationships provided in Youd (2001), which also provides relationships between the normalized CRR values (i.e. CRR_1) and in-situ test data from SPT representing the soil resistance required to prevent soil liquefaction.

The correction for fines content in the analysis of SPT results is reflected in the relationships between CRR_1 and corrected SPT blow counts, i.e. $(N_1)_{60}$.

The ratios of CRR to CSR (i.e. Factors of Safety against soil liquefaction) using data from SPT from test hole TH09 were greater than 1.2.

5 CONCLUSION

The assessment of the results of the geotechnical subsurface investigation in TH09 indicates that liquefaction of deposits of coarse-grained soil below the water table in the waste rock facility foundation are unlikely to occur in the event of the 1:2,475 year return period design earthquake.

6 LIMITATIONS

- The scope of this study excludes any site visit. The study was conducted based on a literature review of the information supplied to GEL in References 1 to 5. GEL is not responsible for the accuracy and adequacy of geotechnical engineering data obtained by others.
- The scope of this study excludes liquefaction assessment of the sand and gravel deposits beyond the waste rock facility influence zone.
- The evaluations of soil liquefaction presented herein are based on a single SPT blow-counts available in the southwestern vicinity of the waste rock facility. For an accurate evaluation of liquefaction, it would be prudent to carry out more than one test hole investigation and that site-specific seismic ground response analyses be carried out using computer programs such as the SHAKE2000 software.

7 REFERENCES

1. Waste rock facility stability assessment – Use of geomembrane instead of clay liners. Murray River Coal Mine Project. Geo Engineering Ltd. (2012). Submitted to Rescan Environmental Services Ltd. September 21, 2012 (Rev 2).
2. Excerpt of Geotechnical Data Report for Surface Facilities. Murray River Coal Project, Tumbler Ridge, BC. Golder Associates. Submitted to BCEGI, Dec 2011 (85 pages).
3. Excerpt of Geotechnical Data Report for Surface Facilities, Murray River Coal Project, Tumbler Ridge, BC. Submitted to BCEGI. December 2011 (8 gradation curves).
4. Shallow Well Logs MW-H17, MW-H18 and MW-H19. Murray River Coal Project, Tumbler Ridge, BC. Prepared by Rescan Environmental Services Ltd. for HD Mining International, Submitted to GEL by emails on Sep 18 to Sep 25, 2012.
5. Murray River Coal Bulk Sample Project. Waste Rock Facility Stability Assessment, Rescan, June 29, 2012.

8 BIBLIOGRAPHY

- Canadian Foundation Engineering Manual (2006). Candaian Geotechnical Society, 4th Edition, 2006.
- Youd (2001). Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils. Journal of Geotechnical and Environmental Engineering, ASCE, 127(10): 297-313.

For and on the Behalf of

Geo Engineering Ltd.

PROFESSIONAL PROVINCE OF A. AMELI #28299 BRITISH COLUMBIA ENGINEER

Oct 3, 2012/2012

Ali Ameli, PE, PEng

APPENDIX A

2010 National Building Code Seismic Hazard Calculation

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , Geo Engineering Ltd. September 30, 2012

Site Coordinates: 55.1258 North 120.9931 West

User File Reference: Tumbler Ridge, BC

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.241	**0.139**	**0.066**	**0.036**	**0.123**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.035	0.105	0.156
Sa(0.5)	0.021	0.060	0.090
Sa(1.0)	0.011	0.028	0.042
Sa(2.0)	0.006	0.016	0.023
PGA	0.022	0.059	0.084

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français