Appendix 3-E

Northern and Southern Coal Reject Pile Design

MURRAY RIVER COAL PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

Ausenco

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Revision Number 1

HD Mining International Ltd
Murray River Project

Northern and Southern Coal Reject Pile Design

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Revision Status

Revision	Date	Description	Author		Approver	
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Table of Contents

Tables

Figures

Appendices

1 Introduction

1.1 General

The Murray River Project is a 160-km2 metallurgical coal property located southwest of Tumbler Ridge in British Colombia Canada as shown on Figure 1.1. The project has estimated reserves of more than 3.18 billion tonnes. The initial mine site development will focus on Plot 1 (37 km2) that contains proven reserves of 147.8 million tonnes. The deposit will be mined over a period of 25 years using long-wall mining methods. Coal will be mined at a nominal rate of 16,600 tonnes/day.

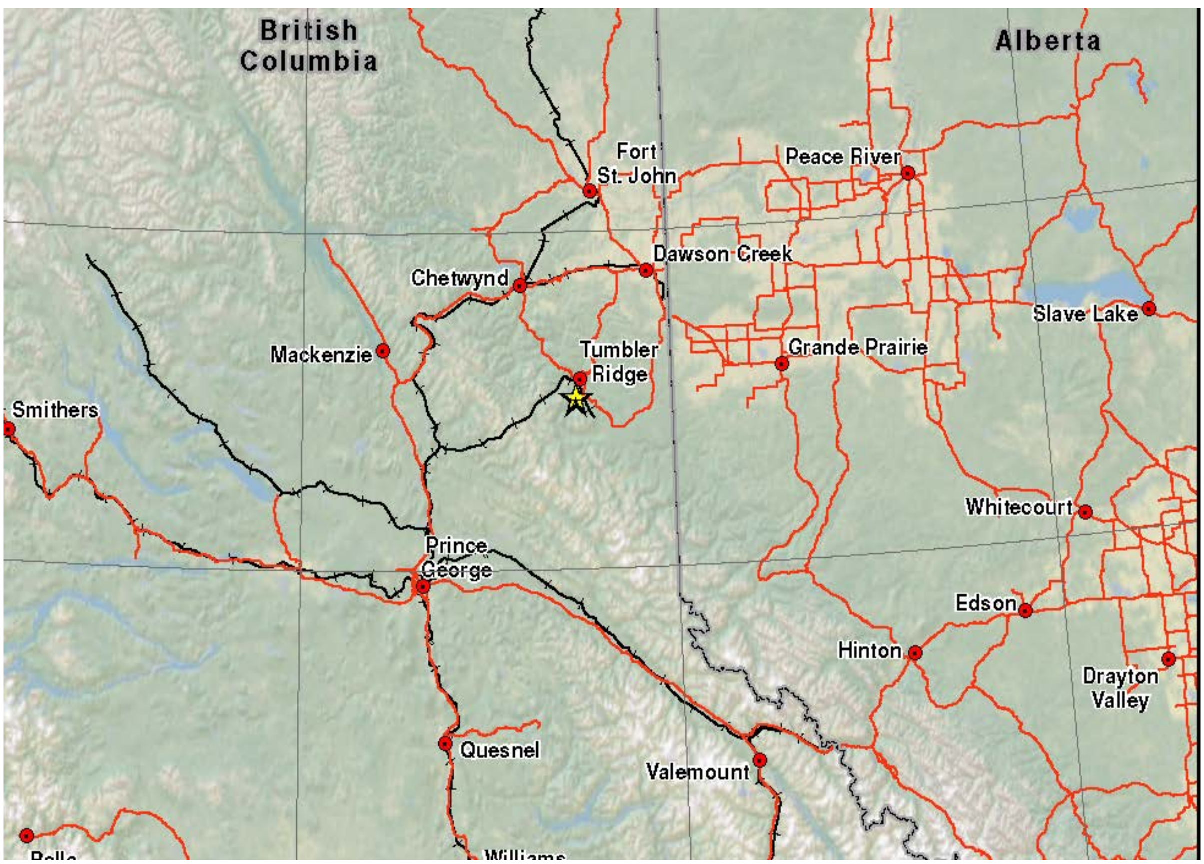


Figure 1.1 Murray River Project Location

The mining and processing of the coal deposit will generate both coarse and fine coal-reject materials, which will be co-mingled in waste management facilities. This report describes how this material will be managed in an environmentally safe and secure long-term manner. The two waste management facilities will be constructed, the northern and the southern piles, which will have sufficient capacity to store approximately 17.4 million cubic meters of waste. The northern coal reject

(CR) pile material may be Potential Acid Generating (PAG) due to the lack of neutralizing materials and therefore will be constructed with a geomembrane liner system. The southern CR pile is expected to be Non-PAG waste, however both piles have potential non-PAG leachate, such as Selenium, that may have discharge concentrations above regulatory requirements and there both facilities are being lined with geomembrane. Both piles will capture seepage flowing through the waste by a seepage collection system above the liner that includes a overliner and series of perforated collection pipes). The seepage captured will be transported to small transfer ponds for monitoring and treatment, if required.

The temporary storage of organic material and topsoil reclaimed during the construction of mine facilities is required to ensure sufficient reclamation medium is available for mine closure. The organic material and topsoil recovered during construction will be stockpiled within the footprint of the two CCR piles. The stockpiles are comparatively low and flat with gently sloped faces.

A general arrangement showing the ultimate layout of the mine site is shown on **Figure 1.2**.

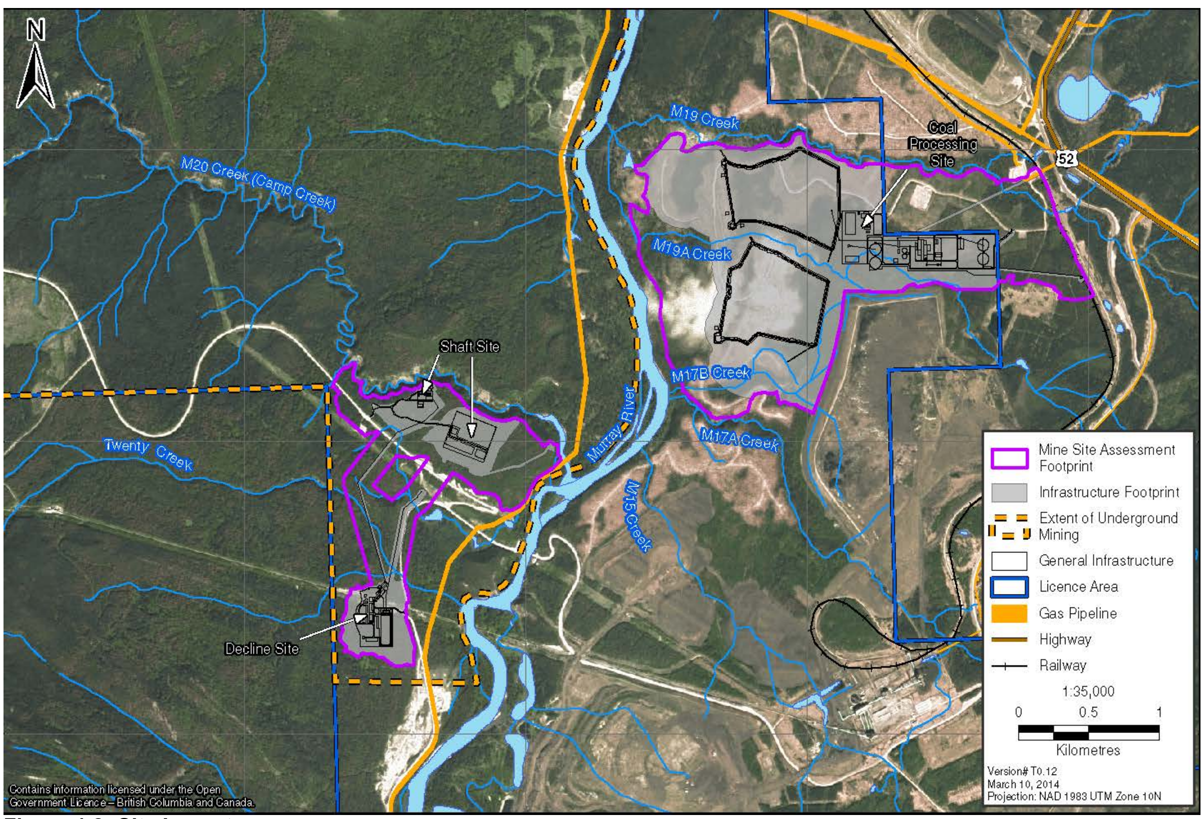


Figure 1.2: Site Layout

1.2 Scope of Work

This report summarizes the conditions and design for geotechnical and hydrogeological aspects of the coal reject management facilities. Specific aspects addressed in this report include the following:

- Site characteristics including physiographic setting, climate, hydrometeorology and seismicity
- Geotechnical conditions at the coal waste management facilities
- Layout and design of the topsoil stockpiles
- Layout and design of the coal waste management facilities
- Coal waste management facility stability rating classification (BC MWRPRC, 1991) and stability factor of safety, and
- Surface water management, including the collection ponds and sediment control measures.

2 Methodology

2.1 Physiographic

The Murray River property is located within the Peace River Coalfield (PRC) in the eastern foothills of the Canadian Rocky Mountains of northeastern British Colombia. The western margin of the Foothills belt is classified as the eastern most major thrust fault that emplaced Paleozoic strata over Mesozoic strata. The eastern margin is a series of echelon thrust faults that separate the Foothills from the gently dipping strata of the Alberta Plateau (Holland 1976). The Foothill's belt is characterized by folded and faulted Mesozoic sediments. In the PRC there are two main coal-bearing units: the Gates Formation and the Gething Formation (British Columbia Geological Survey n.d.). Based on drill core information from the neighbouring Quintette mine (immediately adjacent to the Murray River Project), the coal seams of the Gates Formation can be comprised of up to 10 separate seams and the average cumulative thickness of the coal seams is as high as 17 metres.

The ground surface is relatively gently sloping terrain, with numerous small swamps both along the valley bottom and along the shallow slopes. These wet areas indicate the presence of relatively low permeability surficial materials. Much of the northern and southern piles have been clear-cut and contain a mat of low ground cover from logging operations while the remaining area is heavily forested with young trees.

2.2 Climate and Hydrometeorology

Detailed site hydrometeorology is presented in the Memorandum by Rescan "Murray River Hydrometeorology Report" (September 24, 2013). The following sections summarise information presented in the Hydrometeorology Report.

2.2.1 Precipitation and Evaporation

Long-term estimates of precipitation were made by correlating relatively short-term site values with longer-term data from Meteorological Service of Canada (MSC) stations operated by Environment Canada and BC Ministry of Forests (MOF). Seven regional stations considered to be reasonably relevant to the project site were identified, from which the Tumbler (Denison) station was chosen on the basis of proximity, elevation, and period of record, as the most suitable for assessing precipitation patterns. However, the long-term winter precipitation was unreliable and therefore an estimate was used to develop total annual precipitation. The mean annual precipitation for the Project site was estimated to be 514.7 mm at elevation of 800 m.

Evaporation losses are not available from direct observations or modelling at the project area. Long-term evaporation data are not available at the Meteorological Service of Canada (MSC) regional stations with climate conditions similar to the project area. Estimates of the evaporation were only available through published studies at neighbouring projects in the region, i.e. Quintette Project and Roman Mine Project. The lake evaporation estimates for the project area are estimated to be 470 mm at an elevation of 800 m.

2.2.2 Runoff

The combined effects of rainfall and snowmelt, and the hydrologic condition of the ground cover, which affects evapotranspiration and infiltration, dictate runoff patterns in the project area. The most effective means of determining runoff patterns for undisturbed areas is to use measured flow data. A number of stream flow gauging stations have been operated in the project area, but the gauge that is most relevant to the current project configurations is at MH2. An assessment of the data from this gauge, along with concurrent and long-term regional data, resulted in a long-term mean annual unit runoff estimate of 276 mm for natural areas. Monthly coefficients of variation were also provided, which reflect the inter-annual variability of monthly runoff.

Natural runoff values are not applicable for mine-disturbed areas due to the potential changes in runoff caused by alterations in the ground cover. They are also not applicable for modelling net inflows to water bodies resulting from direct precipitation and evaporation. Notably, natural runoff generally does not occur in the later summer periods of August and September because soil moisture is low and evapotranspiration generally exceeds rainfall. However, as evapotranspiration is generally much lower in disturbed areas, some runoff may occur, while for water bodies there is a net loss due to evaporation exceeding rainfall.

A runoff coefficient of 0.5 was selected for the coal waste piles to reflect the expectation that runoff would be higher than from natural basins (where the runoff coefficient is approximately 0.2) because of lower evapotranspiration losses due to the rapid infiltration of rain and snowmelt and the lack of vegetation.

2.2.3 Storm Events

The storm event precipitation values for a selection of return periods are presented for design of the CR piles and associated facilities. The curves were generated from data in the “Rainfall Frequency Atlas for Canada” (1985)”. Relevant 24-hour storm events are shown in **Table 2.1**.

Table 2.1 Return Period vs. Rainfall

Return Period (Years)	Rainfall (mm)
10	24
50	41
100	44

2.3 Seismicity

2.3.1 Seismic Hazard

The Murray River Project site is situated in the Foreland Belt, on the eastern side of BC, where the level of historical seismic activity is low. The maximum earthquake magnitude for the potential seismic source for this region is estimated to be in the range of 5.5 to 6 (Adams and Halchuk, 2003).

To provide seismic ground motion parameters for design of the CR piles the Natural Resources Canada seismic hazard calculator was utilized. The results are summarized in Table 2.2 showing the earthquake return period, probability of exceedance (for a 25 year design operating life) and the median peak ground acceleration. For geotechnical structures such as waste management facilities recommends that the mean average peak ground acceleration be used for design (Canadian Dam Association Dam Safety Guidelines, 2007). The estimated peak ground accelerations for various return periods are included on **Table 2.2.**

Table 2.2 Peak Ground Acceleration

Probability of Exceedance in 50 Years (%)	Acceleration (g)
2	0.123
5	0.084
10	0.060

2.3.2 Design Earthquake

The design earthquake has been selected from the results of seismic hazard evaluation. The return period for the design earthquake, recommended by the BC Mine Waste Rock Pile Research Committee (1991), is the earthquake with a 10% probability of exceedance in 50 years (with a corresponding return period of 475 years). For the CR piles, the design earthquake has been taken as the 1 in 475 year return period event. The probability of exceedance for this event is only

5% for a 25-year operating period (including a pre-production year). For a return period of 475 years, the corresponding mean average peak acceleration is 0.060g. Limited deformation of the CCR piles is acceptable under seismic loading from the design earthquake, provided their overall stability and integrity is maintained.

3 Geotechnical Conditions

3.1 Near Surface Geology

This section presents an overview of the near surface geotechnical conditions encountered in the northern and southern CR piles. The geotechnical site investigations included test pitting, geotechnical drilling, standard penetration testing of the overburden soils, and in situ permeability testing (refer to Appendix 1). The location of site investigations is shown on **Figure 3.1.**

Figure 3.1 Borehole and Test Pit Location Map

The field investigation included drilling 7 geotechnical boreholes and 10 test pits. The drilling program was utilized to look at deeper soils that might affect the stability of the piles and also shallow ground water conditions. The boreholes were drilled to a depth maximum depth of 100 feet or until refusal with the Standard Penetration Test (SPT) or until bedrock was encountered. The test pits looked at shallow surface condition that might affect construction. Laboratory tests were performed on the recovered core and bulk soil samples to classify subsurface materials with depth along with determining mechanical properties utilized in the design of the CR Piles (refer to Appendix 2).

<u>Northern CR Pile</u>

The Northern CR pile is located on a ridge between creeks M19 and M19A. The proposed pile area consists of two terraces that gently slope to the west, the topography slopes between 4 percent at the west end (lower terrace), 20 percent in the centre (transition between terraces), and 5 percent at the east end (upper terrace). The elevation ranges from Elevation 800 m in the west to 830 m in the east.

The near surface consists of 40 centimetres of topsoil, which will need to be removed and stockpiled for closure. Below the topsoil is a layer of sandy silty clay (CL) to sandy silty (ML) 20 to 30 feet below the surface. The material has a medium stiffness at the surface and very stiff at depth. At BH-02, the south side of the pile, bedrock was not encountered; instead there was a hard clay zone to the end of the borehole. Below the fine grain material in the remainder of the pile footprint, bedrock was encountered that was comprised of siltstone.

Existing physical structures within the CCR include an unpaved logging road, monitoring wells, and remnants of stream crossings. The local roadside ditches were flowing within the pile area at the time of the site visit (May 2013). Major entrenched valley streams (M19 and M19A creeks) located north and south (respectively) of the footprint had minimal stream flows. The vegetation across the site consisted of 50 percent clear-cut with low ground cover and the other 50 percent heavily forested.

Southern CCR Pile

The Southern CCR pile is located between M19A and M17 creeks. The proposed waste pile area also consists of two terraces that gently sloping to the west, the topography ranges between 4 percent at the west end (lower terrace), 13 percent in the centre (transition between terraces), and 4 percent at the east end (upper terrace). The elevation ranges from Elevation 790 m in the west to 832 m in the east.

The near surface geology consists of 40 centimetres of topsoil, which will need to be removed and stockpiled for closure. Below the topsoil is a layer of sandy silty clay (CL) to sandy silty (ML) 10 to 90 feet below the surface. The material has medium stiffness at the surface and very stiff with depth. Below the fine grain material, bedrock was encountered at depths ranging from 10 to 90 feet and was comprised of siltstone.

Existing physical structures within the CR include an unpaved logging roads, monitoring wells, and remnants of stream crossings. The local roadside ditches were flowing within the pile area at the time of the site visit (May 2013). Major entrenched valley streams (M19A and M17 creeks) located north and south (respectively) of the site had minimal stream flows. The vegetation across the site consisted of 40 percent clear-cut with low ground cover and the other 60 percent heavily forested.

3.2 Groundwater Conditions

The proposed coal reject facilities will be constructed on terraces above the Murray River, a gently slopped area dissected by the ravines of the local creeks, M17, M19 and M19A.

A thick strata of silty clay is present below a thin veneer of glaciofluvial sandy sediments at the middle and lower terraces. At some distance between the reject pile sites and Murray River, this clay formation ends and glacial till formation occurs instead. Both silty clay and glacial till rest on mudstone inter-bedded with sandstone. This bedrock formation is exposed along the banks of Murray River near the CCR Site.

Hydraulic conductivity measured in the wells and boreholes around the coal reject facilities ranges from E-6 m/s (sands) to E-9 m/s (clays). Water table below these waste facilities is present within unconsolidated sediments and, at places, within the mudstone bedrock. Deeper groundwater is present under semi-confined and confined conditions. Shallow groundwater beneath these facilities discharges mostly to the local creeks, while deeper groundwater reports to both the creeks and Murray River.

4 Coal Reject Design Criteria

4.1 Introduction

To facilitate the development of the design criteria for the coal reject storage, a break down of each phase of coal handling was reviewed; from the raw coal relieved from underground mining to the final product. Two materials are generated during the process; the product (yield) and the waste (rejects) that are to be placed in a permanent waste storage facility. The annual and total mine life waste tonnes that need to be addressed for the Murray River Project over the 25 year mine life are presented in Table 4.1

Table 4.1 Coal Reject Quantities

	Total Reject	Coarse Reject	Fine Reject
Annual Tonnes (t)	1,082,000	848,000	234,000
Annual Volume (m^3)	696,000	487,000	209,000
Life of Mine (t)	27,039,000	21,193,000	5,846,000
Life of mine (m^3)	17,379,000	12,179,000	5,200,000

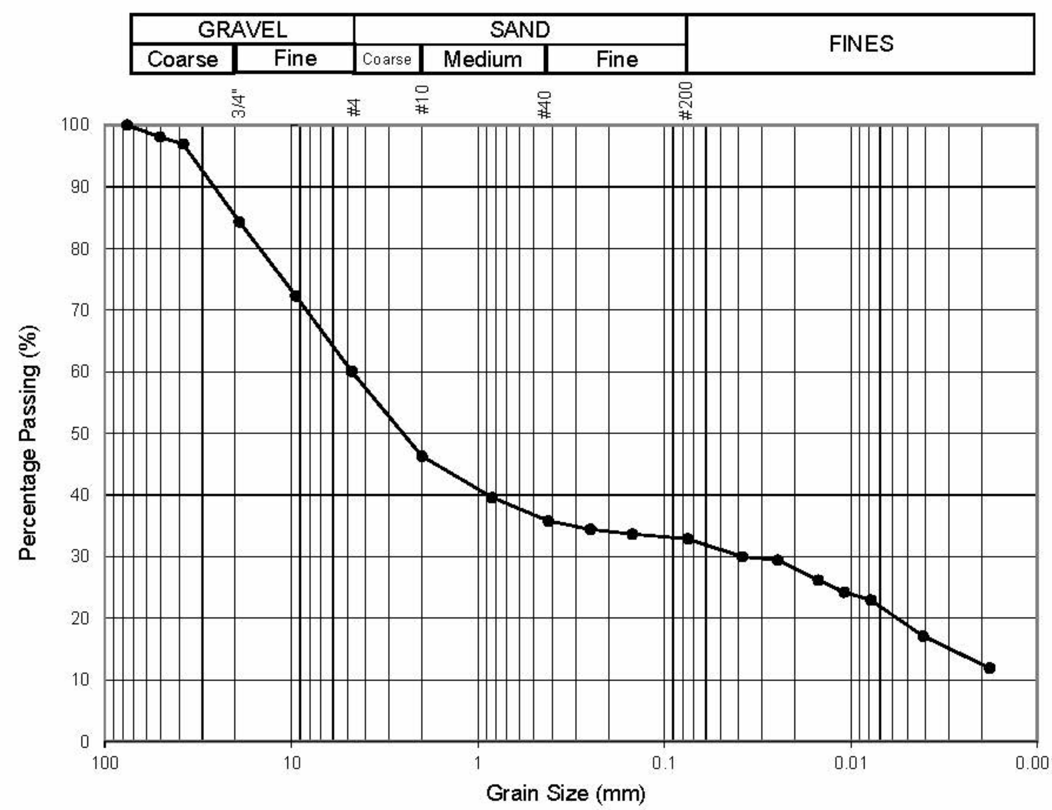
The raw coal will be received by conveyor and stockpiled on the surface at the coal handling process plant (CHPP). Then the raw coal will go through the CHPP and will produce both coarse and fine rejects. Due to the proximity of the site to sensitive waterway, as well as concerns with the potential impacts of coal rejects on groundwater a dry disposal system for the reject has been adopted. A dry disposal system in is understood to mean disposing of the combined streams of dewatered fine and coarse rejects. The fine rejects will be dried using belt press filters system, producing a filter cake. Coarse rejects will discharge onto the main reject conveyor. The filter cake will discharge via chutes onto the reject conveyor over the coarse rejects. This conveyor will convey all rejects to the waste disposal pile. While on the conveyor there will be some mixing of materials.

The co-mingled rejects will be further mixed from the radial stacking equipment and while a low-pressure dozers spreads the waste into thick lifts. The coal reject piles will be environmentally safe and secure in permanent storage facilities describe later in this report.

In addition to the reject piles, temporary stockpiles for topsoil and fine reject material for utilization in the cover system will be developed within the footprint of the northern and southern piles. The stockpiles will be managed in an environmentally sound, safe and secure manner. Below is the development of the design criteria for the reject piles.

4.1.1 Reject Particle Size Distribution

To effectively manage the waste generated from the process plant, it is necessary to understand the materials properties such as the total volume and the physical characteristics of the waste streams. As previously discussed the coarse and fine rejects are going to be co-mingled within the waste storage facilities. In order to determine grain size distribution of the single waste stream, it is necessary to compare percentage of each reject stream. The current process produces the following waste streams; 70% coarse and 30% fine, by weight. Since there were insufficient samples from the Murray River Project for testing, materials from the Quintette Project next door were used to characterise the waste materials. The combination of the two waste streams as a co-mingled product produces the following particle size distribution (refer to Figure 4.1 and Appendix 2)



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	
Composite Sample	N/A	16	24	14	11	3	33

Figure 4.1 – Comingle Reject Particle Size Distribution

The combined waste stream shows an average of 40 percent gravel, 28 percent sand, and 33 percent fines with a plastic index of 13. Therefore, the waste going to the storage facility is classified SM (Silty sand with gravel), in accordance with Unified Soil Classification System (USCS).

4.2 Coal Reject Pile Design Criteria

4.2.1 Coal Reject Physical and Mechanical Properties

In order to determine the general geometry of the waste storage pile slopes, laboratory tests were performed on the Quintette materials since they are of similar characteristics. The laboratory results show the following mechanical properties (refer to Appendix 2):

- Bulk density: 1.55 tonnes/m3
- Angle of Repose: ø=37°
- Effective shear strength: ø=37° and C=0 kPa
- Hydraulic Conductivity = $3.7x10^{-7}$ cm/s

4.2.2 Coal Reject Production Schedule

The coal waste pile volumes generated are estimated based proposed waste stream reported by HD Mining of 1.1 Mt per year, with an average bulk density of 1.55 t/m3. As noted in Section 4.1 the fine rejects will be co-disposed, decreasing the bulk density but without affecting the mechanical stability properties of the disposal facilities. The proposed annual waste stream is estimated at 696,000 m^3.

The most significant waste stream beside the reject material is waste materials being generated from preparing the waste storage facilities to receive waste, which includes vegetation and topsoil. The vegetation shall be gathered into piles and stored within the footprints of the coal reject pile footprints for utilization as erosion protection material. The topsoil will also be stored within the footprint of the two coal reject piles for later reclaim for closure of the two piles.

4.2.3 Geochemistry Characteristic

A waste geochemical characterization program has been completed by Rescan to predict potential acid generation (PAG) and leaching of constituents of concern from the rejects. A total of approximately 17.4 million cubic meters of reject material will be produced over the 25-year mine life. The characterization program has determined that the rejects are comprised of:

- 21.19 million tonnes of coarse rejects
    - 12.05 million tonnes is potentially PAG
    - 9.14 million tonnes is non-PAG
- 5.85 million tonnes of fine rejects
    - 3.32 million tonnes is potentially PAG
    - 2.52 million tonnes is non-PAG

The PAG waste cannot be separated from the non-PAG materials due to mining and processing methods. In addition, HD mining is planning to co-dispose of both coarse and fine rejects into the waste facilities. Based on a study by Rescan, it is predicted that the first five years of mining the material may be PAG (NPR less than 3). Therefore, the northern reject pile will utilize a geomembrane liner containment system to capture and mitigate potential PAG seepage water from this waste pile. In addition, based on the geochemistry of the water that seeps through the two piles the concentration of some constituents of concern, such as selenium, may exceed discharge requirements and therefore HD Mining has decided to line both facilities to capture and treat, if required, the majority of the water that comes in contact with the coal reject materials.

4.2.4 Summary of Coal Reject Design Criteria

The design criteria are based on Ausenco understanding of the project during several discussions with HD Mining and Rescan and our field and laboratory programs. The general design criteria for the coal reject piles are presented below (Table 4.2).

Table 4.2 General Coal Reject Pile Design Criteria

No.	Description	Units	Criteria
1.0	**Mine Operations**		
1.1	**Coal Reject Characteristics**		
1.1.1	Life of Mine	yr	25
1.1.2	Coarse Coal Reject Annual Production	t/yr	848,000
1.1.3	Coarse Coal Reject Life of Mine Project	t	21,193,000
1.1.4	Fine Coal Reject Annual Production	t/yr	234,000
1.1.5	Fine Coal Reject Life of Mine	t	5,846,000
1.1.6	Average Density (Co-mingled)	t/m^3	1.55
1.2	**Stacking Method**		
1.2.1	Material Transport (Plant-Pile)	type	Conveyor
1.1.5	Material Spreading (Pile)	type	Dozer
2.0	**Coal Reject Storage Parameters**		
2.1	**Geotechnical Parameters**		
2.1.1	Static Factor of Safety – Long Term (min)	F.S.	1.5
2.1.2	Static Factor of Safety – Short Term (min)	F.S.	1.3
2.1.3	Design Earthquake (475	Return Period	475

No.	Description	Units	Criteria
2.1.4	Pseudo-static Factor of Safety (min) or Design Criteria 2.1.4 if FS is less than 1	F.S.	1.2
2.1.4	Crest Deformation	m	Less than 1m
2.2	**Coal Reject Pile**		
2.2.1	Reject Pile Height (max)	m	60m
2.2.2	Reject Pile Side Slopes	H:V	2.5:1
2.3	**Reject Pile Liner System**		
2.3.1	Geomembrane	Type	2.0mm SST LLDPE
2.3.2	Leakage Rate Through Liner System	%	Less Than 2
2.3.3	Overliner	Material	Coarse Reject
2.3.4	Overliner Thickness	m	2
2.4	**Underdrain System**		
2.4.1	Material	type	HDPE Dual Wall Pipe
2.4.2	Header Pipe Diameter	mm	300
2.4.3	Lateral Pipe Diameter	mm	150
2.5	**Overliner System**		
2.5.1	Material	type	HDPE Dual Wall Pipe
2.5.2	Header Pipe Diameter	mm	300
2.5.3	Lateral Pipe Diameter	mm	150
2.6	**Perimeter Access**		
2.6.1	Road Width (min)	m	5
2.6.2	Road Surfacing	Type	Gravel
2.7	**Diversion Channels**		
2.7.1	Capacity (Storm Event)	Return Period	25 year 24 hour
2.7.2	Freeboard (min)	m	0.5
2.7.3	Side Slopes	H:V	1:1
2.7.4	Gradient (min)	%	1

5 Coal Reject Pile Design

5.1 Introduction

During the 25-year year mine life, there will be approximately 17.4 million cubic meters of both coarse and fine reject material generated that will require a one or more storage facilities. During the intial design, HD Mining was looking at a single facility that spanned over a small creek (M19A). However, the creek was considered possibly fish bearing habitat, therefore the waste facilities was split into two facilities one facility to the north and one facility to the south of Creek M19A (refer to **Figure 5.1**).

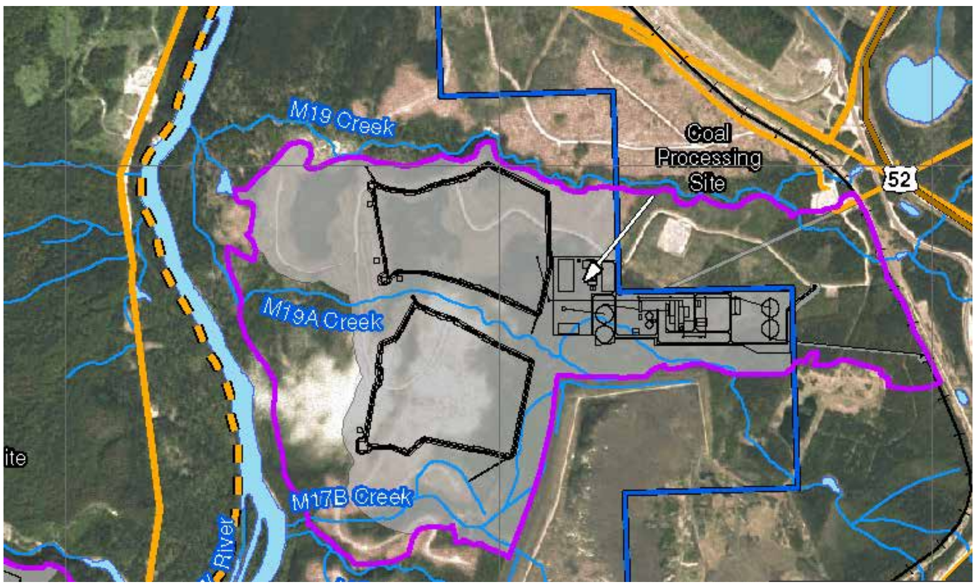


Figure 5.1 – General Northern and Southern CR Piles

5.2 Waste Storage Facility Location

HD Mining's property to the east of the Murray River consists of a relatively small section of land with variable topography and three small creeks transecting the property. As noted, it is necessary to design sufficient storage for 17.4 million cubic metres of waste and available space for surface storage is limited. A review of the available area and the volume of material to be stored did not provide sufficient storage capacity for a single facility due to Creek M19A intersecting the property. Therefore, HD Mining decided to divide the CR pile into two facilities; one north and one south of Creek M19A. Due to limited land space the piles were developed vertically.

Run-off resulting from precipitation from the waste piles and presenting itself as surface runoff and percolation through the waste piles will be collected and treated during the life of mine, if needed to meet water discharge standards. The wastewater will be piped, pumped and/or channelized to a holding pond (designed by others) for discharged or treated, depending on water quality, into the Murray River.

Spontaneous combustion (SC), a process whereby certain materials can ignite through internal reactions, is also an observed phenomenon in exposed coal reject piles. However, based on the mining method, limited coal concentrations in the waste, co-mingling of both coarse and fine rejects, and the history of the neighbouring properties suggests there will not be a problem with spontaneous combustion. Therefore, no considerations for SC were used in the design of these facilities. However, There are several indicators such as heat, smell, sweating, haze, and smoke that are used to detect spontaneous combustion and as a precaution a spontaneous combustion management system should be developed.

Limitation and ultimately the elimination of these issues may be possible through progressive reclamation, i.e. placing a final capping system over the waste piles. Progressive reclamation would consist of capping completed portions of the waste pile with the intent of limiting the exposed surface area of waste coal as much as possible during life of mine. The capping system would consist of placing an impermeable layer, fine coal reject, topsoil, and growth medium, over a graded and compacted coal waste surface. Hydroseeding would be employed to create a root mat to limit erosion of the topsoil layer before vegetation takes hold.

5.3 Borrow Sites

Site preparation for the liner installation will require tree cutting, grubbing of roots and topsoil, and the shaping and grading of the subgrade. In wet areas underdrains will be installed to lower the groundwater below the surface to prevent pore pressure building up below the liner system. In addition, approximately 1000 mm of fill will be placed over wet areas to ensure groundwater stays below the geomembrane liner. These underdrains will be field fitted during construction. The non-saturated *in situ* silty soil, which covers the majority of the site, will be suitable for use as fill material.

5.4 Subgrade Preparation

Subgrade preparation for both waste stockpiles includes clearing and grubbing, topsoil stripping, and installation of underdrain below the northern and the southern stockpiles.

A sufficient area is required for the storage of grubbing materials removed from within the proposed waste pile areas. The grubbing material consists of vegetation, stumps and root-mats. An area of approximately 80,000 m^2 is required to temporarily store 360,000 m^3 of material from each CR pile area. The grubbing materials will be placed in lifts and compacted by off-road haul truck and pushed by a dozer. Due to the organic matter and higher moisture content of the grubbing materials, soft soil conditions, rutting and likely unstable side slopes are expected. Therefore, a maximum height of the stockpile material is 6 meters. It should be noted that after sitting and drying for a period of time, the stumps could be removed, chipped and blended back in with the piles. This method would decrease the bulk of the pile and aid in the decomposition of organic matter. This material will be used for erosion protection and reclamation in the future.

Once the sites have been cleared of vegetation, topsoil will be removed and stockpiled. Based on the field investigation, the topsoil is approximately 40 mm thick across both CR pile sites, and will required temporary storage areas of 30,000 m^2 to store approximately 150,000 m^3 of material. The topsoil consists of organic matter and growth medium. Topsoil will be placed in lifts and compacted by off-road haul truck and pushed by a dozer. The topsoil stockpiles will also be stored to a height of 6 meters with side slopes flatter than 2:1 (H:V). This material will be used for reclamation in the future.

5.4.1 Management Practices for Soil Stripping and Salvage

- Wet conditions will be avoided when possible during soil salvage operations.
- Excessive traffic will be avoided during the salvage process to minimize admixing, compaction and rutting.
- Traffic will be confined to established routes to avoid unnecessary compaction of soil in undisturbed areas.
- Erosion control measures will be implemented on an as needed basis.

5.4.2 Management Practices for Soil Stockpile

- Soil will be stockpiled in locations to minimize the possibility of further disturbance.
- Stockpile locations will, where possible, be located a sufficient distance away from operations to protect soils from contamination.
- Protective ditches around stockpiles will be constructed where practical.
- Erosion will be managed by limiting the height and slope of stockpiles. Erosion control measures will be implemented including prompt vegetation establishment on topsoil stockpiles to reduce exposure of bare soil.
- Where possible stockpiles will be oriented to reduce wind erosion and located to reduce wind exposure.

5.5 Coal Reject Underdrains

Once the topsoil has been removed, any springs or wet areas that are identified in both the northern and southern waste pile footprints, a series of underdrains will be installed to ensure pore pressures do not build up below the geomembrane liner. The system will be placed 1.5 meter below the surface with a minimum slope of 0.5 percent to small ponds located next to the pile for monitoring and discharge or treatment, if required. The underdrain will consist of HDPE dual wall corrugated pipes with a smooth interior (Refer to Appendix 7).

5.6 Coal Reject Pile Design

During the 25-year year mine life, there will be approximately 17.4 million cubic meters of both coarse and fine reject material generated that will require two waste storage facilities (refer to **Table 5.1**).

Table 5.1 Coal Reject Production Schedule

Year	Coarse Coal Reject (m^3)	Fine Coal Reject (m^3)	Total Coal Reject (m^3)
1	493,494	211,497	704,992
2	493,494	211,497	704,992
3	493,494	211,497	704,992
4	493,494	211,497	704,992
5	480,312	205,848	686,160
6	480,312	205,848	686,160
7	493,494	211,497	704,992
8	493,494	211,497	704,992
9	493,494	211,497	704,992
10	493,494	211,497	704,992
11	493,494	211,497	704,992
12	493,494	211,497	704,992
13	493,494	211,497	704,992
14	493,494	211,497	704,992
15	493,494	211,497	704,992
16	489,375	209,732	699,107
17	468,778	200,905	669,683
18	468,778	200,905	669,683
19	496,789	212,909	709,699
20	486,903	208,672	695,576
21	478,664	205,142	683,807
22	478,664	205,142	683,807
23	478,664	205,142	683,807
24	478,664	205,142	683,807

Year	Coarse Coal Reject (m^3)	Fine Coal Reject (m^3)	Total Coal Reject (m^3)
25	478,664	205,142	683,807
Totals	**12,180,003**	**5,220,001**	**17,400,004**

As discussed above, HD Mining was looking at a single facility that spanned over the small creek (M19A). However, the creek was considered possibly fish bearing habitat, therefore the waste facilities was split into two facilities one facility to the north and one facility to the south of Creek M19A.

5.6.1 Northern and Southern Coal Reject Piles

The northern coal reject pile will be developed first because of its proximity to the process plant and is also the easiest to commence disposal operations. Therefore, north pile was design to storage as much waste materials as possible between Creeks M19 and M19A (refer to Appendix 7). This pile will be constructed in two phases, the western section (first) and then the eastern section. This pile has a total capacity of 9,92 million cubic meters and a mine of life of 15 years. The northern coal reject pile has an ultimate footprint of 370,630 m^2; Phase 1 is 207,654 m^2 and Phase 2 is 162,976 m^2.

Similarly, the south pile will be constructed in year 14 to accept waste in year 15. A new conveyor will need to be constructed to dispose of waste in this facility. The pile will be constructed in two phases, the western section (first) and then the eastern section (refer to Appendix 7). This pile has a total capacity of 7.06 million cubic meters and a mine of life of 11 years. The southern coal reject pile has an ultimate footprint of 358,509 m^2; Phase 1 is 207,654 m^2 and Phase 2 is 150,855 m^2.

The subgrade will be moisture conditioned and compacted prior to the placement of the geomembrane liner for both facilities. For this project linear low density polyethylene (LLDPE) will be utilized as a impermeable barrier to capture the majority of the seepage passing through the pile and to accommodate minor differential settlement. The piles will also have an internal drainage system that consists of pipes and a permeable blanket drainage across the entire liner to facilitate capture of any seepage from rain and snow melt through pile and direct it to external ponds for monitoring and treatment, if required.

The piles will be stack in 8 to 10 meter lifts using conveyor and dozers to form them. There shall be benches between lifts to create an overall external slopes of 2.5:1 (H:V). Small drainage channel shall be installed along the benches to capture runoff and convey it safely down to small ponds on the outside of the facility through corrugated metal pipes.

5.6.2 Geomembrane Liner System

The original design concept was to use tile-drains to capture the near surface groundwater and seepage through the pile and monitor and treat, if necessary. However, based both the seepage model through the CR piles (refer to Appendix 5) and the fate of contaminant transport model by Rescan (not included in this report), the system was either not affective in capturing ground water, because it was to deep, or even with a relative high capture rate, the levels of possible consistents of concern entering the neighbouring creeks were above acceptable discharge limits. It should be noted that there model is conservative at this point due to limited test results. Therefore, HD Mining is being proactive at this time and both coal reject piles are being designed with a geomembrane liner system to prevent the migration of constituents of concern into the groundwater below the facilities. This is a fairly new idea for the coal industry in facilitating the protection of the environment. If during operations, HD Mining can demonstrate that levels of constituents, derive from seepage migrating through the pile and into the into the surrounding streams, is below required discharge guidelines then they may apply for a modification in the design, i.e. possibly eliminating the liner system for the southern pile.

The liner system for both piles with consist of 2.0-mm single-sided textured (SST) low density polyethylene (LLDPE). The thickness of the geomembrane is based on the planned depth of coal reject weight on top of the overliner-geomembrane system and numerous tests performed on similar overliner-geomembrane interfaces in our laboratory. The limits of the liner for both piles are shown in Appendix 7.

The geomembrane will be anchored both temporary and permanently around the edge of the pile. Temporary anchorage will be in the form of sand bags and other ballast materials approve by the engineer. These materials are necessary so that the liner materials do not move significantly during deployment, welding, and other construction activities when the liner is most susceptible to wind, water, and extreme temperature fluctuations. Permanent anchorage will be in the form of overliner and berm-anchor trenches. Berm-Anchor trenches serve several functions that include:

- Anchoring the liner from down slope movement;
- Anchoring the liner to prevent excessive movement by temperature;
- Anchoring against wind uplift;
- Minimize the migration of near surface water under the liner;
- Migration of runoff from the piles offsite; and
- Prevent run-on from non-contact water from enter the piles.

5.6.3 Overliner and Seepage Collection System

Based on calculations provided by Rescan on fate of contaminate transport, both piles need to have less than 2 percent of the water that infiltrates through the pile from rain or snow melt from mixing with groundwater. As discussed above the only viable option is to line both facilities with a geomembrane liner system. However, this can also create problems, because the seepage is not allowed to continue to migrate in the subgrade and over time water can build-up along the liner system creating a high phreatic surface, which can destabilize the piles causing external slope failures. Therefore, an overliner and seepage collection system consisting of perforated pipes will be installed above the geomembrane to evacuate seepage quickly.

The seepage collection piping will consist of 150-mm perforated dual wall (smooth interior and corrugated exterior) HDPE laterals placed every 50-meters in a hearing bone pattern across the liner, oriented to positively flow from the natural ridges to the main collectors (refer to Appendices 3 and 7). The laterals will drain and connect to perforated 300-mm dual wall HDPE headers that drain to small external transition ponds (15 m by 15 m).

5.6.4 Leakage Estimate through Geomembrane

Below are the calculated seepage rates through the liner system for both the northern and southern piles (refer to Appendix 3). The success of any liner system to minimize leakage through the geomembrane consists of 3 parts; good liner installation, good operating practices to prevent damage to the liner, and minimizing the head over the liner and possible defects. The calculation for the leakage rate through a liner system is governed by the phreatic surface over a defect in the liner and the height of the head directly over a defect, which is directly affected by pipe spacing along the liner to quickly evacuate seepage.

The piping and overliner system minimizes the seepage head over the liner thus reducing leakage potential through any defect in the geomembrane. The required lateral spacing is a function of the allowable head over the liner, permeability of the overliner, and infiltration rates (seepage). It was assumed that the allowable maximum head over the single-lined areas during normal operations should not exceed 0.5-meter. Larger heads are tolerable but only for a short duration.

The pipe spacing is based on the Darcy's law and the elliptical equation (a standard procedure used in the mining industry).

$$H_{max}=((L^2*r)/(4K))^{0.5}+(d*c)$$

where;

- H_{max} = maximum head over the geomembrane (m)
- L = pipe spacing (m)
- r = average seepage rate ($m^3/hr/m^{2)}$
- K = permeability of the overliner (m/s)
- d = diameter of lateral collection pipe (m)
- c = allowable pipe flow capacity (%)

Based on permeability laboratory testing of the overliner ($5x10^{-3}$ cm/s) and the seepage model average infiltration rate ($2.16x10^{-5}$ m/hr), maximum head over the liner is 0.36 m with an average head of 0.24 m).

When geomembrane liner systems were first utilized as a barrier system, it was thought that there would be zero leakage through these membranes. Through the experiences of designers, regulators, and owners we have come to the realization that these systems do leak even with the highest quality of manufacturing and installation. Therefore with this realization the industry has developed standards for acceptable leakage rates that depend on the facility size, potential constituents of concern, surface conditions, and potential short and long term impacts to the environment beyond the project boundaries.

Based on the average head over the liner and using industry standard installation practices for geomembrane the leakage rate through the geomembrane liner can be calculated based on the following formula.

$$Q = 0.976*C_{qo}*[1+0.1*(h/t_s)^{0.95}]*d^{0.2}*h^{0.9}*k^{0.74}$$

where;

- Q = leakage rate through 1 defect (m^3/s)
- C_{qo} = contact quality factor (unitless)
- h = hydraulic head on top of the geomembrane (m)
- t_s = thickness of the soil below the liner (m/s)
- d = diameter of the circular defect (m)
- k = permeability of the soil below the liner (m/s)

Therefore, based on good installation practices, permeability laboratory testing of the soil liner ($1x10^{-7}$ m/s) with a minimum thickness of 2 meters, and the average head above the liner of 0.24 m; the average seepage rate through a typical defect of 2 mm in diameter is 0.009 m^3/day. Typically a well-installed liner system has approximately 1 defect per 4,000 m^2 due to material defects and construction creating holes in the liner. The average daily leakage rate into the subgrade below the two facilities is approximately 0.91 m^3/day for the Northern pile and 0.88 m^3/day for the Southern pile or less than 1.0% of the total infiltration into the pile from rain and snow melt migrates passes through the liner system into the subgrade through defects. Therefore, the leakage rate is slightly below the design criteria and therefore there is no need to perform any other measures to decrease the leakage rate, such as, decreasing the permeability of the soil liner.

5.6.5 Reject Pile Slope Stability Analysis

Slope stability analyses were conducted to determine the factors of safety for the given slope geometry of the respective coal reject stockpiles. These results are compared against the Dump Stability Rating (DSR) scheme from the Investigation and Design Manual Interim Guidelines (BC MWRPRC, 1991).

5.6.5.1 Reject Pile Stability Rating Scheme

The Investigation and Design Manual Interim Guidelines (BC MWRPRC, 1991) provides recommendations for stability assessment of mine waste piles. These guidelines include a Dump Stability Rating (DSR) scheme. The DSR system provides a semi-quantitative method for assessing the relative potential of pile stability and recommends the appropriate level of pile investigation and design. This is based on individual point ratings for each of the main factors affecting pile stability. Each factor is given a point rating based on qualitative and/or quantitative descriptions accounting for the possible range of conditions. An overall DSR is calculated as the sum of the individual ratings for each of the various factors.

The dump rating guidelines were used to classify the coal reject piles at the Murray River Project. The piles are classified as Class II, Low Hazard. In general, the dump stability classification indicates that a basic stability analysis is required. In accordance with provincial guidelines (BC MWRPRC, 1991) and standard industry practice, the minimum acceptable factor of safety for waste facilities under static conditions is 1.3 for short-term operating conditions and 1.5 after reclamation and abandonment. A factor of safety under seismic conditions of less than 1.0 may be acceptable provided that calculated deformations resulting from seismic loading are not significant.

5.6.5.2 Reject Pile Stability Analyses

Slope stability analyses for the coal reject piles for the ultimate configuration were undertaken. The respective factors of safety are 1.8 and 1.5. These factors of safety are acceptable under the conditions laid out in the DSR scheme outlined above. As the topsoil and organic stockpiles will be depleted after completion of mine work, only the minimum factor of safety of 1.3 for short-term operating conditions is applicable. The most critical section were analysed for each pile and the computed factors of safety for the two piles are included in Appendix 4. The lowest factors of safety for the northern pile are 1.87 (static) and 1.52 (pseudo-static) and for the southern pile are 1.53 (static) and 1.15 (pseudo-static). These factors are acceptable under the conditions laid out in the DSR scheme (see above). The final factors of safety at closure exceeds the minimum factor of safety of 1.5 for structures after reclamation and abandonment and is thus acceptable, all factors of safety are in excess of the minimum factor of safety of 1.3 for short-term operating conditions.

5.7 Coal Reject Pile Surface Water Management and Sediment Control

Surface water modelling was conducted on both the Northern and Southern reject piles in order to effectively design the diversion channels around these facilities. The modelling was used to determine peak discharge and total volume of runoff from the adjacent watersheds. The pile diversion channels were designed for the

25 year 24 hour storm event. The design process consists of a two-step process; 1) to develop a runoff model utilizing HEC-HMS in order to determine the peak discharge and total volume of runoff, and 2) to develop a channel flow model utilizing HEC-RAS to determine the water depth in channels along with freeboard and areas of supercritical flow.

5.7.1 Approach

The watershed areas surrounding the piles were subdivided into smaller watersheds that would contribute surface flow to the proposed diversion channels. The ditches were located around the piles to divert runoff away from the piles, which are depicted in schematic drawing in **Figure 5.1**.

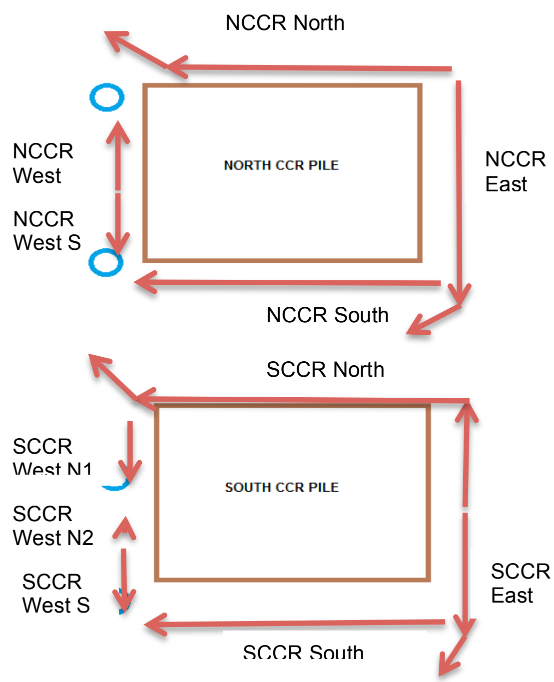


Figure 5.1 Schematic of Diversion Ditches

HEC-HMS was used to determine the peak discharge and total volume of runoff. The longest flow path for each watershed was determined and a flow path profile was generated to calculate incremental distances and slopes along the flow path. This data was used to calculate the time of concentration and lag time for each watershed (NRCS, 2010). The segments along the flow path generally consist of three types: sheet flow, shallow concentrated flow, and open channel flow. The methodology is described in detail in Part 630 National Engineering Handbook (NRCS, 2010). The results of the runoff model are presented in **Table 5.2**.

Table 5.2 Summary of Runoff Model Results for 25 year 24 hour Event

Watershed Name	Watershed Description	Area (m^2)	Maximum Discharge (m^3/s)	Total Volume (m^3)
WS_N1	Upstream watershed	288,227	0.2	7700
WS_N2	East side of north CCR Pile	45,421	0.1	1200
WS_N3	North side of north CCR pile	93,957	0.1	2500
WS_N4	South side of north CCR pile	89,132	0.1	2400
WS_N5	West side and top of north CCR pile	142,054	0.1	3800
WS_S1	Upstream watershed	397,021	0.3	10700
WS_S2	East side of south CCR Pile	18,028	0.05	500
WS_S3	North side of south CCR pile	33,074	0.01	900
WS_S4	South side of south CCR pile	49,797	0.1	1300
WS_S5	West side and top of south CCR pile	269,229	0.2	7200

The maximum discharge values from the HEC-HMS were input into the HEC-RAS model to calculate the depth of flow, freeboard, and areas of supercritical flow in each channel. The results are shown in **Table 5.3**. The results show acceptable freeboard and the Froude numbers indicate high velocities due to the steep channel gradients that exists along certain reaches.

Table 5.3 Channel Flow Depth Summary

CCR Pile	Channel	Channel Depth (m)	Maximum Water Depth (m)	Freeboard (m)	Froude Numbers >1
North	North	1	0.20	0.80	Yes
	East	1	0.37	0.63	Yes
	North western	1	0.14	0.86	Yes
	South western	1	0.14	0.86	Yes
	South	1	0.21	0.79	Yes
South	North	1	0.35	0.65	Yes
	East	1	0.25	0.75	Yes
	North western	1	0.20	0.80	Yes
	South western	1	0.24	0.76	Yes
	South	1	0.19	0.81	Yes

The channel design is 1-meter deep trapezoid channels with 1-meter bottoms and 1:1 (H:V) side slopes. The channels contain a number of segments with highly variable slopes that range from 1% to 50% with median slopes of approximately 3 percent. The relatively flat sections of these channels control the calculated capacity and efficiency of the diversion channels. Based on the results of this model, the channels need to be lined with rip-rap with a minimum diameter of 0.3 m undelayed with 400 g/m^2 to protect the channels from erosion. In some very high velocity sections the rip-rap will need to mortar to prevent.

The channel design was validated with Flowmaster® V8i using a trapezoidal shape with 1%, 3%, and 50% gradients. The results of these flow analyses show that the channel geometry is sufficient to handle the surface runoff from the 25 year 24 hour storm event (refer to Appendix 6).

The channel efficiency was calculated using a method for seepage losses from irrigation canals ("Seepage Losses from Irrigation Canals in southern Alberta", IQBAL et al, (2002)). This method is dependent on the water depth and the maximum discharge. The calculated channel efficiencies ranged from 87.8% to 99.6%, due to very small losses during peak flows.

6 General Recommendations for Construction

The following are generally recommended methods of construction and operation to ensure on going stability and performance of the coal reject stockpiles. These methods may be updated and revised, as necessary, based on field observations and performance monitoring during the initial stages of waste and stockpile construction.

Pre-Production

- Establish Best Management Practices to control runoff.
- Construct water collection ponds.
- Construct diversion and runoff collection ditches where required.
- Clear and grub vegetated areas prior to placement of waste materials or liner system.

Operations

The northern coal reject pile shall be constructed first and placed into operation and then the southern pile will be placed into operation approximately in year 15 of operations, Both piles will have a geomembrane liner system to capture seepage and convey it to transition ponds for monitoring and conveyance to a central pond for treatment of discharge into the Murray River. To prevent build-up of a phreatic surface over the geomembrane a 2 m height blanket drain shall be installed over the liner with perforated HDPE dual wall pipes. The blanket drain will be constructed of coarse coal reject. Therefore in the 1st year, the coarse and fine reject materials will not be co-mingled since the fine reject will be utilized as part of the cover system. The coarse reject material will be transported and placed in the stockpile by overland conveyor and spread with low-pressure dozers in a 2 m lift across the entire lined area. Then dozers shall spread the materials in 10-meter high lifts. The fine reject filter cake will be transported by truck and stockpiled in the southern CR pile. After the 1st year both materials will be co-mingled and sent to the pile by conveyor and spread using dozers.

The southern coal reject pile also has a synthetic liner system. Similarly, for the first year the reject materials will not be co-mingled. The fine reject will be stockpiled on top of the northern stockpile for later reclaim for the southern cover system. The coarse materials will be transported by conveyor and spread using low-pressure dozers in a minimum 2-meter lift across the entire lined area. Then dozers shall spread the materials in 10-meter high lifts.

Trial sections shall be constructed in the field during the initial stages of development to monitor waste pile stability and foundation performance. The coal reject materials shall be sampled for characterization and for durability test work to confirm the design parameters

7 Reclaim Program

Reclamation of the coal reject stockpiles will be required for mine closure. As much as practical the reclamation will be carried out progressively with mine operations. It is anticipated the stockpile reclamation will begin in the latter half of the stockpile life, when the reject pile reaches its final exterior slope configuration and when sectors become inactive. Reclamation will be conducted in conjunction with on-going environmental monitoring to ensure that sediment control and water quality objectives are met.

The closure and reclamation of the reject piles will be required to meet end land use goals. The closure of the stockpiles will include the minor regrading of the dump face, to facilitate the placement of low permeability-soil and revegetation. In addition, surface channels and down drain shall be installed to minimized concentrated runoff down the slopes of the reclaimed piles. The final waste dump bench crests will be rounded and the faces re-shaped to improve the long- term erosion stability of the waste piles. A final cover will consist of a 0.5 m thick layer of fine reject material, 0.4 m thick suitable topsoil layer, a layer of organic material from the clearing an grubbing, and then revegetated with indigenous grasses and shrubs. Reclamation will be conducted in conjunction with on-going geotechnical and environmental monitoring to ensure that slope stability; sediment control and water quality objectives are met.

The topsoil stockpiles will be depleted during reclamation, typical uses of the topsoil may include:

- The roads and decommissioned water management structures will be reclaimed through replacement of windrowed soil.
- To facilitate revegetation of the reject piles will be reclaimed through placement soil in one lift and organic compost in another lift. Where required, soil may be scarified prior to seeding if the surface becomes compacted due to truck or equipment traffic.

Based on the closure seepage model developed by Ausenco, the net rainfall that infiltrates through the closure cap system is less than 1 percent of the equivalent direct rainfall.

On-going monitoring of the reject piles will be required after mine closure to ensure the cover system is functioning in accordance with intended water management plan. The requirements for on-going monitoring will be less extensive than required during operations. The design of the final monitoring program will be developed over the mine life as experience is gained during the reject pile construction and operation. On-going monitoring will be defined in the closure design for the waste dumps. The preliminary closure requirements for the WSA are expected to include:

- On-going monitoring of surface and groundwater quality and flow rates
- Regular periodic inspection of the reject piles, and
- Deformation monitoring as required.

8 References

Appendix 1 – Field Investigation Data

Ausenco

HD Mining Drilling Program

A Comprehensive Review of Field Activities

Omar Berbar

2013

Ausenco completed a drilling program for HD Mining's Murray River Coal Project between the dates of 17JUL2013 and 30JUL2013. A total of seven boreholes were drilled and ten trenches excavated. The following is a summary of data acquired from the field activities.

All figures, photos, and maps can be found on the accompanying flash drive.

Omar Berbar

Coordinates

Borehole and trench coordinates were taken with a *Garmin Colorado* 300 handheld GPS. The GPS was held directly over the borehole/trench when coordinates were recorded. The following table is a summary of all exact coordinates.

Name	Coordinates	Elevation
BH/01	10 U 0628331 6099813	839m
BH/02	10 U 0627958 6099627	823m
BH/03	10 U 0627457 6099896	797m
BH/04	10 U 0627602 6098577	809m
BH/05	10 U 0627373 6098496	795m
BH/06	10 U 0627370 6098496	745m
BH/07	10 U 0627712 6098774	810m
TRENCH 01	10 U 0626916 6099298	806m
TRENCH 02	10 U 0627683 6099091	799m
TRENCH 03	10 U 0627569 6098870	792m

Name	Coordinates	Elevation
TRENCH 04	GPS Data corrupted. (GPS was low on battery at time of collection). Location of Trench 4 shown in Figure 1 as well as approximate coordinates.	
TRENCH 05	10 U 0627571 6098521	810m
TRENCH 06	10 U 0627339 6099518	768m
TRENCH 07	10 U 0627401 6099916	793m
TRENCH 08	10 U 0627933 6099713	825m
TRENCH 09	10 U 0628089 6099799	827m
TRENCH 10	10 U 0628427 6099667	843m

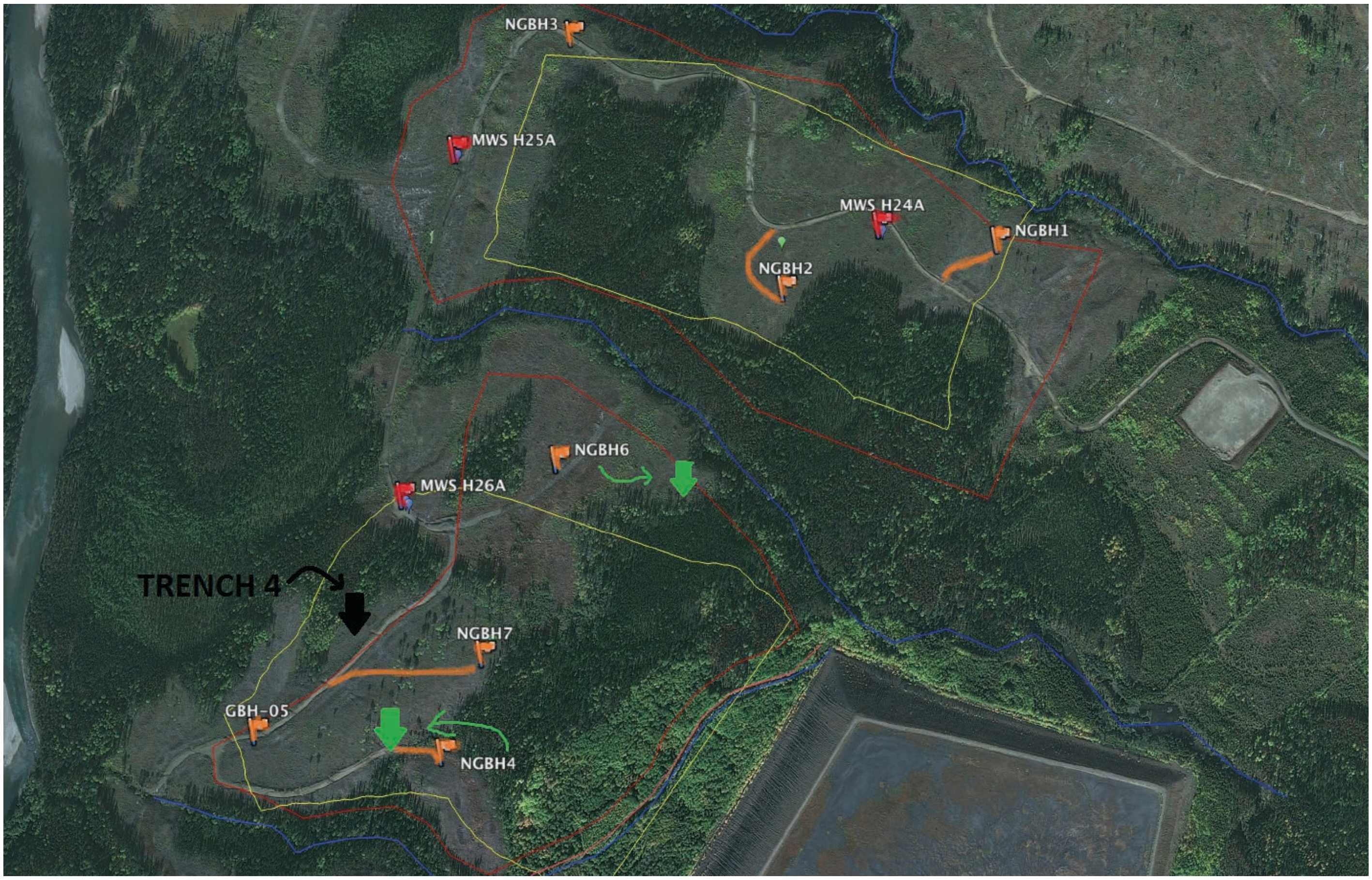


Figure 1 Location of Trench 4

Approximate coordinates from google earth (accuracy +/- 10m):

10 U 0627480

6098769

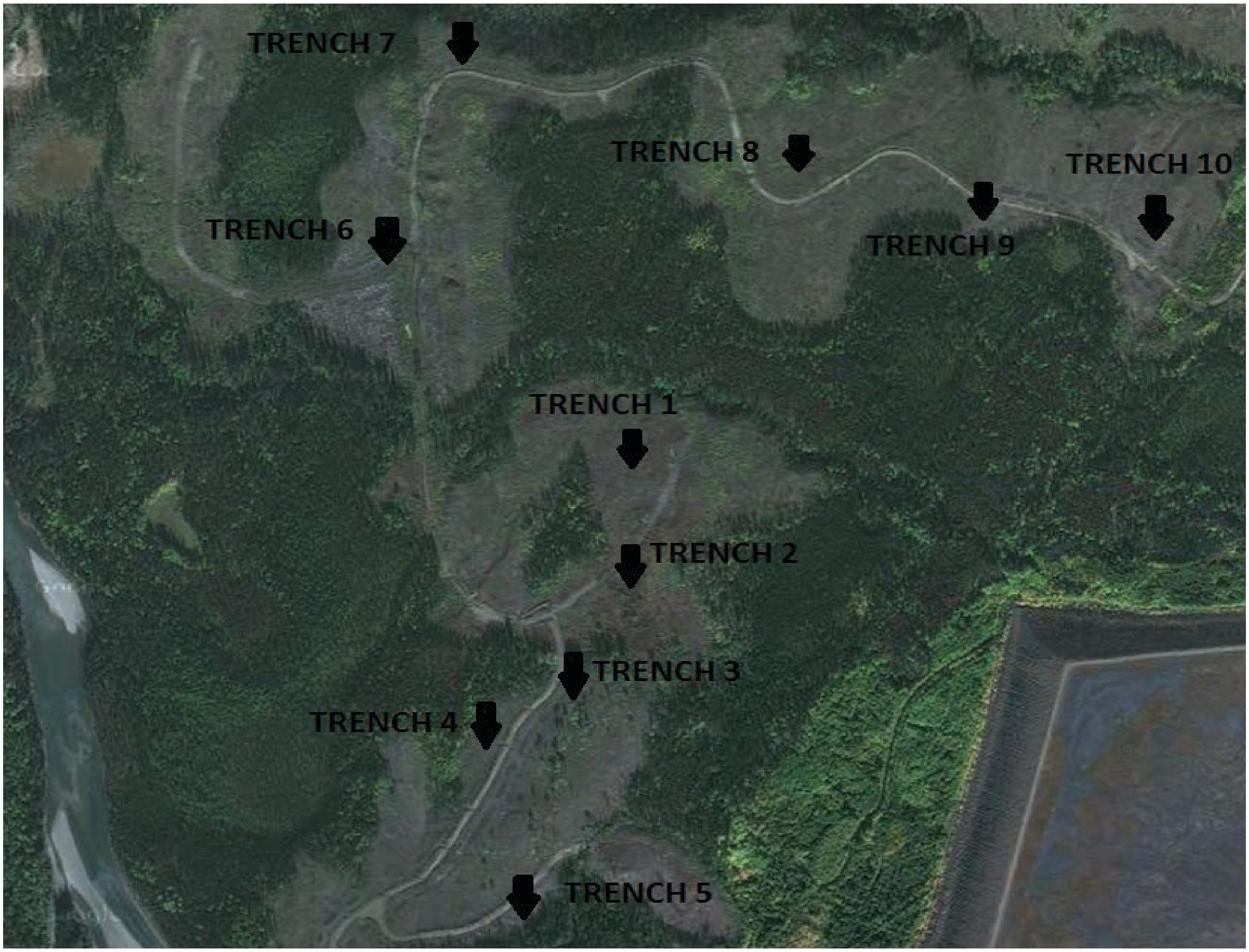


Figure 2 Location of All Trenches

SPT Summary

Standard spoon penetration testing was carried out at all boreholes. The following tables summarize data recorded from the testing.

Table 1 BH - 01

Depth (ft)	Pre- N	1st	2nd
2.5	35	50 for 4in	Refusal
5.0	68	50 for 2in	Refusal
7.5	26	50 for 2in	Refusal

Depth (ft)	Pre- N	1st	2nd
10	82	Refusal	Refusal
15	93	Refusal	Refusal
20	100	Refusal	Refusal
25	68	Refusal	Refusal
30	100 for 5in	Refusal	Refusal
40	100 for 2in	Refusal	Refusal

Table 2 BH - 02

Depth (ft)	Pre- N	1st	2nd	
2.5	4	5	5	7
5.0	6	7	7	
7.5	5	5	7	6
10	8	7	5	6
15	SHELBY →	→	→	
21	SHELBY →	→	→	
25	3	3	4	4
30	Refusal	Refusal	Refusal	

Table 3 BH - 03

Depth (ft)	Pre – N	1st	2nd
2.5	4	6	8
5.0	13	13	16
7.5	27	50 for 5in	Refusal
10	38	50 for 5.5in	Refusal
15	Refusal	Refusal	Refusal

Table 4 BH - 04

Dpeth (ft)	Pre – N	1st	2nd	
7.5	3	5	5	6
10	6	10	23	13
15	7	7	8	9
20	6	9	13	18
25	6	12	13	16
30	7	12	15	18
35	6	10	13	14
40	6	10	13	14
50	6	10	13	15
60	5	7	10	15
70	6	8	9	13
80	6	8	12	14 (No Return)
90	4	5	8	9
100	50	Refusal	Refusal	Refusal

Note: First 5 ft was road fill and therefore not part of the original ground. Hence we started spooning at 7.5 ft. All depths are therefore actually 5 feet shallower than measured. See figure 1:

Figure 3 BH - 04. Note approx. 5 ft of road fill on top of natural ground

Table 5 BH - 05

Depth (ft)	Pre – N	1st	2nd	
2.5	4	4	4	10
5.0	5	8	13	13
7.5	4	8	11	18
10	6	10	15	17
15	3	5	9	12
20	4	6	12	13
25	2	4	7	11

Depth (ft)	Pre – N	1st	2nd	
30	7	8	14	18
40	8	9	16	21
50	6	13	20	24

Table 6 BH - 06

Depth (ft)	Pre – N	1st	2nd	Comments
2.5	8	21	33	Doesn`t pass the silt liquefaction test, but doesn`t feel like clay either. Could be some sort of sandy till. It`s full of little pebbles and stones and other erratics.
				Spoon diameter of 2.5 inches (bigger than normal). Much harder to spoon; too hard to Shelby. We`re going to start coring.
				Turns out material is too soft to core. A 5ft run failed to produce anything of worth. Material is also too hard to Shelby. Went back to regular spooning (not the 2.5in, it was causing too many problems)
10	50	Refusal	Refusal	Looks like we`re in bedrock. Incredibly shallow, drillers suggested we do another spoon at 15ft just to be sure. Looks like we`re going to have to go back to coring. Overburden here is nothing like the other holes. Instead of that typical sitly clay that we find elsewhere, we`re getting a tilly silt with lots of pebbles.
15	Refusal	Refusal	Refusal	Yup, we`re definitely in bedrock here.

Table 7 BH - 07

Depth (ft)	Pre – N	1st	2nd	
2.5	12	5	5	10
5.0	4	7	12	19
7.5	8	9	14	21
10	6	12	16	23
15	8	13	21	22
20	5	10	15	20
25	7	11	17	24
30	8	14	20	25
40	Refusal	Refusal	Refusal	Refusal

Trenches

Ten test pits, each with a depth of roughly 3m, were dug throughout the site to determine near surface conditions. Photographs and observations from these pits are highlighted below.

Tr – 01

Depth (m)	Observations
1	Light brown silty clay 
2	Darker in colour, silty, more erratics. 

Depth (m)	Observations
3	Slaty features. Lots of erratics. Light in colour. 

Tr – 02

Depth (m)	Observations
1	Similar to Trench 1. Light brown silt
2	Darker in colour. Coarser grained more eratics.
3	Slaty features, lighter in colour. This pit in general had more moisture than Trench 1. Otherwise, it was very similar.

Tr – 03

Depth (m)	Observations
1	Silt. Has sandy features. Less erratics, a lot of moisture. Lighter in colour.
2	More erratics, silt.
3	Slaty features, coarser grained. Less erratics throughout. Less moisture than Trench 2.

Tr – 04

Depth (m)	Observations
1	Silty/sandy material 
2	Coarser grained, same material 

Depth (m)	Observations
3	Some slatyness, less than previous trenches. 

Tr – 05

Depth (m)	Observations
1	Pure Silt. Moisture. No sand or clay 
2	Coarser grained, more erratics, still silty 

Depth (m)	Observations
3	Identical to 1m 

Tr- 06

Depth (m)	Observations
1	Organic soil all the way down. Hit logs at about two metres deep, Couldn’t go any deeper. Funny earthy smell. Hoe operator thinks something might have been buried here a while ago.
2	
3	

Tr – 07

Depth (m)	Observations
1	Sandy, low moisture
2	Finer grains
3	Silty clay

Tr- 08

Depth (m)	Observations
1	Silty clay. Few erratics.
2	Coarser grained material
3	Slaty features. Still relatively silty.

Tr – 09

Depth (m)	Observations
1	Big erratics. Plenty of chunks and pebbles. Some moisture, gravelly texture.
2	Gravel, finer grained than above.
3	Coarse grained, silty sand.

Tr – 10

Depth (m)	Observations
1	Big erratics. Plenty of chunks and pebbles. Some moisture, gravelly texture.
2	Gravel, finer grained than above.
3	Coarse grained, silty sand.

Appendix 2 – Laboratory Data

Particle Size Distribution

MEG TECHNICAL SERVICES

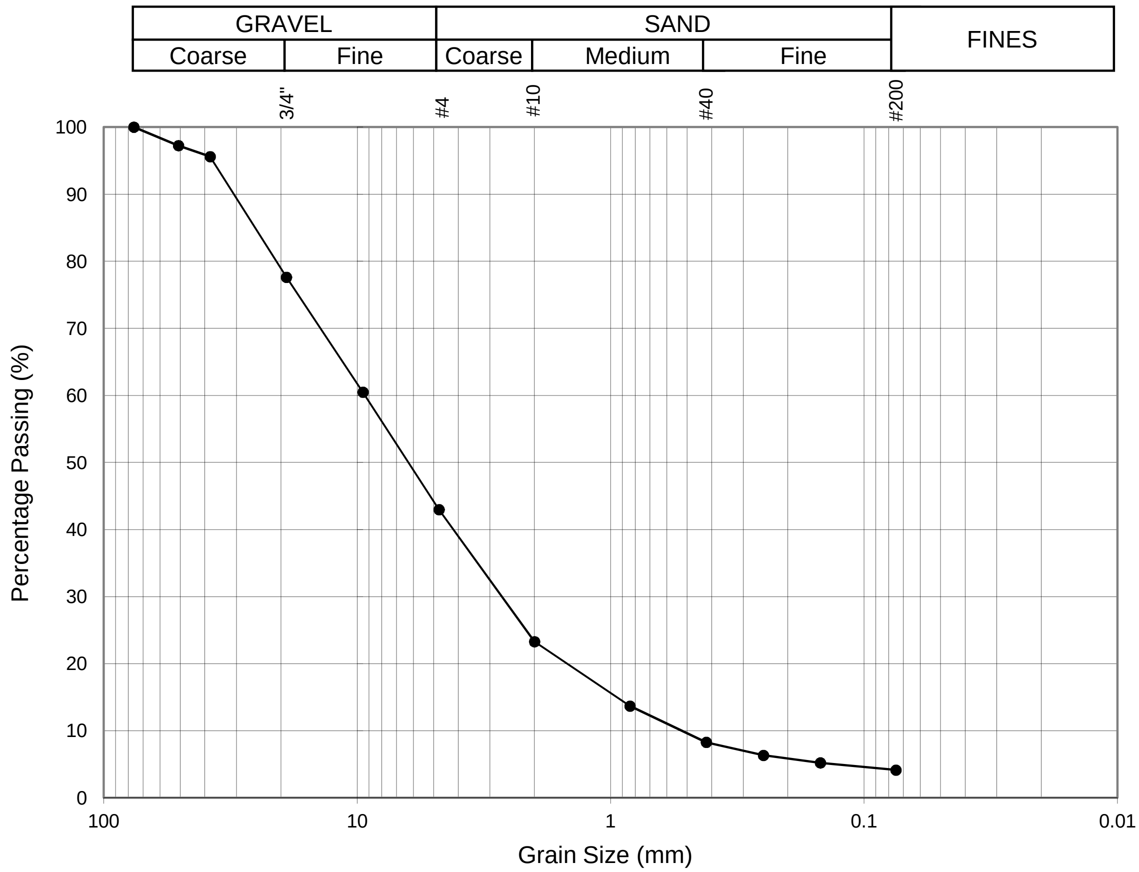
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	February 19, 2014
Borehole:	N/A Sample No.: Bucket Sample 1	Depth (m):	N/A

Unified Soil Classification System (ASTM D 2487)

Description of Material: Black coarse to fine GRAVEL and medium to coarse SAND, trace fine sand and fines (silt/clay)



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	
Bucket Sample 1	N/A	22	35	20	15	4	4

Comments:

Prepared by:	PC	Checked by:	PS	Approved by:	EP
Date:	February 19, 2014	Date:	February 19, 2014	Date:	February 19, 2014

MEG TECHNICAL SERVICES

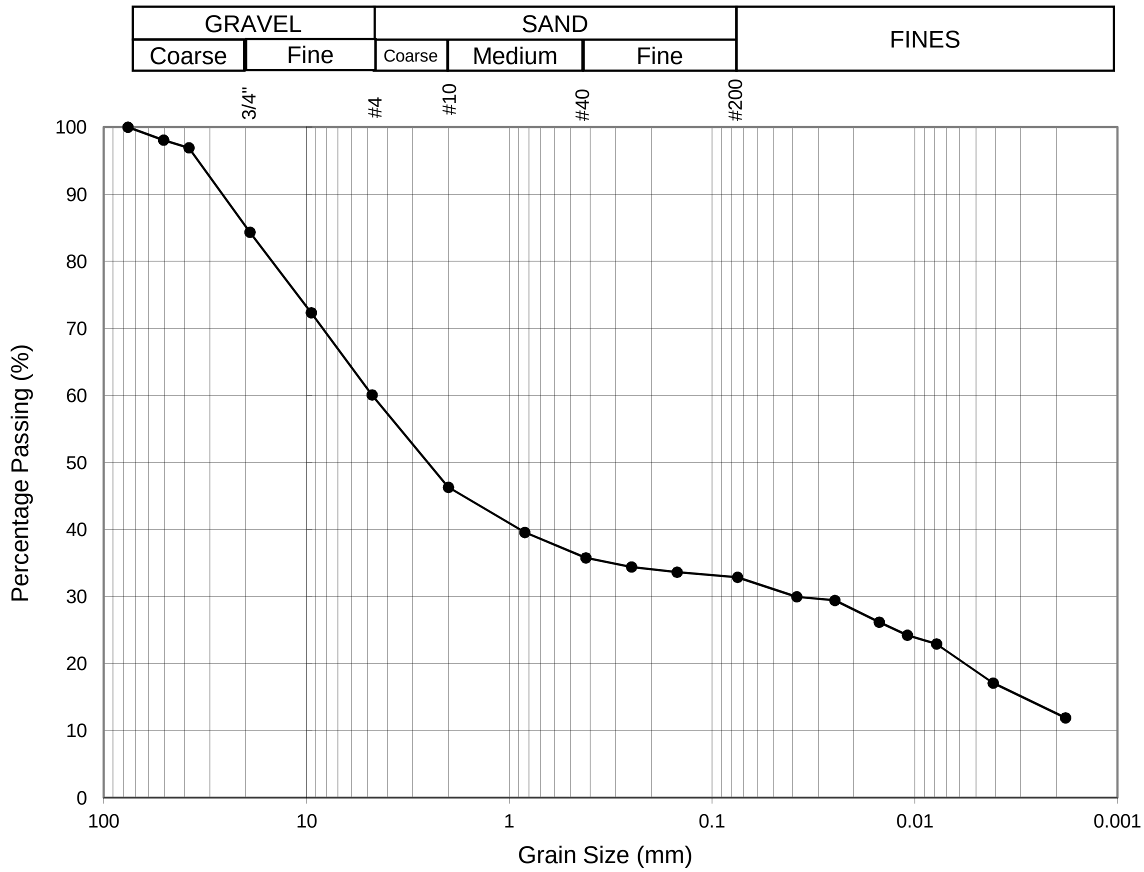
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	February 19, 2014
Borehole: N/A	Sample No.: Composite Sample	Depth (m):	N/A

Unified Soil Classification System (ASTM D 2487)

Description of Material: Black silty/clayey sandy GRAVEL



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	
Composite Sample	N/A	16	24	14	11	3	33

Comments: Hypothetical gradation of a composite sample. Compostite sample would be made up of 70% coarse material (bucket 1 sample) and 30% fine material (bucket 2 sample)

Prepared by:	PC	Checked by:	PS	Approved by:	LC
Date:	February 19, 2014	Date:	February 19, 2014	Date:	February 19, 2014

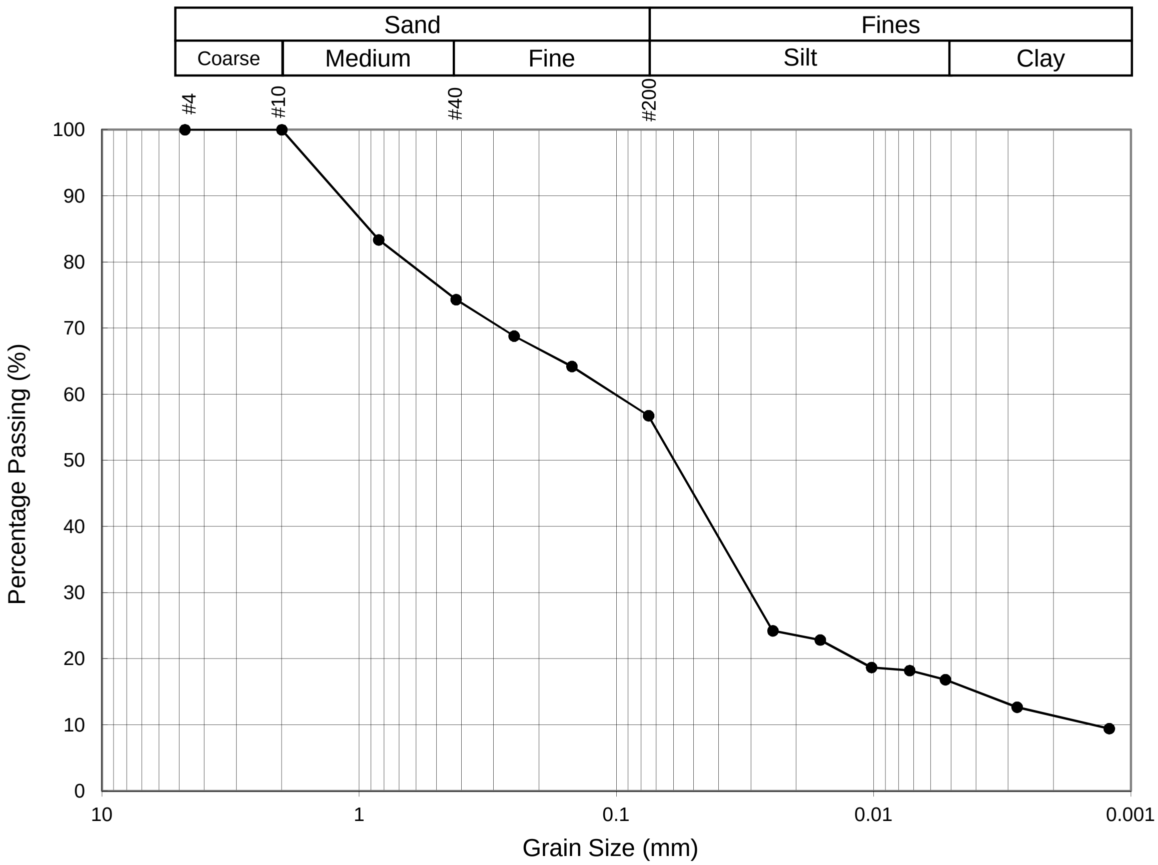
MEG TECHNICAL SERVICES
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	BH-01	Sample No.:	Bag 1	Depth (m):	0.76

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive gray SAND and SILT, some clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	0.76	0	0	26	18	40	16

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 20, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

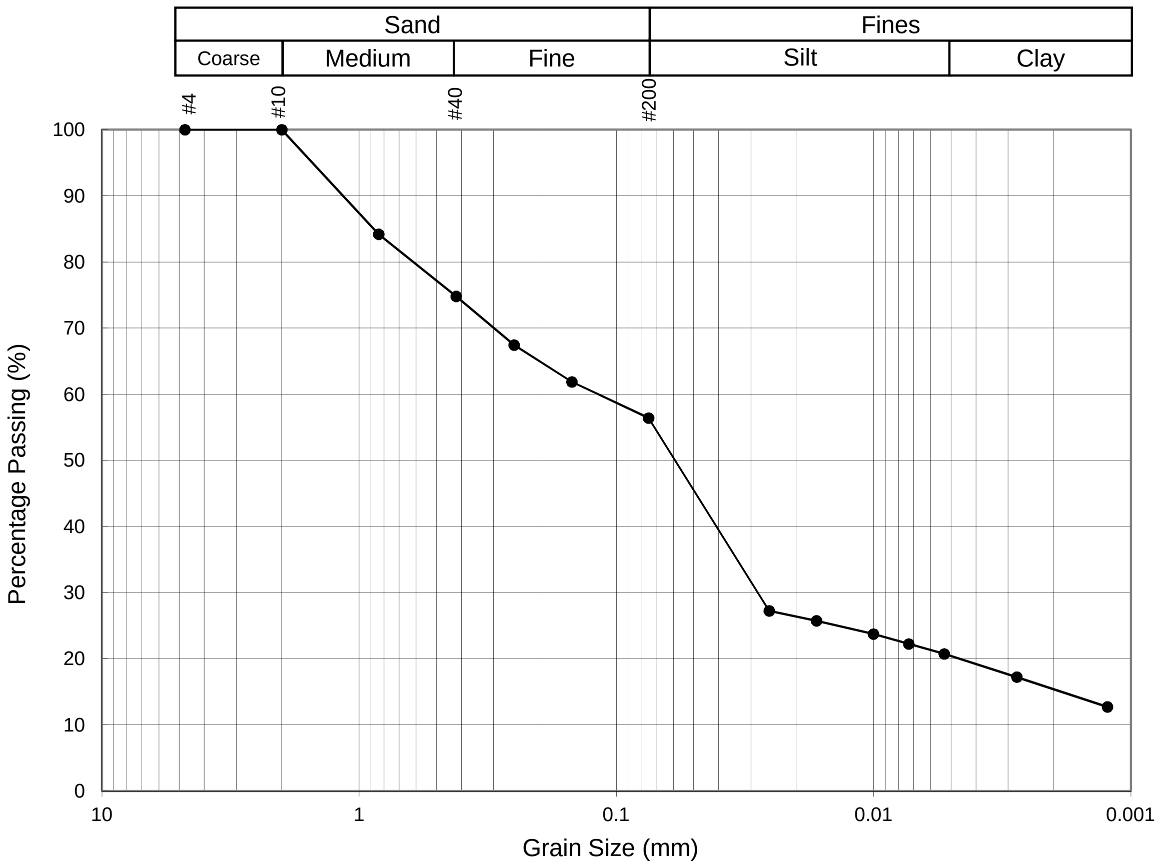
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	BH-01	Sample No.:	Bag 2	Depth (m):	6.1

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive gray clayey medium to fine SAND and SILT



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	6.10	0	0	25	18	36	20

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 23, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

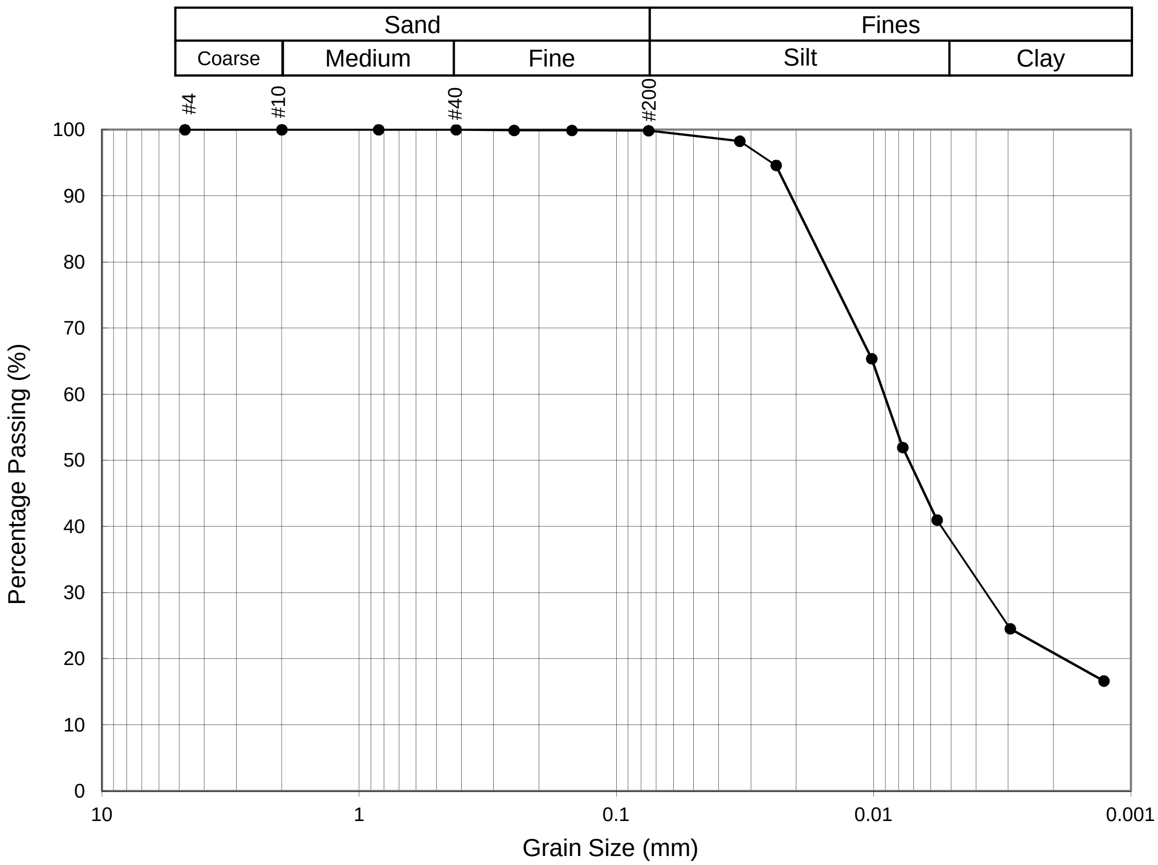
Marine + Earth
MEG
Geosciences

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 23, 2013
Borehole:	BH-02	Sample No.:	Shelby 1	Depth (m):	4.46

Unified Soil Classification System (ASTM D 2487)

Description of Material: Very dark gray SILT and CLAY



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Shelby 1	4.46	0	0	0	0	62	38

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 23, 2013	Date:	September 27, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

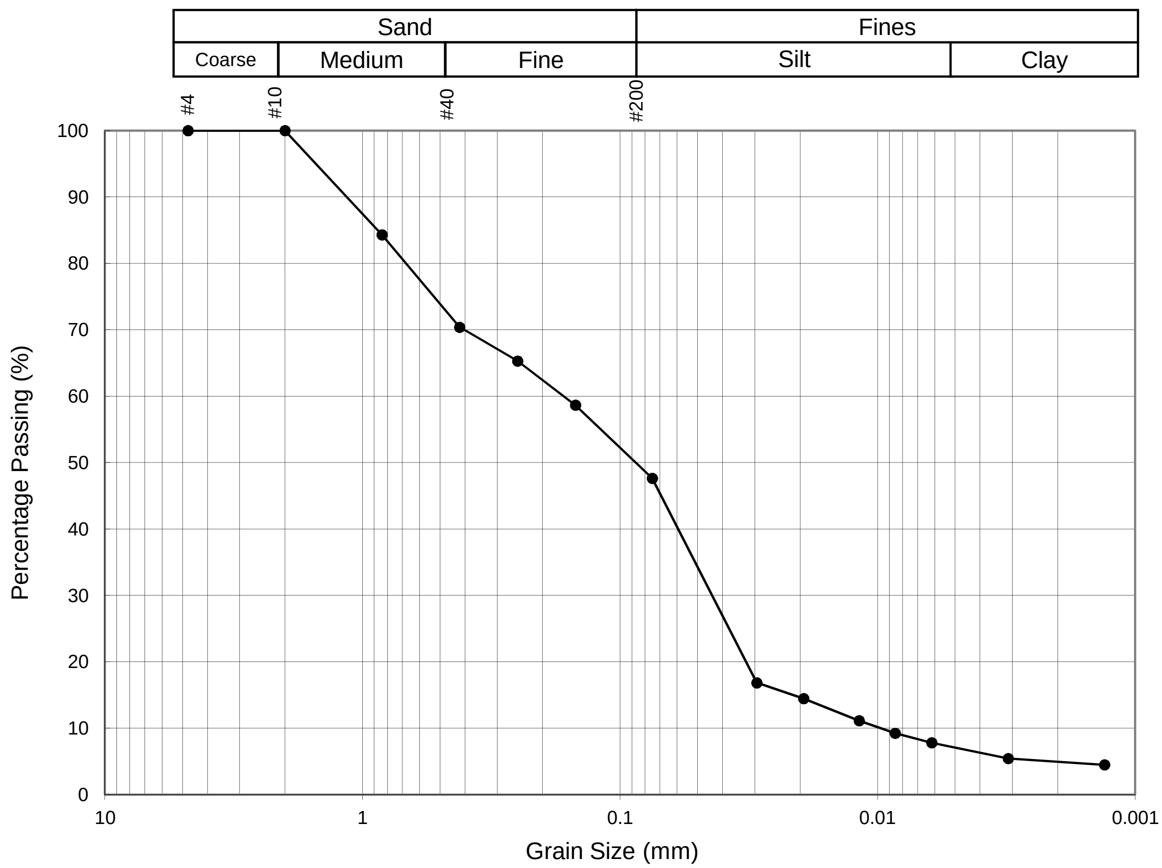
(A Division of MEG Consulting Limited)

ribution (ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	BH-03	Sample No.:	Bag 1	Depth (m):	0.76

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive medium to fine SAND and SILT, some clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	0.76	0	0	30	23	41	7

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 23, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

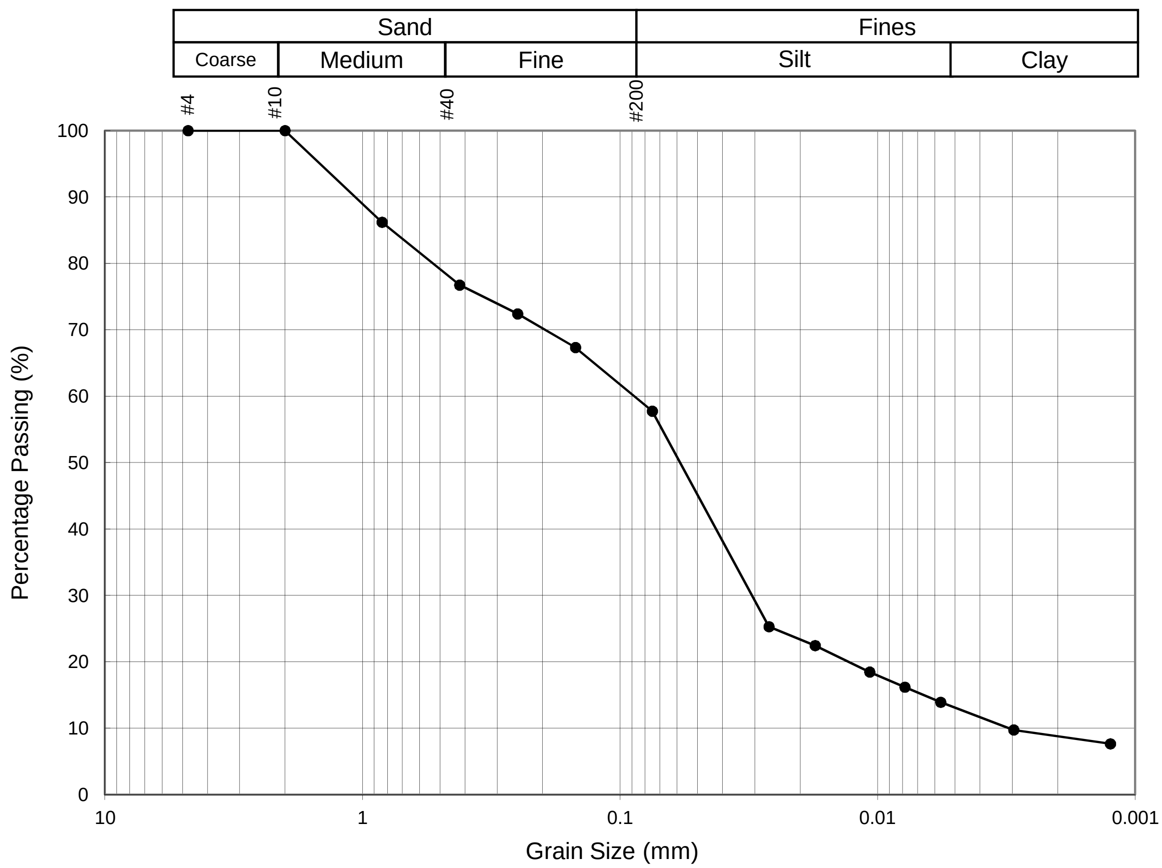
(A Division of MEG Consulting Limited)

ribution (ASTM D 422)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 17, 2013
Borehole:	BH-03 Sample No.: Bag 2	Depth (m):	2.29

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive SILT and SAND, some clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	2.29	0	0	23	19	45	13

Comments:

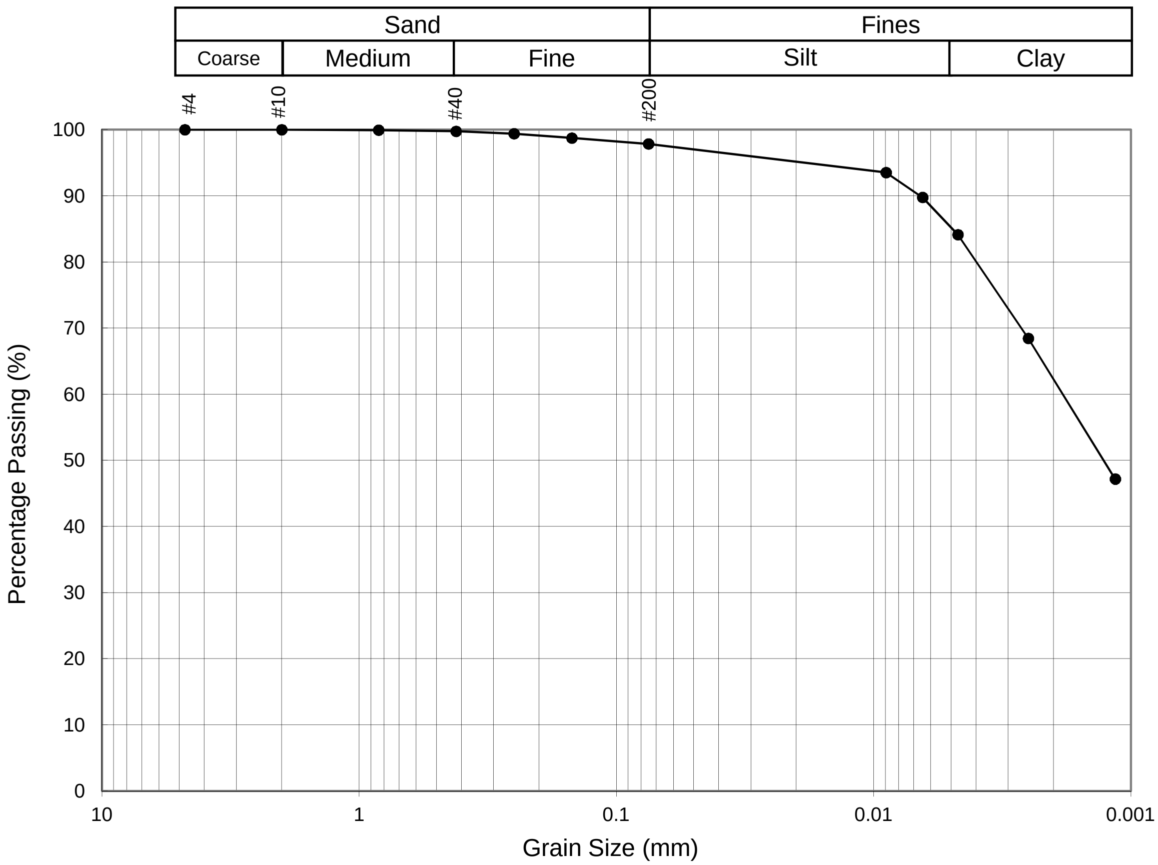
Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 17, 2013	Date:	September 23, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES (A Division of MEG Consulting Limited)			
Particle Size Distribution (ASTM D 422)			

Project:	Ausenco - Murray River		Project No.:	13-MTS-028
Location:	BC		Date:	September 18, 2013
Borehole:	BH-04	Sample No.: Bag 1	Depth (m):	9.14

Unified Soil Classification System (ASTM D 2487)

Description of Material: Dark gray CLAY, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	9.14	0	0	0	2	13	85

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 18, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

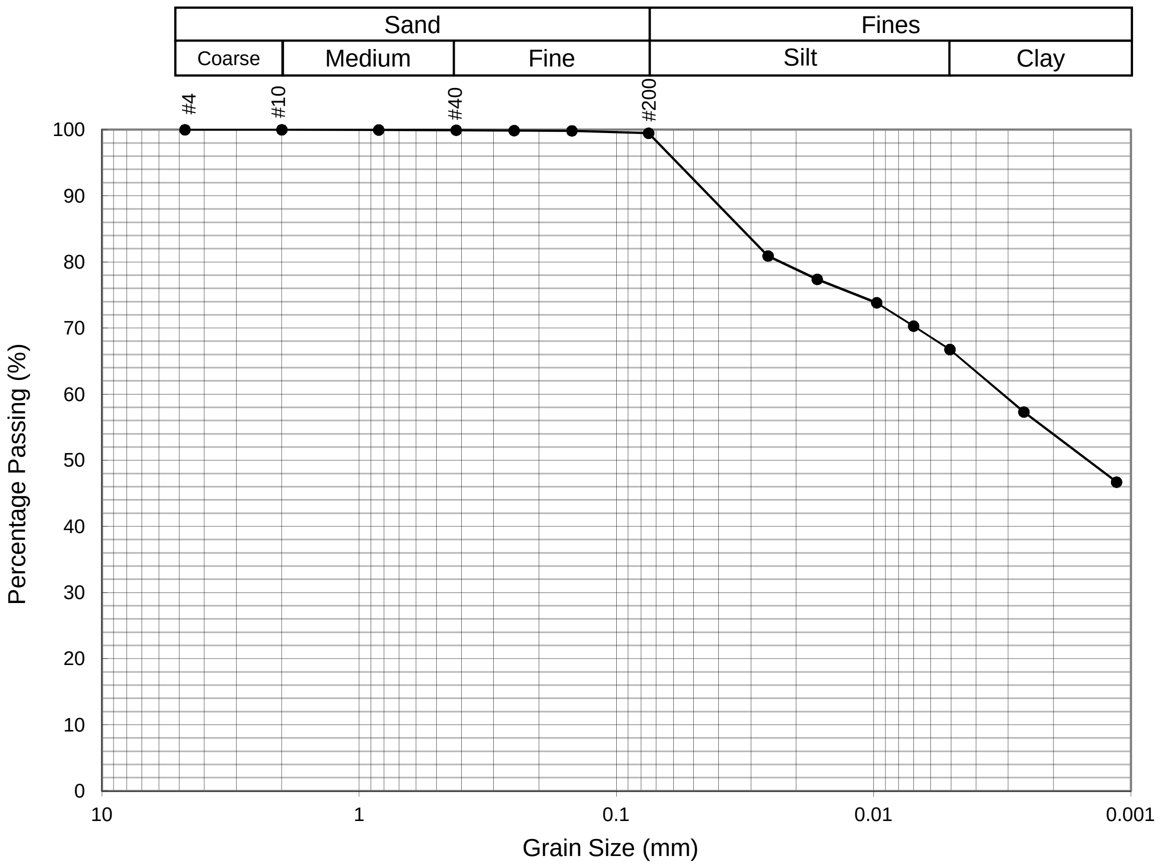
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 24, 2013
Borehole:	BH-04	Sample No.:	Bag 2	Depth (m):	21.34

Unified Soil Classification System (ASTM D 2487)

Description of Material: Dark gray silty CLAY, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	21.34	0	0	0	1	32	67

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

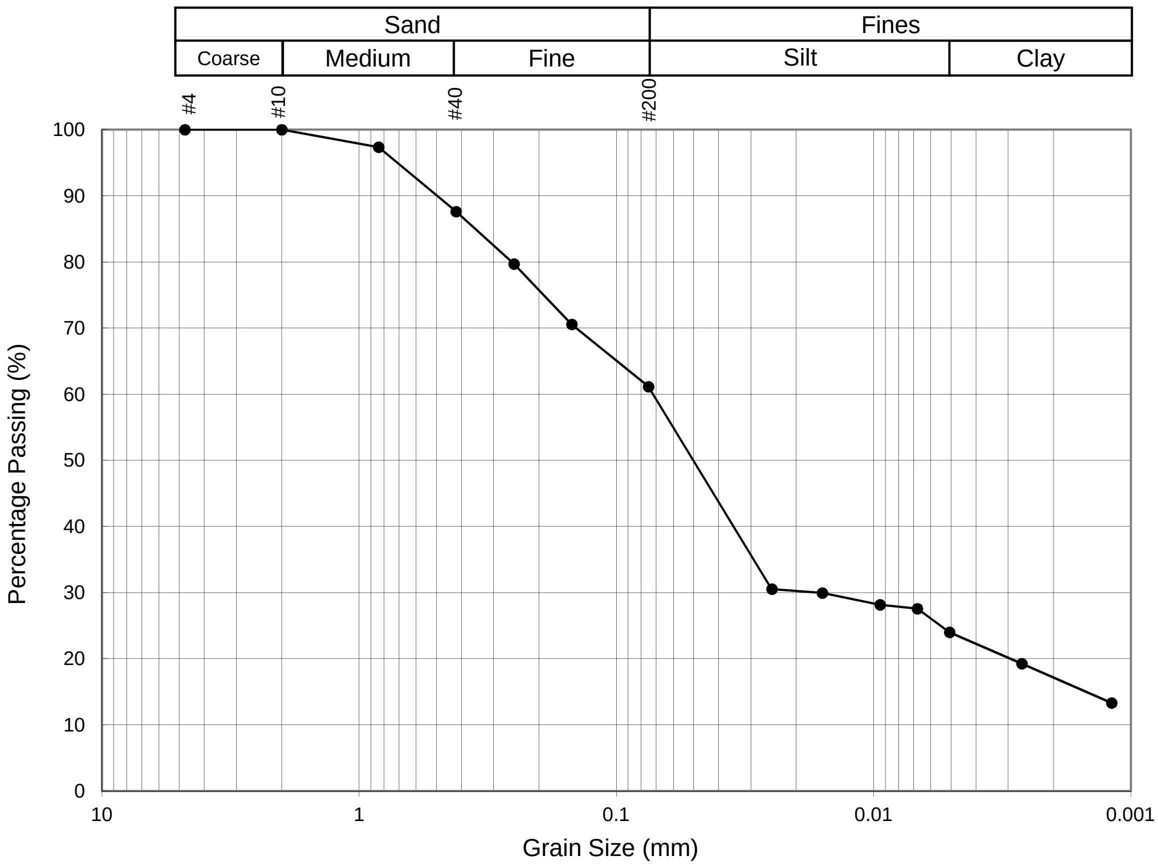
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	BH-05	Sample No.:	Bag 1	Depth (m):	0.76

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive clayey SAND and SILT



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	0.76	0	0	12	26	37	24

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 21, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

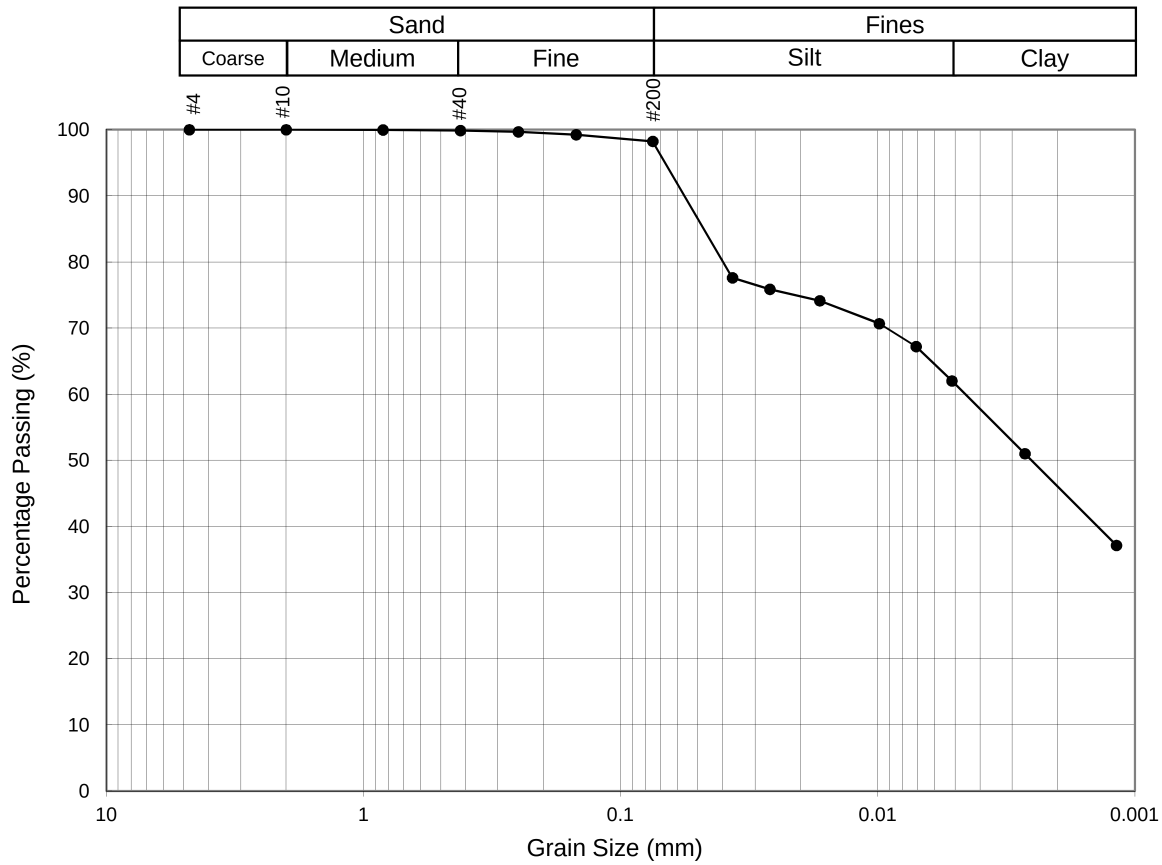
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 24, 2013
Borehole:	BH-05	Sample No.:	Bag 2	Depth (m):	1.5

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive silty CLAY, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	1.50	0	0	0	2	36	62

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

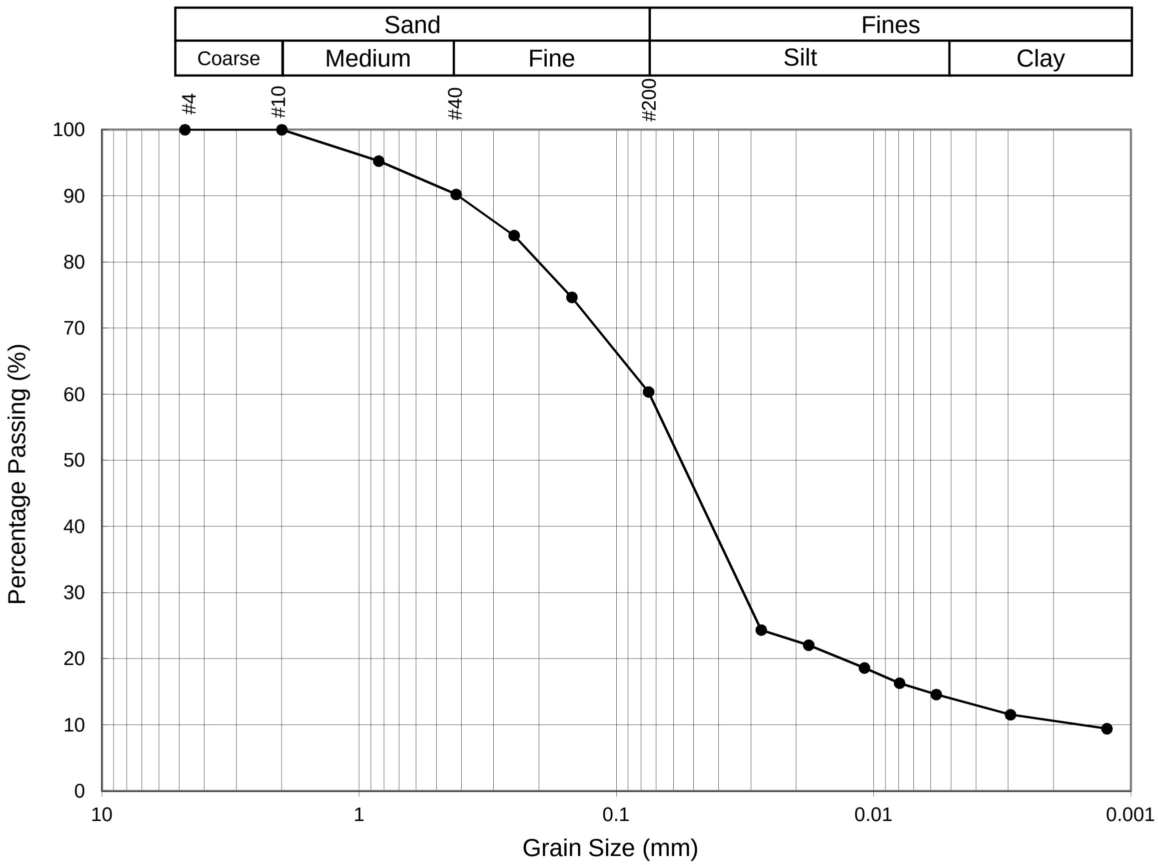
MEG TECHNICAL SERVICES
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 17, 2013
Borehole:	BH-06	Sample No.:	Bag 1	Depth (m):	0.76

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive SAND and SILT, some clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	0.76	0	0	10	30	46	14

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 21, 2013	Date:	October 31, 2013

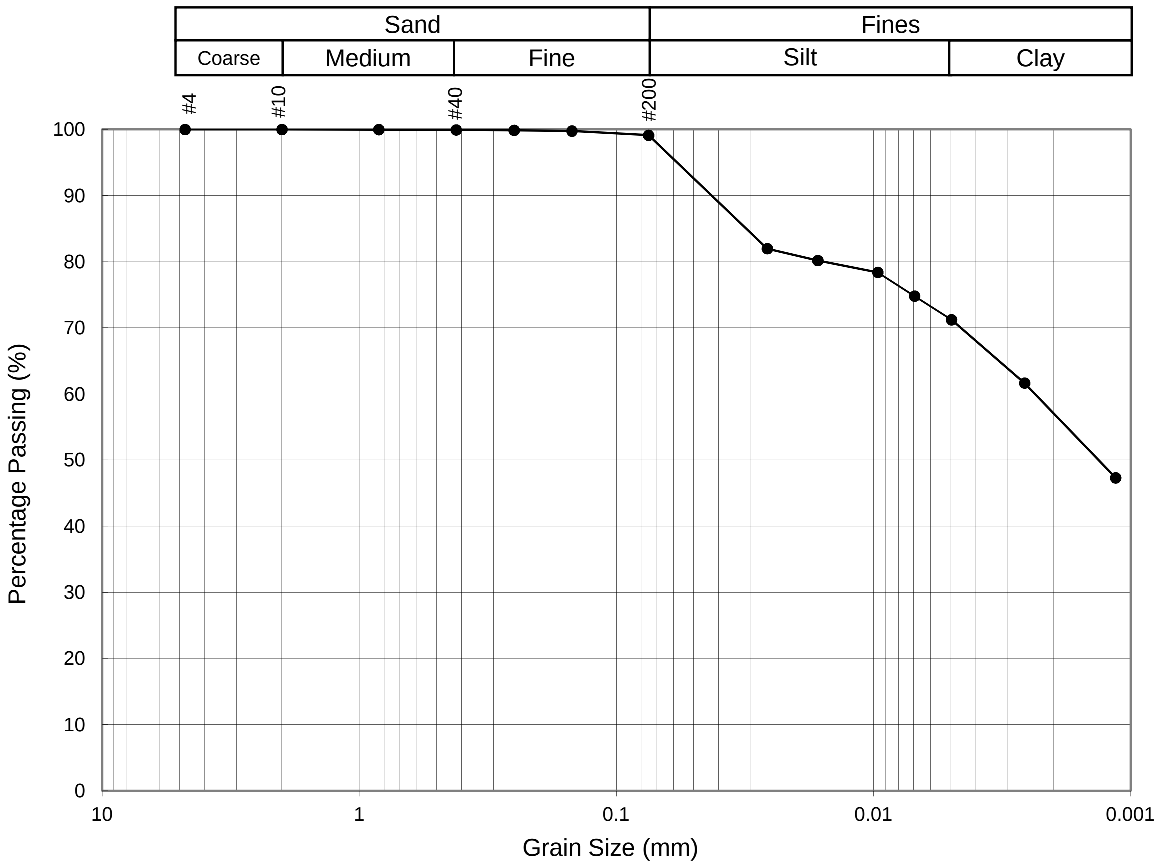
MEG TECHNICAL SERVICES
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 24, 2013
Borehole:	BH-07	Sample No.:	Bag 1	Depth (m):	7.62

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive gray silty CLAY, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	7.62	0	0	0	1	28	71

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

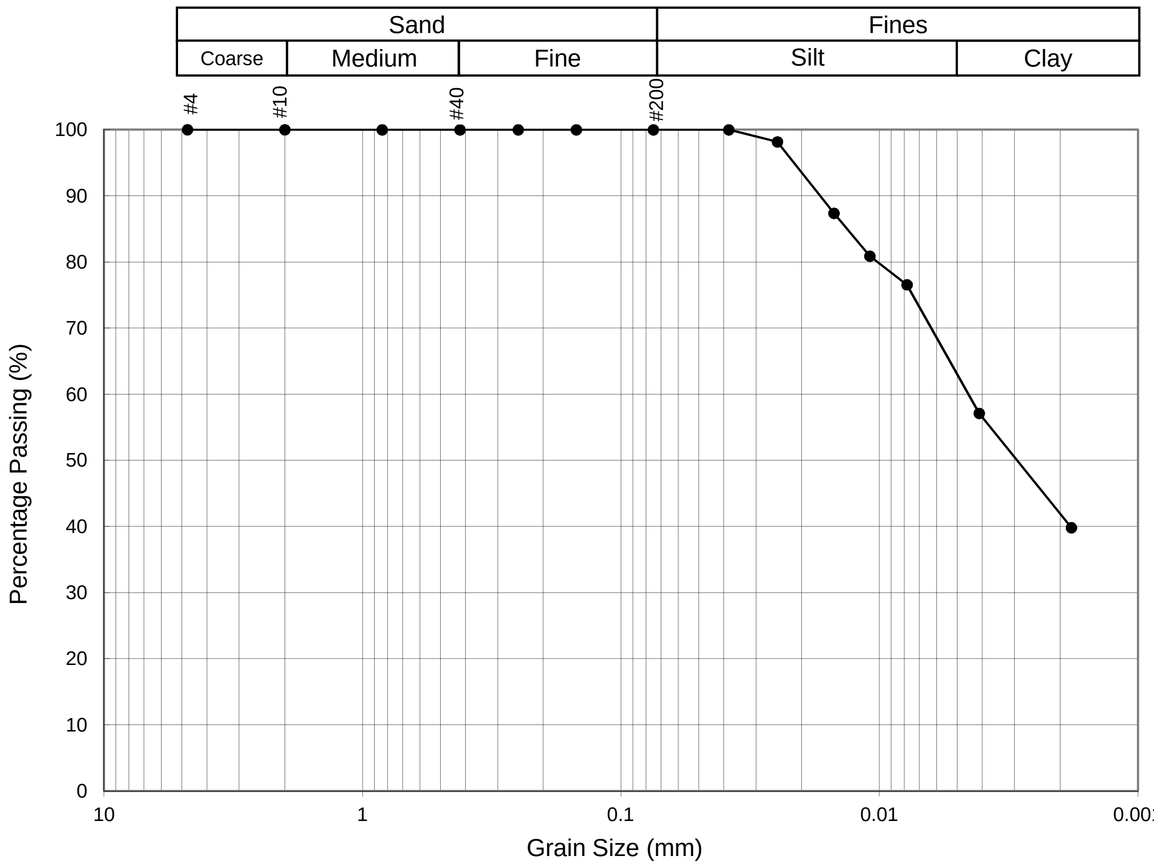
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 19, 2013
Borehole: N/A	Sample No.: Bucket Sample 2	Depth (m):	N/A

Unified Soil Classification System (ASTM D 2487)

Description of Material: Black CLAY and SILT



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
0	N/A	0	0	0	0	40	63

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

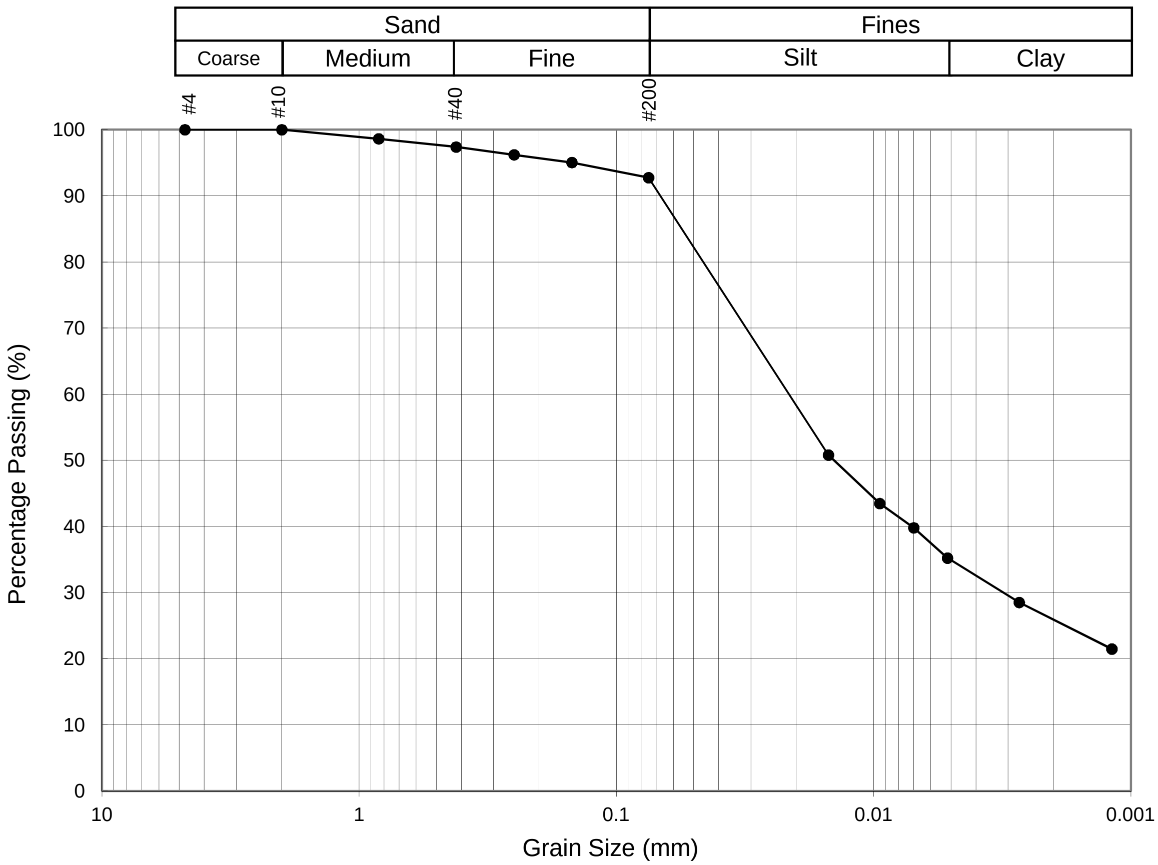
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 17, 2013
Borehole:	T2	Sample No.:	Bag 2	Depth (m):	1.00

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive SILT and CLAY, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	1.00	0	0	3	5	58	35

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 18, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

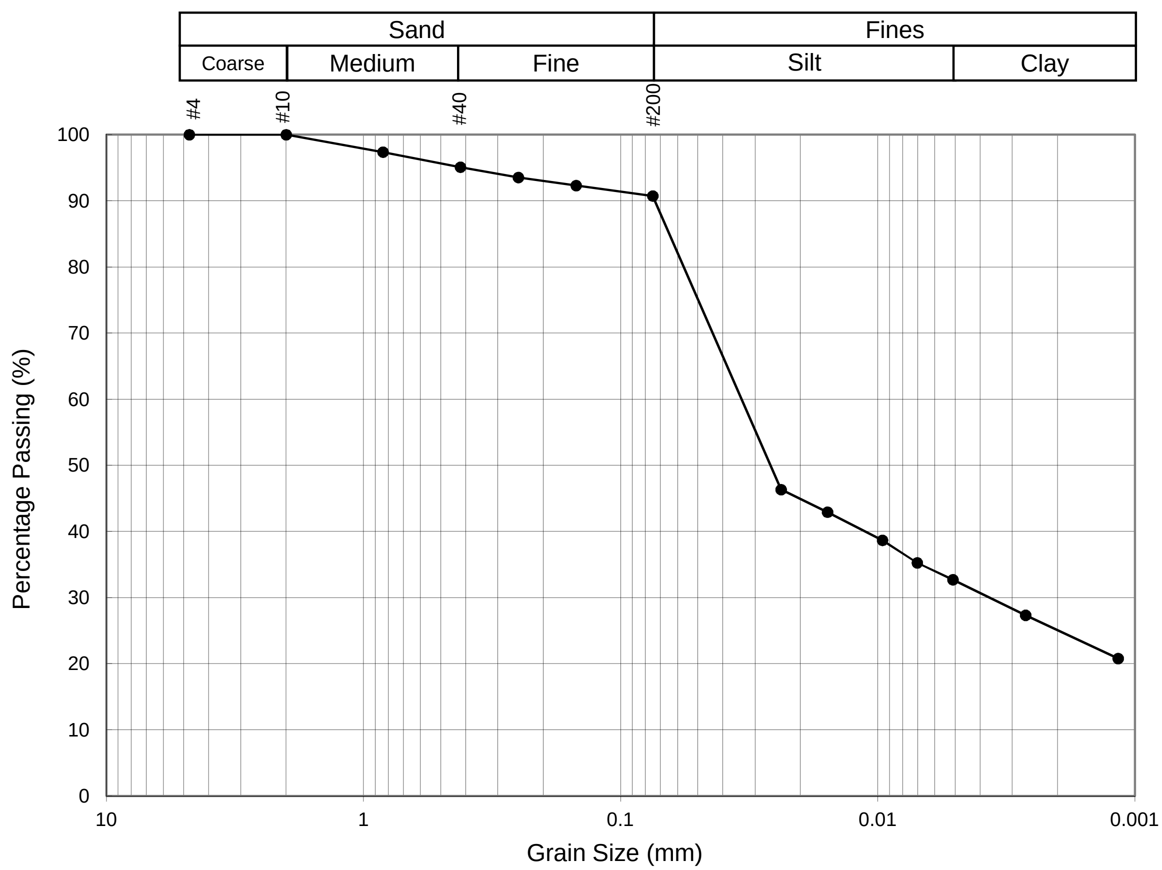
Marine + Earth Geosciences

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 18, 2013
Borehole:	T2	Sample No.:	Bag 2	Depth (m):	2.00

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive clayey SILT



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	2.00	0	0	5	4	58	33

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 18, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

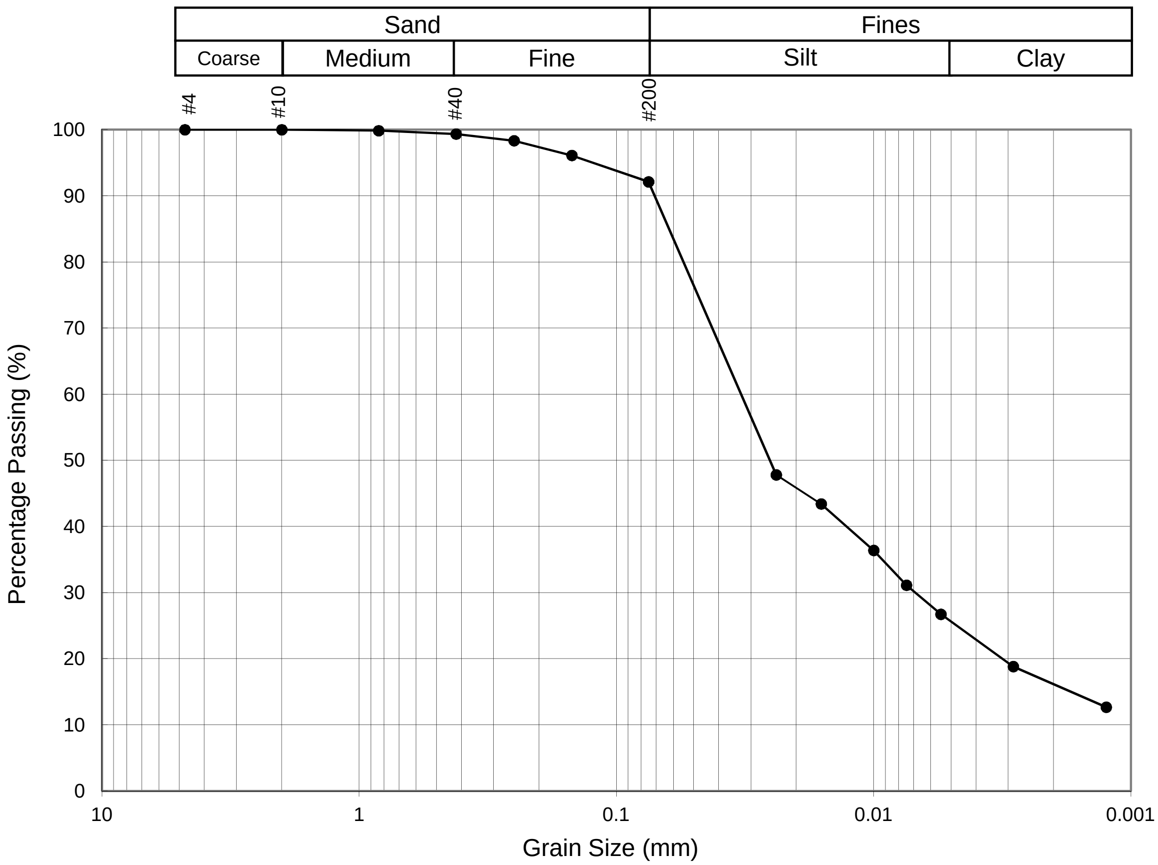
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	T4	Sample No.:	Bag 1	Depth (m):	1.2

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive clayey SILT, trace sand



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	1.20	0	0	1	7	66	26

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

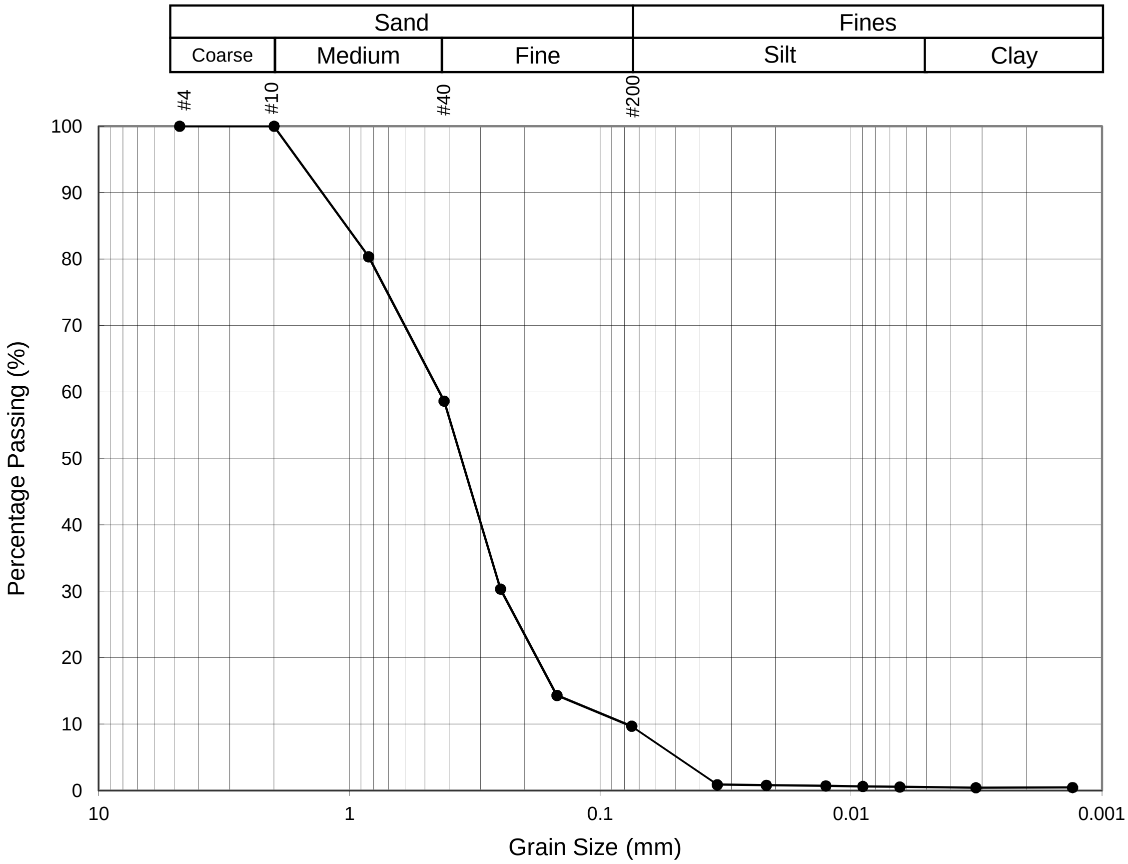
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 18, 2013
Borehole:	T9	Sample No.:	Bag 2	Depth (m):	2

Unified Soil Classification System (ASTM D 2487)

Description of Material: Dark olive gray poorly graded fine to medium SAND, some silt trace clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	2.00	0	0	41	49	9	1

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 18, 2013	Date:	September 21, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

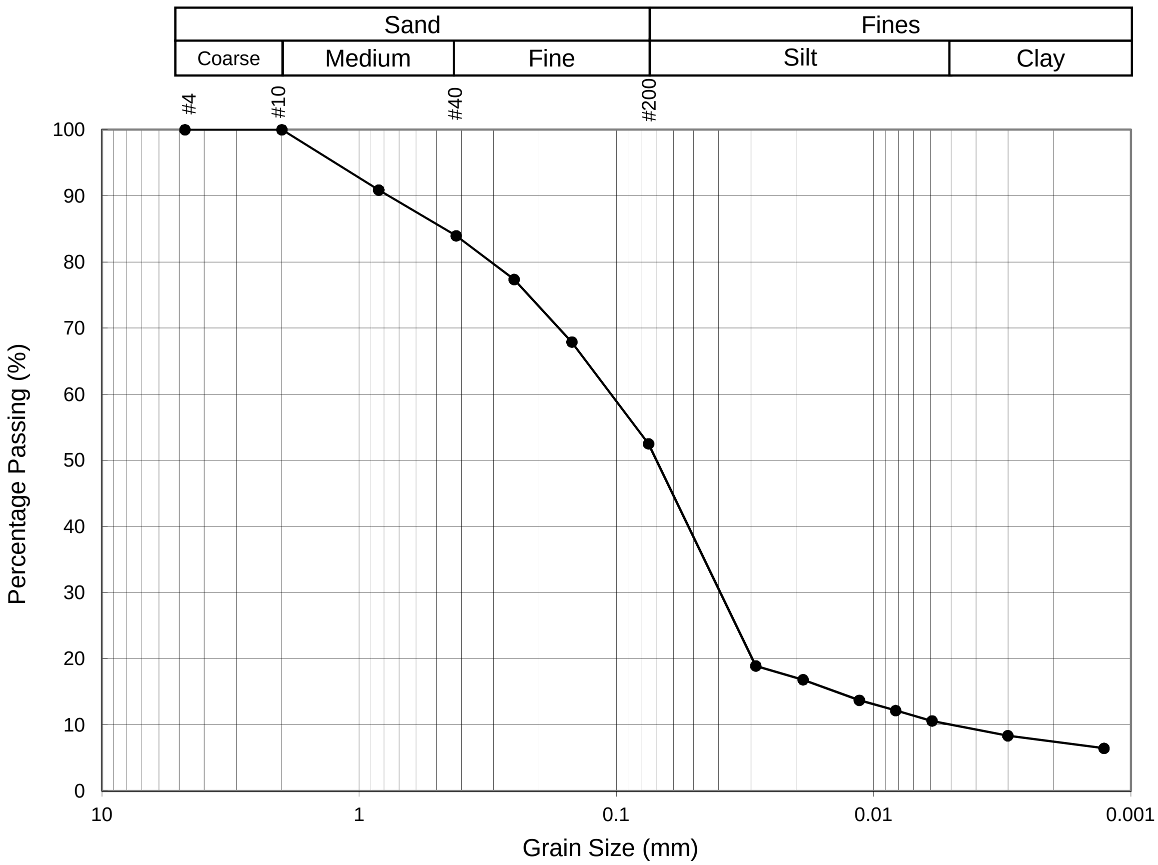
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 17, 2013
Borehole:	T10	Sample No.: Bag 1	Depth (m): 1.00

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive fine to medium SAND and SILT, some clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 1	1.00	0	0	16	31	43	10

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 17, 2013	Date:	September 21, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

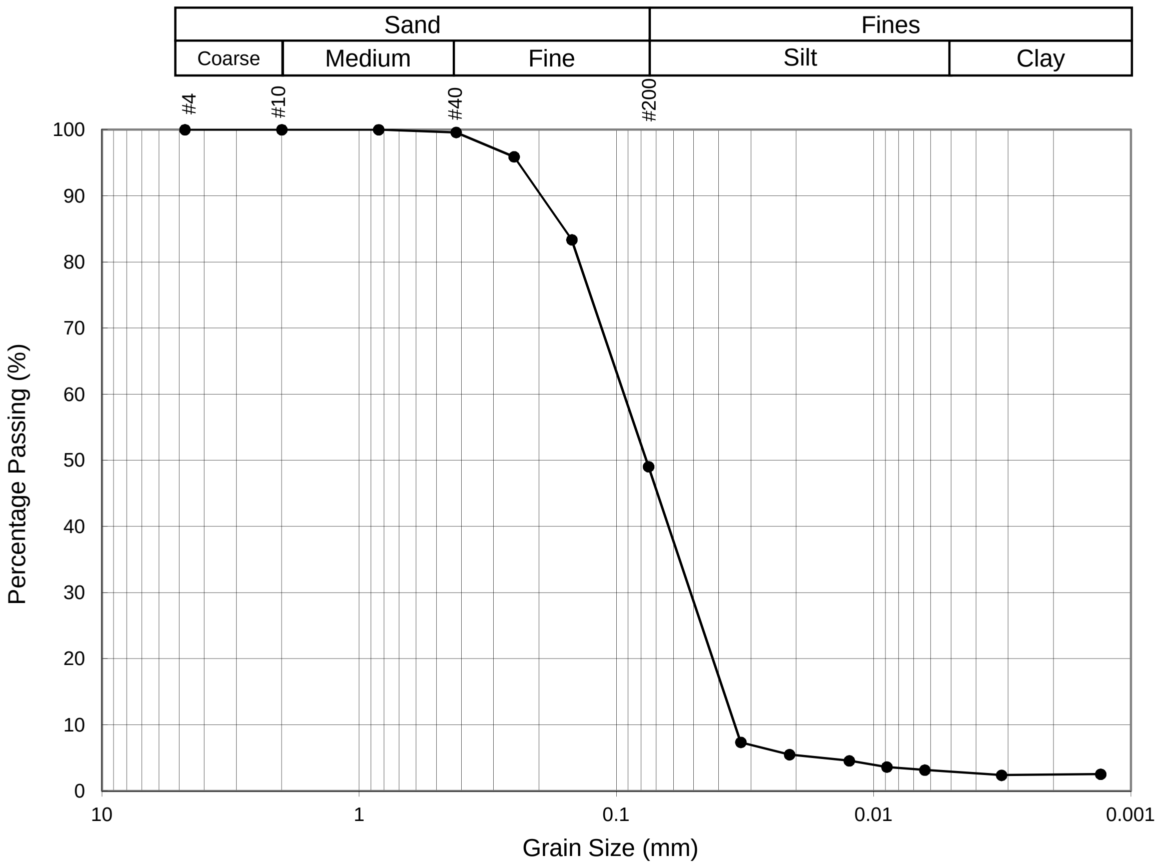
(A Division of MEG Consulting Limited)

Particle Size Distribution
(ASTM D 422)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 13, 2013
Borehole:	T10	Sample No.:	Bag 2	Depth (m):	3

Unified Soil Classification System (ASTM D 2487)

Description of Material: Olive fine SAND and SILT, trace clay



Sample No.	Depth (m)	Percentage of Material by Weight (%)					
		Gravel	Sand			Fines	
			Coarse	Medium	Fine	Silt	Clay
Bag 2	3.00	0	0	0	51	46	3

Comments:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 13, 2013	Date:	September 21, 2013	Date:	October 31, 2013

Atterberg Limits

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

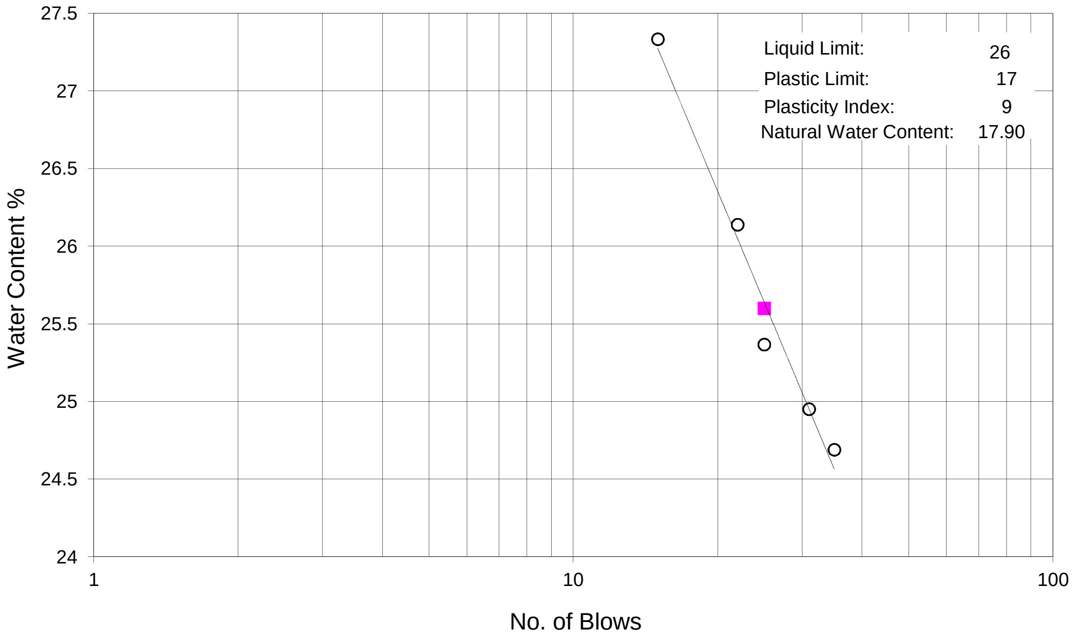
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 13, 2013
Borehole:	BH-01	Sample No.:	Bag 1	Depth (m):	0.76

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
59	31.25	30.04	25.27	1.21	4.77	25.4	25	148	26.10	25.22	20.01	0.88	5.21	16.9
58	31.81	30.54	25.45	1.27	5.09	25.0	31	134	26.17	25.27	20.07	0.90	5.20	17.3
51	39.51	38.12	32.49	1.39	5.63	24.7	35							
40	39.82	38.50	33.45	1.32	5.05	26.1	22							
11	40.55	38.91	32.91	1.64	6.00	27.3	15							

Classification of the material : CL

74.3 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	PC	Checked by:	HB	Approved by:	JPS
Date:	September 16, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

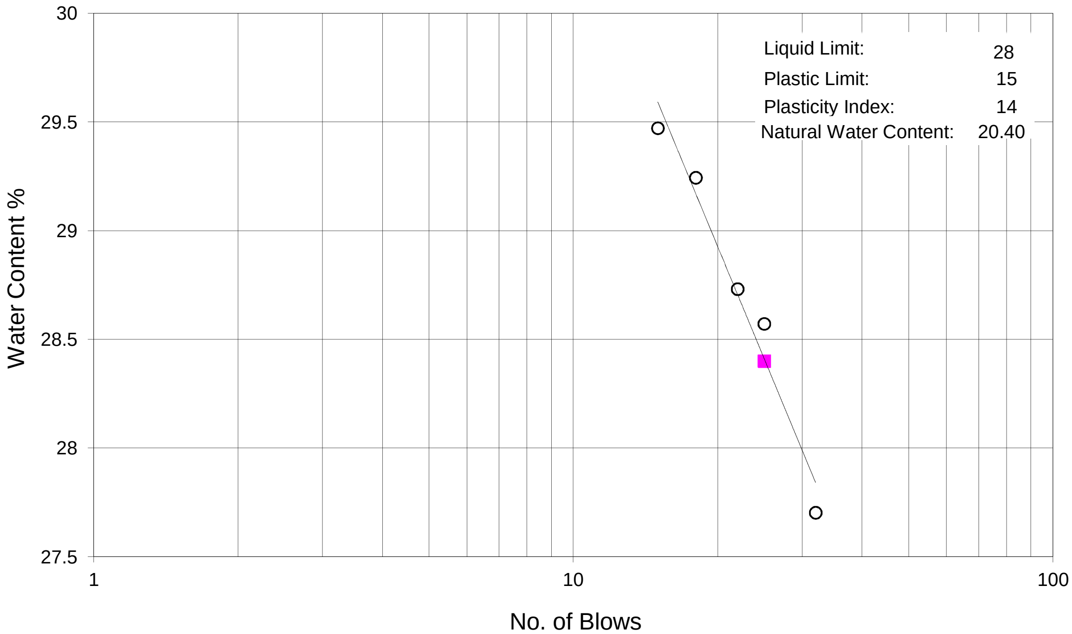
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project: Ausenco - Murray River		Project No.:	13-MTS-028
Location: BC		Date:	September 13, 2013
Borehole: BH-01	Sample No.: Bag 2	Depth (m):	6.10

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
98	41.43	39.79	33.87	1.64	5.92	27.7	32	152	26.24	25.46	20.18	0.78	5.28	14.8
86	33.80	32.02	25.79	1.78	6.23	28.6	25	146	26.27	25.50	20.19	0.77	5.31	14.5
62	31.87	30.33	24.97	1.54	5.36	28.7	22							
55	31.94	30.20	24.25	1.74	5.95	29.2	18							
38	40.96	39.51	34.59	1.45	4.92	29.5	15							

Classification of the material : CL

74.8 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	PC	Checked by:	HB	Approved by:	JPS
Date:	September 16, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

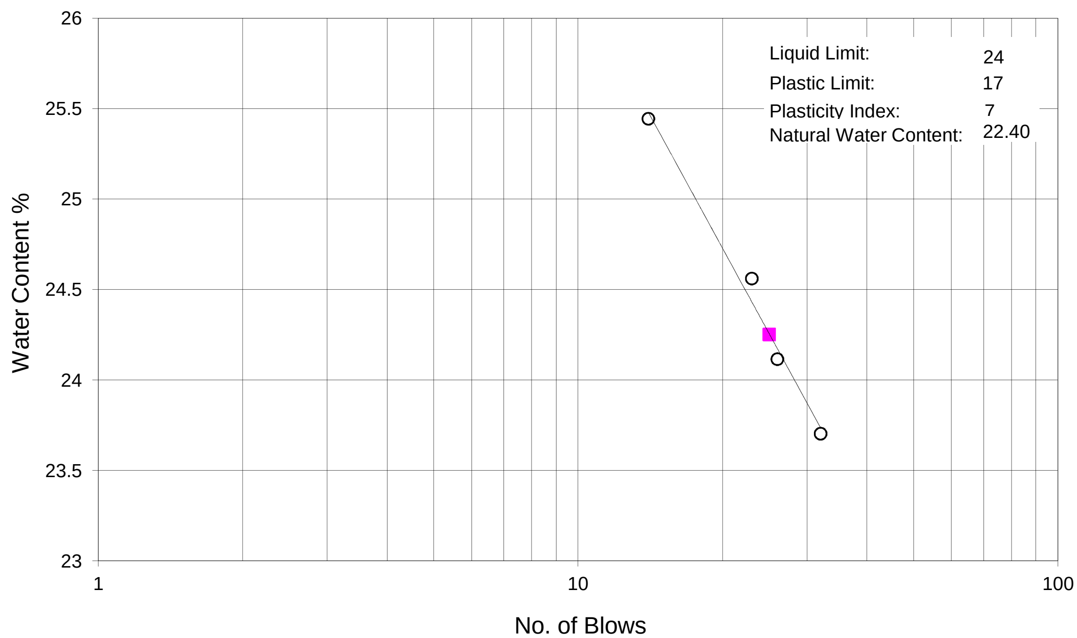
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 23, 2013
Borehole:	BH-02	Sample No.:	Shelby 1	Depth (m):	4.46

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
77	40.87	39.44	33.82	1.43	5.62	25.4	14	68	41.68	40.69	35.06	0.99	5.63	17.6
87	40.16	38.90	33.77	1.26	5.13	24.6	23	8	29.99	29.07	23.68	0.92	5.39	17.1
65A	31.85	30.35	24.13	1.50	6.22	24.1	26							
84	41.18	39.90	34.50	1.28	5.40	23.7	32							

Classification of the material : CL-ML

100 % with respect to the total of the material smaller than sieve No. 40



Observations: ______________________

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

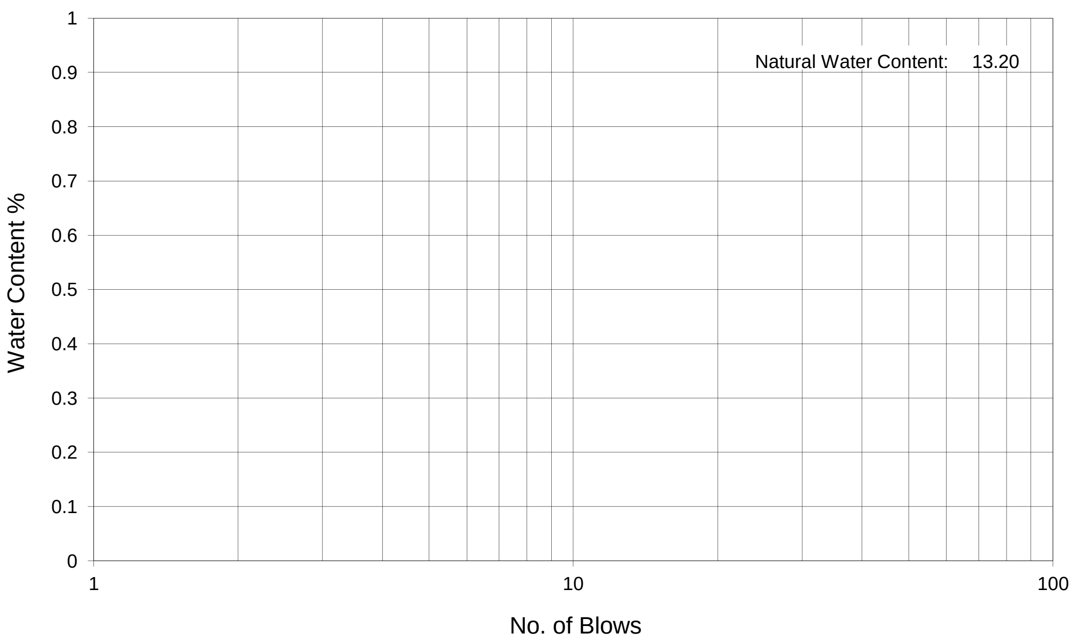
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 13, 2013
Borehole:	BH-03	Sample No.:	Bag 1	Depth (m):	0.76

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)

Classification of the material : N/A

70.4 % with respect to the total of the material smaller than sieve No. 40



Observations: NON-PLASTIC

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 13, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

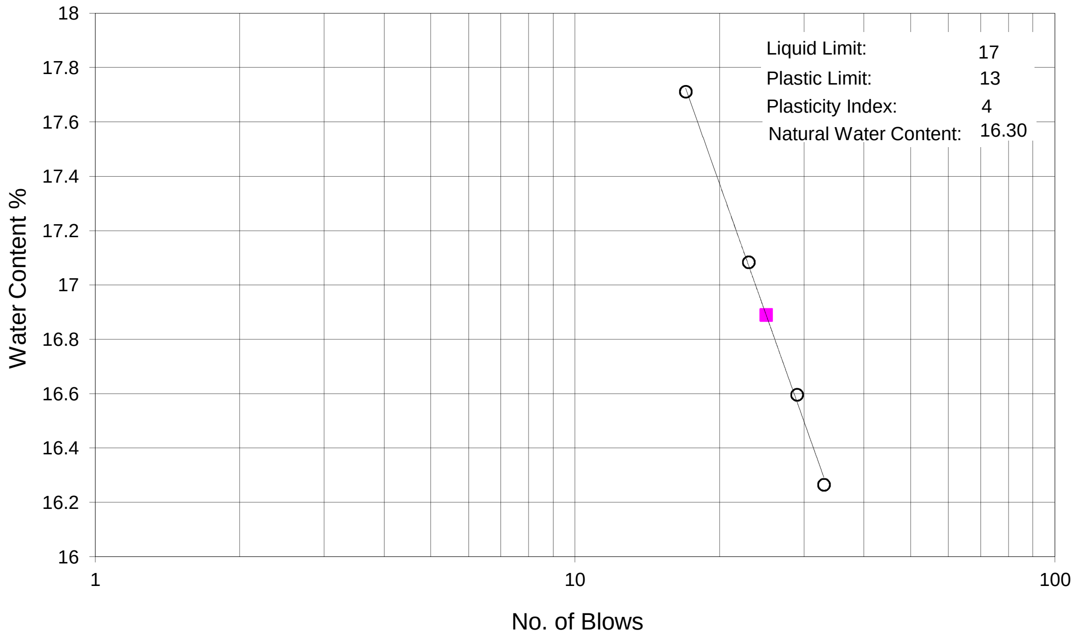
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 18, 2013
Borehole:	BH-03	Sample No.:	Bag 2	Depth (m):	2.29

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
16	31.44	30.31	23.93	1.13	6.38	17.7	17	152	26.38	25.66	20.19	0.72	5.47	13.2
98	41.83	40.67	33.88	1.16	6.79	17.1	23	148	26.19	25.48	20.01	0.71	5.47	13.0
95	30.34	29.16	22.05	1.18	7.11	16.6	29							
59	32.98	31.90	25.26	1.08	6.64	16.3	33							

Classification of the material : ML

76.7 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

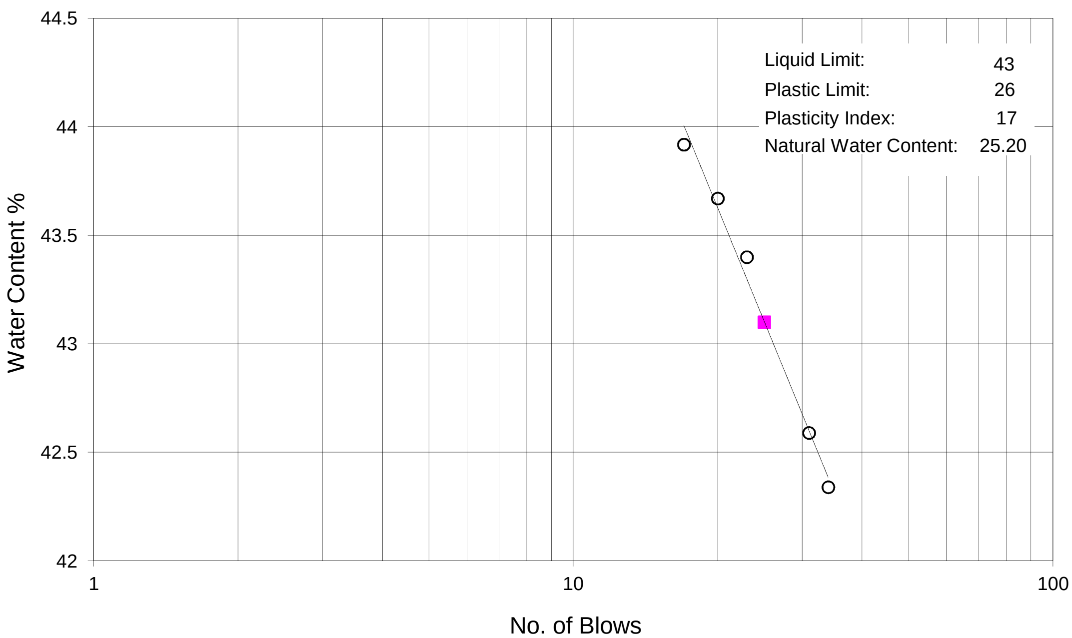
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 18, 2013
Borehole:	BH-04	Sample No.:	Bag 1	Depth (m):	9.14

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
55	32.89	30.32	24.25	2.57	6.07	42.3	34	146	26.23	24.99	20.19	1.24	4.80	25.8
40	41.81	39.31	33.44	2.50	5.87	42.6	31	134	26.13	24.89	20.07	1.24	4.82	25.7
39	32.17	29.54	23.48	2.63	6.06	43.4	23							
24	31.70	29.32	23.87	2.38	5.45	43.7	20							
11	42.02	39.24	32.91	2.78	6.33	43.9	17							

Classification of the material : CL

99.3 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

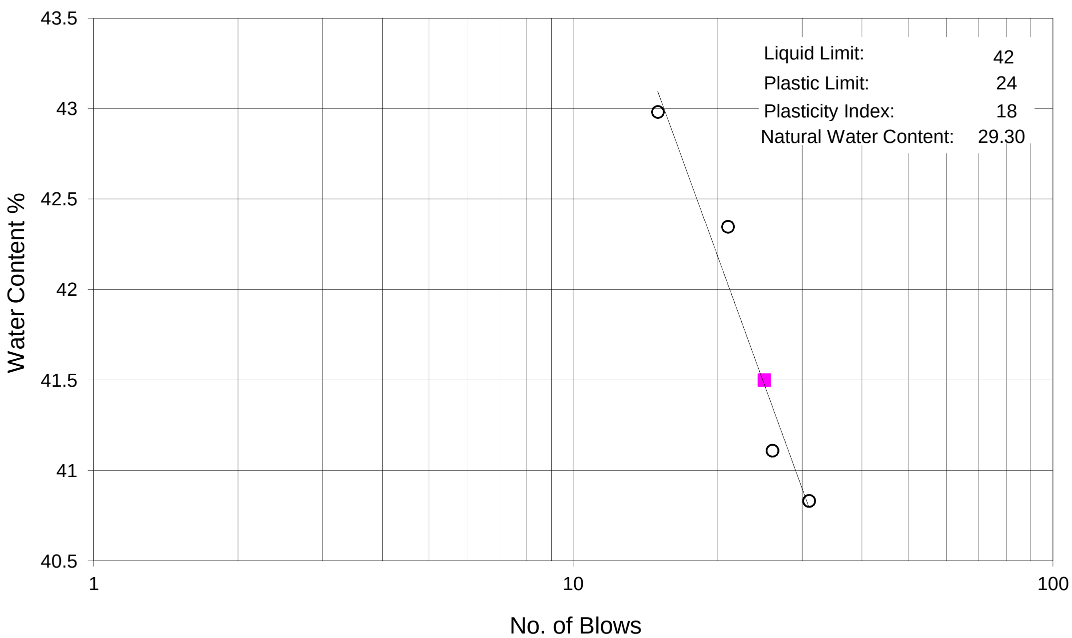
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project: Ausenco - Murray River		Project No.:	13-MTS-028
Location: BC		Date:	September 18, 2013
Borehole: BH-04	Sample No.: Bag 2	Depth (m):	21.34

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
19	42.71	39.86	33.13	2.85	6.73	42.3	21	146	26.20	25.05	20.18	1.15	4.87	23.6
38	43.73	41.08	34.59	2.65	6.49	40.8	31	152	26.24	25.09	20.19	1.15	4.90	23.5
42	44.94	41.68	33.75	3.26	7.93	41.1	26							
51	40.64	38.19	32.49	2.45	5.70	43.0	15							

Classification of the material : CL

99.5 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

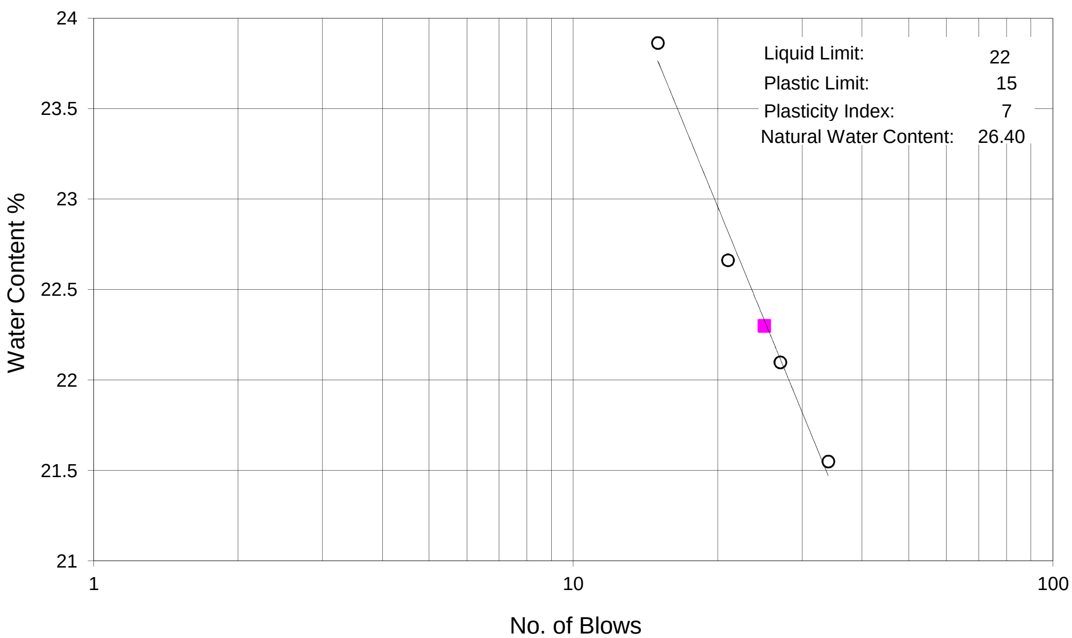
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 18, 2013
Borehole:	BH-05 Sample No.: Bag 1	Depth (m):	0.76

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
82	33.84	32.26	25.11	1.58	7.15	22.1	27	155	26.14	25.33	19.99	0.81	5.34	15.2
76	34.34	32.56	24.30	1.78	8.26	21.5	34	154	26.15	25.35	19.98	0.80	5.37	14.9
41	31.95	30.52	24.21	1.43	6.31	22.7	21							
14A	33.60	31.92	24.88	1.68	7.04	23.9	15							

Classification of the material : CL-ML

87.6 % with respect to the total of the material smaller than sieve No. 40



Observations: ______

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

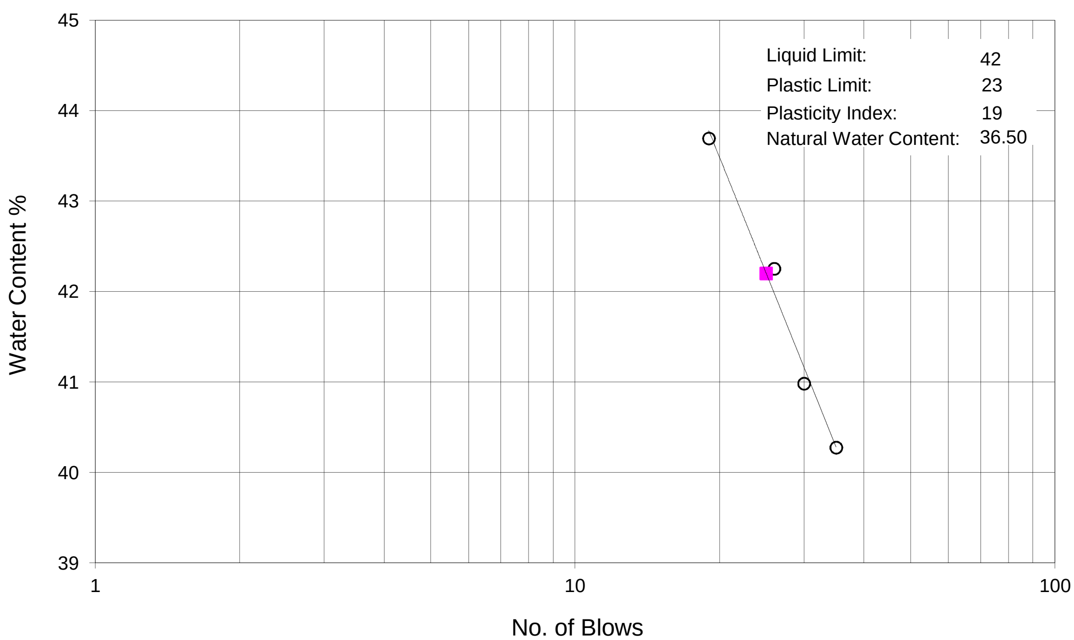
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project: Ausenco - Murray River		Project No.: 13-MTS-028	
Location: BC		Date: September 20, 2013	
Borehole: BH-05	Sample No.: Bag 2	Depth (m): 1.52	

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
59	38.54	34.73	25.27	3.81	9.46	40.3	35	155	26.35	25.15	19.99	1.20	5.16	23.3
40	49.24	44.65	33.45	4.59	11.20	41.0	30	154	26.04	24.88	19.99	1.16	4.89	23.7
76	39.08	34.69	24.30	4.39	10.39	42.3	26							
58	39.70	35.37	25.46	4.33	9.91	43.7	19							

Classification of the material : CL

99.9 % with respect to the total of the material smaller than sieve No. 40



Observations: found traces of gravel during test, gravel particles were removed

Prepared by: MF	Checked by: PS	Approved by: JPS
Date: September 23, 2013	Date: September 24, 2013	Date: October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

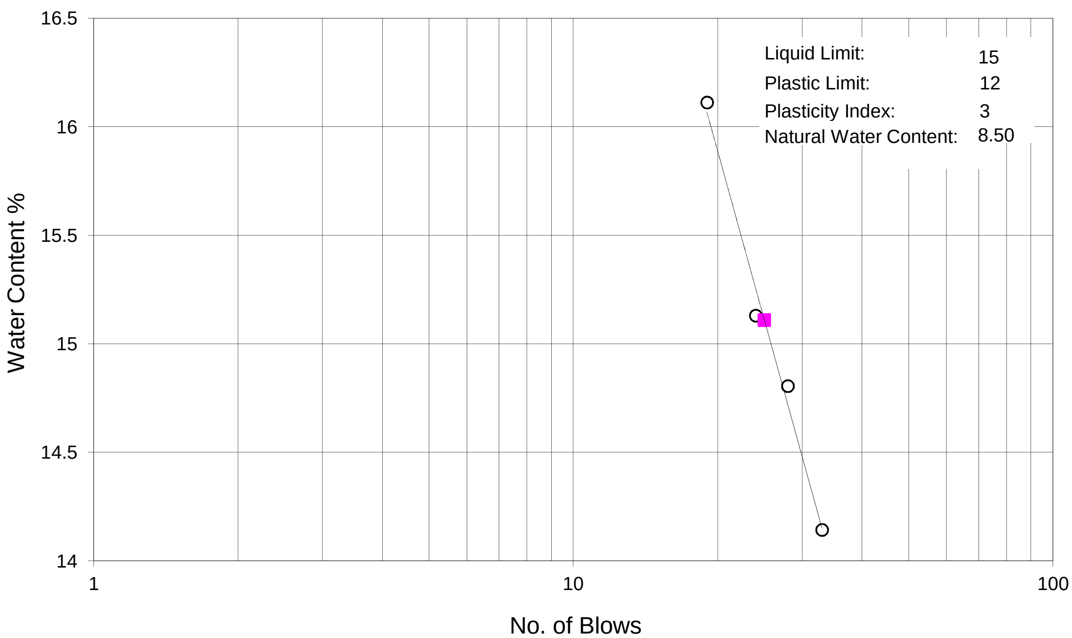
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project: Ausenco - Murray River		Project No.:	13-MTS-028
Location: BC		Date:	September 19, 2013
Borehole: BH-06	Sample No.: Bag 1	Depth (m):	0.76

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
78	30.86	29.87	22.87	0.99	7.00	14.1	33	73	39.69	39.01	33.56	0.68	5.45	12.5
24A	43.84	42.66	34.69	1.18	7.97	14.8	28	2A	39.13	38.47	33.04	0.66	5.43	12.2
45A	43.36	42.08	33.62	1.28	8.46	15.1	24							
87	40.40	39.48	33.77	0.92	5.71	16.1	19							

Classification of the material : ML

90.2 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 23, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

Marine + Earth MEG Geosciences

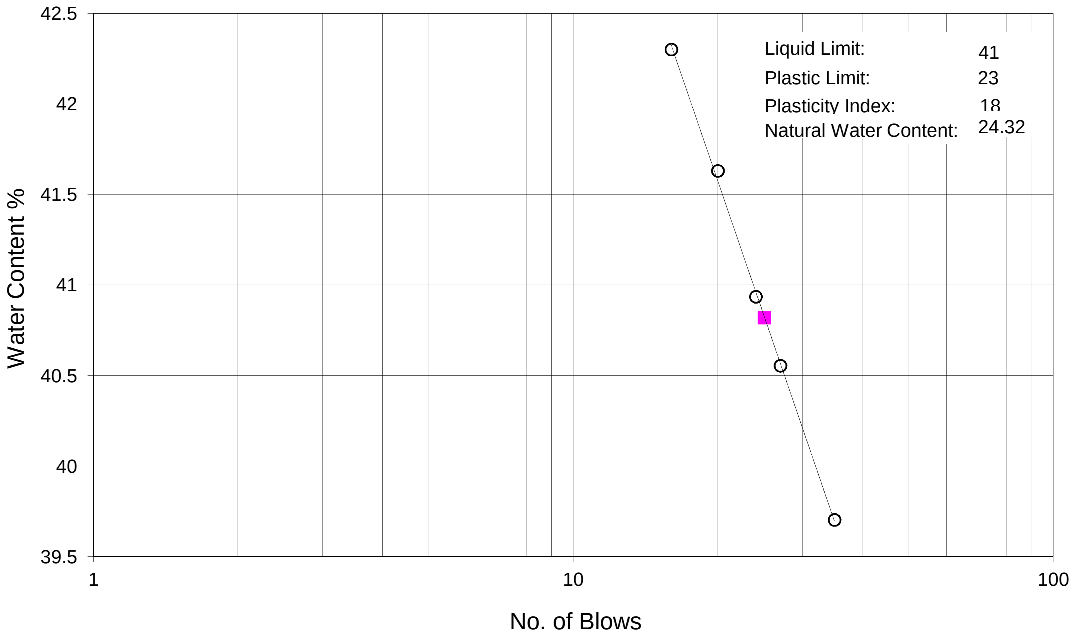
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 23, 2013
Borehole:	BH-07 Sample No.: Bag 1	Depth (m):	7.62

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
22	31.06	29.19	24.48	1.87	4.71	39.7	35	148	26.03	24.92	20.02	1.11	4.90	22.7
70	40.99	38.65	32.88	2.34	5.77	40.6	27	152	26.23	25.12	20.18	1.11	4.94	22.5
24	41.92	39.82	34.69	2.10	5.13	40.9	24							
4	40.57	38.63	33.97	1.94	4.66	41.6	20							
5	43.08	40.47	34.30	2.61	6.17	42.3	16							

Classification of the material : CL

100 % with respect to the total of the material smaller than sieve No. 40



Observations: ______

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

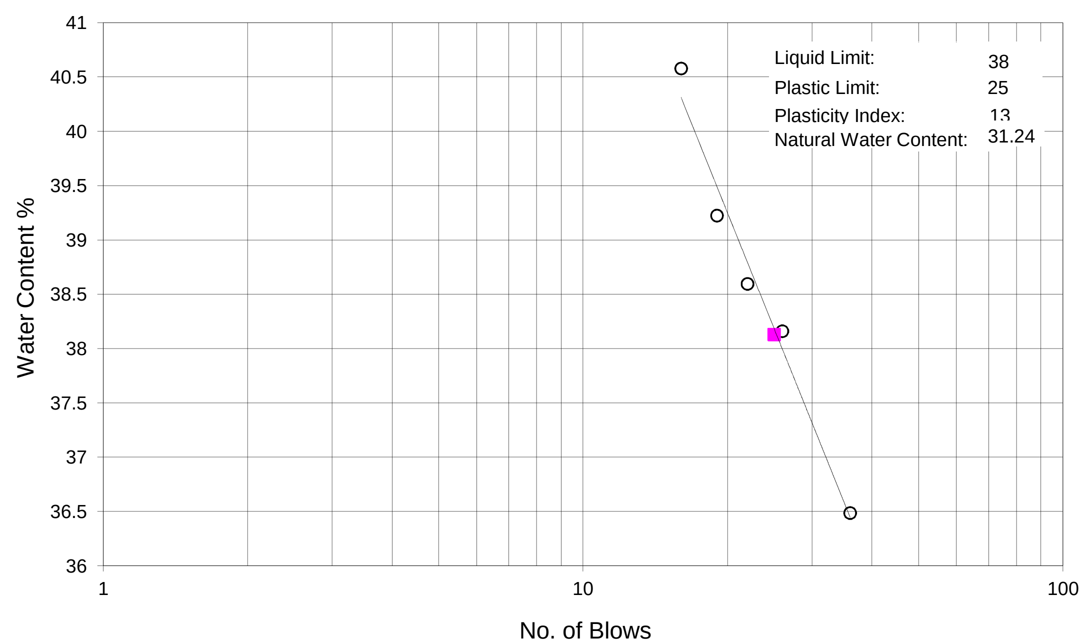
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 23, 2013
Borehole:	N/A	Sample No.:	Bucket Sample 2	Depth (m):	N/A

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
55	31.32	29.43	24.25	1.89	5.18	36.5	36	134	26.09	24.88	20.08	1.21	4.80	25.2
24	29.90	28.24	23.89	1.66	4.35	38.2	26	146	26.20	25.00	20.19	1.20	4.81	24.9
39	29.80	28.04	23.48	1.76	4.56	38.6	22							
13	30.57	28.95	24.82	1.62	4.13	39.2	19							
45A	40.41	38.45	33.62	1.96	4.83	40.6	16							

Classification of the material : CL

100 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 24, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

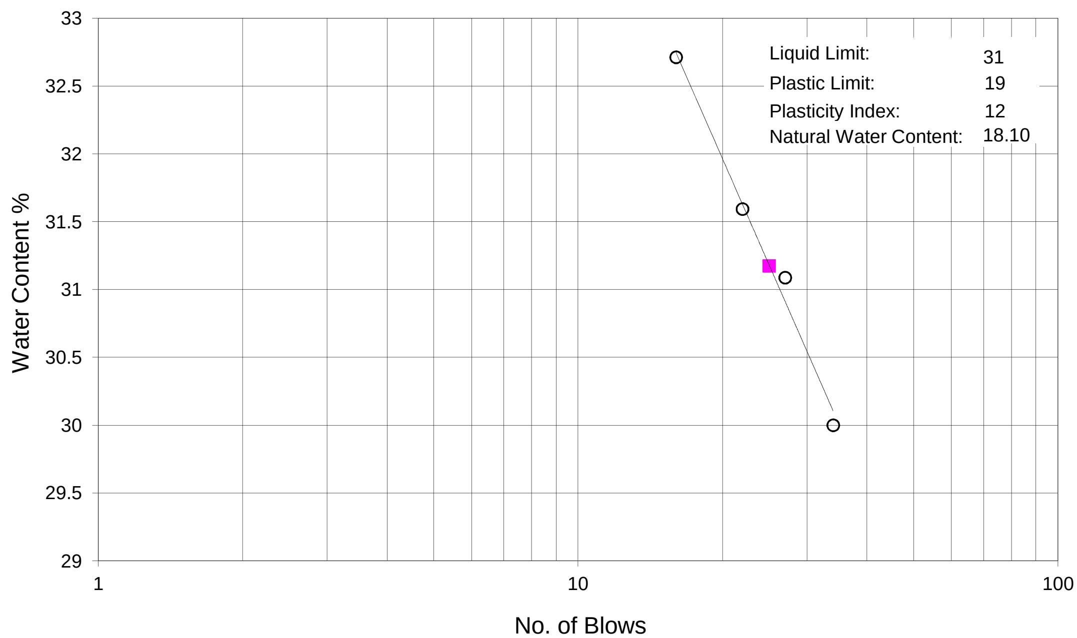
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	T2	Sample No.:	Bag 1	Depth (m):	1.00

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
64	41.81	39.86	33.36	1.95	6.50	30.0	34	86	31.82	30.85	25.79	0.97	5.06	19.2
97B	36.03	33.63	25.91	2.40	7.72	31.1	27	25	40.66	39.69	34.66	0.97	5.03	19.3
34	44.67	42.43	35.34	2.24	7.09	31.6	22							
3	35.48	33.02	25.50	2.46	7.52	32.7	16							

Classification of the material : CL

97.4 % with respect to the total of the material smaller than sieve No. 40



Observations: ______

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 23, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

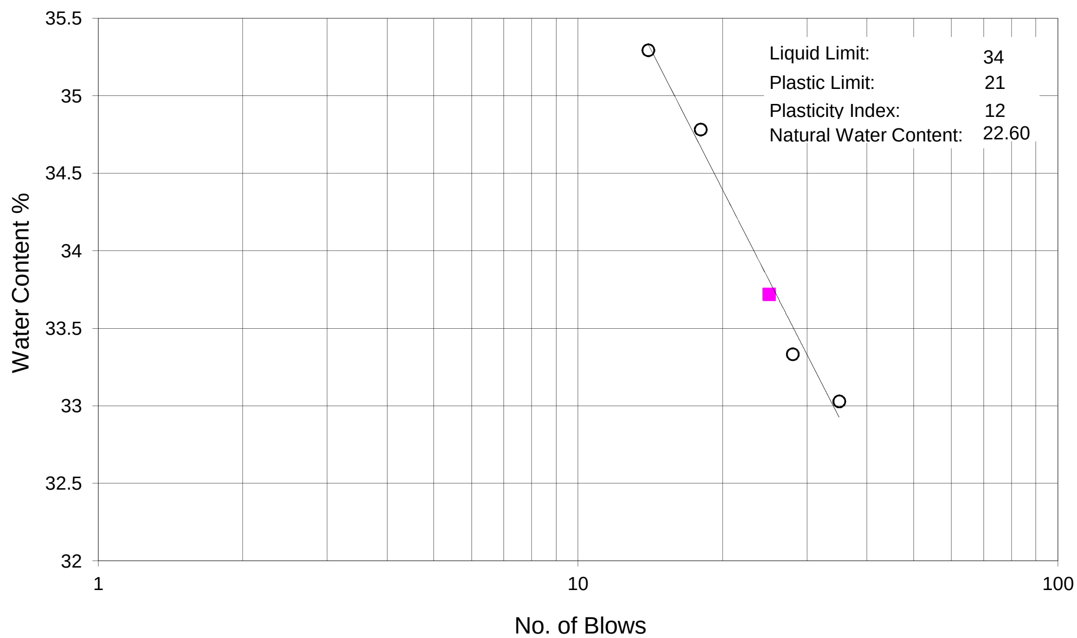
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	T2	Sample No.:	Bag 2	Depth (m):	2.00

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
77	41.11	39.30	33.82	1.81	5.48	33.0	35	8	29.70	28.65	23.69	1.05	4.96	21.2
68	43.27	41.22	35.07	2.05	6.15	33.3	28	27	29.62	28.55	23.55	1.07	5.00	21.4
28	33.60	31.12	23.99	2.48	7.13	34.8	18							
10	42.77	40.55	34.26	2.22	6.29	35.3	14							

Classification of the material : CL

95 % with respect to the total of the material smaller than sieve No. 40



Observations: ______________________

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 23, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

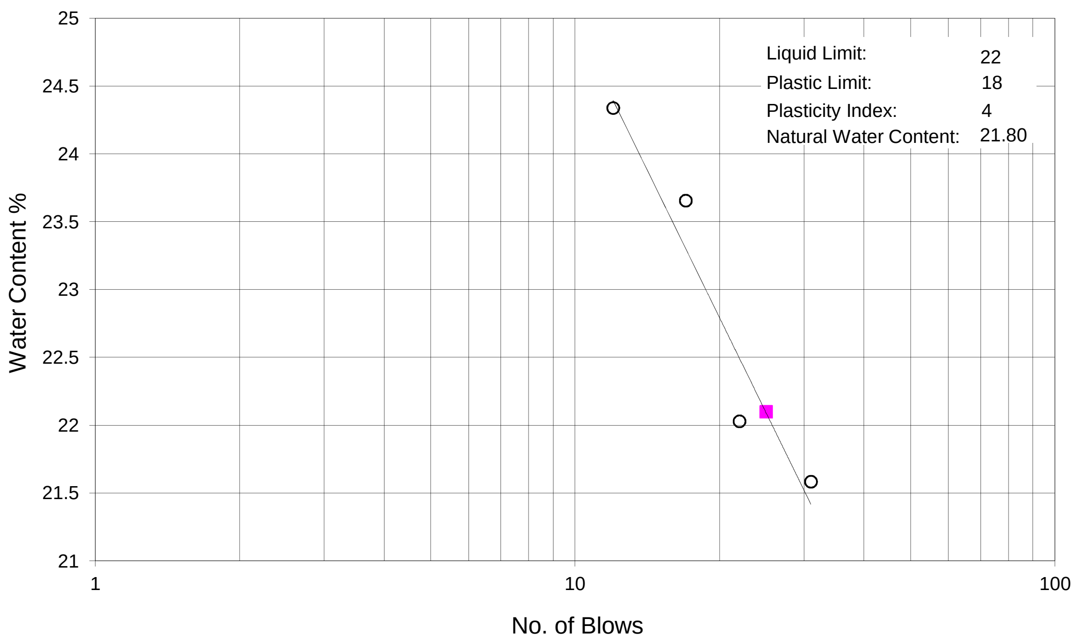
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 19, 2013
Borehole:	T4	Sample No.:	Bag 1	Depth (m):	1.20

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)
5	40.43	39.34	34.29	1.09	5.05	21.6	31	4	40.13	39.22	33.98	0.91	5.24	17.4
22	33.61	31.96	24.47	1.65	7.49	22.0	22	93	29.78	28.85	23.68	0.93	5.17	18.0
63	39.92	38.82	34.17	1.10	4.65	23.7	17							
65A	35.89	33.59	24.14	2.30	9.45	24.3	12							

Classification of the material : CL-ML

99.3 % with respect to the total of the material smaller than sieve No. 40



Observations:

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 23, 2013	Date:	September 26, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

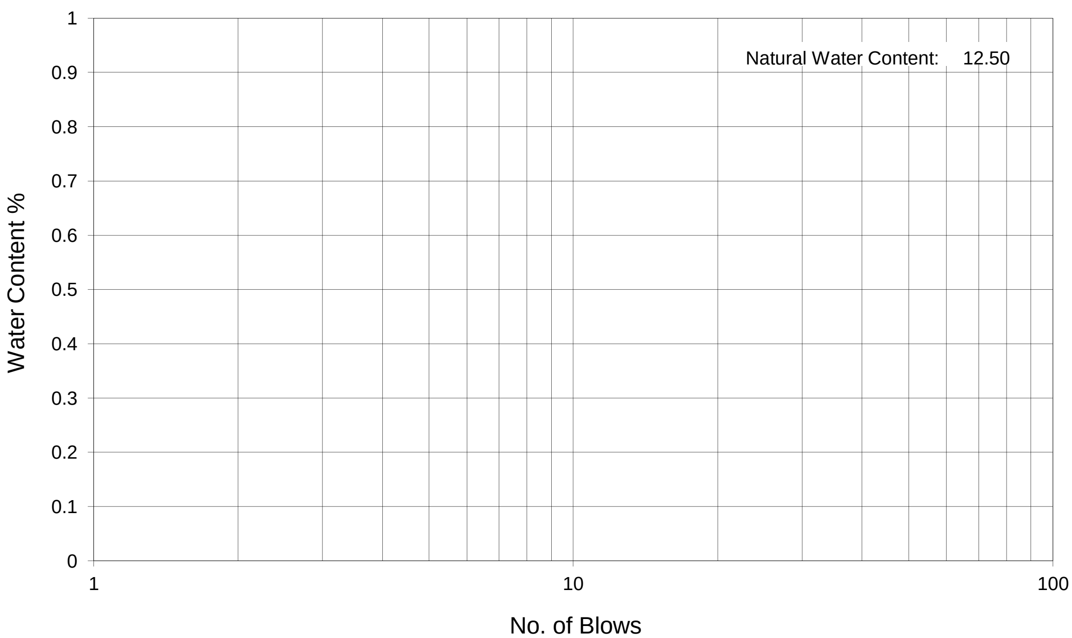
Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D 4318)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 17, 2013
Borehole: T9	Sample No.: Bag 2	Depth (m):	2.00

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)

Classification of the material : N/A

58.6 % with respect to the total of the material smaller than sieve No. 40



Observations: NON-PLASTIC

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

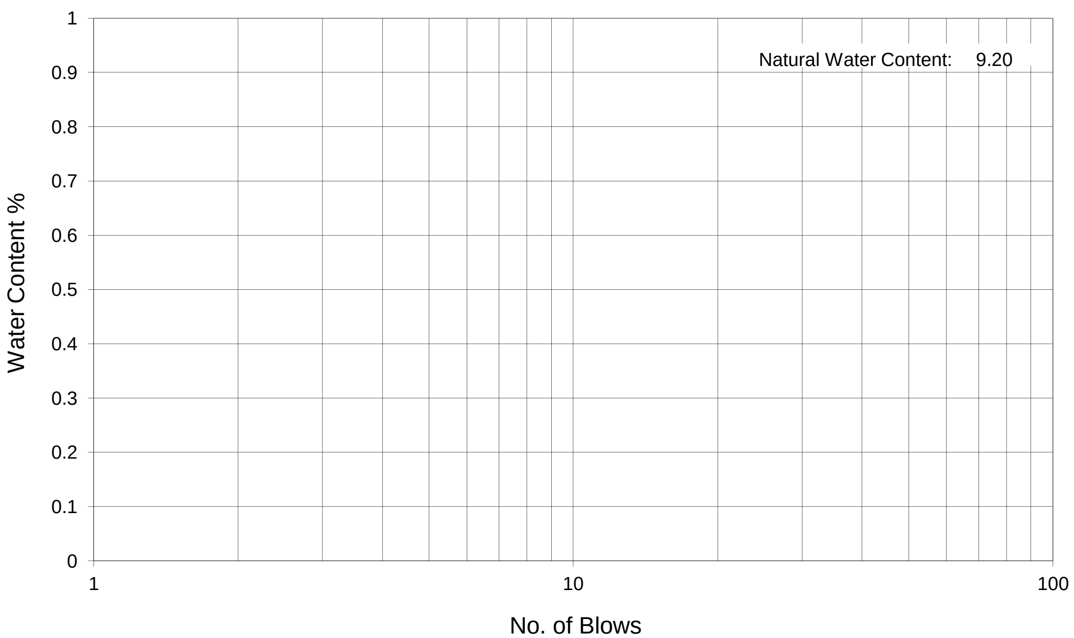
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 17, 2013
Borehole:	T10	Sample No.:	Bag 1	Depth (m):	1.00

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)

Classification of the material : N/A

84 % with respect to the total of the material smaller than sieve No. 40



Observations: NON-PLASTIC

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 19, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

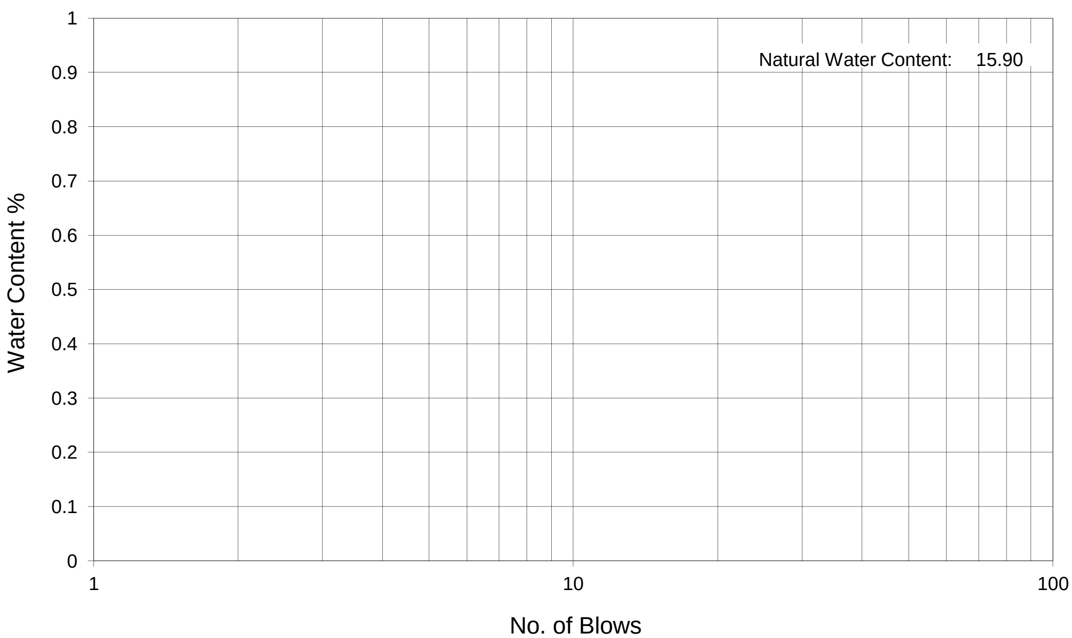
Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D 4318)

Project:	Ausenco - Murray River			Project No.:	13-MTS-028
Location:	BC			Date:	September 9, 2013
Borehole:	T10	Sample No.:	Bag 2	Depth (m):	3.00

LIQUID LIMIT								PLASTIC LIMIT						
TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)	No. of Blows	TIN No.	Tare + Weight of Wet Soil (g)	Tare + Weight of Dry Soil (g)	Weight of Tin (g)	Weight of Water (g)	Weight of Dry Soil (g)	Water Content (%)

Classification of the material : N/A

99.6 % with respect to the total of the material smaller than sieve No. 40



Observations: NON-PLASTIC

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 13, 2013	Date:	September 19, 2013	Date:	October 31, 2013

In Situ Moisture Content and Density

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

Water Content and Unit Weight (ASTM D 2216)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 16, 2013
Borehole:	Various	Page:	1 of 2

Sample Nº	Depth (m)	Tin Nº	Wt. of tare (TW) (g)	TW+ Wet weight (g)	TW+ Dry weight (g)	Water Content (%)	Sample Diameter (mm)	Sample Height (mm)	Sample Weight (g)	Volume (cm^3)	Total Unit Weight (kN/m^3)	Dry Unit Weight (kN/m^3)
Bucket												
Sample 1	N/A	B35	112.28	138.41	132.05	32.2						
Sample 2	N/A	D2	112.83	142.14	135.24	30.8						
BH-01												
Bag 1	0.76	D2	112.84	556.24	488.99	17.9						
Bag 2	6.10	C32	143.45	745.78	643.85	20.4						
BH-02												
Shelby 1	4.46	73	33.57	153.14	131.22	22.4						
BH-03												
Bag 1	0.76	112	106.47	590.20	533.87	13.2						
Bag 2	2.29	D4	206.56	777.54	697.71	16.3						
BH-04												
Bag 1	9.14	B35	112.29	499.29	421.50	25.2						
Bag 2	21.34	C101	210.06	621.49	528.15	29.3						
BH-05												
Bag 1	0.76	C17	206.57	706.87	602.40	26.4						
Bag 2	1.52	C08	142.49	386.01	320.90	36.5						
BH-06												
Bag 1	0.76	D11	210.49	1270.06	1187.46	8.5						
BH-07												
Bag 1	7.62	C03	143.92	519.07	445.67	24.3						

Performed By:	MF	Checked By:	HB	Approved By:	JPS
Date:	September 16, 2013	Date:	September 19, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

Water Content and Unit Weight (ASTM D 2216)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 16, 2013
Borehole:	Various	Page:	2 of 2

Sample Nº	Depth (m)	Tin Nº	Wt. of tare (TW) (g)	TW+ Wet weight (g)	TW+ Dry weight (g)	Water Content (%)	Sample Diameter (mm)	Sample Height (mm)	Sample Weight (g)	Volume (cm^3)	Total Unit Weight (kN/m^3)	Dry Unit Weight (kN/m^3)
T2												
Bag 1	1.00	C20	198.04	2829.37	2425.72	18.1						
Bag 2	2.00	C30	199.10	2770.69	2295.92	22.6						
T4												
Bag 1	1.20	AC10	197.10	1226.30	1041.76	21.8						
T9												
Bag 1	1.00	C34	196.50	2304.04	2247.80	2.7						
Bag 2	2.00	H2	197.68	1768.29	1593.52	12.5						
T10												
Bag 1	1.00	C106	150.68	1278.22	1183.44	9.2						
Bag 2	3.00	H1	196.91	786.85	705.95	15.9						

Performed By:	MF	Checked By:	HB	Approved By:	JPS
Date:	September 16, 2013	Date:	September 19, 2013	Date:	October 31, 2013

Specific Gravity

MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

SPECIFIC GRAVITY (ASTM D 854)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	September 18, 2013
Borehole:	Various		

Sample Number	Depth (m)	Volumetric flask No.	Weight of flask and soil (g)	Weight of flask, water and soil (g)	Weight of dry solid (g)	Temperature (°C)	Specific Gravity Gs
Bucket Sample 2	N/A	2	226.62	692.79	57.13	23	1.77
BH-01 Bag 1	0.76	2	236.51	709.85	67.02	23.0	2.67
BH-01 Bag 2	6.1	1	234.48	706.03	68.60	23.0	2.50
BH-02 Shelby 1	4.57	7	223.13	708.20	36.51	22.0	2.78
BH-03 Bag 1	0.76	8	232.34	705.02	67.34	23.0	2.63
BH-03 Bag 2	2.29	3	239.52	713.88	65.74	23.0	2.72
BH-04 Bag 1	9.14	9	225.16	702.62	57.80	23	2.77
BH-04 Bag 2	21.34	6	238.42	715.06	59.15	23	2.75
BH-05 Bag 1	0.76	9	235.93	708.82	68.58	22.0	2.69
BH-05 Bag 2	1.52	3	232.06	709.64	58.27	20	2.74
BH-06 Bab 1	0.76	4	234.57	707.72	67.58	22.0	2.68
BH-07	7.62	8	222.79	700.11	57.80	21	2.73
T10 Bag 1	1	7	255.91	728.25	69.30	23.0	2.69
T10 Bag 2	3.00	1	268.18	729.59	102.30	21	2.71
T2 Bag 1	1	5	239.19	711.03	71.40	22.0	2.68
T2 Bag 2	2.00	5	241.30	712.70	73.53	23	2.72
T4 Bag 1	1.2	2	238.56	711.55	69.07	22.0	2.70
T9 Bag 2	2.00	4	227.25	703.27	60.26	23	2.71

Comments : ______________________

Prepared by:	MF	Checked by:	HB	Approved by:	JPS
Date:	September 18, 2013	Date:	September 19, 2013	Date:	October 31, 2013

Consolidation

MEG TECHNICAL SERVICES

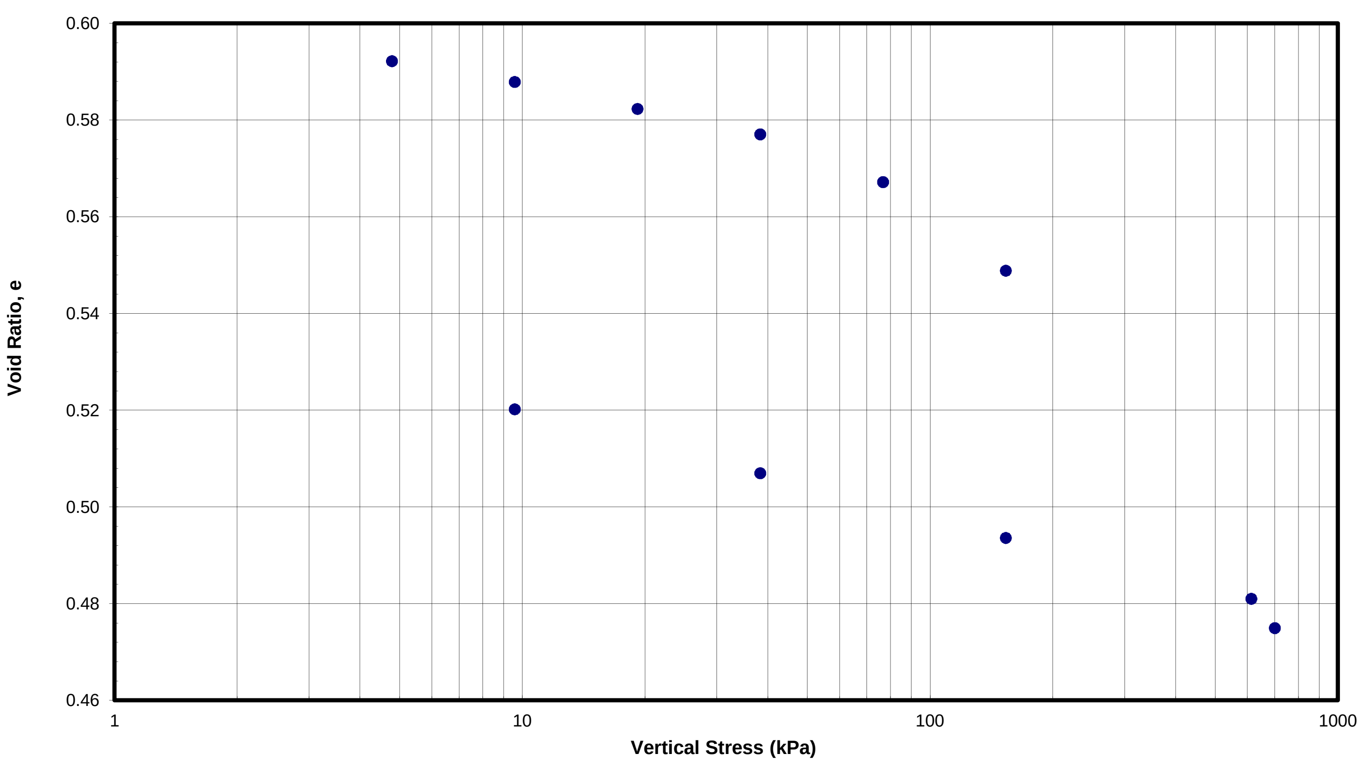
(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A

Weight of Ring (g):	216.85	**Ring + Wet Weight (g):**	334.16	**Initial Void Ratio, e:**	0.59
Initial Height (mm):	25.40	**Ring + Dry Weight (g):**	306.24	**Height of Soil, Hs (mm):**	15.95
Diameter of Ring (mm):	63.50	**Water Content (%):**	31.2	**Height of Void, Hv (mm):**	9.45
Unit Weight (kN/m^3)	14.31	**Specific Gravity, Gs:**	1.77		

Step No.	Vertical Stress (kPa)	Height of Sample (mm)	Vertical Strain (%)	Final Void Ratio e_f	Change in Void Ratio e	Coefficient of Compressibility a_v (m^2/MN)	Coefficient of Volume Compressibility m_v (m^2/MN)
1	5	25.3898	0.0400	0.5922	0.00		
2	10	25.3213	0.3100	0.5879	0.00	0.8982	0.56
3	19	25.2324	0.6600	0.5823	0.01	0.5822	0.37
4	38	25.1485	0.9900	0.5771	0.01	0.2745	0.17
5	77	24.9911	1.6100	0.5672	0.01	0.2578	0.16
6	153	24.6990	2.7600	0.5489	0.02	0.2391	0.15
7	613	23.6169	7.0200	0.4810	0.07	0.1476	0.09
8	700	23.5204	7.4000	0.4750	0.01	0.0695	0.04
9	153	23.8176	6.2300	0.4936	-0.02	0.0341	0.02
10	38	24.0309	5.3900	0.5070	-0.01	0.1164	0.07
11	10	24.2418	4.5600	0.5202	-0.01	0.4602	0.29



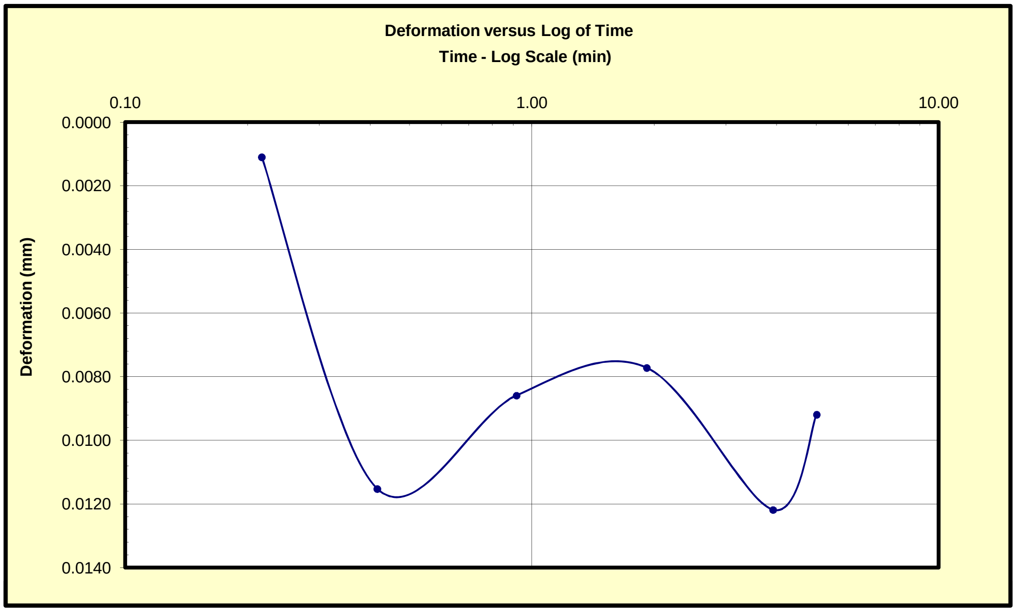
Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

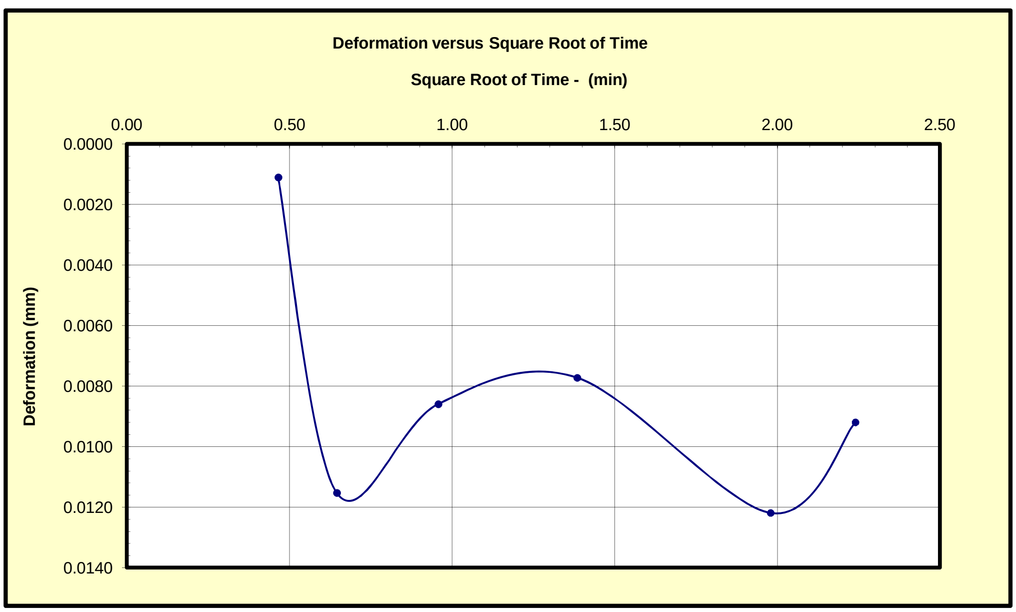
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	1	Vertical Stress (kPa):	4.8





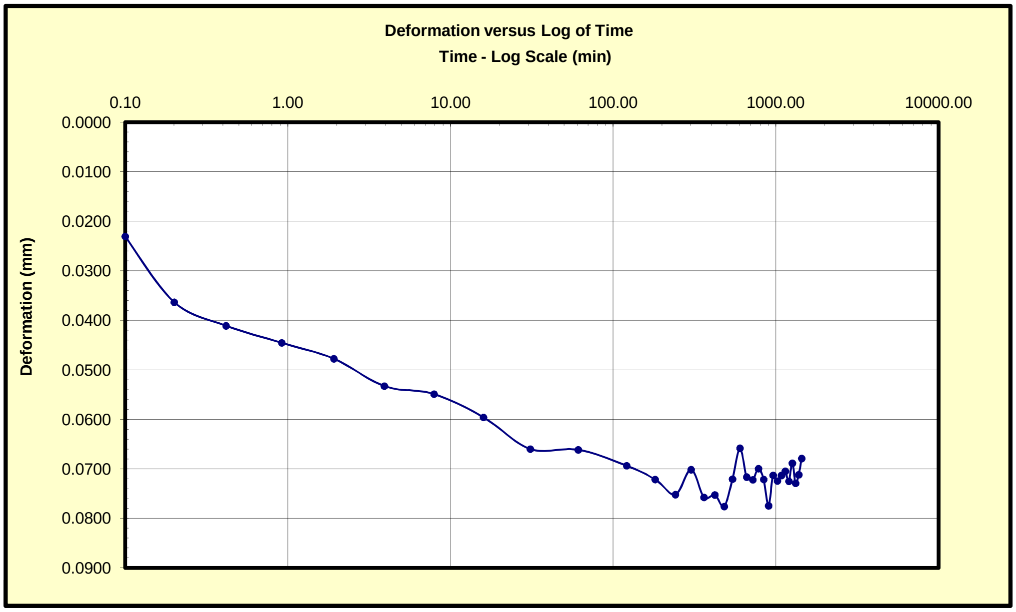
Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

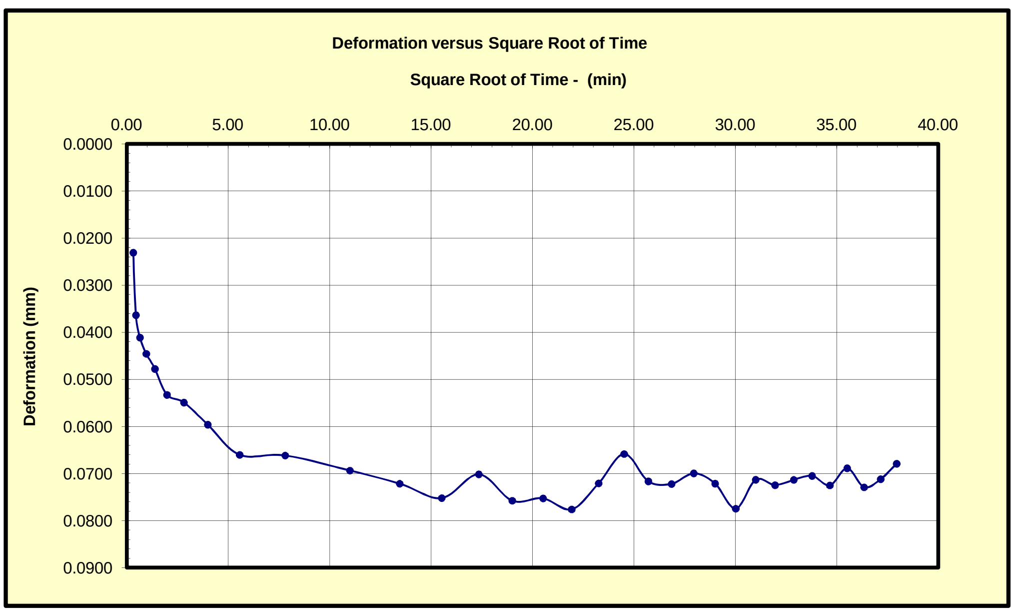
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	2	Vertical Stress (kPa):	9.6





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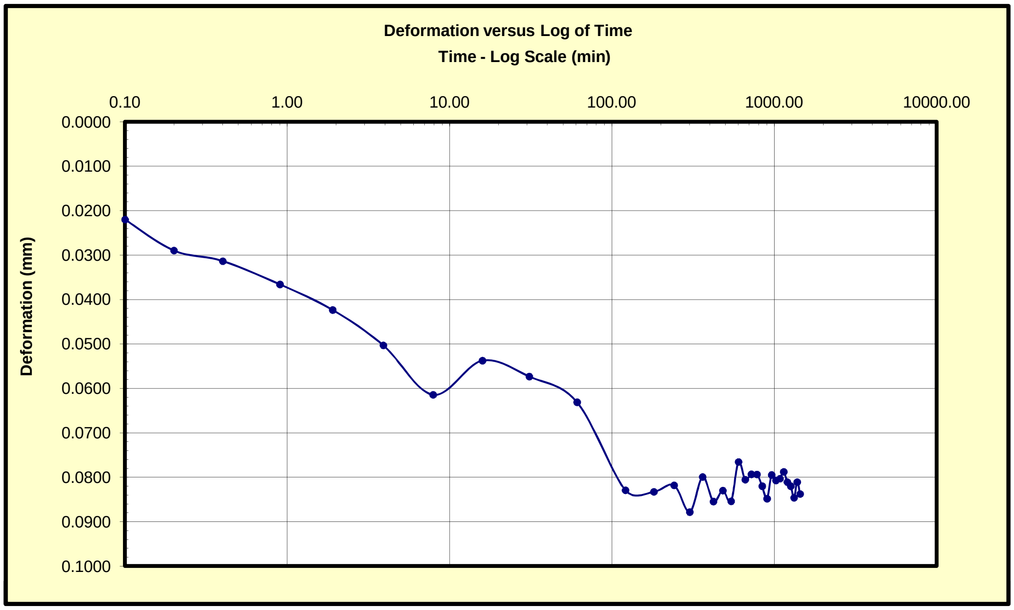
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

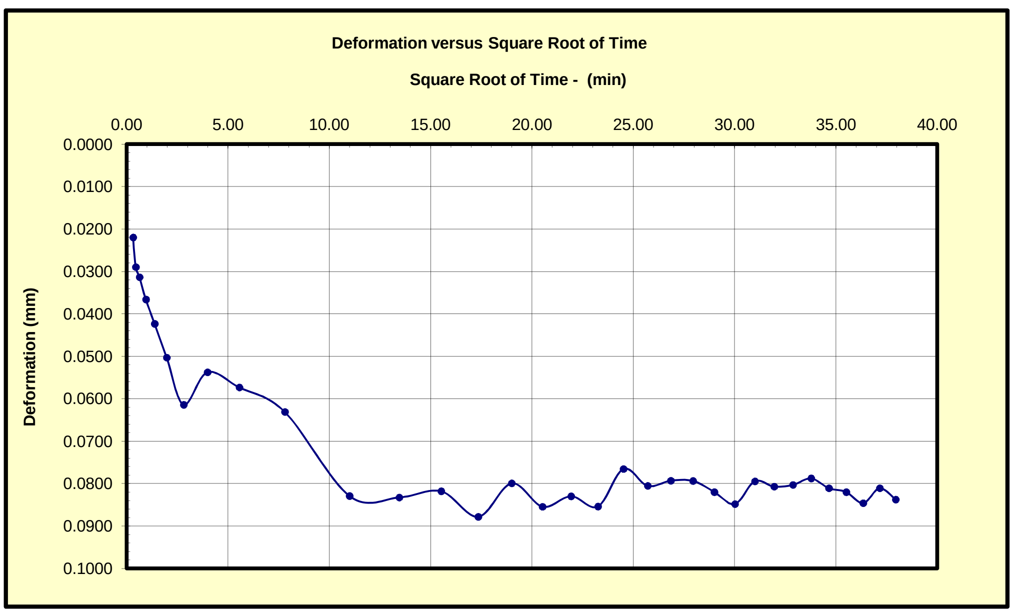
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	3	Vertical Stress (kPa):	19.2





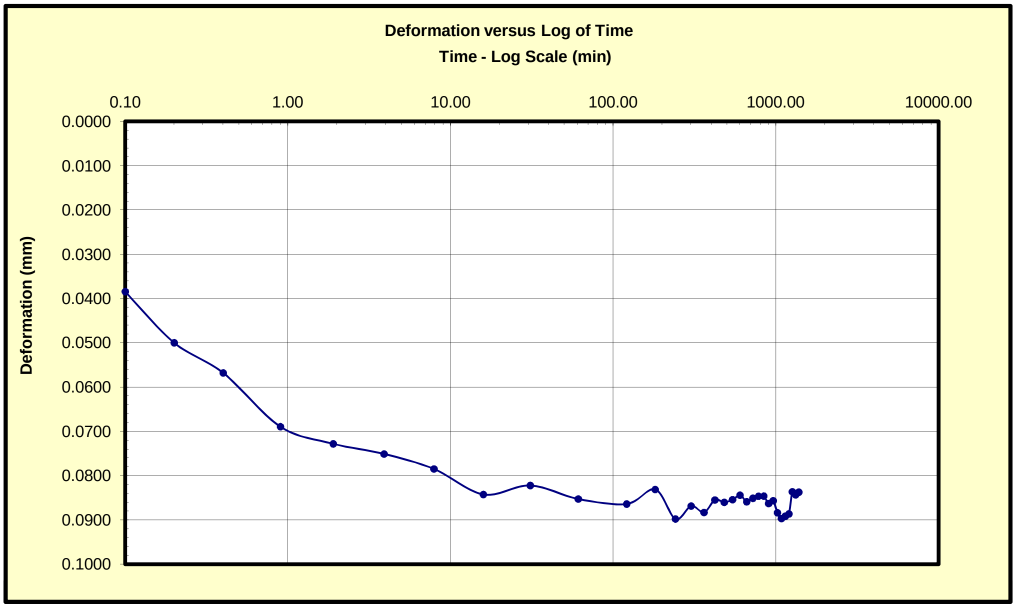
Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

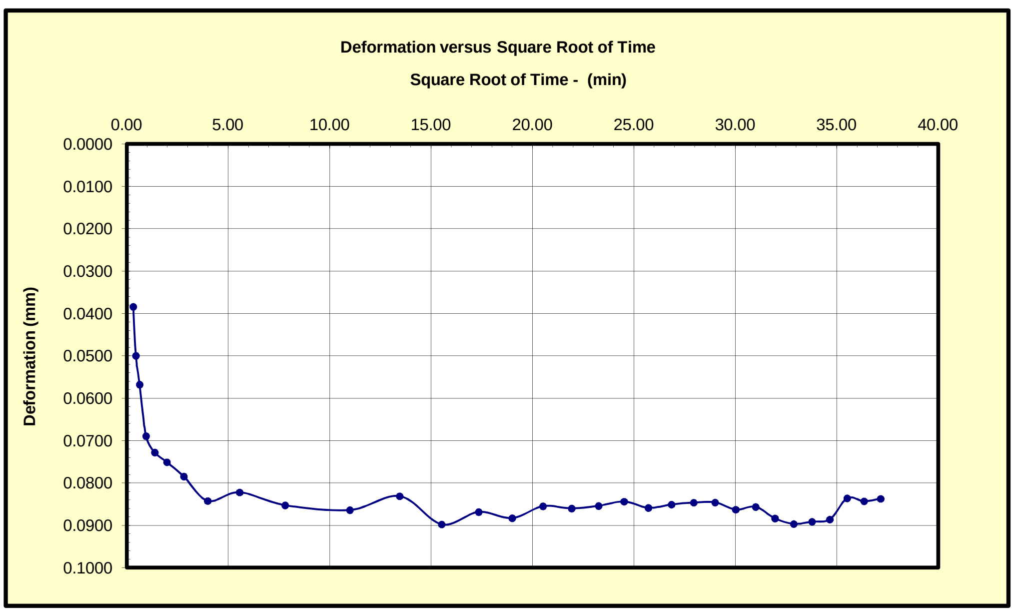
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	4	Vertical Stress (kPa):	38.3





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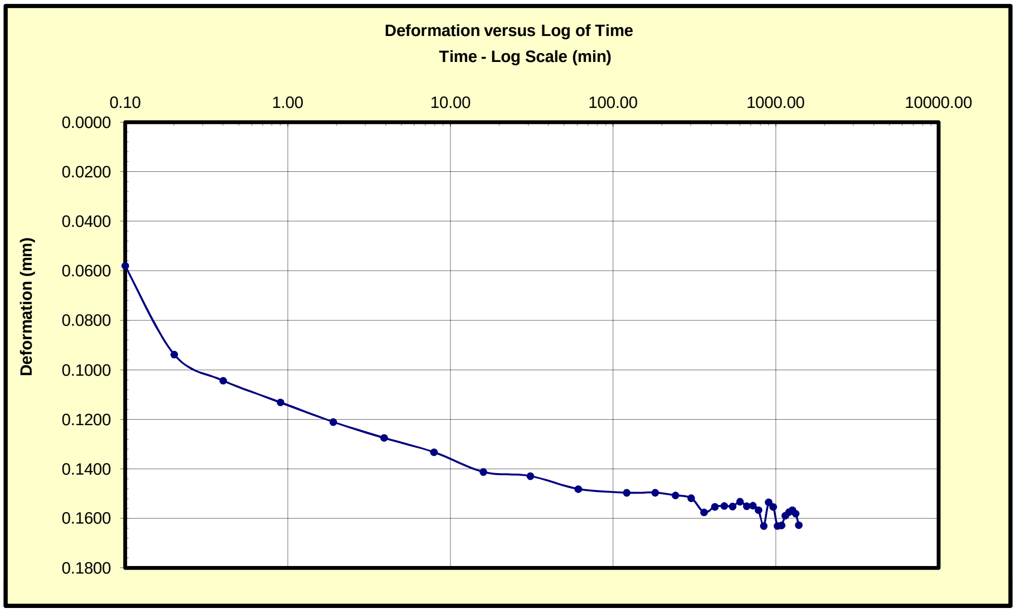
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

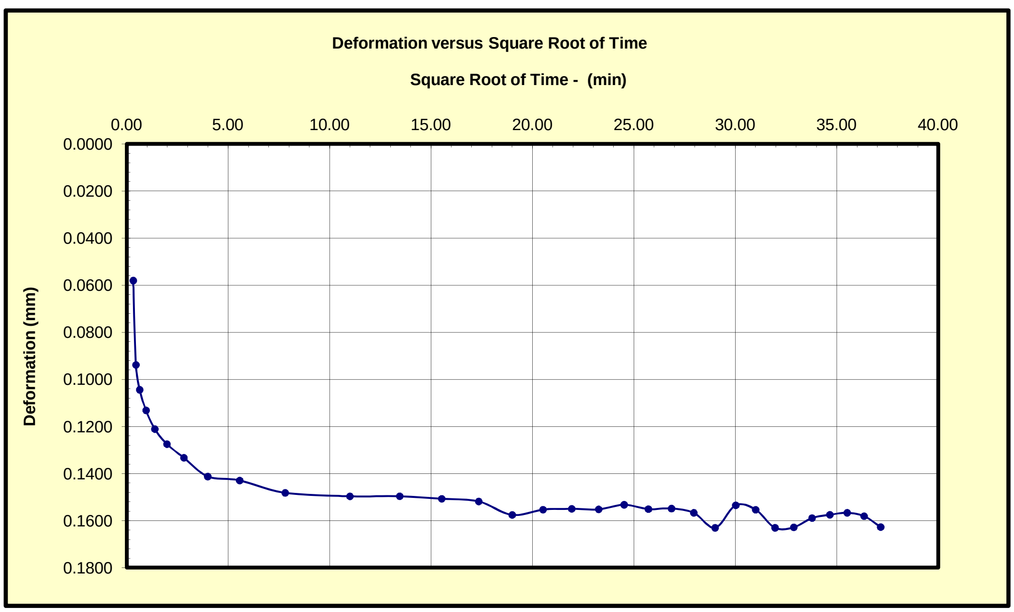
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	5	Vertical Stress (kPa):	76.6





Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

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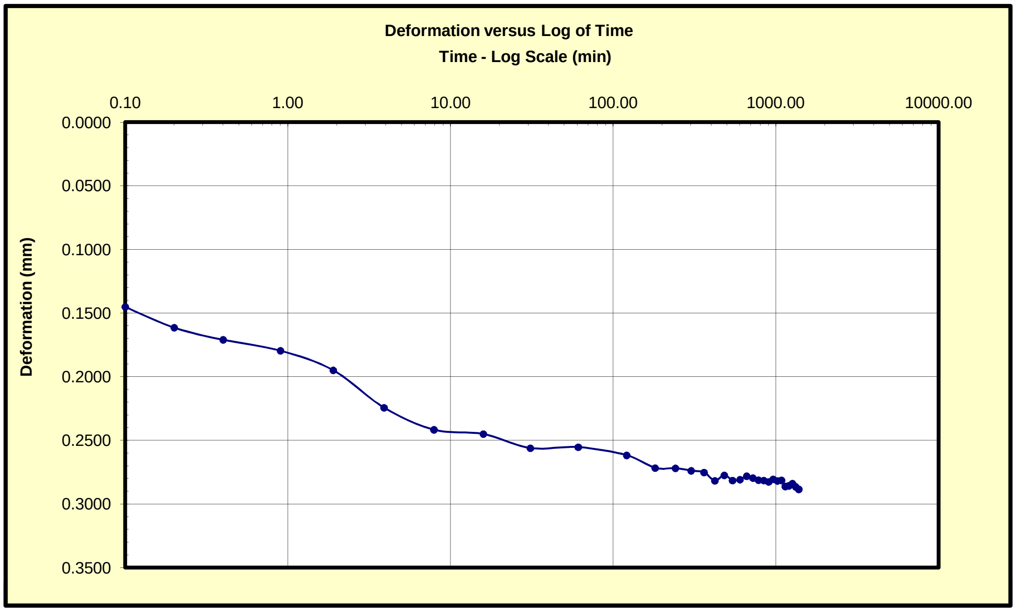
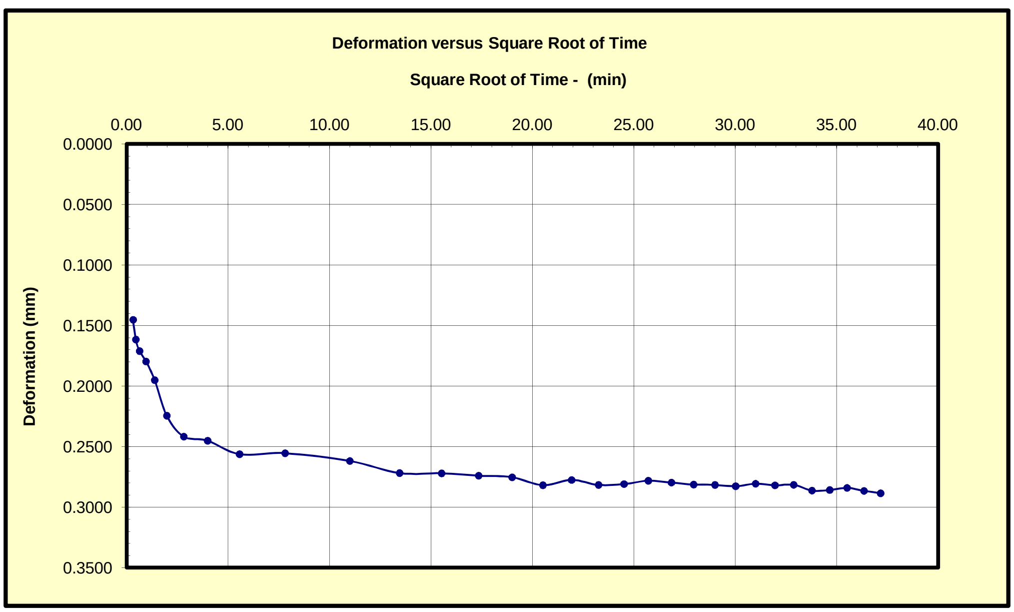
One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	6	Vertical Stress (kPa):	153.2





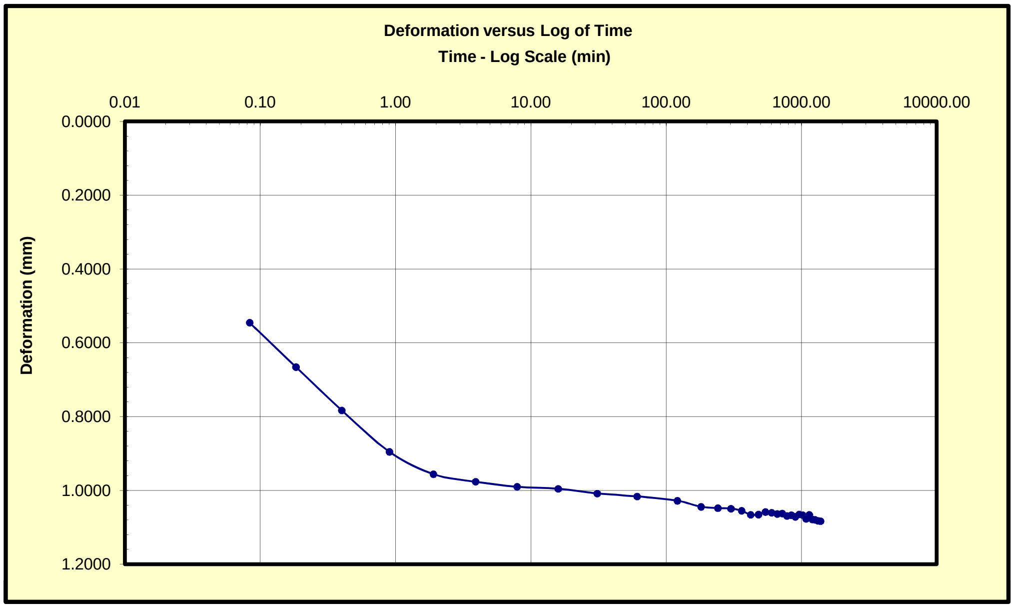
Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

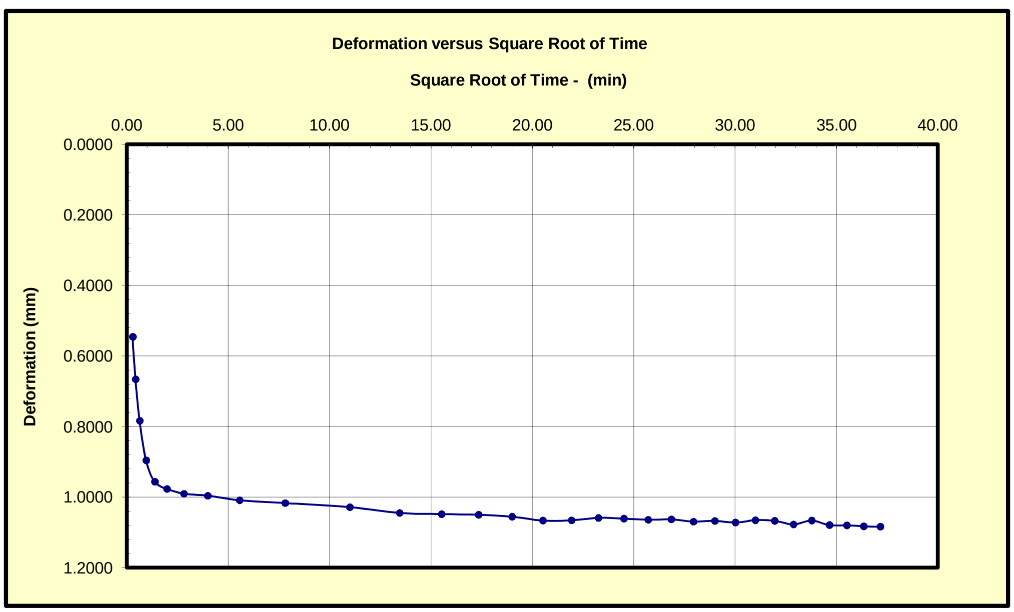
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	7	Vertical Stress (kPa):	612.9





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Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

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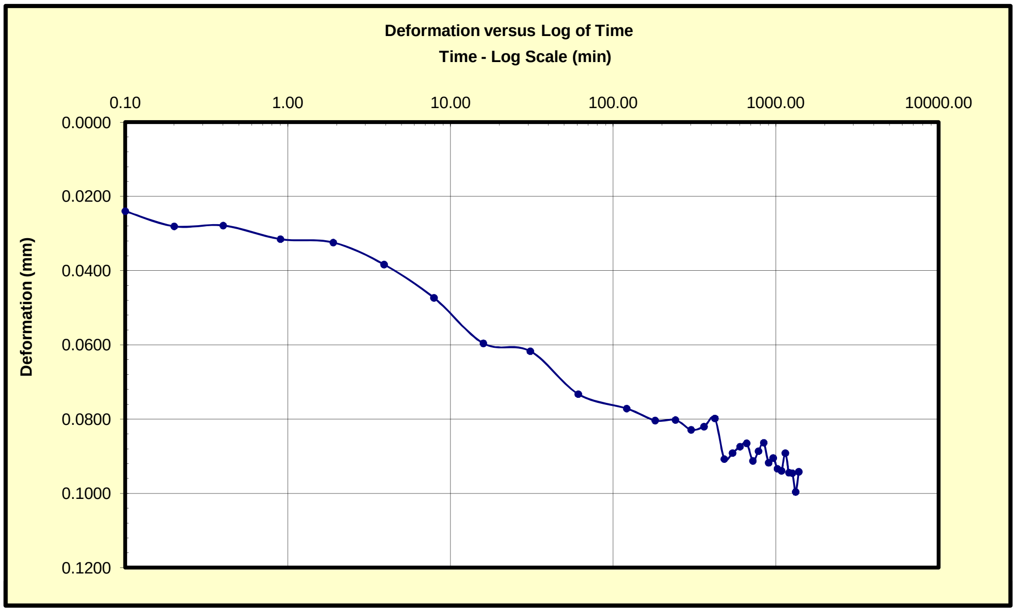
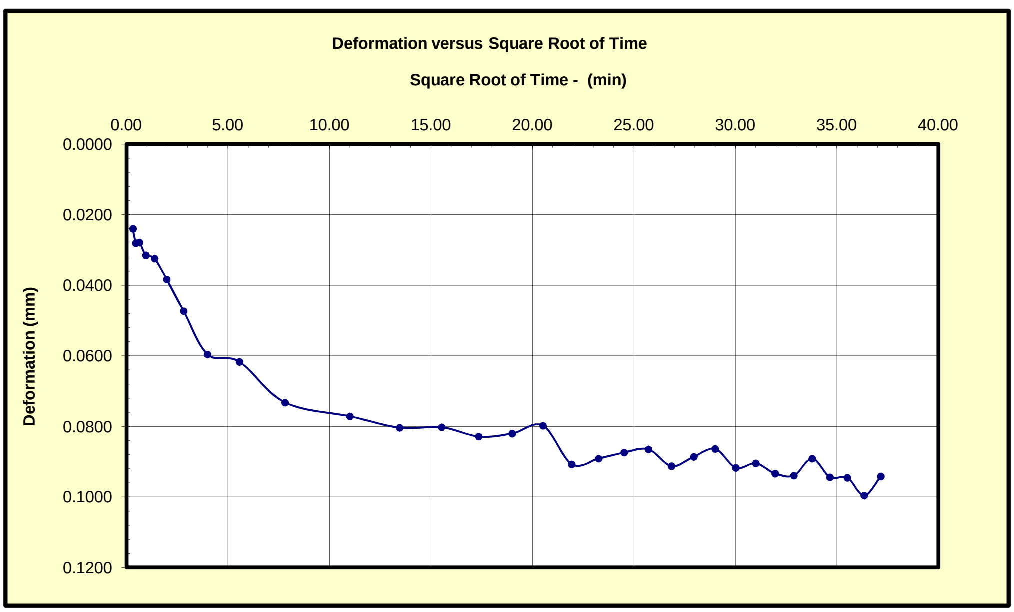
One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	8	Vertical Stress (kPa):	700.0





Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

MEG TECHNICAL SERVICES

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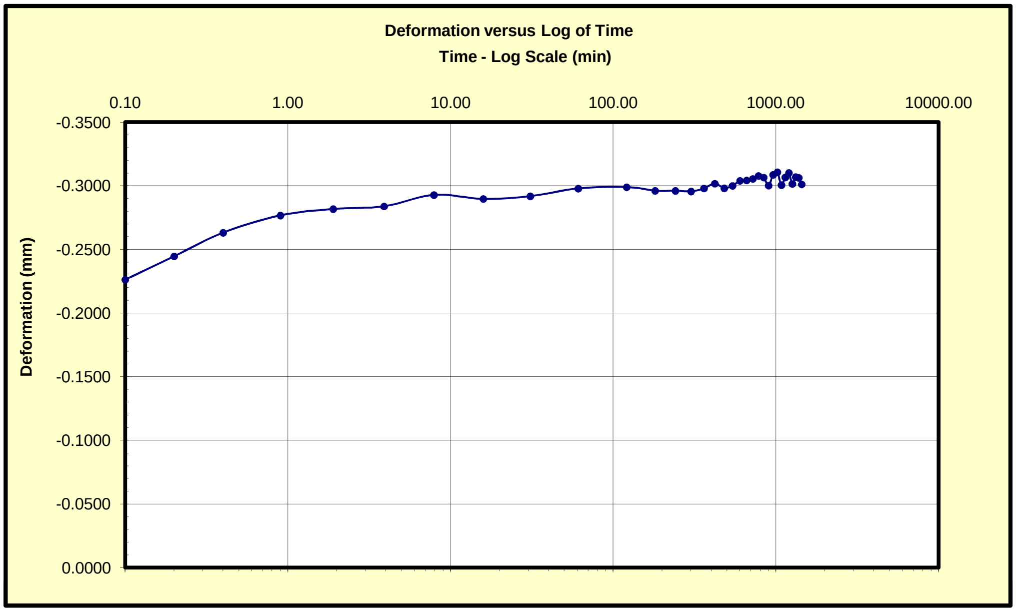
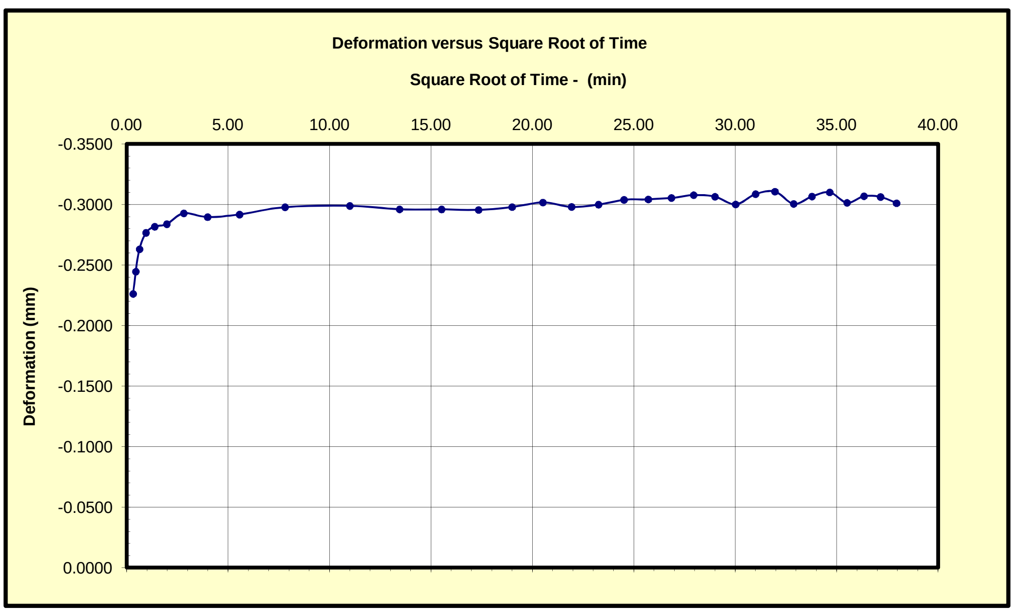
One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	9	Vertical Stress (kPa):	153.2





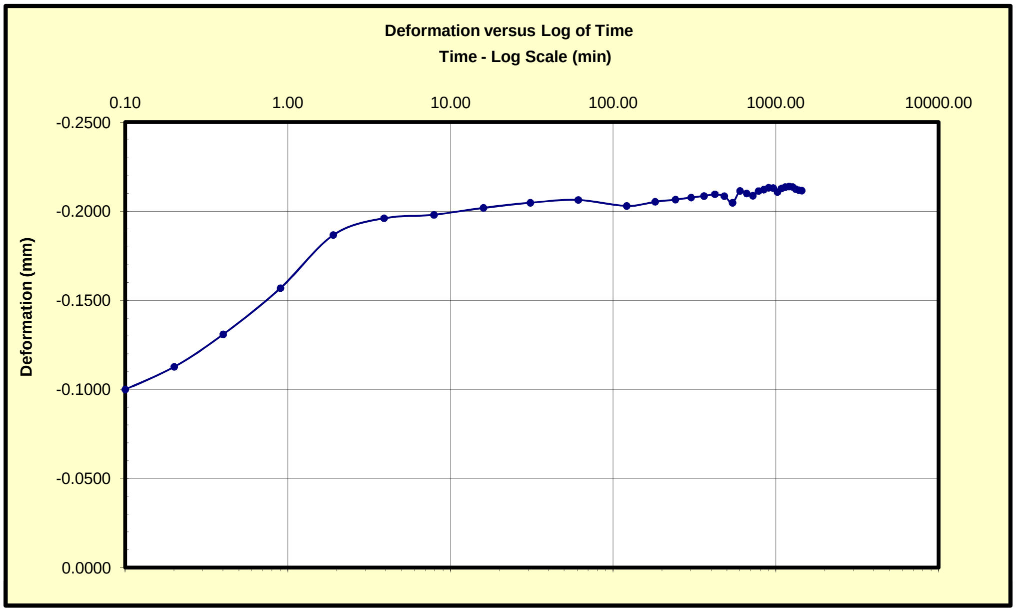
Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

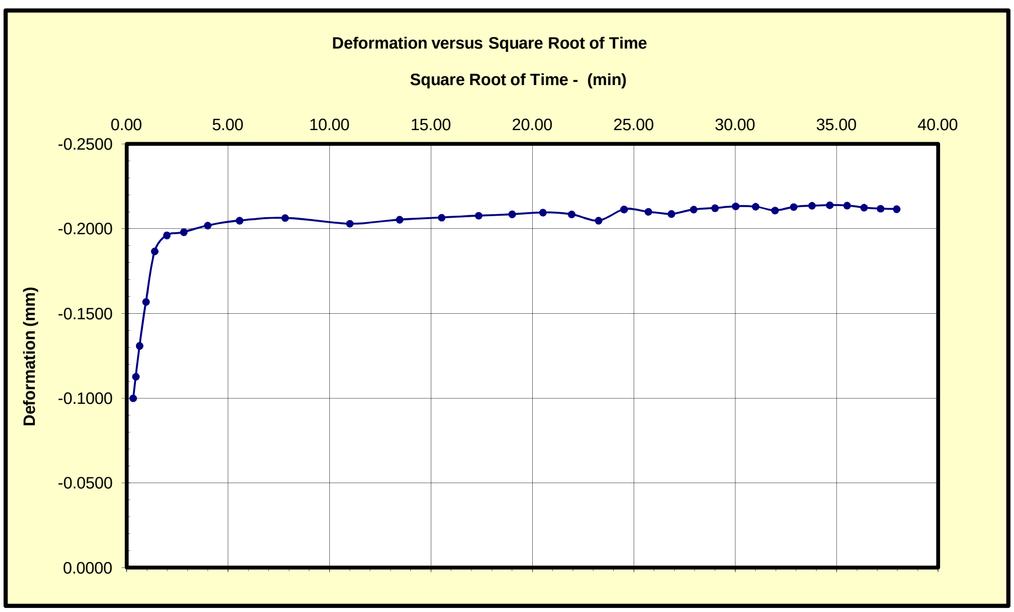
MEG TECHNICAL SERVICES

(A Division of MEG Consulting Limited)

One-Dimensional Consolidation (ASTM D 2435)

Project:	Ausenco - Murray River	Project No.:	13-MTS-028
Location:	BC	Date:	October 21, 2013
Borehole:	N/A	Station:	Station 1
Sample No.:	Bucket Sample 2 (Fines)	Depth (m):	N/A
Consolidation Step:	10	Vertical Stress (kPa):	38.3





Prepared By:	MF	Checked By:	HB	Approved By:	JPS
Date:	October 21, 2013	Date:	October 23, 2013	Date:	October 31, 2013

Maximum Density and Optimum Moisture Content

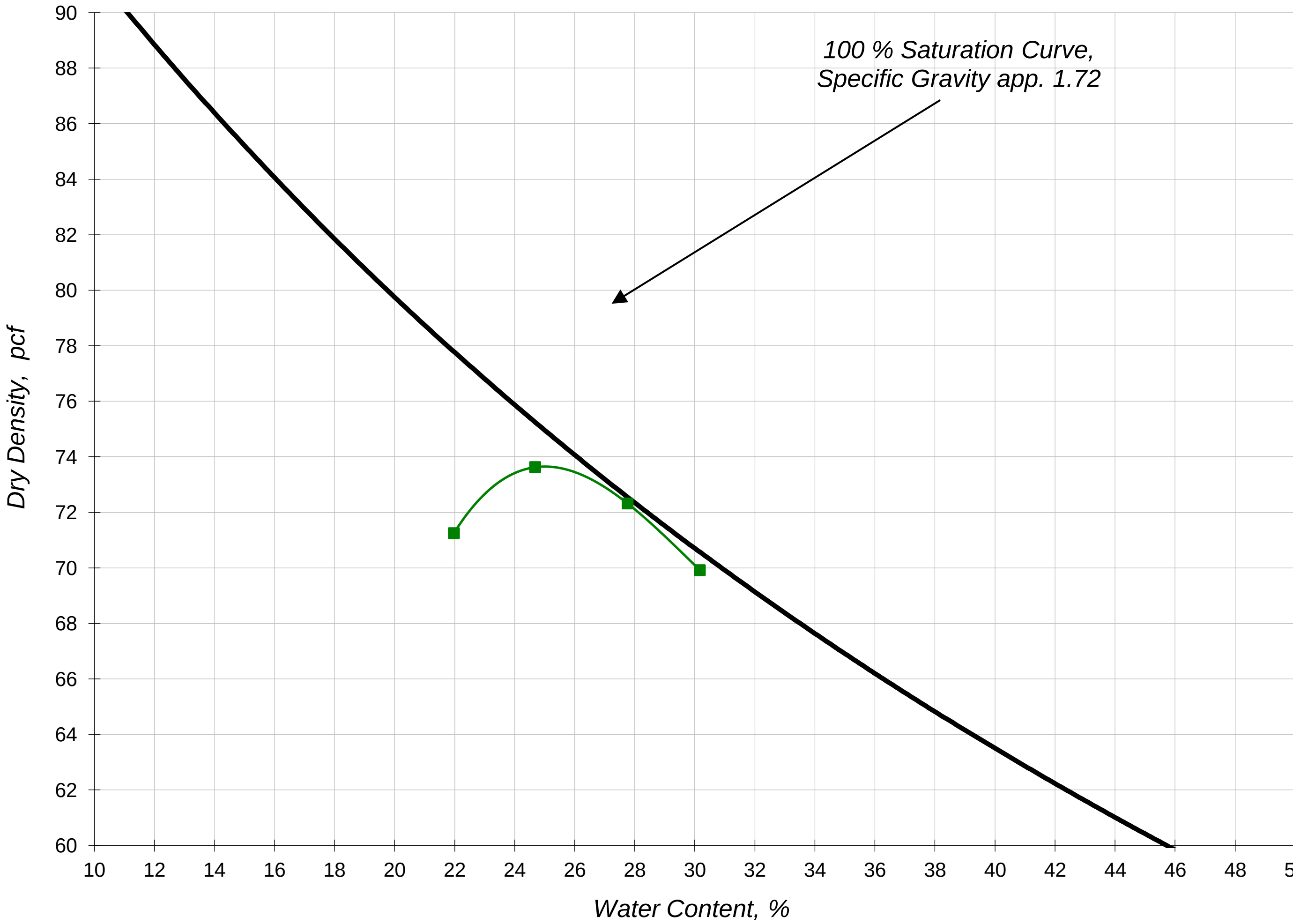
MOISTURE / DENSITY RELATIONSHIPS

Geo-Logic ASSOCIATES

Test Report
ASTM D - 698

Client: Ausenco
Project No.: 2013.A130.100
Lab Log No.: **3602A**

Project Name: Special Shear Testing
Report Date: October 23, 2013



Symbol	Lab No.	Sample Identification	Description	Maximum Dry Density pcf	Maximum Dry Density kg / m^3	Optimum Water Content %
■	3602A	Fine Coal Rejects, FCR	Black Coal	73.7	1180	25.0

Corrected Values For Oversized Particles, per ASTM D-4718

■ 3602A with 0 Percent +1" Gravel, the maximum Dry Density = 73.7 25.0

Note: The test was conducted as method A with 0 percent retained on the no. 4 sieve (minus 1")

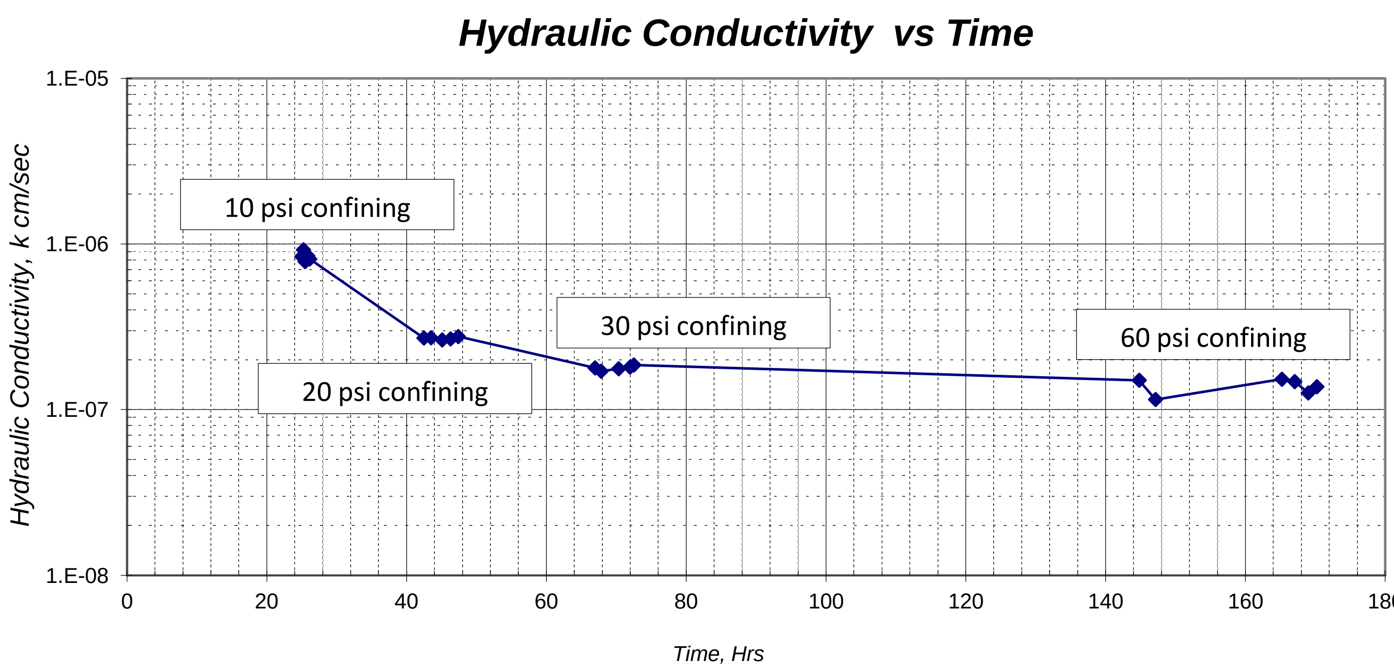
This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

Hydraulic Conductivity

Geo-Logic ASSOCIATES

HYDRAULIC CONDUCTIVITY REPORT

Client / Project Name: **Ausenco / Murray River Coal / #100102-01**
Project No: **2013.A130.100**
Lab Sample Number: **3602A**
Sample ID: **Fine Coal Rejects, FCR**
Report Date: **November 23, 2013**



SPECIMEN DATA

SAMPLE ID:	**Fine Coal Rejects, FCR**	
DESCRIPTION:	Black Coal Fines	
	INITIAL	FINAL
HEIGHT, in.	3.0	2.9
DIAMETER, in.	2.4	2.3
WATER CONTENT, %	26.5	25.8
DRY DENSITY, pcf	63	73
SATURATION, %	65	97
(Specific Gravity assumed as 1.7)		
MAXIMUM DRY DENSITY, pcf	73.7	
OPTIMUM WATER CONTENT, %	25.0	
SPECIFIED COMPACTION, %	85.0	
ACHIEVED COMPACTION, %	85.0	

COMMENTS:

Tap water used as permeant.

TEST DATA

ASTM D-5084, Method C

EFFECTIVE STRESS:	10, 20, 30, 60 psi
GRADIENT RANGE:	11 - 14
IN / OUT RATIO:	0.75
"B" PARAMETER:	0.98

Confining Pressure psi	HYDRAULIC CONDUCTIVITY, k^{20} cm / s
10	8.4E-07
20	2.7E-07
30	1.8E-07
60	1.4E-07

corrected to 20° C

HYDRAULIC CONDUCTIVITY

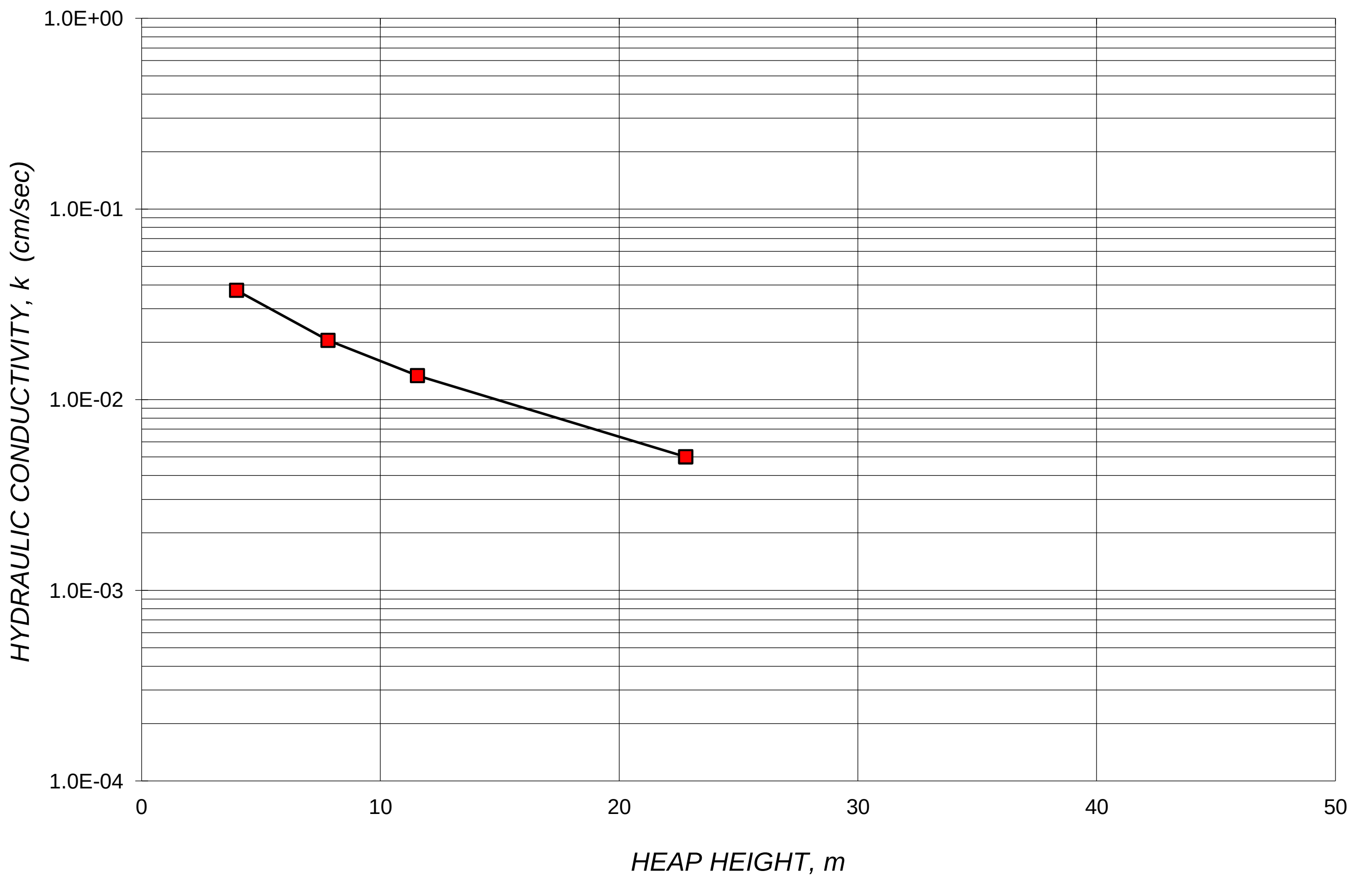
FIXED WALL

ASTM D- 2434, Modified

Client Name / Project Name:	Project No.:	Lab Log:
Ausenco / Murray River Coal / #100102-01	2013A.130.100	3602B

Sample I.D.:	Description:	Report Date:
CCR	Coarse Coal Rejects	November 15, 2013

STAGE NUMBER	WATER CONTENT %	DRY DENSITY pcf	Tonnes/m^3	ESTIMATED ORE HEIGHT (3) feet	meter	NORMAL STRESS psi	kPa	HYDRAULIC CONDUCTIVITY cm / sec
Initial	2.4	87.4	1.40					
2		100.6	1.61	13	4.0	10	68.9	3.7E-02
3		105.0	1.68	26	8	20	137.9	2.0E-02
4		108.6	1.74	38	12	30	206.8	1.3E-02
5		114.5	1.83	75	23	60	413.7	5.0E-03
6								
7								
Drained	12.0	114.5	1.83					



NOTES: 1) Test ran using 12 inch diameter fixed wall permeater. 3) Height, based on running average of wet density, 93 % saturated.

2) CONSTANT HEAD Average Head = 13.1cm

This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

HYDRAULIC CONDUCTIVITY

FIXED WALL

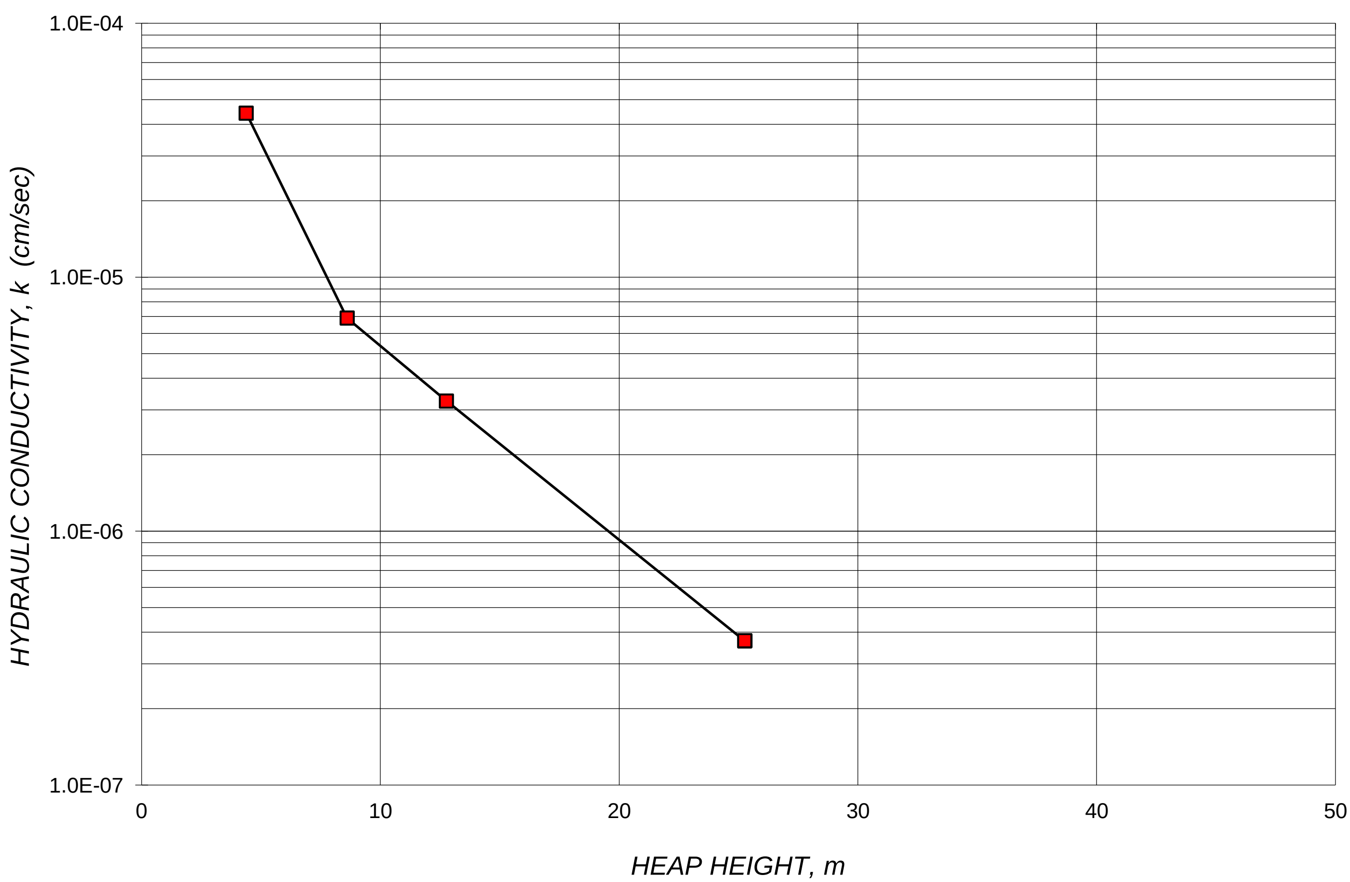
ASTM D- 2434, Modified

Geo-Logic ASSOCIATES

Client Name / Project Name: Ausenco / Murray River Coal / #100102-01
Project No.: 2013A.130.100
Lab Log: 3602C

Sample I.D.: Mix of 70% CCR w/ 30% FCR
Description: Coal Rejects
Report Date: December 4, 2013

STAGE NUMBER	WATER CONTENT	DRY DENSITY		ESTIMATED ORE HEIGHT (3)		NORMAL STRESS		HYDRAULIC CONDUCTIVITY
	%	pcf	Tonnes/m^3	feet	meter	psi	kPa	cm / sec
Initial	6.5	79.5	1.27					
2		88.9	1.42	14	4.4	10	68.9	4.4E-05
3		92.0	1.47	28	9	20	137.9	6.9E-06
4		93.9	1.50	42	13	30	206.8	3.3E-06
5		96.9	1.55	83	25	60	413.7	3.7E-07
6								
7								
Drained	15.6	96.9	1.55					



NOTES: 1) Test ran using 12 inch diameter fixed wall permeater. 3) Height, based on running average of wet density, 72 % saturated.

2) #DIV/0!

This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

L: Labexcel \ Projects \ Client \Client Name \ 2013A. \36
Print Date: 12/06/13
Entered By: PP
Reviewed By: KRC
LLN: **3602C**
DCN: FWP-rp(rev. 6/26/12)

Large Scale Direct Shear

DIRECT SHEAR REPORT

Consolidated - Drained Test

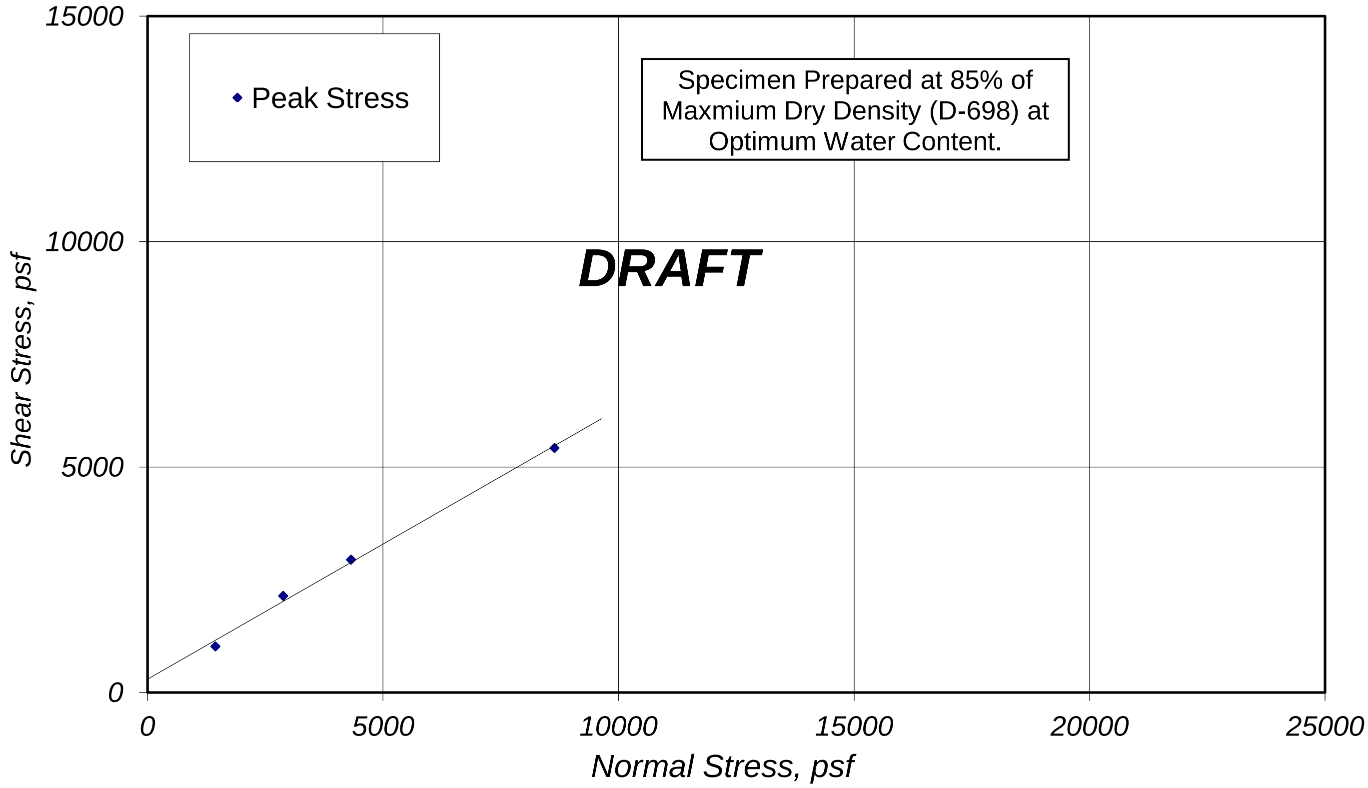
ASTM D- 3080

Client / Project Name: Ausenco / Murray River Coal / #100102-01

Project No. : 2013.A130.100 *Lab Log:* 3602A

Sample : Fine Coal Rejects, FCR *Soil Description:* Black Coal Fines *Report Date:* November 5, 2013

STRENGTH ENVELOPE



		Peak
Coefficient of Friction	:	0.668
Friction Angle	:	33.8
Cohesion, psf:	:	110

Point No.	Normal Stress psf	Shear Stress Peak psf		Initial Water Content %	Initial Dry Density pcf	Final Water Content %	Final Dry Density pcf
1	1440	1021		28.4	61.0	32.9	68.9
2	2880	2141		27.8	61.3	31.0	70.3
3	4320	2945		28.1	61.1	30.7	72.0
4	8640	5422		#DIV/0!	0.0	#DIV/0!	0.0

Horizontal Displacement Rate, in. / min. : 0.002 *Sample Diameter, in.:* 2.50

This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

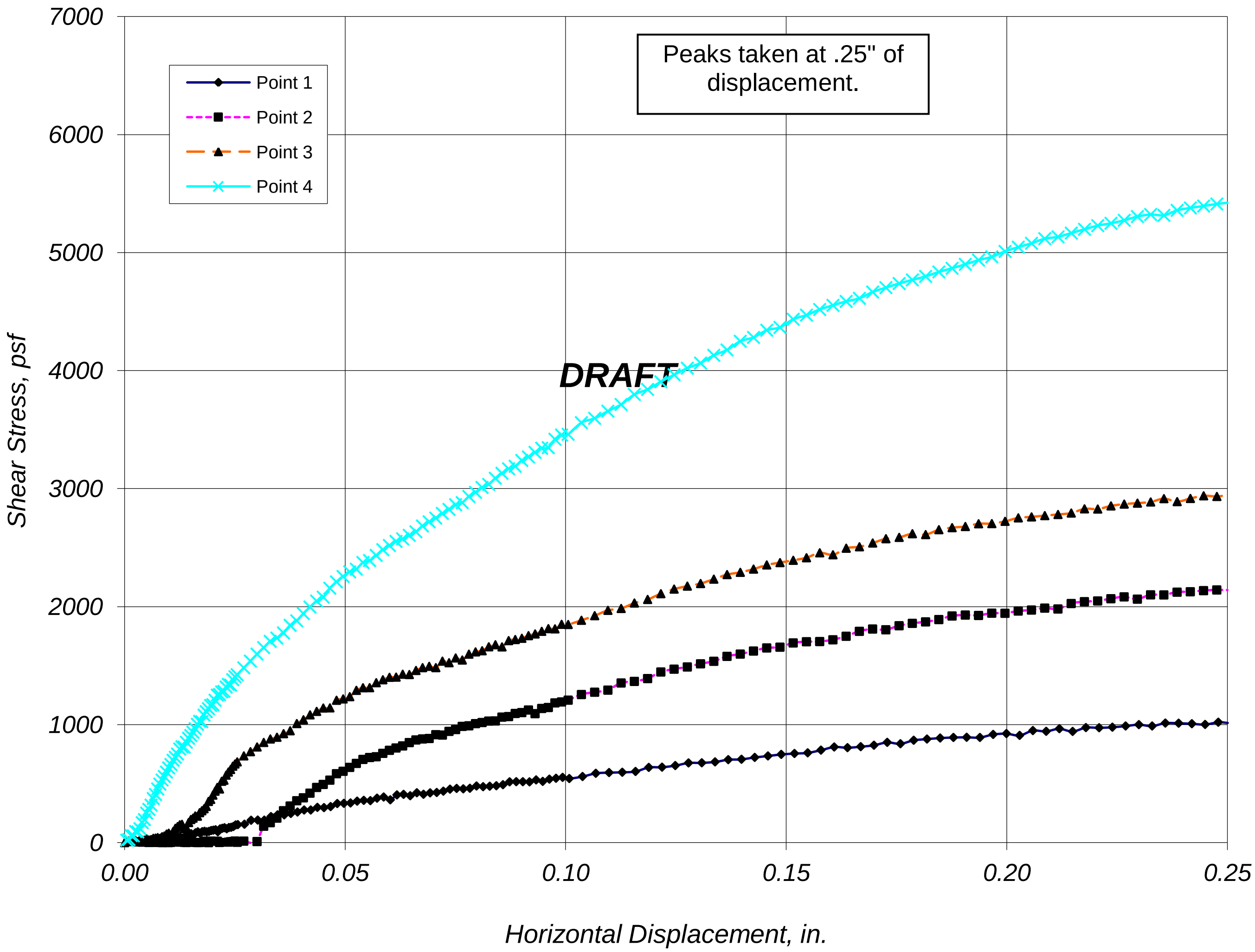
Geo-Logic ASSOCIATES

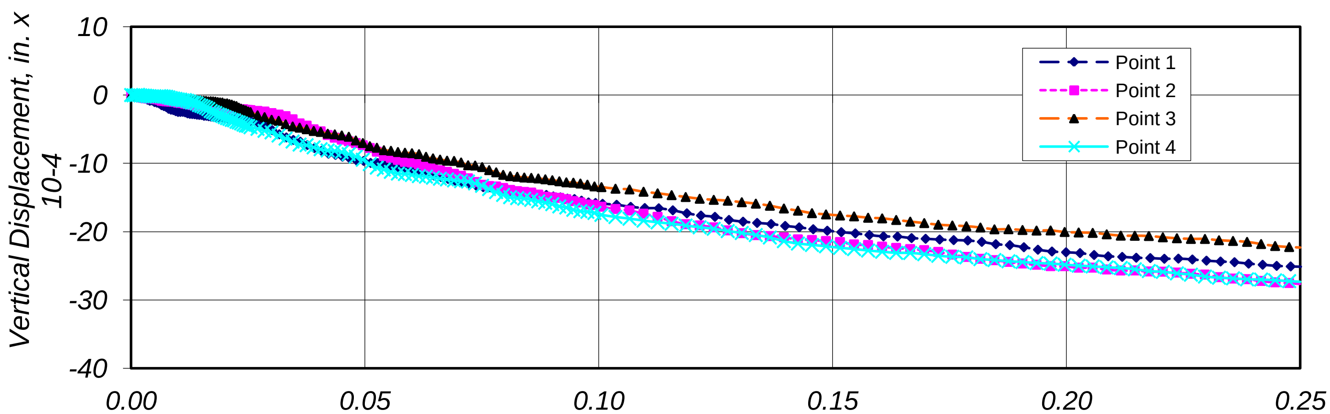
DIRECT SHEAR REPORT

ASTM D- 3080

Client / Project Name:	*Project No. :*	*Lab Log:*
Ausenco / Murray River Coal / #100102-01	2013.A130.100	3602A

Sample :	*Soil Description:*	*Report Date:*
Fine Coal Rejects, FCR	Black Coal Fines	November 5, 2013





NORMAL STRESSES, psf : Point - 1 1440 Point - 2 2880 Point - 3 4320

Point - 4 11520

L:Labexcel \ Projects \ 1920 \ 2013.A \ 3602A-SDS

Entered By:	*Reviewed By:*	*Lab Log:*
KH		**3602A**

DCN: SDS-rp (rev. 03/23/10)

LARGE SCALE DIRECT SHEAR REPORT

Internal Shear

Report Date: November 4, 2013

Client / Project Name: AUSENCO / MURRAY RIVER COAL / #100102-01

Project No: 2013.A130.100

Superstrate: ⇐ Drainage Gravel

Material 1: ⇐ Coarse Coal Rejects CCR — LSN: 3602B — Remolded

Material 2: ⇒ Coarse Coal Rejects CCR — LSN: 3602B — Remolded

Substrate: ⇒ PVC Board

PEAK STRENGTH

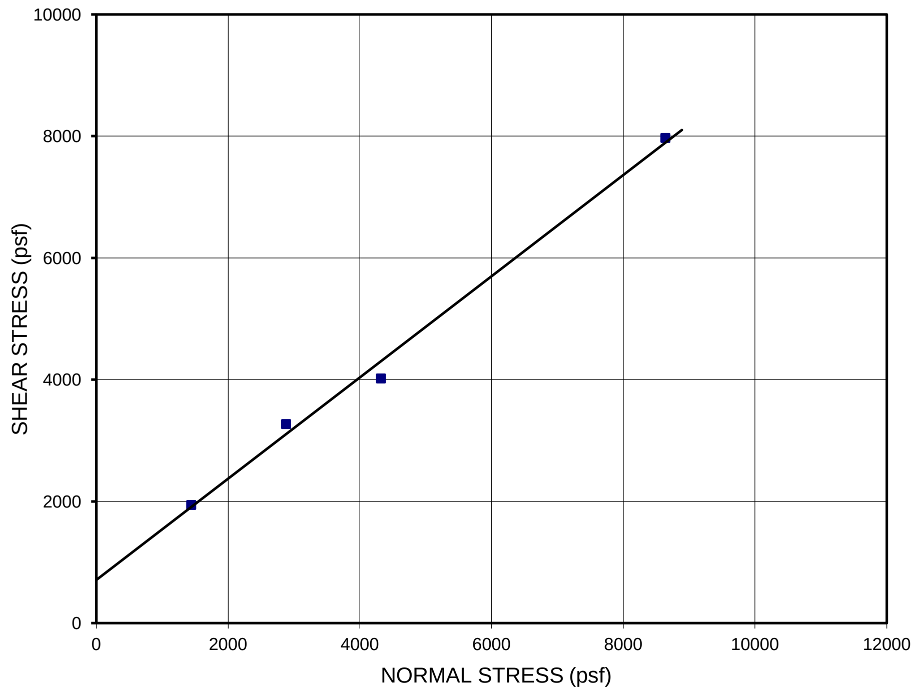
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	10.0	1440	1940	53
2.	20.0	2880	3270	49
3.	30.0	4320	4020	43
4.	60.0	8640	7970	43

Adhesion: 710 psf

Friction Angle: 40 degrees

Coefficient of Friction: 0.83

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 3.0 in. displacement)

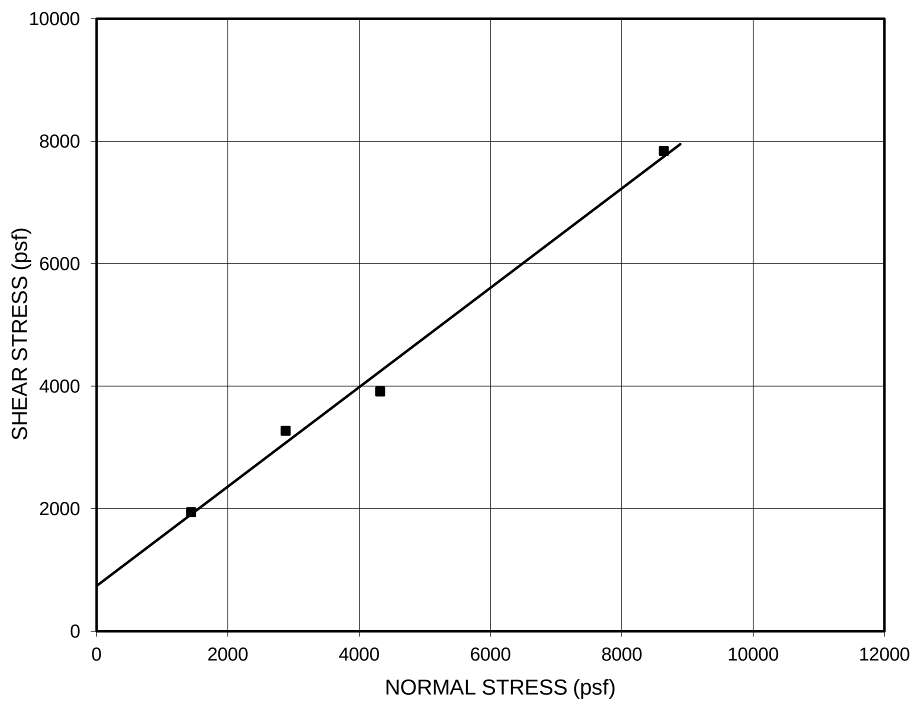
Test Point	Normal Stress psi	Normal Stress psf	Shear Stress psf	Secant Friction Angle
1.	10.0	1440	1940	53
2.	20.0	2880	3270	49
3.	30.0	4320	3910	42
4.	60.0	8640	7840	42

Adhesion: 740 psf

Friction Angle: 39 degrees

Coefficient of Friction: 0.81

NOTE: GRAPH NOT TO SCALE



This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

LARGE SCALE DIRECT SHEAR REPORT

Internal Shear

Report Date: November 4, 2013

Client / Project Name: AUSENCO / MURRAY RIVER COAL / #100102-01

Project No: 2013.A130.100

Superstrate: ⇦ Drainage Gravel

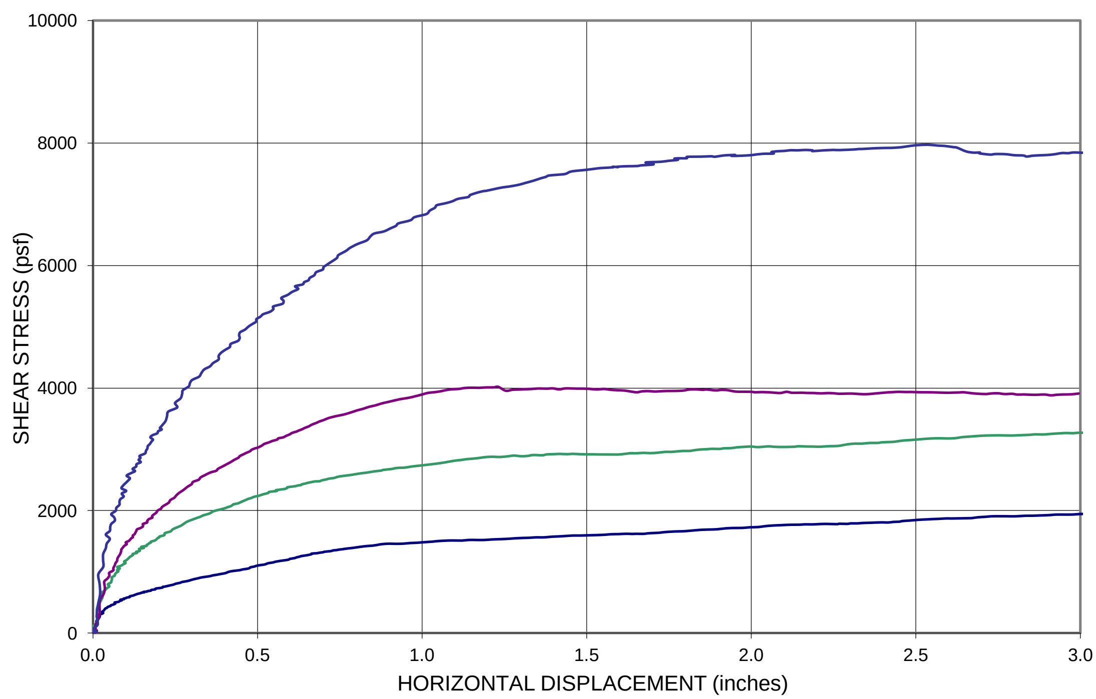
Material 1: ⇦ Coarse Coal Rejects CCR — LSN: 3602B — Remolded

Material 2: ⇨ Coarse Coal Rejects CCR — LSN: 3602B — Remolded

Substrate: ⇨ PVC Board

DISPLACEMENT vs. SHEAR STRESS

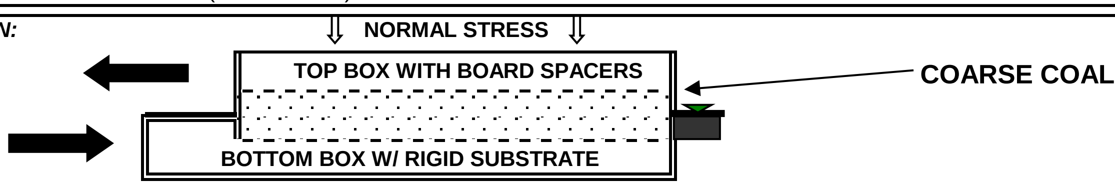
Test Point	Normal Stress psi	Normal Stress psf
1.	10.0	1440
2.	20.0	2880
3.	30.0	4320
4.	60.0	8640



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-3080 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. The test method was modified to measure the internal shear characteristics of the coal.
2. The coarse coal was tamped into both the upper and lower box.
3. Each test specimen was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred internally within the coarse coal.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

LARGE SCALE DIRECT SHEAR REPORT

Internal Shear

Report Date: November 23, 2013

Client / Project Name: AUSENCO / MURRAY RIVER COAL / #100102-01

Project No: 2013.A130.100

Superstrate: ⇐ Drainage Gravel

Material 1: ⇐ Mix of 70% CCR w/ 30% FCR — *LSN:* 3602C Remolded

Material 2: ⇒ Mix of 70% CCR w/ 30% FCR — *LSN:* 3602C Remolded

Substrate: ⇒ PVC Board

PEAK STRENGTH

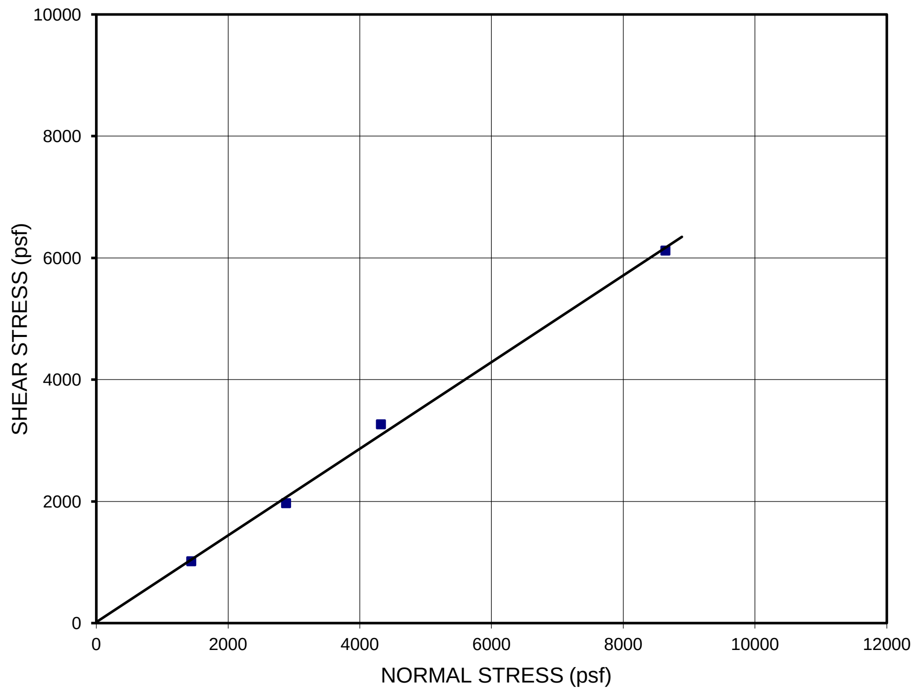
Test Point	*Normal Stress psi*	*Normal Stress psf*	*Shear Stress psf*	*Secant Friction Angle*
1.	10.0	1440	1020	35
2.	20.0	2880	1970	34
3.	30.0	4320	3270	37
4.	60.0	8640	6120	35

Adhesion: 20 psf

Friction Angle: 35 degrees

Coefficient of Friction: 0.71

NOTE: GRAPH NOT TO SCALE



STRENGTH ENVELOPE

(at 3.0 in. displacement)

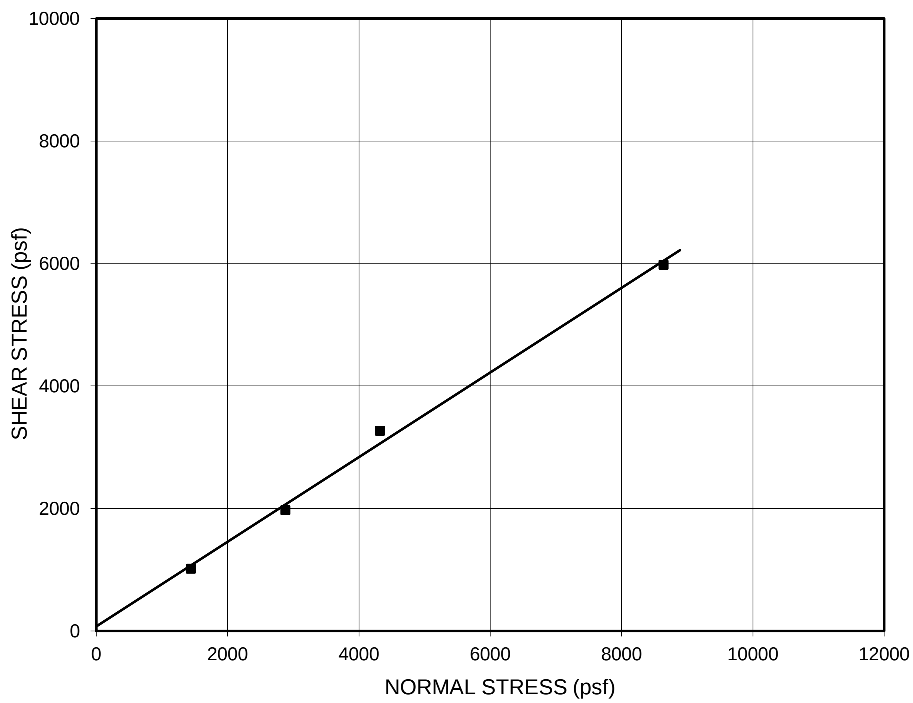
Test Point	*Normal Stress psi*	*Normal Stress psf*	*Shear Stress psf*	*Secant Friction Angle*
1.	10.0	1440	1020	35
2.	20.0	2880	1970	34
3.	30.0	4320	3270	37
4.	60.0	8640	5980	35

Adhesion: 70 psf

Friction Angle: 35 degrees

Coefficient of Friction: 0.69

NOTE: GRAPH NOT TO SCALE



This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

LARGE SCALE DIRECT SHEAR REPORT

Internal Shear

Report Date: November 23, 2013

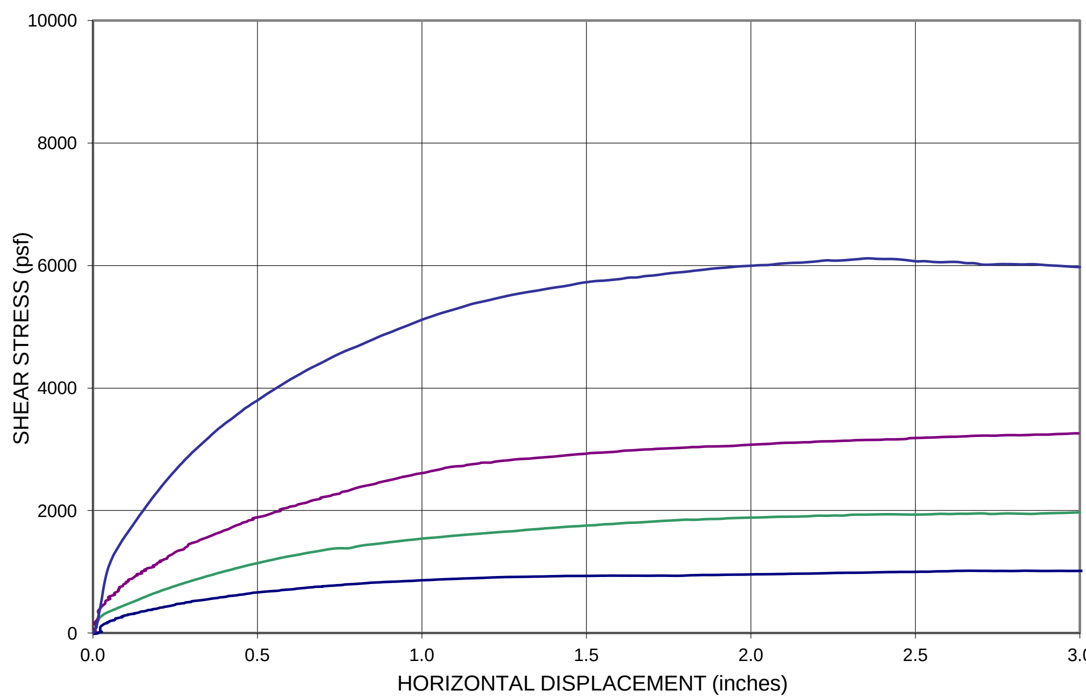
Client / Project Name: AUSENCO / MURRAY RIVER COAL / #100102-01

Project No: 2013.A130.100

Superstrate:	Drainage Gravel		
Material 1:	Mix of 70% CCR w/ 30% FCR	LSN: 3602C	Remolded
Material 2:	Mix of 70% CCR w/ 30% FCR	LSN: 3602C	Remolded
Substrate:	PVC Board		

DISPLACEMENT vs. SHEAR STRESS

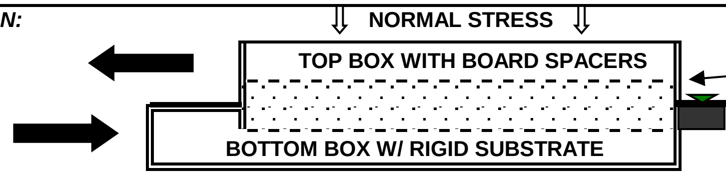
Test Point	Normal Stress	
	psi	psf
1.	10.0	1440
2.	20.0	2880
3.	30.0	4320
4.	60.0	8640



STANDARD CONDITIONS: **SHEAR DISPLACEMENT RATE: 0.04 in/min**

1. The "gap" between shear boxes was set at 80 mil (2.0 mm)
2. The test specimens were flooded during testing unless otherwise noted.
3. High Normal Stresses, >5psi (35 kPa) was applied using air pressure.
4. Low Normal Stresses, <5psi (35 kPa) was applied using dead weights.
5. The tests were terminated after 3.0"(75 mm) of displacement unless otherwise noted.
6. Tests were performed in general accordance with ASTM procedure D-3080 using a Brainard-Killman LG-112 direct shear machine with an effective area of 12" x 12" (300 x300 mm).

TEST ORIENTATION:



SPECIAL TEST NOTES:

1. The test method was modified to measure the internal shear characteristics of the coal.
2. The coal was tamped into both the upper and lower box.
3. Each test specimen was consolidated for 24 hours at the specified normal stress, then sheared.
4. The test was performed in a "wet" or "flooded" condition.
5. Shearing occurred internally within the coal.
6. The Friction Angle and Adhesion (or Cohesion) results given here are based on a mathematically determined best fit line.
7. Further interpretation should be conducted by a qualified professional experienced in geosynthetic and geotechnical engineering.

This testing is based upon accepted industry practice as well as the test method listed. These results apply only to the samples supplied and tested for the above referenced job.

L:Labexcel \Projects \ Client \ Name \ 2013.A130.10 \ 3602C-LSDS-rp	Print Date:	Entered By:	Reviewed By:	LLN:
DCN: LSDS-rp (rev., 11/29/12)	12/06/13	KH	krc	**3602C**

Appendix 3 – Engineering Calculations

Ausenco

Pipe Spacing Collection System Calculator

Project: Murray River Project
Revision: 0
Date: June 1, 2014
Client: HD Mining International Ltd
Approved by: SCE

Calcuation

Maximum and Average Head Over Liner System for North And South Coal Reject Piles

Data:

Application Rate (r)	2.16E-02	$l/hr/m^2$	**6.00E-09**	**m3/s**
Overliner Permeability (K)	5.E-03	cm/s	**5.E-05**	**m3/s**
Pipe Spacing (L)	50	m		
Pipe Diameter (d)	150	mm	**0.15**	**m**
Maximum Capacity of Pipe Flow (c)	60	%		
Maximum Hydraulic Head Above Liner	2	m		

Elisptical Equation

$h_{max} = ((L^2 * r) / 4K)^{0.5} + (d * c)$ 0.3638613 m

Ausenco

Leakage Rate Calculator

Project: Murray River Project

Client: HD Mining International Ltd

Revision: 0
Date: June 1, 201
Approved by: SCE

Calcuation

Leakage Rate Through Primary Liner Syste for North Coal Reject Piles

Data:

Q = Leakage Rate through 1 defect (m3/s)		m3/s
C_{qo} = Contact Quality Factor	0.21	Unitless
h = hydraulic head on top of the geomembrane (m)	0.25	m
t_s = thickness of the soil below the (m)	2	m
d = diameter of the circular defect (m)	0.002	m
k = permeability of the soil below the liner (m/s)	1.00E-07	m/s
a = area of coal reject pile	370,630	m2
n = number of defects per 4,000 m^2	1	

Leakage Equation

$Q_{1\ defect}$ = 0.976*C_{qo}*(1+0.1*(h/t_s)^.0.95)*d^0.2*h^0.9*k^0.74 — 1.14E-07 m3/s

Ausenco

Leakage Rate Calculator

Project:	Murray River Project	**Revision:**	0
		Date:	June 1, 2014
Client:	HD Mining International Ltd	**Approved by:**	SCE

Calcuation

Leakage Rate Through Primary Liner Syste for South Coal Reject Piles

Data:

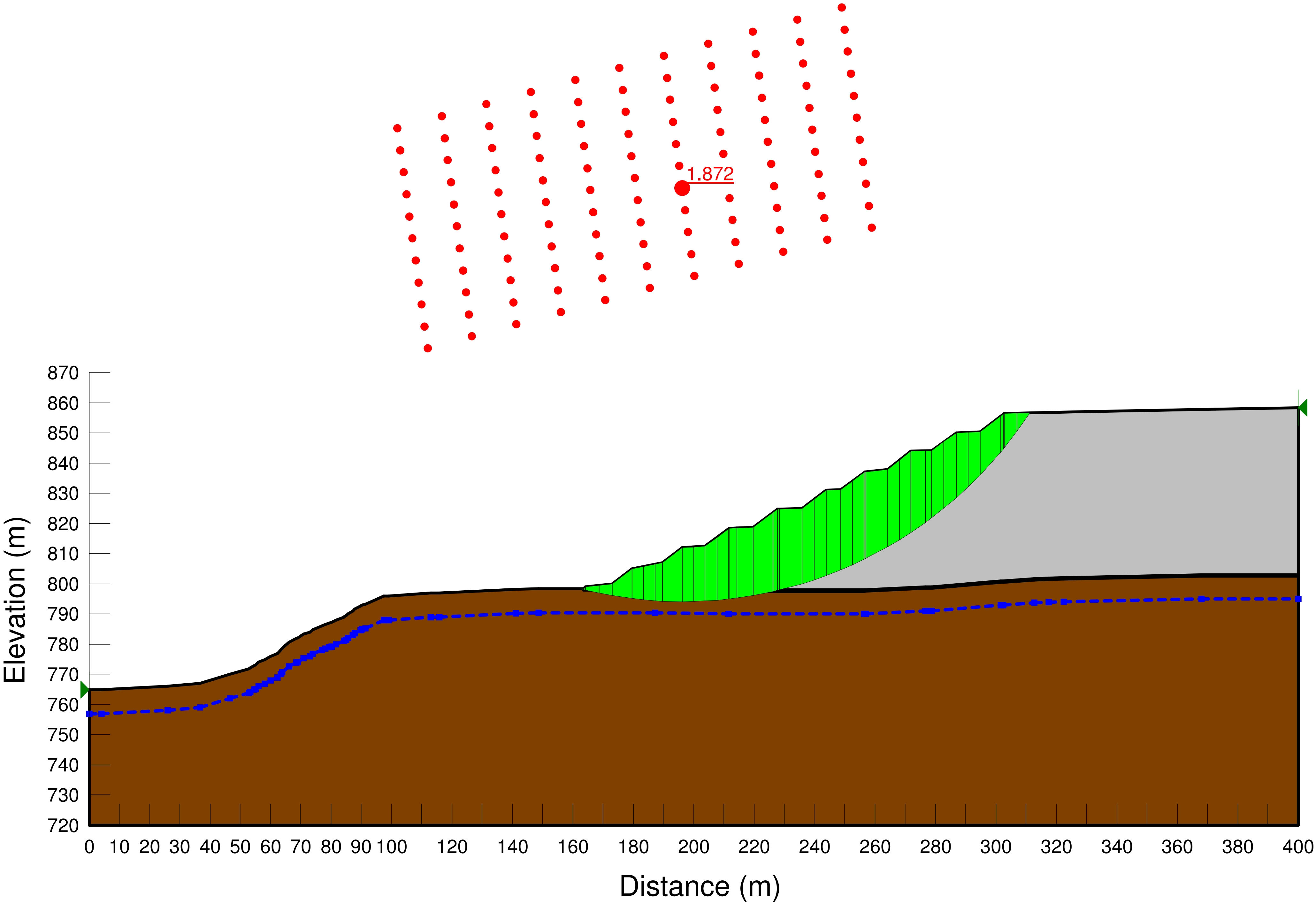
Q = Leakage Rate through 1 defect (m3/s)		m3/s
C_{qo} = Contact Quality Factor	0.21	Unitless
h = hydraulic head on top of the geomembrane (m)	0.25	m
t_s = thickness of the soil below the (m)	2	m
d = diameter of the circular defect (m)	0.002	m
k = permeability of the soil below the liner (m/s)	1.00E-07	m/s
a = area of coal reject pile	358,509	m2
n = number of defects per 4,000 m^2	1	

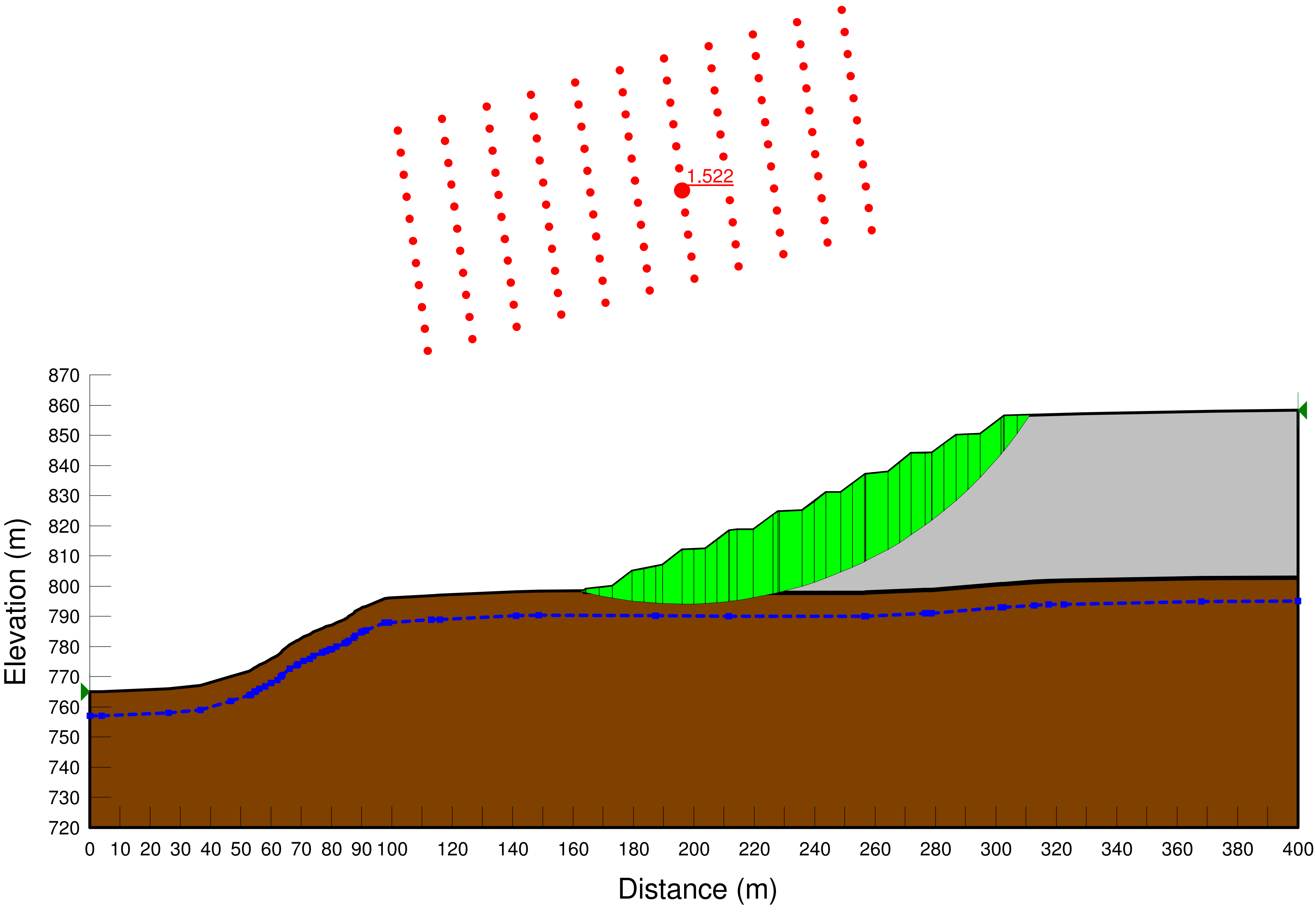
Leakage Equation

$Q_{1\ defect}$ = 0.976*C_{qo}*(1+0.1*(h/t_s)^.0.95)*d^0.2*h^0.9*k^0.74 — 1.14E-07 m3/s

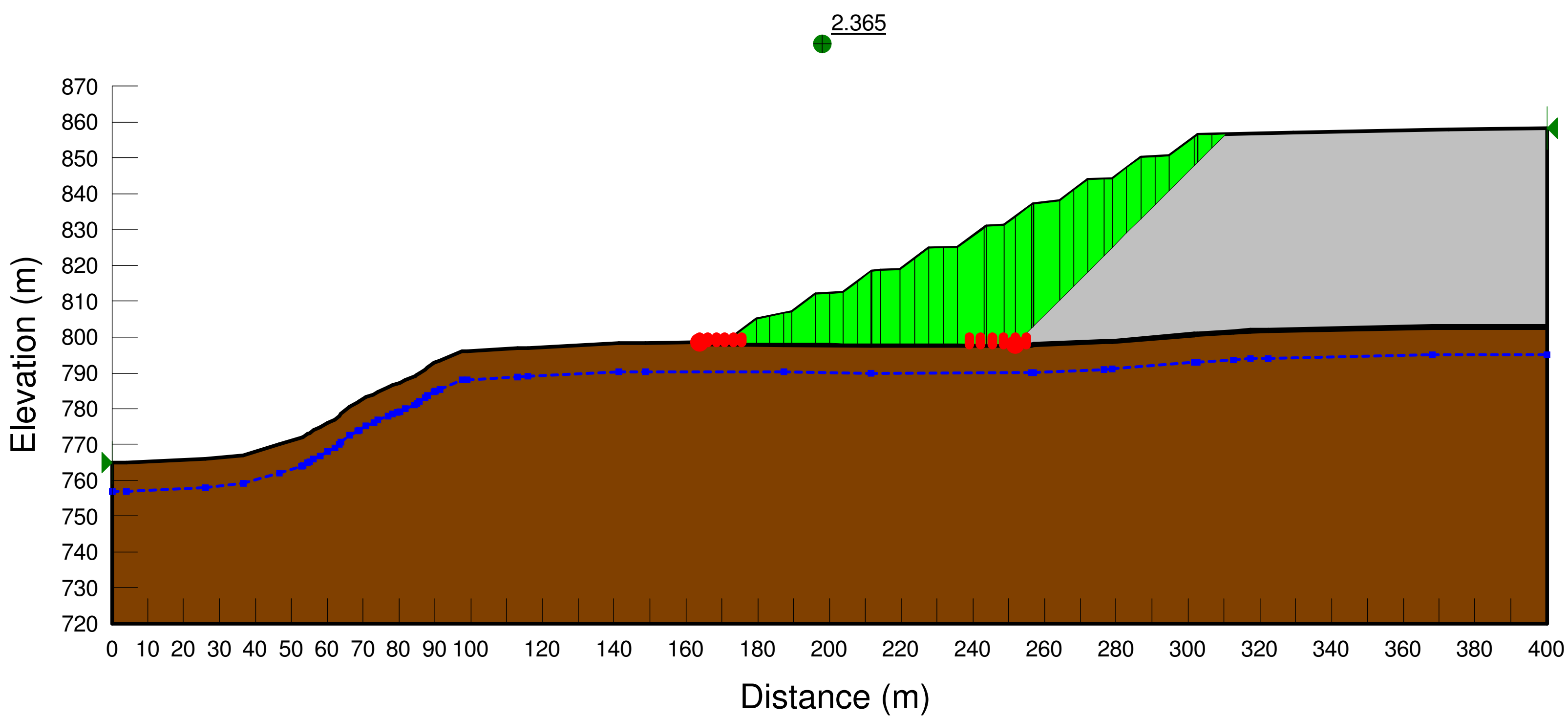
Appendix 4 – Stability Analysis

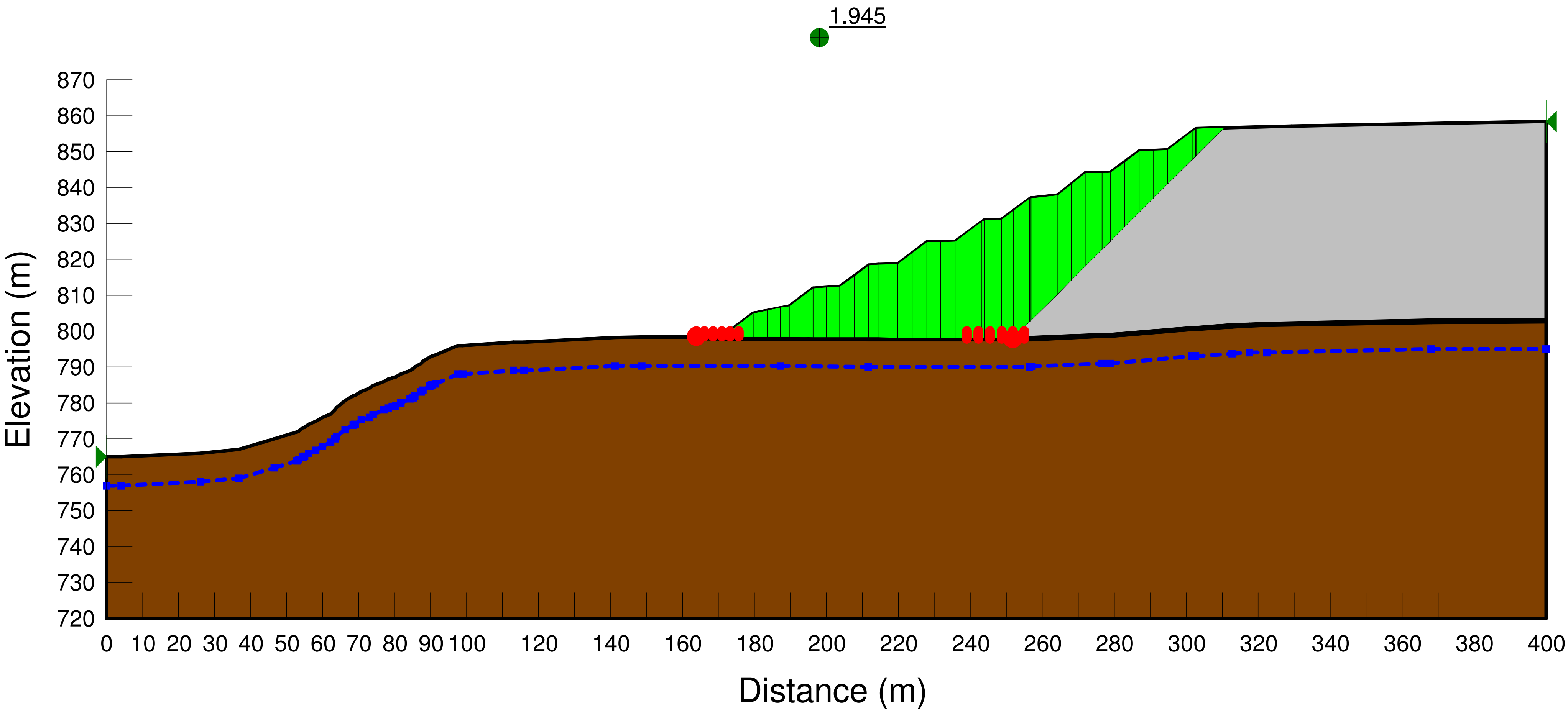
Northern CR Pile


1.872
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
Elevation (m)
0 10 20 30 40 50 60 70 80 90 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
Distance (m)

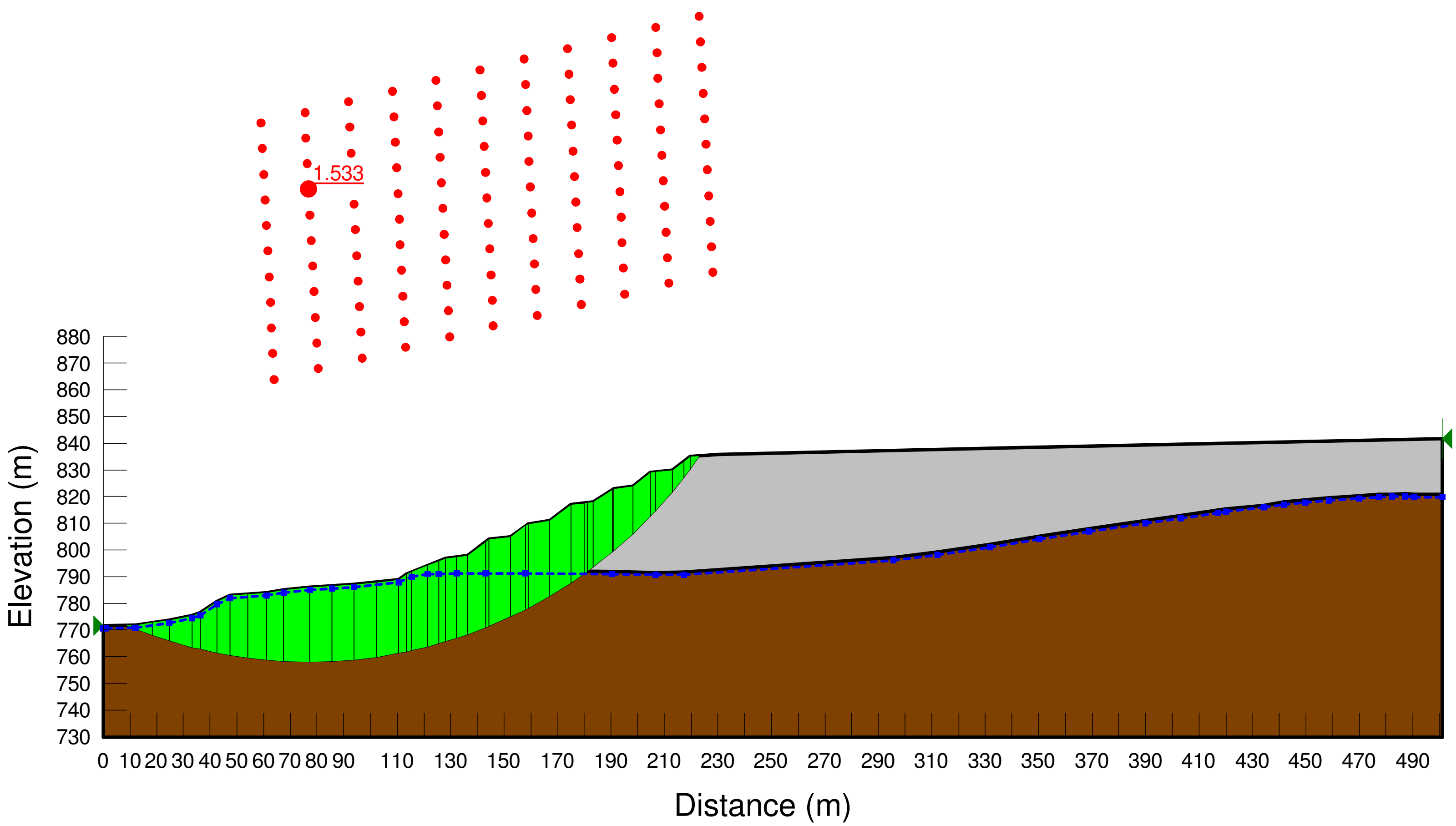


1.522
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
Elevation (m)
0 10 20 30 40 50 60 70 80 90 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
Distance (m)


2.365
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
Elevation (m)
0 10 20 30 40 50 60 70 80 90 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
Distance (m)


1.945
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
Elevation (m)
0
10
20
30
40
50
60
70
80
90
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
Distance (m)

Southern CR Pile


1.533
Elevation (m)
880
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
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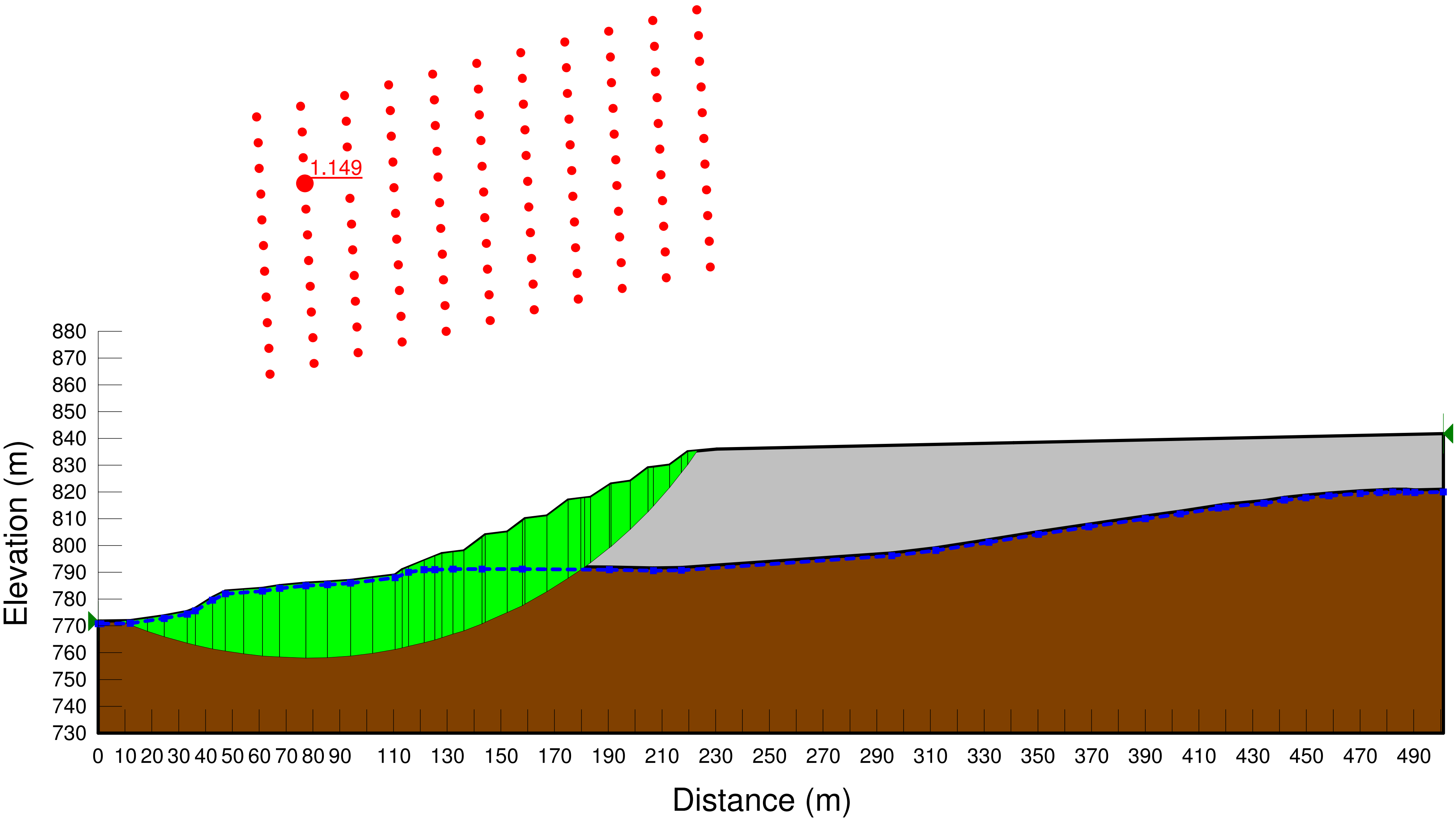
Distance (m)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Elevation (m)
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Distance (m)

Appendix 5 – Coal Reject Pile Seepage Calculations

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Technical Memorandum

To	**Scott Elfin**
Attention	
Cc	**Nick Martin, Jack Wang**
From	**Joel Sobol**
Project	**HD Mining**
Reference	**Vertical Flux Estimates for North and South Coarse Coal Refuse (CCR) Piles Murray River Coal Project, British Columbia, Canada**
Date	**May 23, 2014**
Page	Page 1 of 13

Introduction

HD Mining International Ltd. (HD Mining) is proposing to develop the Murray River Coal Project as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The Project is located approximately 12.5 km south of Tumbler Ridge (**Figure 1**), British Columbia within the Peace River Coalfield (PRC). This area has a long history of metallurgical grade coal mining, mainly from open pit mining. However, HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques. Associated with proposed mining activities, will be coal refuse piles that may pose a potential risk to surface and groundwater quality in the area. In order to assess the potential impact of these disposal areas, Ausenco has been tasked by HD Mining to develop a numerical model to estimate the flux from these refuse piles. As such, the main purpose of this memo is to describe the methodology and results of a modeling study that estimates the flux from natural precipitation through the north and south coarse coal refuse (CCR) piles.

Climate

The Project Site is in the Southern Rocky Mountain Foothills hydrologic zone, which is characterized by a continental climate with low precipitation, moderately warm summers, and cold winters. In general, moist coastal air masses from the west release precipitation on the western side of the Rocky Mountains, which causes dry conditions on the east side of the mountains. In addition, the Project area is often affected by winter Arctic air masses moving in from the northeast. The result is lower annual precipitation and colder temperatures compared to west side of the Rockies. A rare rise in temperature above the freezing point during winter months is possible due to Chinook winds. In general, the climate at the Project area consists of long cold winters and short cool summers with an annual precipitation between 500 to 700 millimeters (Rescan, 2013).

Mean monthly temperatures in the region range from a high of 15˚C in July to a low of -10˚C in January. Temperatures are generally above freezing point from April to October; however freezing conditions may occur at any time of the year at higher elevations (> 1,000 m above sea level).

Mean monthly precipitation, as reported by Canadian Climate Normals, for the Bullmoose, Denison Plantsite, Tumbler Ridge and Chetwynd stations, is summarized in Table 2.3-1. Due to convective weather systems that are most active during the summer, June and July receive significantly more precipitation than other months. The majority of precipitation from November to April occurs as snow and represents about 30 to 50% of the annual total precipitation (Rescan, 2013).

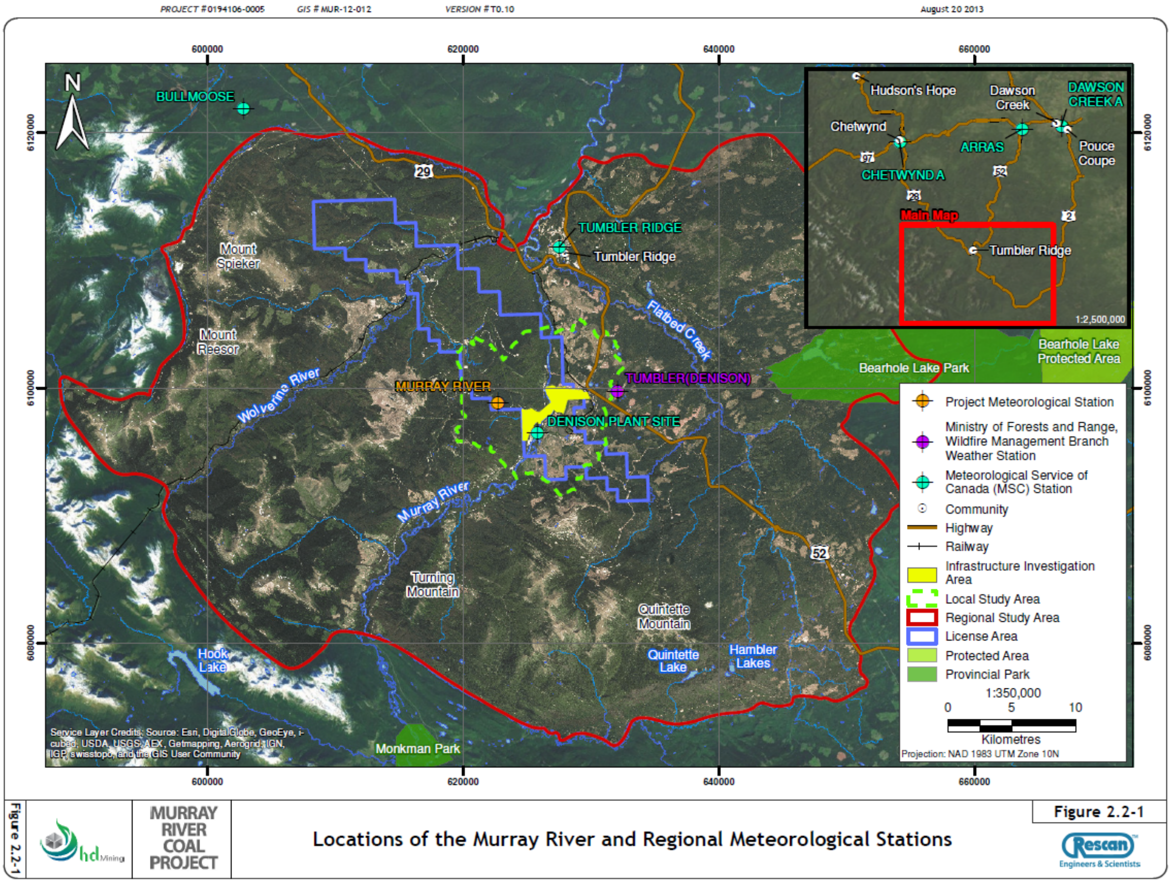


Figure 1

Hydrology

Rivers in the Project area are predominantly fed by spring snowmelt and intense summer rainfall storms. High flow discharges occur from mid-April through July, while the winter to early spring is a period of low flow discharges. The local study is located within portions of the Camp Creek (M20 Creek) and Twenty Creek drainage basins that are discharging to Murray River to the east. The M17 and M19A creeks are located on the east side of Murray River and flow west into it. Murray River flows north into the Pine River, 40 km downstream from the Village of Chetwynd, BC. Both the Pine and Murray Rivers belong to the greater Peace River drainage system, which in turn flows into the Slave River, a tributary of the greater Mackenzie River (Rescan, 2013).

Surface Geology of CCR Site

Three distinct geomorphological units can be described at the CCR Site. For the purpose of this report, they are referred to as the top terrace (topographic high), middle terrace and bottom terrace (topographic low). Surfaces of all those terraces slope toward Murray River. The lithology of the sediments present within the top terrace consists of thin glacial deposits that overlie slightly fractured interbedded siltstone and sandstone. Both middle and bottom terraces contain thin glacial deposits that overlie a thick layer of high plasticity clay-rich lacustrine deposit. A low permeability clay-rich deposit, identified as an aquitard, is 25 m thick in the area of the middle terrace and 50 m thick within the bottom terrace. A slightly fractured siltstone is found below that clay-rich deposit.

Groundwater is absent in the thin layer of overburden materials at the top terrace as the first water bearing zone is found in the weathered siltstone (MW-H24B). The shallow monitoring well at the middle terrace (MW-H26B) reports water table at 2 mbgs, while the water level at the bottom terrace (MW-H25B), situated next to a marsh, is near the ground surface (< 1 mbgs). The bedrock water-bearing units at the CCR Site appear to be semi-confined to confined. The hydraulic head measured in MW-H24A completed within the area of the top terrace is at about 16 mbgs. The other deep monitoring wells completed below the clay-rich deposit within the area of the middle and bottom terraces report hydraulic heads at the surface (in a well MW-H26A) and near the surface (in a well MW-H25A).

Groundwater flow direction within the CCR Site is in a west-north-west direction towards Murray River. A steep downward vertical hydraulic gradient observed within the area of the top terrace is characteristic of a groundwater recharge zone. In contrast, the middle and bottom terraces report very low, upward vertical gradient and water levels at or near the surface, characteristic of a groundwater discharge zone.

Flux Modeling

The purpose of using a model for this project is to be able estimate flux due to precipitation through the North and South CCR piles. The model that was selected is SEEP/W1 (Geo-Slope, 2007), which is a finite element model capable of simulating both saturated and unsaturated flow conditions with Darcy's Law. The model is capable of representing the recharge boundary with a water flux boundary condition rather than with detailed atmospheric coupling. Although Darcy's Law was originally formulated for saturated flow, it can also be applied to unsaturated soil when hydraulic conductivity is allowed to vary with water content and pore-water pressure. In the use of Darcy's Law, it is assumed that pore air pressure remains constant at atmospheric pressure and total hydraulic head is then used in the governing seepage partial differential equation.

Model Input Data

The proposed footprint of the north and south CCRs are presented in Figure 2. These dimensions were used to develop a vertical profile of the piles from which the model grid was developed.

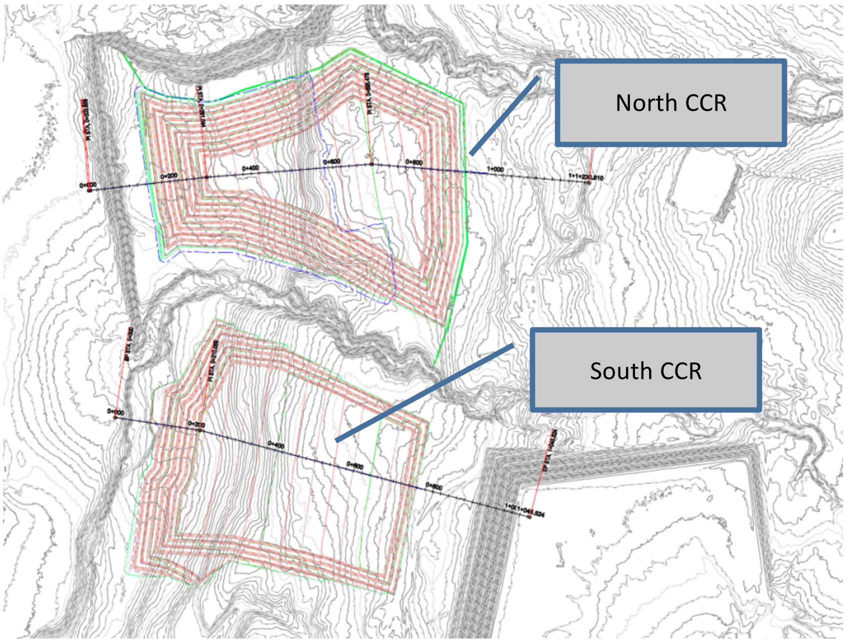
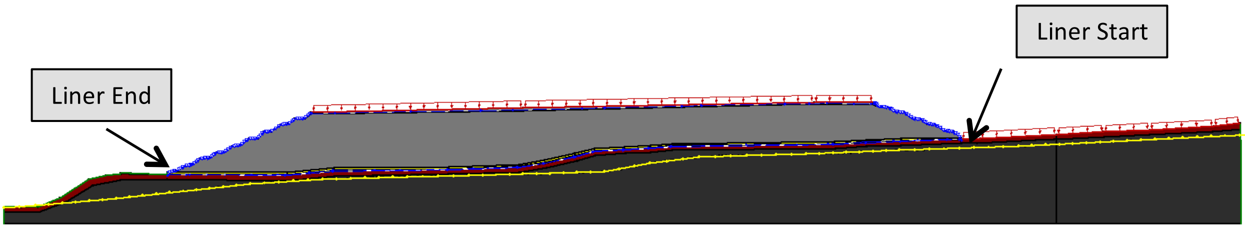


Figure 2 Site Layout

The surface area of the North CCR ≈ 351,500 m^2 and was used to calculate the total vertical flux through the bottom of the pile. A vertical section is shown below where the light brown pattern above the surface represents applied net precipitation and the blue area on the sides of the pile represents seepage faces. The thin black line is used to represent the geomembrane liner. The thick red line is native soil below the refuse pile and the yellow line is the water table surface that was obtained from the groundwater model developed by ERM. The water table surface was adjusted to be below existing ground surface to account for differences in resolution between design drawings and the groundwater model.

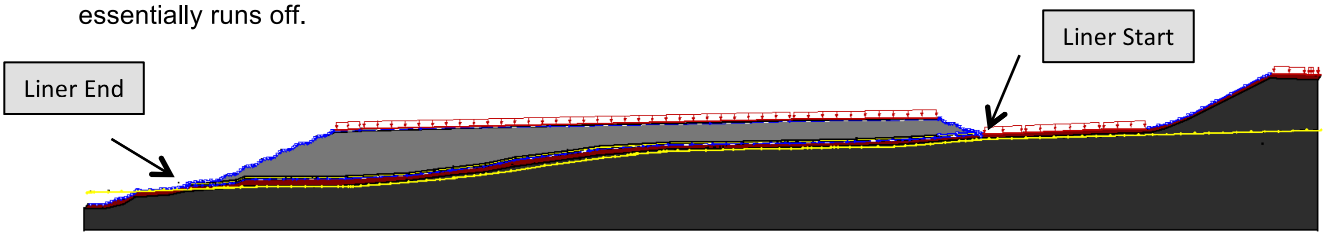
The SEEP/w solution was set to ignore ponding depth so that any ponded, applied net precipitation essentially runs off.



North CCR

The surface area of the South CCR ≈ 348,700 m^2 and was used to calculate the total vertical flux through the bottom of the pile. A vertical section is shown below where the light brown pattern above the surface represents applied net precipitation and the blue area on the sides of the pile represents seepage faces. The thin black line is used to represent the geomembrane liner. The thick red line is native soil below the refuse pile and the yellow line is the water table surface that was obtained from the groundwater model developed by ERM. The water table surface was adjusted to be below existing ground surface to account for differences in resolution between design drawings and the groundwater model.

The SEEP/w solution was set to ignore ponding depth so that any ponded, applied net precipitation essentially runs off.



South CCR

Precipitation Data

The annual net precipitation for an average year was expected to be 190 mm and 57 mm for 1-in-100 dry year. For a 1-in-100 wet year, the net precipitation was assumed to be 530 mm (oral com: Ali Nagihibi at ERM). These net precipitation values were estimated by subtracting evapotranspiration from total precipitation at the site were used as a top flux boundary to the north and south CCRs.

Based on the surface area of the north CCR and net average recharge, the annual volume of water available for recharge is ≈ 66,690 m^3. For the south CCR, the annual volume of water available for recharge is 66,250 m^3.

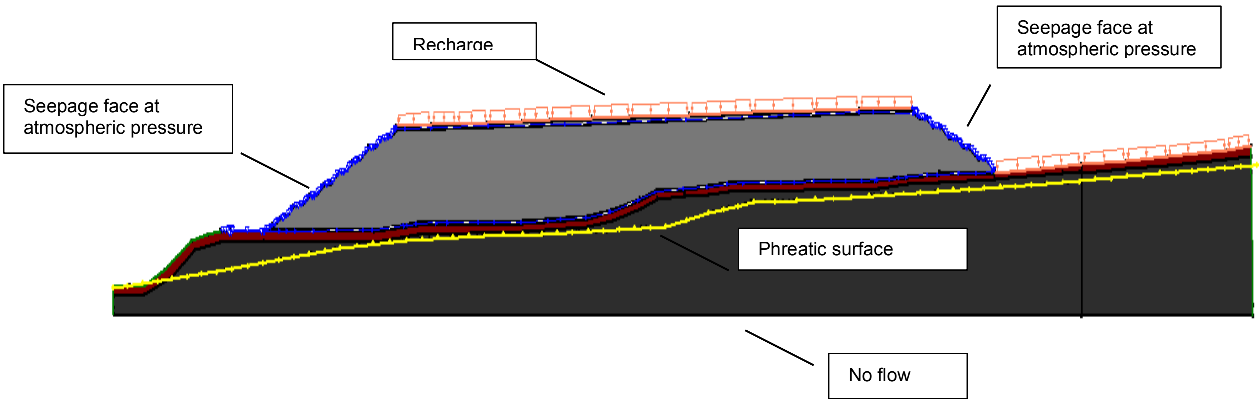
Hydraulic Properties

The hydraulic conductivity (K_{sat}) values of surface and subsurface material comprising the north and south CCR piles used in the model are presented below in **Table 1**. With the exception of the coal reject material, these values were obtained from published literature or were assumed based on professional judgement. The composition of the coal refuse was assumed to be a mixture of 70% coarse grained and 30% fine grained material. The K value of the coal reject material was determined in a laboratory by measuring the permeability under confined pressure conditions. These conditions would tend to reduce the connected void spaces and permeability of the sample and as such suggest that the K value may be underestimated compared to testing under normal atmospheric pressure. The K values of the geologic material that were used in the model are in **Table 1** below and range from 5.00E-10 to 4.05E-05 m/s. The K value for the sand in french drain was assumed to be 8.25E-05, which is within the range for a clean sand (Freeze and Cherry, 1978).

Table 1
Hydraulic Properties According to Material Type

Color	Description	Sat. K (m/s)	Source	Unsaturated Curve Estimation Method
	Coal Reject (70%/30%)	4.40E-07	Confined test, lowest pressure	Data point fitting Function
	Bedrock	8.90E-08	Estimated	Data point fitting Function
	Soil (loamy fine sand)	4.05E-05	Fetter, p. 180	van Genutchen
	Top soil cap (silty loam)	7.20E-07	Fetter, p. 180	van Genutchen
	Clay cap (Clay)	5.00E-10	Fetter, p. 180	van Genutchen
	Sand Drain	8.25E-05	Estimated	van Genutchen
	Liner	1.00E-14	Giroud, 1989	

Boundary Conditions
A schematic showing the boundary conditions presented below. The top of the CCR piles is a recharge boundary with a flux rate equal to the net precipitation at the site.



The sides are seepage faces at atmospheric pressure. The groundwater table represents a hydraulic boundary and the true phreatic surface at the bottom of the pile at atmospheric pressure. The bottom of the model is a no-flow boundary and represents native geologic material.

Model Scenarios

The modeling scenarios include the following simulations of recharge flux through the top of the north and south CCR piles:

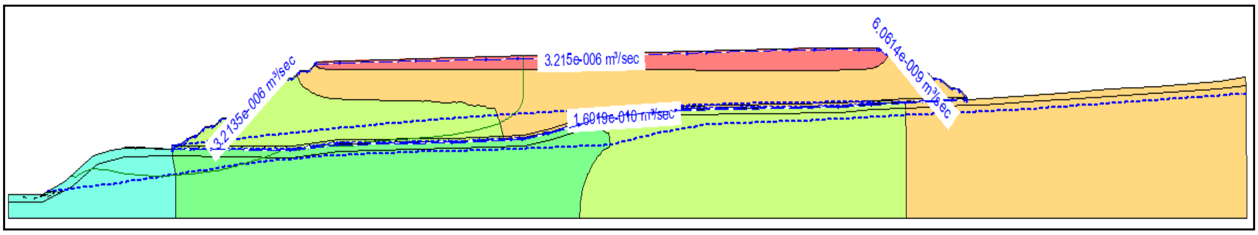
- North CCR pile with steady state simulations for average, dry, and wet years with a geo-membrane liner below refuse pile and a 2-meter french drain above liner
- South CCR pile with steady state simulations for average, dry, and wet years with a geo-membrane liner and a 2-meter french drain above liner
- North CCR pile Closure Plan simulation with steady state simulation for average precipitation with geo-membrane liner below refuse pile, a 2-meter french drain above liner, and cap with 0.30 cm of soil underlain by 0.30 cm of clay.
- South CCR pile Closure Plan simulation with steady state simulation for average precipitation with no liner below refuse pile, tile drain below water table, and cap with 0.30 cm of soil underlain by 0.30 cm of clay.

Steady State Simulations

North CCR

Figure 3 depicts the north CCR pile and shows the location of the geomembrane liner (thick black line) and the recharge flux values at the top, discharge fluxes at the sides, and a 2-meter thick french drain placed on top of the liner. Due to the scale of the drawing the 2-meter thick drain is not visible on the figure.

Figure 3
North CCR Pile



The top blue dashed line on Figure 3 represents the perched water table that results from the accumulation of vertical leakage on top the geo membrane liner. The bottom blue line represents the water table surface and boundary condition, which was obtained from ERM's numerical groundwater model.

Unit flux values shown in the **Table 2** are the flux for a length of section 1 x 1 meter and the total flux is the unit flux multiplied by the section length (532 m). Runoff is not modeled directly in this approach. An estimate of annual average side discharge to surface collection system as a percentage of infiltration was calculated to be 100% of annual infiltration for all seasons. The geomembrane liner is assumed to have a 2 to 5% leakage rate, which means that potential leakage through the bottom liner into the underlying groundwater system may vary from 6.42E-08 to 1.60E-07 m^3/s.

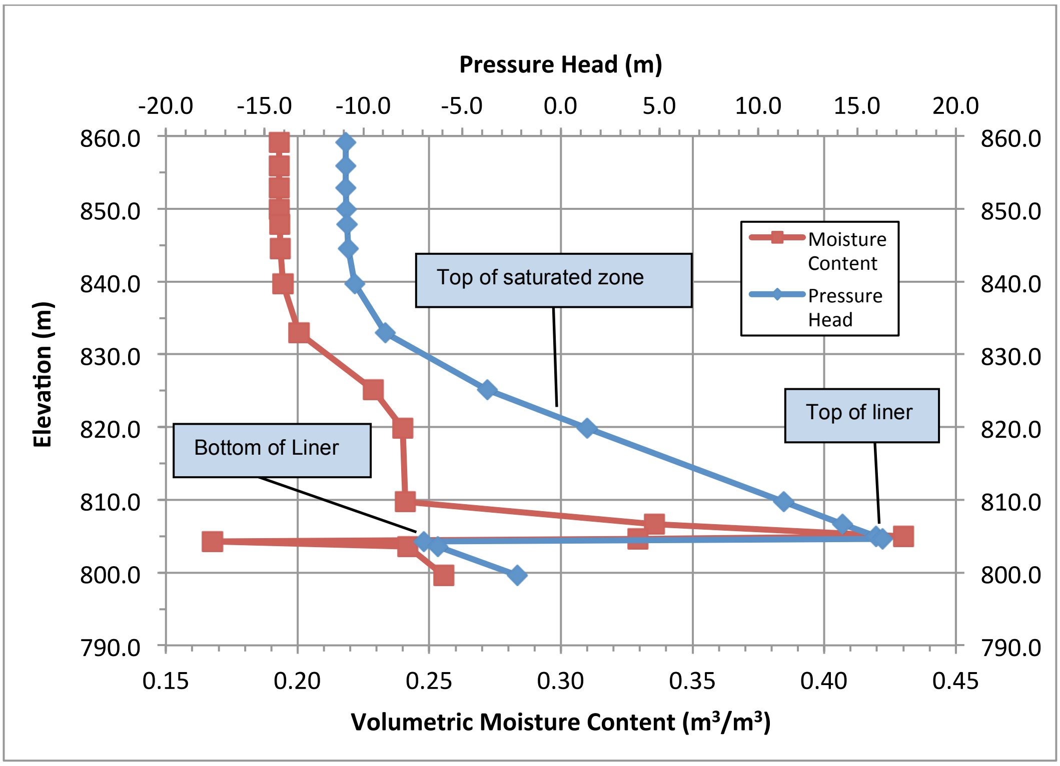
Table 2
Model Results

	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)
	average		dry		wet	
Bottom flux* (m/s)	3.01E-13	1.60E-10	8.08E-13	4.30E-10	4.44E-14	2.63E-11
Infiltration (m/s)	6.03E-09	3.21E-06	1.69E-08	8.97E-06	1.82E-09	9.67E-07
Percentage of Infiltration leaving pile for collection	100%	100%	100%	100%	100%	100%

Section Length = 532 m
Width of CCR = 420 m

Figure 4 shows a moisture content and pressure head profile for a typical vertical section in the North CCR. Note that the moisture content remains constant when the perched water table is encountered and remains constant until the French drain is reached where due to the higher porosity of the drain material the moisture content increases. The moisture content decreases sharply at the bottom of the liner .

Figure 4
North CCR Moisture Content and Pressure Head



North Pile

Using the modeling results and physical and hydraulic characteristics of the north CCR pile presented in **Table 3,** the residence time and travel time of vertical leakage through the pile were estimated. The residence time calculation (V/Q) is the time it takes for the pore volume of the pile to drain at the prevailing leakage rate based on the model results. The average residence time was calculated to be 67.7 years.

Table 3
Residence Time Estimate

Residence Time Estimate				
X-Sectional Area of CCR (m^2)	27,429	1,129	total	28,558
Volume - (assume 1 m width) (m^3)	28,558			
Assumed porosity (n)	0.24			
Pore Volume **V** (m3)	6,854			
Infiltration Flux (m^3/s for 1 m of width)	3.21E-06			
Left Side Discharge Flux (m^3/s for 1 m of width)	3.21E-06			
Average Flux - **Q** (m^3/s for 1 m of width)	3.21E-06			
Residence Time (V/Q) (yr)	67.7			

The travel time is the time it takes for a molecule of water to travel along a pathline vertically downward through the pile and then along the french drain and exit on the downgradient side (left side on Figure 3) of the pile. **Table 4** shows a range of travel times from the fastest (2.6 years conservative) to the slowest (6.7 years) was estimated using a flow path vertically downward (points 1-2) through the pile and then from a points furthest away from and closest to the discharge point (2-3) on the down gradient side of the pile.

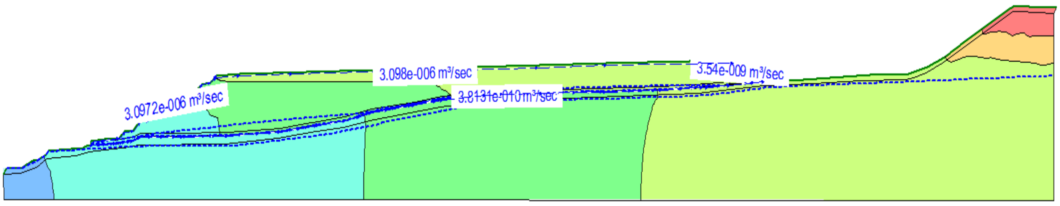
Table 4
Pathline Travel Time

Pathline Estimate	Slowest	Conservative
Assumed K sat. CCR (m/s)	4.40E-07	4.40E-07
Assumed K sat. Drain (m/s)	2.00E-05	2.00E-05
Assumed effective porosity CCR (ne)	0.24	0.24
Assumed effective porosity Drain (ne)	0.43	0.43
Pathline travel time 1 to 2 (yr)	1.5	1.8
Pathline travel time 2 to 3 (yr)	5.2	0.8
Total Pathline travel time (1 to 3) (yr)	6.7	2.6

South CCR

Figure 5 depicts the sourth CCR pile and shows the location of the flux values at the top and dark blue line to demark the bottom of the pile. Seepage from the sides of the pile is also shown as a blue line with associated flux values. The yellow line represents the water table surface and boundary condition, which was obtained from ERM's numerical groundwater model.

Figure 5
South CCR Pile



Unit flux values shown in the **Table 5** are the flux for a length of section 1 x 1 meter and the total flux is the unit flux multiplied by the section length (516 m). Runoff is not modeled directly in this approach. Side discharge to the surface collection system, **as shown on Figure 5,** as a percentage of infiltration was calculated to be 100% of annual infiltration for all seasons. The geomembrane liner is assumed to have a 2 to 5% leakage rate, which means that potential leakage through the bottom liner into the underlying groundwater system may vary from 6.2E-08 to 1.55E-07 m^3/s.

Table 5
Model Results

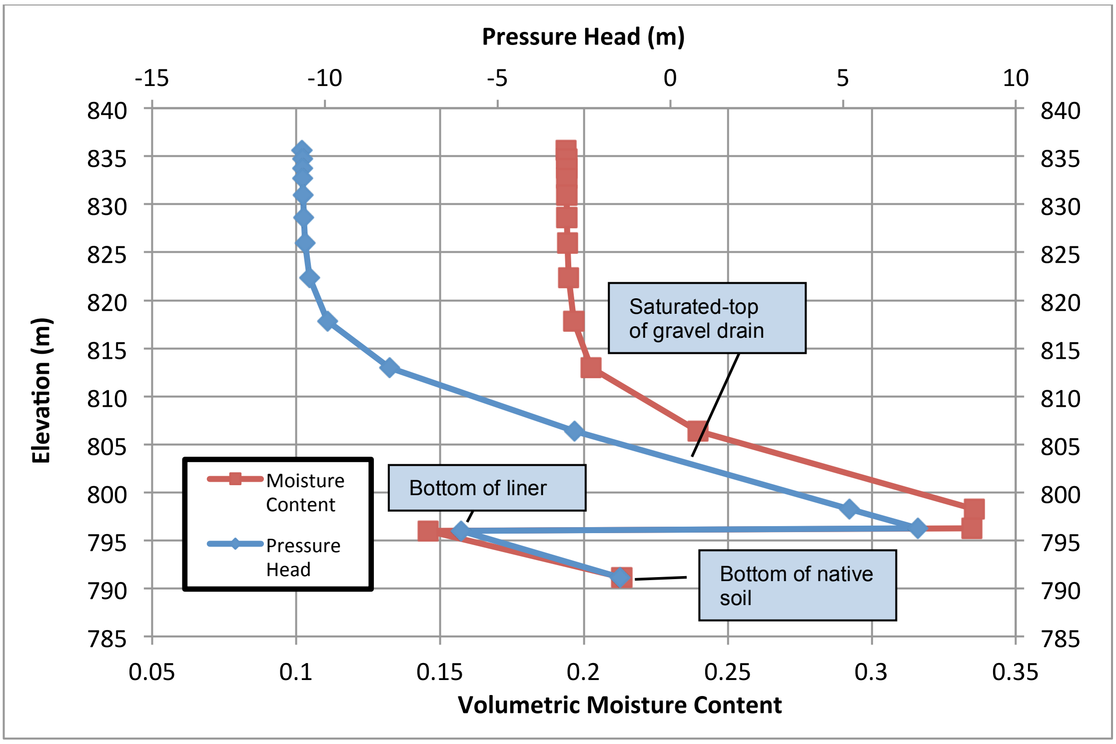
	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)	Unit flux per section of CCR Season	Total flux thru CCR (m3/s)
	average		wet		dry	Total flux thru CCR
Bottom flux (m3/s)	7.42E-13	3.83E-10	5.79E-13	2.99E-10	8.20E-13	4.23E-10
Infiltration (m3/s)	6.00E-09	3.10E-06	1.68E-08	8.65E-06	1.81E-09	9.31E-07
Percentage of Infiltration leaving pile for collection	100%	100%	100%	100%	100%	100%

Section Length = 516 m
Width of CCR = 520 m

Figure 6 shows a moisture content and pressure head profile for a typical vertical section in the North CCR. Note that the moisture content and pressure head remain fairly constant through the CCR material. Below the CCR material is the liner, where the moisture content sharply decreases.

Higher moisture content values are noted in the clayey till due to higher porosity values associated with clay and increased moisture closer to the water table surface.

Figure 6
South CCR Moisture Content and Pressure Head



Using the modeling results and physical and hydraulic characteristics of the north CCR pile presented in **Table 3,** the residence time and travel time of vertical leakage through the pile were estimated. The residence time calculation (V/Q) is the time it takes for the pore volume of the pile to drain at the prevailing leakage rate based on the model results. The average residence time was calculated to be 38.2 years.

Table 6
Residence Time

Residence Time Estimate				
X-Sectional Area of CCR (m^2)	14,857	723	total	15,580
Volume (assume 1 m width) (m^3)	15,580			
Assumed porosity (n)	0.24			
Pore Volume **V** (m3)	3,739			
Infiltration Flux (m^3/s for 1 m of width)	3.10E-06			
Left Side Discharge Flux (m^3/s for 1 m of width)	2.07E-08			
Average Flux **Q** (m^3/s for 1 m of width)	3.10E-06			
Residence Time (V/Q) (yr)	38.2			

For the South CCR, the travel time is the time it takes for a molecule of water to travel along a pathline vertically downward through the pile then along the french drain and exit on the downgradient side (left side on Figure 5) of the pile. A range of travel times from the fastest (2.6 years conservative) to the slowest (6.7 years) is shown in **Table 6** and was estimated using a flow paths vertically downward from points on the thickest and thinnest parts of the CCR. These flow paths represent the longest and shortest flow paths to the groundwater surface below the pile.

Table 7
Pathline Travel Time

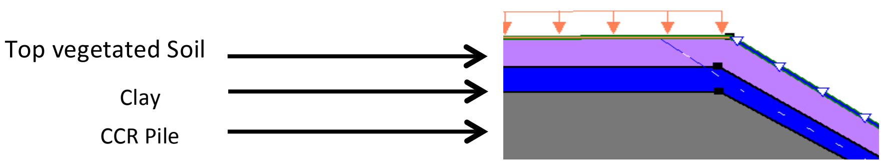
Pathline Estimate	Slowest	Conservative
Assumed K sat. CCR (m/s)	4.40E-07	4.40E-07
Assumed K sat. Drain (m/s)	2.00E-05	2.00E-05
Assumed effective porosity CCR (ne)	0.24	0.24
Assumed effective porosity Drain (ne)	0.43	0.43
Pathline travel time 1 to 2 (yr)	1.5	1.8
Pathline travel time 2 to 3 (yr)	5.2	0.8
Total Pathline travel time (1 to 3) (yr)	6.7	2.6

Closure Plan Simulations

North CCR

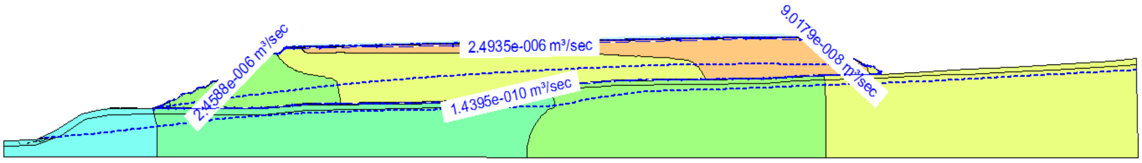
Closure Plan model simulations were conducted on the North and South CCR piles. Figure 7 depicts the North CCR pile and shows, that a similar model layout for the steady state simulations was used except that a cap was modeled and the recharge flux has been reduced. A liner was installed all the way across the CCR pile and a french drain was placed 2 meters above of the liner. The french drain has a hydraulic conductivity = 2E-05 m/s.

The cap is illustrated in the schematic below and consisted of a soil layer (0.30 m) at the top of the cap layer with a Ksat = 7.2E-07 m/s. A clay layer (0.30 m) with a saturated hydraulic conductivity = 5E-10 m/s was put below the soil layer and on top of the coal pile.



Recharge was reduced to 5.0E-09 m/s, which is slightly lower than 6.02E-09 m/s in the original steady state runs without a cap to account for additional evapotranspiration due to the vegetated top soil layer.

Figure 7
North CCR Closure Plan Simulation



The vertical flux through the cap is 2.49E-06m^3/sec as seen in **Table 8** shows that the cap has reduced infiltration going into the CCR pile. The french drain takes 100% of the vertical flux and drains through the toe of the CCR pile (left flux). By assuming that flux through the liner (1.44E-10 m^3/sec) and the flux towards the right side of the pile (9.0E-08m^3/sec) are negligible, the efficiency of the drain is essentially 100%.

Table 8
Model Results

North CCR pile without Closure Plan			North CCR pile Closure Plan		
Outlet	Flux (m^3/s)	Unit Flux (m^2/s)		Flux (m^3/s)	Unit Flux (m^2/s)
Top	3.21E-06	6.04E-09	Top	2.66E-06	5.0E-09
Left	2.48E-06	4.67E-09	Bottom (below cap)	2.49E-06	4.68E-09
Right	7.26E-07	1.36E-09	Left	2.46E-06	4.62E-09
Bottom (below liner)	1.31E-10	2.47E-13	Right	9.00E-08	1.69E-10
			Bottom	1.44E-10	2.70E-13

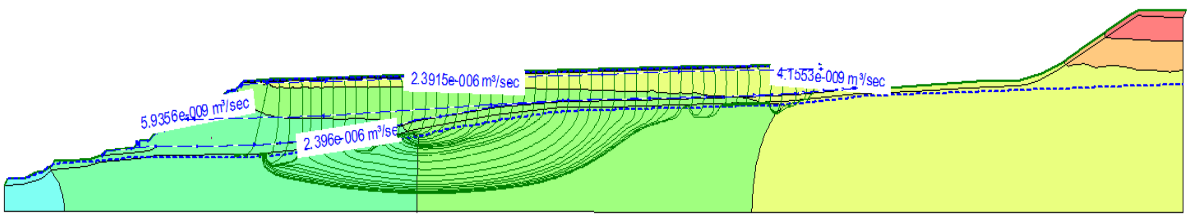
Section Length = 532 m
Width of CCR = 420 m

South CCR

Figure 8 depicts the South CCR pile and shows, that a similar model layout for the steady state simulations was used except that a cap was added to the model and the recharge flux has been reduced. No liner was installed at the bottom of the south CCR pile. Instead, a series of tile drains were put under the native soil layer below CCR pile to capture the leakage from the CCR pile.

A soil layer was put on top of the cap with a Ksat = 7.2E-7 m/s. A clay layer was put below the soil layer and on top of the coal pile with a saturated hydraulic conductivity = 5E-10 m/s.

Recharge was reduced to 5.0E-09 m/s, which is slightly lower than 6.02E-09 m/s, which is original recharge value without cap to account for additional evapotranspiration due to a vegetated top soil layer



The vertical flux through the bottom of the south CCR pile is 2.40E-006 m^3/s, which is less than the flux without the cap. The percentage of the particles that are captured by the tile drain is 100%.

South CCR pile without Closure Plan	South CCR pile Closure Plan	

Outlet	Flux (m^3/s)	Unit Flux (m^2/s)		Flux (m^3/s)	Unit Flux (m^2/s)
Top	3.10E-06	6.01E-09	Top	2.58E-06	5.00E-09
Infiltration	3.10E-06	6.01E-09	Bottom (below cap)	2.40E-06	4.65E-09
			Infiltration	2.40E-06	4.65E-09
Percentage of particle being captured by tile drain	100%		100%		

Conclusions

- North CCR –Discharge from french drain is approximately 100% of infiltration for all seasons. The geomembrane is assumed to have a 2 to 5% leakage rate, which means that potential leakage through the bottom liner into the underlying groundwater system may vary from 6.42E-08 to 1.60E-07 m^3/s.

- The residence time calculation (V/Q) is the time it takes for the pore volume of the pile to drain at the prevailing leakage rate based on the model results. The average residence time was calculated to be 67.7 years.

- The travel time is the time it takes for a molecule of water to travel along a pathline vertically downward through the pile and then along the french drain and exit on the downgradient side of the pile. The fastest (2.6 years conservative) to the slowest (6.7 years) was estimated using a flow path vertically downward through the pile and then from points furthest away from and closest to the discharge point on the down gradient side of the pile.

- South CCR –Discharge from french drain is approximately 100% of infiltration for all seasons. The geomembrane is assumed to have a 2 to 5% leakage rate, which means that potential leakage through the bottom liner into the underlying groundwater system may vary from 6.2E-08 to 1.55E-07 m^3/s.

- The residence time calculation (V/Q) is the time it takes for the pore volume of the pile to drain at the prevailing leakage rate based on the model results. The average residence time was calculated to be 38.2 years.

- The travel time is the time it takes for a molecule of water to travel along a pathline vertically downward through the pile to the groundwater surface. A range of travel times from the fastest (2.6 years conservative) to the slowest (6.7 years) was estimated using a flow paths vertically downward from points on the thickest and thinnest parts of the CCR.

- The Closure Plan simulation for the North CCR showed a reduction of the vertical flux through the cap and the french drain removed 100% of the vertical flux through the pile. Assuming that flux through the liner (1.44E-10 m^3/sec) and the flux towards the right side of the pile (9.0E-08m^3/sec) are negligible, the efficiency of the drain is essentially 100%.

- The Closure Plan simulation for the South CCR showed the vertical flux through the bottom of the south CCR pile is less than the flux without the cap. No liner was installed at the bottom of the south CCR pile. Instead, a series of tile drains were put under the native soil layer below CCR pile to capture the leakage from the CCR pile. The percentage of the particles that were captured by the tile drain is 100%.

Appendix 6 – Surface Runoff Diversion Channel Calculations

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Technical Memorandum

To	**Scott Elfin**
Attention	
Cc	
From	**Joel Sobol**
Project	**HD Mining**
Reference	**Surface Water Modeling for Drainage Ditches for North and South Coarse Coal Refuse (CCR) Piles** **Murray River Coal Project, British Columbia, Canada**
Date	**May 2, 2014**
Page	Page 1 of 7

Introduction

Surface water modeling was conducted on the North and South Coarse Refuse Piles in order to effectively design the capacity of diversion channels around the piles. The modeling was used to determine peak discharge and total volume of runoff from the adjacent watersheds and to evaluate the freeboard for the diversion channels and to determine areas of concern for the channel designs. The analysis consisted of a two-step process; 1) to develope a runoff model HEC-HMS of the watersheds in order to determine the peak discharge and total volume of runoff, and 2) to develop a channel analysis model (HEC-RAS) to determine the water depth in the channel, freeboard, and areas of supercritical flow.

Approach

The watershed areas surrounding the piles were subdivided into smaller watersheds that would contribute surface water flow to the proposed diversion channels. The ditches were located around the North and South piles to divert runoff away from the piles and are depicted in schematic drawing in **Figure 1**. Five (5) watershed areas for each pile that contribute flow into the diversion channels were delineated from a topographic map of the area presented on **Figure 2**. **Table 1** summarizes the characteristics of these watershed areas.

Figure 1
Schematic of Diversion Ditches

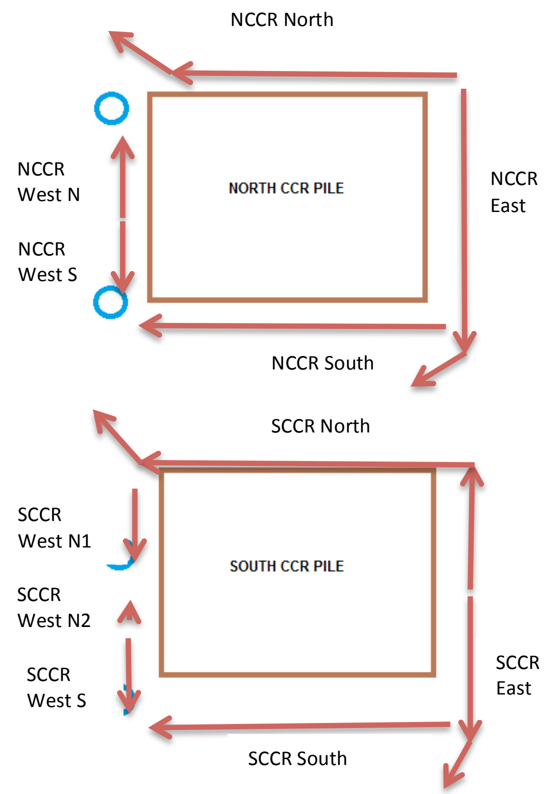

Figure 2
Watershed Areas

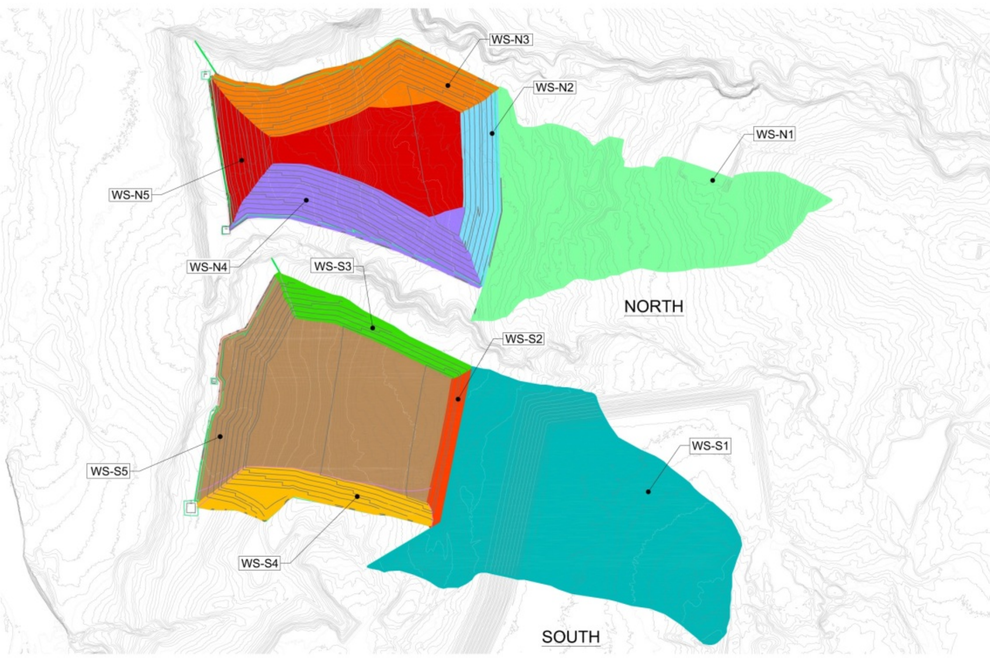

Table 1

Watershed	Ditch Description	Watershed Description	Area (m²)
WS-N1	North CCR East	Upstream watershed	288,226.52
WS-N2	North CCR East	East side of north CCR Pile	45,421.12
WS-N3	North CCR North	north side of north CCR pile	93,956.97
WS-N4	North CCR South	south side of north CCR pile	89,131.60
WS-N5	North CCR West	west side and top of north CCR pile	142,053.54
WS-S1	South CCR East and North	Upstream watershed	397,021.12
WS-S2	South CCR East and North	East side of south CCR Pile	18,028.04
WS-S3	South CCR North	north side of south CCR pile	33,073.56
WS-S4	South CCR South	south side of south CCR pile	49,796.80
WS-S5	South CCR West	west side and top of south CCR pile	269,228.72

Runoff Modeling

Watershed areas, presented in **Table 1** were delineated for each of the CCR pile diversion channels. The longest flow path for each watershed was determined and a flow path profile was generated to calculate incremental distances and slopes along the flow path. These data were used to calculate the time of concentration and lag time for each watershed by using the velocity method (NRCS, 2010). The velocity method assumes that the time of concentration is the sum of the travel times for segments along the hydraulically most distant path. The segments along the flow path generally consist of three types: sheet flow, shallow concentrated flow, and open channel flow. The methodology is described in detail in Part 630 National Engineering Handbook (NRCS, 2010). The time of concentration is defined as the time required to for runoff to travel from the hydraulically most distant point in the watershed to the outlet. On the hydrograph, it is the time from the end of excess rainfall to a point on the falling limb of the unit hydrograph. The lag time (L) is generally defined by: $L = 0.6T_c$ where T_c = time of concentration.

The HEC-HMS model parameters assumed:

- Loss Method: SCS Curve Number (72 used for all watersheds)
- Transform method: SCS Unit Hydrograph
- Precipitation Type: SCS Type 1A storm, used the 24-hour duration, 25-year recurrence interval precipitation event of 3.6 mm/hr (86.4 mm)

Input to HEC-HMS included lag time, and total volume of precipitation event (86.4mm) each watershed area contributing runoff to diversion channels around the North and South CCR piles. The results of the runoff modeling are presented in **Table 2**.

Table 2

Watershed Name	Watershed Description	Area (m^2)	Maximum Discharge (m^3/s)	Total Volume (m^3)
WS_N1	Upstream watershed	288,227	0.2	7700
WS_N2	East side of north CCR Pile	45,421	0.1	1200
WS_N3	North side of north CCR pile	93,957	0.1	2500
WS_N4	South side of north CCR pile	89,132	0.1	2400
WS_N5	West side and top of north CCR pile	142,054	0.1	3800
WS_S1	Upstream watershed	397,021	0.3	10700
WS_S2	East side of south CCR Pile	18,028	0.05	500
WS_S3	North side of south CCR pile	33,074	0.01	900
WS_S4	South side of south CCR pile	49,797	0.1	1300
WS_S5	West side and top of south CCR pile	269,229	0.2	7200

The maximum discharge values estimated in HEC-HMS were input into HEC-RAS to determine the water depth, freeboard, and areas of supercritical flow in each channel.

Table 3 below shows the results of the HEC-RAS modeling and indicates that areas of supercritical flow occur in all the channels since Froude numbers are greater than 1. The high Froude numbers indicate that flow velocities are high due to the steep slope that exists along certain reaches of the channel.

Table 3

CCR Pile	Channel	Channel Depth (m)	Maximum Water Depth (m)	Freeboard (m)	Froude Numbers >1
North	North	1	0.2	0.8	Yes
	East	1	0.37	0.63	Yes
	Northwestern	1	0.14	0.86	Yes
	Southwestern	1	0.14	0.86	Yes
	South	1	0.21	0.79	Yes
South	North	1	0.35	0.65	Yes
	East	1	0.25	0.75	Yes
	Northwestern	1	0.2	0.8	Yes
	Southwestern	1	0.24	0.76	Yes
	South	1	0.19	0.81	Yes

Ditch Design

The current ditch design contains segments with highly variable slopes that range from 1% to >50%. The median slope is approximately 3%. These relatively steep slopes control the calculated capacity and the calculated efficiency of the diversion channel and based on these preliminary calculations further drainage design may need to be completed. Based on the results of this modeling, more realistic design criteria may be desired where the slopes are limited to 1%, in which case the calculated capacity may go down along with the calculated efficiency.

Initial channel design was analyzed in Flowmaster® V8i using a trapezoidal shape with 1%, 3%, and 50% slopes and 1:1 side slopes and bottom width of 1m. The results of these flow analyses are presented in **Tables 4-6 and** show that the channel geometry can sufficiently handle runoff flow from adjacent watersheds.

Table 4

Trapezoidal Channel - 1% Slope

Project Description		
Friction Method	Manning Formula	
Solve For	Discharge	
Input Data		
Roughness Coefficient	0.069	
Channel Slope	0.01000	m/m
Normal Depth	0.70	m
Left Side Slope	1.00	m/m (H:V)
Right Side Slope	1.00	m/m (H:V)
Bottom Width	1.00	m
Results		
Discharge	0.94	m³/s
Flow Area	1.19	m²
Wetted Perimeter	2.98	m
Hydraulic Radius	0.40	m
Top Width	2.40	m
Critical Depth	0.39	m
Critical Slope	0.08669	m/m
Velocity	0.79	m/s
Velocity Head	0.03	m
Specific Energy	0.73	m
Froude Number	0.36	
Flow Type	Subcritical	

Table 5

Trapezoidal Channel - Median Slope 3%

Project Description		
Friction Method	Manning Formula	
Solve For	Discharge	
Input Data		
Roughness Coefficient	0.069	
Channel Slope	0.03000	m/m
Normal Depth	0.70	m
Left Side Slope	1.00	m/m (H:V)
Right Side Slope	1.00	m/m (H:V)
Bottom Width	1.00	m
Results		
Discharge	1.62	m³/s
Flow Area	1.19	m²
Wetted Perimeter	2.98	m
Hydraulic Radius	0.40	m
Top Width	2.40	m
Critical Depth	0.54	m
Critical Slope	0.08230	m/m
Velocity	1.36	m/s
Velocity Head	0.09	m
Specific Energy	0.79	m
Froude Number	0.62	
Flow Type	Subcritical	

In addition, flow is subcritical with design slopes of 1% and 3% but in the 50% slope range flow is clearly in the supercritical range with Froude numbers greater than 1.

Table 6
Trapezoidal Channel – Median Slope 50%

Input Data			
Roughness Coefficient		0.069	
Channel Slope		0.50000	m/m
Normal Depth		0.70	m
Left Side Slope		1.00	m/m (H:V)
Right Side Slope		1.00	m/m (H:V)
Bottom Width		1.00	m
Results			
Discharge		6.61	m³/s
Flow Area		1.19	m²
Wetted Perimeter		2.98	m
Hydraulic Radius		0.40	m
Top Width		2.40	m
Critical Depth		1.14	m
Critical Slope		0.07218	m/m
Velocity		5.56	m/s
Velocity Head		1.57	m
Specific Energy		2.27	m
Froude Number		2.52	
Flow Type	Supercritical		

Ditch Efficiency

Ditch efficiency was calculated using a method for seepage losses from irrigation canals ("Seepage Losses from Irrigation Canals in southern Alberta", IQBAL et al, (2002)). This method is dependent on the water depth and the maximum discharge. As a result, these results may change if attenuation or dissipation structures are employed in the ditch design and if the design slopes are changed to be less steep. The calculation of ditch efficiency estimates ranges from 87.8% to 99.6%.

Conclusions

- Diversion ditches were located around the North and South piles to divert runoff away from the piles and five (5) watershed areas that contribute flow into the diversion channels for each pile were delineated from a topographic map of the area.

- The longest flow path for each watershed was determined and a flow path profile was generated to calculate incremental distances and slopes along the flow path. These data were used to calculate the time of concentration and lag time for each watershed by using the velocity method (NRCS, 2010).

- HEC-HMS model parameters assumed the Loss Method with SCS Curve Number (72 used for all watersheds), Transform method for SCS Unit Hydrograph, and precipitation Type is SCS Type 1A storm, using the 24-hour duration, 25-year recurrence interval precipitation event of 3.6 mm/hr (86.4 mm).

- Peak discharge in the channels ranged from 0.05 to 0.3 m^3/s with slopes that range from 1% to 50%. The median slope of the ditches is 3% but segments of the ditches have higher slopes >8% where flow is in the supercritical ranges with Froude numbers greater than 1.

- Segments of ditches with slopes with Froude numbers >1 are subjected to turbulent and high velocity flows with potential for significant erosion.

- Ditch efficiency was calculated using a method for seepage losses from irrigation canals ("Seepage Losses from Irrigation Canals in southern Alberta", IQBAL et al, (2002)) and was estimated to range from 87.8% to 99.6%.

References

NRCS, 2010, Part 630 Hydrology National Engineering Handbook, Natural Resources Conservation Service

U.S. Army Corp of Engineers, 2010, HEC-HMS Hydrologic Engineering Center, Hydrologic Modeling System

U.S. Army Corp of Engineers, 2010, HEC-RAS Hydrologic Engineering Center, River Analysis System

IQBAL et al, 2002, Seepage Losses from Irrigation Canals in southern Alberta

Appendix 7 – Drawings

HD MINING

MURRAY RIVER PROJECT

NORTHERN AND SOUTHERN COAL REJECT PILE DESIGN

CANADA

N° DRAWING	DRAWING TITLE	REVISION ID	ISSUED DATE
GENERAL LAYOUTS			
100102-01-001	COVER	C	30/04/2014
100102-01-002	GENERAL ARRANGEMENTS	C	30/04/2014
100102-01-003	OVERDRAIN AND LINER SYSTEM - NORTHERN CR PILE	C	30/04/2014
100102-01-004	OVERDRAIN AND LINER SYSTEM - NORTHERN CR PILE	C	30/04/2014
100102-01-005	NORTHERN CR PILE - PLAN VIEW	C	30/04/2014
100102-01-006	NORTHERN CR PILE - SECTIONS	C	30/04/2014
100102-01-007	STACKING PLAN NORTHERN CR PILE - YEAR 01	C	30/04/2014
100102-01-008	STACKING PLAN NORTHERN CR PILE - YEAR 02	C	30/04/2014
100102-01-009	STACKING PLAN NORTHERN CR PILE - YEAR 03	C	30/04/2014
100102-01-010	STACKING PLAN NORTHERN CR PILE - YEAR 04	C	30/04/2014
100102-01-011	STACKING PLAN NORTHERN CR PILE - YEAR 05	C	30/04/2014
100102-01-012	STACKING PLAN NORTHERN CR PILE - YEAR 06	C	30/04/2014
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100102-01-016	STACKING PLAN NORTHERN CR PILE - YEAR 10	C	30/04/2014
100102-01-017	STACKING PLAN NORTHERN CR PILE - YEAR 11	C	30/04/2014
100102-01-018	STACKING PLAN NORTHERN CR PILE - YEAR 12	C	30/04/2014
100102-01-019	STACKING PLAN NORTHERN CR PILE - YEAR 13	C	30/04/2014
100102-01-020	STACKING PLAN NORTHERN CR PILE - YEAR 14	C	30/04/2014
100102-01-021	STACKING PLAN NORTHERN CR PILE - YEAR 15	C	30/04/2014
100102-01-022	OVERDRAIN AND LINER SYSTEM - SOUTHERN CR PILE	C	30/04/2014
100102-01-023	SOUTHERN CR PILE - PLAN VIEW	C	30/04/2014
100102-01-024	SOUTHERN CR PILE - SECTIONS	C	30/04/2014
100102-01-025	STACKING PLAN SOUTHERN CR PILE - YEAR 15	C	30/04/2014
100102-01-026	STACKING PLAN SOUTHERN CR PILE - YEAR 16	C	30/04/2014
100102-01-027	STACKING PLAN SOUTHERN CR PILE - YEAR 17	C	30/04/2014
100102-01-028	STACKING PLAN SOUTHERN CR PILE - YEAR 18	C	30/04/2014
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100102-01-030	STACKING PLAN SOUTHERN CR PILE - YEAR 20	C	30/04/2014
100102-01-031	STACKING PLAN SOUTHERN CR PILE - YEAR 21	C	30/04/2014
100102-01-032	STACKING PLAN SOUTHERN CR PILE - YEAR 22	C	30/04/2014
100102-01-033	STACKING PLAN SOUTHERN CR PILE - YEAR 23	C	30/04/2014
100102-01-034	STACKING PLAN SOUTHERN CR PILE - YEAR 24	C	30/04/2014
100102-01-035	STACKING PLAN SOUTHERN CR PILE - YEAR 25	C	30/04/2014
100102-01-036	UNDERDRAIN, OVERDRAIN AND LINER SYSTEM DETAILS	C	30/04/2014

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
COVER

SCALE: INDICATED
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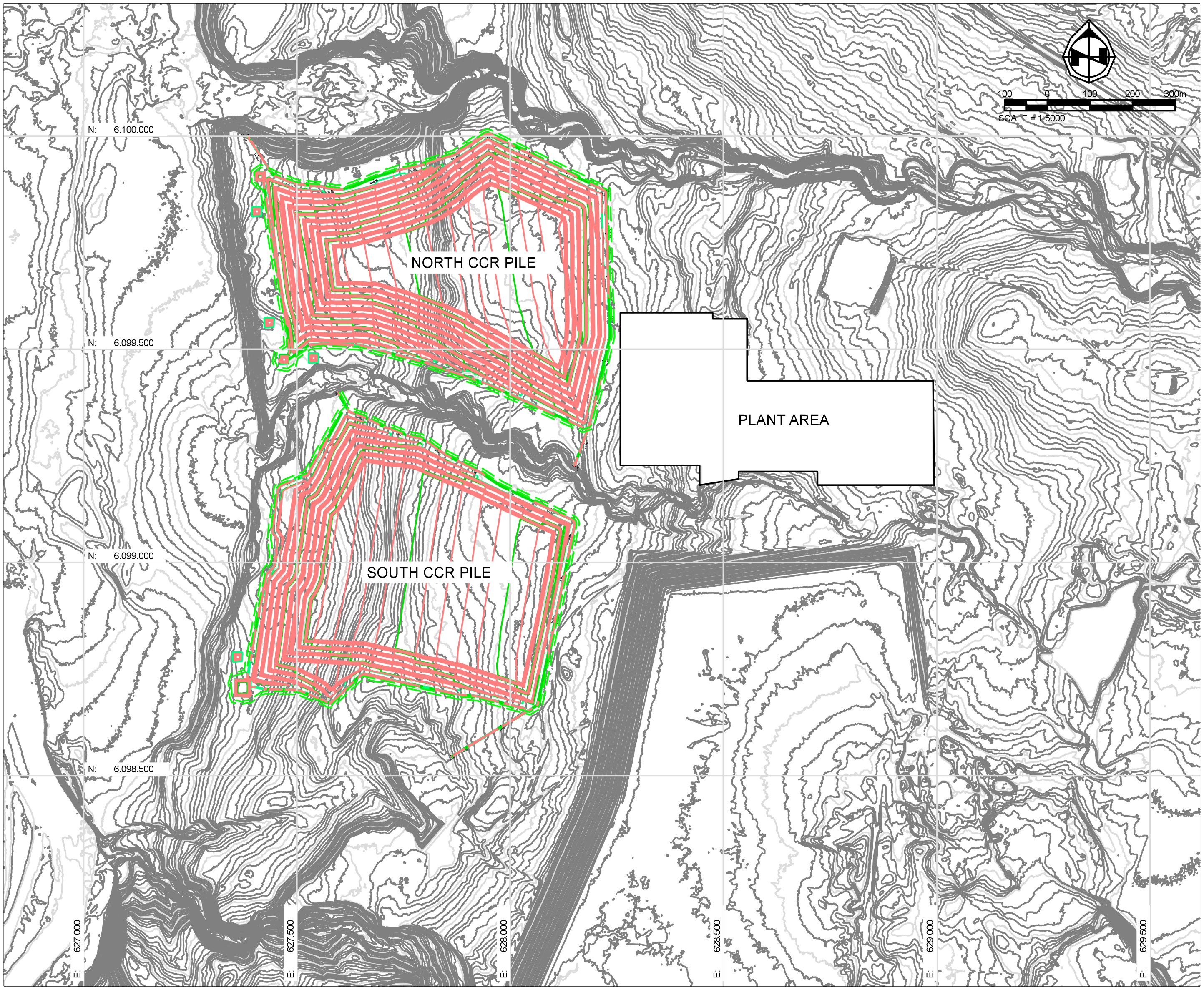

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MAJOR CONTOUR

Note: countours every 1 meters

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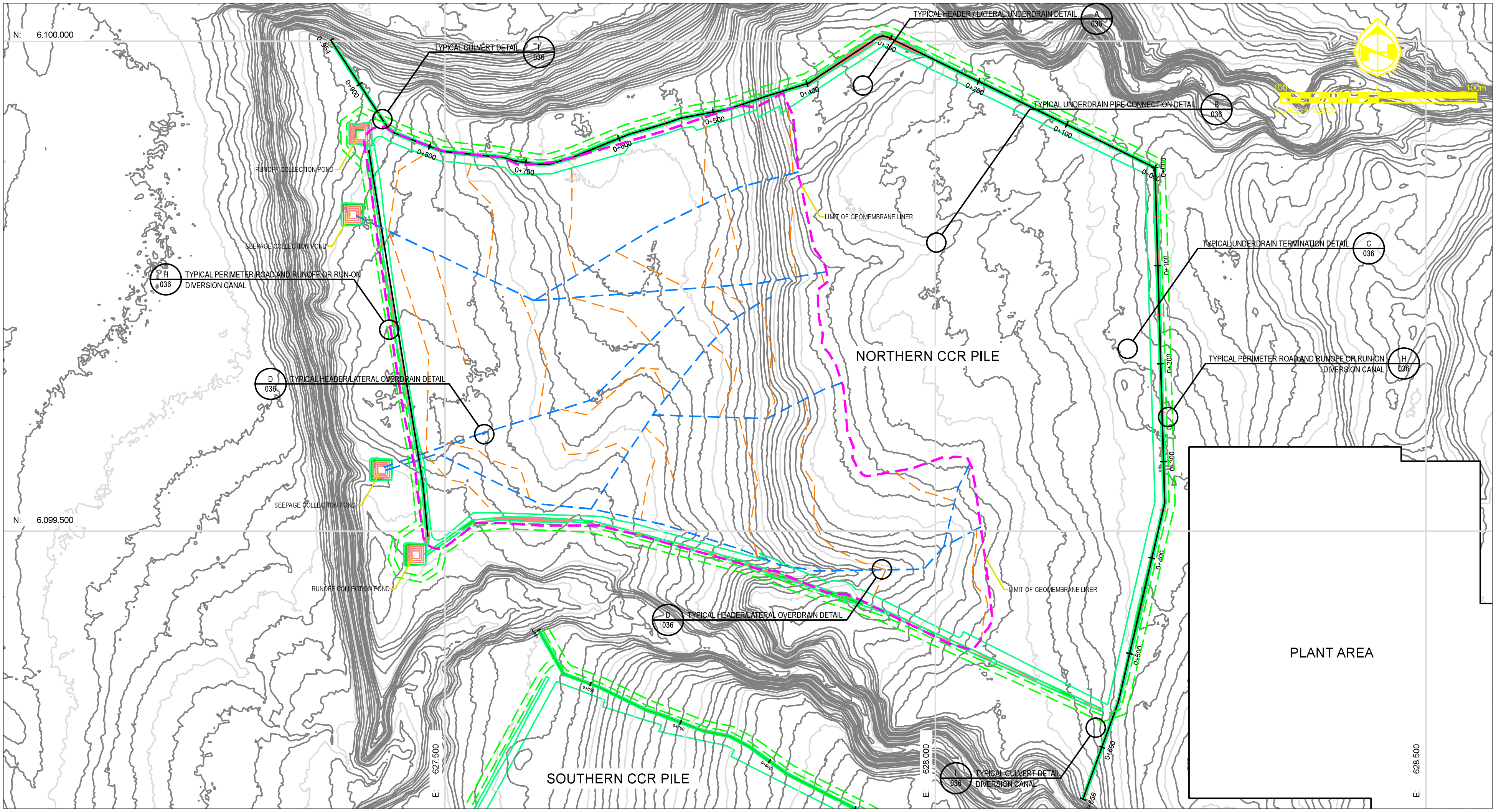

MAJOR CONTOUR

MINOR CONTOUR

300 mm HDPE DW PIPE FOR OVERDRAIN

200 mm HDPE DW PIPE FOR OVERDRAIN

PERIMETER ROAD

LIMIT OF GEOMEMBRANE LINER

Note: countours every 1 meters

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NORTHERN CR PILE
OVERDRAIN SYSTEM PHASE 1 - PLANT VIEW

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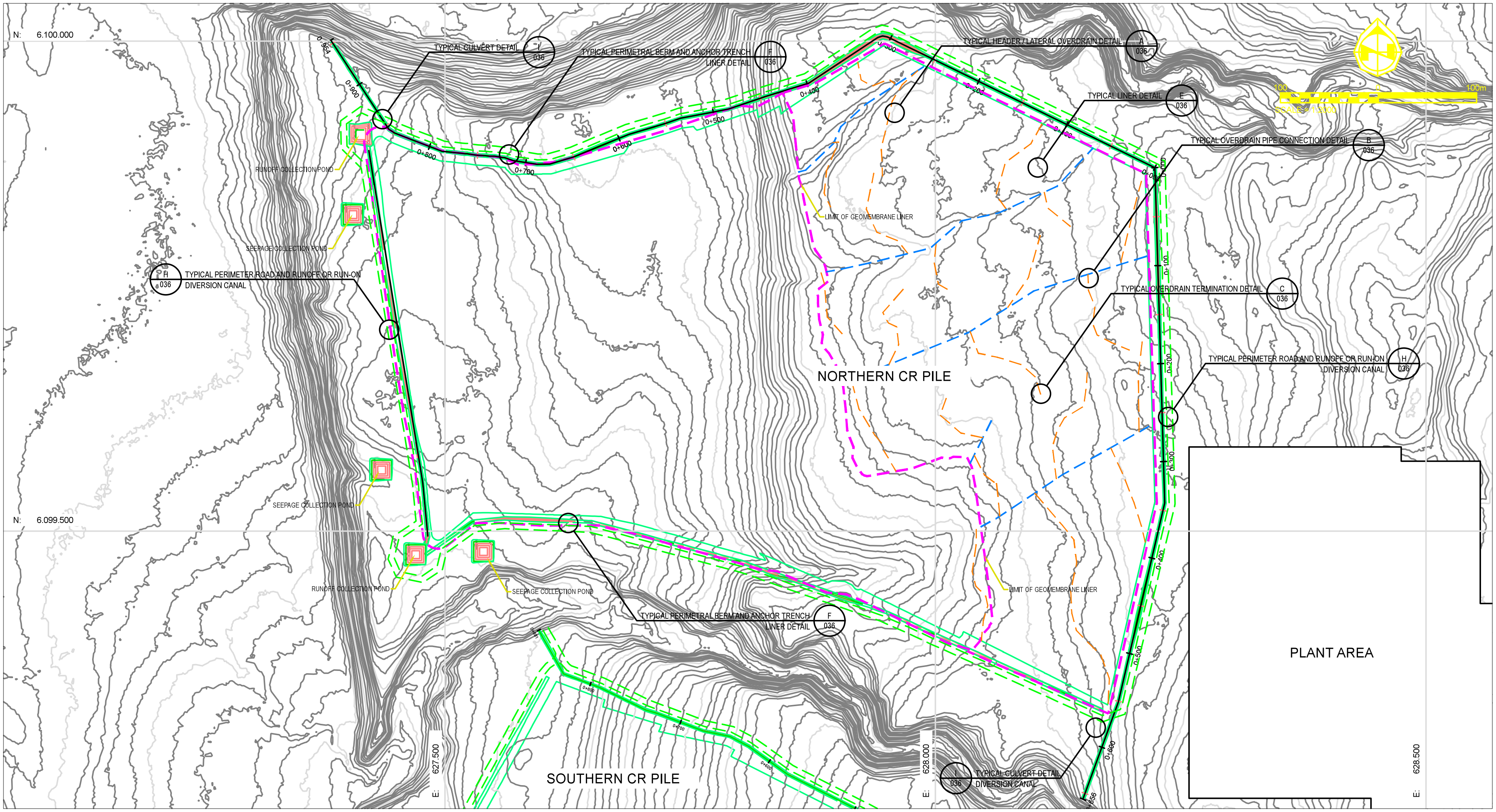

MAJOR CONTOUR

MINOR CONTOUR

300 mm HDPE DW PIPE FOR OVERDRAIN

200 mm HDPE DW PIPE FOR OVERDRAIN

300 mm HDPE NON PERFORATED OVER DRAIN PIPE

PERIMETER ROAD

LIMIT OF GEOMEMBRANE LINER

Note: countours every 1 meters

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TITLE: MURRAY RIVER PROJECT
NORTH CR PILE
OVERDRAIN SYSTEM PHASE 2 - PLANT VIEW

SCALE 1:2000

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ALL DIMENSIONS IN MILLIMETRES

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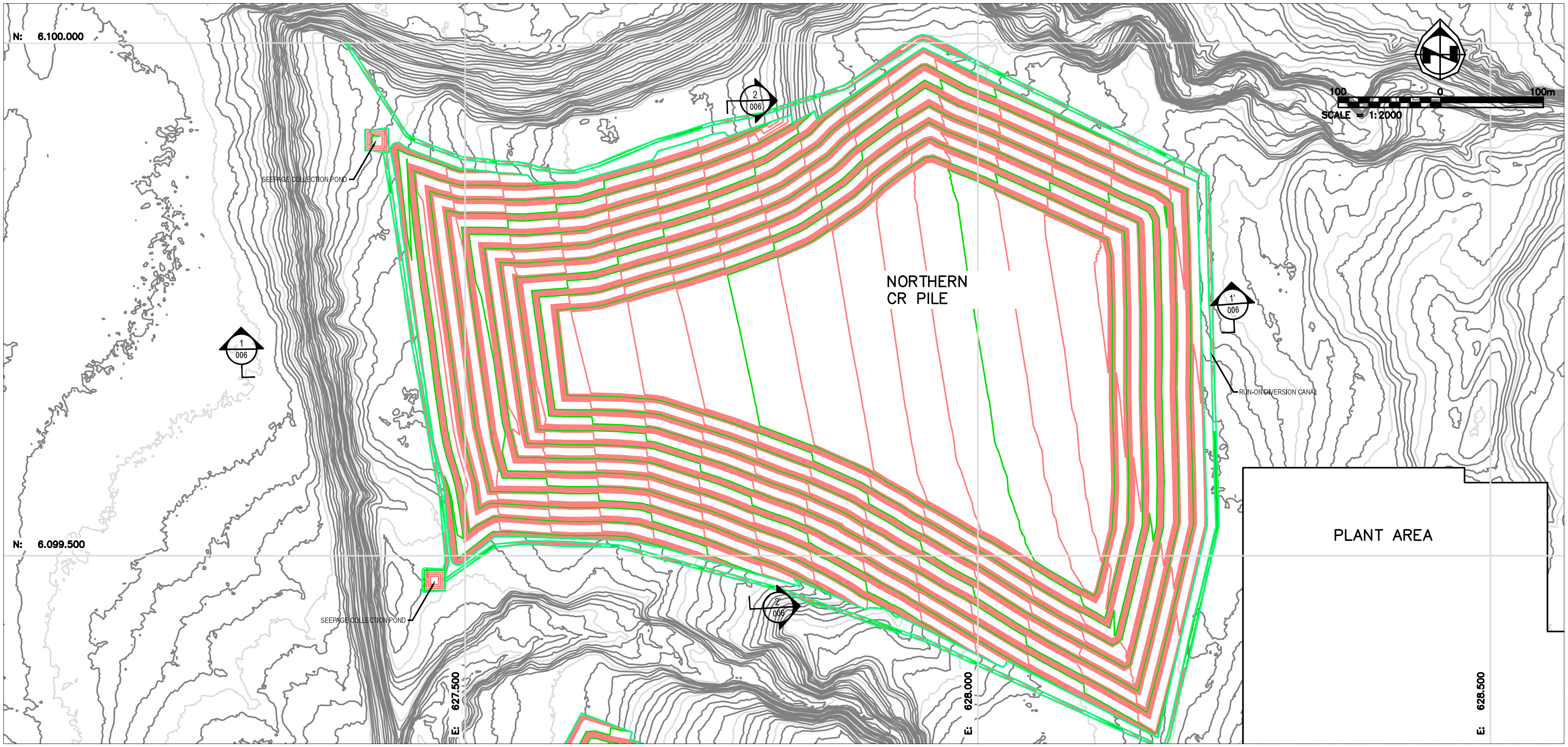

MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

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NORTHERN CR PILE
PLAN VIEW

SCALE 1:2000 | SIZE A1

ALL DIMENSIONS IN MILLIMETRES

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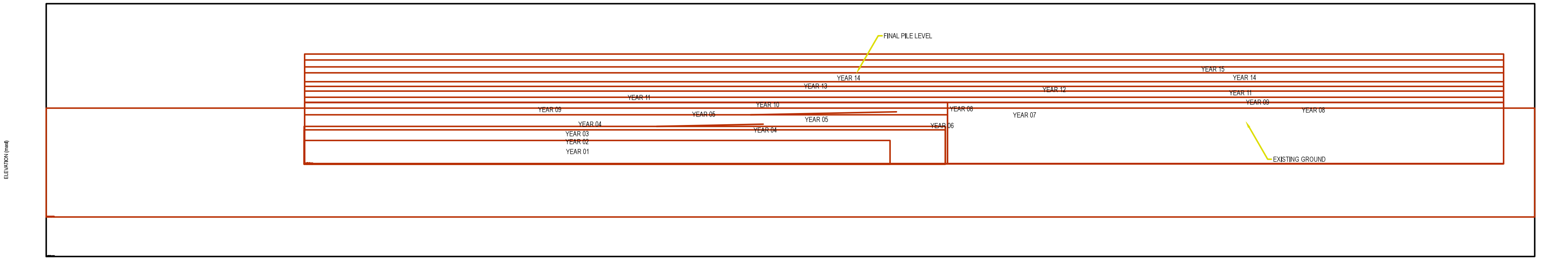

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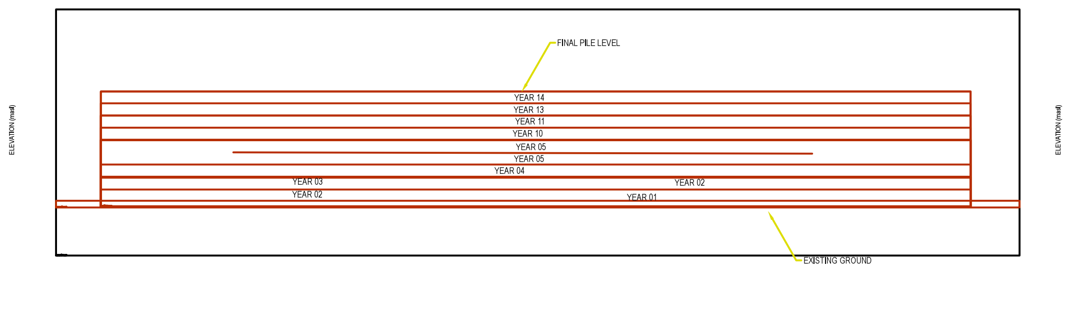

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NORTHERN AND SOUTHERN CCR PILE
NORHTERN CR PILE - SECTIONS

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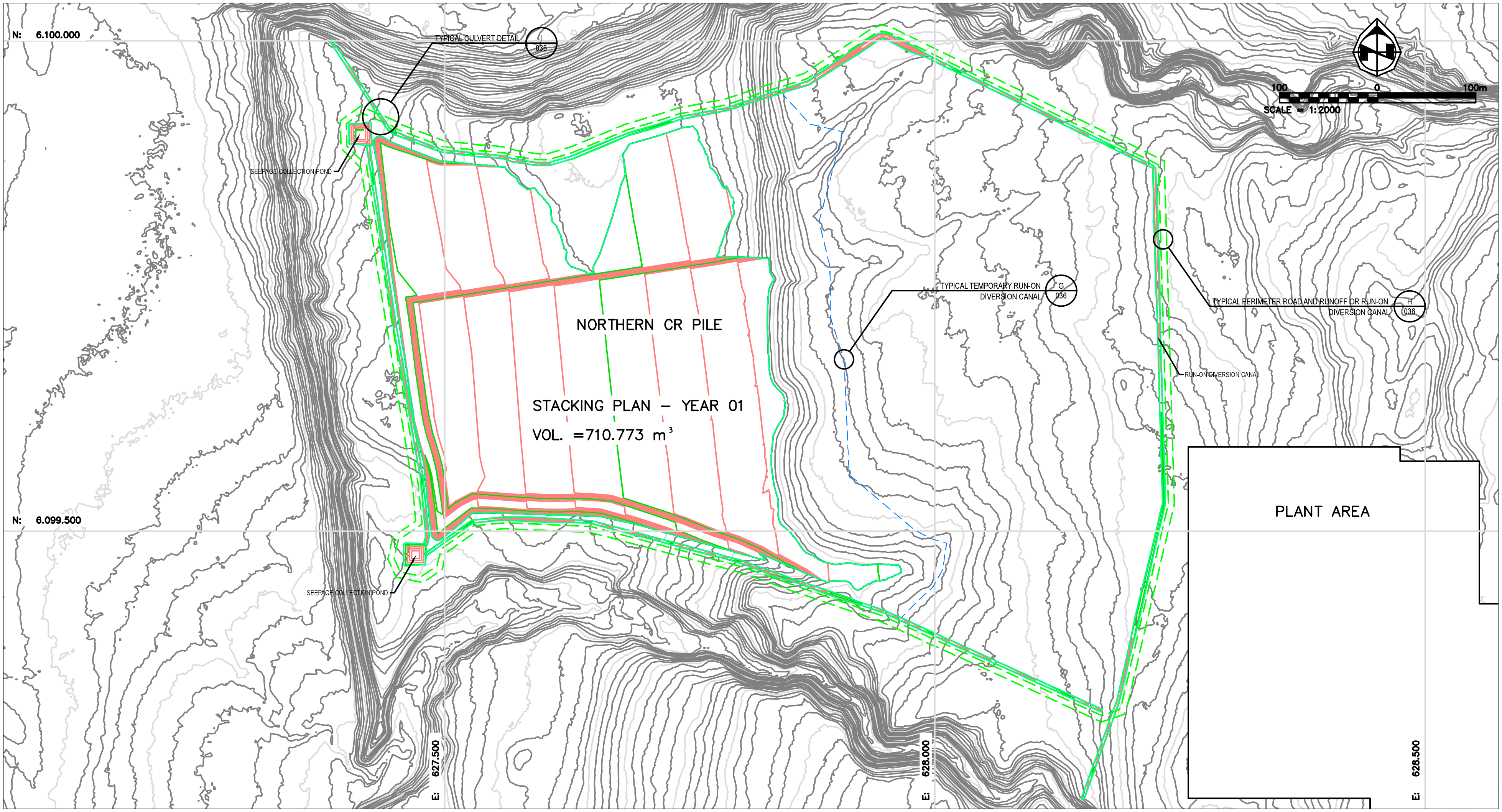

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MINOR CONTOUR

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NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 01

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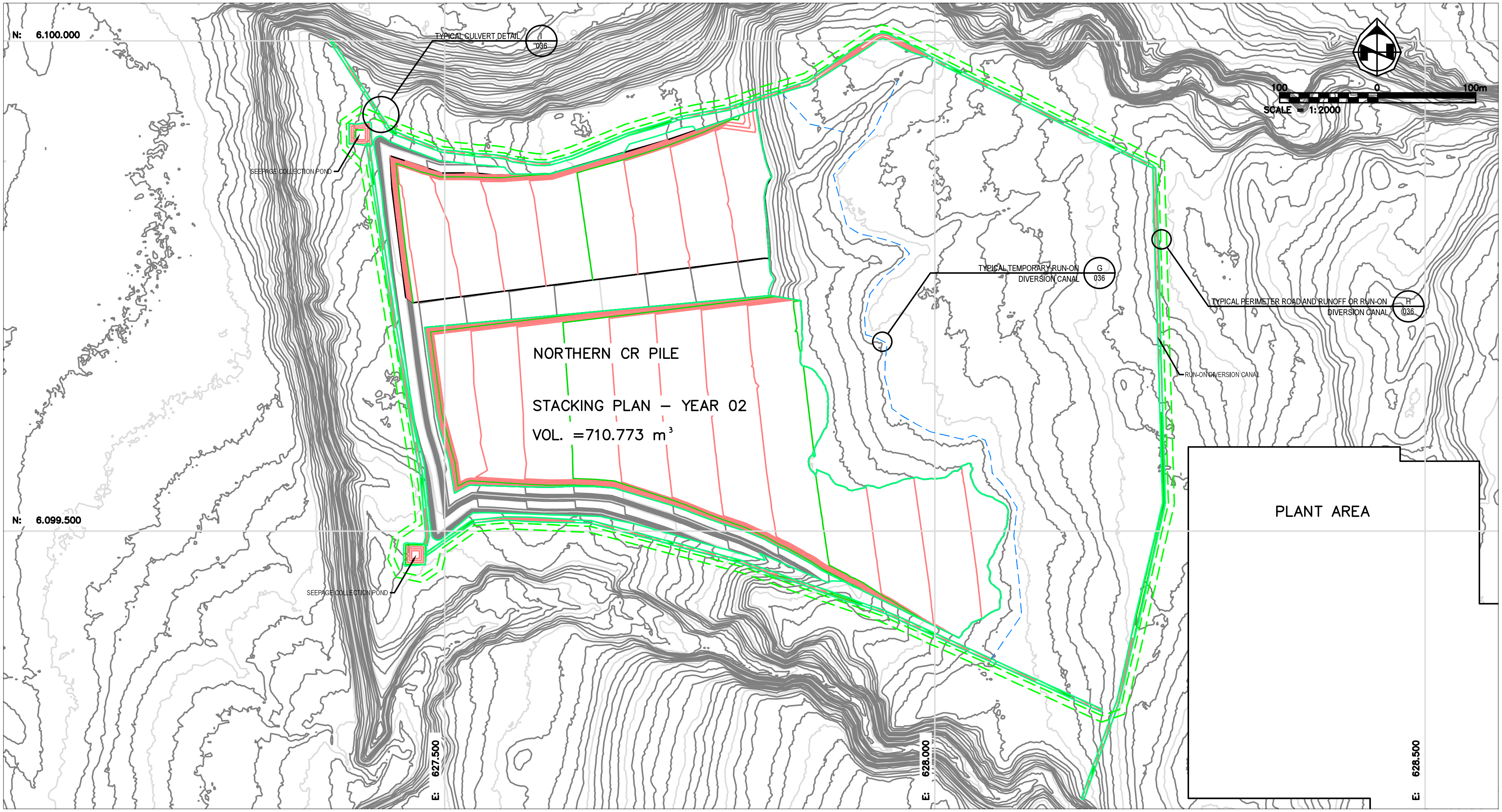

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Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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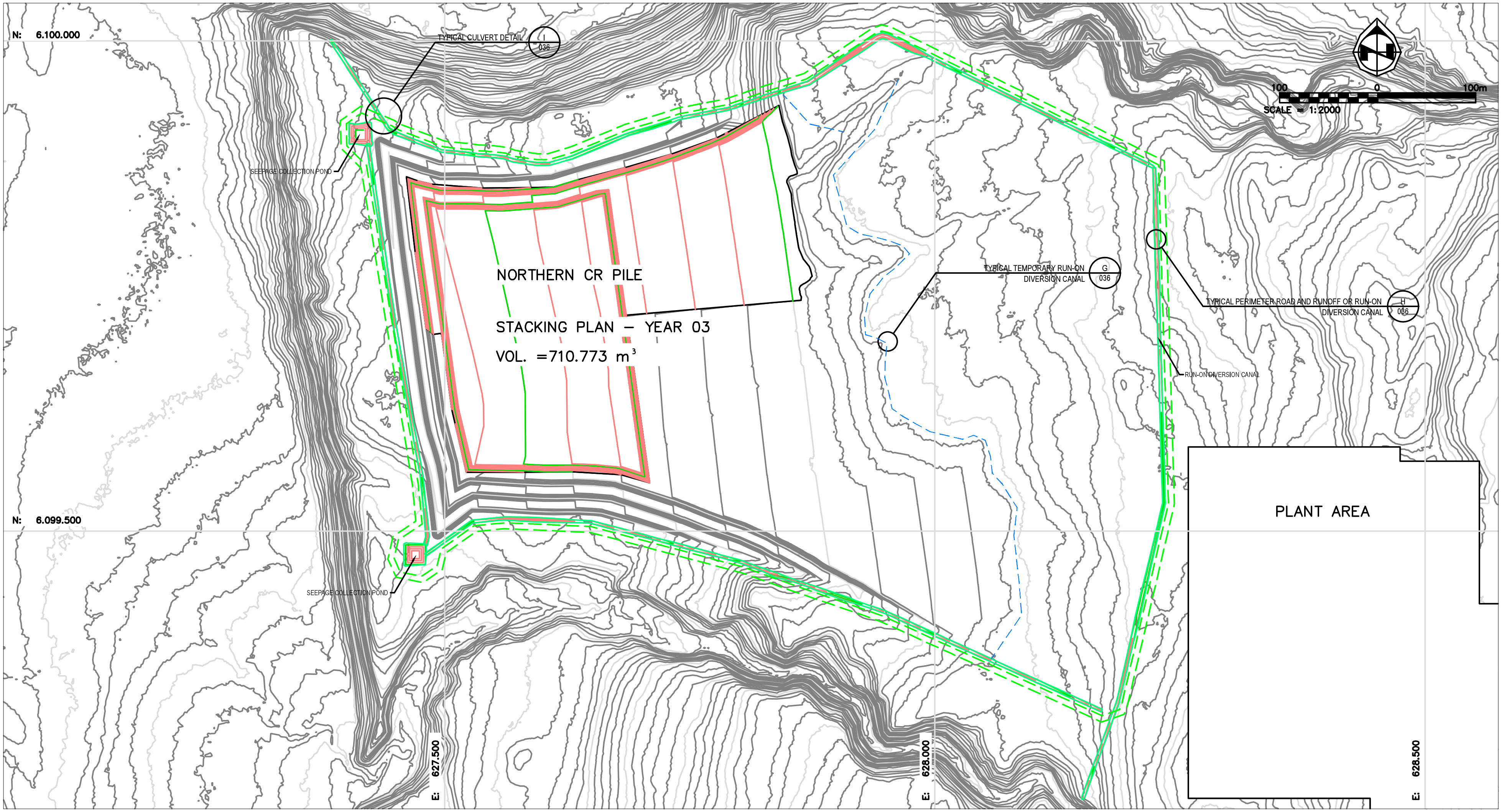
CLIENT HD MINING

TITLE MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 02

SCALE INDICATED
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-008



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 03

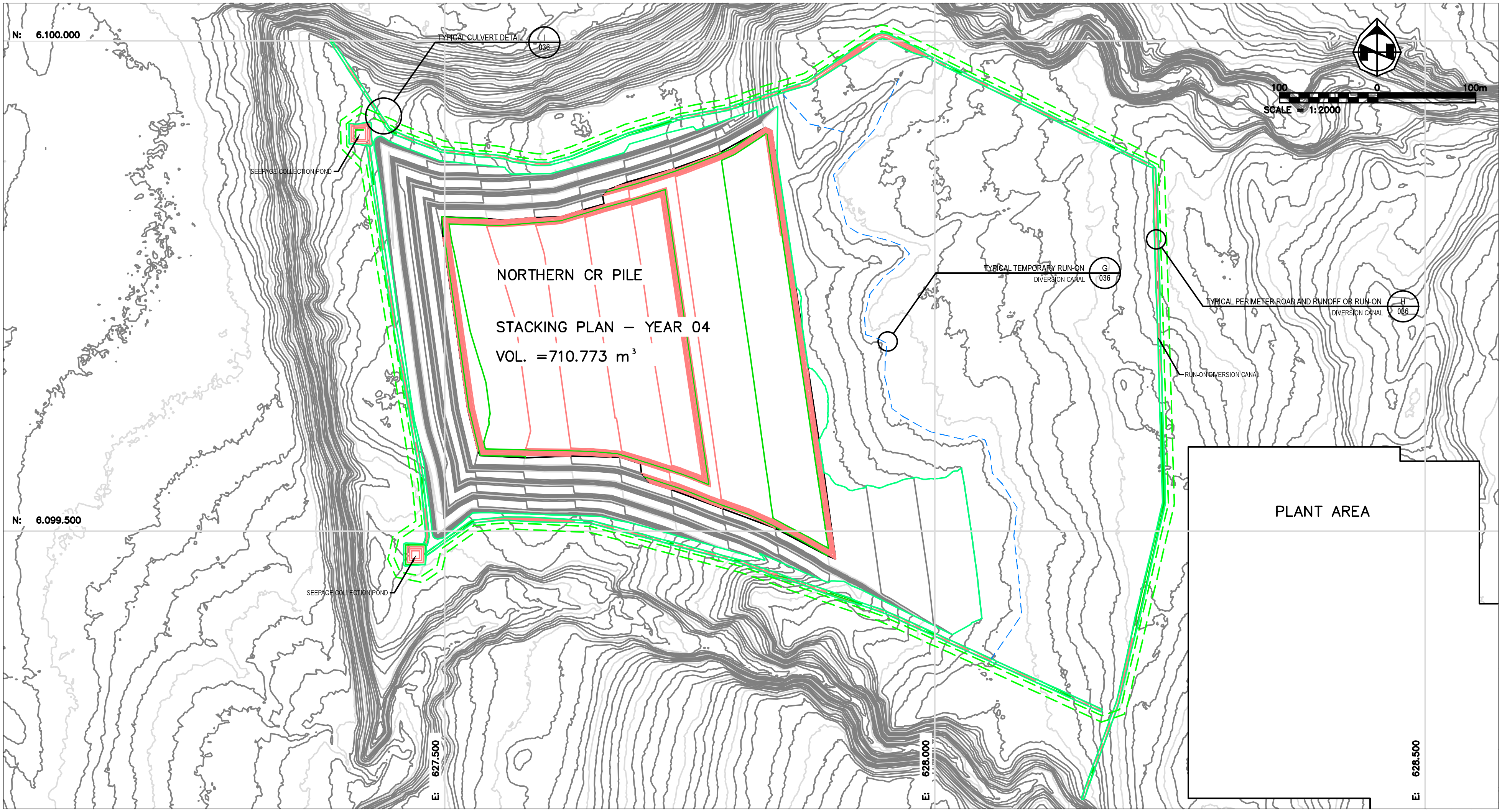
SCALE: INDICATED

SIZE: A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No: 100102-01-009



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 04

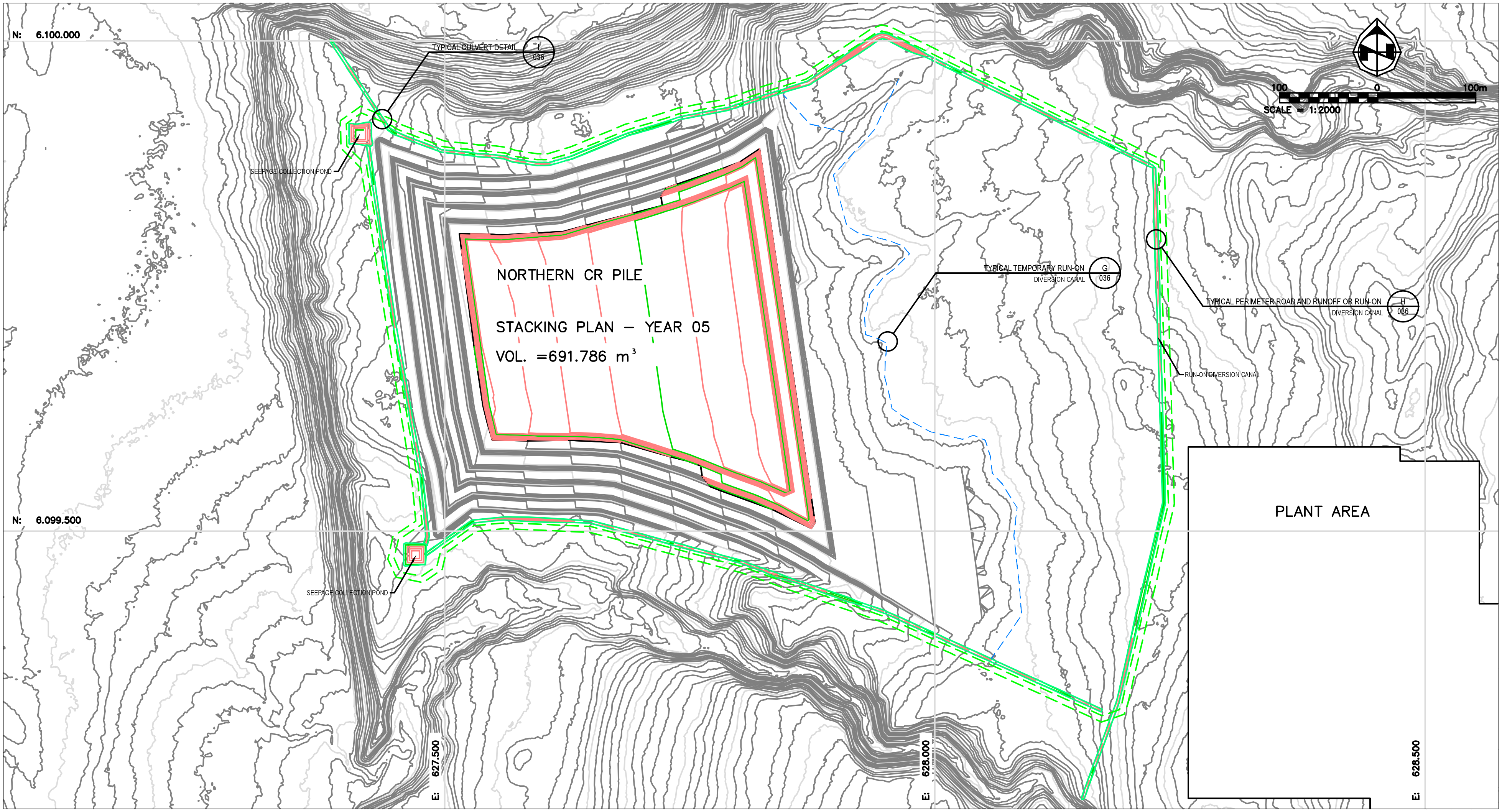
SCALE: INDICATED

SIZE: A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No: 100102-01-010



MAJOR CONTOUR
MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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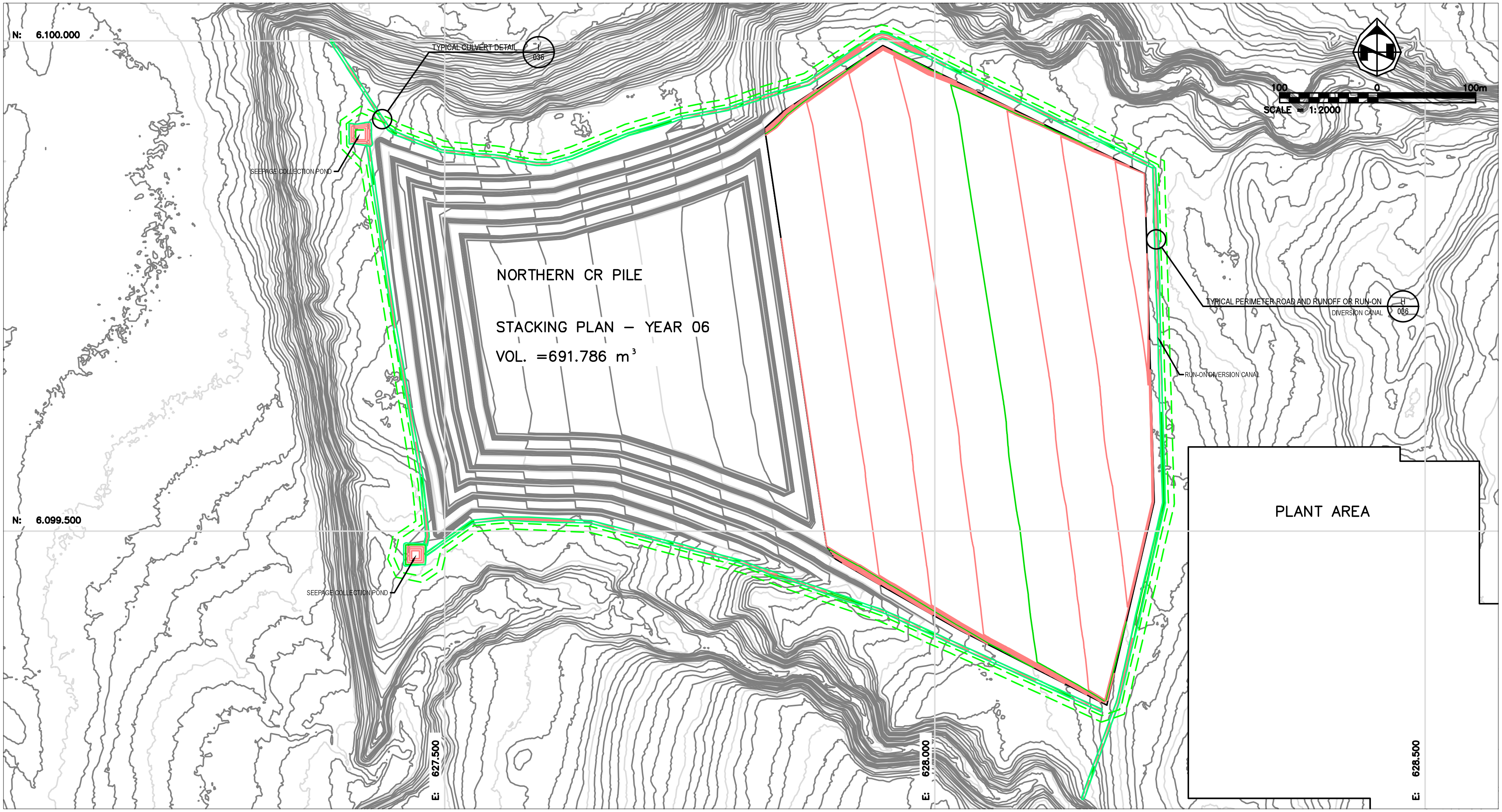
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 05

SCALE INDICATED
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-011



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 06

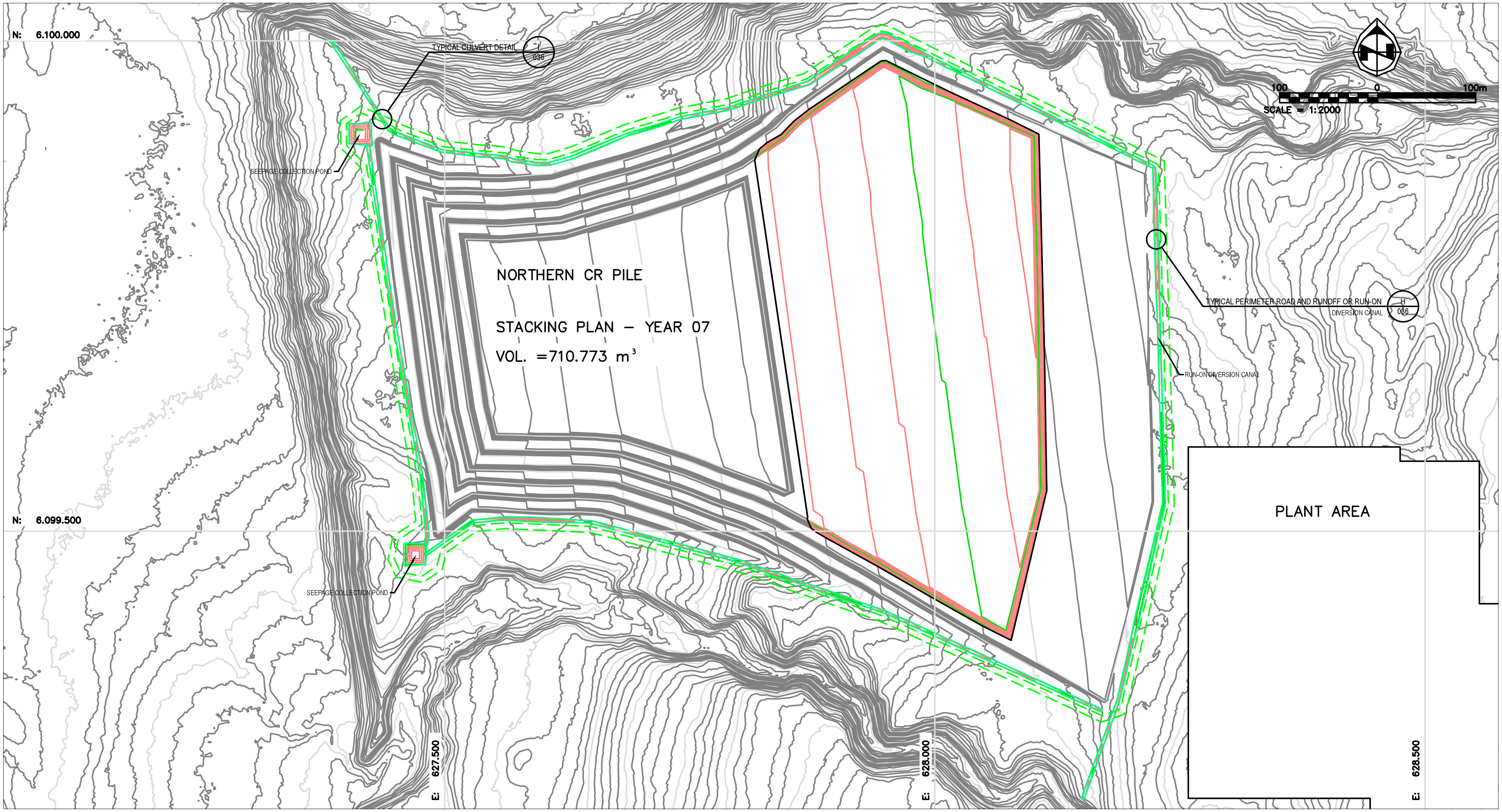
SCALE: INDICATED

SIZE: A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No: 100102-01-012



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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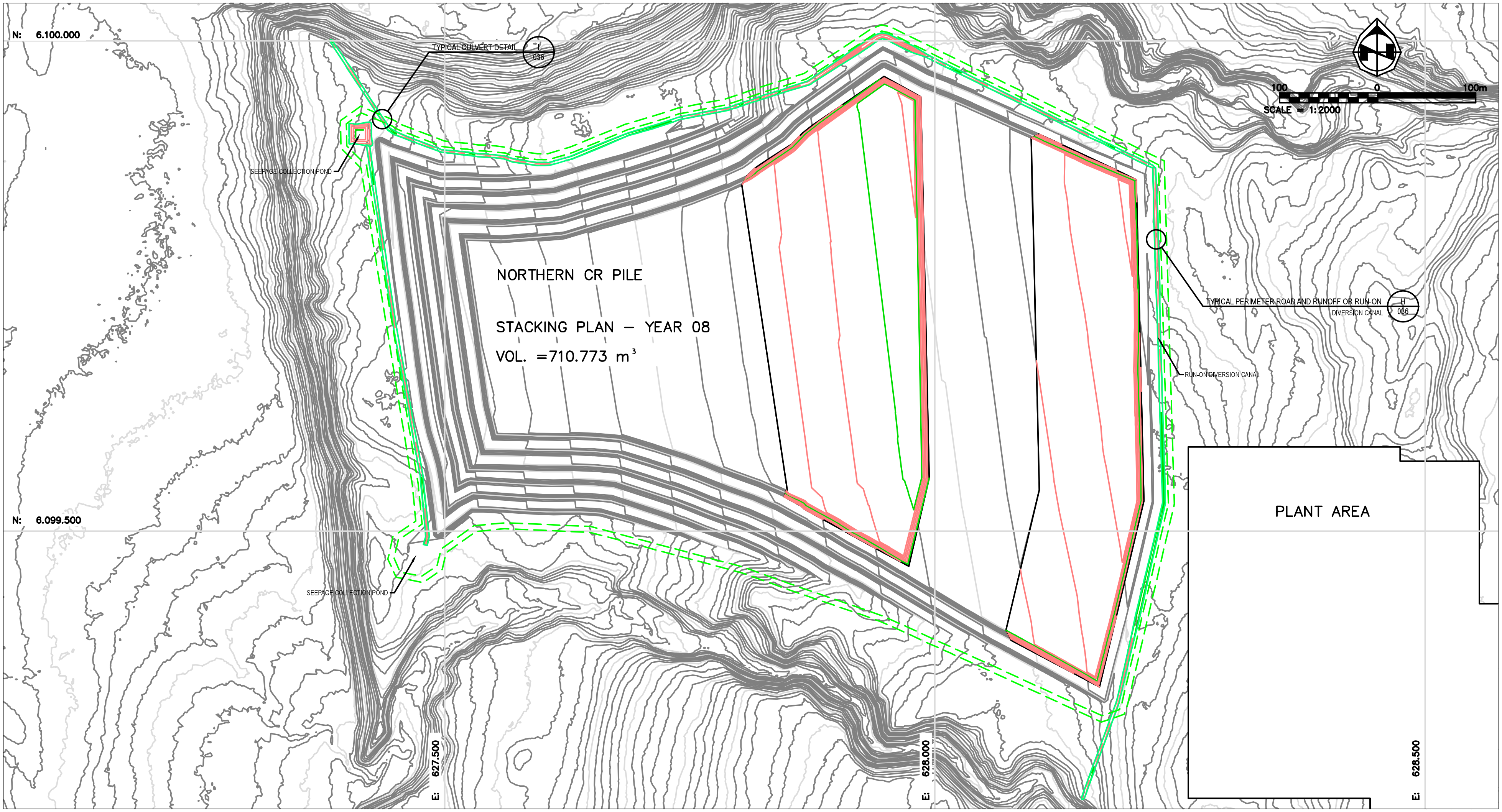
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 07

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-013



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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								A			DRAFT		

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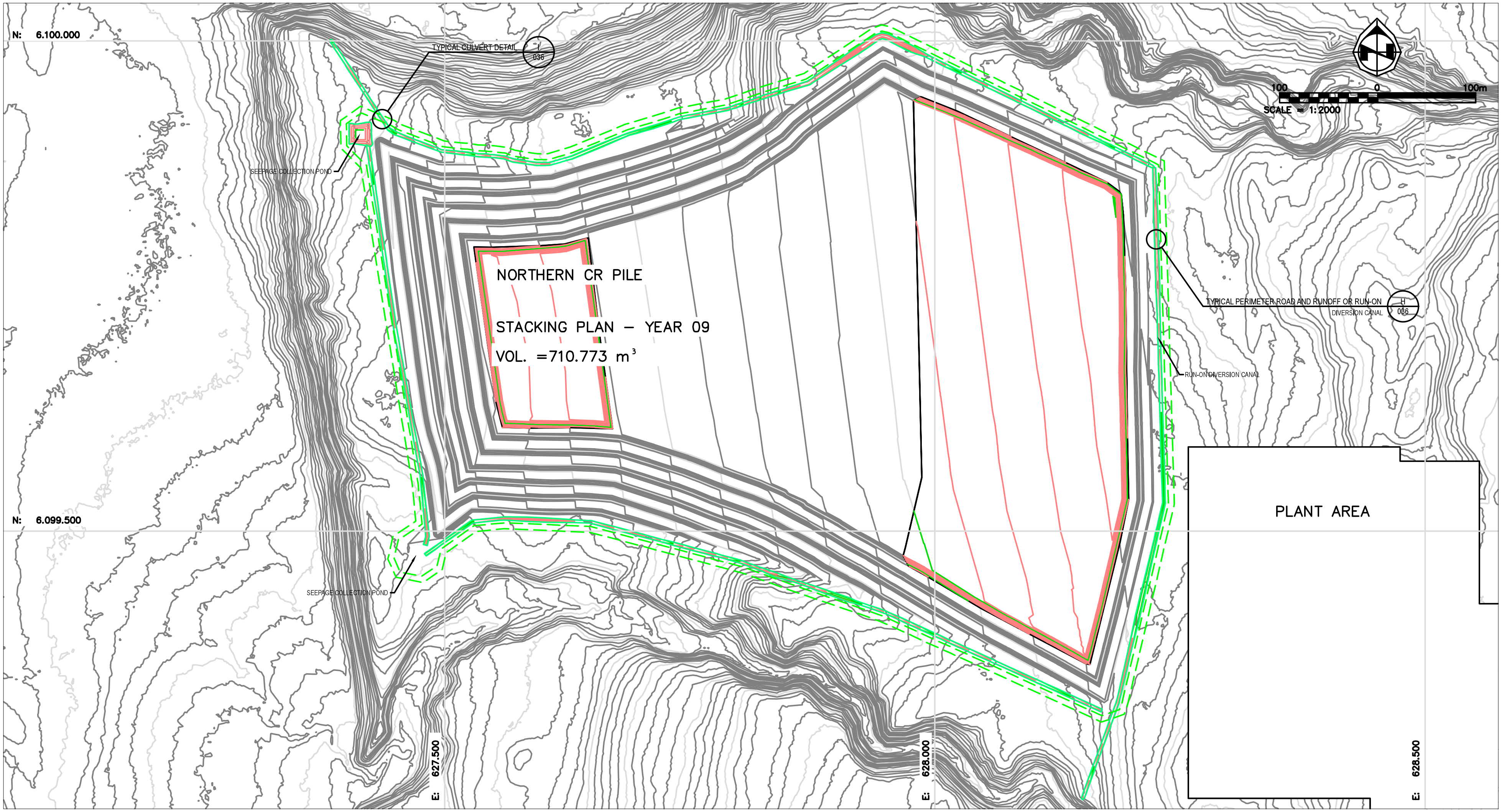
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 08

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-014



MAJOR CONTOUR MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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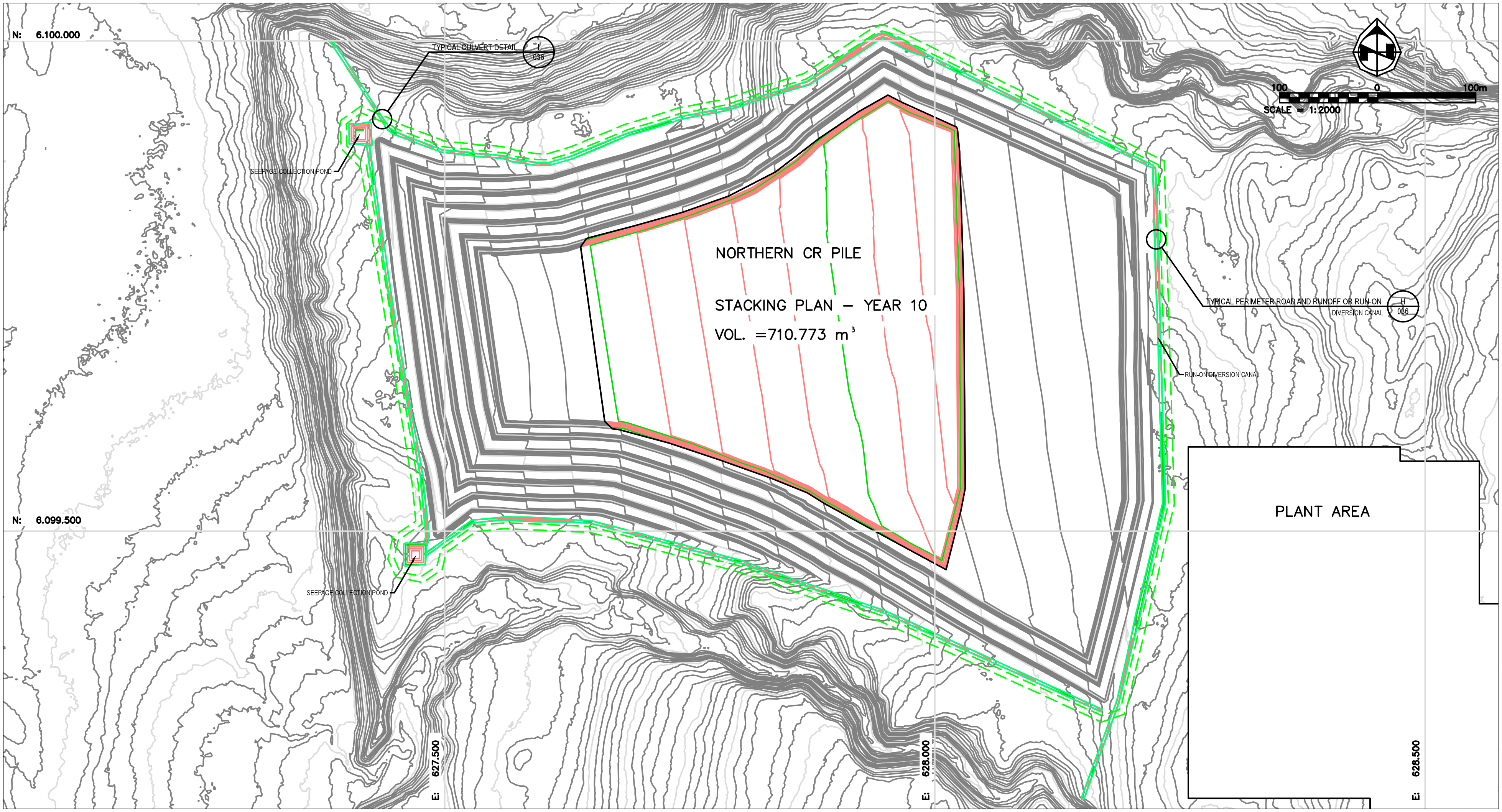
CLIENT HD MINING

TITLE MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 09

SCALE INDICATED
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-015



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
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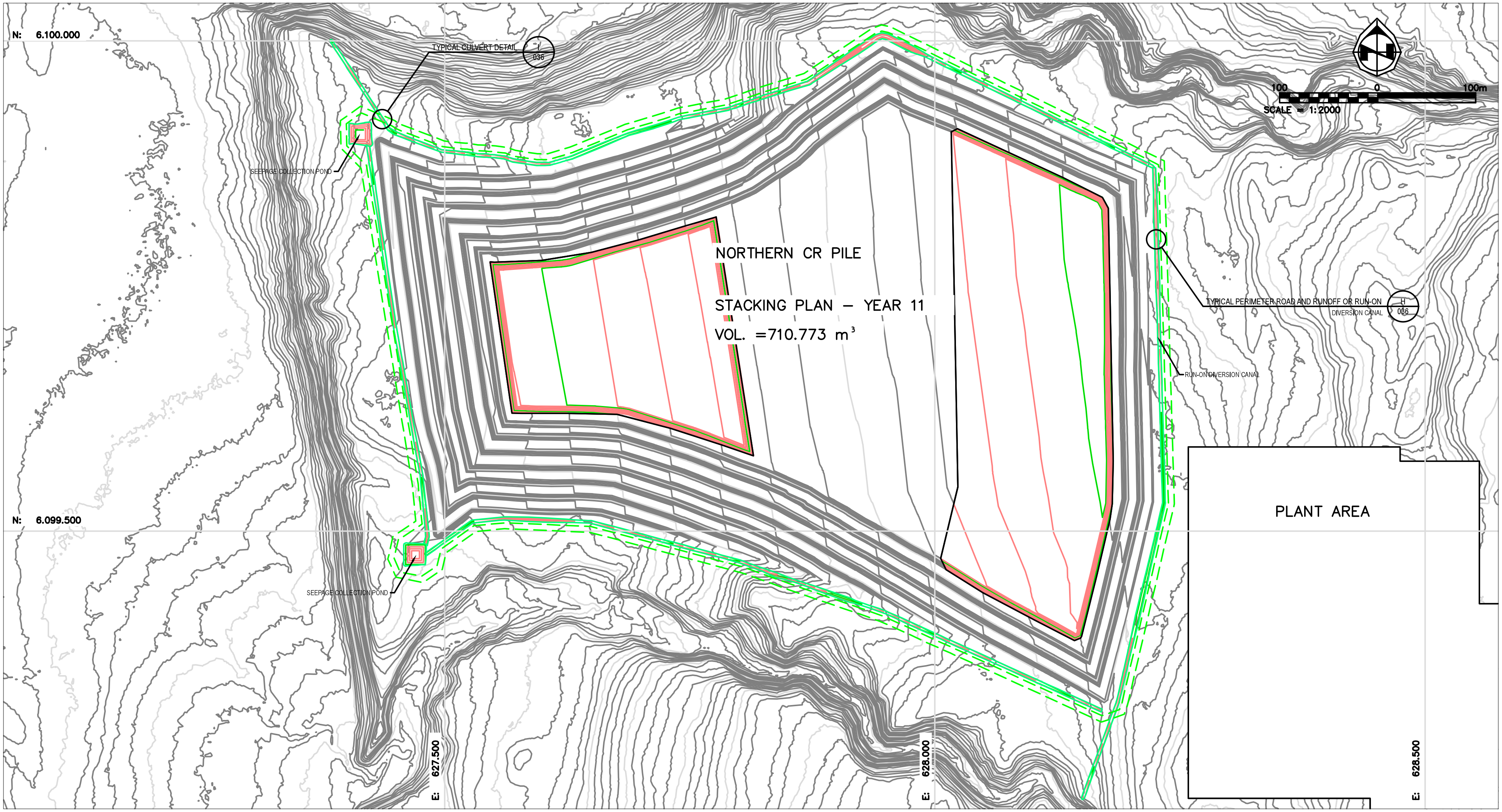
TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 10

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-016



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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								B			FIRST ISSUE		
								A			DRAFT		

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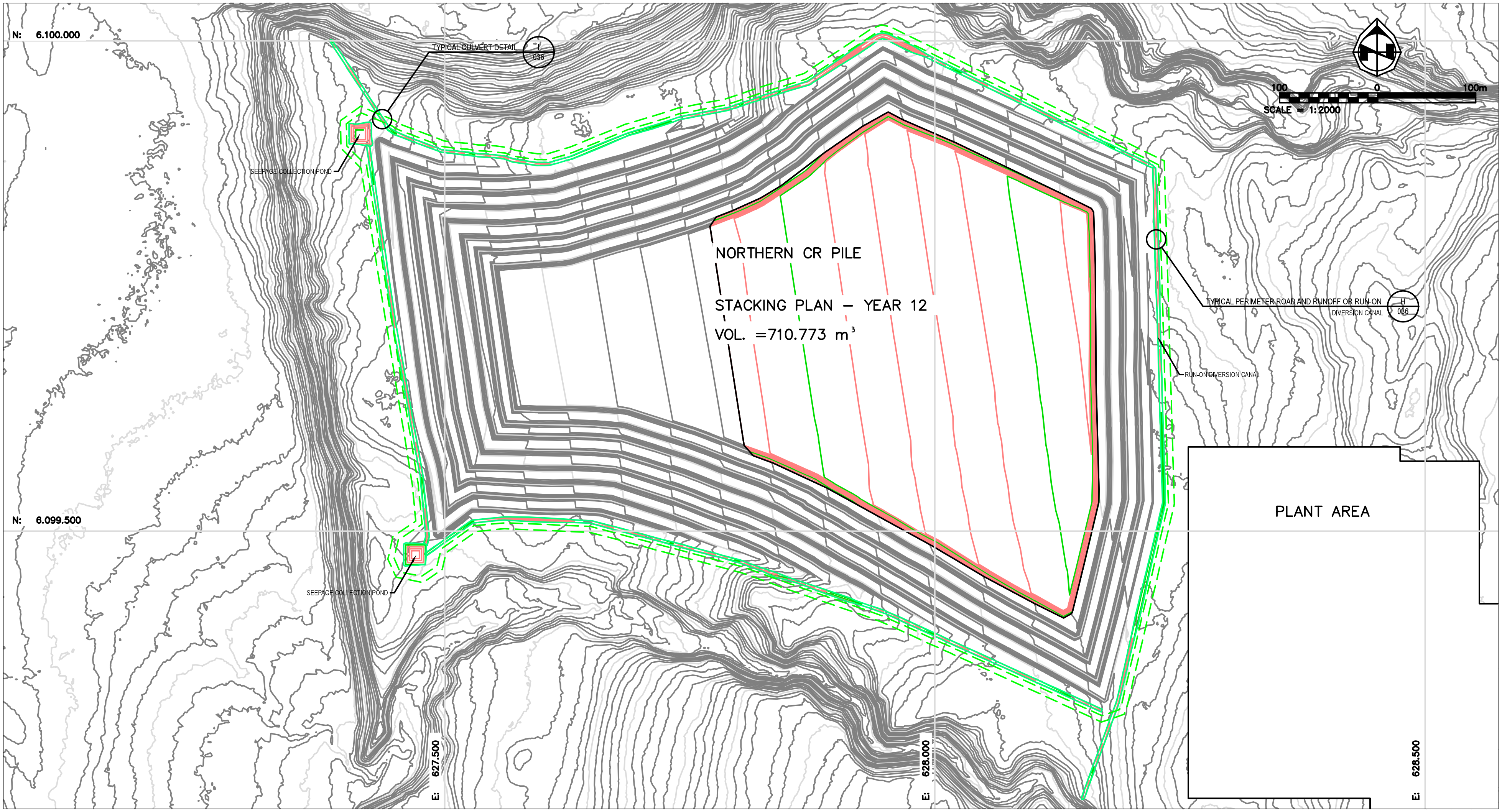
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 11

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-017



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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								B			FIRST ISSUE		
								A			DRAFT		

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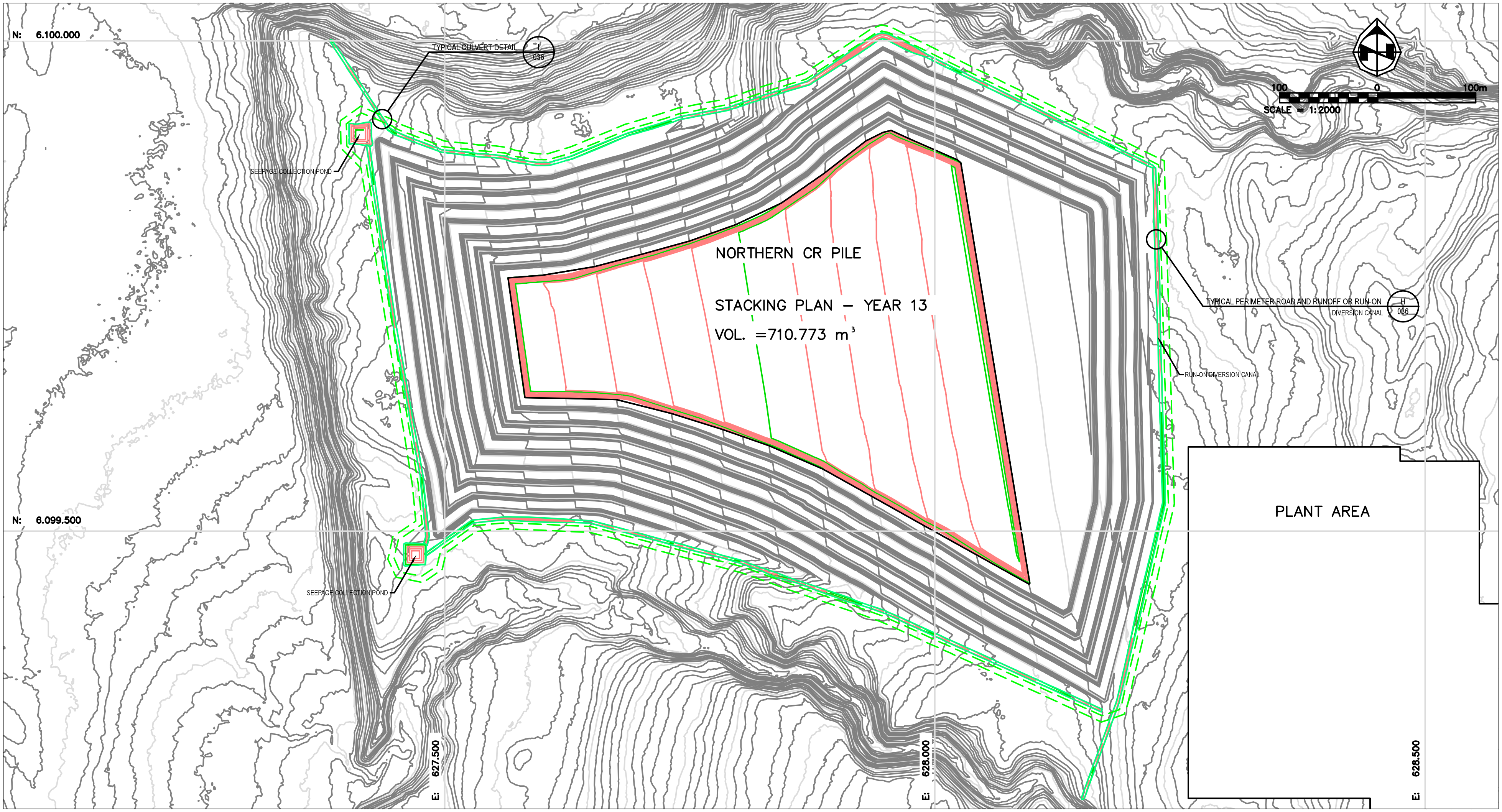
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 12

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-018



MAJOR CONTOUR MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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								A			DRAFT		

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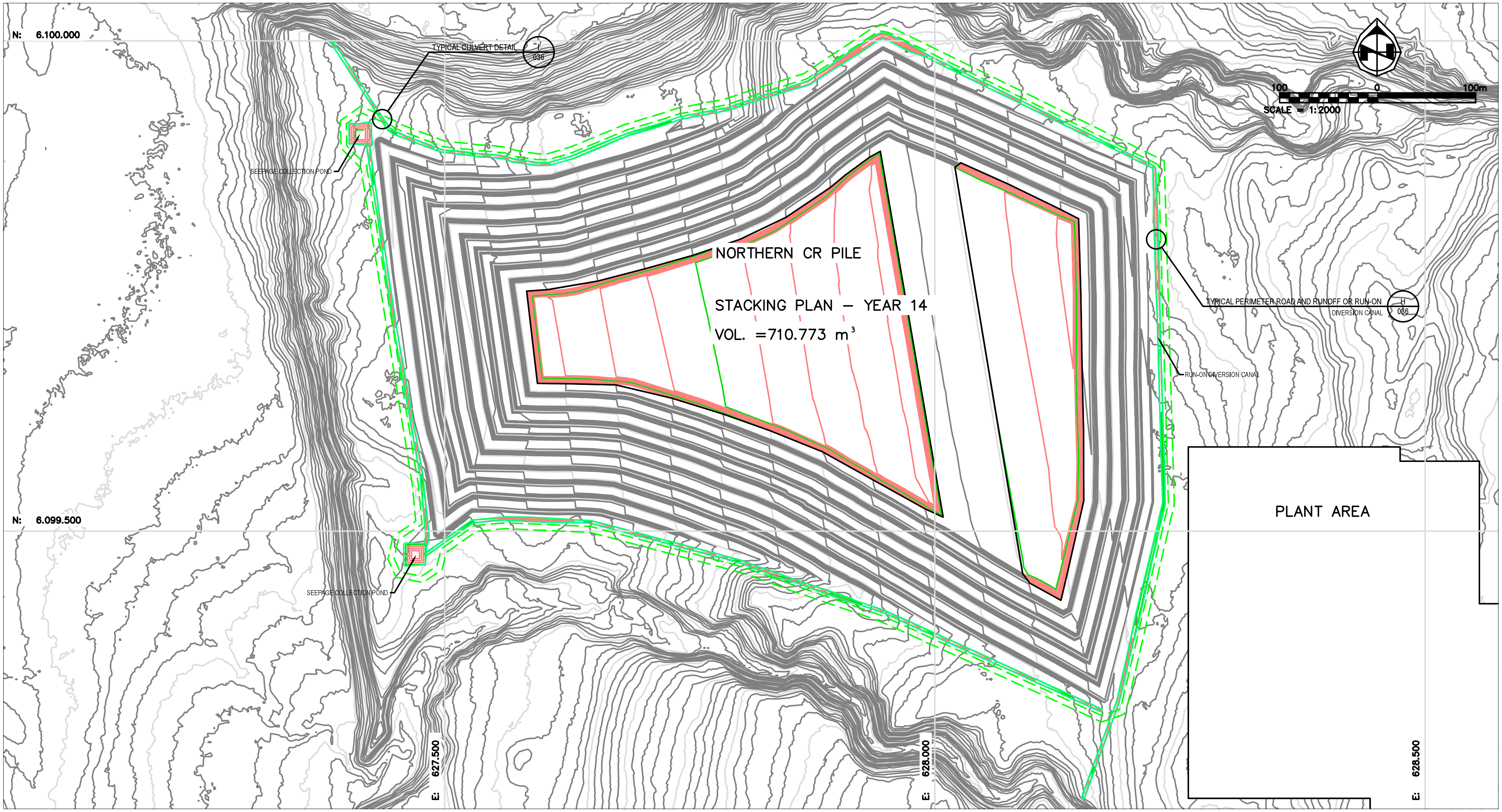
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 13

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-019



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
B			FIRST ISSUE		
A			DRAFT		

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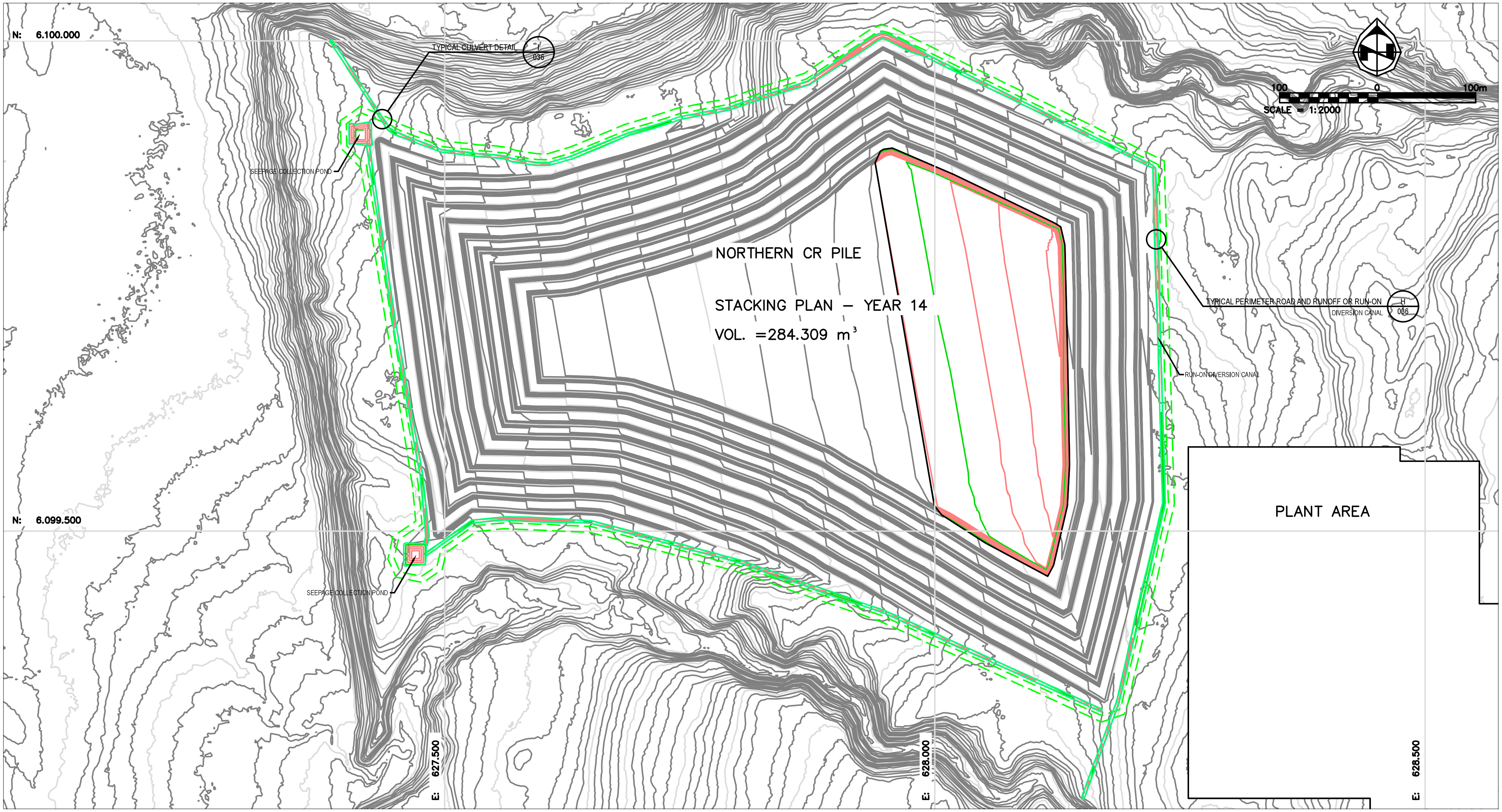
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 14

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No: 100102-01-020



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILES
STACKING PLAN NORTHERN CR PILE - YEAR 15

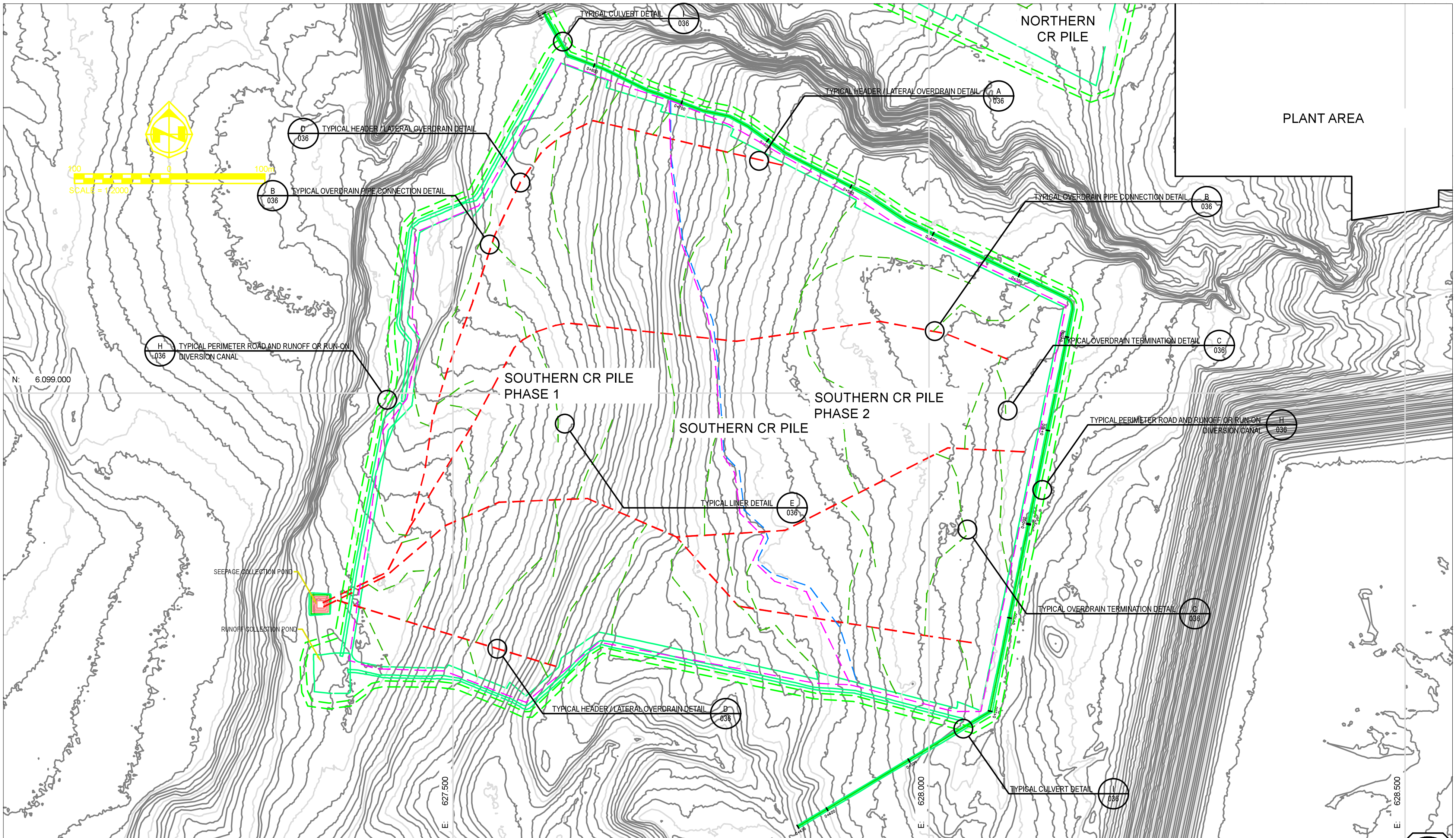
SCALE: INDICATED

SIZE: A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No: 100102-01-021



MAJOR CONTOUR

MINOR CONTOUR

300 mm HDPE DW PIPE FOR OVERDRAIN

200 mm HDPE DW PIPE FOR OVERRDRAIN

PERIMETER ROAD

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR

No	BY	DATE	REVISION DETAILS	CHKD	APPR
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CLIENT: HD MINING

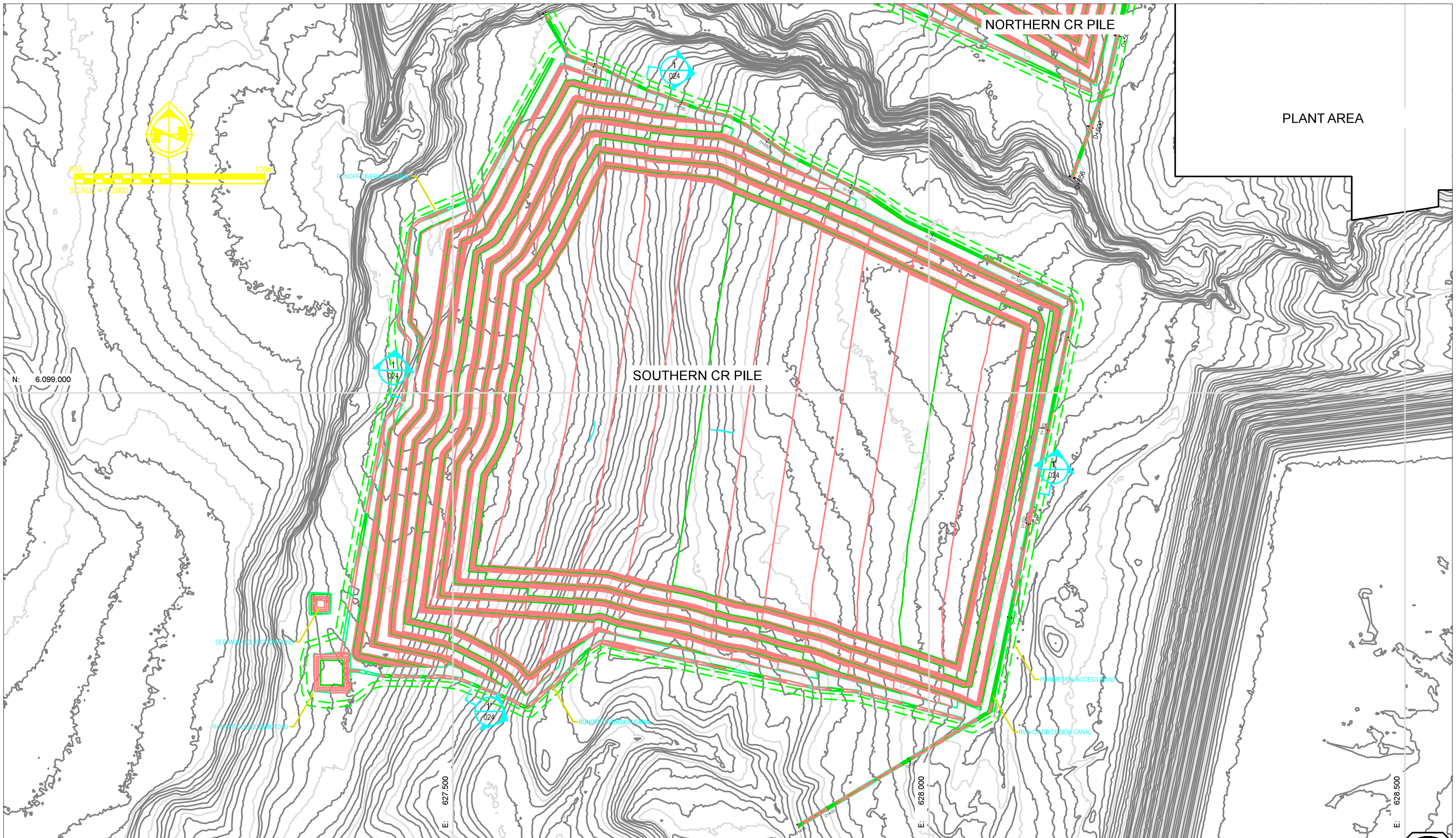
TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN OVERDRAIN SYSTEM - PLAN VIEW

SCALE 1:2000 SIZE A1

ALL DIMENSIONS IN MILLIMETRES

REV No A B C

DRAWING No 100102-01-022



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
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STD DETAIL DRAWINGS APPLY

CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN PLAN VIEW

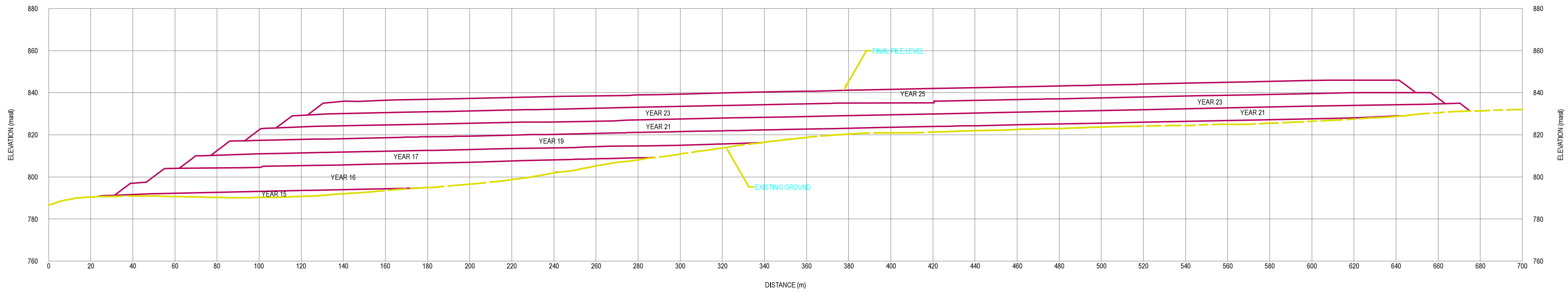
SCALE 1:2000

SIZE A1

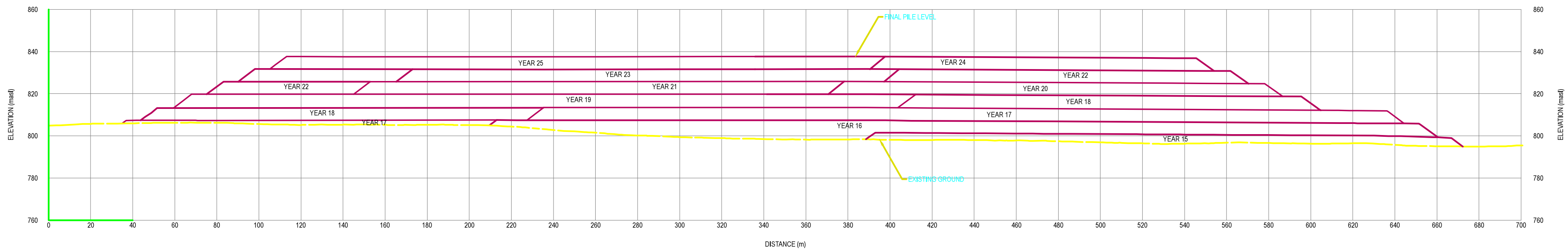
ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No 100102-01-023



1-1' / 023 SECTION
SCALE: 1 : 1000



2-2' / 024 SECTION
SCALE: 1 : 1000

Note: countours every 1 meters

No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
B			FIRST ISSUE		
A			DRAFT		

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR

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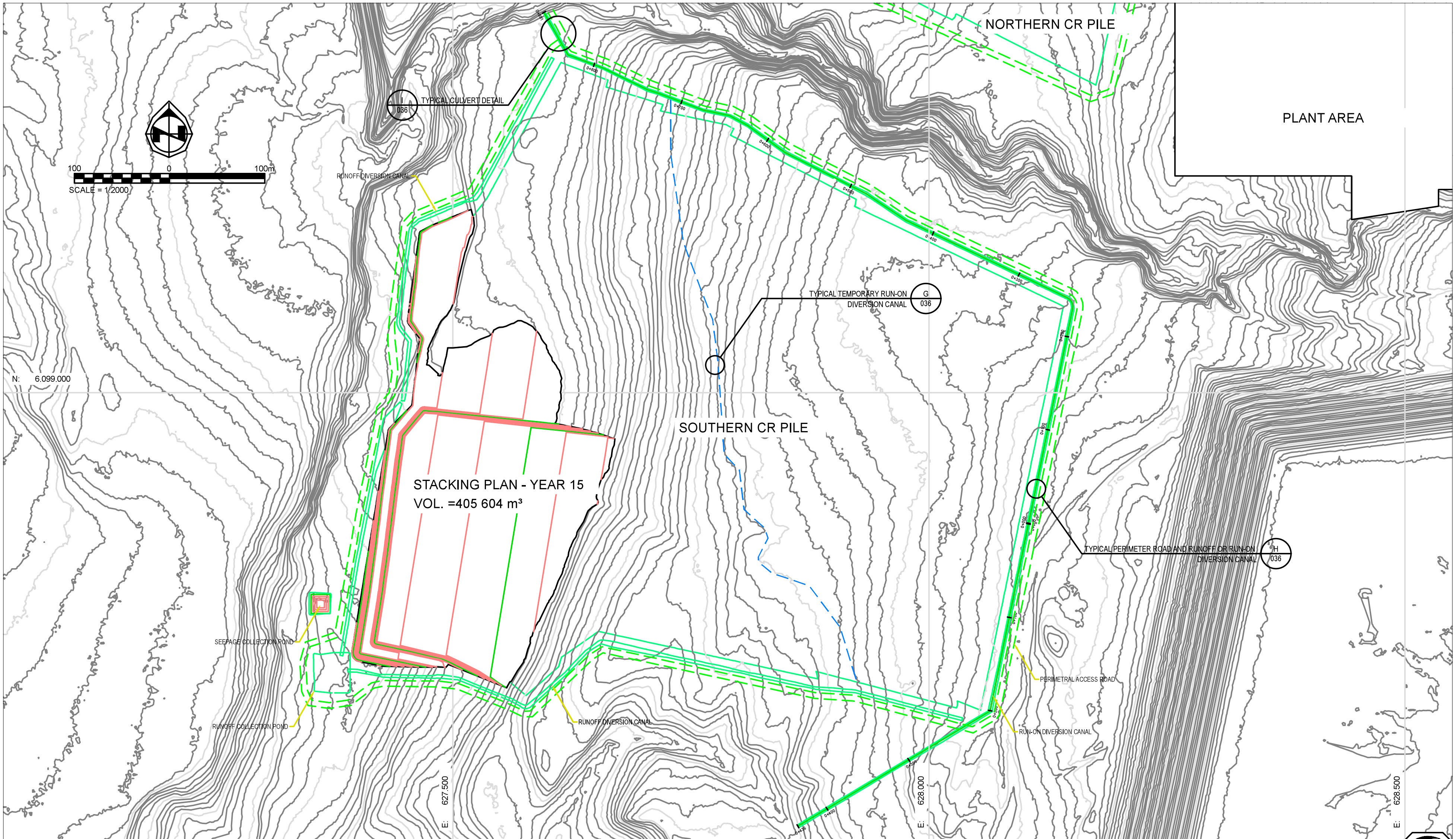
STD DETAIL DRAWINGS APPLY

CLIENT: HD MINING

TITLE: MURRAY RIVER PORJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN PILE - SECTIONS

SCALE: INDICATED
ALL DIMENSIONS IN MILLIMETRES
SIZE: A1
REV No: A B C
DRAWING No: 100102-01-024



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 15

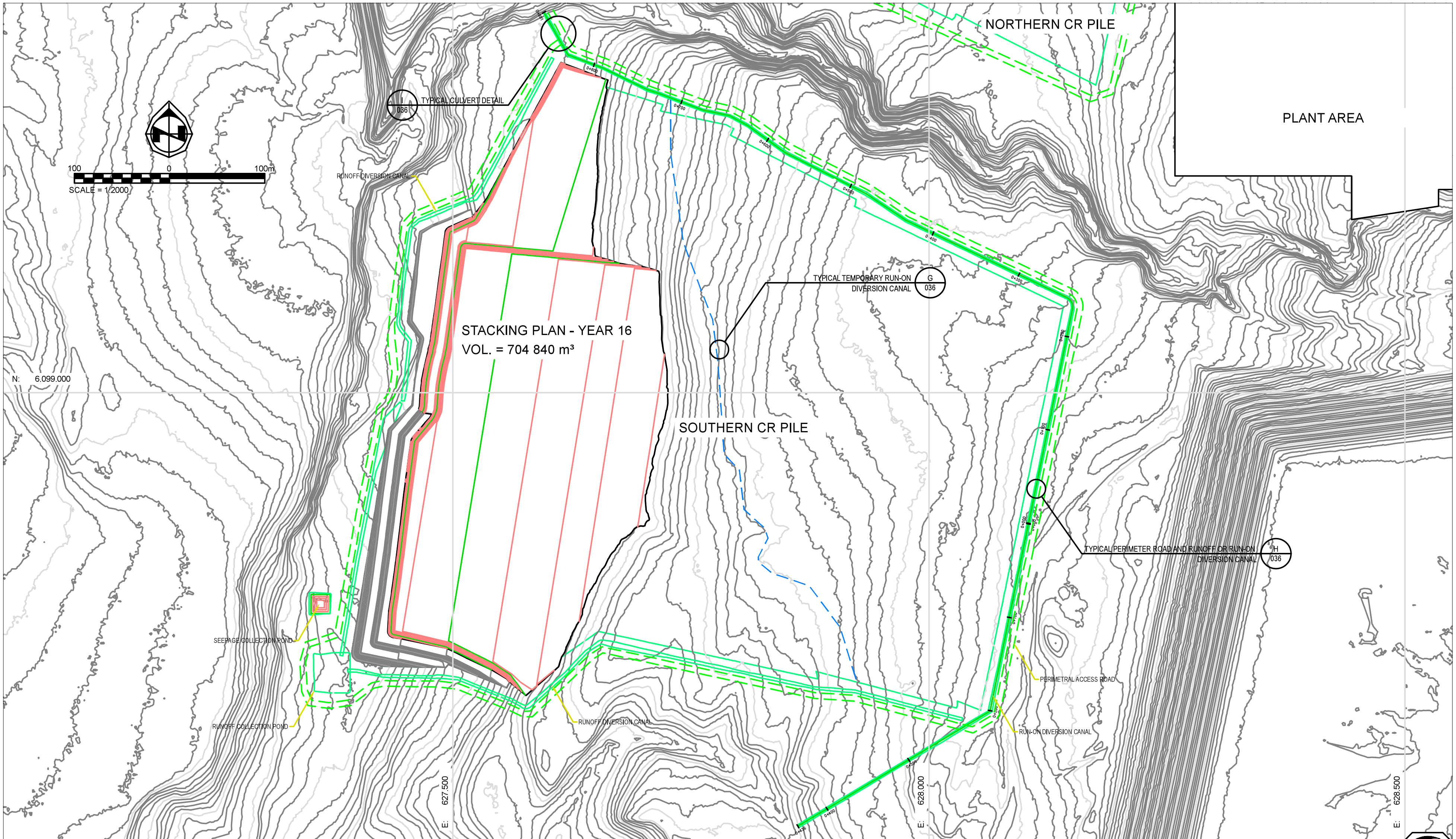
SCALE 1:2000

SIZE A1

ALL DIMENSIONS IN MILLIMETRES

REV No A B C

DRAWING No 100102-01-025



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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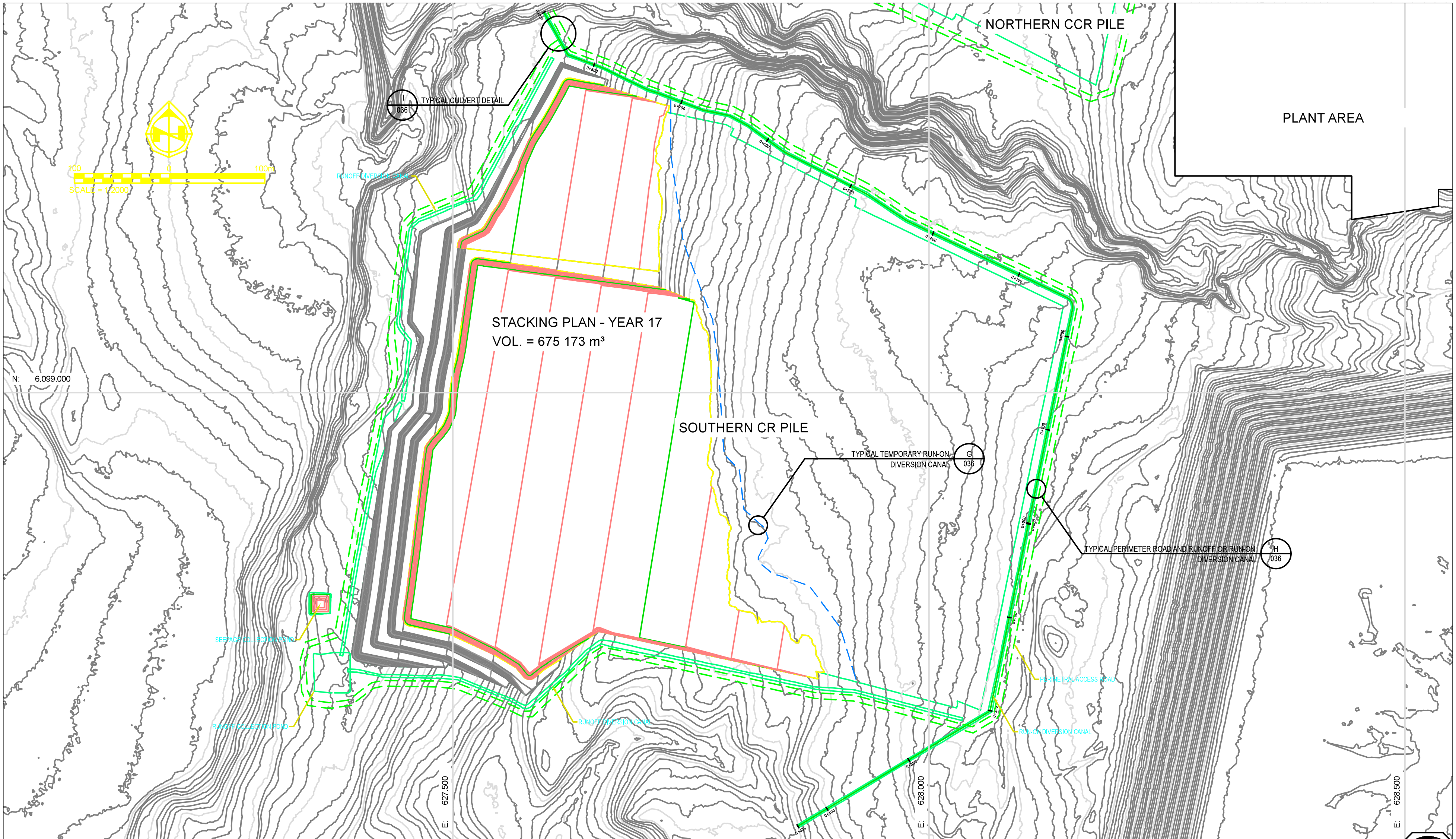
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORHTERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 16

SCALE 1:2000 | SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B C
DRAWING No 100102-01-026



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
								C	JG	5/30/14	FINAL	JG	SCE
								B			FIRST ISSUE		
								A			DRAFT		

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DESIGNED
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PROJ APPR

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Ausenco

CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 17

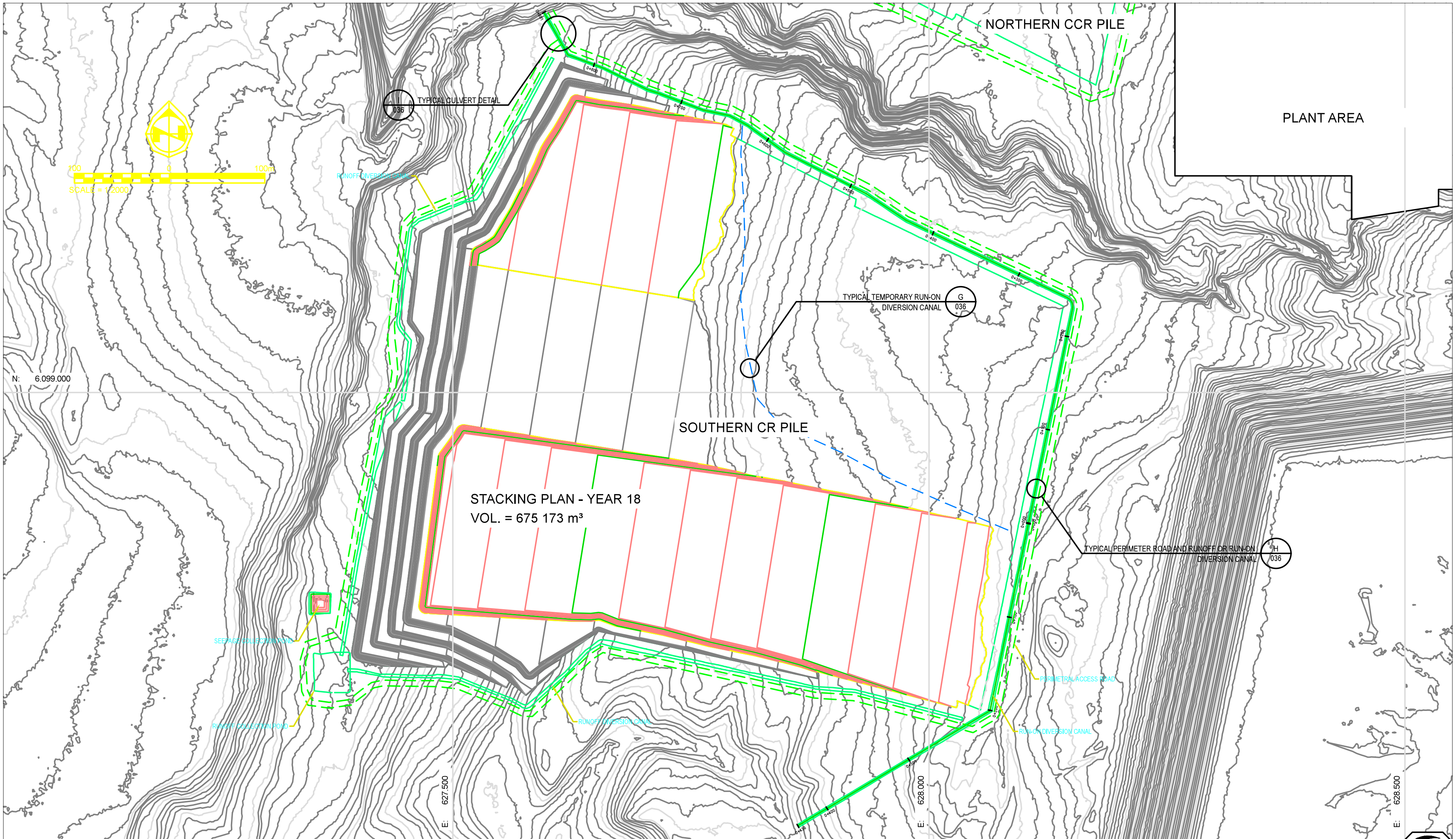
SCALE 1:2000

SIZE A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No 100102-01-027



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
B			FIRST ISSUE		
A			DRAFT		

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CCR PILE
SOUTHERN CR STACKING PLAN - YEAR 18

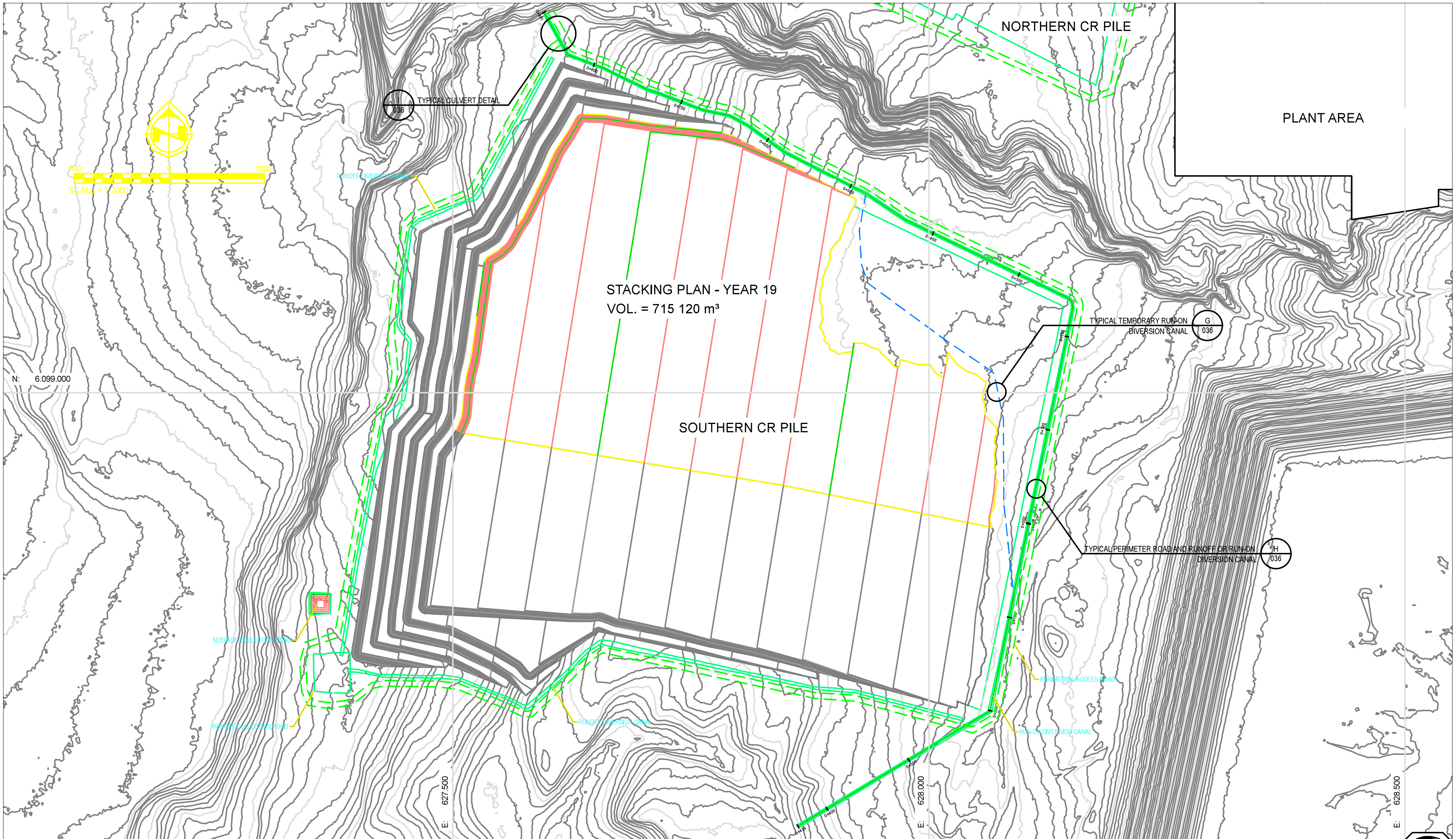
SCALE 1:2000

SIZE A1

ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No 100102-01-028



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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								B			FIRST ISSUE		
								A			DRAFT		

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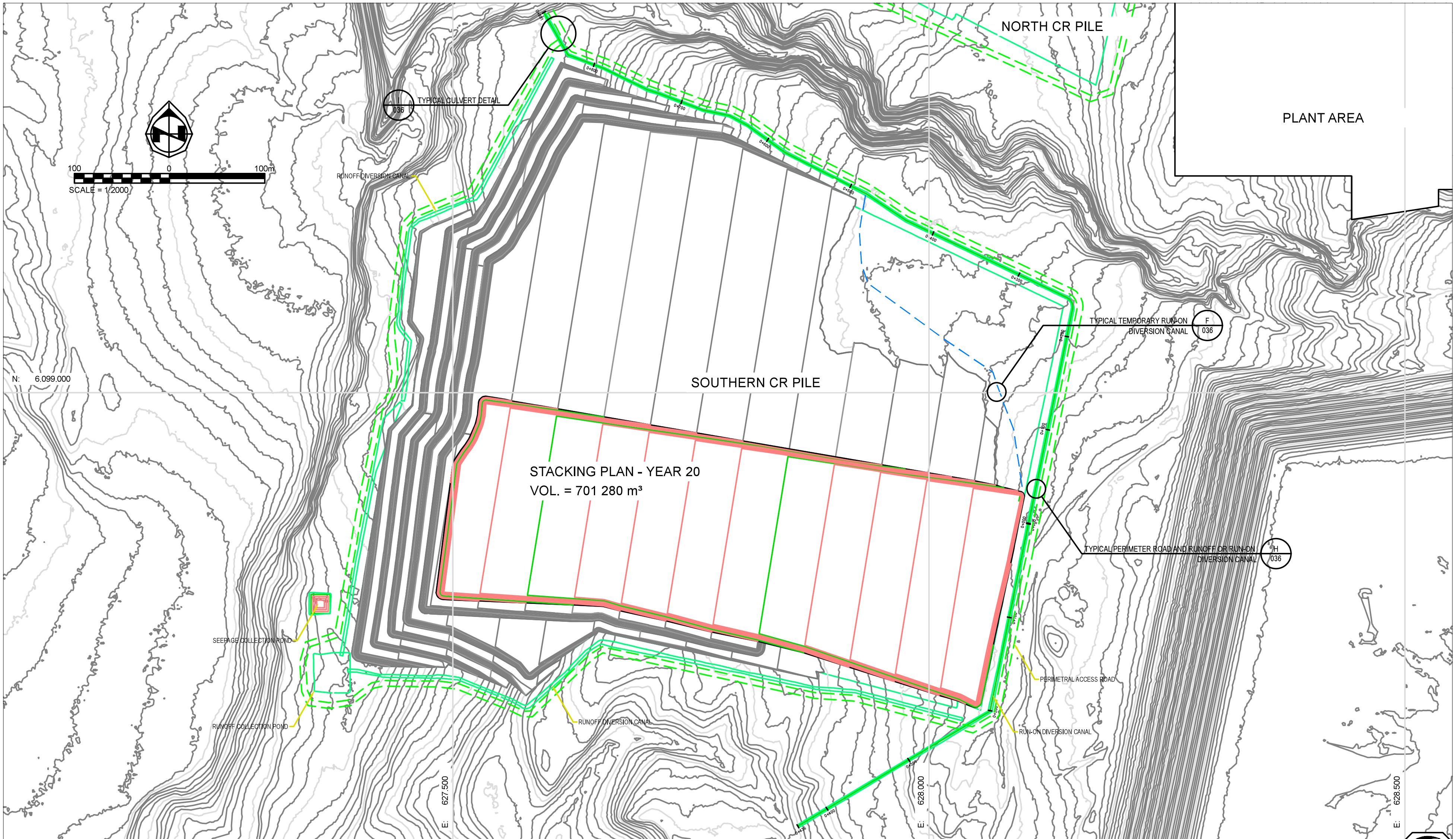
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 19

SCALE 1:2000
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-029



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
B			FIRST ISSUE		
A			DRAFT		

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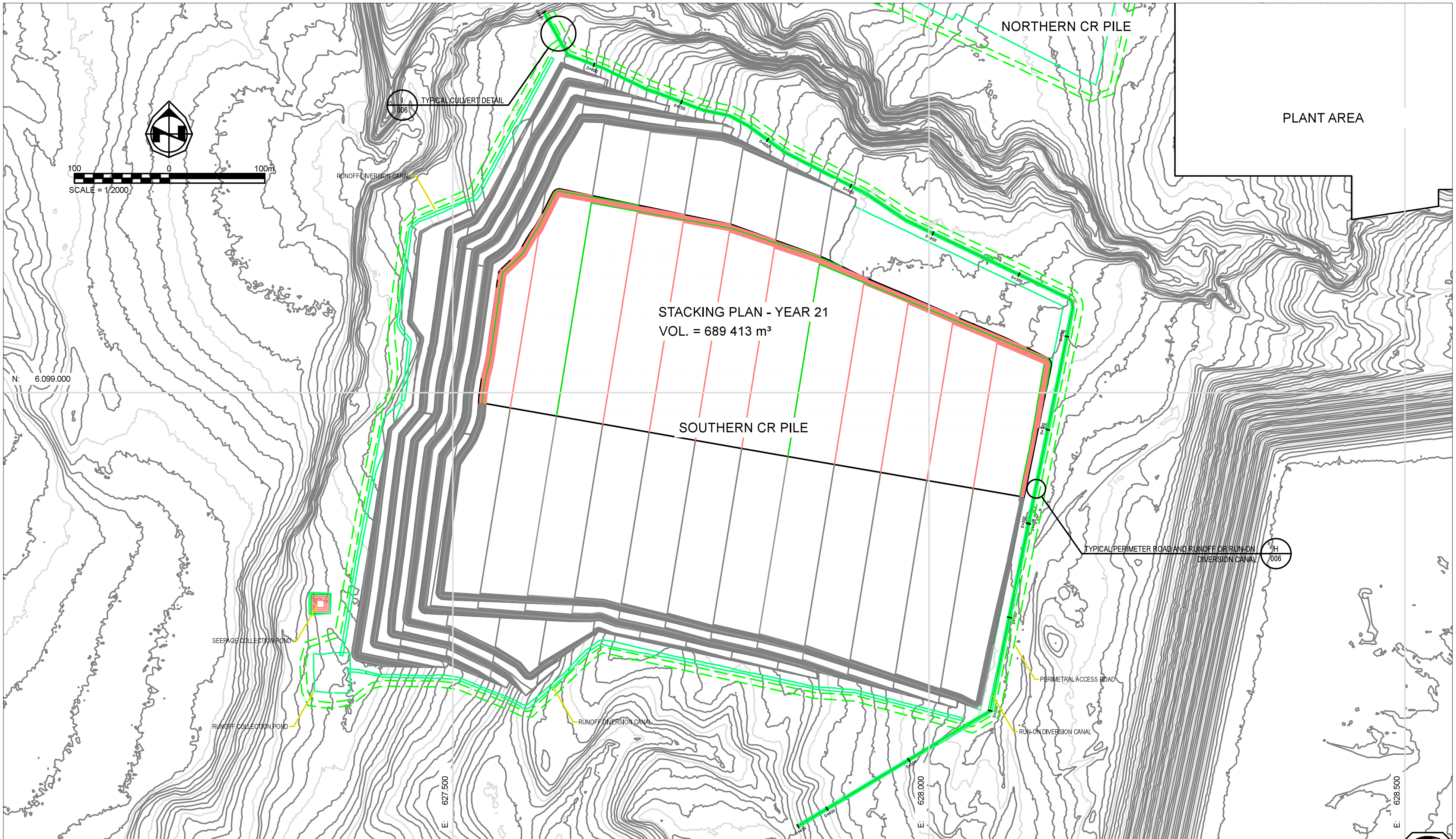
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CCR PILE
SOUTHERN CR STACKING PLAN - YEAR 20

SCALE 1:2000
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-030



MAJOR CONTOUR
MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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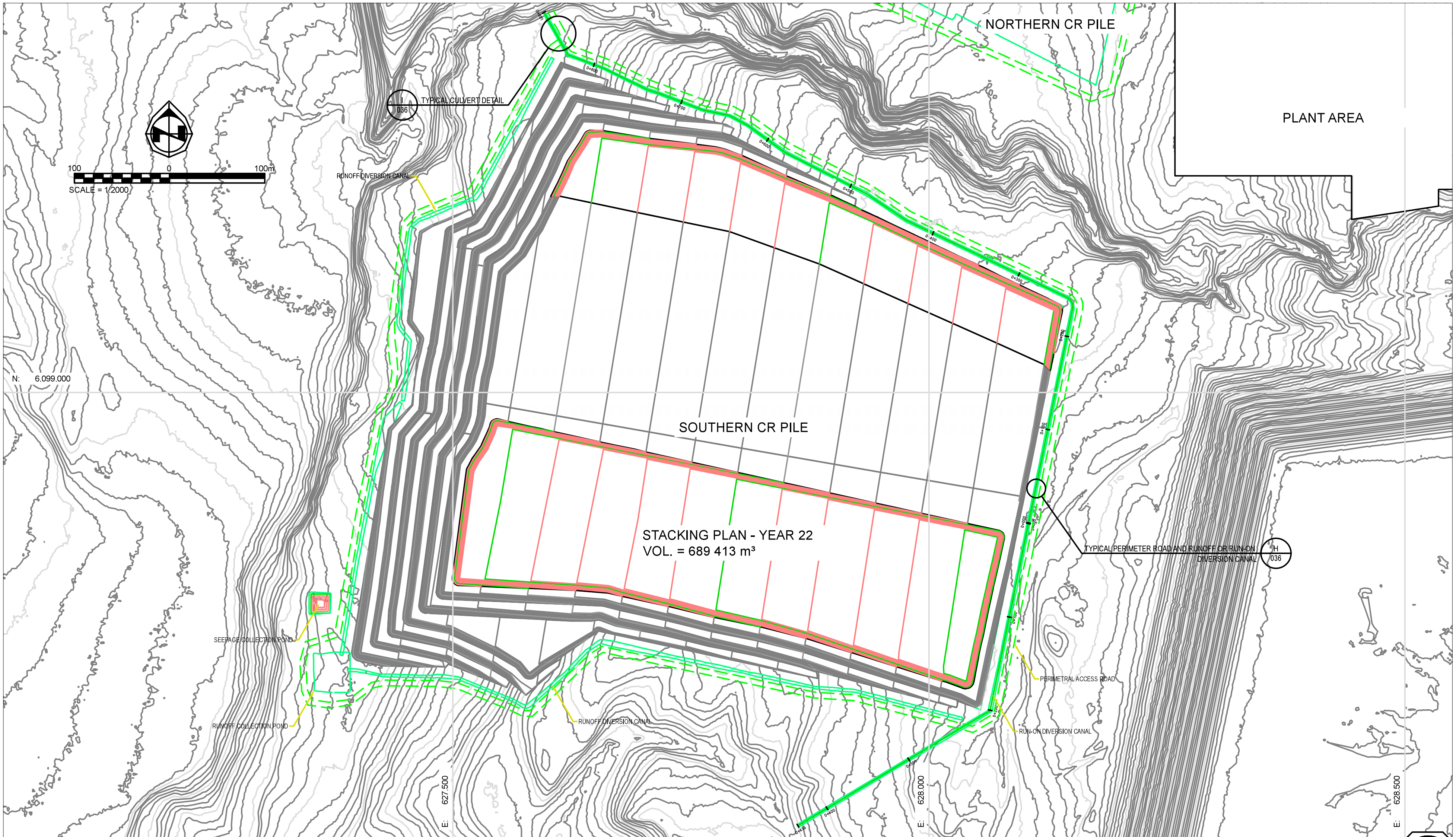
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 21

SCALE: 1:2000
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES

REV No: A B C

DRAWING No: 100102-01-031



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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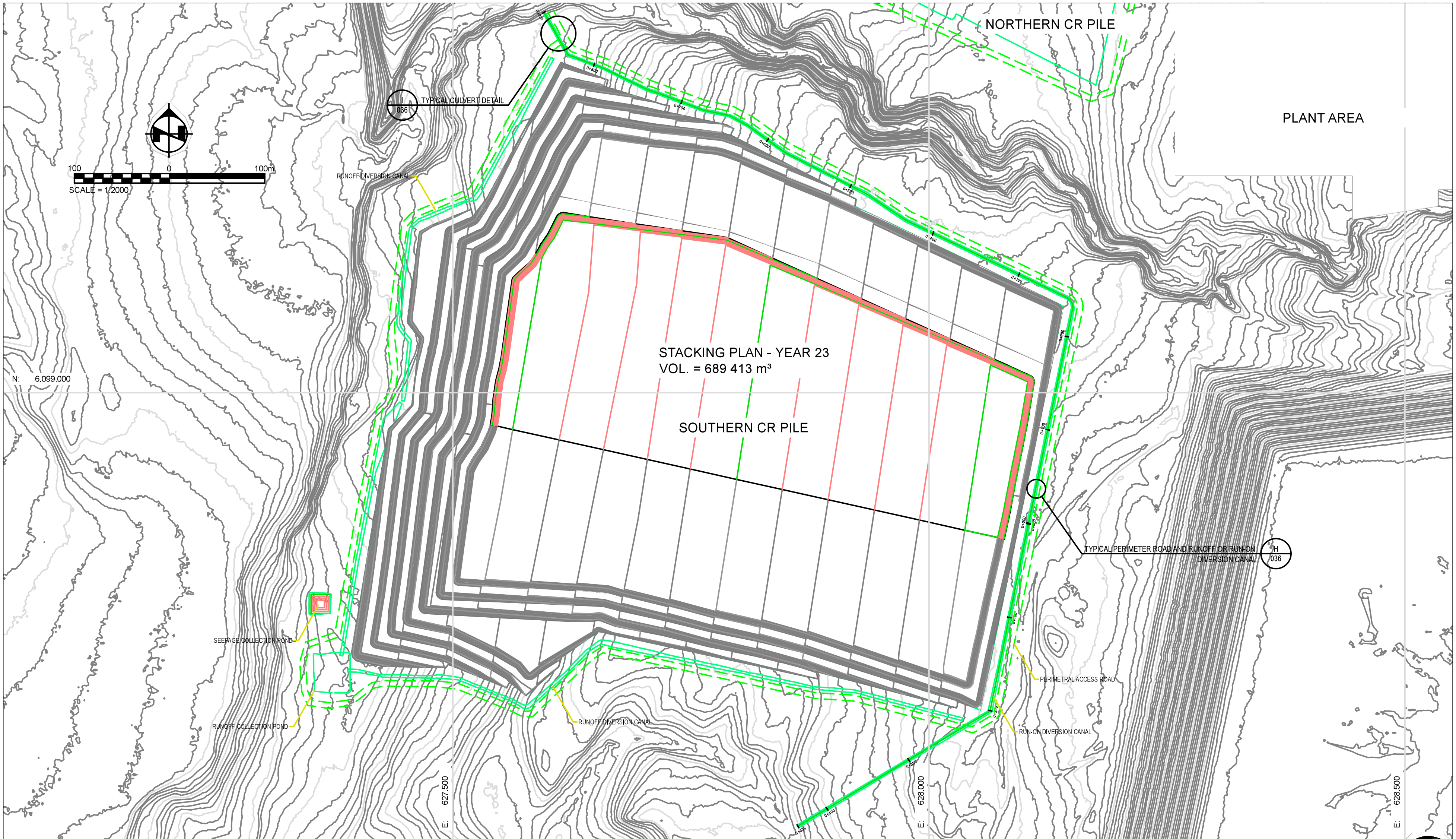
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 22

SCALE 1:2000
ALL DIMENSIONS IN MILLIMETRES
SIZE A1
REV No A B C
DRAWING No 100102-01-032



MAJOR CONTOUR
MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
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								B			FIRST ISSUE		
								A			DRAFT		

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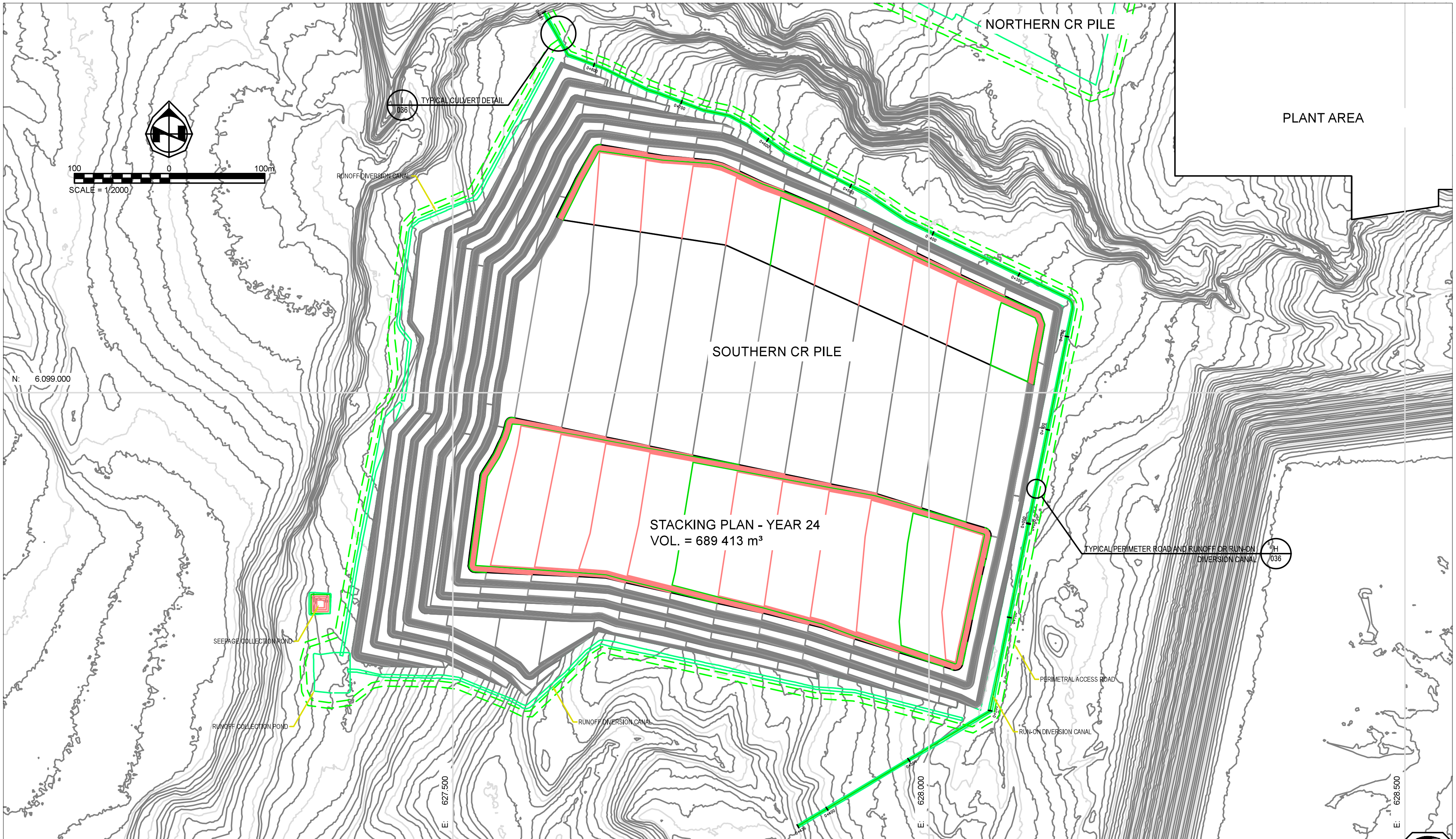
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 23

SCALE 1:2000
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-033



MAJOR CONTOUR   MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR

No	BY	DATE	REVISION DETAILS	CHKD	APPR
C	JG	5/30/14	FINAL	JG	SCE
B			FIRST ISSUE		
A			DRAFT		

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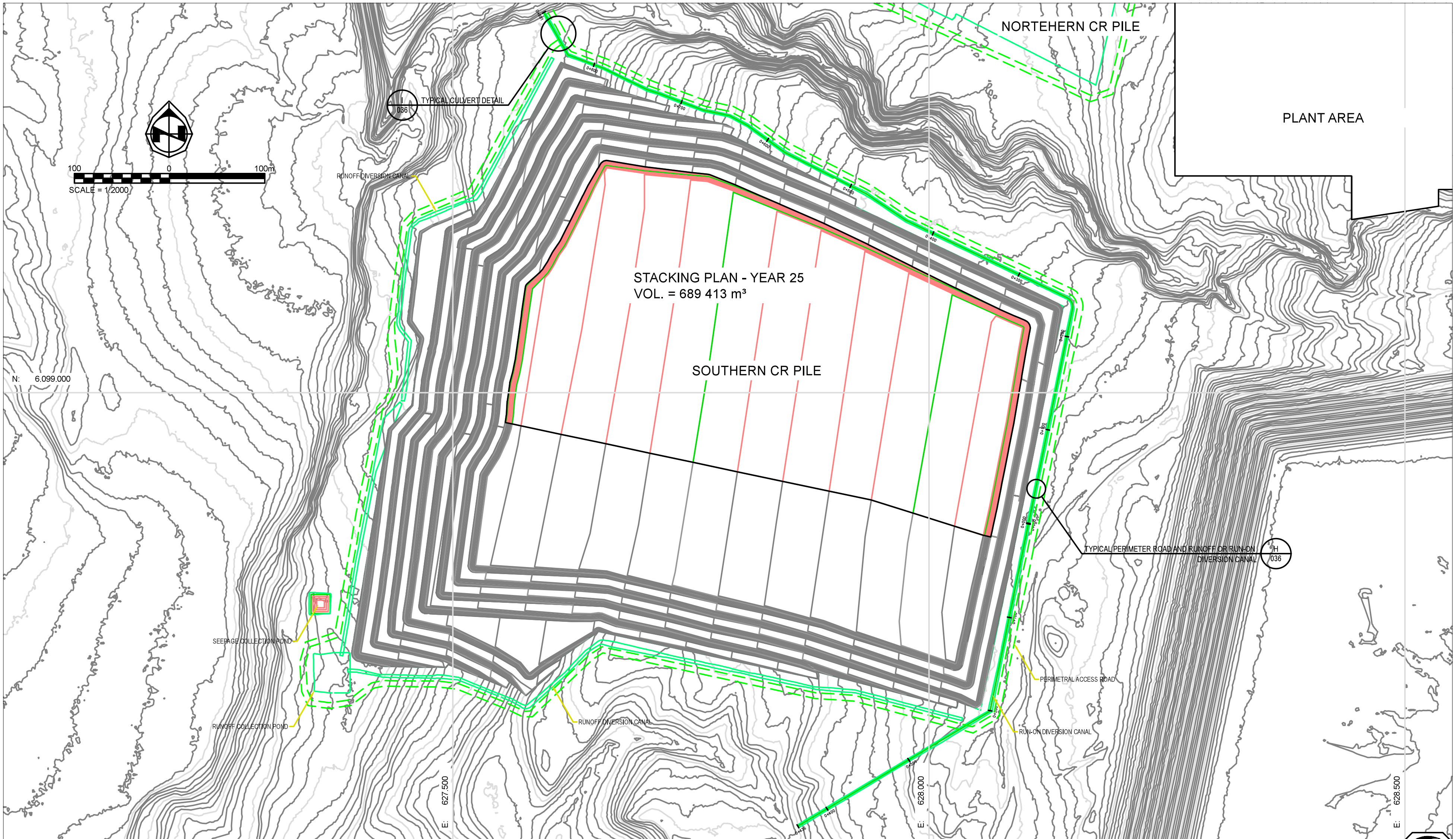
CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 24

SCALE 1:2000
SIZE A1
ALL DIMENSIONS IN MILLIMETRES
REV No A B C
DRAWING No 100102-01-034



MAJOR CONTOUR

MINOR CONTOUR

Note: countours every 1 meters

STD DETAIL DRAWINGS APPLY

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CR PILE
SOUTHERN CR STACKING PLAN - YEAR 25

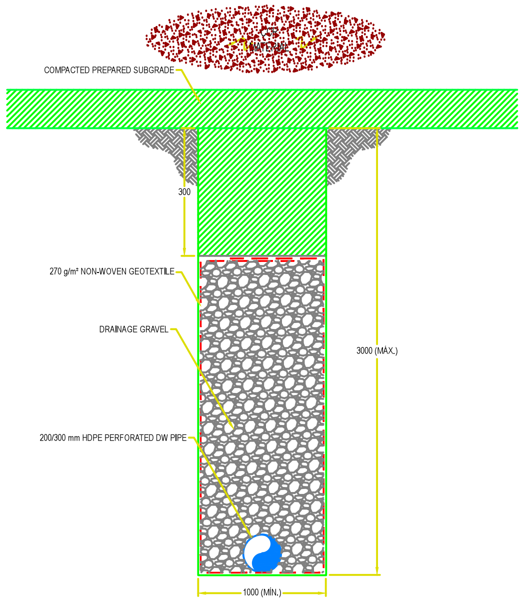
SCALE 1:2000

SIZE A1

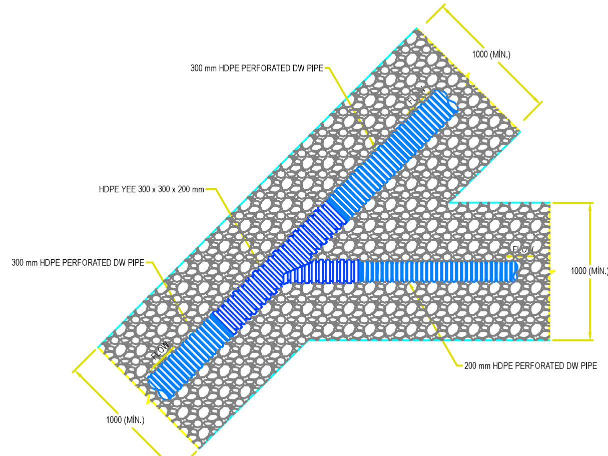
ALL DIMENSIONS IN MILLIMETRES

REV No A B C

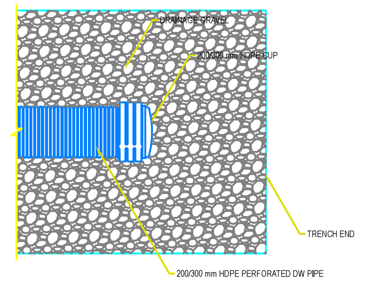
Drawing No 100102-01-035



A 003 - 005 TYPICAL HEADER / LATERAL UNDERDRAIN DETAIL
SCALE: 1 : 20



B 003 - 005 TYPICAL OVERDRAIN PIPE CONNECTION DETAIL
SCALE: 1 : 25



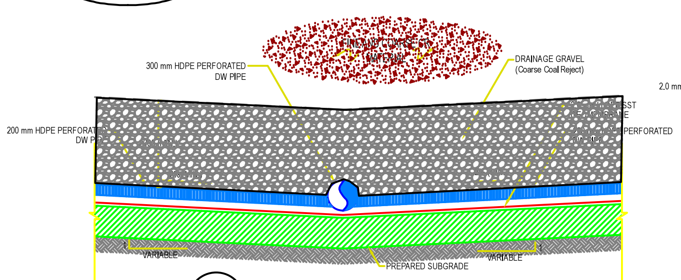
C 003 - 005 TYPICAL OVERDRAIN TERMINATION DETAIL
SCALE: 1 : 10

LEGEND

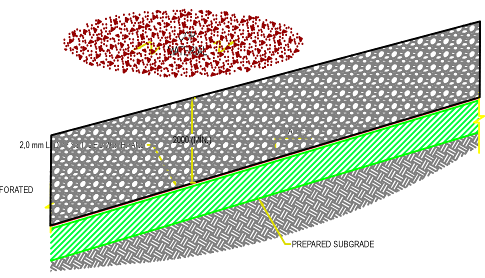
- PREPARED SUBGRADE
- 1,5 mm LLDPE SST GEOMEMBRANE
- 270 g/m² NON-WOVEN GEOTEXTILE
- WATER TABLE LEVEL
- EXISTING GROUND
- STRUCTURAL FILL
- LOW PERMEABILITY SOIL LINER
- ROAD BASE
- STONEWORK

NOTES:

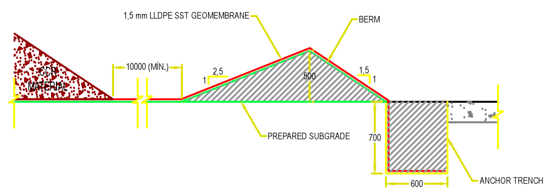
1. LLDPE = LINEAR LOW DENSITY POLYETHYLENE
HDPE = HIGH DENSITY POLYETHYLENE
SST = SINGLE-SIDED TEXTURE
DW = DUAL WALL
2. UNSUITABLE MATERIAL FOUND DURING CONSTRUCTION SHALL BE REMOVED AND REPLACED BY COMPACTED STRUCTURAL FILL, OR EXCAVATED UNTIL FOUNDATION LEVELS AS INDICATED IN THIS DRAWING AND/OR REQUIRED BY THE ENGINEER.
3. THE CUT SLOPE SHALL BE EXCAVATED IN ACCORDANCE WITH THE SAFETY REQUERIMENTS, GROUND CONDITIONS, AND AS DETERMINED AND APPROVED BY THE ENGINEER.
4. IF DURING UNDERDRAIN INSTALLATION THE ENGINEER DETERMINES THE GROUND CONDITIONS ARE SUITABLE, BEDDING LAYER PLACEMENT MAY BE ELIMINATED. EXCAVATIONS SHALL BE REVIEWED AND APPROVED BY THE ENGINEER BEFORE RE-STARTING THE WORKS.
5. ALL PIPE CONNECTIONS AND ACCESORIES FOR THE UNDERDRAIN AND LINER DRAIN SYSTEM SHALL BE PROVIDED BY THE PIPE MANUFACTURER.
6. DRAINAGE GRAVEL SHALL MEET THE TECHNICAL SPECIFICATIONS. LIKEWISE, THE PLACEMENT PROCEDURES SHALL FOLLOW THE GUIDELINES OF THIS DOCUMENT.
7. THE PERIMETER ANCHOR TRENCH FILL SHALL BE DONE BY UTILIZING COMPACTED MATERIAL WITH NO GRAVEL EXCESS.
8. THE 1,5 mm LLDPE SST GEOMEMBRANE SHALL BE DEPLOYED WITH THE TEXTURED SIDE ADJACENT SUBGRADE.



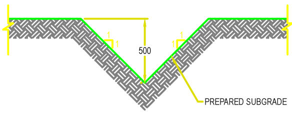
D 004 TYPICAL HEADER / LATERAL OVERDRAIN DETAIL
SCALE: 1 : 25



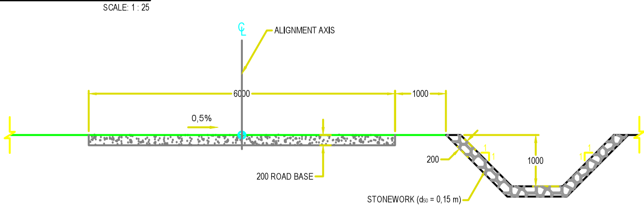
E 003 TYPICAL LINER DETAIL
SCALE: 1 : 25



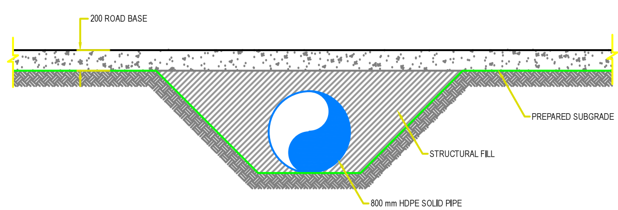
F 003 TYPICAL PERIMETRAL BERM AND ANCHOR TRENCH LINER DETAIL
SCALE: 1 : 25



G 009 - 019 TYPICAL TEMPORARY RUN-ON DIVERSION CANAL
SCALE: 1 : 20



H 003 - 019 TYPICAL PERIMETER ROAD AND RUNOFF OR RUN-ON DIVERSION CANAL
SCALE: 1 : 50



I 003 - 019 TYPICAL CULVERT DETAIL
SCALE: 1 : 25

STD DETAIL DRAWINGS APPLY

DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	APPR	No	BY	DATE	REVISION DETAILS	CHKD	APPR
								B			FIRST ISSUE		
								A			DRAFT		

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CLIENT: HD MINING

TITLE: MURRAY RIVER PROJECT
NORTHERN AND SOUTHERN CCR PILES
OVERDRAIN, UNDERDRAIN AND LINER SISTEM DETAILS

SCALE: INDICATED
SIZE: A1
ALL DIMENSIONS IN MILLIMETRES
REV No: A B
DRAWING No: 100102-01-036