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Comox Valley REGIONAL DISTRICT

Memo

File: 3060-20/DP 3A 20
3060-20/DP 4A 20

DATE: June 30, 2020

TO: Advisory Planning Commission
Baynes Sound – Denman / Hornby Islands (Electoral Area A)

FROM: Planning and Development Services Branch

RE: Development Permit (Shoreline Protection) – Coal Hills, Island Highway
(West Fraser Mills Ltd. and Province of British Columbia)
Lot A District Lot 28 Nelson District, and District Lot 154, Nanaimo District, Plan EPP56910, PID 030-110-254
Block B, District Lot 155, Nanaimo District, No PID

The attached development proposal is for commission members' review and comment. An application (Appendix A) has been received to consider Development Permit (DP) under the Shoreline Protection Devices guidelines (Appendix B). Shoreline protection devices are alterations to the natural boundary of the sea (or a watercourse) for the purposes of preventing the erosion of land from waves and water currents. Alterations to the shoreline require a Development Permit for the purposes of protecting the natural environment, ecosystems and biological diversity, and for the protection of development from hazardous conditions.

The subject properties (Figures 1 and 2) are the site of the Union Bay coal hills: an abandoned stockpile of carbonaceous waste rock, along the shores of Baynes Sound and Hart Creek, left over from a former coal washing and port facility. It is a Contaminated Site as defined by the *Contaminated Sites Regulation* and has been prioritized for remediation under the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's Crown Contaminated Sites Program. The applicants are seeking to conduct remediation work to address acid rock drainage and metal leaching from the site by capping the stockpile with a bituminous geomembrane liner, shoreline protection devices, and a rainwater management system that would prevent drainage through the stockpile.

The scope of project work involves the following:

- Clearing and grubbing the surface of the stockpile;
- Grading and compacting to lower slopes and to create level strips and trenches;
- Install the bituminous geomembrane liner, anchored in trenches;
- Install shoreline protection devices;
- Cover liner with sand, drainage rock, and a geotextile filter;
- Cover with soil; and
- Vegetate with native grasses (Figure 3).

Development Permit

In accordance with Section 83 of the Official Community Plan, Bylaw No. 337 being the "Rural Comox Valley Official Community Plan Bylaw No. 337, 2014", proposals to harden a shoreline, including replacement and/or maintenance of an existing hard shoreline requires board approval of the DP. The guidelines require such an application to include a professional report addressing the necessity of the proposed alterations, an evaluation of potential negative impacts to the natural environment and adjacent properties, a Biophysical Assessment, and a Landscape Plan.

Objectives and Guidelines

It is the objective of these DP guidelines to encourage shoreline resiliency by following soft shore (e.g. "Greenshore") principles:

- Conserve or restore natural coastal or riparian processes (e.g. sediment transfer);
- Maintain habitat function and diversity;
- Prevent pollutants from entering the aquatic or riparian environment; and
- Avoid or reduce cumulative impacts on the shoreline environment, including coastal or riparian processes.

Soft shore measures typically involve re-grading the foreshore/backshore areas to allow for a more gradual dissipation of wave energy, and the use of large woody debris (such as anchored logs) and vegetative plantings to assist in energy absorption and to contribute nutrients and habitat for aquatic life. Hardened shorelines (e.g. vertical walls, sloped revetments, etc.) will often deflect wave energy to unprotected openings, reduce space for habitat, and interrupt natural coastal processes (e.g. sediment transport, spawning, etc.). To be specific, the guidelines contain a general condition that "*New revetment walls (rip rap) shall not be permitted*."

Application

According to the application (Appendix A), the acid rock drainage and metal leaching is the result of rainwater draining through the stockpile. The shoreline protection measures along the edges of the Coal Hills are required for the purposes of protecting the edges from erosive forces and for containing the waste rock within the property. These shoreline measures were originally designed with rip rap revetment, but to address the DP Guidelines the applicant commissioned a study to review potential soft shore alternatives. The report prepared by Paul Hoo, P.Eng., of Moffat & Nichol, found opportunity for soft shore measures on the northern facing shoreline. The report characterizes this north-facing shoreline as being subject to less wave action (relative to the eastern facing shoreline) due to its orientation relative to waves and currents and as a receiving environment for some sediment from Washer Creek (Hart Creek). Here, the report recommends creating a cobble beach with a layer of sand and pea-sized rock, which is suitable for forage fish habitat, supplemented with anchored logs and vegetated sand dunes (predominately American dune grass; *Leymus mollis*).

However, the report ruled out soft shore measures on the eastern facing shoreline due to its orientation relative to prevailing wind direction, waves and longshore current. To achieve the desired level of safety, soft shore measures here would necessitate a significant amount of fill to create a long, low-grade beach and the longshore sediment transport would require continual interventions to supplement additional fill.

On the western side, along Washer Creek (Hart Creek), the report identifies evidence of erosion along the banks due to high flows and meandering nature of the watercourse. In order to keep the

capped stockpile in such proximity to the river/shore line where steep slopes exist, combined with the immediacy of the neighbouring lot across the river, the report concludes that soft shore measures would not be possible and recommends maintaining the existing creek flow cross section supplemented with a rip rap revetment.

The rip rap would be keyed into the beach to inhibit movement and scour. The rip rap structure would reach a maximum height of 4.8 metres in accordance with the calculated designated flood level of 4.0 metres (accounting for sea level rise to 2100 and a 1-in-200 year storm surge), at an approximately 3H:1V slope. To ensure long term stability under static and seismic conditions, a report titled *Riprap Stability Assessment* prepared by Kevin Bodnar, P.Eng. of Geopacific Consulting Engineers was submitted

In addition, a Biophysical Assessment prepared by Dave Langill, R.Bio., and Warren Appleton, R.P. Bio., of Keystone Environmental was submitted. This report identifies the habitat values of the project area, potential impacts, and recommended mitigation and offsetting measures. To add habitat values post-construction, the report provides recommendations for planting of a native seed grass mixture (predominately fescue and oatgrass with some yarrow and camas), as well as the above noted soft shore measures on the northern shoreline. Over top of the liner, plantings must be restricted to those with root depths less than 0.4 metres. Due to the impact of the proposed work, the report recommends the construction of 660 square metres of intertidal marsh (predominately Pickleweed, Seashore saltgrass and Seaside plantain) as an offset. In addition, the Landscape Plan includes dunegrass plantings within gaps in the rip rap.

Keystone Environmental also submitted a Post-Construction Monitoring Plan. The plan recommends reviewing the shoreline protection areas every year in early spring. The soft shore measures are dynamic (expected to shift) but should be reviewed for signs of scour and log displacement. The rip rap should be reviewed for signs of scour, stone displacement, settling, material accumulation and unwanted vegetation growth. Additional monitoring recommended to occur, periodically as prescribed by the Qualified Professionals, in relation to the project includes visual inspections of the soil cover for signs of erosion and stability and to eliminate undesirable vegetation; air quality monitoring at venting locations (in the rip rap areas); water quality samplings to review acidity, dissolved metals and sulphate; and documenting the change in the intertidal iron-stained area.

Sincerely,

T. Trieu

Ton Trieu, RPP, MCIP
Manager of Planning Services
Planning and Development Services Branch

/jm

Attachments Appendix A – "Application submissions"
Appendix B – "Development Permit Guidelines: Shoreline Protection Devices"

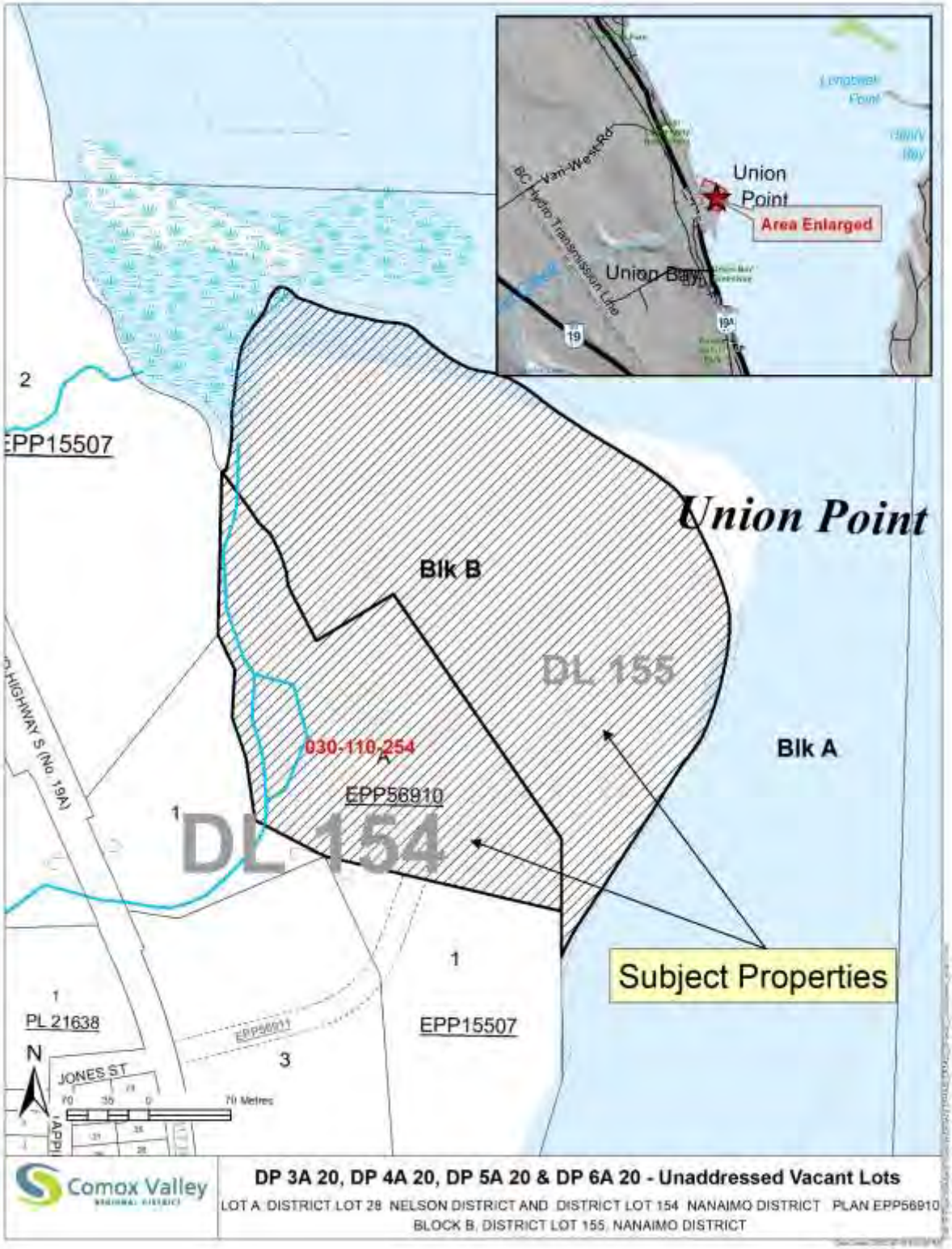

Figure 1: Subject Properties

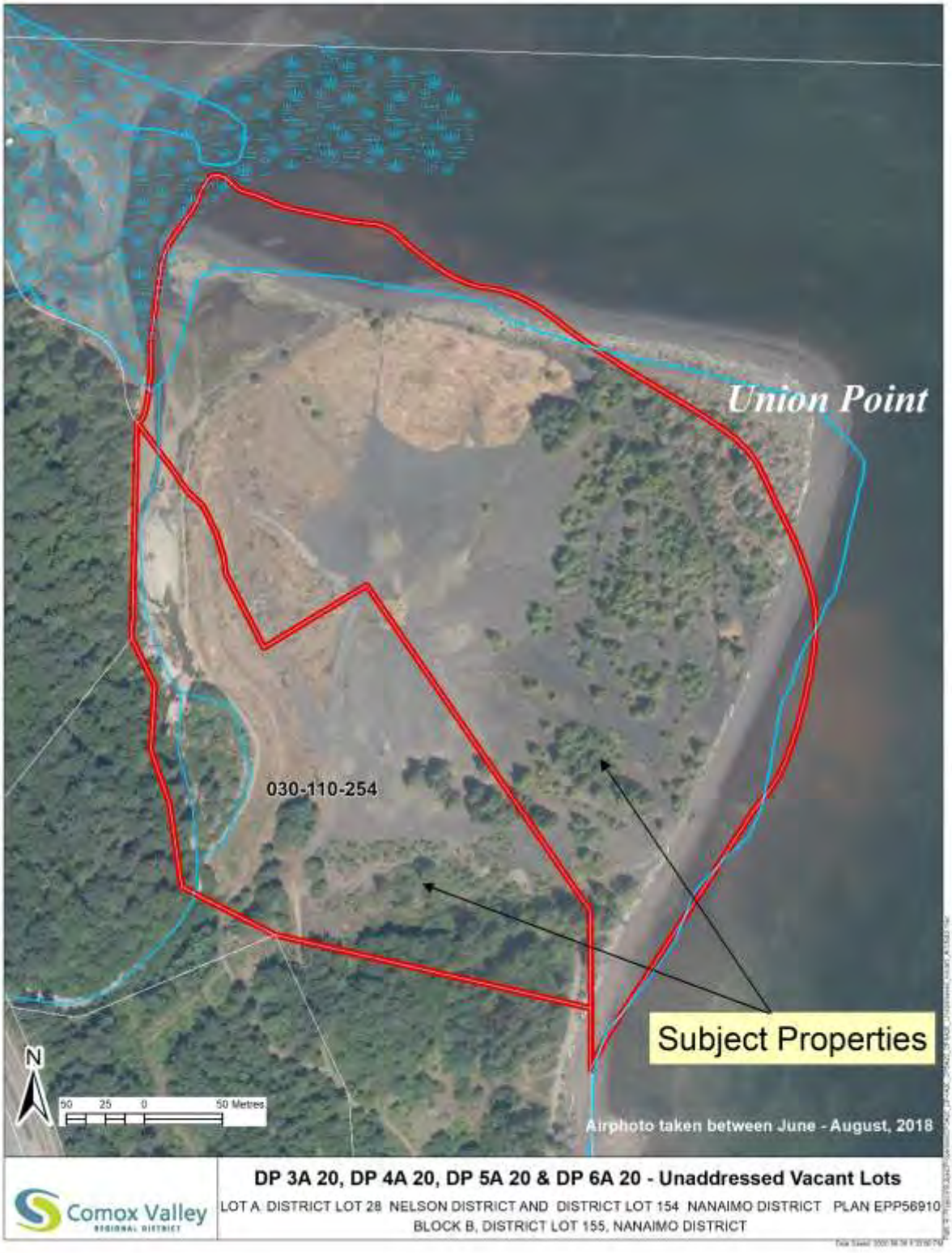

Figure 2: Air Photo

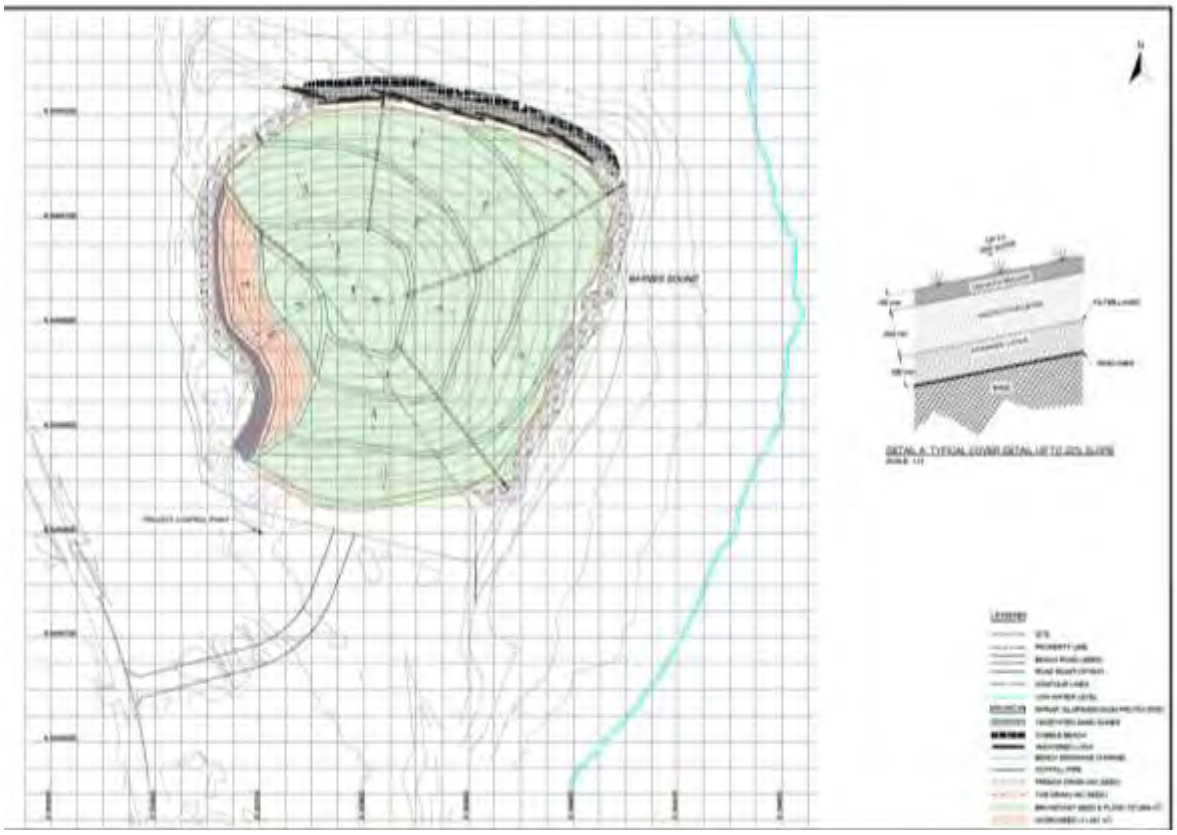

Figure 3: Proposed Final Site Plan

Keystone Environmental
Knowledge-Driven Results

May 13, 2020

Ms. Brianne Labute
Policy and Planning Analyst
Comox Valley Regional District
600 Comox Road
Courtenay, BC V9N 3P6

Dear Ms. Labute:

Re: Supporting Documents for Development Permit Application
Remediation Works for Union Bay Coal Pile
Union Bay, BC
Our Project No.: 13470

Please find attached the supporting documents for the Development Permit (DP) application for the Remediation Works of the Union Bay Coal Pile in Union Bay, BC (the Site), in accordance with the requirements of the Rural Comox Valley Official Community Plan (Bylaw No.337).

The legal plan for the Site is attached to this letter as Attachment H. The title certificates for the Site is attached to Attachment I. The letter of appointment from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR), the registered owner of the Site, is attached in Attachment K. A Site Profile already exists for the site (current Site ID No. 23289, formerly filed under Site ID No. 4291, Victoria/Regional File: 26250-20/4291). The attached Site Registry Report in Attachment J was obtained on January 16, 2020.

The Cumberland coal mine developed Union Bay as a port for processing mined coal. Cumberland transported the rock and low-grade coal as slurry down a metal lined flume, which settled out at the end of Union Point to form the existing Coal Pile. Cumberland deposited approximately one million cubic metres of low-grade coal and rock on the near shore and intertidal zone at Union Bay. The Coal Pile occupies approximately 13 hectares of Crown Lease land. Environmental investigations found the discharge from the Coal Pile to the marine environment contained acidity, sulphate, various dissolved metals and other elements, and toxicity testing of groundwater and seep water indicated high toxicity to marine organisms tested (i.e., fish, sand dollars, sea urchins and mussels) with iron being the primary toxicant.

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The purpose of the Remediation Works is to achieve improvement of the receiving environmental conditions surrounding the Coal Pile. Improvement of these conditions is anticipated to be achieved by reducing infiltration of precipitation through the Coal Pile with the installation of an engineered cover, consisting of low-permeability bituminous geomembrane (BGM) liner and vegetated soil cover and vegetated geocell in areas of steeper slopes.

The nature and development of the remediation works are complex. The overall design of the remediation works is presented in the attached report titled "*Detail Design Plan, Remediation Works, Union Bay Coal Pile, Union Bay, BC*" (Attachment A). Additional supporting documents are also attached as required under Bylaw No. 337.

As defined in Bylaw No. 337, the proposed Remediation Works at the Site fall under three DP areas:

- Aquatic and riparian habitat – the proposed remediation works is located within 30 m of Hart Creek and Baynes Sound.
- Shoreline protection devices – the proposed remediation works includes installation of shoreline protection devices to protect the engineered cover along Hart Creek and Baynes Sound.
- Steep slopes area (hazardous conditions) – a portion of the remediation works is located on an area with greater than 30% slope for a vertical distance of more than 3 m.

The following sections are presented to guide the CVRD in finding the relevant information for the development permit application process for these particular DP areas.

1. AQUATIC AND RIPARIAN HABITAT DEVELOPMENT PERMIT AREA REQUIREMENTS

Requirements	Document Reference	Notes
Biophysical Assessment		
Site Plan	Attachment B: Biophysical Assessment Appendix A Drawing 20-13470-CVRD-01	
Project Description	Attachment B: Biophysical Assessment Section 2, Section 8	Project refers to coal pile remediation works described in Section 2; additional habitat offsetting works described in Section 8.
Development Alternatives	Attachment B: Biophysical Assessment Section 2	Green Shores™ soft shoreline approaches used where possible.
Sensitive Feature Inventories	Attachment B: Biophysical Assessment Section 4.5 Section 9 and Appendix E	Sensitive features include the Hart Creek riparian zone and vegetated buffer. Critical habitat not identified at Site.
Assessment of Impacts	Attachment B: Biophysical Assessment Section 5	
Measures to Preserve / Protect / Enhance	Attachment B: Biophysical Assessment Section 6	
Erosion and Sediment Control Measures	Attachment B: Biophysical Assessment Section 6 and Appendix F Attachment A: Detail Design Plan Appendix A: CEMP Section 5.6 and Appendix A and Appendix F, Section 313800	
Planting Plan	Attachment B: Biophysical Assessment Section 9 and Appendix A	
Detailed riparian area assessment	Attachment B: Biophysical Assessment Appendix E	Applies to non-tidal portions of Hart Creek.
Post-Construction Recommendations	N/A	To be provided within 60 days of Project completion

Requirements	Document Reference	Notes
Site Design		
Site Design	Attachment B: Biophysical Assessment Section 2 and Appendix A	
Vegetation Buffer		
Landscape / Planting Plan	Attachment B: Biophysical Assessment Section 9 and Appendix A	
Buffer around sensitive features	Attachment B: Biophysical Assessment Section 9 and Appendix A	
Replanting to separate sensitive habitat from development	Attachment B: Biophysical Assessment Section 9 and Appendix A	
Removal of invasive from buffer	Attachment B: Biophysical Assessment Section 9 and Appendix A	
Retention of large woody debris	Attachment B: Biophysical Assessment Section 9	
Rainwater treatment pond and engineered wetlands	N/A	Remediation works do not include treatment pond or engineered wetlands.
Site Drainage Plan		
Site Drainage Plan	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14 to 20	Surface runoff will be collected and conveyed via lateral surface swales, longitudinal sub-surface piping (French drains), and perimeter sub-surface piping (toe drains) to the discharge points. The swales will incorporate detention features such as vegetation and check dams in order to decrease discharge flow rates to the receiving watercourse and environment. Infiltrated flows will be detained and conveyed through the Drainage Layer which will be connected to the longitudinal and perimeter sub-surface piping to the discharge points.

Requirements	Document Reference	Notes
Driveways, parking areas, and pathways	N/A	No proposed driveways, parking areas, and pathways are included in the remediation work. Access road to the Site was constructed in 2019 and will be completed in 2020.
Contour alterations	Attachment A of this letter – Detail Design Plan – Drawings 18-13470-04 through 18-13470-06.	The grading plan has been developed to limit coal pile disturbance and subsequently reduce the buried unspent coal exposure to the atmosphere. Therefore, the grading plan profile will be generally consistent with the existing coal pile profile, which is a parabolic dome, with an off-centred apex. The total area to be graded, as delineated by the black dashed outline in Dwg 18-13470-05, is approximately 111,200 square meters. Approximately 75% of this area will require minor grading (less than ± 1 m elevation adjustment).
Impervious surface area	Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD) – Section 5 Pre and Post Remediation Condition Numerical Model	The Remediation Works does not incorporate hard, impervious surface, such as asphalt pavement or concrete. Although the BGM liner is placed to reduce the infiltration of precipitation through the Coal Pile, the remediation plan includes absorbent landscaping above the liner to provide flow quantity control. This absorbent landscaping includes 900mm of vegetated soil cover, which provides stormwater retention through the Cover System, such as evaporation-transpiration and interflow.

2. SHORELINE PROTECTION DEVICES

Requirements	Document Reference	Notes
BCLS Recent Survey		
BCLS recent survey	Attachment G of this letter – Drawing 20-13470-DP-01	
Detailed Design of the Shoreline Protection Devices		
Necessity of the proposed devices	Attachment F of this letter – Union Bay Coal Pile Green Shores Design	The east facing shoreline is exposed to significant wave action from Baynes Sound and is recommended to be a riprap structure. Significant wave heights along the east shoreline are estimated to range from 0.92 m to 1.57 m in a 200-year storm event. The largest waves during a storm will be between 1.8 and 3.1 metres in height. Wave action of this magnitude categorizes as a severe wave exposure. Only a manmade structure or shore protection, e.g., in the form of large rock would be able to withstand this level of wave exposure. The north shoreline is slightly more resilient to wave action than the eastern shoreline due largely to the direction of wave approach to shore. The shoreline profile is very wide and flat in this area and receives much of the coarser sediments from Hart Creek, which helps offset loss of sediments due to wave erosion. During storm conditions and high-water levels due to storm surge and/or high tides, the wave exposure along the northern shoreline can be nearly as severe as for the eastern shoreline. The recommended solution that can provide a stable protection of the shoreline is a cobble beach type protection. For the west side of the coal pile, Hart Creek meanders along the toe of the coal pile, at times located nearby the limits of the property to the west of the pile. Observed site conditions along Hart Creek indicate the impact of high creek flows have eroded the existing banks. For the Hart Creek shoreline, evaluation of soft shoreline design alternatives also considered the level of design and associated maintenance and repair. Due to the close proximity of the creek to the adjacent property to the west, it is recommended that shoreline improvement would be located such that the existing creek flow cross sectional area be maintained.

Requirements	Document Reference	Notes
Evaluation of potential negative impacts to environment and adjacent properties, mitigation recommendations	Attachment F of this letter – Union Bay Coal Pile Green Shores Design	
Description of construction details, materials, methods	Attachment A of this letter – Detail Design Plan – Section 5.3 Slope Protection Plan Attachment A of this letter – Detail Design Plan – Drawings G-001 through G-008 Attachment A of this letter – Detail Design Plan – Appendix F – Sections 310516, 313710, and 313800	The shore protection design incorporates soft shore (i.e., Green Shore) principles. The northern portion of the Coal Pile includes anchored logs, vegetated sand dunes, and a cobble beach area. The eastern and western sides of the Coal Pile require rip rap based on the environmental loads and effects; however, the voids of the rip rap will be planted.
Inspection details of the proposed works to be conducted by an engineer qualified to carry out shoreline protection device design (during construction)	Attachment A of this letter – Detail Design Plan – Drawings G-002 and G-003	
Inspection details of the proposed works to be conducted by an engineer qualified to carry out shoreline protection device design (post-construction)	Attachment E – Post-construction Monitoring Plan – Attachment 2 Moffatt & Nichol Post Construction Monitoring of Shoreline Protection	
Biophysical Assessment (see Section 1 Aquatic and Riparian Habitat Development Permit Area Requirements)		
Landscape Plan (see Section 1 Aquatic and Riparian Habitat Development Permit Area Requirements)		

Requirements	Document Reference	Notes
Archaeological Assessment		
Archaeological Assessment	Attachment C of this letter - Archaeological Impact Assessment Attachment C of this letter - Archaeological Investigations at DjSf-25 and DjSf-26	
Post Development Compliance Report		
Post Development Compliance Report	N/A	Post Development Compliance Report will be prepared at the completion of the works

3. STEEP SLOPES DEVELOPMENT PERMIT AREA (HAZARDOUS CONDITIONS)

Requirements	Document Reference	Notes
Site Survey		
Site Survey	Attachment A of this letter – Detail Design Plan – Drawings 18-13470-02	
Slope Analysis	Attachment G of this letter – Drawing 20-13470-DP-02	
Geotechnical Report		
Existing surface and subsurface conditions (soil depths, groundwater levels, depth to rock)	Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Geotechnical Report (February 25, 2020) – Section 4 Subsurface Conditions	
Existing surface and subsurface conditions (slope stability)	Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Geotechnical Report (February 25, 2020) – Section 5.2 Slope Stability Analysis Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Revised Slope Stability (June 1, 2018) Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Revised Slope Stability (November 22, 2018)	
Suitability for reuse of existing soils and rock including optimal moisture content, maximum angle of repose	Attachment D of this letter - Field Density Report Nuclear Densometer Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Geotechnical Report (February 25, 2020) – Section 5.2 Slope Stability Analysis	

Requirements	Document Reference	Notes
Hazards (Liquefaction)	Attachment A of this letter – Detail Design Plan – Appendix G Geopacific Geotechnical Report (February 25, 2020) – Section 5.3 Liquefaction Analysis Attachment A of this letter – Detail Design Plan – Appendix C Densification	Gravel columns are proposed for ground densification at the north and east ends of the Coal Pile due to the presence of potentially liquefiable sands. A ground densification analysis was completed to determine the required width of the densification ("seismic berm") to mitigate lateral spread and to provide a densification specification, indicating densification methods and performance requirements. The Contractor will densify the soils beneath the specified areas to a minimum Electronic Piezo-Cone Penetration Tip Resistance (qc). The performance specification allows a Contractor to specify the gravel column spacing, diameter, and equipment requirements that they require to achieve the performance specification. The specification indicates that ground improvement is required from 1 metre below finished grade to a depth of -10 metre geodetic elevation. From 0 to 1 m below finished grade, beach sand will be placed.
Hazards (Storm surge, sea level rise, creek run-off, waves)	Attachment A of this letter – Detail Design Plan – Appendix E Moffatt & Nichol Shoreline Protection Design – Section 2.7	The proposed shoreline protection is designed to protect the toe of the engineered cover from erosion due to the creek run-off, tidal and wave actions.
Potential impacts of development	Remedial Options Feasibility Report, Union Bay Waste Coal Pile, Union Bay, BC – Sections 9.5 Cover Only	Document reference available upon request Based on a one-dimensional numerical modelling, the engineered cover will reduce infiltration through the coal pile to less than 1% of the mean annual precipitation (baseline condition 515 mm/year) and reduce iron concentration on the foreshore area (baseline average of 233 mg/L) to less than 5 mg/L in 2 years.
Erosion control and mitigation measures during construction	Attachment A of this letter – Detail Design Plan – Appendix A CEMP – Section 5.6 and Appendix A Erosion and Sediment Control Plan	

Requirements	Document Reference	Notes
Erosion control and mitigation measures after construction	Attachment E of this letter - Post-Construction Monitoring Plan – Sections 2.1 and 2.2	
Recommendations for safety, site protection, development and mitigation	Attachment A of this letter – Detail Design Plan – Appendix F – Sections 013523, 013526, and 015713	
Recommendations for vegetation protection, enhancement or retention	Attachment E of this letter - Post-Construction Monitoring Plan – Sections 2.1.3	
Siting plan for buildings and other structures, utilities, services and impervious surfaces	N/A	Remediation works do not include proposed buildings or other structures, utilities, services and impervious surfaces
Plans and analyses for watercourse channelling and drainage systems	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14 to 20 Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD)	Remediation works do not include proposed watercourse channelling.
Measures to safeguard adjacent properties and structures	Attachment A of this letter – Detail Design Plan – Appendix F – Sections 013526 and 015713	
Grading Plan		
Existing topography	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-02	
Proposed topography and limit of grading	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-09	
Cross sections	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-10	
Cut and fill areas	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-05	

Requirements	Document Reference	Notes
Rainwater Management Plan		
Water quality characteristics of proposed flows and suggestions of appropriate methods to deal with any quality concerns	Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD) – Section 2.2 Quality Control Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14 to 20	Quality control will be provided through the implementation of a vegetated cover, check dams, sub-surface piping, and armouring (riprap protection) at inlet and discharge points. Swales will be vegetated, and check dams will be placed every 25 m to slow the runoff down prior to entering the longitudinal French drains. These swales provide water quality improvements through infiltration and filtering.
Catchment areas	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-13	
Flow routes	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14	
Drainage capacities	Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD) – Appendix A Summary of Stormwater Calculations	
Designated flood level	Attachment A of this letter – Detail Design Plan – Appendix E - Moffatt & Nichol Shoreline Protection Design – Section 2.7.7	
Quality Constraints	Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD) – Section 2.2 Attachment A of this letter – Detail Design Plan – Appendix A CEMP – Section 5.6 and Appendix A Erosion and Sediment Control Plan Attachment A of this letter – Detail Design Plan – Appendix F – Section 313800	Minimal change to stormwater quality under the proposed conditions (total suspended solids source loading, pH, or additional contaminants) is anticipated compared to existing conditions. Quality control will be provided through the implementation of a vegetated cover, check dams, sub-surface piping, and armouring (riprap protection) at inlet and discharge points. Prior to the start of construction of the remediation and until the vegetation has fully established, erosion and sediment control measures should be implemented to provide quality control.

Requirements	Document Reference	Notes
Hydraulic Constraints	Attachment A of this letter – Detail Design Plan – Appendix H Stormwater Management Detail Design (SWMDD) – Section 2.1	The quantity control measure will maintain existing drainage patterns where possible and will control the peak post-remediation stormwater flows for the 1-in-100-year design storm. The stormwater management strategy to provide quantity control is to use absorbent landscaping which provides stormwater retention through the Cover System, such as evaporation-transpiration and interflow. The proposed remediation works includes absorbent landscaping within a 900 mm Cover System. Surface runoff will be collected and conveyed via lateral surface swales, longitudinal sub-surface piping (French drains), and perimeter sub-surface piping (toe drains) to the discharge points. The swales will incorporate detention features such as vegetation and check dams in order to decrease discharge flow rates to the receiving watercourse and environment. Infiltrated flows will be detained and conveyed through the Drainage Layer which will be connected to the longitudinal and perimeter sub-surface piping to the discharge points. The stormwater management infrastructure has been designed to meet the 1-in-100-year, 24-hour storm event. Based on the effects of climate change the design of the stormwater management infrastructure, swales, French drain, toe drain, and outfalls can convey the increase in flow due to climate change. The proposed stormwater management infrastructure are located above the designated flood level plus 0.8 m of free board. When and if the wave action or flood level exceeds the outfall elevation, the water will inundate the outfall pipe. This will likely cause the backup of water in the toe drain system. This backup is temporary in nature and under severe storm events, most of the water will be draining off the surface onto the riprap.

Requirements	Document Reference	Notes
Rainwater routing using piped and open systems	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14	
Rainwater controls for infiltration or groundwater recharge	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14	On slopes less than 20%, infiltration of rainwater will be limited to 900 mm below final grade, above the BGM liner, and will not contribute to groundwater recharge. Rainwater that infiltrates through the soil cover above the BGM liner will be directed towards the French drains and discharged through one of the outfalls. On slopes greater than 20%, infiltration of rainwater will be limited within the geocell above the BGM liner and will not contribute to groundwater recharge. The surface runoff and infiltrated rainwater in this area will discharge to the riprap to Hart Creek.
Impacts of irrigation on short/long term stability of slopes	N/A	Occasional irrigation with water spray truck may be conducted within the first 60 days of seeding. Irrigation will be carried out to avoid dry periods of five days or greater and ensure sufficient watering to prevent grass and underlying growing medium from drying out (saturate to 100 mm soil depth). Water used for irrigation purposes will be controlled to prevent water ponding or runoff that may erode soils. This short-term irrigation is not expected to impact the stability of any slope. Long-term irrigation is not planned for the Site.
Protection of drainage swales and major event flow routes	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-17 and 18	The following measures will be put in place to protect drainage swales from erosion: Swales will be vegetated The average swale slope is 2%, which resulted in a maximum stormwater flow velocity of 0.76 m/s in the swale Check dams will be placed every 25 m along the swales French drain and toe drain trench will be filled with drain rocks for protection.

Requirements	Document Reference	Notes
Proposed roof and footing drains for individual lots, on-site treatment or connections to storm sewers	Attachment A of this letter – Detail Design Plan – Section 5.2.2	The remediation works will not include any roof or footing drains, on-site treatment, nor connections to storm sewers. A 300 mm thick granular drainage layer will be placed immediately above the BGM liner. The drainage layer is continuous throughout the proposed cover and will follow the proposed contours of the cover material. A different configuration using geocells will be installed on areas with slopes exceeding 20%. Swales along the bench road are designed to break the flow along the slope of the coal pile, on and below the surface of the cover material. Precipitation that infiltrates through the absorbent landscaping and enters the drainage layer will encounter the bottom of the swale and bench road. Due to preferential pathways, the water in the drainage layer at the bench road, will likely follow the swale slope towards the French drain. The drainage layer is directly connected to the French drain. This design will minimize the inundation of the downhill portions of the drainage layers.
Proposed means of controlling short term erosion	Attachment A of this letter – Detail Design Plan – Appendix A CEMP – Section 5.6 and Appendix A Erosion and Sediment Control Plan Attachment A of this letter – Detail Design Plan – Appendix F – Section 313800	For short-term erosion protection, the site Contractor is required to develop a site-specific Erosion and Sediment Control (ESC) plan for the various stages of remediation works that meet the requirements of the construction environmental management plan (CEMP). The objective of the ESC is to minimize sediments from migrating from the Coal Pile. The ESC plan will be required to clearly outline the applicable regulations, construction timing, monitoring requirements, Contractor responsibilities with respect to sampling, maintenance, mitigation measures and decommissioning.
Proposed means of controlling long-term erosion (engineered cover system)	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-23 Vegetation and Seeding Plan	Most of the surface of the cover system will be vegetated for long-term erosion protection. The areas that are not vegetated include the French drain and toe drain trenches that are filled with drain rocks and along the shoreline.

Requirements	Document Reference	Notes
Proposed means of controlling long-term erosion (shoreline)	Attachment A of this letter – Detail Design Plan – Drawing G-001 through G-008	For shoreline protection, the northern portion of the Coal Pile includes anchored logs, vegetated sand dunes, and a cobble beach area. The eastern and western sides of the Coal Pile require rip rap based on the environmental loads and effects; however, the voids of the rip rap will be planted.
Hydrogeological considerations (existing condition)	Remedial Options Feasibility Report, Union Bay Waste Coal Pile, Union Bay, BC – Section 3	Document reference is available upon request. Discussion on site climate, geology, hydrogeology, tidal influence, groundwater flow models, Hart Creek flows, groundwater chemistry, delineation, and groundwater geochemistry were presented in the document reference.
Monitoring of groundwater regimes	Attachment E of this letter – Post-construction Monitoring Plan – Section 2.3 Intertidal Stain Area Monitoring	Monitoring of the groundwater regime will initially be conducted by visual inspection of the spatial extent of the iron staining. If staining appears to be increasing in size, groundwater monitoring program will be implemented on a semi-annual basis. Contingency measures will be considered if condition continue to worsen after 5 to 10 years.
Energy dissipation into existing ravines at source and down slope where concentration or erosion may occur	Attachment A of this letter – Detail Design Plan – Drawing 18-13470-14 and 20 Attachment A of this letter – Detail Design Plan – Drawing G-001 through G-008	Surface runoff discharge over the cover system will be directed to five outfall locations. The down-gradient area of these outfalls is protected by riprap.

We trust that this is the information you require at this time. Should you have any questions, please contact the undersigned.

Sincerely,

Keystone Environmental Ltd.

Dave Langill, R.P.Bio.
Biologist

Richard Johns, P.Eng.
Department Head, Engineering

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ATTACHMENTS:

- Attachment A: Detail Design Plan, Remediation Works, Union Bay Coal Pile, Union Bay, BC
- Attachment B: Biophysical Assessment, Union Bay Coal Pile Remediation Project, Union Bay, BC
- Attachment C: Archeological Works
- Attachment D: McElhanney Field Density Report Nuclear Densometer
- Attachment E: Post-Construction Monitoring Plan
- Attachment F: Union Bay Coal Pile Green Shores Design
- Attachment G: Drawings
- Attachment H: Legal Plan
- Attachment I: Land Title Certificates
- Attachment J: Site Registry
- Attachment K: FLNR Letter of Appointment

Keystone Environmental
Knowledge-Driven Results

Detail Design Plan
Remediation Works

Union Bay Coal Pile
Union Bay, BC

Prepared for: West Fraser Mills Ltd.

Project No. 13470
March 19, 2020

Environmental Consulting • Engineering Solutions • Environmental Planning

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EXECUTIVE SUMMARY

West Fraser Mills Ltd. (West Fraser) retained Keystone Environmental Ltd. (Keystone Environmental) to provide a detailed engineering design (Detail Design) for an Engineered Cover system for the Union Bay Coal Pile (Coal Pile) in Union Bay, BC. The desired outcome of the Coal Pile remediation is 'improvement over time' of the receiving environment conditions. The improvement is achieved by reducing precipitation infiltration through the Coal Pile with the installation of a bituminous geomembrane liner (BGM) and engineered soil cover over the Coal Pile. This design includes an effective, durable cover system that is to be constructed at the Coal Pile. Keystone Environmental has designed a detail design plan to improve the receiving environment over time within the following sections and appendices:

- Site preparation;
- Base Grading;
- Engineered cover design comprising a BGM liner, Drainage Layer, Filter Layer, Protection Layer and Growth Medium;
- Slope Protection Plan (Riprap design and cover/riprap interface);
- Storm Water Management Plan;
- Erosion and sediment control plan;
- Densification Design;
- Access Road Design;
- Vegetation Plan;
- Monitoring Wells;
- Construction Environmental Management Plan; and
- Drawings and Specifications.

This Executive Summary is subject to the same general limitations as contained in the report and must be read in conjunction with the entire report.

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LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
BC ENV	British Columbia Ministry of Environment and Climate Change Strategy
BGM	Bituminous Geomembrane
BMP	Best Management Practices
CEMP	Construction Environmental Management Plan
CSA	Canadian Standards Association
DA	Drainage Area
DFL	Designated Flood Level
D.L.	District Lot
DNA	David Nairne + Associates Ltd.
DP	Discharge Point
ESC	Erosion and Sediment Control
HDPE	High Density Polyethylene
HHWLT	Higher High Water Large Tide
IDF	Intensity-Duration-Frequency
KIP	Kensington Island Properties
M&N	Moffatt and Nichol, Inc.
MW	Monitoring Well
NBC	National Building Code
Province	BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development
RCP	Reinforced Concrete Pipe
RSLR	Relative Sea Level Rise
SPMDD	Standard Proctor Maximum Dry Density
SLR	Sea Level Rise
SROW	Statutory Right-of-Way
SS	Storm Surge

1. INTRODUCTION

This report presents the detail design plan for the remediation of the Union Bay Coal Pile (Coal Pile). The Coal Pile is located in Union Bay, BC, which is on the eastern shore of Vancouver Island, approximately 13 kilometers (km) south of Courtenay and 118 km north of Nanaimo (Drawing 18-13470-01). The Coal Pile is on a point of land that extends into Baynes Sound, a marine water body connected with the Strait of Georgia but protected by Denman Island. The Coal Pile is located on provincial Crown Land bounded by Baynes Sound to the east and north, Hart Creek to the west and private lands to the south. The BC Ministry of Environment and Climate Change Strategy (BC ENV) Site identification number is 4291. The Site consists of the area commonly known as the Union Bay Coal Pile and comprises parts of:

- District Lot 155, Nanaimo District
- District Lot 154, Nanaimo District
- District Lot 28, Nelson Land District

1.1 Site Background

The Cumberland coal mine (Cumberland) developed Union Bay as a port for processing mined coal. Cumberland transported the rock and low-grade coal as slurry down a metal lined flume, which settled out at the end of Union Point to form the existing Coal Pile. Cumberland deposited approximately one million cubic metres of low-grade coal and rock on the near shore and intertidal zone at Union Bay. The Coal Pile occupies approximately 13 hectares of Crown Lease land as outlined on Drawing 18-13470-02. Several consultants completed environmental investigations at the Coal Pile between 2005 and 2017.

1.2 Regulatory Framework

The regulations applicable to the detailed design portion of the Coal Pile remediation work remain essentially the same as those administered in April 2012, the date of the Keystone Environmental Remedial Options Feasibility Report [1]. A list of those applicable statutes, guidelines and regulations as well as reference documents that apply to the Coal Pile can be found in the April 2012 report [1].

2. SCOPE OF WORK

The site history, previous land use and previous investigations up to 2011 were presented in the April 2012, Keystone Environmental Remedial Options Feasibility Report [1]. Keystone Environmental screened and evaluated applicable remedial technologies, and ultimately a bituminous geomembrane liner (BGM liner) with a vegetated soil cover was selected. Various other reports were completed by Keystone Environmental and other consultants. The Coal Pile cover objective was "*to most effectively achieve a reduction in acid and contaminant loadings…to reduce oxygen access and infiltration.*" [1]

This Detail Design Plan is consistent with, and builds upon, the April 2012 Remedial Options Feasibility Report [1]. It presents the detailed engineering design for the selected remedial technology (i.e. BGM liner and vegetated soil cover). This document sets out the design drawings and specifications, and addresses the following:

- Site preparation including clearing, grubbing and grading;
- Sub-grade and base preparation;
- Cover/cap design including geomembrane and bituminous liner [collectively the BGM liner] drainage layer, soil layer and growing medium and vegetation;
- Geomembrane and bituminous liner [collectively the BGM liner] specifications, handling, installation, joints, repair during construction and testing;
- Drainage plan;
- Riprap design and cover and riprap interface;
- Erosion and sediment control plan; and
- Monitoring well design.

Other ancillary items include:

- Retaining a general contractor (Contractor) to construct the access road and laydown (staging) area;
- Obtaining regulatory permits; and
- Providing periodic written status reports to the BC Ministry of Forest, Lands, Natural Resource Operations & Rural Development (the Province) during construction.

3. SITE CHARACTERISTICS SUMMARY

The Coal Pile site characteristics summary was included in the 2012 Keystone Environmental Remedial Options Feasibility Report [1]. The following characteristics were discussed:

- General site description and topography,
- Climate and Meteorology,
- Geology/stratigraphy,
- Hydrogeology and water balance,
- Geochemistry, and
- Geotechnical.

Drawing 18-13470-03 shows the BGM liner extent, soil cover extent (which includes the drain rock transition area), topography and surrounding bathymetry, proposed access road, densification area, geocell slope stabilization area, riprap erosion and slope protection, venting extent, and drainage features such as French drains, toe drain swales, outfalls and culverts. The access road construction is anticipated to be completed prior to the other aspects of the remediation works, and therefore the access road design drawings are appended in Appendix B and are not included in the design drawing package.

Site climate, geology, hydrogeology, tidal influence, groundwater flow models, Hart Creek flows, groundwater chemistry, delineation, and groundwater geochemistry were presented in the Keystone Environmental 2012 report [1]. The geochemical characteristics of the Coal Pile is unusual compared to typical construction projects. The material has the potential for acid generation and metal leaching.

In May 2017, Keystone Environmental completed a Baseline Investigation and further geotechnical studies to assess the current Coal Pile conditions as previous information was from 2010 [2] [3]. In the Baseline Investigation Keystone Environmental obtained groundwater quality data from existing monitoring wells. The analytical results were consistent with previous accounting for minor temporal and spatial variability. Hence, the design based on the 2010 data was continued based on the 2017 data. Unless otherwise specified, assumptions stated in the Remedial Options Feasibility Report [1] remain valid and were carried forward into this Detail Design Plan.

GeoPacific Consultants Ltd. (GeoPacific) provided guidance on potential settlement following cover placement, maximum safe slope angles under static and seismic conditions, liquefaction mitigation design options, and access road compaction [4]. GeoPacific's study is provided in Appendix G.

4. REMEDIATION OBJECTIVE AND DESIGN CRITERIA

The Coal Pile project remediation objective is outlined in the Remedial Options Feasibility Report [1], where Keystone Environmental identified that the selected remedy was a BGM liner with a vegetated cover. This section provides an overview of the design objective and the key design criteria that were used during detailed design.

4.1 Design Basis and Objective

The desired outcome of the Coal Pile remediation is 'improvement over time' of the conditions at the receiving environment. The improvement is achieved by reducing precipitation infiltration through the Coal Pile by the installation of a BGM liner and soil cover over the Coal Pile. The design includes an effective, durable cover system that is able to be constructed at the Coal Pile. The cover is designed to prevent vegetation from contacting contaminated material or groundwater and therefore no new operable pathways will be introduced in the cover area.

4.2 Design Criteria

4.2.1 Base Grading

The base grading plan was developed to minimize coal pile disturbance and subsequently reduce exposure to potentially acid generating coal material. The grading plan will consider installation of the BGM liner roll lengths, anchor trench requirements, and overlap requirements, and therefore the maximum slope length will be 77 m.

Following grading, the majority of the Coal Pile is to have a slope less than 20% with the exception of the west side near Hart Creek that is up to a maximum slope of 40%. The Coal Pile is to be graded to promote surface drainage towards the pile perimeter and prevent water ponding, and will have a minimum slope of 1.5% to 3%.

4.2.2 Climate Data

Site-specific climate data is not available, and therefore data from the COMOX-A weather station was used to assess climatic conditions. The COMOX-A weather station is located at the Comox Airport, approximately 14 km north of the Site. The Intensity-Duration-Frequency (IDF) curve for this weather station is obtained from Environment Canada, utilizing 40 years of historic data from 1963 to 2006.

The stormwater management infrastructure and the drainage layer are designed for a 1-in-100-year, 24-hour storm event. Climate change assessment to the impacts to the stormwater management infrastructure is also conducted.

As result of climate change, the BC ENV has estimated that the average annual precipitation is expected to increase 2% to 12% by 2050, with increased frequency and intensity of heavy precipitation [5], and therefore the effects of climate change should be taken into account where applicable. The Capital Regional District, also predicts the largest increase in rainfall to occur in the fall season, increasing 11% by 2050 and 21% by 2080 [6].

4.2.3 Permeability of Cover

It is expected that the liner and associated cover system will reduce infiltration through the Coal Pile to less than 1% of mean annual precipitation [1].

4.2.4 Materials

The coal material has a high soluble sulphate content making it prone to break down a standard mix concrete; therefore, concrete used on-Site is required to satisfy Exposure Class S-1 (Canadian Standard Association) [4]. In addition, polyester grids in contact with the waste coal are not recommended for geogrid reinforced retaining walls, if used [4].

4.2.5 Cover Capacity

The vegetated area within the final cover system and post-construction maintenance access roads and culverts on the cover area are to be designed for a 1-ton pick-up truck for maintenance. The gross vehicle weight of a 2019 Ford F-350 has been used in design calculations (i.e. 6,500 kg weight, ground pressure 24 kPa).

4.2.6 Slope Stability

In their September 2017 geotechnical report, GeoPacific recommended that the final grading have finished slopes not exceeding 2.3H to 1V (23.5 degrees), however if steeper grades are required, that additional stability measures be considered [4].

The seismic design criteria include employing the 1/475 and 1/2475 return period design earthquakes defined by the 2015 National Building Code (NBC) and based on the following performance criteria [4]:

- 1 in 2475-year event “no collapse” criteria.
- 1 in 475-year event: deformations permissible, but the cap remains functional.

The peak ground acceleration (PGA) in the Union Bay area during the 2015 NBC 1/2475 and 1/475 design earthquakes is 0.33g and 0.22g, respectively. GeoPacific has employed 50% of the PGA in accordance with US Federal Highways Association (FHWA-SA-97-077) [4].

4.2.7 Shoreline Protection

Design criteria for shoreline protection is provided in Moffatt & Nichol’s Basis of Design, which is provided in Appendix E.

4.2.8 Stormwater Management Infrastructure

The primary objectives of the stormwater management design was to identify appropriate water quantity and quality control measures of the post-remediation stormwater runoff, manage the stormwater quality prior to discharge, and minimize erosion. Quality control will be provided through the implementation of a vegetated cover, check dams, sub-surface piping, infiltration in the toe drain, and armouring (riprap protection) at inlet and discharge points.

The following design criteria were used:

- Stormwater infrastructure (swale, French drain, toe drain, outfall) designed for the 1-in-100-year, 24 hour storm event.
- Precipitation data from Environment Canada's intensity-duration-frequency (IDF) curve for the Comox Airport (station Comox A, #1021830, 2014).
- Lateral swales: trapezoidal swale 1.5 m wide base, 1:1 side slopes, 1.8 m wide at top, maximum depth of 0.15 m, minimum 2% slope. Check dam placed every 25 m in the swale.
- French drain: 375 mm diameter, corrugated single wall HDPE perforated pipe, ASTM D2412, embedded in a 0.9 m depth and 0.75 m width drain rock trench above the BGM liner, and minimum slope of 4%
- Drain rock: 25 mm rounded clean drain rock
- Culverts at French drain and bench road crossing: 525 mm diameter Class IV RCP
- Toe drain: 600 mm diameter, corrugated HDPE perforated pipe, CSA 182.8, embedded in a 1.2 m depth x 1.2 m width drain rock trench., and minimum slope of 0.5%
- Outfall pipe: 600 mm diameter HDPE pipe, CSA 182.8.
- Culverts at outfall pipe and riprap armouring: 750 mm diameter RCP, Class IV, Type V RCP
- Numerical model design assumptions:
  - Design storms used in numerical model based on SCS Synthetic Rainfall Distribution (Type 1A 24-hr)
  - Design of toe drain:
    - Porosity of drain rock = 0.40
    - Exfiltration rate = 210 mm/hr
    - Embedded perforated pipe size = 0.6 m
  - Curve number: Pre-remediation = 69 (HSG B), Post-remediation = 89 (HSG D)
  - Time of concentration based on sheet flow for the first 30 m of flow path (roughness coefficient (n) of 0.13), shallow concentrated flow (n = 0.022), channel, and pipe flow (n = 0.02), where applicable.
  - Antecedent Moisture Condition (AMC) = 2

4.2.9 Access Road

The Access Road design has the following design criteria, and will be constructed under a separate scope prior to the remediation works:

- Length: Approximately 320 m, dual lane
- Surface treatment: gravel
- Stormwater runoff: Comply with the Guidelines for Mine Haul Road Design
- Number of trucks total:
- Option 1: 5,000 rock trucks in and 5000 rock trucks out, or
- Option 2: 7,250 truck and transfers in and 7,250 truck and transfers out.
- Vehicle: Truck and Transfer or 745C Articulated Rock Truck
- Operating conditions: All weather
- Traffic speeds: 30 km/hr maximum
- Cul-de-sac (15 m turning radius) located just past statutory right-of-way.

5. DETAIL DESIGN

The following sections summarize the design components. The associated design drawings are appended to this report, and the specifications can be found in Appendix F.

5.1 Site Preparation

To prepare a proper foundation for the cover system installation, the Coal Pile will require clearing, grubbing and grading. Vegetation will be cleared and grubbed from the working surface of the Coal Pile in preparation for grading. The vegetation, after disposal of invasive plants, will be chipped and stockpiled for use to contribute organics content in the top-most Growth Medium layer.

Clearing and grubbing details are shown on Drawing 18-13470-02. Once the vegetation is removed, the Coal Pile base will be graded in preparation for the BGM liner.

5.1.1 Base Grading

With the vegetation removed, the coal surface will be cut, filled, graded and compacted. The primary purpose of the grading plan is to promote natural drainage towards the Coal Pile perimeter. The grading plan base layer is presented on Drawing 18-13470-04. Following grading, the majority of the Coal Pile will have slopes less than 20% with the exception of the west side near Hart Creek that is up to a maximum of 40% slope (Drawing 18-13470-05). The grading program was designed to limit the coal area being disturbed to minimize potential leachate generation. The cut and fill areas are presented on Drawing 18-13470-06. Prior to grading, the erosion and sediment control measures specified in the Construction Environmental Management Plan (CEMP) will be implemented to limit sediment-laden surface run-off during construction. During construction, Coal Pile surface benches (Drawing 18-13470-09) will be created for multiple purposes including:

- Construction vehicle access to:
  - Deliver and remove materials to the work zone,
  - Install anchor trenches, and
  - Allow post-remediation vehicle access.
- Create ditches alongside the benches that will decrease surface water run-off velocities during and post remediation.

During the cut and fill grading process, the type and size of subgrade materials will be limited to the BGM liner manufacturer's standards. Acceptable base materials consist of stones and rocks smaller than 25 mm diameter. Surface transitions shall be smooth and rounded with the final base surface graded level without protrusions. A bedding layer shall be spread over areas that are visually identified to potentially compromise the BGM liner integrity. The base shall be compacted to minimum 95% Standard Proctor Maximum Dry Density (SPMDD) [7].

Base completion is contingent on inspection and acceptance of the Engineer. Once the base is completed; the engineered cover will be installed.

5.1.2 Slope Stability Assessment

GeoPacific provided a slope stability assessment based on the grading plan and the proposed Engineered Cover system. In their summary letter (provided in Appendix G), GeoPacific indicated that the static stability of the cover system is sufficient, and that the conclusions from the previous seismic slope stability assessment [4] remain valid.

5.2 Engineered Cover

In areas where base grading is less than 20%, a conventional multi-layer Engineered Cover system has been designed. Starting from the base, the engineered cover consists of five layers (Drawings 18-13470-10, -11) with their respective thicknesses, as applicable:

1. BGM liner
2. Drainage Layer (300 mm thickness)
3. Filter Layer
4. Protection Layer (450 mm thickness)
5. Growth Medium (150 mm thickness)

The cover extent as shown on the design drawings (e.g. 18-13470-03) includes the transition area between the vegetated cover and the rip rap, which consists of drain rock fill.

A portion of the Coal Pile on the west side near Hart Creek has surface grades ranging from 25% to 40%. On this steeper slope, a geocell system will be used to hold the growth medium material in place on top of the BGM liner.

5.2.1 Bituminous Geomembrane (BGM) Liner

The Detail Design Plan will describe layers in the order that they will be constructed, from bottom to top. The BGM layer is the key component of the Engineered Cover in that it will minimize infiltration into the Coal Pile. BGM liner was selected as the infiltration barrier layer for its effectiveness, durability, constructability and longevity [7].

The BGM liner is made of a combination of needle punched, non-woven geotextile, glass reinforcement, and polyester geotextile impregnated and faced with bituminous mastic (mixture of bitumen and filler). BGM liner is reported to have a very low permeability of 10^{-14} m/s. The geotextile layer is encased by bitumen so chemical and biological processes are prevented from acting on it [7]. BGM liner can withstand tensile stress levels of 27 kN on average in the longitudinal direction and has shown to have a long service life based on case histories and laboratory testing [7] [8] [9]. The BGM liner warranty is for 20 years, but the operating life is anticipated to exceed this duration [9].

The cover design accounts for the Higher High Water Large Tide (2.00 m geodetic), the future sea level rise (1.00 m), the relative crustal uplift (-0.25 m), and the 1-in-200 year storm surge (1.25 m) for a designated flood construction level of 4.00 m. This provides an elevation basis of the cover toe for the west, east and north sides of the Coal Pile, adjacent to Baynes Sound and

the tidally influenced Hart Creek. The liner edge is set above the Higher High Water Large Tide so as to mitigate cover materials erosion and tidal force pressure on the BGM liner. The liner extent on the south side of the Coal Pile was determined based on the area where limiting infiltration is anticipated to achieve a reduction in acid and contaminant loading.

Taking into account BGM liner tension under its own weight and wind uplift, along with a maximum slope length of 77 m, Keystone Environmental specified the BGM liner as the 4.0 mm thick Coletanche ES2 or approved equivalent where slopes are less than 13%. For slopes greater than 13% the Coletanche ES2HFA, a BGM liner with two roughened sides, shall be used [10].

The BGM liner shall be placed according to the manufacturer's specifications following proper base preparation and once test seams meet manufacturer's specifications. The Contractor shall arrange for independent field quality assurance and quality control testing of seam strengths. All BGM liner sheets, seams, anchors, seals and defect repairs shall be visually inspected as installation progresses and at completion. Ultrasound, vacuum and destructive testing shall be completed on a specified basis. The testing will be supervised by the Quality Control and Quality Assurance Managers as well as the Consultant.

BGM Liner Anchor

The BGM liner shall be secured in an anchor trench at the top of the pile and at each bench to provide a safety factor (Drawing 18-13470-11). Keystone Environmental evaluated wind uplift on the exposed geomembrane during construction and evaluated anchor trench depth based on allowable geomembrane load tension. The geomembrane shall be placed at winds less than 31 km/h and ballasted to prevent wind uplift. The anchor trenches will be 0.5 m deep with a minimum run out length of 1.0 m.

Tidal Venting Plan

Keystone Environmental evaluated pressure changes caused by groundwater flux from tidal influences and how they would affect slope stability and stress on the liner.

Keystone Environmental made the following assumptions in our calculations:

- BGM liner footprint was estimated to be a circle with a radius of 200 m;
- The maximum thickness of the coal pile is estimated to be 17.5 m;
- The point of maximum thickness is assumed to be located in the centre of the pile;
- The BGM liner was estimated to be a spherical cap;
- The air below the BGM liner acts as an ideal gas;
- The liner is a closed system under adiabatic conditions, and that air or heat is not vented out from the edges of the pile; and
- The BGM liner behaves like a segment of a spherical thin walled pressure vessel.

Assuming the BGM liner is uniformly and equally weighted by the cover system, the normal stresses acting on the liner due to pore pressure will be less than those of the cover weight and therefore in equilibrium. Keystone Environmental considered the high-pressure zone next to the eastern and north-eastern edge of the Coal Pile near monitoring well MW10-3 A/B/C (as shown on drawings 18-13470-07, -08). In the high-pressure area, with a groundwater level fluctuation of 1.4 m, GeoPacific's recommended minimum safety factor of 1.5 could not be obtained, therefore it was determined that either greater loading on the cover or venting would be required. As a venting layer is a more cost-effective means, it was selected to utilize venting to manage the high pressure zone.

The venting layer consists of perforated pipe strip drains equally spaced within gas relief aggregate material. The strip drains direct air towards vent headers and atmospheric vent points to relieve pressure.

From field data collected from the existing Coal Pile, the coal has a hydraulic conductivity greater than the calculated minimum required hydraulic conductivity of 2.3×10^{-4} m/s needed to be used as gas relief aggregate material, therefore, in the high-pressure zone near monitoring well 10-3 A/B/C, the existing coal can be used as venting material with strip drains spaced 20 m apart.

Outside of the high-pressure zone, GeoPacific's recommended factor of safety appears to be able to be obtained without the use of a venting layer. In these areas the groundwater level fluctuation varied between 0.1 and 0.6m. GeoPacific's recommended factor of safety of 1.5 is indicated in the June 2018 slope stability letter [10], which can be found in Appendix G.

The high-pressure zone is located along the Coal Pile's eastern and north-eastern boundary with Baynes Sound. The area was estimated using groundwater table data showing tidal elevation changes. The high-pressure area is delineated to the north with data from MW10-2A/B/C indicating a groundwater table fluctuation of 0.6m and to the south by the edge of the engineered cap. Considering a slope of approximately 6.5% and a groundwater table fluctuation of 0.6m, it appears that GeoPacific's recommended factor of safety can be obtained without the use of a venting layer along the north and north-west portion of the coal pile.

Landfill Gas Assessment

The majority of the Coal Pile material within the cover extents can be considered inert and is not expected to contribute to landfill gas generation. There are, however, trace amounts of moderately decomposable material that are located within the Coal Pile cover extents, such as wood and trace shell fragments, indicating the potential for organic materials.

Keystone Environmental completed a landfill gas assessment based on BC ENV's Landfill Gas Generation Assessment Procedure Guidelines (Guidelines) and their corresponding Generation Estimation Tool (Tool) [11].

The Tool is based on a first-order kinetic decomposition rate equation for quantifying emissions from the waste decomposition in municipal solid waste landfills. The Coal Pile is not a municipal solid waste landfill, and therefore use of the Tool for this application is considered conservative due to the nature of the materials in the Coal Pile (i.e., coal waste material as opposed to municipal solid wastes).

Although the Tool indicated that there will be some landfill gas generated based on the small amount of organic material inferred to be present within the sediment beneath the coal, the estimated amount of landfill gas is low enough that it can be considered negligible compared to the gas flux resulting from intertidal movement. In addition, the proposed vents are anticipated to discharge into the rip-rap slope protection bank and allow for the gases to mix with outdoor air prior to reaching potential receptors. This suggests that landfill gas controls are not recommended within the coal or final cover system.

Assessment of Loading of Oxidation Products to Groundwater

The placement of the liner and vegetated cover will result in lower oxygen ingress than the current uncovered conditions. Due to the presence of organic carbon in the Coal Pile, it is possible that iron oxyhydroxides formed by oxidation of iron sulphide could break down and convert arsenic that is currently sequestered in the iron oxyhydroxides to leachable form. However, the core of the Coal Pile is already considered anoxic and therefore influence is not anticipated to be significant in unsaturated portions of the Coal Pile due to negligible infiltration of water after the cover is placed. Within the saturated zone, it is anticipated that oxygenated water from Hart Creek underflow and/or tidal fluctuations will continue to interact with groundwater at the periphery of the Coal Pile to mitigate reduced conditions. Select monitoring wells will remain in place to monitor for potential changes after construction.

5.2.2 Drainage Layer

The Drainage Layer is designed to direct precipitation that has filtered through the Growth Medium and Protection Layer to the toe of the graded pile. The design considers precipitation and infiltration requirements, as well as compatibility with the overall cover system.

Precipitation design criteria is discussed in Section 4.2. In considering infiltration capacity, it was noted that Seacor Environmental Inc. (Seacor) conducted a study in 2005 in which they used dual-ring infiltrometers to determine the infiltration rates for the coal pile material [1]. The infiltration rates were noted to be between 13 mm/hr and 800 mm/hr, which exceed the precipitation rates, and therefore, surface runoff is considered to be near zero except during the significant storm events (when the rainfall intensity is greater than 13 mm/hr) [1]. The vertical hydraulic conductivity of the coal material is approximately $1x10^{-5}$ m/s [1]. The coal hydraulic conductivity is similar to that of a silty sand unit [14], and therefore is comparable to the specification of the growth medium. For this reason, overland surface runoff is considered to be near zero under existing conditions.

Geosynthetic and granular materials were considered, using clogging potential, material properties of adjacent layers, capillary barrier effect, compressive loading, slope variation and construction feasibility as criteria for evaluation. The advantages of geosynthetics are mainly related to shorter-term benefits such as ease of sourcing, transport, and installation, whereas the advantage of granular material is shown in the longer-term performance and compatibility with the overall cover system. The long-term performance of the drainage layer is critical to the performance and longevity of the cover system, and therefore a granular drainage layer has been selected.

The specification for the granular drainage layer was determined based on material compatibility considerations (i.e. compatibility with the BGM liner); thickness, slope, and particle size based on literature reviews; and flow capacity compared to required flow.

The granular Drainage Layer will be 300 mm thick, which is the recommended thickness based on literature reviews. The material specification for the drainage layer is as follows:

- 100% of the material must pass the 25 mm (1-inch) sieve,
- A maximum of 10% of the material may pass the 4 mm (No. 5) sieve, and
- A maximum of 5% of the material may pass the 0.074 mm (No. 200) sieve.

Based on flow capacity and maximum liquid head calculations, the drainage layer material specifications and thickness provide a higher factor of safety than recommended in design literature. The maximum liquid head in the Drainage Layer was also checked using several theoretical methods, and was deemed to be sufficient.

Overall the drainage layer is continuous throughout the proposed cover and will follow the proposed contours of the cover material (including the BGM liner). Swales along the bench road are designed to break the flow along the slope of the coal pile, on and below the surface of the cover material. Precipitation that infiltrates through the cover material and enters the drainage layer will encounter the bottom of the swale and bench road (see Swale Detail on Drawing 18-13470-18). Due to preferential pathways, the water in the drainage layer at the bench road, will likely follow the swale slope towards the French drain. The drainage layer is directly connected to the French drain (see Typical French Drain Cross-Section at Swale detail, same drawing number). This design will minimize the inundation of the downhill portions of the drainage layers.

5.2.3 Filter Layer

The primary purpose of the filter layer is to minimize the potential for clogging of the coarse granular drainage layer due to the intrusion of finer soil from the two top layers of the final cover system, noted as the growth medium and the protection layer. The filter layer is designed to:

- Allow water to flow through into the drainage layer, which can be accomplished by ensuring that the filter layer has a relatively high hydraulic conductivity relative to the material above it, and
- Retain soil particles in place and prevent their migration through the filter without blinding or clogging the underlying media.

The growth medium and the protection layer will be placed for the purpose of supporting vegetation growth. Therefore, a certain percentage of finer grained material such as sand and silt are required in these layers. If these two top layers were to be placed directly above the drainage layer, which is specified to have a gradation between a coarse gravel and a coarse sand, finer material from the growth medium and protection layer would likely enter the drainage material voids, compromising the cover system functions.

Clogging can be prevented by incorporating a filter layer of soil or geotextile between the drainage layer and the overlying soil. Keystone Environmental evaluated granular and geosynthetic filter layers. Based on the composition of the protection layer and the drainage layer, an evaluation to determine the gradation for a granular filter layer was conducted. Due to the narrow gradation range required and subsequent potential material sourcing difficulties, a geosynthetic (geotextile) filter layer is recommended.

Keystone Environmental has evaluated permeability, retention criteria, clogging potential, permittivity, and endurance. Based on the evaluation, a standard 8 oz/yd^2 geotextile is recommended.

In addition, to prevent geotextile clogging or blinding, intimate contact between the soil and geotextile should be assured during construction. Seam and overlap requirements should be specified based on manufacturer requirements, but a minimum overlap of 0.3 m is generally recommended for geotextile applications.

5.2.4 Protection Layer

The protection layer is a 450 mm soil layer that sits above the filter layer and below the growth medium. The goal of the protection layer is to:

- Minimize potential damage to underlying components of the final cover system from burrowing animals,
- Protect the underlying components from the potentially damaging effects of moisture and freeze/thaw cycling,
- Store water for vegetation in the growth medium, and
- Provide sufficient soil thickness to allow for expected long-term erosion losses.

The protection layer will consist of mostly sand-sized particles with 85 to 100% passing the 4.75 mm (No. 4) sieve and less than 10% passing the 0.075 mm sieve (silt and clay). The maximum allowable particle size for the protection layer material is 6.35 mm (1/4 inch sieve).

Keystone Environmental conducted a biophysical assessment in 2017 [16], which did not identify the presence of any burrows or dens within the limits of the Coal Pile in either the grassland, bare coal, bare/sapling or shoreline habitat zones. Evidence of burrowing animals was limited to two small burrows within the forest zone (south of the Coal Pile and at the southwest of the Coal Pile). Since burrows within the vicinity of the Site were minimal and limited to forested areas, and cover system vegetation will be limited to grass species, the risk of burrowing animals damaging the cover system is deemed to be low. It is possible that there may be more susceptibility to burrows into the cover materials compared to the coal material due to the nature of the materials and therefore monitoring for burrows should be conducted during construction and post-remediation is recommended.

5.2.5 Growth Medium

A 150 mm thick layer of growth medium material will be placed on top of the protection layer. This material type is designed to promote and sustain the growth of vegetation, which in turn assists with limiting erosion of cover soils protecting the BGM liner. The growth medium will comprise 20–30% silt, 60–70% sand and <5% clay with 5% volume of organics (e.g., composted manure). Mulched organic material will be placed following seeding; and this material may be composed of chipped salvaged material from tree clearing. Care must be taken to ensure that no invasive vegetation is included in the mulch material and that any imported hay or straw does not include seeds of invasive plants.

The specification for the growth medium is based on standard required growth mediums for the anticipated plant species and typical soils in the region of the site.

5.2.6 West Side Geocell Design

A portion of the Coal Pile, on the west side near Hart Creek, has surface grades from 25% to 40%. On this steeper slope, a geocell system will be used to hold the growth medium material in place. The Envirogrid 200 mm deep EGA30 geocell will lie on top of the two rough-sided BGM liner and will be backfilled with Growth Medium soils and subsequently hydroseeded. GeoPacific has completed a Geocell Anchor Design, which is included in Appendix D and is referred to on Drawing 18-13470-12. GeoPacific recommended anchoring the geocell panels with 3–19 mm wide tendons tied to a 150 mm diameter PVC Schedule 80 pipe or a HDPE equivalent as shown in Figure G2, Appendix D. Based on a maximum geocell slope length of 23 m, GeoPacific recommended a 600 mm by 600 mm anchor trench backfilled with compacted granular fill, compacted to 98% SPMDD. GeoPacific field reviews will be required during anchor installation.

5.3 Slope Protection Plan

Keystone Environmental retained Moffatt & Nichol, Inc. (M&N) to assess and recommend a slope and erosion protection plan for the Coal Pile and to prepare a foreshore protection design [15]. The shore protection design incorporates soft shore principles. The northern portion of the Coal Pile includes anchored logs, vegetated sand dunes, and a cobble beach area. The eastern and western sides of the Coal Pile require rip rap based on the environmental loads and effects; however, the voids of the rip rap will be planted.

As part of their assessment, M&N considered environmental loads and effects, as well as marine criteria. M&N inputted this information into their Spectral Wave Model to assess wave heights. The riprap elevation is based on the Designated Flood Level (DFL) defines as:

$$DFL = SLR + RSLR + HHWLT + SS$$

Where SLR is future sea level rise, which is adjusted for relative sea level rise (RSLR) at Higher High Water Large Tide (HHWLT) with Storm Surge (SS). Taken from M&N's Union Bay Coal Pile Shoreline Protection Design [15], the DFL is:

Design Criteria	Height/ Elevation
2100 Sea Level Rise	1.00 m
Relative Crustal Uplift	-0.25 m
Higher High Water Large Tide Level	+2.00 m GD
1-in-200 year Storm Surge	1.25 m
Designated Flood Level (DFL)	**+4.00 m GD**

M&N specified preferred construction materials as:

Design Elements	Preferred Construction Material
Shoreline Protection	Sound, hard, angular quarried rock
Geotextile	Amoco 4553 or Nilex C34 or similar approved

The design includes riprap keyed into the beach below 0.0 m elevation on the Coal Pile east side. Riprap maximum heights shall be of +4.8 m geodetic with a horizontal top of minimum 2.25 m except on the coal pile west side where the horizontal top shall be 3.2 m wide. The riprap is placed in the areas that it is required to limit erosion of the coal pile. The riprap along the east side of the pile extends to the southeast corner in an area where the riprap is tapered to fit into the existing terrain and toe of the Coal Pile. The riprap wraps around the southeast corner so that this portion of the waste pile is protected. The intent is to provide protection where the landside profile transitions from shallow to the deeper water.

In cases where the existing ground is higher than the riprap toe elevation, the riprap toe will be constructed below existing ground and then filled over to match the existing ground surface. For the sections near Baynes Sound and Hart Creek, the riprap protects the Coal Pile for a design flood level at elevation of 4.0m (GD) as the top of riprap is at elevation 4.6m (GD).

General Arrangement and Section and Details are shown in M&N's drawing package, which is provided in the Drawings appended to this document, along with M&N's Basis of Design, which is provided in Appendix E.

Keystone Environmental retained GeoPacific to conduct a slope stability assessment on M&N's riprap design. GeoPacific concluded that the slope stability of the Coal Pile with the proposed riprap erosion protection is acceptable under both static and seismic conditions. GeoPacific's riprap assessment letters are provided in Appendix E.

5.4 Stormwater Management Plan

A Stormwater Management Detailed Design letter is provided in Appendix H. The stormwater management plan primary objectives are to identify appropriate water quantity and quality control measures for stormwater runoff, manage the stormwater quality prior to discharge, and minimize erosion. Water quantity control measures are used to maintain the water balance in the local area (Drawings 18-13470-14, -15).

The proposed stormwater measures will consist of stormwater infrastructure(s) to retain and convey flows from the surface to infiltrate through the Engineered Cover to the surrounding receiving environments (Baynes Sound, Hart Creek, Estuary, and Upland), as shown in Drawing 18-13470-13. The selected stormwater measures include: swales, French drains, and toe drains, which will convey the flows to four (4) discharge points (outfalls).

Keystone Environmental obtained precipitation data from Environment Canada's intensity-duration-frequency (IDF) curve for the Comox Airport [17]. Table 5-1 summarizes the pre- and post-remediation areas for comparison and are shown on Drawing 18-13470-13.

Table 5-1 Summary of Pre- and Post-Remediation Drainage Areas (DA)

Receiving Environment *(Discharge Zones)*	Pre-Remediation Drainage Areas (ha)	Post-Remediation Drainage Areas (ha)	Post-Remediation Sub-Catchment Areas	Post-Remediation Discharge Point (DP#)
Baynes Sound (BS)	3.6	5.7	3A – 3F	3
			4A – 4E	4
Upland (UP)	2.2	n/a[a]	n/a[a]	n/a[a]
Hart Creek (HC)	1.3	0.9	5	n/a[b]
Estuary (ES)	3.8	4.4	1A – 1D	1
			2A – 2E	2

Notes:
[a] There will be no discharge to the Upland areas under post-remediation conditions as the runoff will be collected in the proposed toe drain and discharge to Baynes Sound at discharge point # 4.
[b] Sub-catchment area 5 will sheet flow into the Hart Creek, similar to pre-remediation conditions, there will be no discharge point under post-remediation conditions.

5.4.1 Quantity Control

Under post-remediation conditions, an Engineered Cover will be installed above the existing Coal Pile. As a result, more stormwater runoff is expected to be generated as infiltration into the groundwater will be impeded. The quantity control measure will maintain existing drainage patterns where possible and will control the peak post-remediation stormwater flows for a 1-in-100 year design storm. The stormwater management strategy to provide quantity control is to use absorbent landscaping which provides stormwater retention through the Cover System, such as evaporation-transpiration and interflow. The proposed remediation works includes absorbent landscaping within a 900 mm Cover System.

Surface runoff will be collected and conveyed via lateral surface swales, longitudinal sub-surface piping (French drains), and perimeter sub-surface piping (toe drains) to the discharge points, as shown on Drawings 18-13470-14 through 18-13470-20. The swales will incorporate detention features such as vegetation and check dams in order to decrease discharge flow rates to the receiving watercourse and environment.

Infiltrated flows will be detained and conveyed through the Drainage Layer which will be connected to the longitudinal and perimeter sub-surface piping to the discharge points. The specifications for the drainage layer are detailed in earlier sections of this report.

5.4.2 Quality Control

Quality control will be provided through the implementation of a vegetated cover, check dams, sub-surface piping, and armouring (riprap protection) at inlet and discharge points.

Prior to the start of remediation and until the vegetation has fully established, erosion and sediment control measures should be implemented to provide quality control. A site-specific Erosion and Sediment Control (ESC) Plan is provided in the Construction Environmental Management Plan (CEMP). Minimal change to stormwater quality is expected under the proposed conditions, in regards to TSS source loading, pH, or other contaminants compared to existing conditions.

5.4.3 Swales

Swales are proposed on the surface of the Cover System, along the bench road that runs laterally, in a spiral direction (Drawing 18-13470-18). These swales will be vegetated and check dams will be placed every 25 m to slow the runoff down prior to entering the longitudinal French drains. These swales provide water quality improvements through infiltration and filtering.

The swale design is based on the sub-catchment area that results in the greatest peak runoff flow. A 10-minute concentration time based on the slope and ground cover, the corresponding rainfall intensity of 62 mm/hr for a 1-in-100 year rainfall event, and a runoff coefficient of 0.6 results in a peak runoff flow of 5.1 m^3/min.

To accommodate the peak flow, the typical swale design is a 1.5 m wide base trapezoidal channel with 1:1 side slopes, resulting in a top width of 1.8 m. The maximum depth of the swale is 0.15 m (includes freeboard of 0.08 m) and a minimum slope of 2%. Typical details are provided on Drawing 18-13470-18.

5.4.4 French Drains

Surface water collected in lateral swales will be collected and conveyed to the base of the Coal Pile along the French drains aligned longitudinal to the Coal Pile (Drawings 18-13470-16, -17). The French drain system is a perforated pipe surrounded by drain rock that collects and conveys surface runoff from the swales to the bottom of the Coal Pile into the toe drain. In addition, the French drain will also be keyed into the Drainage Layer. An impermeable layer (Barrier Layer) underneath the Drainage Layer will prevent further stormwater infiltration, therefore, infiltrated stormwater will drain through the cover system and will flow along the barrier layer through the drainage layer towards the French drains.

Based on the calculated peak flow of 13.7 m^3/min (1-in-100 year), the pipe diameter of the French drain that will have adequate capacity to accommodate this peak flow, is a 375 mm corrugated single wall HDPE perforated pipe, in accordance with ASTM D2412 [18] and minimum stiffness of 210 kPa, with a minimum design slope of 4%. A typical detail is provided on Drawing 18-13470-17.

Where the longitudinal French drain crosses the bench road, a 525 mm diameter reinforced concrete pipe (RCP), in accordance with ASTM 76 – IV [19] and CSA A257.2 [20], culvert will need to be installed to prevent crushing of the perforated pipe for vehicle or equipment access. Eleven 5 m long culverts are proposed for the French drains. French drain layout plans are provided on Drawing 18-13470-15. Profiles of the French drains are provided on Drawing 18-13470-16.

5.4.5 Toe Drains

A perimeter toe drain is proposed around the base of the Coal Pile. The purpose of the toe drain is to collect and convey surface runoff and infiltration flow from the downgradient sub-catchment areas and stormwater from the contributing French drain to the ultimate discharge points (outfalls).

Based on the calculated peak flow of 13.7 m^3/min (1-in-100 year event), the pipe diameter with adequate capacity to accommodate this peak flow is 600 mm HDPE perforated pipe, in accordance with CSA 182.8 [21] and minimum stiffness of 320 kPa, with a minimum slope of 0.4%. Layout plan of the toe drain is provided on Drawing 18-13470-15. Profile of the toe drain is provided on Drawing 18-13470-16 and typical details are provided on Drawing 18-13470-17.

5.4.6 Outfall Pipes

At each discharge point a 600mm diameter HDPE outfall pipe will be required, in accordance with CSA 182.8 [21] and a minimum stiffness of 320 kPa. The Outfall pipe is sized to convey the flows from the longitudinal French drains and the perimeter toe drains. The Outfalls will intersect the riprap armouring which will provide erosional protection at the end of the Outfall pipes.

Where the Outfall pipes extend into the riprap armouring, a 750 mm diameter reinforced concrete pipe (RCP) culvert, Class IV, made with Type V (sulfate resistance cement), in accordance with ASTM 76 [19], CSA A257.2 [20], and ASTM C150 [22], will be installed to prevent crushing of the perforated pipe. The weight of the riprap armouring could cause the pipe to deform or crush over time. Four culverts, at approximately 8 to 13 m in lengths are proposed for the Outfalls.

The cross-section of the outfall pipes and riprap protection areas are provided on Drawings 18-13470-19 and 18-13470-20. The connection detail of the French drain, toe drain, and the Outfalls are shown on Drawing 18-13470-19.

5.5 Erosion and Sediment Control (ESC) Plan

The site Contractor is required to develop a site-specific ESC plan for the various stages of remediation works that meet the requirements of the construction environmental management plan (CEMP). The objective of the ESC is to minimize sediments from migrating off of the Coal Pile site. The ESC plan will be required to clearly outline the applicable regulations, construction timing, monitoring requirements, Contractor responsibilities with respect to sampling, maintenance, mitigation measures and decommissioning. The CEMP and an example ESC plan are included in Appendix A. Applicable figures and design details include:

- 18-13470-ESC01 – Erosion and Sediment Control: Clearing/Grubbing & Grading Plan
- 18-13470-ESC02 – Erosion and Sediment Control: Construction Plan
- 18-13470-ESC03 – Erosion and Sediment Control: Details and Construction Notes
- 18-13470-ESC04 – Erosion and Sediment Control: Details and Construction Notes
- 18-13470-ESC05 – Erosion and Sediment Control: Construction Notes

5.6 Densification Design

Due to the presence of potentially liquefiable sands at the north and east end of the Coal Pile, GeoPacific recommended ground densification with gravel columns [4]. For the Detail Design Plan, GeoPacific has completed a ground densification analysis to determine the required width of the densification ("seismic berm") to mitigate lateral spread and to provide a densification specification, indicating densification methods and performance requirements.

GeoPacific's Densification Plan drawing (Drawing Number G-D1), which indicates the required ground densification area, is provided in Appendix C. In addition, GeoPacific has provided a ground improvement specification for the installation of "gravel columns" in the area of drawing G-D1, also located in Appendix C. The specification is related on performance and indicates that the Contractor shall densify the soils beneath the specified areas to a minimum Electronic Piezo-Cone Penetration Tip Resistance (qc). The performance specification allows a Contractor to specify the gravel column spacing, diameter, and equipment requirements that they require to achieve the performance specification. The specification indicates that ground improvement is required from 1 metre below finished grade to a depth of -10 metre geodetic elevation. From 0 to 1 m below finished grade, beach sand will be placed.

5.7 Access Road Design

Access road construction began in the Fall of 2019 and is anticipated to be completed by Spring 2020. The access road will provide access to the work area from the Old Island Highway (Highway 19A). Keystone Environmental retained David Nairne + Associates Ltd. (DNA) to provide a detailed design of the access road between the Old Island Highway (Highway 19A) and the Coal Pile. Keystone Environmental also retained GeoPacific in March 2018 to assist DNA in designing the road material and compaction level. Refer to Appendix B for DNA's Access Road Design drawings and for GeoPacific's road and asphalt material recommendations letters.

The road alignment is based on the Statutory Right-of-Way (SROW) Plan over Lot 1, D.L. 28, Nelson District and D.L. 154 Nanaimo District, Plan EPP 15507, Except Part in Plan EPP56910 and over Lot 3, D.L. 28, Nelson District, Plan EPP 15507.

Intersection Design is based on BC MoT Supplement to TAC Geometric Design Guide, June 2007 Typical Left Turn Lane Layout Figure 710.C Type A Rural.

The access road will be crowned at the centre, placed in 200 mm lifts and compacted to a minimum 100% SPMDD with a heavy vibratory drum roller within 2% of the optimum moisture content.

The cul-de-sac is designed for truck turning during construction and requires a large turning radius. It is a temporary feature and will be removed during construction. The cul-de-sac will be adjusted or no longer in use once the cover is installed in this section. The Contractor is expected to manage the scheduling related to the accessibility and requirements of cul-de-sac use.

5.7.1 Staging Area Design

The staging area south of the Coal Pile is the preferred area for stockpiling construction materials and shall be used at the Contractor's discretion. Should it be used for equipment or soil storage, a plan for its use shall be provided by the Contractor for Engineer's approval. Included plan items but not limited to are clearing, grubbing and grading, compaction, erosion and sediment control, pre- and post- environmental sampling, and reclamation, if required. The staging area is planned for eventual redevelopment by the property owner.

5.8 Vegetation Plan

In addition to prevent erosion of cover soils, the intention of the vegetation plan is to provide benefits to fish and wildlife species and include the creation of a large vegetated habitat for migration, roosting and food. The vegetation plan in concert with the cover system will provide a reduction in the direct access to the existing Coal Pile, reduction in water infiltration and subsequent potential seepage into the aquatic environment, and the long-term sediment and water quality improvement of the receiving environment.

In its biophysical field survey of the existing Coal Pile [16], Keystone Environmental identified six different vegetation zones that have similar physical and biological characteristics (Drawing 18-13470-22). These zones have been identified as marine backshore, bare/sapling, bare, grassland, disturbed shrub and forest. Although not identified within the cover extent area, Keystone Environmental found Japanese knotweed (Fallopia japonica) in the Hart Creek riparian area west of the Coal Pile (Drawing 18-13470-22).

5.8.1 Invasive Plants Management

A few invasive plant species: blackberry, Scotch broom, Japanese knotweed are typically fast-growing and colonize disturbed areas. The rooting depth of most plants found on the Coal Pile is one metre or less. However, a few plants like Japanese knotweed may grow to a depth of over three metres. Although the cover system includes a 0.45 m (450 mm) thick protection layer designed to separate the drainage layer and BGM liner from vegetation roots, plants that can root in excess of 0.6 m may penetrate the drainage layer and must be appropriately managed and prevented from becoming established within the cover extent.

The following best management practices (BMPs) will be followed during construction and when removing invasive plants:

- Identify the locations of invasive plant species that have the potential to form roots at a depth exceeding 0.6 m within the Project footprint prior to clearing of vegetation;

- Keep noxious weeds (e.g., knotweed) separate from other vegetation to reduce offsite disposal costs;
- Contact an appropriate disposal facility prior to removal of the invasive plants and related soil to coordinate disposal;
- Load invasive plant material and weed infested soil directly into trucks if possible. If invasive plant material and soil are to be stockpiled, it shall be placed on tarps or poly sheets and in bags, before transporting to a pre-approved and designated disposal site;
- Use separate trucks for hauling of invasive plant materials and fill materials to prevent cross-contamination;
- Haul trucks shall have loads tarped when removing materials off-Site;
- Inspect and clean (wash if water truck is available) vehicles and equipment including tires and undercarriage before entering areas without invasive vegetation or prior to leaving areas infested with invasive vegetation;
- Confirm that salvaged cleared vegetation from the Site does not contain invasive plants prior to utilizing as mulch; and
- Should the growing medium or other exposed surface be left unplanted for 14 days consecutively, the area will be covered with tarpaulin, coco-matting or geotextile to suppress invasive species regrowth and minimize their re-establishment.

5.8.2 Seeding

Seeding shall occur as quickly as possible after growth medium placement to avoid erosion and invasive plants establishment (Drawing 18-13470-23). Spring seeding with a fall reseeding is preferred as it allows a full growing season for plant establishment before winter. Spring seeding shall occur as soon as possible to ensure sufficient time for grass establishment prior to the summer dry season.

Vegetation planned for the cover system is limited to grass species with shallow roots (0.3 m rooting depth). Grass roots are expected to extend through the growing medium layer and into the protection layer but are not anticipated to impact the layers beneath. Plants that can root in excess of 0.6 m could penetrate the drainage layer and must be appropriately managed and prevented from becoming established within the cover extent. Post-remediation maintenance is not part of the scope of this Detail Design Plan.

5.8.3 Irrigation

Actions shall be taken to ensure seed and germinating plants receive regular watering during the first 60 days after application. Irrigation shall be carried out to avoid dry periods of five days or greater and ensure sufficient watering to prevent grass and underlying growing medium from drying out (saturate to 100 mm soil depth). Water application should be either early or late in the day to avoid evaporation. Water must be free of impurities that would inhibit seed germination and growth. Water used for irrigation purposes must be controlled to prevent water ponding or runoff that may erode soils.

The engineered cover system is designed to sustain ground pressure from maintenance vehicles up to the size of a 1-tonne truck. Should watering be required, a temporary watering system using tanks and piping may be established, however water trucks that exert a ground pressure in excess of a 1-tonne truck shall not drive on the engineered cover system.

5.9 Monitoring Wells

During previous investigations, groundwater monitoring wells were installed in and around the Coal Pile. Many of the monitoring wells will be decommissioned during construction, but some will remain for continued monitoring (Drawing 18-13470-21). Identified monitoring wells shall be decommissioned during base preparation following the requirements described in the BC ENV Water Sustainability Act – Groundwater Protection Regulation. The remaining monitoring wells within the liner extent shall be sealed to minimize infiltration. Monitoring wells located within the cover extent will be flush-mounted while wells located within riprap areas will be completed with a stick-up monument casing. Table 5-3 shows the monitoring well status.

Table 5-2 Union Bay Coal Pile Monitoring Wells

Monitoring Well Retain/Removals		
To Retain	Outside of liner extent	MW10-3 A/B, -10B, -12 to -15, -19 A/B/C, -20 A/B/C, -21 A/B
	Within liner extent	MW10-2 A/B/C
To Remove	Within liner extent	MW10-1A/B, -4A/B, -5 A/B/C, -6 A/B, -7 A/B, -8 A/B/C, -9 A/B, -10A

The Contractor shall confirm monitoring well integrity is maintained.

5.10 Construction Sequencing

The Engineered Cover system construction sequence will be determined by the Contractor; however, we have outlined an example construction sequence for design purposes.

The purpose of construction sequencing is to prevent Cover System damage during construction. The sequencing plan preferences moving materials and equipment into place, as much as possible, before Coal Pile fine grading and BGM liner placement. The entire pile will be rough graded according to the design drawings. At the same time, rip rap will be moved adjacent to the Coal Pile toe in preparation for placement.

Keystone Environmental has divided the Coal Pile into zones, beginning with the steepest slope on the west side. The barrier layer and the rip rap will be placed on the west slope, moving clockwise towards the north of the pile. The base will be fine graded and inspected for sharp objects, debris and vegetation prior to BGM liner placement. Once a minimum of two BGM liner panels are placed, seamed, inspected and approved, backfill of the cover system remaining layers can begin in sequence. Anchor trenches, toe drains, French drains and outfalls will be installed as the work moves through the zone.

While the Engineered Cover is installed in the first zone, fine grading and base preparation may begin in the adjacent zone. We have assumed an open throughway from the Staging Area to the Coal Pile northeast corner to allow vehicle access over the Coal Pile during construction. Similarly, we have assumed that benches are not covered until work in that zone is complete in order to allow equipment to move along the benches.

Once the zones have been covered, then the final strip from the Staging Area to the Northeast Corner will be covered moving from the Northeast Corner towards the Staging Area.

Rip rap placement can take place after a zone is complete.

Exclusion fencing shown on the design drawings is temporary and is anticipated to be removed during placement of rip rap. The exclusion fencing on the south side of the Coal Pile may be kept in place during the revegetation period.

6. GENERAL LIMITATIONS

Findings presented in this report are based upon: (i) a review of available site and historic reports; (ii) the results of the previous investigations and studies conducted by Keystone Environmental; and (iii) the results of studies completed by others at the Site. Site conditions (geologic, hydrogeologic, and chemical characterization) may vary from that extrapolated from the data collected during this and previous investigations. While findings and conclusions documented in this report have been prepared in a manner consistent with that level of care and skill normally exercised by other members of the environmental science and engineering profession practicing under similar circumstances in the area at the time of the work, this report is not intended, nor is it able to provide a totally comprehensive review of present or past site environmental conditions.

This report has been prepared solely for the internal use of West Fraser Mills Ltd. (West Fraser) and the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Province) and BC Ministry of Environment and Climate Change Strategy (BC ENV), pursuant to the agreement between West Fraser and Keystone Environmental, for the sole purpose of implementing the Union Bay Detail Design Plan overseen by Keystone Environmental Ltd. By using this report, West Fraser, the Province and the BC ENV agree that they will review and use the report in its entirety. Any use that parties outside of this agreement make of this report, or any reliance on or decisions to be made based on it, are the responsibility of such parties. Keystone Environmental accepts no responsibility for damages, if any, suffered by any party outside of this agreement, as a result of decisions made or actions based on this report.

7. PROFESSIONAL STATEMENT

Keystone Environmental Ltd.[2] confirms that this report titled *Detail Design Plan, Remediation Works – Union Bay Coal Pile, Union Bay, BC* has been prepared and was reviewed by Keystone Environmental Ltd. approved personnel who have the credentials and knowledge of the applicable public laws, regulations and/or policies, which apply to this report and have demonstrable experience in design work of the type.

This report was prepared by Zahra Pirani, Thuy Wong, Mathew Barker, Antonia Gunardi, and Jamie Slogan, and reviewed by Jason Christensen and Richard Johns. The engineer of record for compilation of design components and overall management is Jason Christensen. The engineer of record for the associated design components are as follows:

Antonia Gunardi	Cover Grading Design
Thuy Wong	Stormwater Management
Zahra Pirani	Cover System: Protection Layer, Filter Layer, Drainage Layer, BGM Liner
Mathew Barker	Cover Venting System
Jamie Slogan	Growth Medium and Vegetation

March 19, 2020
Date

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. M. GUNARDI
41410
March 20, 2020

Antonia Gunardi, P.Eng.
Project Engineer

PROFESSIONAL ENGINEER
PROVINCE OF
Z. PIRANI
37241
March 20, 2020

Thuy Wong, P.Eng.
Project Engineer

Zahra Pirani, M.Eng., P.Eng.
Project Engineer

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Suite 320 – 4400 Dominion Street, Burnaby, BC V5G 4G3
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Mathew Barker, P.Eng.
Project Engineer

Jamie Slogan, Ph.D., R.P.Bio.
Department Head, Biological Services

Jason Christensen, P.Eng.
Senior Engineer

8. REFERENCES

[1] Keystone Environmental Ltd., "Remedial Options Feasibility Report, Union Bay Waste Coal Pile, Union Bay, BC. Prepared by Keystone Environmental Ltd. Project No. 9842. Prepared for West Fraser Mills Co. Ltd.," 2012.

[2] Keystone Environmental Ltd., "Initial Works –Baseline Investigation Summary Letter. Prepared by Keystone Environmental Ltd. Project No. 13470. Prepared for West Fraser Mills Ltd.," 2018.

[3] GeoPacific Consultants Ltd., "Geotechnical Report – Union Bay Waste Coal Pile, Highway 19A and Russel Street, Union Bay, BC," 2012.

[4] GeoPacific Consultants Ltd. , "Geotechnical Report – Union Bay Waste Coal Pile, Highway 19A and Russell Street, Union Bay, BC," 2017.

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[13] BC Ministry of Environment and Climate Change Strategy (BC ENV), "Landfill Criteria for Municipal Solid Waste," 2016.

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[16] Keystone Environmental Ltd., Biophysical Assessment Report, Union Bay Coal Pile, 5426 Island Highway, Union Bay, BC. Prepared by Keystone Environmental Ltd. Project No. 13470. Prepared for West Fraser Mills Ltd., 2017.

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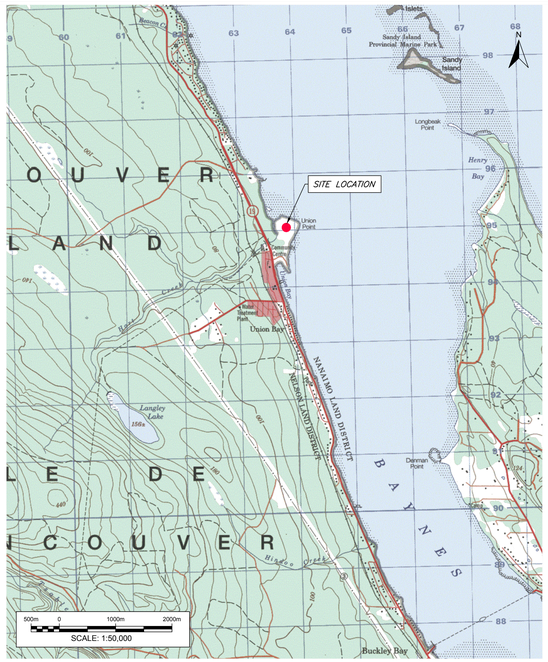
[21] ADS, Inc., "ADS CANADA N-12® WT IB PIPE SPECIFICATION (CSA 182.8)," in *ADS, Inc. Drainage Handbook*, 2015, p. 2.

[22] ASTM International (ASTM), "Standard Specification for Portland Cement," ASTM Standard C150 / C150M-18, West Conshohocken, PA, 2018.

DRAWINGS



WEST FRASER MILLS LTD.

UNION BAY COAL PILE REMEDIATION WORKS DETAILED DESIGN (FINAL)

DRAWING INDEX				
SHEET NO.	DRAWING NO.	TITLE	REVISION NO.	REVISION DATE
GENERAL DESIGN DRAWINGS				
1	18-13470-01	COVER PAGE AND GENERAL NOTES	00	2020-02-26
2	18-13470-02	SITE PLAN	00	2020-02-26
3	18-13470-03	REMEDIATION PLAN	00	2020-02-26
4	18-13470-04	GRADING PLAN: BASE LAYER	00	2020-02-26
5	18-13470-05	GRADING PLAN: BASE LAYER CUT AND FILL AREAS	00	2020-02-26
6	18-13470-06	GRADING PLAN: BASE LAYER SECTIONS	00	2020-02-26
7	18-13470-07	VENTING LAYER PLAN	00	2020-02-26
8	18-13470-08	VENTING LAYER DETAILS	00	2020-02-26
9	18-13470-09	FINAL COVER PLAN	00	2020-02-26
10	18-13470-10	FINAL COVER: CROSS-SECTIONS	00	2020-02-26
11	18-13470-11	COVER SYSTEM AND ANCHOR TRENCH DETAILS	00	2020-02-26
12	18-13470-12	GEOCELL SYSTEM AND DETAILS	00	2020-02-26
13	18-13470-13	PRE & POST REMEDIATION DRAINAGE AREAS	00	2020-02-26
14	18-13470-14	STORMWATER MANAGEMENT PLAN	00	2020-02-26
15	18-13470-15	STORMWATER MANAGEMENT PLAN LAYOUT AREAS	00	2020-02-26
16	18-13470-16	FRENCH DRAIN AND TOE DRAIN PROFILES	00	2020-02-26
17	18-13470-17	FRENCH DRAIN AND TOE DRAIN DETAILS	00	2020-02-26
18	18-13470-18	SWALE AND CHECK DAM DETAILS	00	2020-02-26
19	18-13470-19	OUTFALL DETAILS	00	2020-02-26
20	18-13470-20	OUTFALL CROSS SECTIONS	00	2020-02-26
21	18-13470-21	MONITORING WELL LOCATION PLAN	00	2020-02-26
22	18-13470-22	INVASIVE PLANTS LOCATION PLAN	00	2020-02-26
23	18-13470-23	SEEDING DETAILS	00	2020-02-26
SLOPE PROTECTION DRAWINGS				
24	G-001	COVER SHEET AND DRAWING INDEX	J	2020-02-24
25	G-002	GENERAL NOTES & DESIGN CRITERIA SHEET 1 OF 2	H	2020-02-24
26	G-003	GENERAL NOTES & DESIGN CRITERIA SHEET 2 OF 2	F	2019-07-17
27	G-004	EXISTING SITE PLAN	G	2019-07-24
28	G-005	GENERAL ARRANGEMENT	I	2019-08-01
29	G-006	CONTROL POINTS LISTING	B	2019-07-17
30	G-007	SECTION AND DETAILS	J	2020-02-24
31	G-008	MISCELLANEOUS DETAILS	B	2019-07-17
GEOCELL DRAWINGS				
32	G-1	GEOCELL COVER	A	2019-08-23
33	G-2	GEOCELL - SECTION A, B, DETAIL A, B	A	2019-08-23

GENERAL NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. CONTOUR ELEVATIONS ARE IN METRE GEODETIC DATUM (GD). GROUND LEVEL COORDINATES WERE DERIVED FROM GRID ORIGIN POINT 3515 (N5494937.404, E363954.592, ELEVATION 6.322 m). DATUM IS BASED ON UTM NAD83 (CSRS) 3.0.0.BC.NVI. THE GEODETIC ELEVATION WAS DERIVED FROM DUAL FREQUENCY DIFFERENTIAL GNSS BASELINE TIES TO GEODETIC CONTROL MARKERS 90H6255 (N5502217.587 m, E350844.657 m, Z156.012 m) AND 90H6253 (N5499538.171 m, E354481.622 m, Z134.139 m). PROJECT COMBINED SCALE FACTOR IS 0.99982883767. THE DATUM AND GEODETIC ELEVATION DERIVATION IS ACCURATE WITHIN +/- 5 cm, WHILE THE RELATIVE ACCURACY OF THE TOPOGRAPHIC SURVEY IS LESS THAN +/- 5 cm.
3. CHART DATUM TO GEODETIC DATUM CONVERSION = GD + 3.2 m.
4. BATHYMETRY SOUNDINGS AND CONTOURS ARE IN METRES WITH RESPECT TO GEODETIC DATUM AND HAVE BEEN REPRODUCED FROM A BASE DRAWING PROVIDED BY ATEK HYDROGRAPHIC SURVEY LTD. DESCRIBING A SURVEY CONDUCTED IN 2018.
5. TOPOGRAPHY CONTOURS AND ELEVATIONS WERE BASED ON A 2017 SURVEY DONE BY MCELHANNEY CONSULTANTS AND PROVIDED TO KEYSTONE ENVIRONMENTAL. THIS DRAWING WAS MERGED WITH ATEK HYDROGRAPHIC SURVEY MARCH 2018 BATHYMETRY SURVEY TO PROVIDE A BASE DRAWING.
6. THE CONTRACTOR IS REQUIRED TO COMPLETE A BC ONE CALL PRIOR TO ANY INTRUSIVE WORK, AND THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING ANY EXISTING UTILITIES.
7. THE CONTRACTOR TO SET UP THE CONTROL POINT 1 COORDINATES AT 5494800 NORTHING AND 363700 EASTING AND CONTROL POINT 2 COORDINATES AT 5494850 NORTHING AND 363700 EASTING (NAD 83 / UTM ZONE 10N).

CADD FILE NO. \\wsy-fs2012\Common\13400-13499\13470\61K Drwgs_Specs\Figs\GIS_CADD_Final\R01\18-13470-01-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

West Fraser

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
Z.P./A.M.G.	J.K.C
DRAWN	CHECKED
A.B.	R.P.J.
SCALE	

CLIENT: West Fraser Mills Ltd.

Union Bay Coal Pile
Cover Page and General Notes

SHEET No. 1 of 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-01

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\Rb\18-13470-02-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2. DATE OF ORTHO PHOTO IS 2019.

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

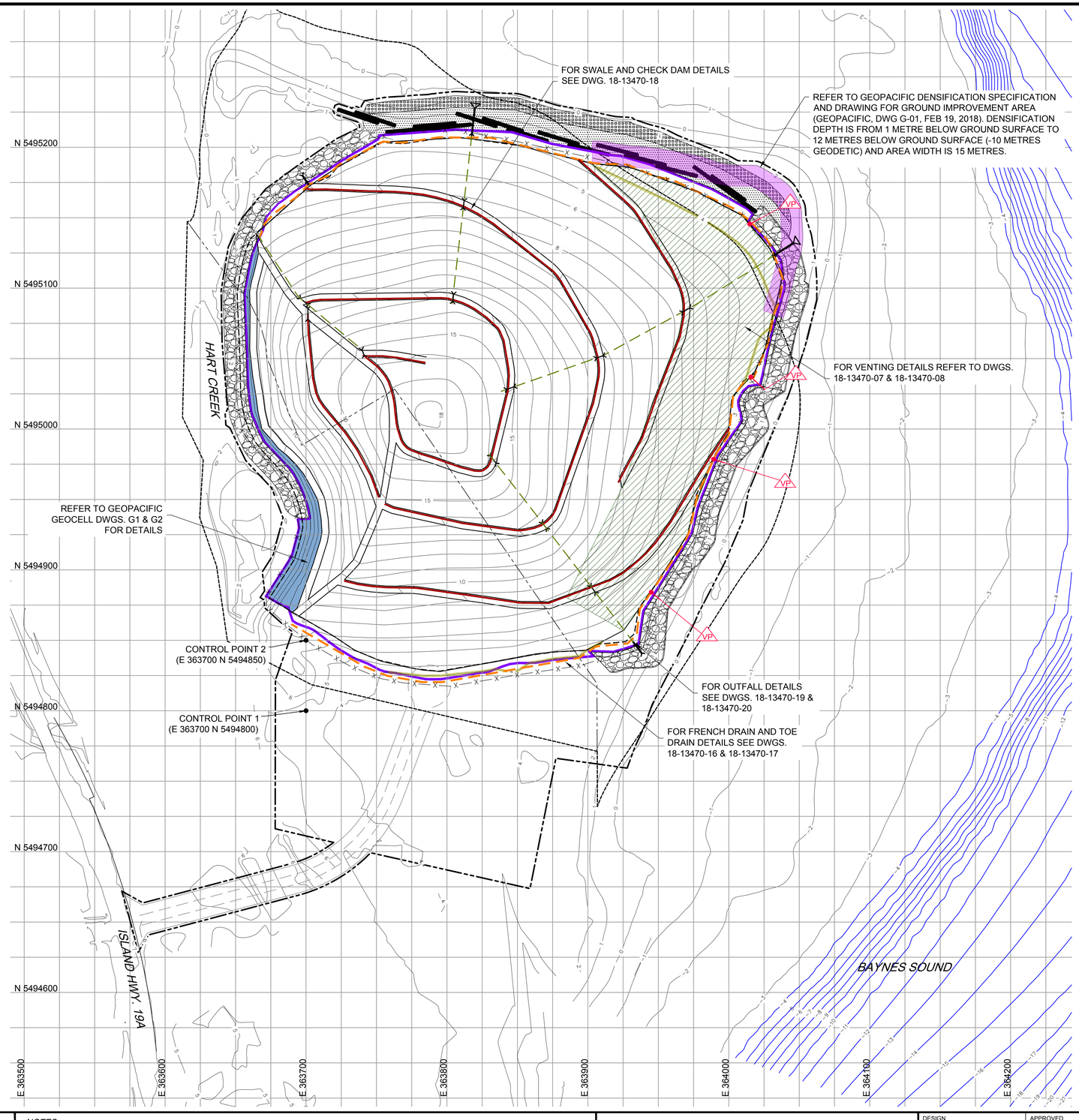
DESIGN	APPROVED
Z.P./A.M.G.	J.K.C.
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
25m 0 75m
SCALE: 1:1500

CLIENT: West Fraser Mills Ltd.

Site Plan

SHEET No.	2 OF 23
PROJECT No.	13470-61K
REVISION No.	00
DRAWING No.	18-13470-02



LEGEND

- SITE
- PROPERTY LINE
- ROAD RIGHT-OF-WAY
- CONTOUR LINES
- BATHYMETRIC CONTOUR LINES
- COVER EXTENT
- BGM LINER EXTENT
- PROPOSED ACCESS ROAD
- Ddensification AREA
- GEOCELL
- RIPRAP (SLOPE/EROSION PROTECTION)
- COBBLE
- SAND
- ANCHORED LOGS
- VENTING EXTENTS
- PLANNED WORK AREA (APPROX.)
- FRENCH DRAIN
- TOE DRAIN
- SWALE
- OUTFALL PIPE
- PROPOSED CULVERT
- TEMPORARY EXCLUSION FENCE LINE
- VENT POINT
- DESIGNATED FLOOD LEVEL (4.0m GD)

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
Z.P./A.M.G.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
25m 0 75m
SCALE: 1:1500

CLIENT: West Fraser Mills Ltd.

Remediation Plan

SHEET No. 3 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-03

PLOT SCALE: 1:1

CADD FILE NO. \\wpy-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-03-R0.dwg

SUBGRADE STAKEOUT POINTS			
POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)
100	363,690.3	5,494,869.9	7.22
101	363,695.0	5,494,867.3	7.22
102	363,727.0	5,494,848.0	5.64
103	363,763.6	5,494,832.8	4.27
104	363,803.0	5,494,829.2	3.80
105	363,842.4	5,494,836.5	4.17
106	363,881.9	5,494,842.1	3.98
107	363,921.7	5,494,843.0	3.34
108	363,950.2	5,494,861.3	2.02
109	363,973.0	5,494,893.2	2.03
110	363,984.5	5,494,931.1	2.13
111	363,999.8	5,494,968.0	2.06
112	364,014.3	5,495,003.8	2.12
113	364,018.4	5,495,040.9	2.79
114	364,024.8	5,495,064.9	2.86
115	364,034.5	5,495,103.6	2.33
116	364,017.4	5,495,137.7	2.55
117	363,985.5	5,495,161.2	2.49
118	363,948.0	5,495,175.0	2.56
119	363,909.8	5,495,186.7	2.97
120	363,870.8	5,495,195.8	3.41
121	363,832.2	5,495,206.0	3.07
122	363,792.9	5,495,212.1	3.13
123	363,754.4	5,495,205.8	3.82
124	363,719.5	5,495,186.2	3.21
125	363,685.6	5,495,165.1	4.21
126	363,669.8	5,495,129.7	5.88
127	363,661.4	5,495,090.1	6.06
128	363,663.6	5,495,050.2	6.47
129	363,669.0	5,495,010.7	6.54
130	363,691.8	5,494,978.3	6.85
131	363,709.2	5,494,943.0	7.03
132	363,705.1	5,494,904.1	7.68
133	363,722.4	5,494,889.3	9.92
134	363,719.2	5,494,893.0	9.56
135	363,727.3	5,494,893.2	9.83
136	363,772.9	5,494,883.3	9.00
137	363,768.2	5,494,888.4	9.00
138	363,821.1	5,494,877.1	8.00
139	363,814.9	5,494,883.0	8.00
140	363,875.7	5,494,873.4	7.00
141	363,869.1	5,494,877.3	7.00
142	363,917.5	5,494,888.8	6.32
143	363,915.4	5,494,893.4	6.22
144	363,940.5	5,494,905.0	6.00
145	363,932.4	5,494,904.6	6.00
146	363,956.8	5,494,924.5	5.52
147	363,952.8	5,494,927.5	5.42
148	363,971.3	5,494,947.2	5.00
149	363,964.2	5,494,945.1	5.00
150	363,992.8	5,494,982.3	4.00
151	363,986.6	5,494,981.7	4.00
152	364,009.0	5,495,006.2	3.00
153	364,002.8	5,495,005.9	3.00
154	364,012.8	5,495,011.8	2.61
155	364,011.5	5,495,018.6	2.03
156	363,732.7	5,494,906.1	11.00
157	363,738.0	5,494,904.6	11.08
158	363,743.1	5,494,929.0	13.00
159	363,747.7	5,494,927.0	13.00
160	363,749.7	5,494,944.9	13.83
161	363,752.6	5,494,951.8	13.90
162	363,756.3	5,494,947.6	13.91
163	363,754.2	5,494,943.0	14.01
164	363,802.5	5,494,930.9	13.00
165	363,799.2	5,494,936.7	13.00
166	363,859.7	5,494,925.1	12.00
167	363,854.1	5,494,929.1	12.00
168	363,873.6	5,494,931.4	11.73
169	363,870.4	5,494,935.3	11.63

SUBGRADE STAKEOUT POINTS			
POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)
170	363,880.9	5,494,941.4	11.53
171	363,876.4	5,494,943.4	11.43
172	363,889.8	5,494,966.3	11.00
173	363,883.5	5,494,963.5	11.00
174	363,906.0	5,495,012.4	10.00
175	363,899.9	5,495,010.2	10.00
176	363,911.7	5,495,036.8	9.62
177	363,906.8	5,495,037.3	9.52
178	363,906.9	5,495,066.4	9.00
179	363,903.5	5,495,060.5	9.00
180	363,880.3	5,495,112.5	8.00
181	363,878.3	5,495,107.0	8.00
182	363,843.2	5,495,142.8	7.00
183	363,843.5	5,495,136.2	7.00
184	363,797.7	5,495,167.2	6.00
185	363,801.4	5,495,161.0	6.00
186	363,747.0	5,495,172.9	5.00
187	363,751.4	5,495,167.8	5.00
188	363,700.2	5,495,174.5	4.00
189	363,693.6	5,495,170.3	3.83
190	363,924.2	5,494,958.2	8.03
191	363,922.7	5,494,966.3	8.03
192	363,949.6	5,495,013.7	7.00
193	363,943.2	5,495,010.4	7.00
194	363,968.0	5,495,061.4	6.00
195	363,961.7	5,495,059.0	6.00
196	363,972.3	5,495,089.0	5.56
197	363,967.3	5,495,088.7	5.46
198	363,964.2	5,495,113.1	5.00
199	363,961.3	5,495,107.6	5.00
200	363,937.5	5,495,156.0	4.00
201	363,936.1	5,495,149.0	4.00
202	363,902.9	5,495,188.3	3.04
203	363,893.0	5,495,190.5	2.79
204	363,755.3	5,494,968.7	15.00
205	363,759.4	5,494,964.5	15.00
206	363,757.7	5,494,983.1	16.00
207	363,762.3	5,494,981.0	16.00
208	363,763.9	5,494,990.3	16.56
209	363,768.5	5,494,992.2	16.65
210	363,785.9	5,494,976.7	16.00
211	363,782.5	5,494,982.9	16.00
212	363,819.0	5,494,966.3	15.33
213	363,819.8	5,494,971.3	15.23
214	363,832.2	5,494,970.7	15.19
215	363,828.3	5,494,973.8	15.09
216	363,836.9	5,494,984.1	15.00
217	363,830.8	5,494,980.3	15.00
218	363,847.9	5,495,033.7	14.00
219	363,842.5	5,495,029.1	14.00
220	363,844.2	5,495,064.0	13.43
221	363,839.4	5,495,062.5	13.33
222	363,829.4	5,495,083.2	13.00
223	363,829.3	5,495,076.8	13.00
224	363,812.1	5,495,093.5	12.64
225	363,810.3	5,495,088.8	12.54
226	363,778.7	5,495,096.9	12.00
227	363,783.9	5,495,091.9	12.00
228	363,728.6	5,495,096.1	11.00
229	363,733.9	5,495,091.2	11.00
230	363,694.4	5,495,092.3	10.39
231	363,698.0	5,495,088.1	10.34
232	363,697.1	5,495,081.7	11.03
233	363,683.5	5,495,098.2	9.00
234	363,687.7	5,495,100.9	9.00
235	363,672.0	5,495,116.5	7.00
236	363,676.2	5,495,119.1	7.00
237	363,667.4	5,495,123.8	5.91
238	363,702.3	5,495,076.7	11.49
239	363,708.8	5,495,071.6	12.00

SUBGRADE STAKEOUT POINTS			
POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)
240	363,714.9	5,495,074.4	12.00
241	363,734.3	5,495,051.4	14.00
242	363,735.5	5,495,057.9	14.00
243	363,738.0	5,495,055.8	14.28
244	363,744.2	5,495,050.8	14.53
245	363,767.9	5,495,049.2	15.00
246	363,773.8	5,495,053.2	15.00
247	363,784.5	5,495,046.2	15.33
248	363,785.4	5,495,051.1	15.23
249	363,749.6	5,495,046.4	15.00
250	363,747.0	5,495,041.3	15.00
251	363,756.7	5,495,026.0	16.00
252	363,760.6	5,495,030.5	16.00
253	363,759.2	5,495,006.8	16.39
254	363,764.7	5,495,007.6	16.61
255	363,759.0	5,494,991.1	16.56
256	363,779.4	5,495,019.6	17.00
257	363,778.2	5,495,002.4	17.00
258	363,796.3	5,494,999.3	17.00
259	363,796.7	5,495,019.8	17.00
260	363,787.4	5,495,011.1	17.33
261	363,737.0	5,494,985.8	13.70
262	363,732.7	5,494,983.2	13.60
263	363,708.7	5,495,014.0	13.37
264	363,712.7	5,495,017.0	13.47
265	363,702.6	5,495,027.2	13.27
266	363,707.3	5,495,029.0	13.36
267	363,697.7	5,495,067.5	12.00
268	363,702.6	5,495,069.2	12.00

CADD FILE NO. \\wjv-fs201\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\From Contractor\18-13470-04-06-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

LEGEND

GRADED AREA

110 STAKEOUT POINTS

NOTES

1. ADDITIONAL STAKEOUT POINTS/OR THE SURFACE MODEL MAY BE PROVIDED DURING THE WORKS AT THE REQUEST OF THE CONTRACTOR.

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjustment Lands

Union Bay, B.C.

DESIGN	APPROVED
A.M.G.	J.K.C
DRAWN	CHECKED
M.D.D.S.	R.P.J.

SCALE

0m 20 40

1 : 1000

CLIENT: West Fraser Mills Ltd.

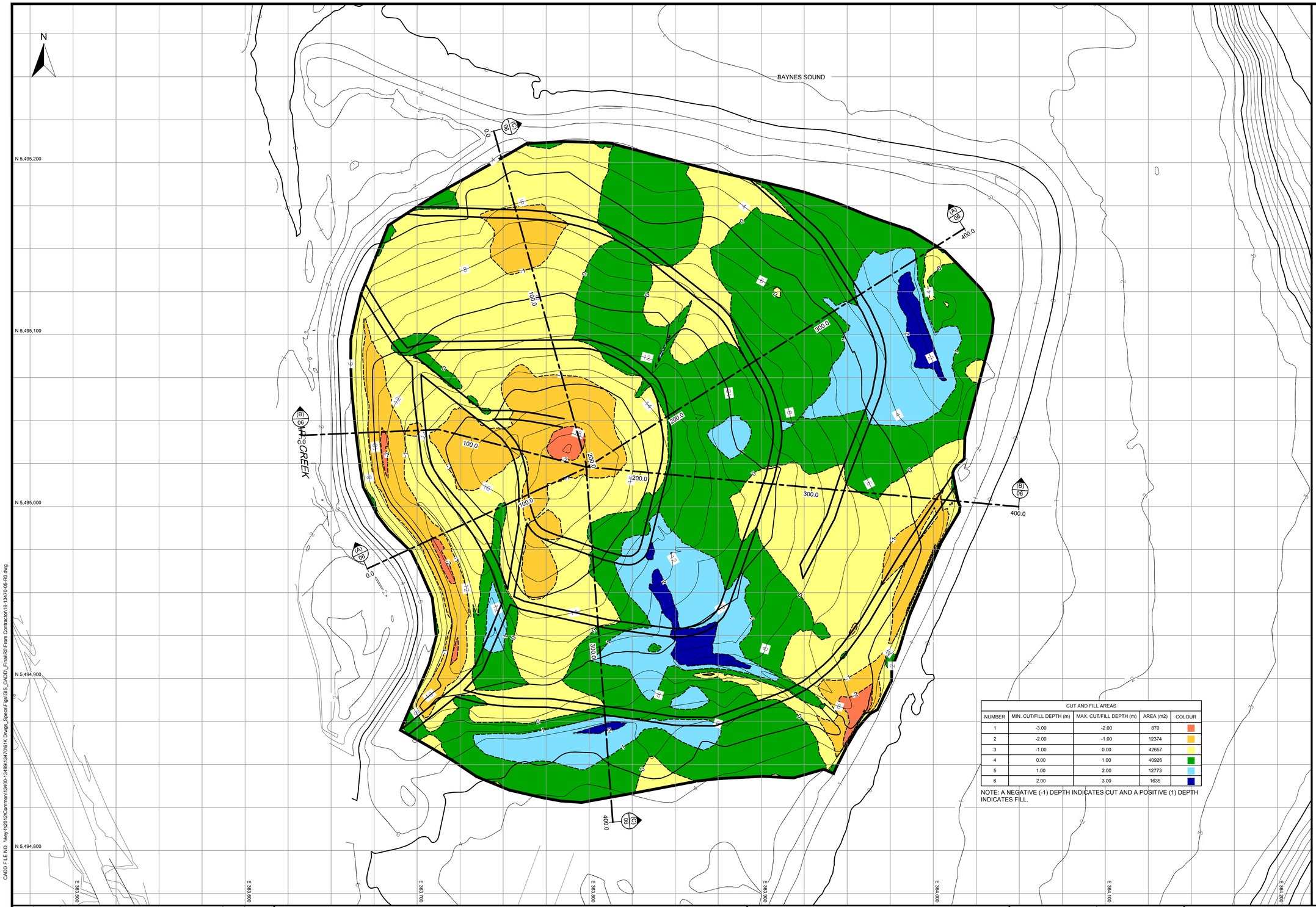
Grading Plan
Base Layer

SHEET No. 4 OF 23

PROJECT No. 13470-61K

REVISION No. 00

DRAWING No. 18-13470-04



CUT AND FILL AREAS				
NUMBER	MIN. CUT/FILL DEPTH (m)	MAX. CUT/FILL DEPTH (m)	AREA (m2)	COLOUR
1	-3.00	-2.00	870	
2	-2.00	-1.00	12374	
3	-1.00	0.00	42657	
4	0.00	1.00	40926	
5	1.00	2.00	12773	
6	2.00	3.00	1635	

NOTE: A NEGATIVE (-1) DEPTH INDICATES CUT AND A POSITIVE (1) DEPTH INDICATES FILL.

LEGEND

- BASE LAYER GRADING EXTENTS
- BENCHES
- DEPTH CONTOURS

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\From Contractor\18-13470-05-R0.dwg

PLOT SCALE: 1:1

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Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjustment Lands

Union Bay, B.C.

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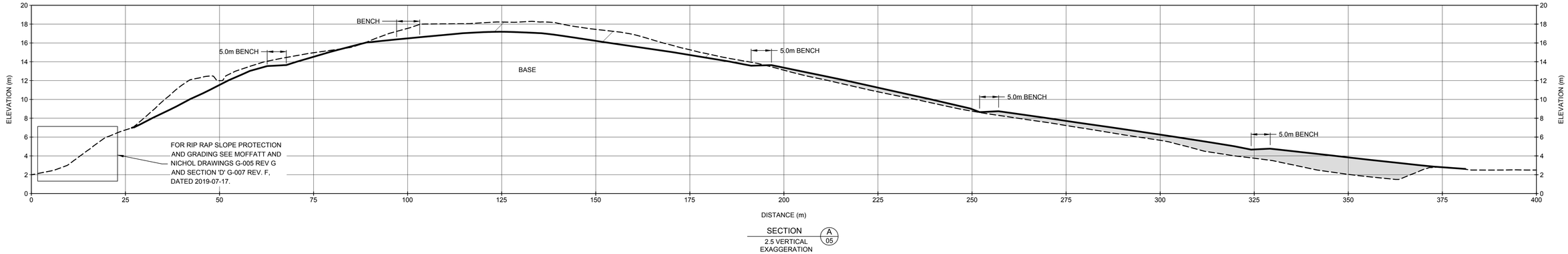
M.D.D.S.	R.P.J.

SCALE
0m 20 40
1 : 1000

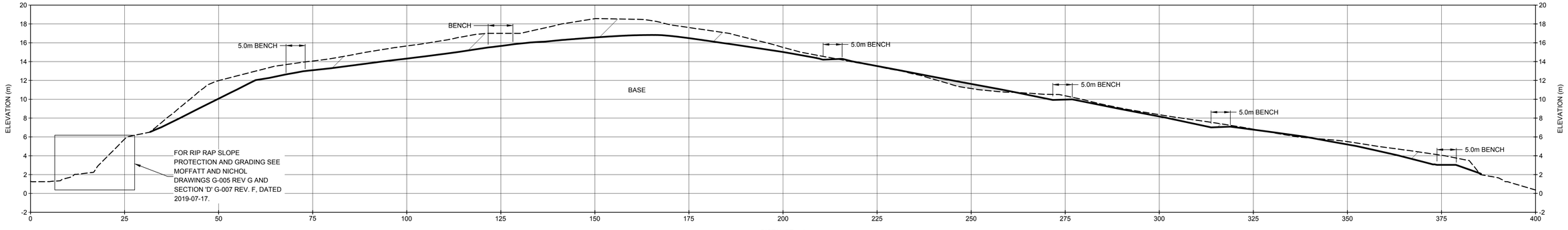
CLIENT: West Fraser Mills Ltd.

Grading Plan
Base Layer Cut and Fill Areas

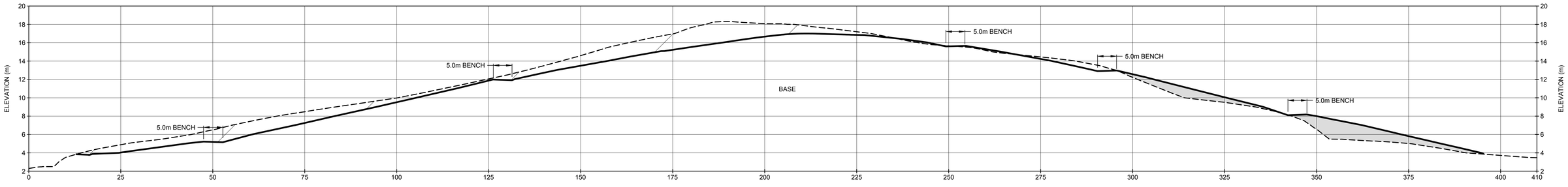
SHEET No. 5 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-05



SECTION A
2.5 VERTICAL EXAGGERATION
05



SECTION B
2.5 VERTICAL EXAGGERATION
05



SECTION C
2.5 VERTICAL EXAGGERATION
05

LEGEND
- EXISTING GROUND SURFACE
- GRADED BASE
- CUT ZONE
- FILL ZONE

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\From Contractor\18-13470-04-06-R0.dwg

PLOT SCALE: 1:1

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REVISIONS

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Keystone Environmental Ltd.
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Burnaby, British Columbia

Union Bay Coal Pile & Adjustment Lands

Union Bay, B.C.

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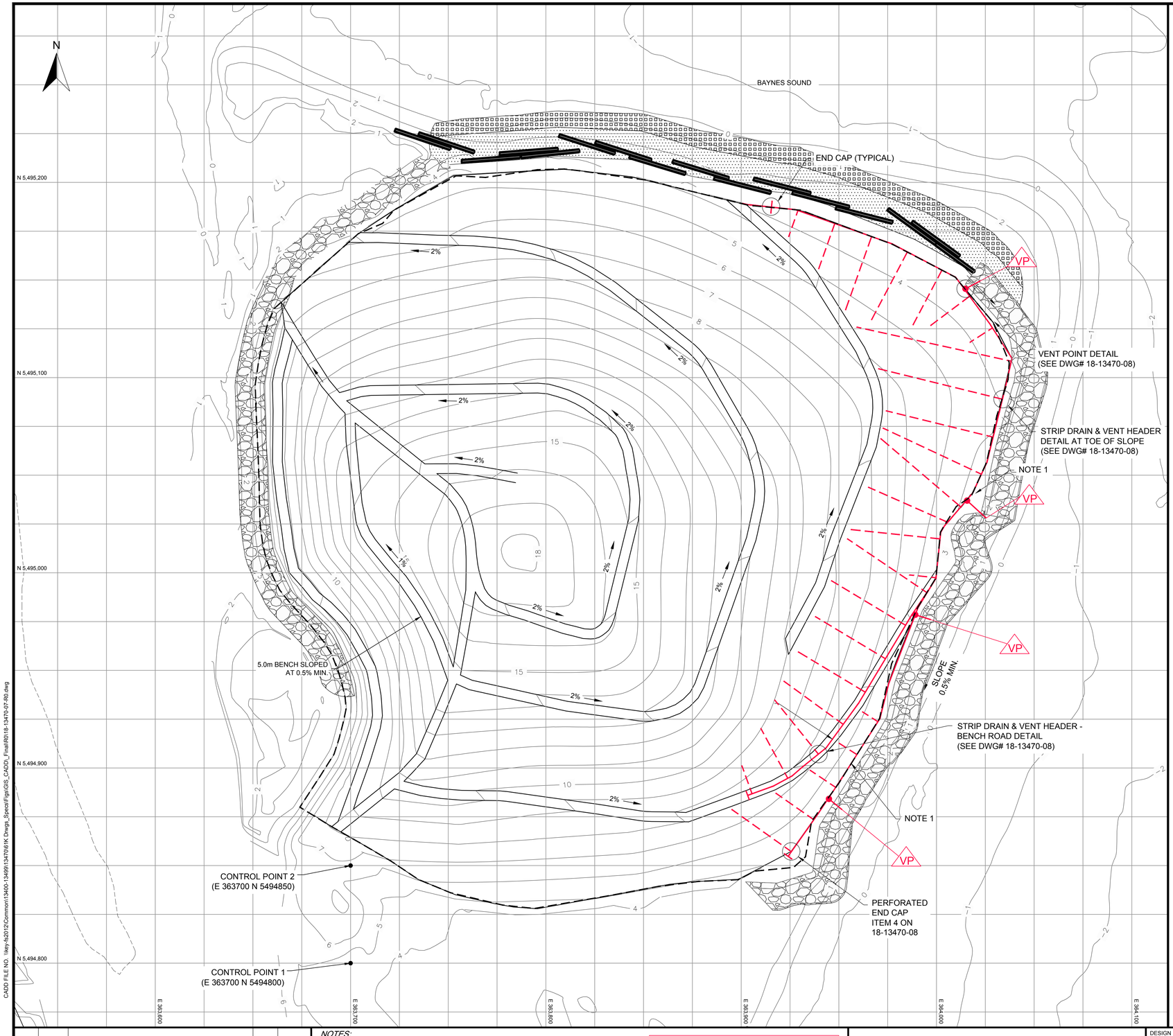
DRAWN	CHECKED
M.D.D.S.	R.P.J.

SCALE
0m 5 10 15 20
1 : 500

CLIENT
West Fraser Mills Ltd.

Grading Plan
Base Layer Sections

SHEET No. 6 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-06



LEGEND

- BGM LINER EXTENT
- VENT HEADER
- STRIP DRAIN
- VP VENT POINT

CADD FILE NO. \\eqv-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-07-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. LOW POINT DRAIN T-FITTING WITH PERFORATED END CAP (TYP.) TO BE SPACED EVERY 20m.

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjustment Lands

Union Bay, B.C.

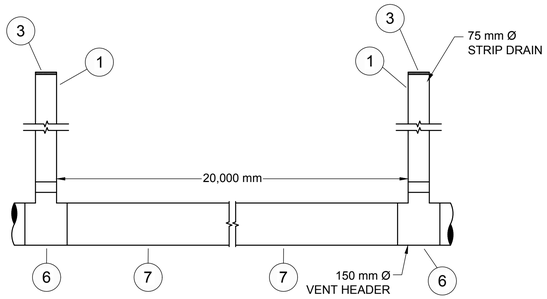
DESIGN	APPROVED
M.B./T.W.	J.K.C
DRAWN	CHECKED
MDDS/T.L.	R.P.J.

SCALE 0m 20 40 — 1 : 1000

CLIENT: West Fraser Mills Ltd.

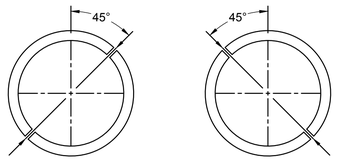
Venting Layer Pan

SHEET No. 7 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-07

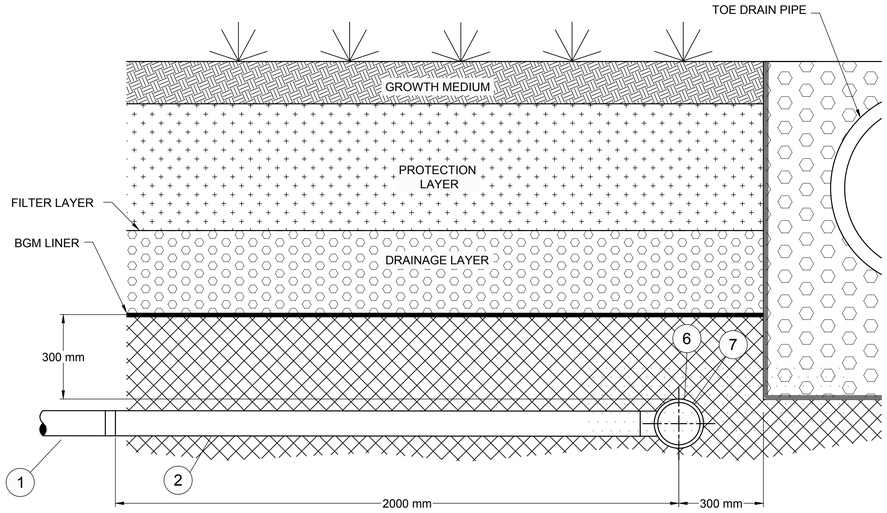


STRIP DRAIN PLAN VIEW (TYP.)
SCALE: 1:10

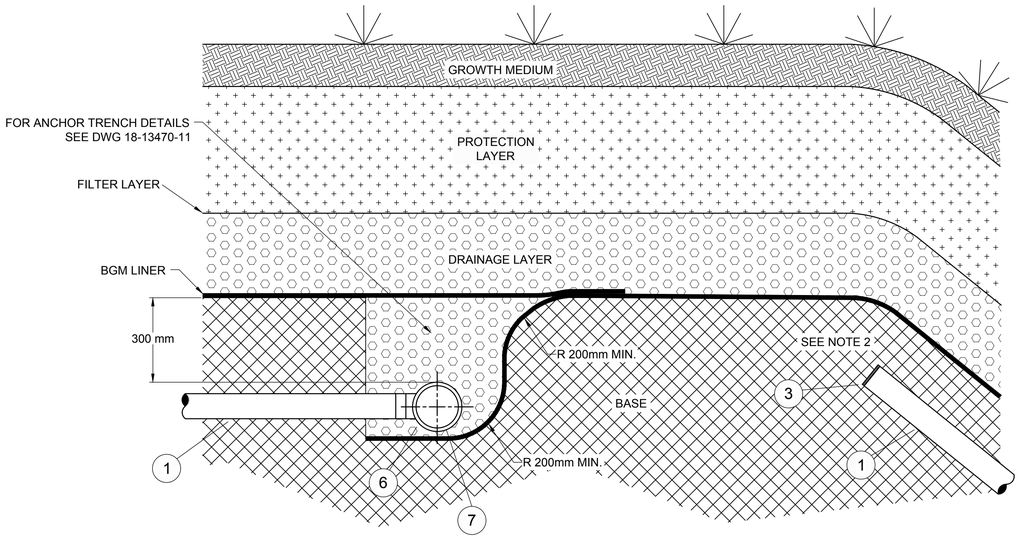
TYPE A PATTERN



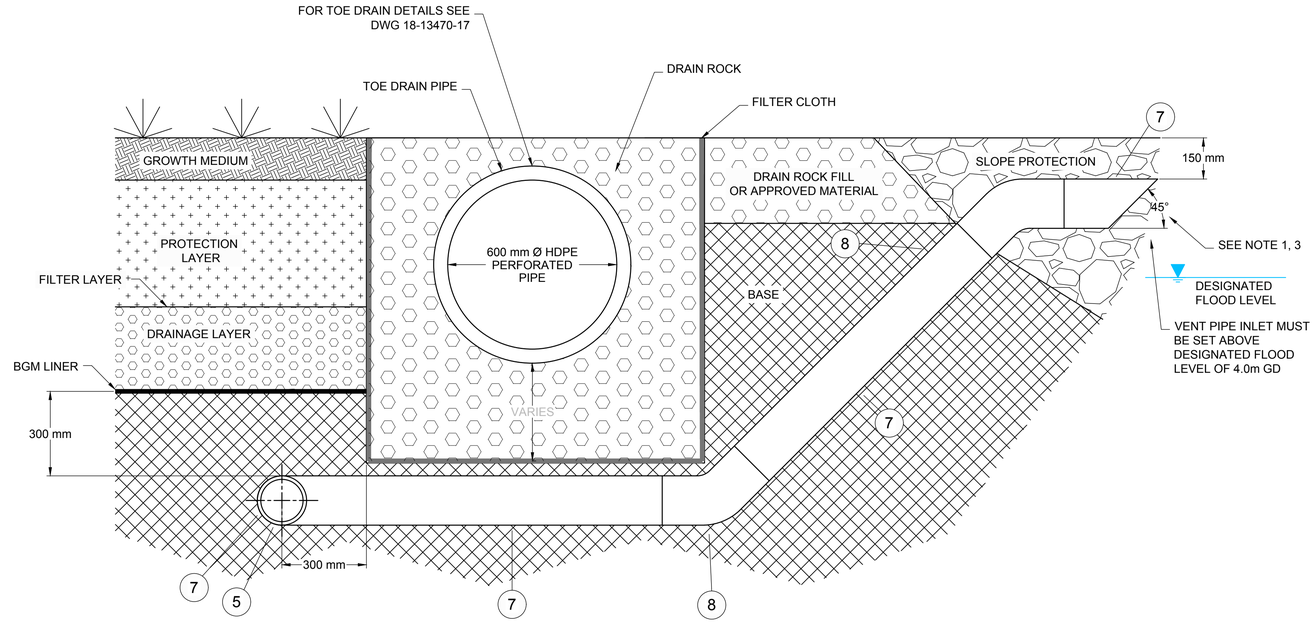
STRIP DRAIN PERFORATED PIPE 2 HOLE PATTERN
PERFORATIONS ROTATED 90° EVERY OTHER VALLEY
SCALE: 1:2



STRIP DRAIN AND VENT HEADER DETAIL AT TOE OF SLOPE (TYP.)
SCALE: 1:10



STRIP DRAIN AND VENT HEADER BENCH ROAD DETAIL (TYP.)
SCALE: 1:10



VENT POINT DETAIL (TYP.)
SCALE: 1:10

BILL OF MATERIALS

Item #	Item description	Size	Details
1	Corrugated Perforated Pipe w/ Geotextile Sock	75mm	75mm Ø , PERFORATED SINGLE-WALL HPDE PIPE, ASTM F 667/667M, cw Geotextile Filter Sock, ASTM D6707, MINIMUM STIFFNESS 240 kPa
2	Corrugated Single Wall Pipe	75mm	75mm Ø , SINGLE-WALL HPDE PIPE, ASTM F 667/667M, MINIMUM STIFFNESS 240 kPa
3	End Cap	75mm	75mm Ø , SNAP OR PLUG TYPE, SINGLE-WALL HPDE , ASTM F 667/667M
4	Perforated End Cap	75mm	75mm Ø , SNAP OR PLUG TYPE, PERFORATED SINGLE-WALL HPDE , ASTM F 667/667M
5	Tee Fittings	150mm	150mm Ø , SINGLE-WALL HPDE PIPE, ASTM F 667/667M
6	Reducing Tee	75mm x 150mm	"75mm Ø x 150mm Ø, SINGLE-WALL HPDE, ASTM F 2648/2648M"
7	Corrugated Dual Wall Pipe	150mm	150mm Ø , DUAL-WALL HPDE PIPE, AASHTO M252, MINIMUM STIFFNESS 340 kPa
8	45° Degree Elbow	150mm	"150mm Ø , DUAL-WALL HPDE , 45° ELBOW, ASTM F 2648/2648M"

NOTE:
1. *TRIM PIPE TO ANGLE DOWN.*
2. *STRIP DRAINS TO TERMINATE WITHIN 2.0m OF BENCH.*
3. *FIELD FIT SO THAT VENT PIPE EXTENDS BETWEEN 100 mm AND 300 mm IN TO RIPRAP.*

PRELIMINARY
NOT FOR CONSTRUCTION

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
M.B./T.W.	J.K.C.
DRAWN	CHECKED
T.L.	R.P.J.
SCALE	
AS SHOWN	

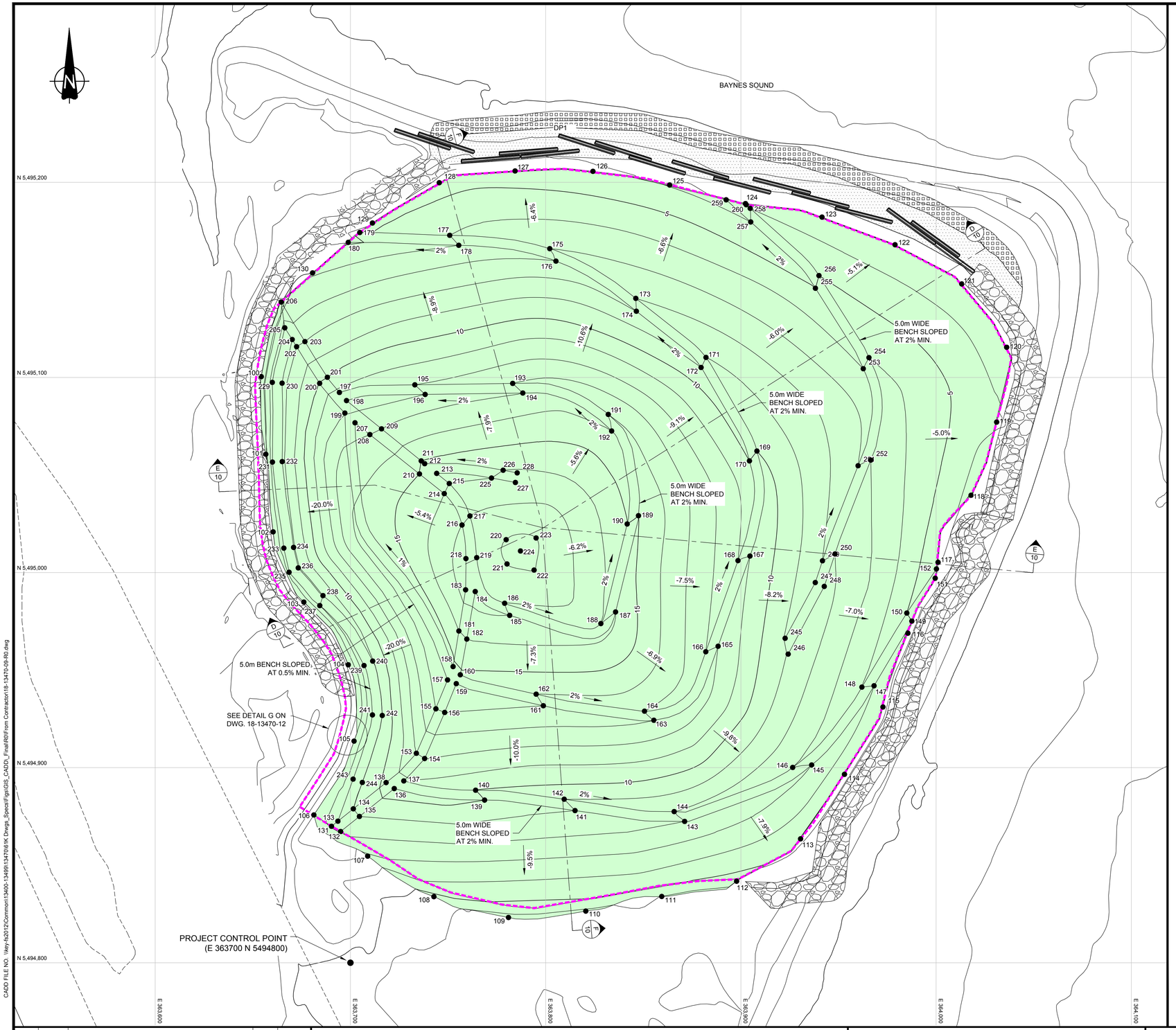
CLIENT: West Fraser Mills Ltd.

Venting System Details

SHEET No.	8 OF 23
PROJECT No.	13470-61K
REVISION No.	00
DRAWING No.	18-13470-08

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-08-R0.dwg

PLOT SCALE:



FINAL COVER STAKEOUT POINTS			
NAME	EASTING (m)	NORTHING (m)	ELEVATION (m)
100	363,654.3	5,495,100.4	5.0
101	363,656.7	5,495,060.6	5.6
102	363,660.4	5,495,020.8	6.0
103	363,676.1	5,494,984.8	6.0
104	363,698.9	5,494,952.7	6.0
105	363,701.9	5,494,913.6	7.0
106	363,681.3	5,494,875.7	7.0
107	363,708.8	5,494,854.6	6.7
108	363,742.8	5,494,833.9	4.7
109	363,781.0	5,494,823.2	3.6
110	363,820.6	5,494,826.5	3.8
111	363,859.5	5,494,834.0	4.0
112	363,897.8	5,494,841.8	3.8
113	363,930.6	5,494,863.5	4.2
114	363,953.1	5,494,896.6	4.3
115	363,972.8	5,494,931.1	4.3
116	363,985.6	5,494,968.9	4.3
117	364,001.0	5,495,005.2	3.2
118	364,017.9	5,495,039.6	2.8
119	364,031.0	5,495,077.1	3.4
120	364,036.1	5,495,115.5	2.4
121	364,013.1	5,495,147.9	2.5
122	363,979.0	5,495,168.0	2.5
123	363,941.6	5,495,182.2	2.4
124	363,902.4	5,495,189.1	3.0
125	363,863.5	5,495,198.6	3.1
126	363,824.2	5,495,205.6	3.2
127	363,784.3	5,495,205.8	3.5
128	363,745.5	5,495,199.8	3.8
129	363,711.3	5,495,179.1	3.8
130	363,680.6	5,495,153.6	5.0
131	363,690.3	5,494,869.9	8.1
132	363,695.0	5,494,867.3	8.1
133	363,693.6	5,494,872.5	9.0
134	363,701.5	5,494,878.9	9.0
135	363,704.6	5,494,875.0	9.0
136	363,722.4	5,494,889.3	10.8
137	363,727.3	5,494,893.2	10.7
138	363,718.3	5,494,892.3	10.3
139	363,768.7	5,494,883.4	10.0
140	363,764.1	5,494,888.4	10.0
141	363,815.1	5,494,878.0	9.0
142	363,809.5	5,494,883.8	9.0
143	363,871.2	5,494,872.4	8.0
144	363,865.8	5,494,877.5	8.0
145	363,936.2	5,494,901.4	7.0
146	363,926.5	5,494,900.1	7.0
147	363,968.2	5,494,942.0	6.0
148	363,962.0	5,494,941.3	6.0
149	363,987.6	5,494,975.1	5.0
150	363,985.0	5,494,979.2	5.0
151	363,999.5	5,494,997.1	4.3
152	364,000.2	5,495,001.8	4.2
153	363,733.8	5,494,907.3	12.0
154	363,738.0	5,494,904.7	12.0
155	363,743.8	5,494,930.1	14.0
156	363,748.3	5,494,928.3	14.0
157	363,749.7	5,494,944.9	14.7
158	363,752.6	5,494,951.8	14.8
159	363,754.2	5,494,943.0	14.9
160	363,756.3	5,494,947.6	14.8
161	363,798.8	5,494,931.7	14.0
162	363,795.1	5,494,937.7	14.0
163	363,855.4	5,494,924.3	13.0
164	363,850.6	5,494,928.9	13.0
165	363,888.3	5,494,962.2	12.0
166	363,882.0	5,494,959.4	12.0
167	363,904.6	5,495,008.4	11.0
168	363,898.5	5,495,006.1	11.0
169	363,908.2	5,495,062.3	10.0

FINAL COVER STAKEOUT POINTS			
NAME	EASTING (m)	NORTHING (m)	ELEVATION (m)
170	363,904.4	5,495,057.2	10.0
171	363,882.1	5,495,110.2	9.0
172	363,879.6	5,495,105.1	9.0
173	363,846.2	5,495,140.5	8.0
174	363,846.5	5,495,133.9	8.0
175	363,802.1	5,495,166.0	7.0
176	363,805.3	5,495,159.6	7.0
177	363,750.8	5,495,172.8	6.0
178	363,755.5	5,495,167.7	6.0
179	363,704.8	5,495,174.3	5.0
180	363,698.9	5,495,169.2	4.9
181	363,755.6	5,494,970.0	16.0
182	363,759.6	5,494,965.9	16.0
183	363,759.0	5,494,991.1	17.5
184	363,763.9	5,494,990.3	17.5
185	363,781.6	5,494,978.0	17.0
186	363,779.0	5,494,984.2	17.0
187	363,835.8	5,494,979.8	16.0
188	363,828.3	5,494,973.8	16.0
189	363,847.5	5,495,029.1	15.0
190	363,841.8	5,495,024.9	15.0
191	363,832.1	5,495,081.0	14.0
192	363,833.8	5,495,072.5	14.0
193	363,783.1	5,495,096.9	13.0
194	363,788.3	5,495,092.0	13.0
195	363,733.0	5,495,096.2	12.0
196	363,738.3	5,495,091.3	12.0
197	363,694.4	5,495,092.3	11.3
198	363,698.0	5,495,088.1	11.2
199	363,697.1	5,495,081.7	11.9
200	363,684.2	5,495,097.0	10.0
201	363,688.2	5,495,100.1	10.0
202	363,672.4	5,495,115.8	8.0
203	363,676.7	5,495,118.4	8.0
204	363,670.2	5,495,119.4	7.6
205	363,666.4	5,495,125.4	7.5
206	363,664.5	5,495,138.6	5.7
207	363,702.3	5,495,076.7	12.4
208	363,710.0	5,495,070.7	13.0
209	363,715.9	5,495,073.6	13.0
210	363,735.4	5,495,050.5	15.0
211	363,736.3	5,495,057.2	15.0
212	363,738.0	5,495,055.8	15.2
213	363,744.2	5,495,050.8	15.4
214	363,748.1	5,495,040.4	16.0
215	363,750.6	5,495,045.6	16.0
216	363,757.2	5,495,024.4	17.0
217	363,761.2	5,495,029.0	17.0
218	363,759.2	5,495,007.1	17.3
219	363,764.7	5,495,007.6	17.5
220	363,779.8	5,495,016.8	18.0
221	363,780.2	5,495,004.4	18.0
222	363,794.1	5,495,001.3	18.0
223	363,795.1	5,495,017.7	18.0
224	363,787.1	5,495,011.0	18.2
225	363,772.3	5,495,048.4	16.0
226	363,778.2	5,495,052.4	16.0
227	363,784.5	5,495,046.2	16.2
228	363,785.4	5,495,051.1	16.1
229	363,660.0	5,495,097.5	7.5
230	363,665.0	5,495,097.1	7.6
231	363,660.0	5,495,056.6	7.6
232	363,665.0	5,495,056.9	7.7
233	363,665.9	5,495,012.5	7.8
234	363,670.9	5,495,012.9	7.9
235	363,668.6	5,495,000.1	7.5
236	363,673.3	5,495,002.4	7.6
237	363,684.3	5,494,983.0	8.0
238	363,685.9	5,494,988.2	8.0
239	363,707.0	5,494,952.3	8.8

FINAL COVER STAKEOUT POINTS			
NAME	EASTING (m)	NORTHING (m)	ELEVATION (m)
240	363,711.4	5,494,954.6	8.9
241	363,711.3	5,494,927.0	8.9
242	363,716.3	5,494,926.7	9.0
243	363,701.4	5,494,894.1	8.9
244	363,706.1	5,494,892.4	9.0
245	363,922.7	5,494,966.3	8.9
246	363,924.2	5,494,958.2	8.9
247	363,938.1	5,494,994.9	8.2
248	363,942.7	5,494,992.9	8.3
249	363,941.8	5,495,006.0	8.0
250	363,948.2	5,495,009.5	8.0
251	363,960.0	5,495,054.7	7.0
252	363,966.5	5,495,057.6	7.0
253	363,962.7	5,495,104.5	6.0
254	363,965.6	5,495,110.2	6.0
255	363,938.2	5,495,145.7	5.0
256	363,940.0	5,495,152.2	5.0
257	363,905.0	5,495,179.7	4.0
258	363,904.8	5,495,186.6	4.0
259	363,892.4	5,495,191.0	3.9
260	363,902.7	5,495,188.5	3.9

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PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
		REVISIONS		
00	2/26/20	Issued for Client Review	T.L.	J.K.C

LEGEND

LINER EXTENTS; RIPRAP EXTENTS; COBBLE; SAND; GRADING EXTENTS; 110 STAKEOUT POINTS; ANCHORED LOGS

NOTES

1. ADDITIONAL STAKEOUT POINTS/OR THE SURFACE MODEL MAY BE PROVIDED DURING THE WORKS AT THE REQUEST OF THE CONTRACTOR.

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjustment Lands

Union Bay, B.C.

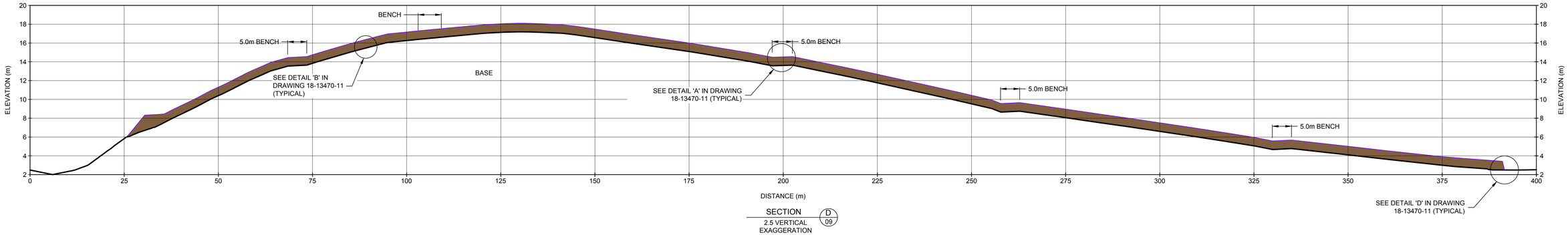
DESIGN	APPROVED
A.M.G.	J.K.C
DRAWN	CHECKED
M.D.D.S.	R.P.J.

SCALE 0m 20 40 — 1 : 1000

CLIENT: West Fraser Mills Ltd.

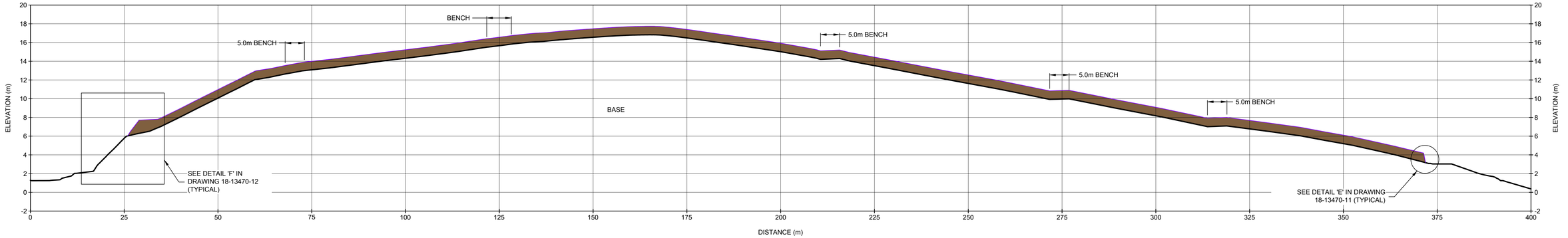
Final Cover Plan

SHEET No. 9 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-09



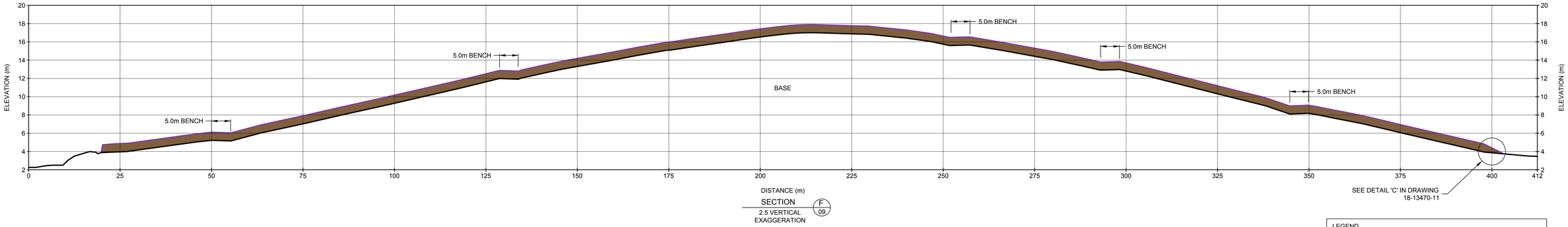
SECTION D / 09

2.5 VERTICAL EXAGGERATION



SECTION E / 09

2.5 VERTICAL EXAGGERATION



SECTION F / 09

2.5 VERTICAL EXAGGERATION

LEGEND

- BASE LAYER
- FINAL COVER
- VEGETATED COVER LAYER

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTE: THE RIPRAP HAS BEEN REMOVED FROM THIS CROSS SECTION AS IT IS NOT DEEMED TO BE PART OF THE COVER. CROSS SECTIONS OF THE RIPRAP ARE PRESENTED IN SLOPE PROTECTION DRAWINGS (REVISION F) BY MOFFATT AND NICHOL.

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay BASE & Adjustment Lands

Union Bay, B.C.

DESIGN	APPROVED
A.M.G.	J.K.C
DRAWN	CHECKED
M.D.D.S.	R.P.J.

SCALE 0m 5 10 15 20 — 1 : 500

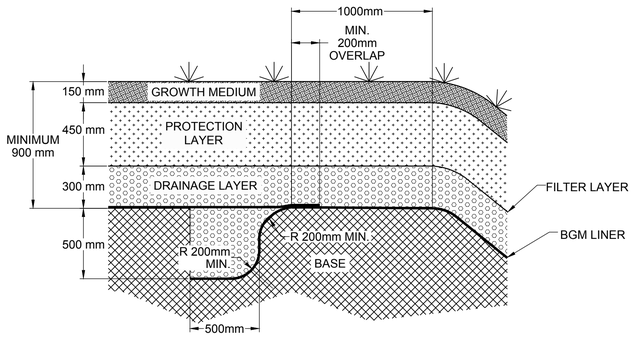
CLIENT: West Fraser Mills Ltd.

Final Cover Cross-Sections

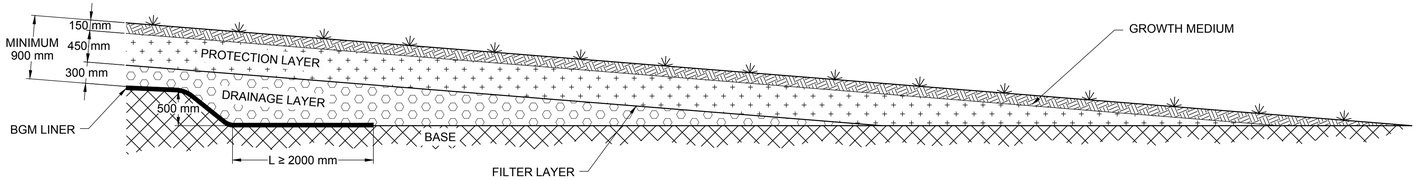
SHEET No.	10 OF 23
PROJECT No.	13470-61K
REVISION No.	00
DRAWING No.	18-13470-10

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\From Contractor\18-13470-10-R0.dwg

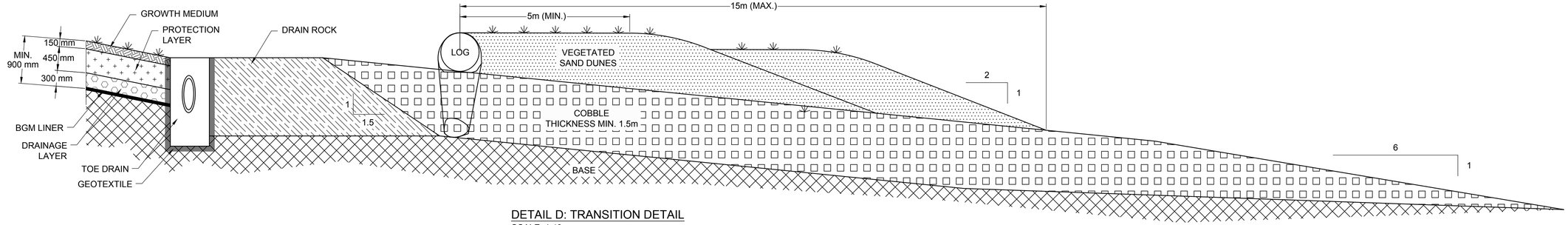
PLOT SCALE: 1:1



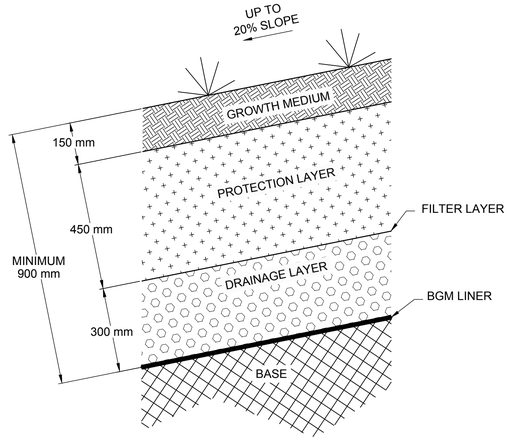
DETAIL A: TYPICAL ANCHOR TRENCH DETAIL
SCALE: 1:20



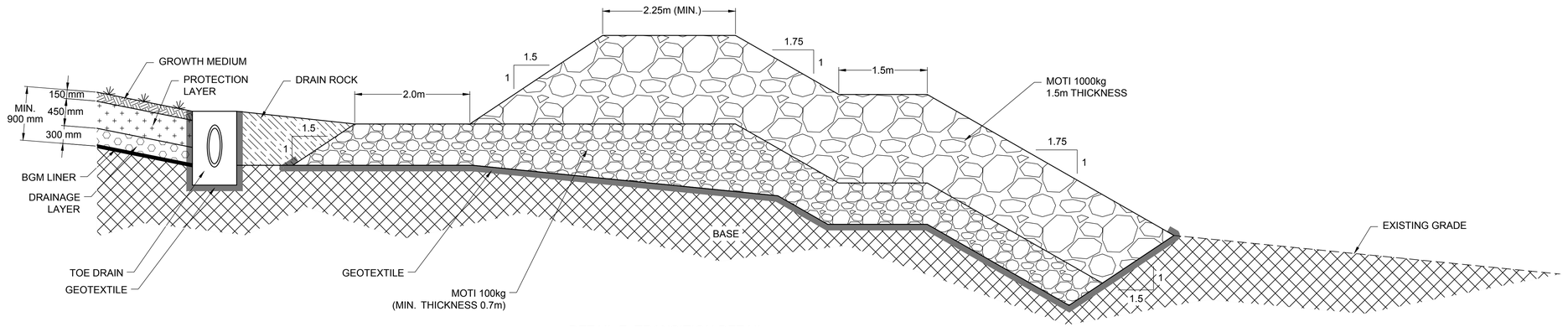
DETAIL C: TYPICAL ANCHOR DETAIL AT TOE OF SLOPE ON SOUTH SIDE
SCALE: 1:40



DETAIL D: TRANSITION DETAIL
SCALE: 1:40



DETAIL B: TYPICAL COVER DETAIL UP TO 20% SLOPE
SCALE: 1:10



DETAIL E: TRANSITION DETAIL
SCALE: 1:40

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R018-13470-11-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

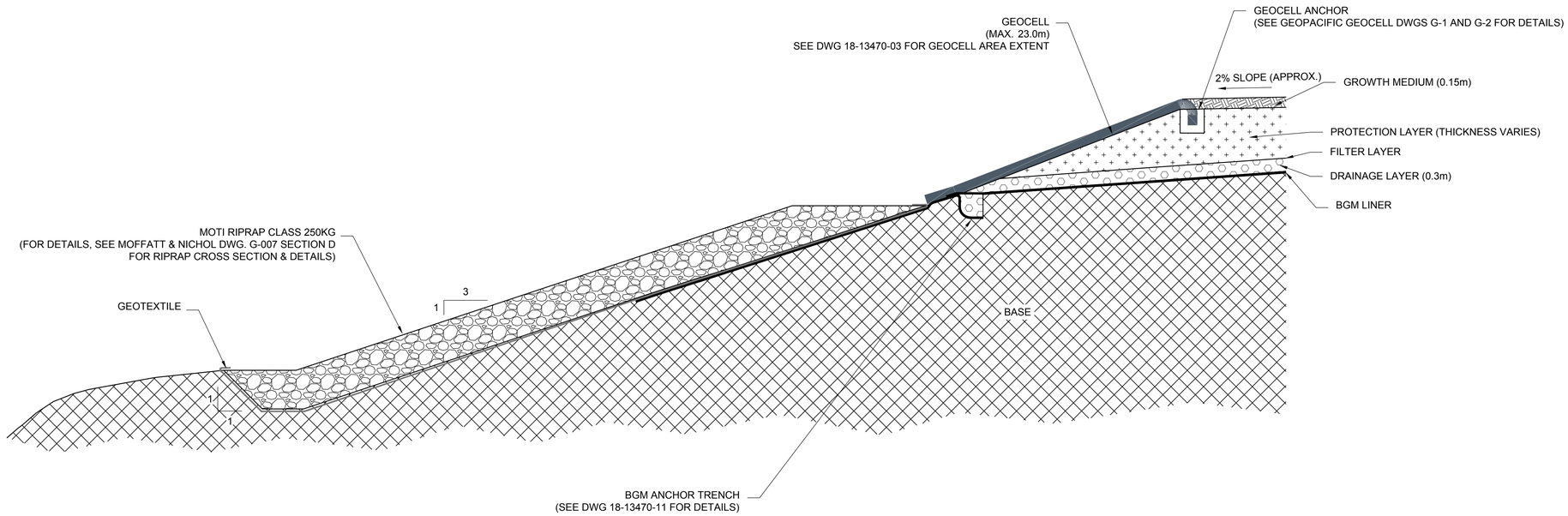
DESIGN	APPROVED
M.M./Z.P.	J.K.C.
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
AS SHOWN

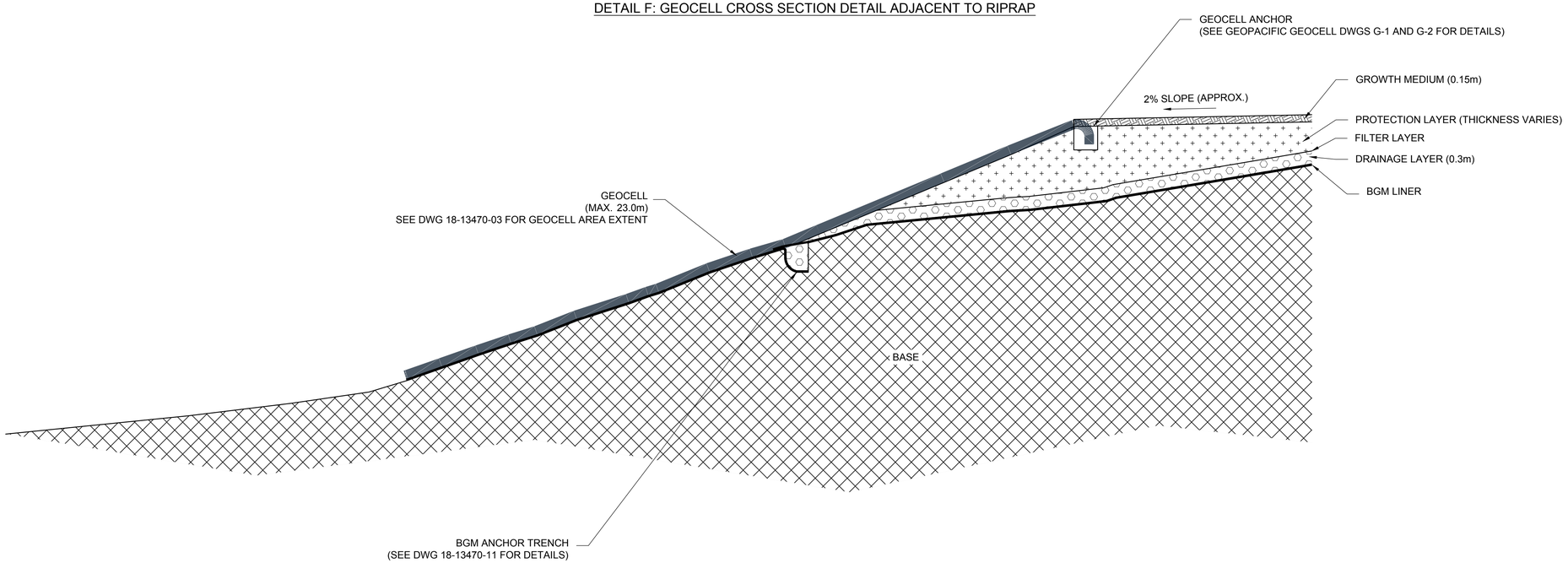
CLIENT
West Fraser Mills Ltd.

Cover System and
Anchor Trench Details

SHEET No. 11 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-11



DETAIL F: GEOCELL CROSS SECTION DETAIL ADJACENT TO RIPRAP



DETAIL G: GEOCELL CROSS SECTION DETAIL

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-12-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
Z.P./M.M.	J.K.C.
DRAWN	CHECKED
T.L.	R.P.J.

SCALE

0.5m 0 2.5m

SCALE: 1:50

CLIENT: West Fraser Mills Ltd.

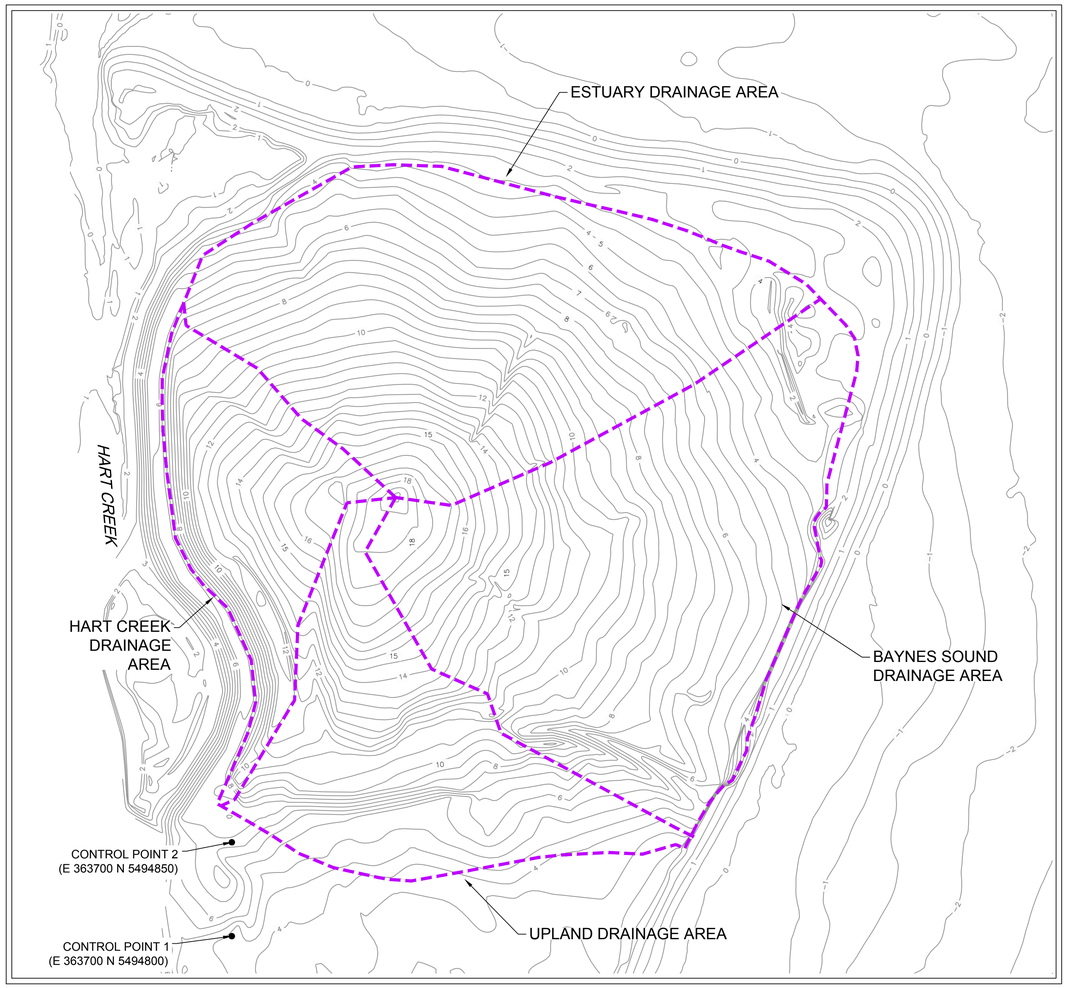
Geocell System and Details

SHEET No. 12 OF 23

PROJECT No. 13470-61K

REVISION No. 00

DRAWING No. 18-13470-12



N

PRE-REMEDIATION DRAINAGE AREAS

POST-REMEDIATION DRAINAGE AREAS

Receiving Environment	Pre-Remediation Drainage Areas	Post-Remediation Drainage Areas	Post-Remediation Sub-Catchment Areas	Post-Remediation Discharge Point
(Discharge Zones)	(ha)	(ha)		(DP#)
Baynes Sound	3.6	3.0	3A – 3F	3
Upland	2.2	2.6	4A – 4E	4
Hart Creek	1.3	0.9	5	n/a*
Estuary	3.8	4.4	1A – 1D	1
			2A – 2E	2

LEGEND

- DRAINAGE AREA BOUNDARY
- SUBCATCHMENT AREA BOUNDARY
- 8 TOPOGRAPHIC CONTOUR LINES
- DP1 DISCHARGE POINT

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. *THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*
2. *SUB-CATCHMENT AREA 5 WILL SHEET FLOW INTO HART CREEK, SIMILAR TO PRE-REMEDIATION CONDITIONS, THERE WILL BE NO DISCHARGE POINT UNDER POST-REMEDIATION CONDITIONS.*

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
J.L./T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE

25m 0 75m

SCALE: 1:1500(approx.)

CLIENT: West Fraser Mills Ltd.

Pre and Post Remediation Drainage Areas

SHEET No. 13 OF 23

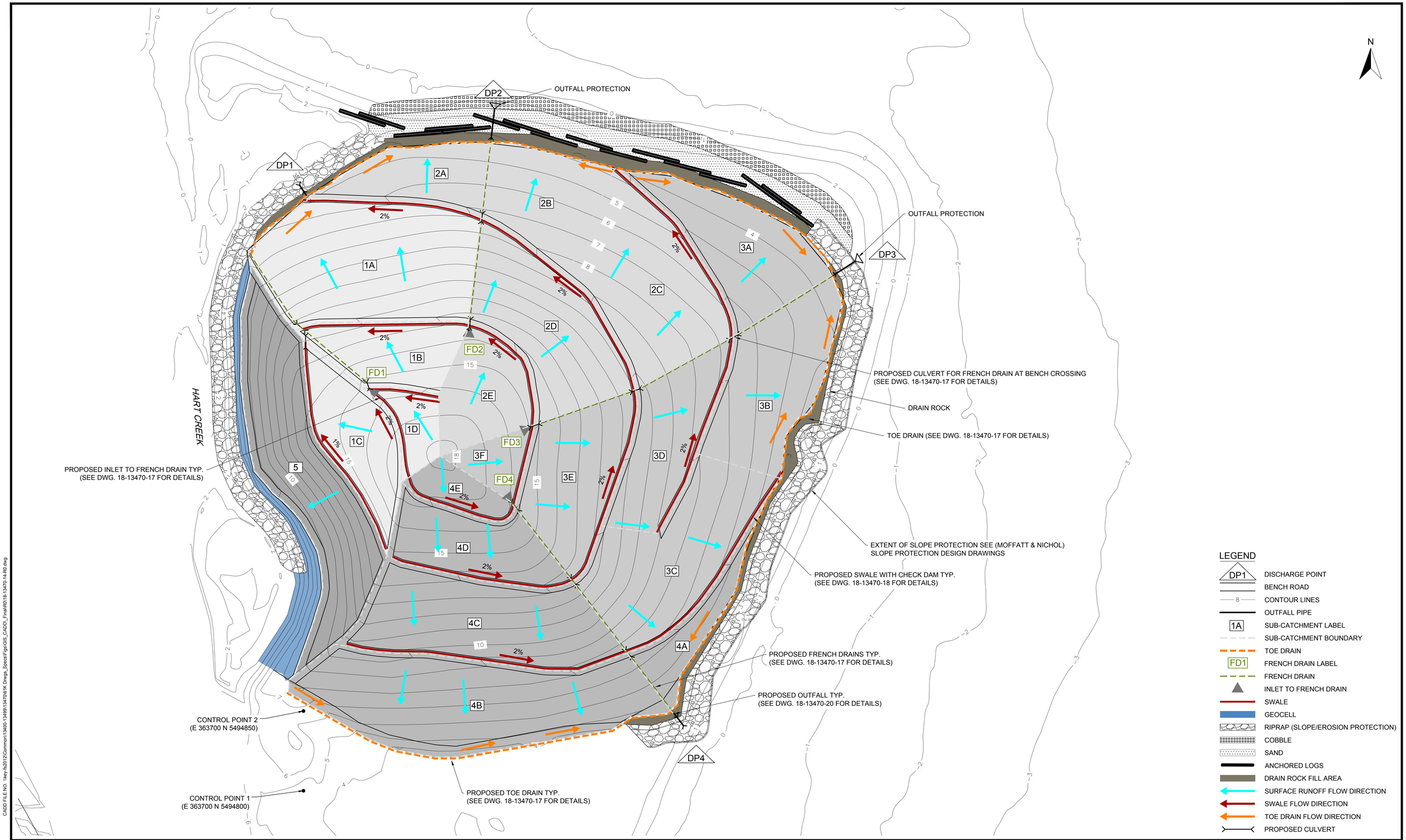
PROJECT No. 13470-61K

REVISION No. 00

DRAWING No. 18-13470-13

CADD FILE NO. \\eqv-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R01\18-13470-13-R00.dwg

PLOT SCALE:



LEGEND

- DP1 — DISCHARGE POINT
- BENCH ROAD
- 8 — CONTOUR LINES
- OUTFALL PIPE
- 1A — SUB-CATCHMENT LABEL
- SUB-CATCHMENT BOUNDARY
- TOE DRAIN
- FD1 — FRENCH DRAIN LABEL
- FRENCH DRAIN
- INLET TO FRENCH DRAIN
- SWALE
- GEOCELL
- RIPRAP (SLOPE/EROSION PROTECTION)
- COBBLE
- SAND
- ANCHORED LOGS
- DRAIN ROCK FILL AREA
- SURFACE RUNOFF FLOW DIRECTION
- SWALE FLOW DIRECTION
- TOE DRAIN FLOW DIRECTION
- PROPOSED CULVERT

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. *THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*
2. *SLOPE PROTECTION DRAWINGS (REVISION F), BY MOFFATT AND NICHOL.*

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Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
10m 0 50m
SCALE: 1:1000

CLIENT: West Fraser Mills Ltd.

Stormwater Management Plan

SHEET No.	14 OF 23
PROJECT No.	13470-61K
REVISION No.	00
DRAWING No.	18-13470-14

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-14-R0.dwg

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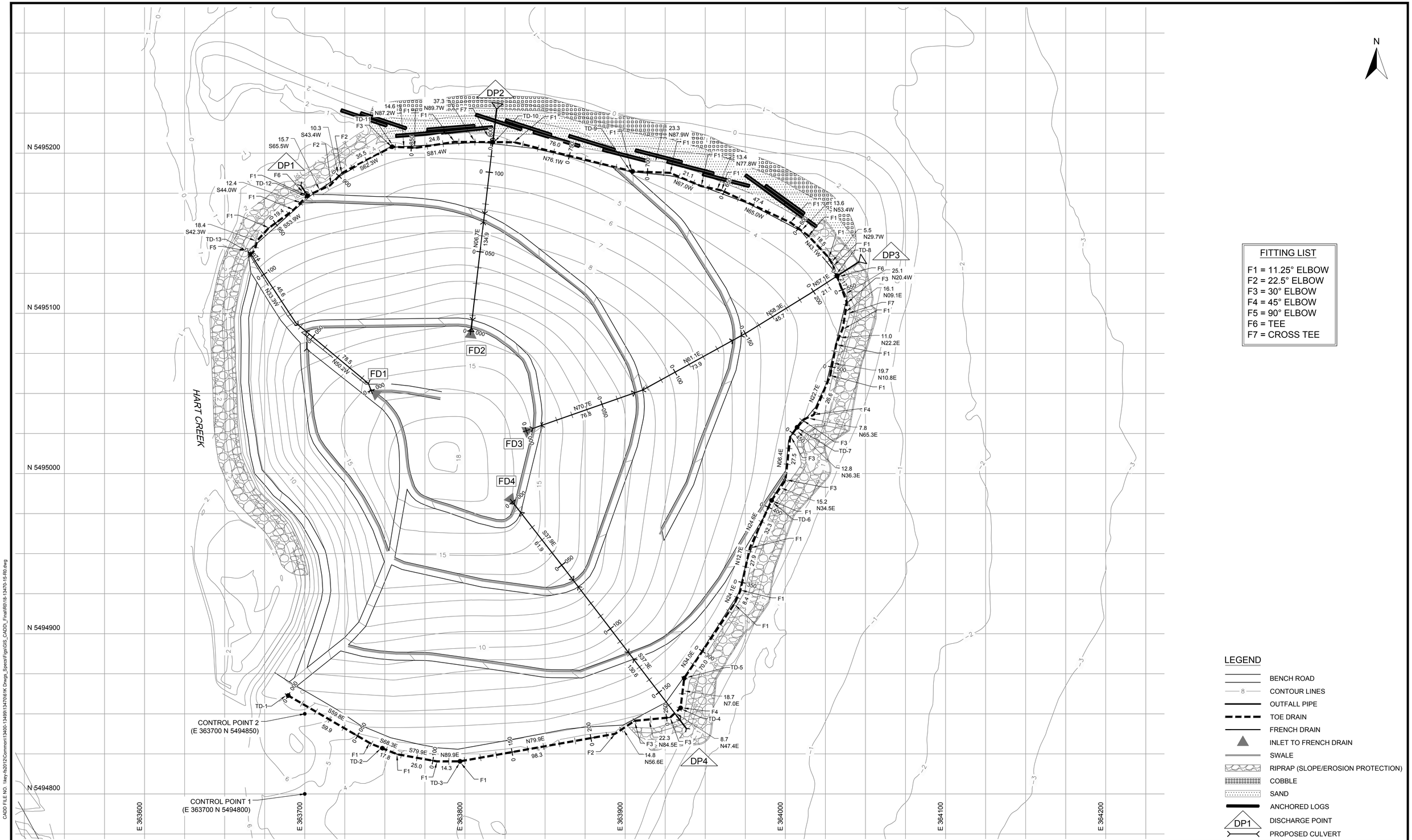


CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R01\18-13470-15-R0.dwg

PLOT SCALE:

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. *THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*
2. *SLOPE PROTECTION DRAWINGS (REVISION F), BY MOFFATT AND NICHOL.*

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
T.W.	J.K.C.
DRAWN	CHECKED
T.L.	R.P.J.

SCALE

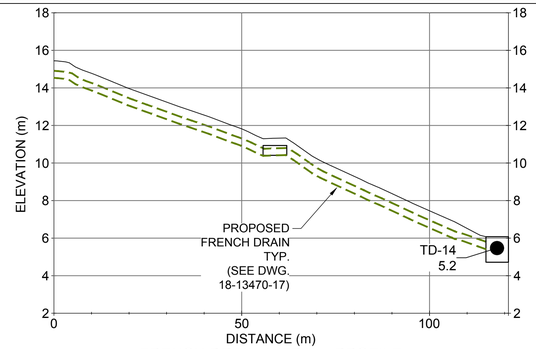
10m 0 50m

SCALE: 1:1000

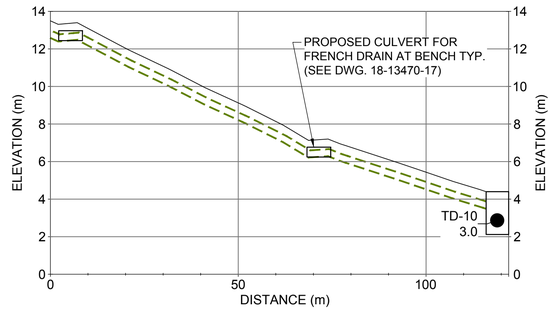
CLIENT: West Fraser Mills Ltd.

Stormwater Management Plan Layout Areas

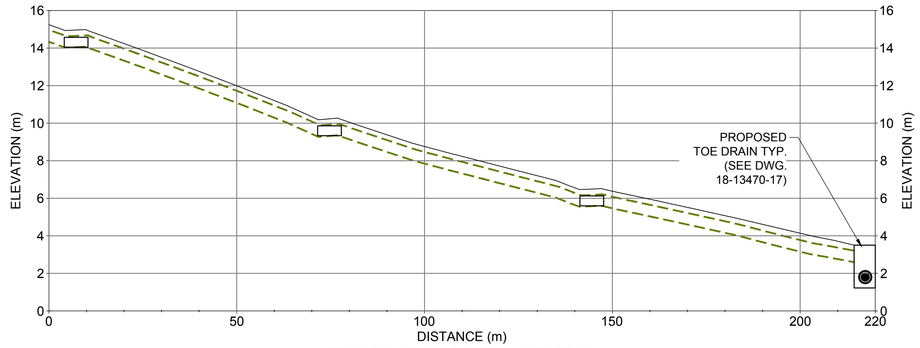
SHEET No.	15 OF 23
PROJECT No.	13470-61K
REVISION No.	00
DRAWING No.	18-13470-15



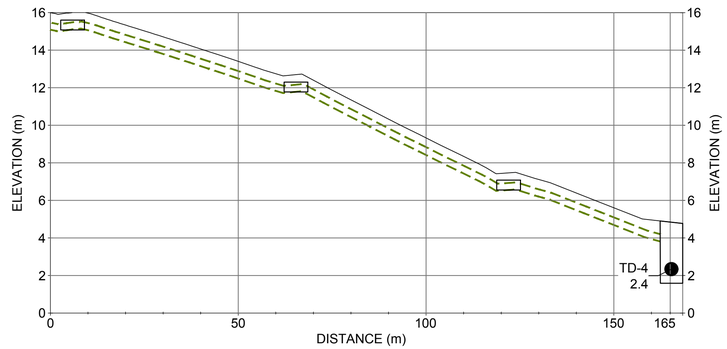
FRENCH DRAIN 1 (FD1) - PROFILE



FRENCH DRAIN 2 (FD2) - PROFILE



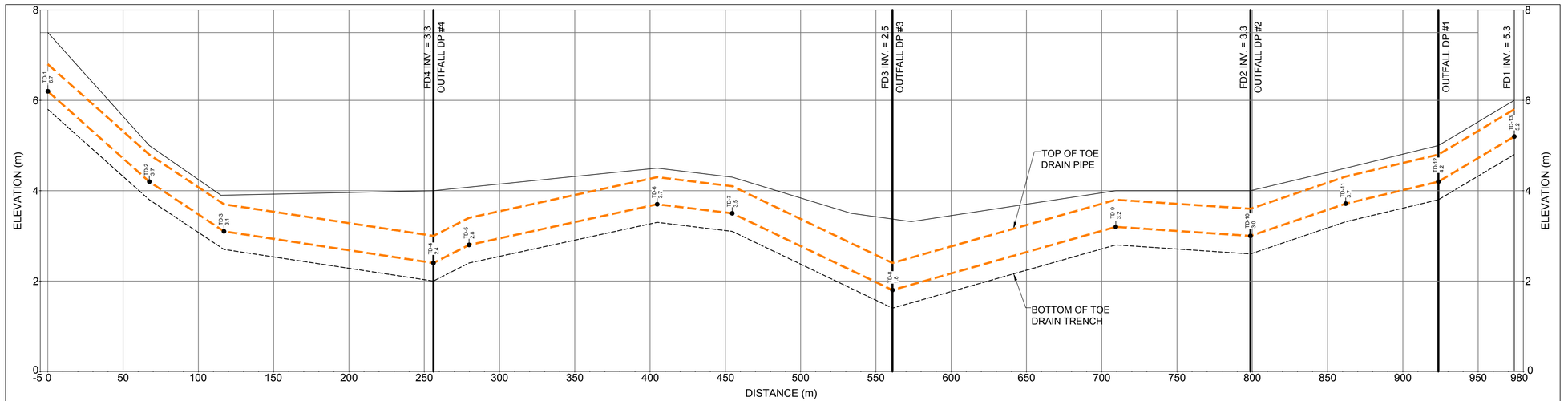
FRENCH DRAIN 3 (FD3) - PROFILE



FRENCH DRAIN 4 (FD4) - PROFILE

FRENCH DRAIN PROFILES

SCALE: HOR. 1:750 VERT.1:150



TOE DRAIN PERFORATED PIPE INVERT PROFILE

SCALE: HOR. 1:1500 VERT.1:50

LEGEND

- RIPRAP (SLOPE/EROSION PROTECTION)
- PROPOSED SURFACE
- TOE DRAIN
- FRENCH DRAIN

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2. OUTFALL CROSS SECTIONS SHOWN ON DRAWING 18-13470-20.

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE: AS NOTED

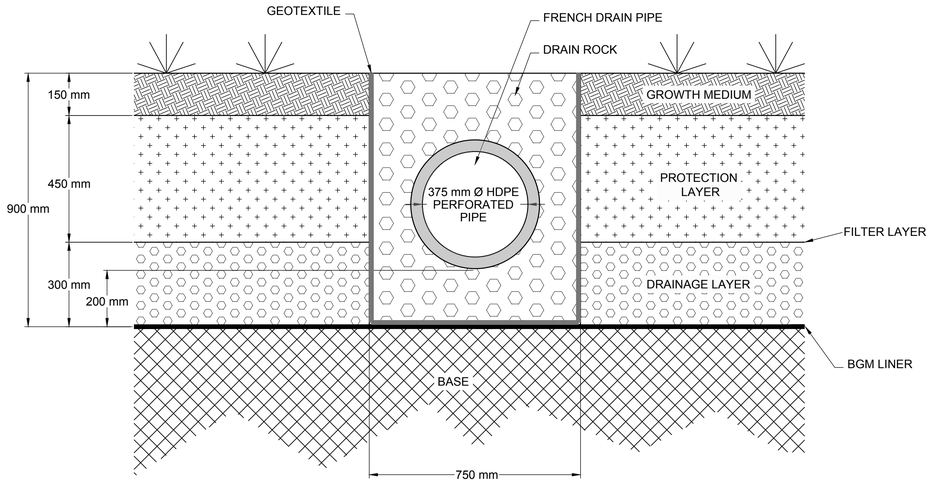
CLIENT: West Fraser Mills Ltd.

French Drain & Toe Drain Profiles

SHEET No. 16 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-16

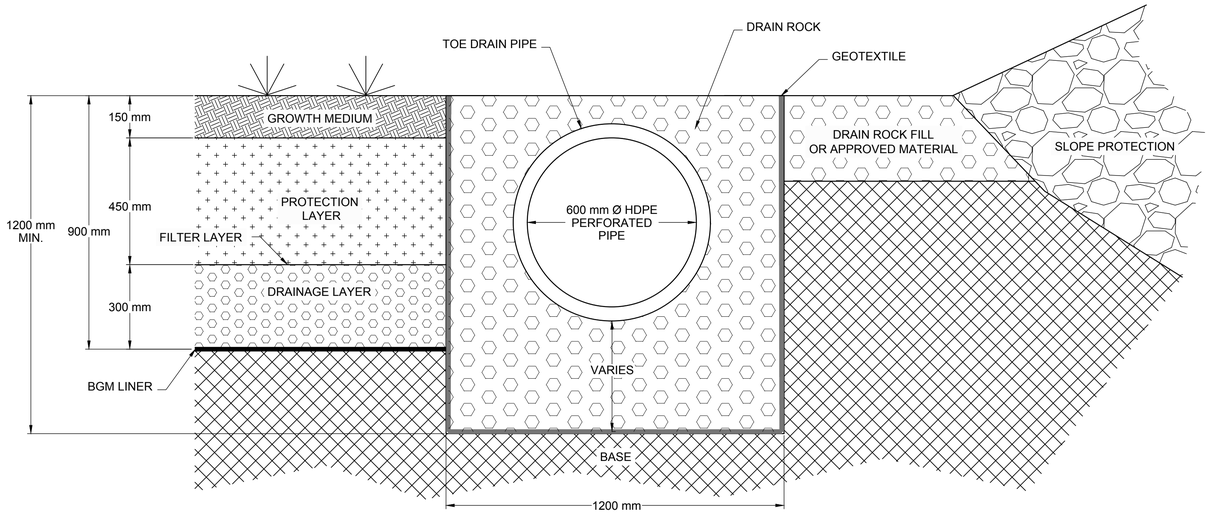
PLOT SCALE: 1:1

CADD FILE NO. \\exy-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-16-R0.dwg



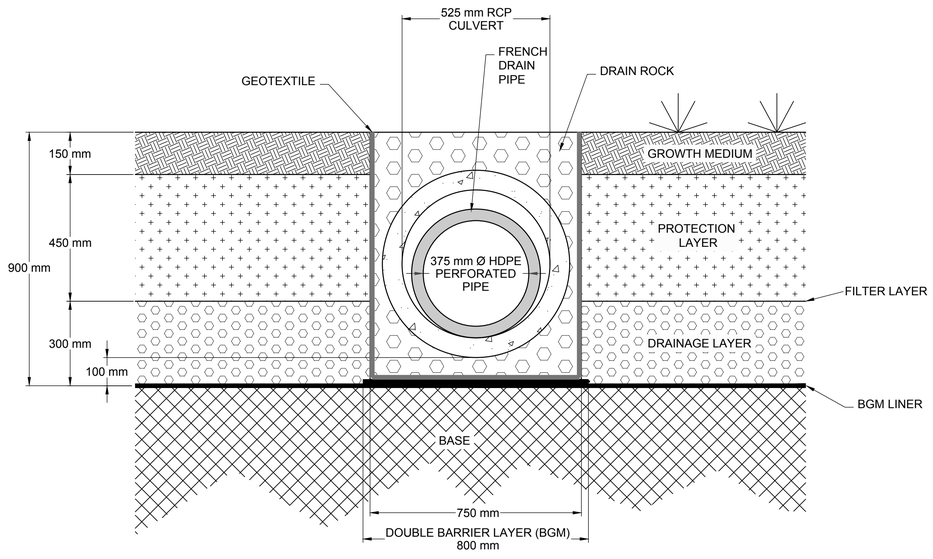
- DRAIN ROCK - 25 mm ROUNDED CLEAN DRAIN ROCK, UNVEGETATED SURFACE
- GEOTEXTILE - 8 oz. NON-WOVEN GEOTEXTILE FABRIC
- FRENCH DRAIN PIPE - 375 MM DIAMETER PERFORATED SINGLE-WALL HDPE PIPE, ASTM F667, MINIMUM STIFFNESS OF 210 kPa, ASTM D2412. ALL FITTINGS SHALL CONFORM TO ASTM D3350.

TYPICAL FRENCH DRAIN CROSS-SECTION



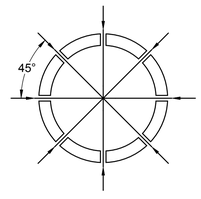
- DRAIN ROCK - 25 mm ROUNDED CLEAN DRAIN ROCK, UNVEGETATED SURFACE
- GEOTEXTILE - 8 oz. NON-WOVEN GEOTEXTILE FABRIC
- TOE DRAIN PIPE - 600 mm DIAMETER PERFORATED HDPE PIPE, ASTM F667 AND CSA 182.8, MINIMUM PIPE STIFFNESS OF 320 kPa. ALL FITTINGS SHALL CONFORM TO ASTM D3350.

TYPICAL TOE DRAIN CROSS-SECTION

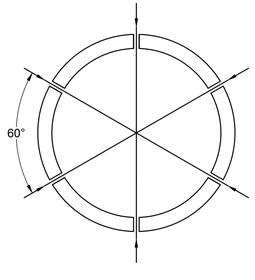


- RCP CULVERT FOR FRENCH DRAIN - 525 mm DIAMETER CLASS IV RCP, AND AT A MINIMUM MEETS ASTM C-76 AND CSA A257.2 SPECIFICATIONS. ALL JOINTS SHOULD BE DESIGNED IN ACCORDANCE WITH ASTM C990-09 FOR BUTYL RUBBER SEALANT.
- LENGTHS OF RCP CULVERT FOR FRENCH DRAIN TO BE 4.5 m MINIMUM AT EACH BENCH CROSSING.

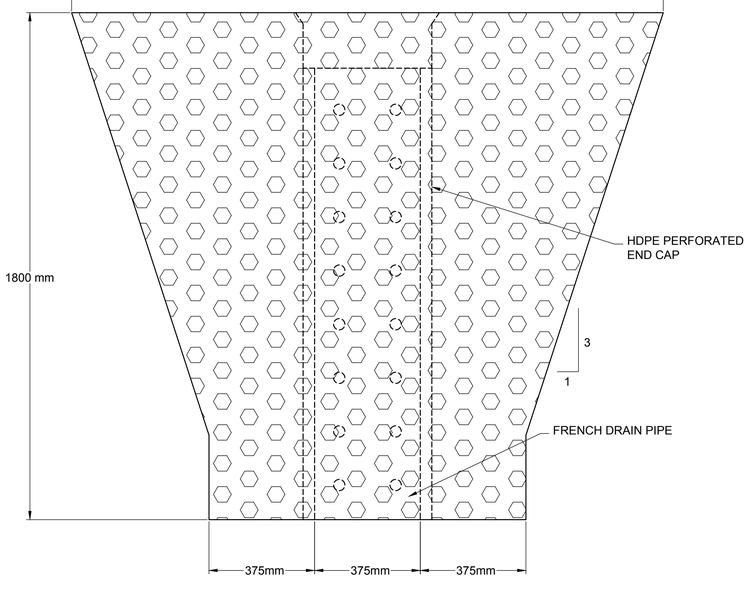
TYPICAL CULVERT FOR FRENCH DRAIN AT BENCH CROSS-SECTION



FRENCH DRAIN PERFORATED PIPE 8 HOLE PATTERN



TOE DRAIN PERFORATED PIPE 6 HOLE PATTERN



- DRAIN ROCK - 25mm ROUNDED CLEAN DRAIN ROCK
- ALL FITTINGS TO CONFORM TO ASTM 3350

PLAN VIEW OF INLET TO FRENCH DRAIN

CADD FILE NO. \\ey-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-17-R0.dwg

PLOT SCALE:

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

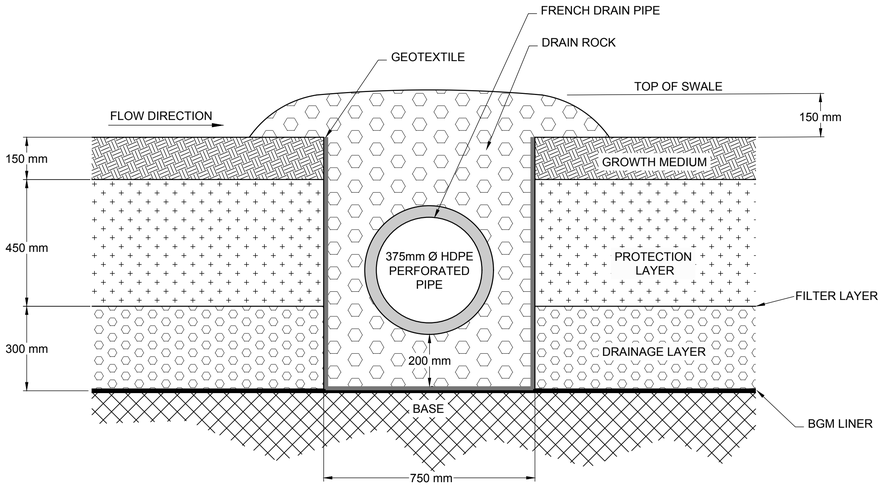
DESIGN	APPROVED
J.L./T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
0.1m 0 0.5m
SCALE: 1:10

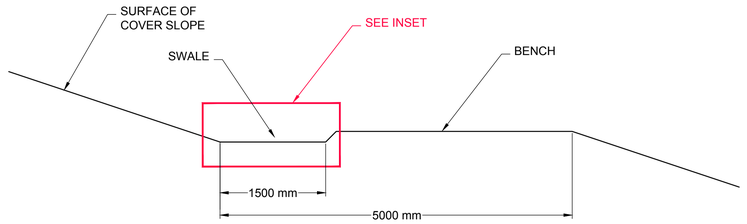
CLIENT: West Fraser Mills Ltd.

French Drain & Toe Drain Details

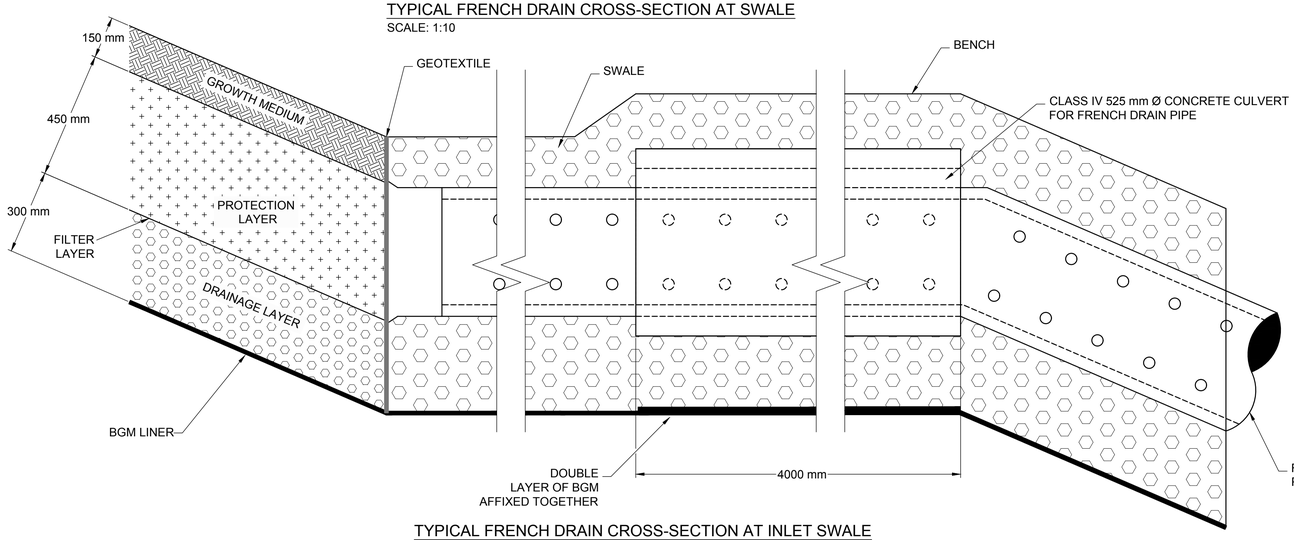
SHEET No. 17 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-17



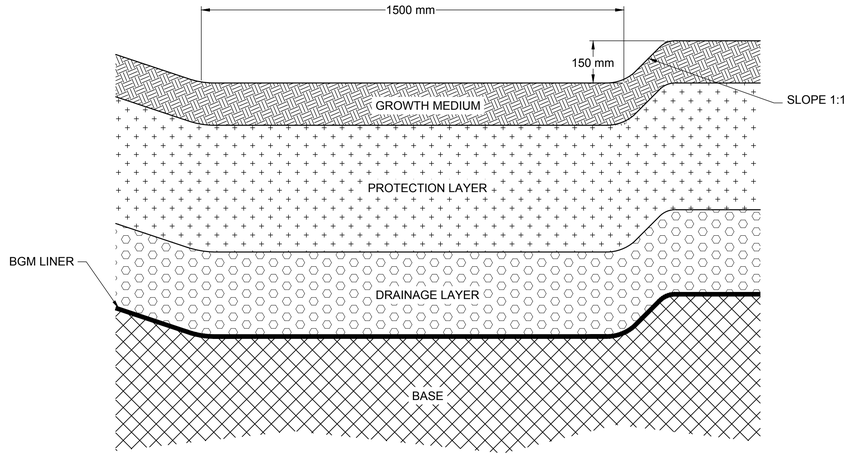
TYPICAL FRENCH DRAIN CROSS-SECTION AT SWALE
SCALE: 1:10



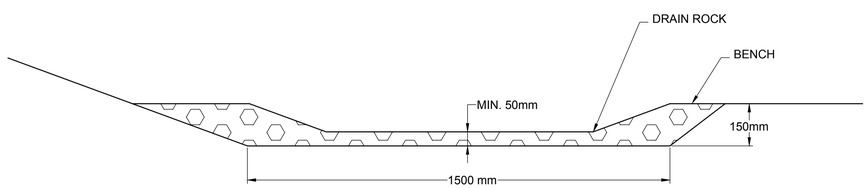
TYPICAL SWALE CROSS-SECTION
SCALE: 1:40



TYPICAL FRENCH DRAIN CROSS-SECTION AT INLET SWALE
SCALE: 1:10

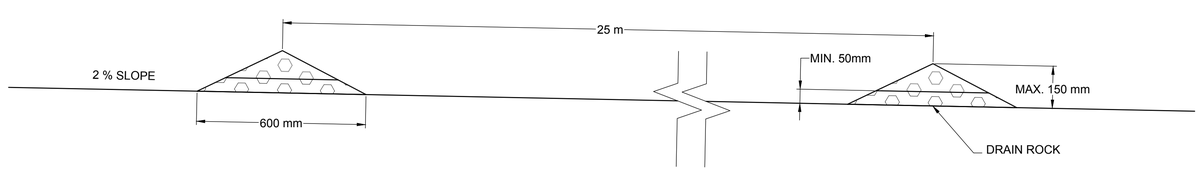


INSET: SWALE DETAIL
SCALE: 1:10



- DRAIN ROCK - 25mm ROUNDED CLEAN DRAIN ROCK

TYPICAL CROSS SECTION OF CHECK DAM
SCALE: 1:10



- MAXIMUM 25m SPACING BETWEEN CHECK DAMS ALONG THE LENGTH OF THE SWALE

TYPICAL CROSS-SECTION OF CHECK DAMS IN SWALE
SCALE: 1:10

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-18-R0.dwg

PLOT SCALE:

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PRELIMINARY
NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

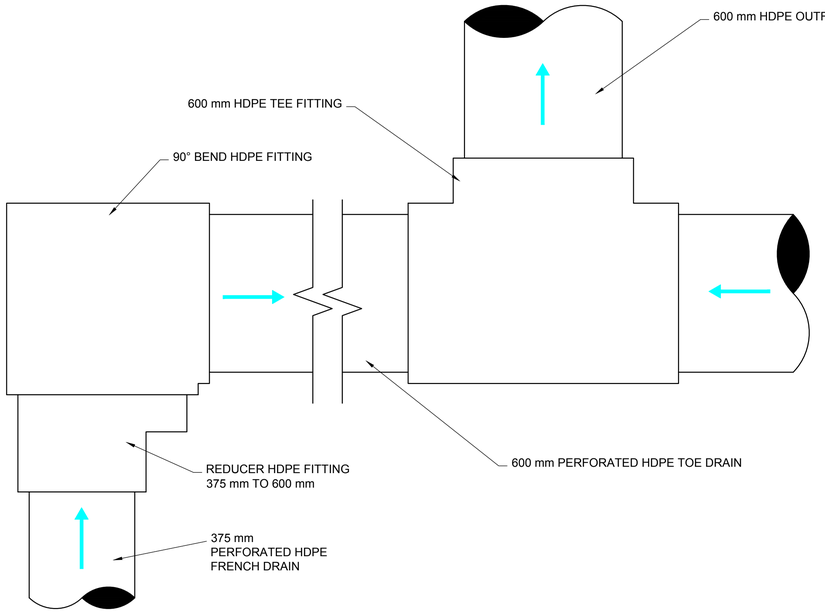
DESIGN	APPROVED
J.L./T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE: AS SHOWN

CLIENT: West Fraser Mills Ltd.

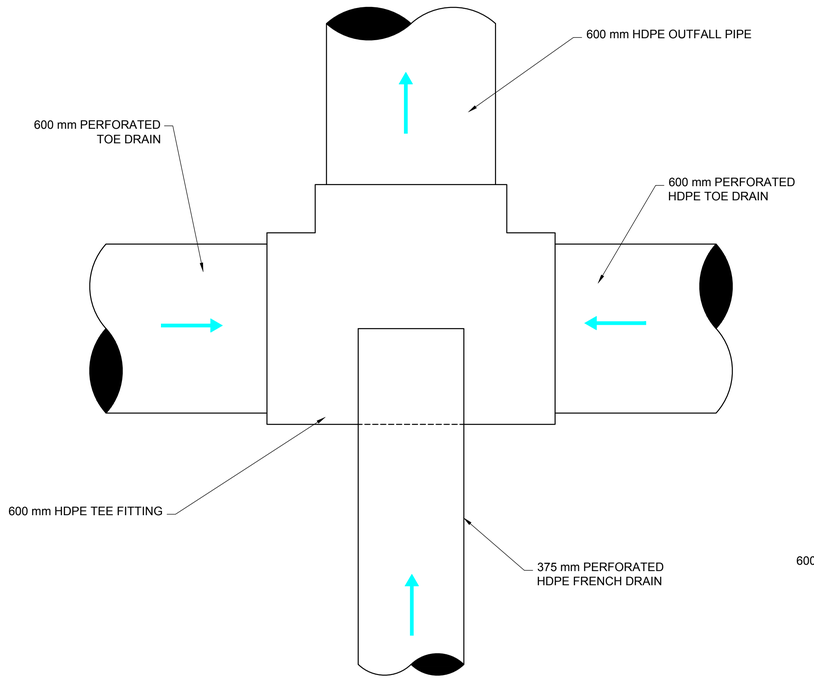
Swale & Check Dam Details

SHEET No. 18 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-18

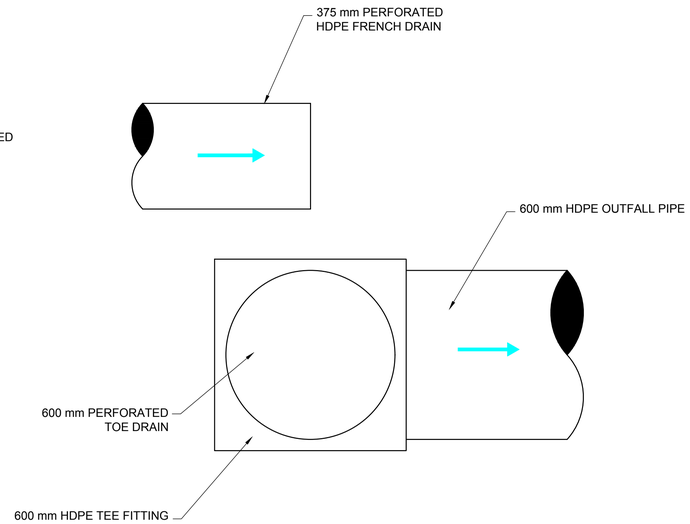


- ALL HDPE FITTINGS SHALL CONFORM TO ASTM 3350

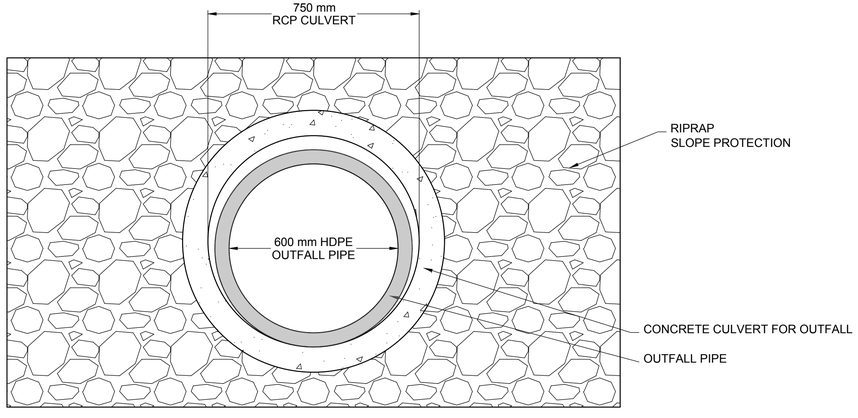
OUTFALL 1 DETAIL



OUTFALL 2, 3 & 4 PLAN DETAIL

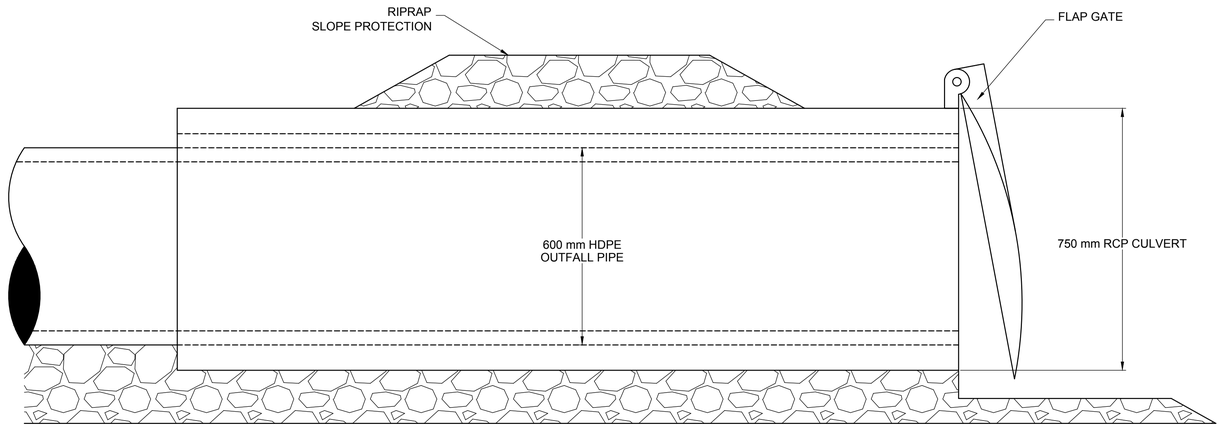


OUTFALL 2, 3 & 4 PROFILE DETAIL



- RCP CULVERT FOR OUTFALL - 750 mm DIAMETER CLASS IV RCP, MADE WITH TYPE V (SULFATE RESISTANCE CEMENT), AND AT A MINIMUM MEETS ASTM C-76, CSA A257.2, AND ASTM C150 SPECIFICATIONS. ALL JOINTS SHOULD BE DESIGNED IN ACCORDANCE WITH ASTM C990-09 FOR BUTYL RUBBER SEALANT.
- OUTFALL PIPE - 600 mm DIAMETER HDPE PIPE, CSA 182.8, MINIMUM PIPE STIFFNESS OF 320 kPa.

TYPICAL FRONT VIEW OF OUTFALL



- FLAP GATE: 750 mm GATE SIZE, ALUMINUM ALLOY 6061 OR STAINLESS STEEL 316, FLANGE OR SPIGOT MOUNTED TO RCP CULVERT
- SEE DRAWING 18-13470-20 FOR OUTFALL DETAILS

TYPICAL SIDE VIEW OF OUTFALL

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTE: SLOPE PROTECTION DRAWINGS (REVISION F), BY MOFFATT AND NICHOL.

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Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
J.L./T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
0.1m 0 0.5m
SCALE: 1:10

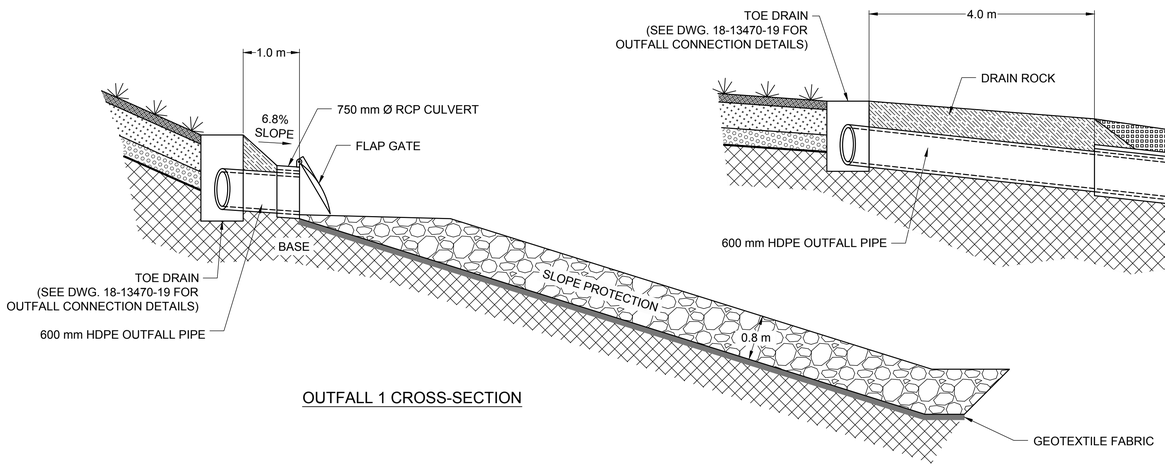
CLIENT: West Fraser Mills Ltd.

Outfall Details

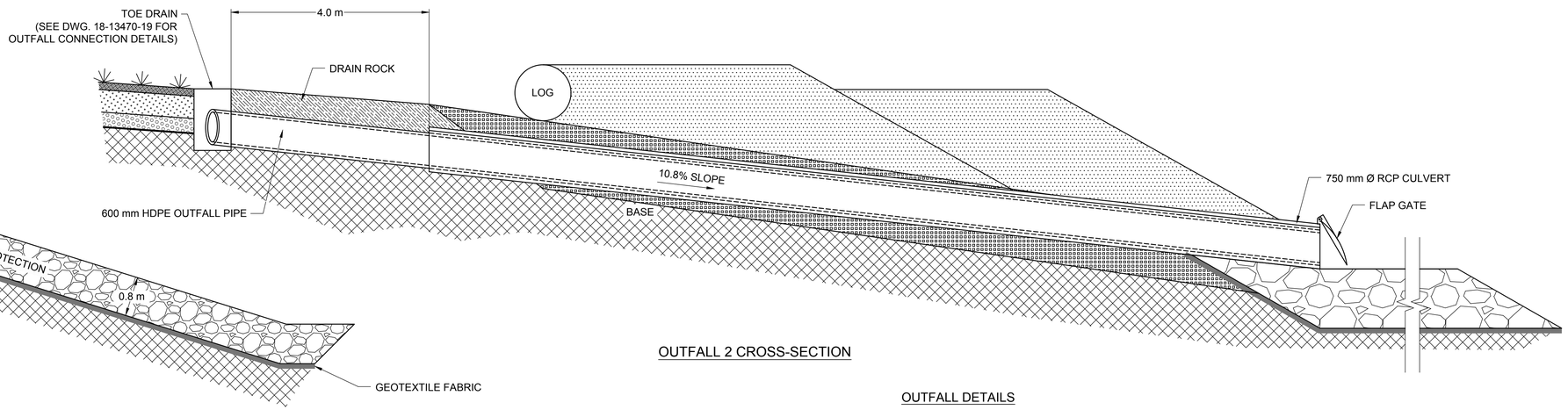
SHEET No. 19 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-19

CADD FILE NO. \\kay-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-19-R0.dwg

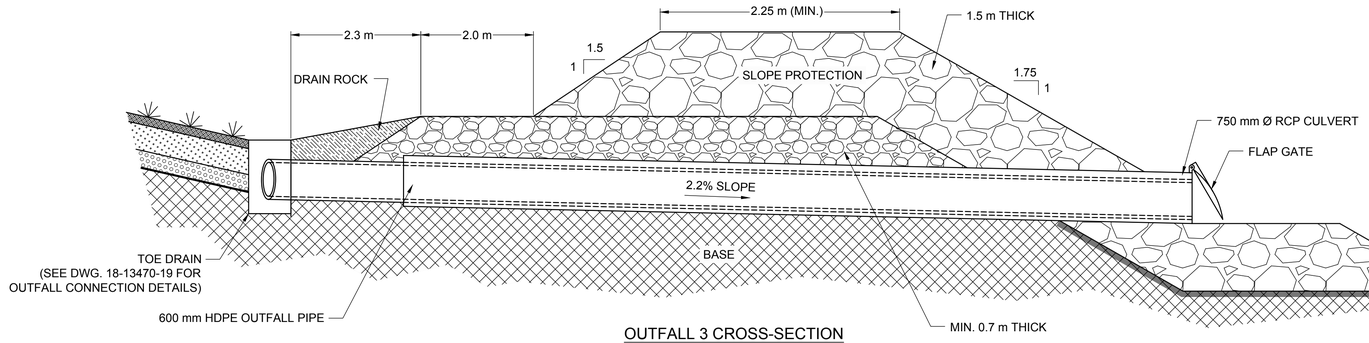
PLOT SCALE:



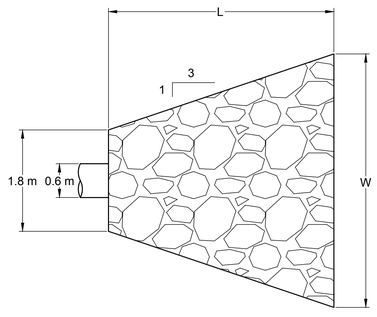
OUTFALL 1 CROSS-SECTION



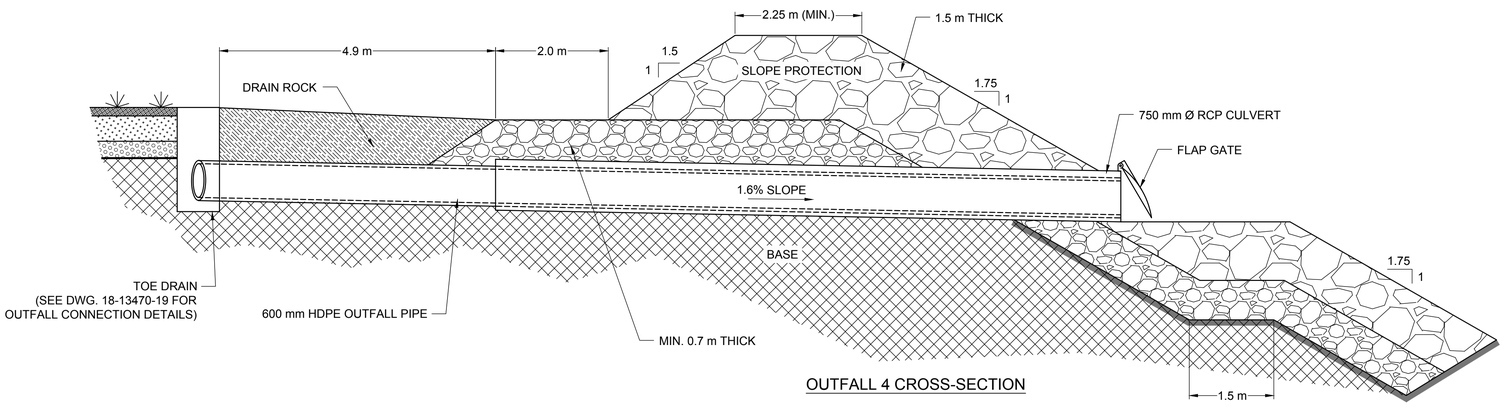
OUTFALL 2 CROSS-SECTION



OUTFALL 3 CROSS-SECTION



OUTFALL 2 & 3 PROTECTION - PLAN VIEW



OUTFALL 4 CROSS-SECTION

OUTFALL DETAILS

- OUTFALL PIPE - 600 mm DIAMETER HDPE PIPE, CSA 182.8, MINIMUM PIPE STIFFNESS OF 320 kPa.
- LENGTHS OF OUTFALL PIPE:

Outfall ID (DP #)	Length (m)	Inlet Invert (m)	Outlet Invert (m)	Slope (%)
1	1.0	4.20	4.13	6.8
2	22.0	3.00	0.62	10.8
3	16.0	1.80	1.45	2.2
4	16.0	2.40	2.14	1.6

- CONCRETE CULVERT FOR OUTFALL - 750 mm DIAMETER CLASS IV RCP, MADE WITH TYPE V (SULFATE RESISTANCE CEMENT), AND AT A MINIMUM MEETS ASTM C-76, CSA A257.2, AND ASTM C150 SPECIFICATIONS. ALL JOINTS SHOULD BE DESIGNED IN ACCORDANCE WITH ASTM C990-09 FOR BUTYL RUBBER SEALANT.
- LENGTHS OF CONCRETE CULVERT FOR OUTFALL:

Outfall ID (DP #)	Length (m)	Outlet Invert (m)	Slope (%)	L (m)	W (m)
1	0.5	4.08	6.8	-	-
2	18.0	0.57	10.8	12.7	9.1
3	14.0	1.39	2.2	4.0	4.5
4	11.0	2.08	1.6	-	-

* SLOPE PROTECTION AT OUTFALL IS SHOWN FOR INFORMATION ONLY. SEE SLOPE PROTECTION DRWAINGS (REVISION F) BY MOFFATT & NICHOL FOR CONSTRUCTION DETAILS.

LEGEND

- GEOTEXTILE FABRIC
- COBBLE
- SAND
- MOTI RIPRAP CLASS 1000 KG
- MOTI RIPRAP CLASS 100 KG
- BASE

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PLOT SCALE:

CADD FILE NO. \\kay-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-20-R0.dwg

PRELIMINARY NOT FOR CONSTRUCTION

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
T.W.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE

0.5m 0 2.5m

SCALE: 1:50

CLIENT: West Fraser Mills Ltd.

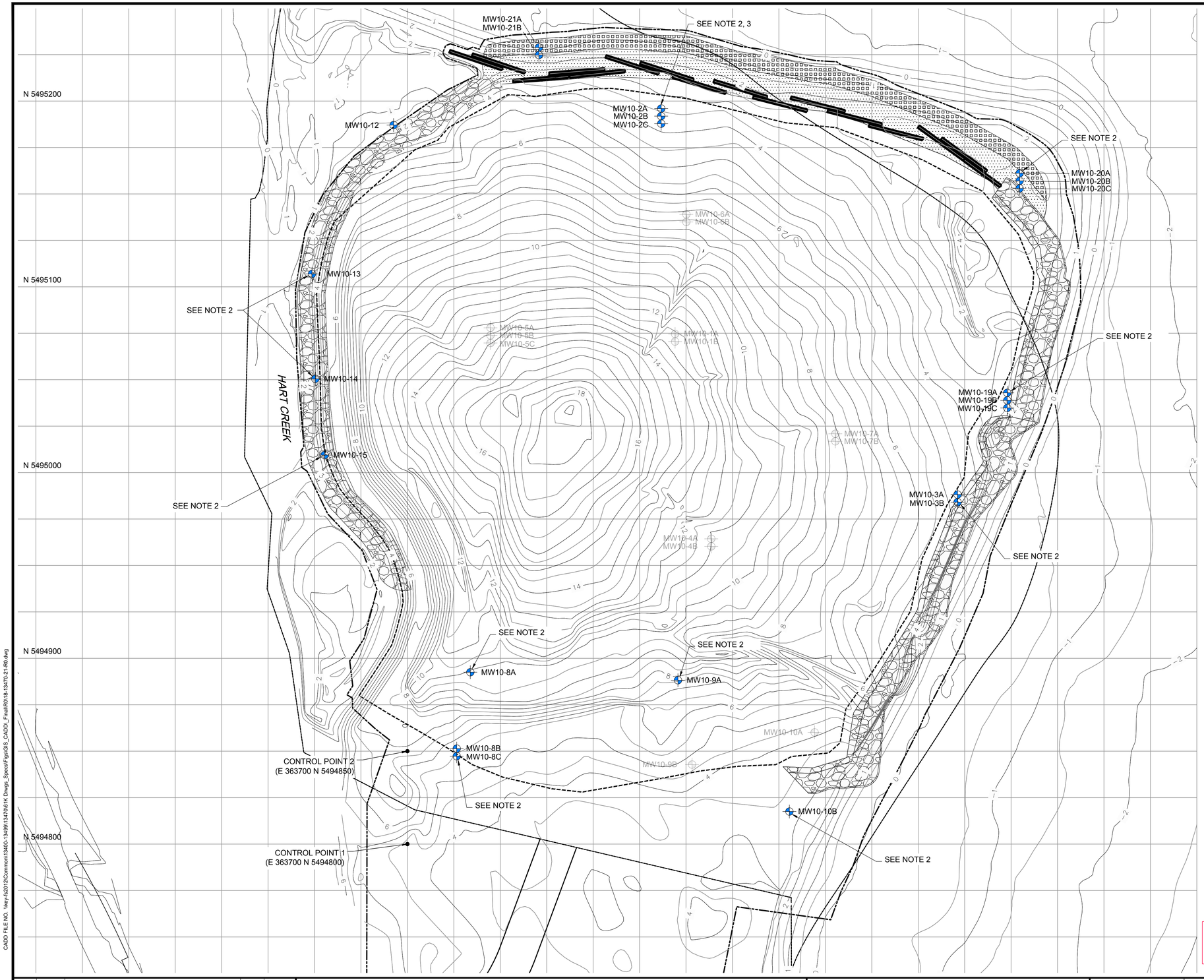
Outfall Cross Sections

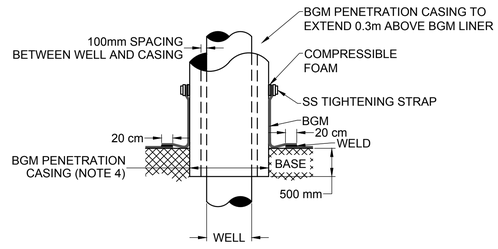
SHEET No. 20 OF 23

PROJECT No. 13470-61K

REVISION No. 00

DRAWING No. 18-13470-20





DETAIL A - EXAMPLE WELL PENETRATION THROUGH BGM LINER
SCALE: 1:5

LEGEND

- ROAD RIGHT-OF-WAY
- CONTOUR LINES
- BGM LINER EXTENTS
- RIPRAP (SLOPE/EROSION PROTECTION)
- COBBLE
- SAND
- ANCHORED LOGS
- PLANNED WORK AREA (APPROX.)
- KEYSTONE MONITORING WELL
- KEYSTONE MONITORING WELL TO BE DECOMMISSIONED

PRELIMINARY
NOT FOR CONSTRUCTION

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

PLOT SCALE: 1:1

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Drwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-21-R0.dwg

NOTES:
1. *THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*
2. *TO BE PRESERVED AND PROTECTED DURING CONSTRUCTION.*
3. *REQUIRES PENETRATION THROUGH BGM LINER - DETAIL A OR EQUIVALENT.*
4. *SIZE TO BE DETERMINED IN FIELD.*

Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
M.B.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
10m 0 50m
SCALE: 1:1000

CLIENT: West Fraser Mills Ltd.

Monitoring Well Location Plan

SHEET No. 21 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-21

N

HABITAT ZONE	AREA WITHIN COVER EXTENT (m^2)	AREA WITHIN ACCESS ROAD (m^2)	AREA WITHIN OPTIONAL STAGING AREA (m^2)	DESCRIPTION OF INVASIVE SPECIES PRESENT
MARINE BACKSHORE	500	-	-	SPARSE SCOTCH BROOM & BLACKBERRY.
BARE/SAPLING	40,200	-	-	SPARSE ST. JOHN'S WORT & BLACKBERRY.
BARE	33,500	5,235	13,146	LACKS VEGETATION, NO INVASIVES PRESENT.
GRASSLAND	30,800	-	-	MAY CONTAIN SOME SCOTCH BROOM & BLACKBERRY. INVASIVES ARE RARE.
DISTURBED SHRUB	4,485	377	4,732	INVASIVES ARE COMMON & INCLUDE BLACKBERRY, SCOTCH BROOM & ST. JOHN'S WORT.
FOREST	700	-	7,260	DOES NOT CONTAIN SIGNIFICANT NUMBERS OF INVASIVE VEGETATION.

LEGEND

- ROAD RIGHT-OF-WAY
- BGM LINER EXTENT
- OPTIONAL STAGING AREA
- JAPANESE KNOTWEED
- BARE/SAPLING
- BARE
- MARINE BACKSHORE
- FOREST
- DISTURBED SHRUB
- GRASSLAND

CADD FILE NO. \\spy-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-22-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2. DATE OF ORTHO PHOTO IS 2009.

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Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

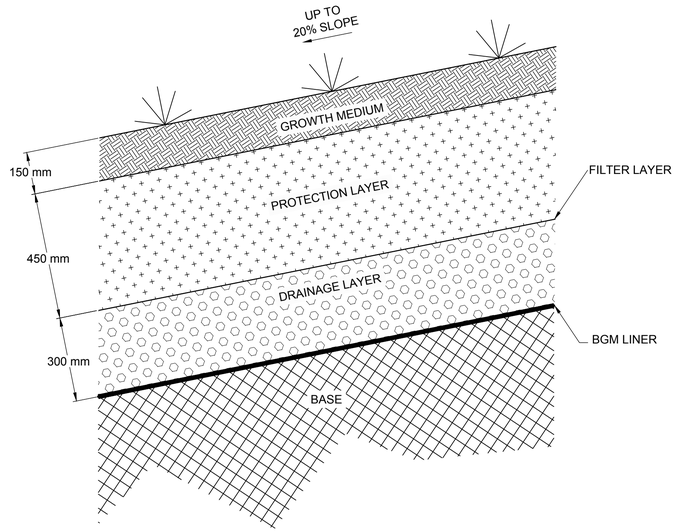
DESIGN	APPROVED
J.R.S	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
25m 0 75m
SCALE: 1:1500(approx.)

CLIENT: West Fraser Mills Ltd.

Invasive Plants Location Plan

SHEET No. 22 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-22



DETAIL A: TYPICAL COVER DETAIL UP TO 20% SLOPE
SCALE: 1:10

NATIVE SEED GRASS MIXTURE

SPECIES	% SEED COUNT
ROEMERS FESCUE	30
IDAHO FESCUE	30
CALIFORNIA OATGRASS	10
PERENNIAL RYEGRASS	10
BLUE WILD RYE	7
YARROW	6
CLOVE (NATIVE)	5
CAMAS	2

LEGEND

- SITE
- COVER EXTENT
- BENCH ROAD (SEED)
- CONTOUR LINES
- GEOCELL
- RIPRAP (SLOPE/EROSION PROTECTION)
- COBBLE
- SAND
- ANCHORED LOGS
- BENCH DRAINAGE CHANNEL
- OUTFALL PIPE
- FRENCH DRAIN (NO SEED)
- TOE DRAIN (NO SEED)
- MECHANICAL SEEDING (101,081 m^2)
- HYDROSEED (10,700 m^2)

CADD FILE NO. \\key-fs2012\Common\13400-13499\13470\61K Dwgs_Specs\Figs\GIS_CADD_Final\R0\18-13470-23-R0.dwg

PLOT SCALE: 1:1

No.	DATE	DESCRIPTION	BY	APPROVED
00	2/26/20	Issued for Client Review	T.L.	J.K.C

REVISIONS

NOTES:
1. *THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.*
2. *DATE OF AERIAL IS 2009.*
3. *CONTOUR ELEVATIONS ARE IN METRES (m) GEODETIC DATUM (GD).*
4. *CHART DATUM TO GEODETIC DATUM CONVERSION = GD + 3.2m.*
5. *SLOPE PROTECTION DRAWINGS (REVISION F), BY MOFFATT AND NICHOL.*
6. *FRENCH DRAIN & TOE DRAIN TO BE COVERED & PROTECTED WITH GEOTEXTILE DURING SEEDING WORKS.*

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Keystone Environmental

Keystone Environmental Ltd.
Ste. 320 4400 Dominion Street
Burnaby, British Columbia

Union Bay Coal Pile & Adjacent Lands

Union Bay, B C

DESIGN	APPROVED
J.R.S.	J.K.C
DRAWN	CHECKED
T.L.	R.P.J.

SCALE
10m 0 50m
SCALE: 1:1000

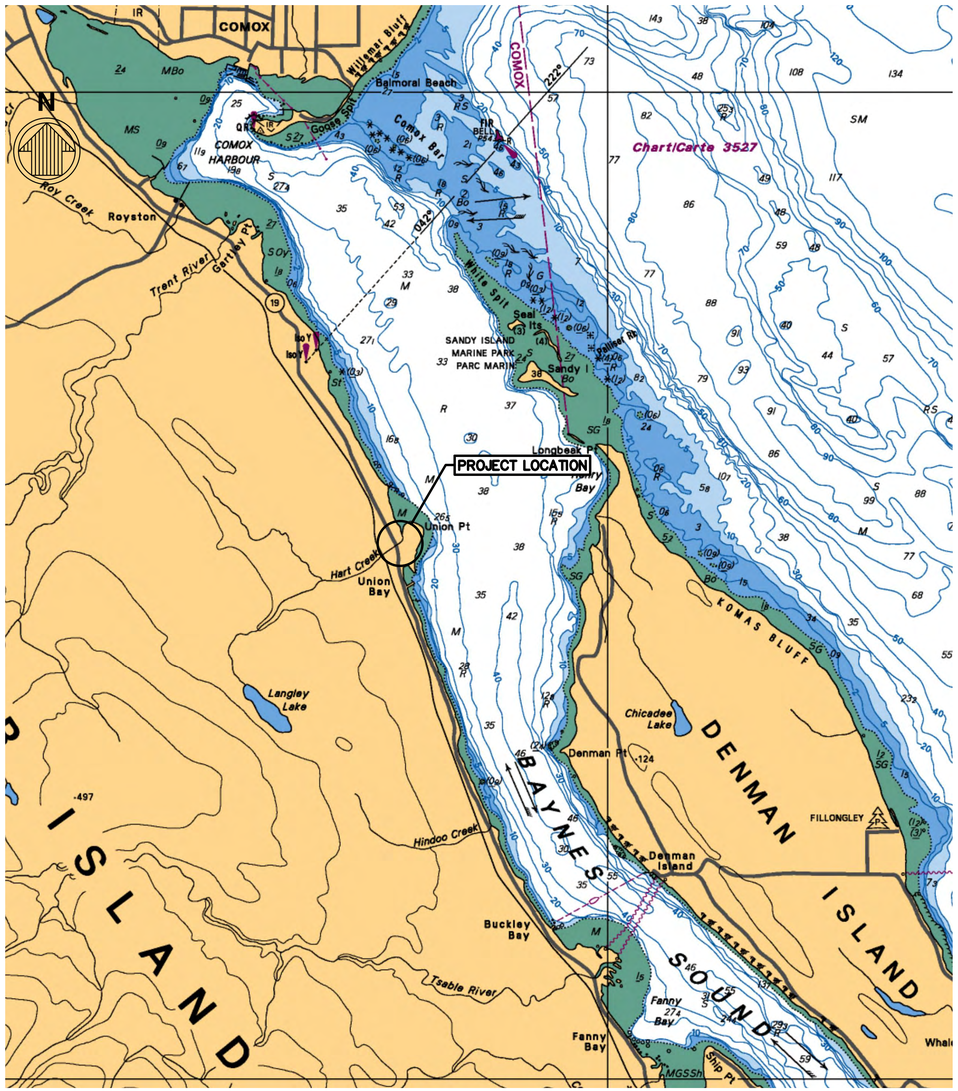
CLIENT: West Fraser Mills Ltd.

Seeding Details

SHEET No. 23 OF 23
PROJECT No. 13470-61K
REVISION No. 00
DRAWING No. 18-13470-23

UNION BAY ENVIRONMENTAL REMEDIATION
UNION BAY, VANCOUVER ISLAND, BRITISH COLUMBIA

SLOPE PROTECTION



VICINITY MAP
IMAGE: MARINE CHART

LOCATION MAP
IMAGE: GOOGLE MAPS

DRAWING LIST		
Sheet Number	Sheet Title	RevNo
G-001	COVER SHEET AND DRAWING INDEX	J
G-002	GENERAL NOTES & DESIGN CRITERIA SHEET 1 OF 2	H
G-003	GENERAL NOTES & DESIGN CRITERIA SHEET 2 OF 2	F
G-004	EXISTING SITE PLAN	G
G-005	GENERAL ARRANGEMENT	I
G-006	CONTROL POINTS LISTING	B
G-007	SECTION AND DETAILS	J
G-008	MISCELLANEOUS DETAILS	B

100% DESIGN
ISSUED: 2020-02-24
NOT TO BE USED FOR CONSTRUCTION

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

Keystone Environmental
Knowledge-Driven Results

Mark	Description	Date	Appr.
J	UPDATED 100% DRAWING	2020.02.24	PH
I	UPDATED 100% DRAWING	2019.08.01	PH
H	UPDATED 100% DRAWING	2019.07.24	PH
G	UPDATED 100% DRAWING	2019.07.17	EC
F	REVISED 100% DESIGN	2019.07.11	EC
E	100% DESIGN	2019.05.17	MT
GS	GREEN SHORES REVISION 60% SUBMITTAL	2018.04.04	PH
D	REVISED LINER LAYOUT	2018.05.04	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH

UNION BAY ENVIRONMENTAL REMEDIATION

COVER SHEET AND DRAWING INDEX

Designed by: PH
Drawn by: CA
Chkd by: MJ
Reviewed by: MT
Submitted by: MOFFATT & NICHOL
Date: 2019-07-11
M&N Project No: 10091
Drawing code:
Drawing Scale:
Plot scale: 1:1 (Metric D)
Rev. J

moffatt & nichol
777 WEST BROADWAY, SUITE 301
VANCOUVER, BC, CANADA, V5Z 4J7
604-707-9004

SEAL

Sheet Reference No.
G-001
INDEX: 1 OF 8

GENERAL NOTES

1.0 GENERAL

1.1 CONTRACTOR'S WORK SHALL BE CARRIED OUT IN ACCORDANCE WITH KEYSTONE ENVIRONMENTAL'S SPECIFICATIONS PACKAGE, DRAWINGS AND CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN (CEMP).

1.2 BATHYMETRY SOUNDINGS AND CONTOURS ARE IN METRES WITH RESPECT TO GEODETIC DATUM AND HAVE BEEN REPRODUCED FROM A BASE DRAWING PROVIDED BY ATEK HYDROGRAPHIC SURVEY LTD. DESCRIBING A SURVEY CONDUCTED IN MARCH 2018.

1.3 TOPOGRAPHY CONTOURS AND ELEVATIONS WERE BASED ON SURVEYS DONE BY MCELHANNEY CONSULTANTS IN 2017 AND 2018 AND PROVIDED BY KEYSTONE ENVIRONMENTAL.THIS DRAWING WAS MERGED WITH ATEK HYDROGRAPHIC SURVEY MARCH 2018 BATHYMETRY SURVEY TO PROVIDE A BASE DRAWING.

1.4 LOCATIONS AND ELEVATIONS OF EXISTING ELEMENTS AS SHOWN ON THE DRAWINGS ARE SUBJECT TO CONSTRUCTION VARIATIONS. THE CONTRACTOR SHALL VISIT THE SITE AND TAKE THEIR OWN MEASUREMENTS OF ALL EXISTING STRUCTURES, GROUND AND OTHER WORK. ALL DIMENSIONS AND DETAILS SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO FABRICATION AND CONSTRUCTION. DISCREPANCIES SHALL PROMPTLY BE BROUGHT TO THE ATTENTION OF THE ENGINEER.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

1.4.1 THE CONTRACTOR'S WORK SHALL BE CARRIED OUT IN STRICT ACCORDANCE WITH THE PERMITS AND APPROVALS OBTAINED BY THE OWNER AS LISTED IN KEYSTONE ENVIRONMENTAL'S SPECIFICATIONS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OBLIGATIONS OF THE OWNER AS SET OUT IN THE AUTHORIZATIONS/PERMITS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING AND ADHERING TO ALL ADDITIONAL PERMITS, AUTHORIZATIONS AND LICENSES NECESSARY FOR UNDERTAKING THE WORK.

1.4.2 THE CONTRACTOR SHALL COMPLY WITH REGIONAL, PROVINCIAL AND FEDERAL CODES AND REGULATIONS RELATING TO THE WORK, INCLUDING WORK SAFE BC OCCUPATIONAL HEALTH AND SAFETY (OHS) AND REGULATIONS GOVERNING TRAFFIC OR USE OF ANY ROAD UPON OR OVER WHICH IT IS NECESSARY TO DO WORK OR TRANSPORT MATERIALS. THE CONTRACTOR SHALL OBTAIN AND ADHERE TO ALL NECESSARY PERMITS FOR TRANSPORT OF MATERIALS.

1.5 OPERATING ENVIRONMENT

1.5.1 MANAGEMENT OF ENVIRONMENTAL EFFECTS (SUCH AS STORM WATER, WIND, GROUNDWATER AND WATER LEVELS) ON EXCAVATED SLOPES AND GRADES SHALL BE THE SOLE RESPONSIBILITY OF THE CONTRACTOR.

1.5.2 THE WATER LEVEL RANGE IS INDICATED IN DESIGN CRITERIA, ON SHEET G-003.

1.5.3 THE CONTRACTOR SHALL TAKE NECESSARY STEPS TO BECOME FULLY FAMILIAR WITH SITE CONDITIONS. THE ENGINEER WILL NOT ENTERTAIN ANY CLAIM BASED ON THE WEATHER, SEA, OR CREEK CONDITIONS.

1.6 SCHEDULING

1.6.1 THE SCHEDULING OF THE WORK SHALL BE CARRIED OUT IN STRICT ACCORDANCE WITH ALL APPLICABLE ACTS, REGULATIONS AND PERMIT OR AUTHORIZATION REQUIREMENTS AS WELL AS IN ACCORDANCE WITH KEYSTONE ENVIRONMENTAL'S SPECIFICATIONS. THE CONTRACTOR SHALL HOLD HARMLESS AND PROTECT THE OWNER FROM ALL CLAIMS, COSTS AND DELAYS WHICH COULD OR DO ARISE FROM THE CONTRACTOR'S NON-COMPLIANCE WITH ANY ACT, REGULATION, PERMIT OR AUTHORIZATION REQUIREMENT.

1.7 EXECUTION

1.7.1 THE CONTRACTOR SHALL PROVIDE ADEQUATE FLAG-PERSONS AND/OR TRAFFIC SIGNAL DEVICES TO CONTROL TRAFFIC ACCESS TO THE SITE.

1.7.2 AT THE END OF EACH WORKING DAY, SWEEP ROADWAY AND CLEAN UP ALL FALLEN ROCK, DUST AND DEBRIS ARISING FROM ALL WORK, TO THE ENGINEER'S SATISFACTION IN ACCORDANCE WITH KEYSTONE ENVIRONMENTAL'S CEMP AND SPECIFICATIONS.

1.7.3 THE CONTRACTOR SHALL ENSURE THE NECESSARY ENVIRONMENTAL, TRAFFIC AND SAFETY CONTROLS ARE IN PLACE IN ACCORDANCE WITH THE CONTRACTOR'S TRAFFIC MANAGEMENT PLAN AND ENVIRONMENTAL PROTECTION PLAN.

1.8 PROTECTION OF EXISTING AND PARTIALLY COMPLETED FEATURES

1.8.1 PROTECT EXISTING STRUCTURES, FENCES, BENCH MARKS, MONITORING WELLS AND MONUMENTS FROM DAMAGE WHILE WORK IS IN PROGRESS AND REPAIR DAMAGE RESULTING FROM WORK.

1.8.2 THE CONTRACTOR SHALL PROTECT PARTIALLY COMPLETED WORK/FEATURES AGAINST ENVIRONMENTAL DAMAGE, SUCH AS WATER LEVEL FLUCTUATIONS AND WAVE EROSION.

2.0 EXCAVATION

2.1 SUBMITTALS

2.1.1 IN ACCORDANCE WITH THE SUBMITTAL REQUIREMENTS OUTLINED IN KEYSTONE'S SPECIFICATIONS, AN ENVIRONMENTAL PROTECTION PLAN INCLUDING THE FOLLOWING ITEMS SHALL BE SUBMITTED FOR THE ENGINEER'S REVIEW, AND SHALL BE ADHERED TO THEREAFTER EXCEPT AS ALLOWED OTHERWISE BY THE ENGINEER.

2.1.2 DESCRIPTION OF EXCAVATING EQUIPMENT INCLUDING MANUFACTURER, AGE, CONDITION AND RATED CAPACITY.

2.1.3 FUELING EQUIPMENT, PROCEDURES, FREQUENCY AND EMERGENCY SPILL PLANS.

2.1.4 DESCRIPTION AND ESTIMATED NUMBER OF TRUCKS AND OTHER EQUIPMENT TO BE USED FOR DISPOSAL OF EXCAVATED MATERIAL (IF APPROVED BY ENGINEER), AND FOR IMPORT OF MATERIALS.

2.1.5 STOCKPILING PLAN DESCRIBING, WITH THE AID OF LAYOUT DRAWING(S), THE CONTRACTOR'S PROPOSED METHODOLOGY AND SCHEDULING/TIMING FOR TEMPORARY STOCKPILES OF EXCAVATED, AND IMPORTED MATERIALS FOR USE IN THE WORKS.

2.1.6 QUALITY CONTROL PLAN DESCRIBING EXCAVATING AND FILLING OPERATIONS, ENSURING TOLERANCES ARE MET AND PROPOSED SURVEY CONTROL METHODS.

2.1.7 DETAILS OF ANY METHODS FOR CONTROL OF WATER QUALITY AND OTHER PERMIT OR ENVIRONMENTAL AUTHORIZATION REQUIREMENTS SUCH AS SILT CURTAINS OR TEMPORARY BERMS.

2.1.8 DETAILS OF ANY METHODS FOR TEMPORARY PROTECTION, STORMWATER, GROUNDWATER CONTROL, MAINTENANCE AND SAFETY REQUIREMENTS FOR THE EXISTING UTILITIES, SURFACE FEATURES, ROADWAYS AND PARTIALLY COMPLETED WORKS.

2.2 SCHEDULE OF WORK

2.2.1 SEQUENCE WORK TO MINIMIZE THE LENGTH OF TIME THAT EXCAVATED SLOPES REMAIN EXPOSED TO THE OPERATING ENVIRONMENT PRIOR TO INSTALLATION OF SLOPE PROTECTION.

2.3 ACCEPTANCE OF THE WORK

2.3.1 THE ENGINEER WILL APPROVE THE APPLICABLE SURVEYS WHEN THE EXCAVATION HAS BEEN COMPLETED TO THE DESIGNATED LIMITS AND THE GRADE OR SLOPE IS SUBSTANTIALLY FREE OF LOOSE, UNCONSOLIDATED, OR DISTURBED SOILS OR SILT.

2.4 EXECUTION

2.4.1 EXCAVATE TO LINES, GRADES, ELEVATIONS AND DIMENSIONS AS INDICATED ON THE DRAWINGS, AND AS APPROVED BY ENGINEER.

2.4.2 EARTH BOTTOMS OF EXCAVATIONS TO BE UNDISTURBED SOIL OR FILL, LEVEL, FREE FROM LOOSE, SOFT OR ORGANIC MATTER. REMOVE UNSUITABLE MATERIAL FROM EXCAVATIONS TO EXTENT AND DEPTH AS DIRECTED BY THE ENGINEER.

2.4.3 WHERE REQUIRED DUE TO UNAUTHORIZED OVER-EXCAVATION, CORRECT BY BACKFILLING AND COMPACTING AS APPROVED BY THE ENGINEER. NO SEPARATE QUANTITY ADJUSTMENTS WILL BE MADE FOR UNAUTHORIZED OVER-EXCAVATION BEYOND THE NEAT LINE EXCAVATION LIMITS.

2.4.4 THE CONTRACTOR SHALL MAINTAIN THE EXCAVATION IN AN ACCEPTABLE STATE UNTIL PLACEMENT OF THE SLOPE PROTECTION MATERIALS COMMENCES. MATERIAL THAT SLOUGHS OR RAVELS DOWN THE SLOPES OF THE EXCAVATION SHALL BE REMOVED AT THE CONTRACTOR'S COST.

2.4.5 THE CONTRACTOR SHALL BE RESPONSIBLE FOR ACCURACY OF THE WORK, SET OUT CONTROLS FOR UNDERTAKING THE WORK, PROVIDE AND MAINTAIN ALL NECESSARY POSITION FIXING, DISTANCE MEASURING, AND DEPTH CONTROL EQUIPMENT, AND SUCH OTHER EQUIPMENT AS NORMALLY REQUIRED FOR ACCURATE EXCAVATING CONTROL.

2.5 TOLERANCES

2.5.1 THE MAXIMUM PERMISSIBLE VARIATIONS IN ELEVATION FROM THE SPECIFIED GRADE AND SIDE SLOPES FOR EXCAVATIONS, MEASURED VERTICALLY, SHALL BE +0.0m AND -0.03m.

2.6 DISPOSAL OF EXCAVATED MATERIAL

2.6.1 EXCAVATED MATERIALS COVERED BY THE WORK UNDER THIS SECTION ARE TO BE STOCKPILED OR DISPOSED OFF-SITE IN AN ENVIRONMENTALLY ACCEPTABLE MANNER IN ACCORDANCE WITH THE ENVIRONMENTAL AUTHORIZATION PERMIT TO THE ENGINEER'S SATISFACTION AND IN ACCORDANCE WITH ANY OTHER PERMITS OR AUTHORIZATIONS OBTAINED BY THE CONTRACTOR.

2.7 RESTORATION

2.7.1 UPON COMPLETION OF WORK, REMOVE SURPLUS MATERIALS AND DEBRIS, TRIM SLOPES, AND CORRECT DEFECTS AS APPROVED BY THE ENGINEER.

3.0 GEOTEXTILES

3.1 SUBMITTALS

SUBMIT TO THE ENGINEER TWO (2) COPIES OF MILL TEST DATA AND CERTIFICATE AT LEAST 2 WEEKS PRIOR TO START OF WORK.

3.2 MATERIALS

3.2.1 GEOTEXTILES SHALL BE NILEX (AMOCO) 4553, (ALSO REFERRED TO AS NILEX TYPE C34) OR APPROVED EQUAL, UNLESS INDICATED OTHERWISE ON THE DRAWINGS.

3.3 EXECUTION

3.3.1 GEOTEXTILES SHALL BE PLACED IN ACCORDANCE WITH THE MANUFACTURER'S INSTALLATION PROCEDURES AND AS INDICATED ON THE DRAWINGS.

3.3.2 GEOTEXTILE MATERIAL MAY BE RETAINED IN PLACE WITH APPROPRIATE WEIGHTS PLACED ONTO THE GEOTEXTILE MATERIAL.

3.3.3 PLACE GEOTEXTILE MATERIAL BY UNROLLING ONTO GRADED SURFACE IN ORIENTATION, MANNER AND LOCATIONS DETERMINED IN CONJUNCTION WITH THE ENGINEER.

3.3.4 PLACE GEOTEXTILE MATERIAL WITH FULL CONTACT ON BASE MATERIAL, SMOOTH AND FREE OF TENSION STRESS, FOLDS, WRINKLES AND CREASES.

3.3.5 PLACE GEOTEXTILE MATERIAL ON SLOPING SURFACES IN ONE CONTINUOUS LENGTH FROM TOE OF SLOPE TO UPPER EXTENT OF GEOTEXTILE.

3.3.6 OVERLAP EACH SUCCESSIVE STRIP OF GEOTEXTILE A MINIMUM OF 750 MM OVER PREVIOUSLY LAID STRIP.

3.3.7 SECURE SUCCESSIVE STRIPS OF GEOTEXTILE WITH APPROPRIATE WEIGHTS PLACED TO PREVENT FOLDS, WRINKLES AND CREASES.

3.3.8 PROTECT INSTALLED GEOTEXTILE MATERIAL FROM DISPLACEMENT, DAMAGE OR DETERIORATION BEFORE, DURING AND AFTER PLACEMENT OF MATERIAL LAYERS.

3.3.9 REPLACE DAMAGED, TORN, OR DETERIORATED GEOTEXTILE TO APPROVAL OF ENGINEER.

3.3.10 VEHICULAR TRAFFIC IS NOT PERMITTED DIRECTLY ON GEOTEXTILE.

4.0 RIPRAP

4.1 GENERAL

4.1.1 IMPORTED ROCK SHALL BE TESTED FOR ACID ROCK DRAINAGE AND METAL LEACHING. TESTING SHALL MEET THE BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE (MOTI) REQUIREMENTS OUTLINED IN MINISTRY'S TECHNICAL CIRCULAR T04-13. RESULTS SHALL BE PROVIDED TO THE ENGINEER FOR APPROVAL. REFER TO KEYSTONE ENVIRONMENTAL'S SPECIFICATIONS FOR REQUIREMENTS RELATED TO IMPORTING MATERIALS.

4.1.2 THE NORMAL WATER LEVELS ARE GIVEN IN DESIGN CRITERIA; SEE DRAWING G-003.

4.2 PRODUCTS

4.2.1 STONE SHALL BE QUARRIED ROCK, HARD, SOUND, AND SHALL NOT DISINTEGRATE FROM ACTION OF ATMOSPHERE, WATER, HANDLING OR PLACING. IT SHALL BE FREE FROM CRACKS, BLAST FRACTURES, BEDDING, SEAMS AND OTHER DEFECTS THAT WOULD TEND TO INCREASE ITS DETERIORATION FROM NATURAL CAUSES. INSPECTIONS FOR CRACKS, FRACTURES, SEAMS AND DEFECTS SHALL BE MADE BY VISUAL EXAMINATION. IF, BY VISUAL EXAMINATION, IT IS DETERMINED THAT 10% OR MORE OF THE STONE PRODUCED CONTAINS HAIRLINE CRACKS, THEN ALL STONE PRODUCED BY THE MEANS AND MEASURES WHICH CAUSED THE FRACTURES SHALL BE REJECTED. A HAIRLINE CRACK THAT IS DEFINED AS BEING DETRIMENTAL SHALL HAVE A MINIMUM WIDTH OF 4 MM AND SHALL BE CONTINUOUS FOR ONE-THIRD THE DIMENSION OF AT LEAST TWO SIDES OF THE STONE.

4.2.2 ALL STONE SHALL BE DURABLE MATERIAL AS APPROVED BY THE ENGINEER. STONE SHALL BE OF A SUITABLE QUALITY TO ENSURE PERMANENCE IN THE STRUCTURE AND IN THE CLIMATE IN WHICH IT IS TO BE USED.

4.2.3 THE STONE SHALL BE CLEAN AND ADEQUATELY FREE FROM ALL FOREIGN MATTER. ANY FOREIGN MATERIAL ADHERING TO OR COMBINED WITH THE STONE AS A RESULT OF STOCKPILING SHALL BE REMOVED PRIOR TO PLACEMENT, TO THE SATISFACTION OF THE ENGINEER.

4.2.4 THE MAXIMUM DIMENSIONS OF ANY PIECE OF RIP RAP ROCK IN SLOPE PROTECTION SHALL NOT BE MORE THAN 2 ½ TIMES ITS LEAST DIMENSION.

4.2.5 ANY RANDOMLY SELECTED SAMPLE OF SLOPE PROTECTION ROCK SHALL MEET ALL OF THE REQUIREMENTS STIPULATED IN TABLE 1 WHEN TESTED IN ACCORDANCE WITH THE SPECIFIED STANDARD PROCEDURES:

TABLE 1 –SLOPE PROTECTION ROCK PROPERTIES

TEST	REQUIREMENTS	TEST STANDARD
SPECIFIC GRAVITY	> 2.60	ASTM D-6473
WATER ABSORPTION	< 1 %	ASTM D-6473
COMPRESSIVE STRENGTH	> 100 MPA	ASTM D-7012 METHOD C
MICRO – DEVAL ABRASION LOSS FACTOR	< 20 %	ASTM D-6928
SULPHATE SOUNDNESS	< 5 % (FOLLOWING 5 CYCLES)	ASTM D-5240
PARTICLE SHAPE	L/D < 2.5	

4.3 MATERIALS

4.3.1 FILTER STONE AND RIP RAP SHALL CONSIST OF IMPORTED QUARRIED ROCK, AND SHALL COMPLY WITH GRADATION LIMITS GIVEN IN TABLES 2 AND 3 RESPECTIVELY.

4.3.2 AT LEAST FOURTEEN (14) DAYS PRIOR TO COMMENCING PLACEMENT OF SLOPE PROTECTION, THE CONTRACTOR SHALL AT HIS COST IDENTIFY THE PROPOSED SOURCE(S) AND SUBMIT TO THE ENGINEER FOR REVIEW:

4.3.2.1 QUALIFICATION TEST DATA CONFIRMING THAT THE PROPOSED MATERIAL(S) MEET OR EXCEED THE REQUIREMENTS OF THIS SPECIFICATION. THE CONTRACTOR SHALL ALSO PROVIDE ACCESS FOR QUALIFICATION SAMPLING BY THE ENGINEER; THE ENGINEER MAY, AT HIS DISCRETION, COLLECT QUALIFICATION SAMPLES FROM THE PROPOSED SOURCE(S) AND CARRY OUT INDEPENDENT TESTS, ALL AT NO COST TO THE CONTRACTOR;

4.3.2.2 EVIDENCE THAT QUALITY AND ADEQUATE MATERIAL QUANTITIES ARE AVAILABLE FROM THE PROPOSED SOURCE(S);

4.3.2.3 EVIDENCE THAT ADEQUATE RATES OF PRODUCTION AND DELIVERY CAN BE CONSISTENTLY MAINTAINED.

4.3.3 THE ENGINEER WILL, WITHIN SEVEN (7) DAYS OF RECEIVING THE ABOVE SUBMISSION, ADVISE THE CONTRACTOR OF THE ACCEPTABILITY OF THE PROPOSED MATERIALS AND PROCEDURES.

4.3.4 DURING PLACEMENT, THE ENGINEER MAY AT HIS DISCRETION INSPECT THE SLOPE PROTECTION FOR CONFORMANCE TO THE SPECIFICATION. THIS QUALITY ASSURANCE INSPECTION MAY INCLUDE SAMPLING AND TESTING AT NO COST TO THE CONTRACTOR, UNLESS MATERIAL DOES NOT CONFORM, WHEREON THE TESTING SHALL BE AT THE CONTRACTOR'S EXPENSE.

4.3.5 FAILURE OF A SAMPLE TO MEET ANY ONE OF THE SPECIFIED GRADATION AND PHYSICAL PROPERTIES CONSTITUTES AN UNACCEPTABLE MATERIAL AND SUCH MATERIAL MAY BE SUBJECT TO REJECTION BY THE ENGINEER.

4.3.6 DURING THE COURSE OF THE WORK, SHOULD THE CONTRACTOR PROPOSE TO OBTAIN SLOPE PROTECTION FROM AN ADDITIONAL SOURCE, OR SHOULD THE ROCK FROM AN APPROVED QUARRY APPEAR DIFFERENT IN ANY WAY FROM THE QUARRY SAMPLES TESTED, THE CONTRACTOR SHALL HAVE A SAMPLE FROM EACH ADDITIONAL SOURCE TESTED, OR EXISTING SOURCES RETESTED, AS DESCRIBED ABOVE AT THE CONTRACTOR'S EXPENSE.

G 4.3.7 CONTRACTOR TO PLACE A LAYER OF 60% PEA GRAVEL AND 40% SAND AT LEAST 0.1m THICK OVER COBBLE BETWEEN 0 AND 2m GEODETIC DATUM. PEA GRAVEL AND SAND WILL BE ROUNDED AND WASHER, AND GRADED TO ASTM C136, WITHIN THE FOLLOWING LIMITS:

SIEVE SIZE	PEA GRAVEL	WASHED SAND
RELATIVE PERCENT	0.6	0.4
16.00 mm (5/8")	85 – 100 %	100
12.5 mm (1/2")	15 – 85 %	100
9.5 mm (3/8")	0 – 15 %	100
4.75mm (#4)	0 – 5 %	80 – 100 %
600 µm (#300)	0	20 – 80 %
150 µm (#100)	0	0 – 20 %
75 µm (#200)	0 – 3 %	0 – 3 %

ALTERATIONS TO BE APPROVED BY PROJECT ENGINEER PRIOR TO PURCHASE.

100% DESIGN
ISSUED: 2020-02-24
NOT TO BE USED FOR CONSTRUCTION

Mark	Description	Date	Appr
H	UPDATED 100% DRAWING	2020.02.24	PH
G	UPDATED 100% DRAWING	2019.07.24	PH
F	UPDATED 100% DRAWING	2019.07.17	PH
E	100% DESIGN	2019.05.17	EC
CS	GREEN SHORES REVISION 60% SUBMITTAL	2019.04.04	MT
D	FINAL ISSUE	2018.05.17	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH
A	ISSUED FOR CLIENT REVIEW	2018.04.04	PH

Keystone Environmental
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UNION BAY ENVIRONMENTAL REMEDIATION

GENERAL NOTES & DESIGN CRITERIA SHEET 1 OF 2

Rev. H
Date: 2019-07-11
M&N Project No. 10091
Drawing code:
Drawing Scale: Plot scale: 1:1 (Metric D)
Designed by: PH
Drawn by: CA
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SEAL

Sheet Reference No.
G-002
INDEX: 2 OF 8

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

TABLE 2 – CLASS 100kg RIPRAP

	% SMALLER (BY WEIGHT) THAN			
MASS (Kg)	TARGET	LOWER LIMIT	UPPER LIMIT	D (m)
500	100	95	100	0.72
300	85	70	95	0.60
100	50	40	65	0.42
10	15	5	25	0.20
1.4	5	0	5	0.10

TABLE 3 – CLASS 1000kg RIPRAP

	% SMALLER (BY WEIGHT) THAN			
MASS (Kg)	TARGET	LOWER LIMIT	UPPER LIMIT	D (m)
4000	100	95	100	1.43
3000	85	70	95	1.30
1000	50	40	65	0.90
100	15	5	25	0.42
50	5	0	5	0.33

4.4 EXECUTION

4.4.1 GENERAL
AT THE END OF EACH WORKING DAY, CLEAN UP ALL ROCK THAT HAVE FALLEN FROM DELIVERY EQUIPMENT, DUST AND DEBRIS ARISING FROM ROCK DELIVERIES, TO THE ENGINEER'S SATISFACTION.

4.4.2 STOCKPILING
THE CONTRACTOR SHALL NOT STOCKPILE IMPORTED RIPRAP ON THE EXISTING PARKING AREAS, EMBANKMENT SLOPES OR FORESHORE THAT CAUSES TRAFFIC DISRUPTIONS, SETTLEMENT TO EXISTING PARKING AREA, DAMAGE TO STRUCTURES WITHIN THE PROPERTY AND THAT IS HARMFUL TO THE ENVIRONMENT. IN THE EVENT THAT THE CONTRACTOR CAUSES SUCH DAMAGE, THEN THEY SHALL BE RESPONSIBLE FOR ALL NECESSARY REPAIRS AT NO COST TO THE OWNER.

4.4.3 PLACING

4.4.3.1 IN ACCORDANCE WITH KEYSTONE ENVIRONMENTAL'S GRADING PLAN, THE UNDERLYING SURFACE SHALL BE TRIMMED AND COVERED WITH GEOTEXTILE PRIOR TO PLACING THE SLOPE PROTECTION. ANY LOSS OF MATERIAL OR FLATTENING OF THE SLOPES DURING THE WORK DUE TO WAVE ACTION OR OTHER CAUSE SHALL BE CORRECTED PROMPTLY. EXISTING PROFILE SHALL BE APPROVED BY THE ENGINEER PRIOR TO PLACING SLOPE PROTECTION.

4.4.3.2 PLACE SLOPE PROTECTION IN THE LOCATIONS AND TO THE ELEVATIONS, THICKNESS AND DETAILS INDICATED ON THE DRAWINGS OR AS DIRECTED BY THE ENGINEER. USE METHODS TO ENSURE THAT THE FINER ONE THIRD OF THE GRADATION IS EVENLY DISTRIBUTED THROUGHOUT THE LAYER AND OVER THE SURFACE BEING COVERED.

4.4.3.3 BEGIN PLACEMENT OF SLOPE PROTECTION AT THE TOE OF THE SLOPE AND CONTINUE WORKING UP THE SLOPE. PLACE THE ROCK IN TWO LAYERS IN SUCH A MANNER AS TO CREATE FIRM BEDDING AND INTERLOCKING OF INDIVIDUAL PIECES TO OBTAIN A TIGHTLY PACKED STRUCTURE. THE FINISHED SURFACE SHALL BE DENSELY PACKED BY PLACING SUITABLY SIZED ROCKS WITHIN VOIDS SO THAT RIPRAP IS WELL KEYED AND UNIFORM. FILL VOIDS, RE-WORK ROCKS NOT PROPERLY EMBEDDED, AND REMOVE PROTUBERANCES TO THE SATISFACTION OF THE ENGINEER. REMOVE AND REPLACE THAT PORTION OF ANY LAYER IN WHICH MATERIAL BECOMES SEGREGATED DURING SPREADING.

4.4.3.4 ENSURE THAT SLOPE PROTECTION DOES NOT EXTEND BEYOND THE NEAT LINE LIMITS AS SHOWN ON THE DRAWINGS.

4.4.3.5 PLACE SLOPE PROTECTION ON THE SLOPES EXPEDITIOUSLY AFTER COMPLETION OF EXCAVATION AND FILL PLACEMENT TO AVOID LOSSES DUE TO ENVIRONMENTAL AND/OR WAVE CONDITIONS.

4.5 TOLERANCES

4.5.1 ALL ROCK MATERIALS SHALL BE PLACED TO THE LINES, GRADES AND ELEVATIONS INDICATED ON THE DRAWINGS. THE MAXIMUM PERMISSIBLE VARIATION IN ELEVATION FROM THE PRESCRIBED LINE, MEASURED VERTICALLY AT COMPLETION OF PLACEMENT, SHALL BE +0.0 M AND −0.10 M.

4.5.2 THE MAXIMUM PERMISSIBLE VARIATION IN THE FINISHED THICKNESS OF SLOPE PROTECTION LAYERS, WHEN MEASURED AS THE PERPENDICULAR DIMENSION BETWEEN THE TOP AND BOTTOM SURFACE PLANES SHALL BE +/− 15 % OF THE LAYER THICKNESS AS INDICATED ON THE DRAWINGS.

4.5.3 THE FINAL SURFACE SHALL BE SURVEYED AND THE CONTRACTOR SHALL CORRECT ANY DEFICIENCIES TO THE SPECIFIED LIMITS AND SATISFACTION OF THE ENGINEER.

5.0 ANCHORED LOGS

5.1 GENERAL
NATURAL LOGS ARE TO BE ANCHORED ALONG THE BACK OF THE BEACH GENERALLY FOLLOWING THE CONTROL LINE. LOGS SHALL BE PLACED SO THAT THEY ARE ROUGHLY PARALLEL TO THE SHORELINE AND REACH AN ELEVATION OF +4.6 m LOGS SHALL BE OVERLAPPED TO PROVIDE CONTINUOUS SHORE PROTECTION AND OFFSET EVERY ~60 m TO ALLOW PEDESTRIAN ACCESS TO THE SHORELINE. LOGS WILL BE ANCHORED TO PRECAST CONCRETE ANCHOR BLOCKS WITH MOORING CHAIN.

5.2 ANCHOR LOGS SHALL BE APPROXIMATELY 50 TO 80 cm IN DIAMETER EACH LOG SHALL BE 4.5 TO 6 m IN LENGTH.

5.3 DOUGLAS FIR TREES AND OTHER TREES SPECIES AS APPROVED BY THE ENGINEER. THAT ARE TO BE REMOVED AS PART OF SITE CLEARING AND GRUBBING MAY BE USED AS ANCHORED LOGS.

5.4 ANCHOR CHAIN SHALL BE USED TO SECURE LOGS IN PLACE. ANCHOR CHAIN SHALL BE STEEL CHAIN, GRADE 30, HOT-DIPPED GALVANIZED. SIZE SHALL BE MINIMUM 13mm.

5.5 PRECAST CONCRETE BLOCKS ANCHOR SHALL BE 136 Kg MINIMUM.

6.0 COBBLE SLOPE

6.1 GENERAL
COBBLE SHALL BE WHOLE NATURAL ROCKS WITH ROUND EDGES GENERALLY FREE OF FRACTURED PIECES AND SHARP EDGES. 80% OF THE MATERIAL SHALL BE 60-260 mm IN GRAIN SIZE. CONTRACTOR TO STOCKPILE MATERIAL TO MINIMIZE RELEASE OF FINES DURING PLACEMENT AND STORAGE.

7.0 VEGETATED SAND DUNE

7.1 GENERAL
VEGETATED SAND DUNES SHALL BE CONSTRUCTED ALONG THE NORTH SHORELINE OF THE PROJECT AS SHOWN IN THE PLANS. SAND DUNES MAY BURY PORTIONS OF THE ANCHORED LOGS BUT SHALL BE CONFIGURED TO ALLOW PEDESTRIAN ACCESS TO THE SHORELINE. SAND FENCING MAY BE IMPLEMENTED TO CONTROL WIND BLOWN SAND AND DURING VEGETATION ESTABLISHMENT.

SAND SHALL BE FREE OF CONTAMINANTS AND CHEMICAL HAZARDS PER REQUIREMENTS OF KEYSTONE'S ENVIRONMENTAL'S SPECIFICATIONS FOR IMPORTED MATERIALS. THE MAXIMUM PROPORTION OF FINE-GRAINED PARTICLES (OR FINES, DEFINED AS SILTS AND CLAYS PASSING THROUGH 0.075 mm SIEVE) TO TOTAL VOLUME THAT COULD BE PLACED ON THE BEACH UNDER ANY CIRCUMSTANCES IS 25%, WITH THE REMAINDER BEING 75% LARGER-GRAINED SAND. THE MATERIAL MUST BE FREE OF TRASH AND DEBRIS. THE PRESENCE OF UNSATISFACTORY SAND OR OBJECTIONABLE FOREIGN MATERIAL SHALL BE REASON FOR REJECTION OF AN ENTIRE LOAD OF SAND. A REJECTED LOAD OF SAND SHALL BE REMOVED FROM THE SITE AND DISPOSED OF AT THE CONTRACTOR'S EXPENSE.

DESIGN CRITERIA

STRUCTURES SHALL CONFORM TO THE MOST CURRENT VERSION OF THE FOLLOWING CODES AND STANDARDS:

- NATIONAL BUILDING CODE OF CANADA (NBCC, 2015)
- BC CLIMATE CHANGE ADAPTION GUIDELINES FOR SEA DIKES AND COASTAL FLOOD HAZARD LAND USE (MOE, 2011A, B, C).
- THE ROCK MANUAL (CIRIA, 2007).
- COASTAL ENGINEERING MANUAL (CEM, 2011).
- STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION (MOTI, 2016).
- RIPRAP DESIGN AND CONSTRUCTION GUIDE (MOE, 2000).

2.0 MATERIALS AND TESTING

MATERIALS AND TESTING IS SPECIFIED TO CONFORM TO THE MOST CURRENT EDITION OF THE RELEVANT STANDARDS, WHERE APPLICABLE, AS PUBLISHED BY THE FOLLOWING ORGANIZATIONS:
- CANADIAN STANDARDS ASSOCIATION (CSA)
- AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)
- REQUIREMENTS RELATED TO MATERIALS TESTING IS DETAILED IN KEYSTONE ENVIRONMENTAL'S SPECIFICATIONS PACKAGE.

3.0 UNITS OF MEASUREMENT

CONSTRUCTION DRAWINGS AND SPECIFICATIONS ARE IN ACCORDANCE WITH THE INTERNATIONAL SYSTEM OF UNITS (SI) METRIC UNITS. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

4.0 PROJECT DATUM AND ELEVATIONS

COORDINATES ARE IN METERS TO A SITE-SPECIFIC LOCAL GRID COORDINATE SYSTEM. ALL ELEVATIONS ARE REFERENCED TO GEODETIC DATUM, AND ARE IN METRES UNLESS NOTED OTHERWISE.

5.0 MARINE DESIGN CRITERIA

5.1 WATER LEVELS
THE CANADIAN HYDROGRAPHIC SERVICE TIDE HEIGHTS FOR DENMAN ISLAND (CHS CHART 3527) REFERENCED TO CHART DATUM (CD).

TABLE 4 – WATER LEVEL CHART DATUM

ELEVATION ABOVE CHART DATUM (M)					
LOCATION	LARGE TIDE		MEAN TIDE		MEAN WATER LEVEL
	HHW	LLW	HHW	LLW	
DENMAN ISLAND	5.2	0.0	4.5	1.1	3.2

CHART DATUM AT DENMAN ISLAND IS 3.2M BELOW GEODETIC DATUM, WHERE GEODETIC DATUM IS THE MEAN WATER LEVEL.

TABLE 5 – WATER LEVEL GEODETIC DATUM

ELEVATION ABOVE GEODETIC DATUM (M)					
LOCATION	LARGE TIDE		MEAN TIDE		MEAN WATER LEVEL
	HHW	LLW	HHW	LLW	
DENMAN ISLAND	2.0	−3.2	1.3	−2.1	0.0

5.2 GROUND SNOW AND RAIN
BASED ON NBCC, THE COMOX SNOW AND RAIN LOADINGS ARE:
- SS GROUND SNOW LOAD 1 IN 50 YEAR – 2.6 KPA
- SR ASSOCIATED RAIN LOAD 1 IN 50 YEAR – 0.4 KPA

5.3 WIND PRESSURE
BASED ON NBCC, THE COMOX HOURLY WIND PRESSURES ARE:
- 1/10 YEAR – 0.40 KPA
- 1/50 YEAR – 0.52 KPA
- 1/200 YEAR – 0.63 KPA

5.4 TEMPERATURE
THE MAXIMUM AND MINIMUM TEMPERATURE RANGES FOR COMOX ARE CONSIDERED APPLICABLE TO UNION BAY:

TABLE 6 – TEMPERATURE

JANUARY		JULY 2.5%	
2.5%	1%	DRY	WET
°C	°C	°C	°C
−7	−9	27	18

6.0 DESIGNATED FLOOD LEVEL

THE DESIGNATED FLOOD LEVEL (DFL) IS GIVEN BY (MOE, 2011A, B):

DFL=SLR+RSLR+HHWLT+SS

WHERE SLR IS THE FUTURE SEA LEVEL RISE, ADJUSTED FOR RELATIVE SEA LEVEL RISE (RSLR). AT HIGHER HIGH WATER LARGE TIDE (HHWLT), WITH STORM SURGE (SS).

TABLE 7 – DESIGNATED FLOOD LEVEL

DESIGN CRITERIA	HEIGHT / ELEVATION
2100 SEA LEVEL RISE	1.00 M
RELATIVE SLR (UPLIFT)	−0.25 M
HIGHER HIGH WATER LARGE TIDE LEVEL	2.00 M (GD)
1 IN 200 YEAR STORM SURGE	1.25 M
DESIGNATED FLOOD LEVEL (DFL)	**+4.00 M (GD)**
FREEBOARD	+0.60 M

7.0 WAVE EFFECTS

WAVE EFFECTS INCLUDING WAVE RUNUP FOR THE RIPRAP DESIGN ARE SUMMARIZED IN TABLE BELOW:

TABLE 8 – WAVE EFFECTS

LOCATION SECTION	Hs WAVE HEIGHT (M)	Tp WAVE PERIOD (SEC)	WAVE EFFECT (M)
D	1.0	5.2	0.77
B–C	4.4	3.8–3.7	1.53–1.57
A	4.4	3.7	0.92

F

F

100% DESIGN
ISSUED: 2019-07-17
NOT TO BE USED FOR CONSTRUCTION

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

Keystone Environmental
Knowledge-Driven Results

Rev.	Description	Date	Appr.
F	UPDATED 100% DRAWING	2019.07.17	PH
E	100% DESIGN	2019.05.17	EC
GS	GREEN SHORES REVISION 60% SUBMITTAL	2019.04.04	MT
D	FINAL ISSUE	2018.05.17	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH
A	ISSUED FOR CLIENT REVIEW	2018.04.05	PH
Mark			

UNION BAY ENVIRONMENTAL REMEDIATION

GENERAL NOTES & DESIGN CRITERIA SHEET 2 OF 2

Designed by: PH
Drawn by: CA
Ckd by: MJ
Reviewed by: MT
Submitted by: MOFFATT & NICHOL
Date: 2019-07-11
Rev. F
M&N Project No. 10091
Drawing code:
Drawing Scale:
Plot scale: 1:1 (Metric D)

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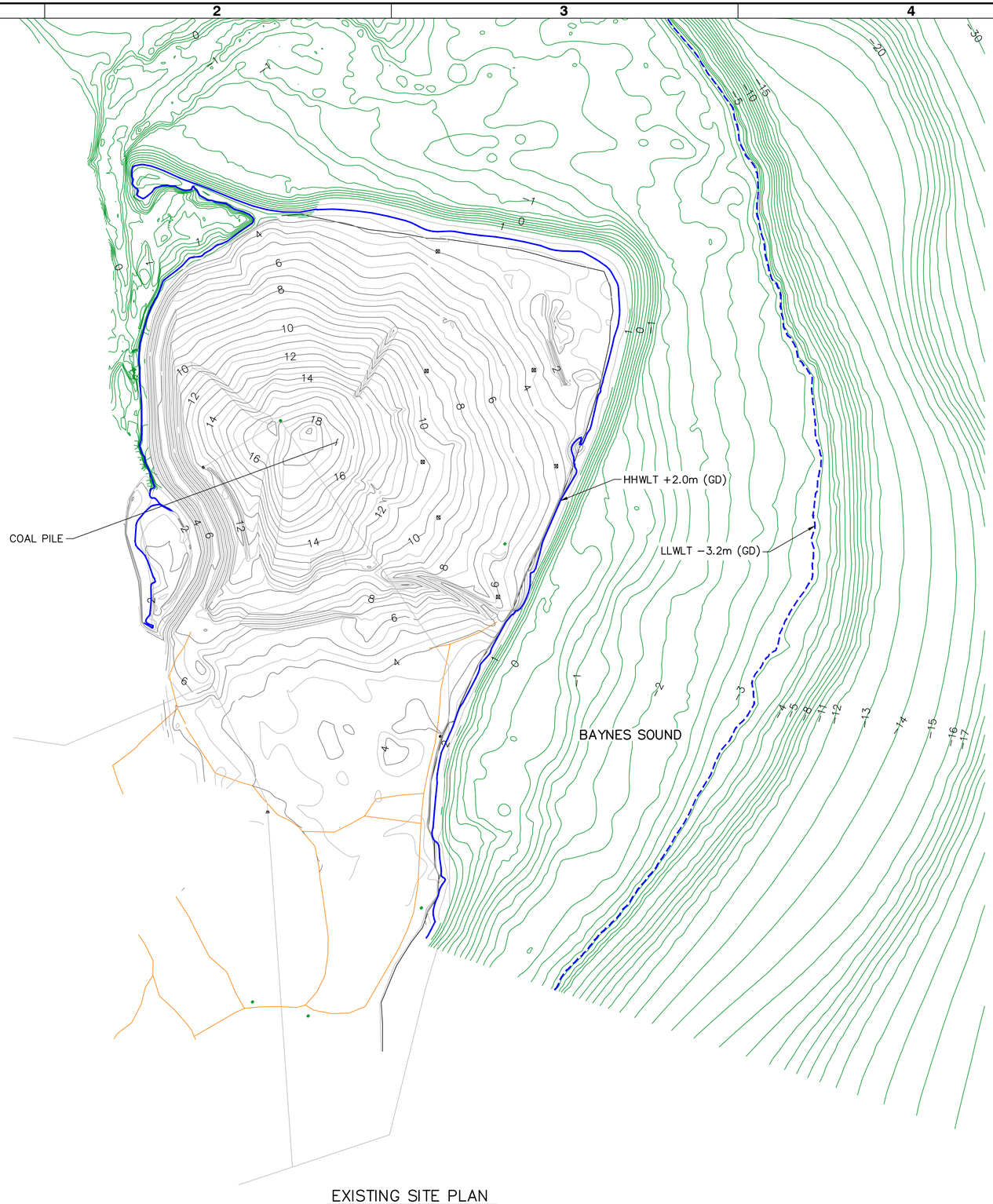
SEAL

Sheet Reference No.
G-003
INDEX: 3 OF 8

File: Q:\VAN\10091 VC18 Detailed Design of Riprap\CAD_Active_Preliminary\10091000-003; Plotted: 8/1/2019 3:14 PM by LU, LINDA; Saved: 7/24/2019 2:50 PM by LU



EXISTING SITE PLAN
SCALE: 1:2000

LEGEND:

- PROPERTY LINE
- LLWLT −3.2m (GD)
- HHWLT +2.0m (GD) (G)
- −4 TOPOGRAPHIC CONTOUR
- −8 BATHYMETRIC CONTOUR
- TRAIL

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. CONTOUR ELEVATIONS ARE IN METRE GEODETIC DATUM (GD).
3. GEODETIC DATUM TO CHART DATUM CONVERSION = GD+3.2m.

40 0m 40 80
SCALE: 1 : 2000

(G) **100% DESIGN**
ISSUED: 2019-07-24
NOT TO BE USED FOR CONSTRUCTION

Keystone Environmental
Knowledge-Driven Results

Mark	Description	Date	Appr.
G	UPDATED 100% DRAWING	2019.07.24	PH
F	UPDATED 100% DRAWING	2019.07.17	PH
E	100% DESIGN	2019.05.17	EC
CG	GREEN SHORES REVISION 60% SUBMITTAL	2019.04.04	MT
D	FINAL ISSUE	2018.05.17	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH
A	ISSUED FOR CLIENT REVIEW	2018.04.05	PH

UNION BAY ENVIRONMENTAL REMEDIATION

EXISTING SITE PLAN

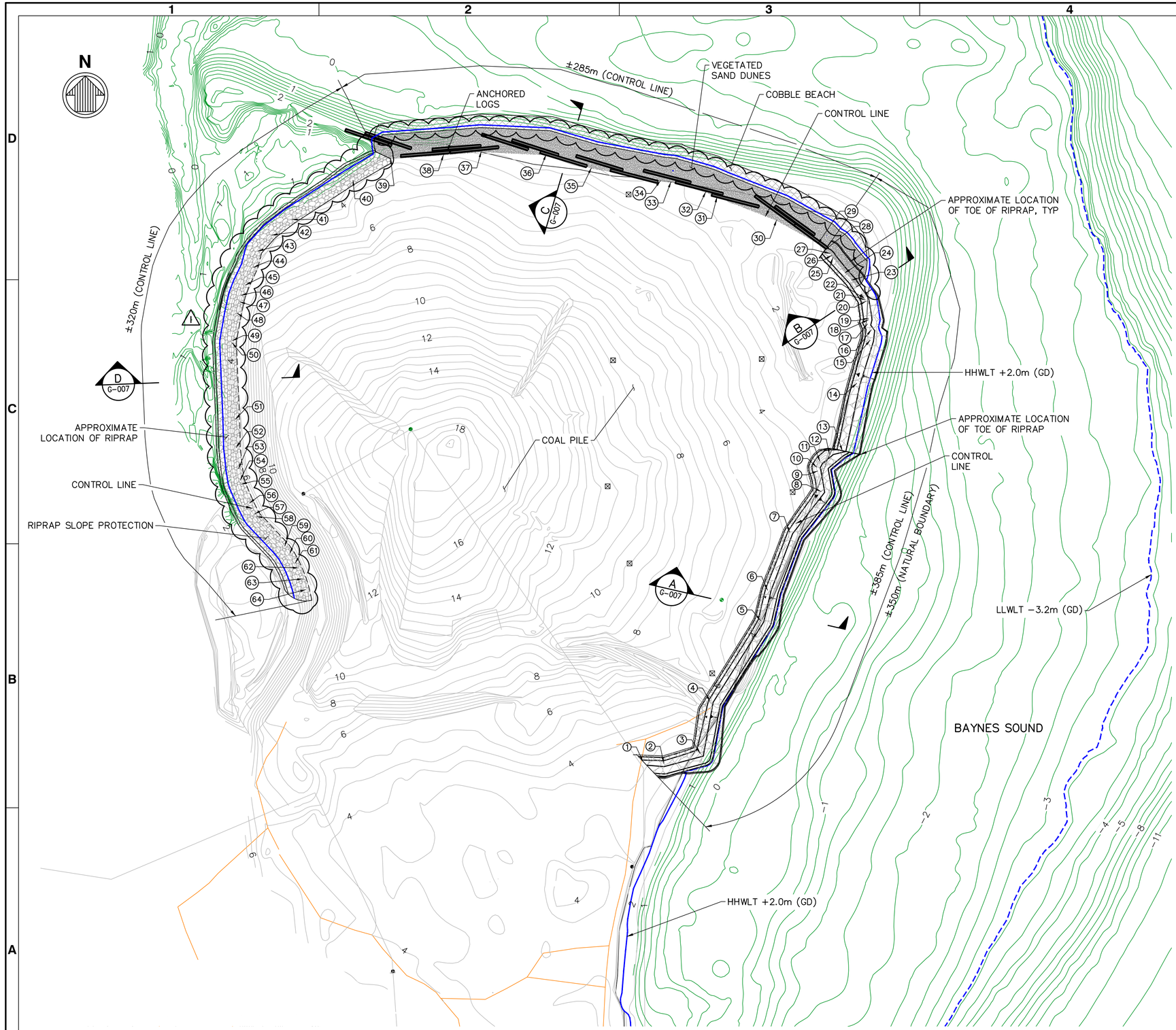
Date: 2019-07-11 | Rev. G
Designed by: PH | Drawn by: CA | Chkd by: MJ | Reviewed by: MT
M&N Project No. 10091
Drawing code:
Submitted by: MOFFATT & NICHOL
Drawing Scale: Plot scale: 1:1 (Metric D)

moffatt & nichol
777 WEST BROADWAY, SUITE 301
VANCOUVER, BC, CANADA, V5Z 4J7
604-707-9004

SEAL

Sheet Reference No.
G-004
INDEX: 4 OF 8

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



GENERAL ARRANGEMENT PLAN
SCALE: 1:1250

LEGEND:

- COBBLE BEACH
- RIPRAP
- VEGETATED SAND DUNES
- PROPERTY LINE
- CONTROL LINE
- LLWLT −3.2m (GD)
- HHWLT +2.0m (GD)
- −4 TOPOGRAPHIC CONTOUR
- −8 BATHYMETRIC CONTOUR
- TRAIL
- 00 CONTROL POINT NO.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. CONTOURS ELEVATIONS ARE IN METRE GEODETIC DATUM (GD).
3. GEODETIC DATUM TO CHART DATUM CONVERSION = GD+3.2m.
4. TIDE ELEVATIONS PREDICTED BY THE CANADIAN HYDROGRAPHIC SERVICE ARE:

−HIGHER HIGH WATER, LARGE TIDE (HHWLT):	2.0m
−HIGHER HIGH WATER, MEAN TIDE (HHWMT):	1.3m
−MEAN WATER LEVEL (MWL):	0.0m
−LOWER LOW WATER, MEAN TIDE (LLWMT):	−2.1m
−LOWER LOW WATER, LARGE TIDE (LLWLT):	−3.2m

5. KEYSTONE ENVIRONMENTAL LTD. PROVIDED THE TOPOGRAPHIC SURVEY INFORMATION.
6. ESTIMATED SEA LEVEL RISE FOR UNION BAY IS +1.0m IN YEAR 2100.
7. SEE SHEET G−006 FOR CONTROL LINE POINTS NOS AND COORDINATES.

25 0m 25 50
SCALE: 1 : 1250

1 **100% DESIGN**
ISSUED: 2019-08-01
NOT TO BE USED FOR CONSTRUCTION

Keystone Environmental
Knowledge-Driven Results

Mark	Description	Date	Appr.
I	UPDATED 100% DRAWING	2019.08.01	PH
H	UPDATED 100% DRAWING	2019.07.24	PH
G	UPDATED 100% DRAWING	2019.07.17	PH
F	REVISED 100% DESIGN	2019.07.11	EC
E	100% DESIGN	2019.05.17	EC
GS	GREEN SHORES REVISION 60% SUBMITTAL	2019.04.04	MT
D	REVISED LINER LAYOUT	2018.05.04	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH
A	ISSUED FOR CLIENT REVIEW	2018.04.05	PH

UNION BAY ENVIRONMENTAL REMEDIATION

GENERAL ARRANGEMENT

Rev.: I
Date: 2019−07−11
M&N Project No.: 10091
Drawing code:
Drawing Scale: Plot scale: 1:1 (Metric D)
Designed by: PH
Drawn by: CA
Chd by: MJ
Reviewed by: MT
Submitted by: MOFFATT & NICHOL

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604−707−9004

SEAL

Sheet Reference No.
G-005
INDEX: 5 OF 8

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

File: G:\VAN\10091 VC18 Detailed Design of Riprap\CADD_Active_Preliminary\10091000−005; Plotted: 8/1/2019 3:14 PM by LU, LINDA; Saved: 8/1/2019 3:12 PM by LU

POINT TABLE		
CONTROL PT No.	EASTING	NORTHING
1	363905.97	5494837.74
2	363918.91	5494836.72
3	363941.25	5494842.73
4	363947.21	5494874.89
5	363978.45	5494924.54
6	363982.75	5494943.29
7	363996.29	5494979.12
8	364015.67	5495004.06
9	364013.53	5495016.54
10	364012.91	5495019.13
11	364015.01	5495022.71
12	364020.80	5495027.58
13	364028.86	5495029.13
14	364037.61	5495070.55
15	364045.87	5495097.07
16	364046.58	5495103.51
17	364044.23	5495107.11
18	364044.82	5495109.76
19	364044.83	5495110.68
20	364043.18	5495121.09
21	364042.86	5495122.10
22	364042.32	5495123.10
23	364034.69	5495134.28
24	364030.58	5495138.74
25	364023.06	5495147.94
26	364022.18	5495149.47
27	364021.08	5495150.69
28	364017.86	5495152.56
29	364013.90	5495156.73
30	363988.30	5495171.01

POINT TABLE		
CONTROL PT No.	EASTING	NORTHING
31	363951.69	5495185.41
32	363944.64	5495188.42
33	363923.19	5495194.58
34	363916.60	5495195.21
35	363874.22	5495203.25
36	363846.34	5495211.46
37	363806.36	5495213.26
38	363783.13	5495211.36
39	363750.55	5495209.12
40	363727.43	5495195.70
41	363690.12	5495171.59
42	363677.75	5495162.10
43	363668.88	5495152.26
44	363666.29	5495142.17
45	363661.16	5495131.23
46	363658.78	5495125.05
47	363657.71	5495120.90
48	363656.22	5495113.87
49	363653.23	5495096.99
50	363653.15	5495095.49
51	363655.07	5495048.57
52	363655.54	5495031.19
53	363656.91	5495018.19
54	363658.06	5495011.08
55	363658.81	5495008.50
56	363663.75	5494996.94
57	363667.04	5494990.31
58	363668.36	5494988.41
59	363685.38	5494970.44
60	363688.60	5494966.12

POINT TABLE		
CONTROL PT No.	EASTING	NORTHING
61	363691.94	5494960.08
62	363693.46	5494956.93
63	363696.15	5494950.11
64	363698.12	5494943.46

NOTES:

1. REFER TO DWG. G-005 FOR PLAN VIEW OF COORDINATE POINT LOCATIONS.

25 0m 25 50

SCALE: 1 : 1250

100% DESIGN
ISSUED: 2019-07-17
NOT TO BE USED FOR CONSTRUCTION

Keystone Environmental
Knowledge-Driven Results

Rev.	Description	Date	Appr.
B	UPDATED 100% DRAWING	2019.07.17	PH
A	100% DESIGN	2019.07.11	EC
Mark			

UNION BAY ENVIRONMENTAL REMEDIATION

CONTROL POINTS LISTING

Date: 2019-07-11
Rev: B
M&N Project No. 10091
Drawing code:
Drawing Scale: Plot scale: 1:1 (Metric D)
Designed by: DESIGNER
Dwn by: CA
Chd by: MJ
Reviewed by: MT
Submitted by: MOFFATT & NICHOL

moffatt & nichol
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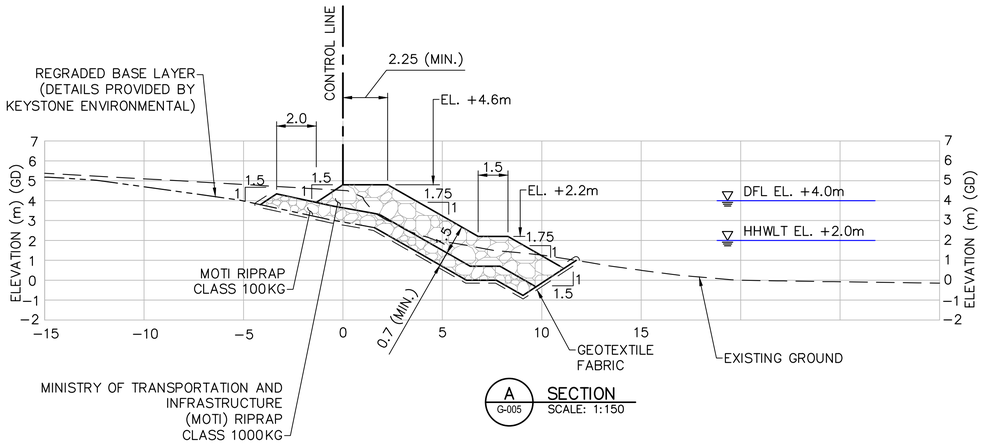
VANCOUVER, BC, CANADA, V5Z 4J7
604-707-9004

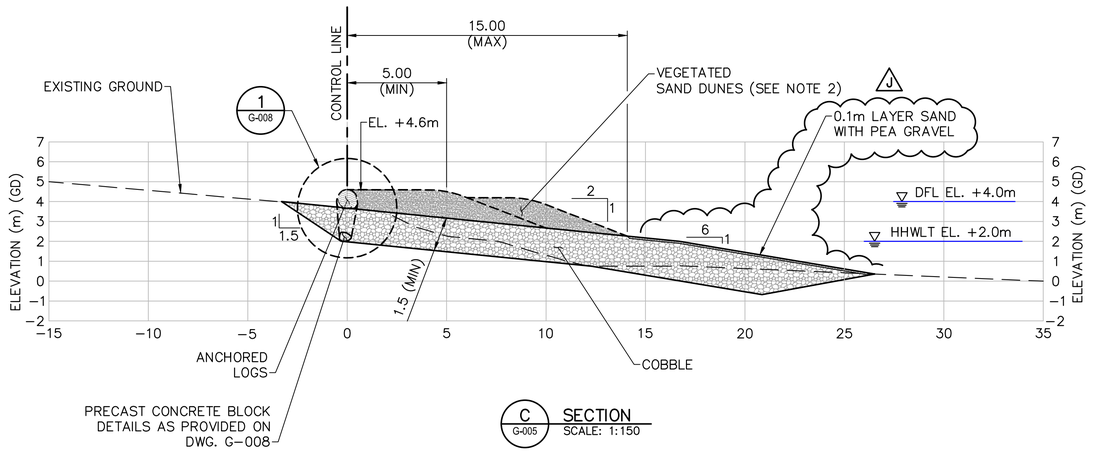
SEAL

Sheet Reference No.
G-006
INDEX: 6 OF 8

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



A G-005 SECTION
SCALE: 1:150



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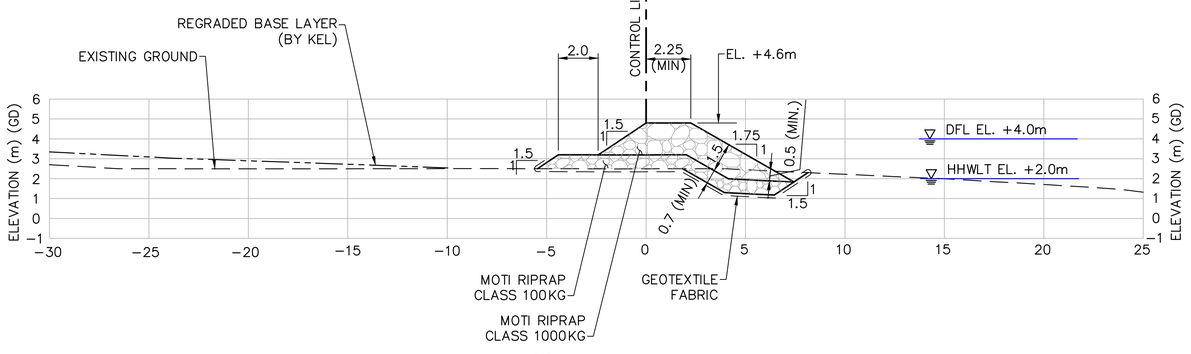

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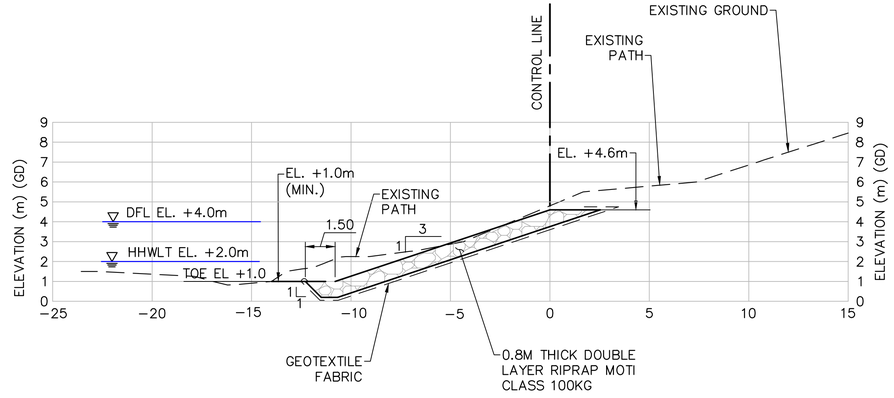

D G-005 SECTION
SCALE: 1:150

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. KEYSTONE ENVIROMENTAL TO PROVIDE VEGETATION TYP.

3 0m 3 6
SCALE: 1 : 150

100% DESIGN
ISSUED: 2020-02-24
NOT TO BE USED FOR CONSTRUCTION

Keystone Environmental
Knowledge-Driven Results

Mark	Description	Date	Appr.
J	UPDATED 100% DRAWING	2020.02.24	PH
H	UPDATED 100% DRAWING	2019.08.01	PH
G	UPDATED 100% DRAWING	2019.07.24	PH
F	UPDATED 100% DRAWING	2019.07.17	PH
E	100% DESIGN	2019.07.11	EC
GS	GREEN SHORE REVISION 60% SUBMITTAL	2019.04.04	MT
D	FINAL ISSUE	2018.05.17	PH
C	REVISED LAYOUT	2018.05.03	PH
B	REVISED LAYOUT	2018.05.02	PH
A	ISSUED FOR CLIENT REVIEW	2018.04.05	PH

UNION BAY ENVIRONMENTAL REMEDIATION

SECTION AND DETAILS

Rev.	J
Date:	2019-07-11
M&N Project No.	10091
Drawing code:	
Drawing Scale:	Plot scale: 1:1 (Metric D)
Designed by:	PH
Dwn by:	CA
Ckd by:	MJ
Reviewed by:	MT
Submitted by:	MOFFATT & NICHOL

moffatt & nichol
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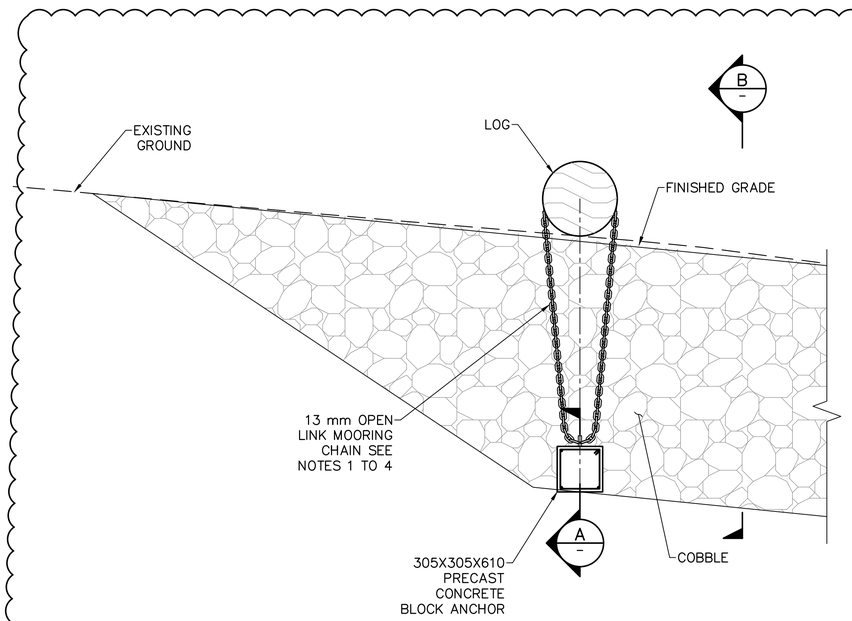
VANCOUVER, BC, CANADA, V5Z 4J7
604-707-9004

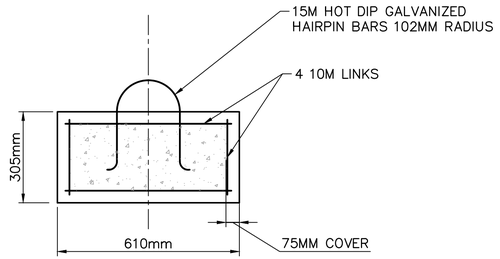
SEAL

Sheet
Reference No.
G-007
INDEX: 7 OF 8

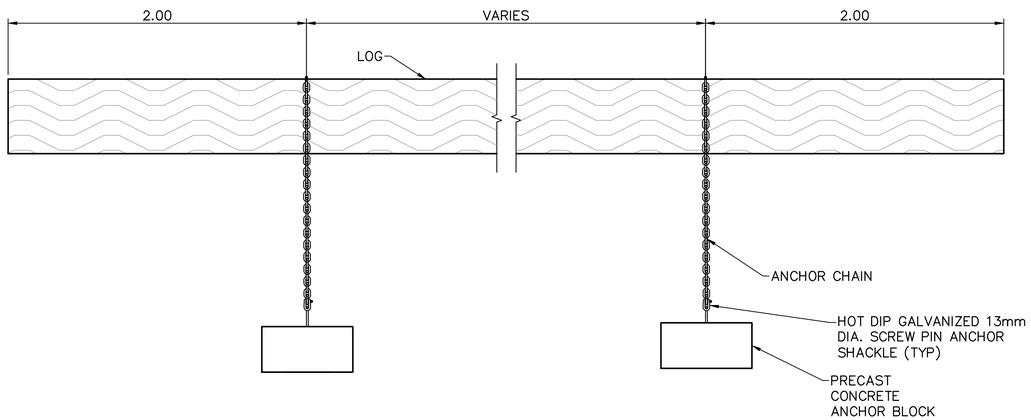
DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



1 / G-007 DETAIL OF LOG ANCHOR
SCALE: 1:20
SAND DUNE OMITTED FOR CLARITY



A – SECTION
SCALE: 1:10



B – ELEVATION
SCALE: 1:10
COBBLE OMITTED FOR CLARITY

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. WRAP CHAIN TWICE AROUND LOG
3. ATTACH CHAIN TO CONCRETE ANCHOR USING SHACKLE.
4. ALL CHAINS AND SHACKLES ARE HOT DIP GALVANIZED
5. PRECAST CONCRETE SHALL BE 30 MPA MIN. 28 DAY COMPRESSIVE STRENGTH.

0.2 0m 0.2 0.4
SCALE: 1 : 10

0.4 0m 0.4 0.8
SCALE: 1 : 20

100% DESIGN
ISSUED: 2019-07-17
NOT TO BE USED FOR CONSTRUCTION

Keystone Environmental
Knowledge-Driven Results

B	UPDATED 100% DRAWING	2019.07.17	PH
A	100% DESIGN	2019.07.11	EC
Mark	Description	Date	Appr.

UNION BAY ENVIRONMENTAL REMEDIATION

MISCELLANEOUS DETAILS

Designed by: DESIGNER
Dwn by: CA
Ckd by: MJ
Reviewed by: MT
Submitted by: MOFFATT & NICHOL
Date: 2019-07-11
M&N Project No. 10091
Drawing code:
Drawing Scale: Plot scale: 1:1 (Metric D)
Rev. B

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604-707-9004

SEAL

Sheet Reference No.
G-008
INDEX: 8 OF 8

DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

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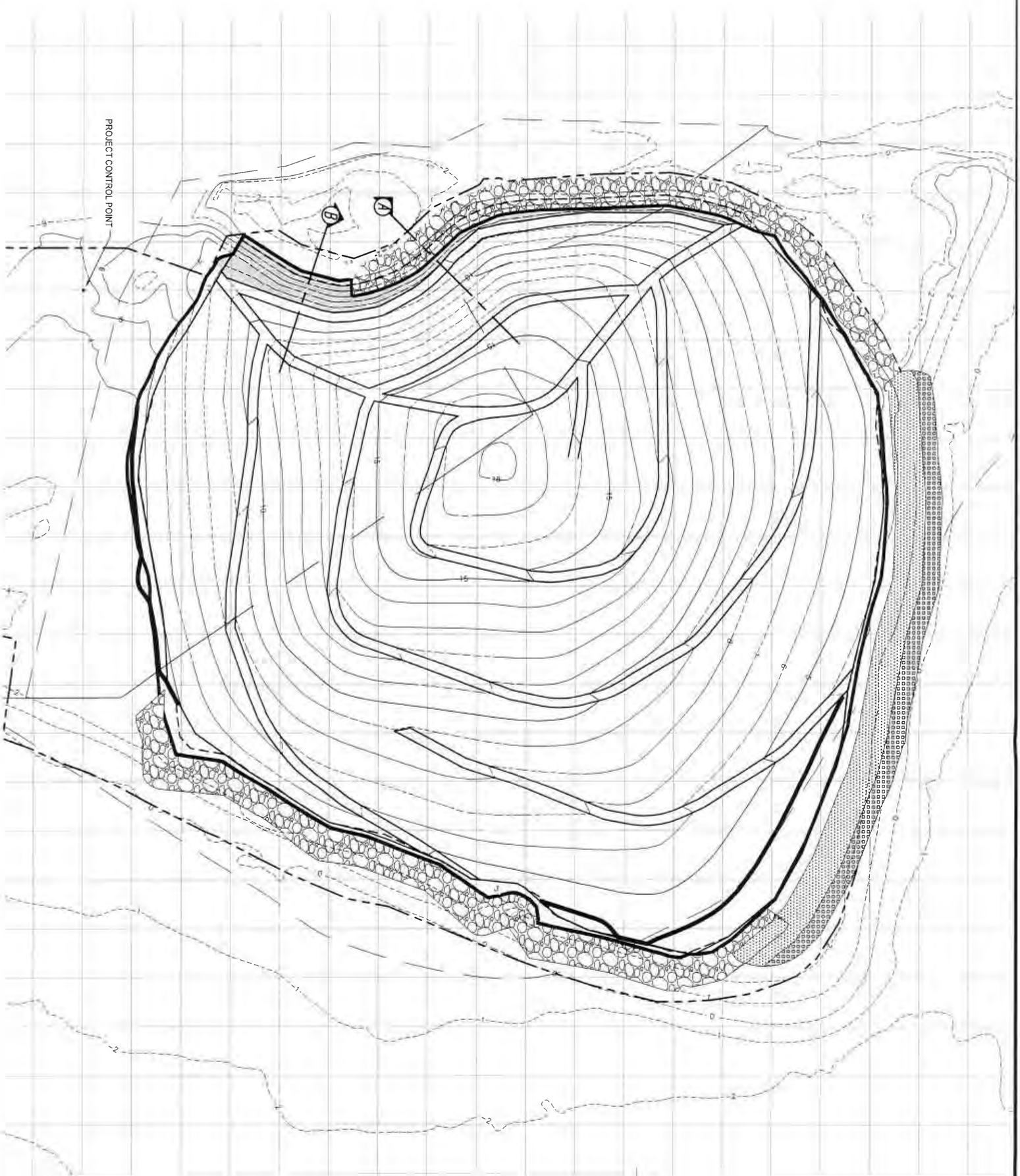


LEGEND

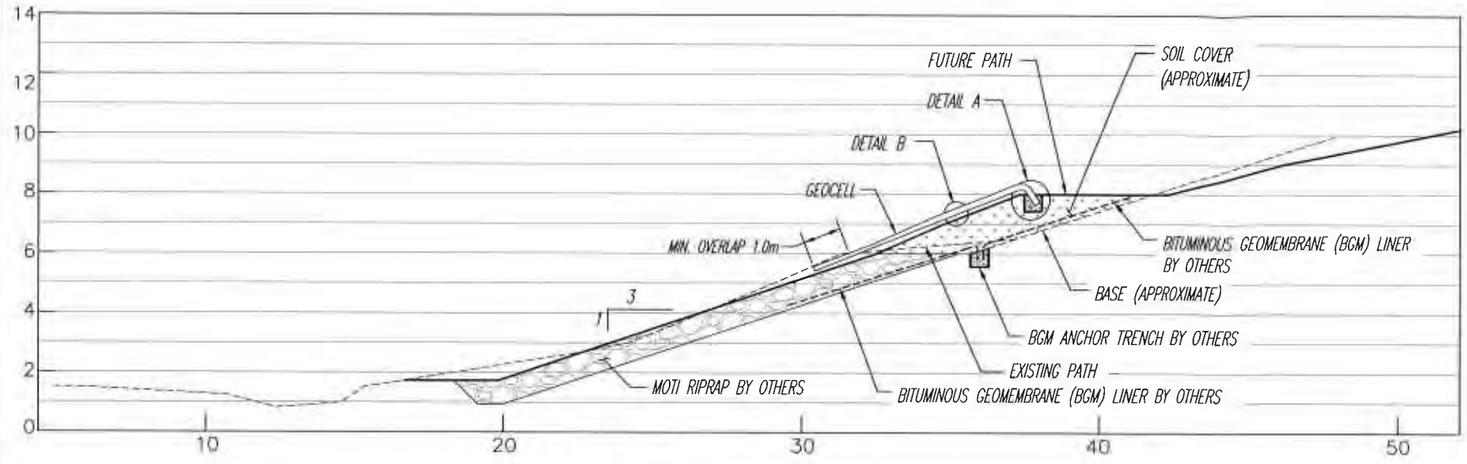
- RIPRAP
- GEOCELL COVER

SITE PLAN
SCALE 1:2000

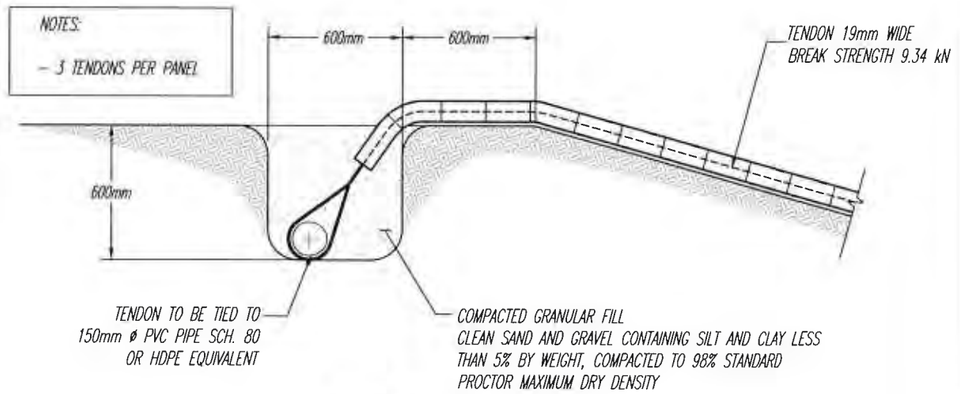
N
W
E
S

REVISIONS:
1 AUGUST 23, 2019 – New Keystone dwg.
2
3

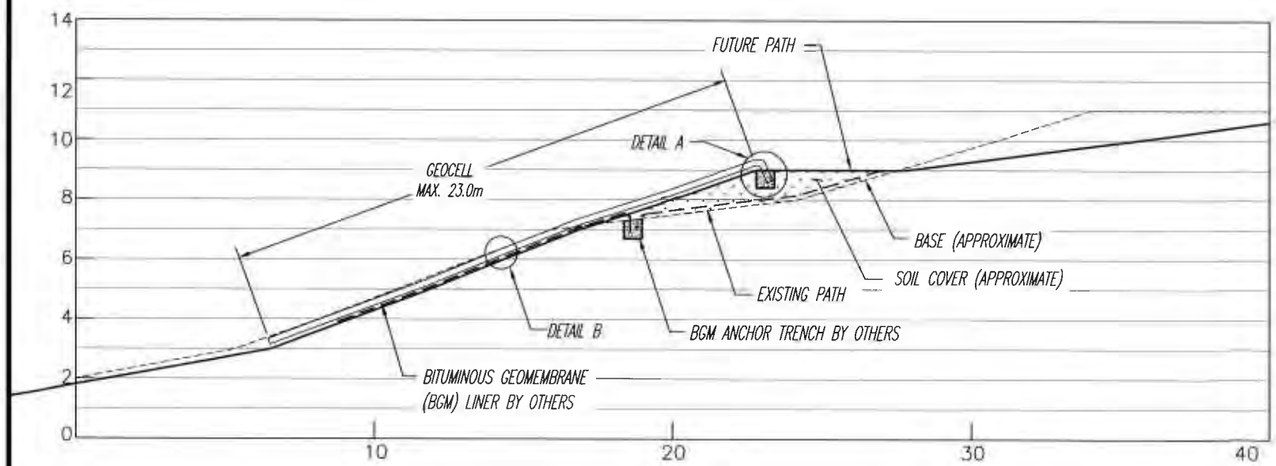
REFERENCE:	GEOPACIFIC VANCOUVER KAMLOOPS CALGARY	DATE: MAY 2, 2018	UNION BAY WASTE COAL PILE	FILE NO.: 9422
ARCHITECTS	1779 W. 75th Avenue, Vancouver, B.C. V6P 6P2	DRAWN BY: M.S. / APPROVED BY: M.X.L. / REVIEWED BY: M.X.L.	UNION BAY, B.C.	DWG. NO.: G-1
PROJECT No.:	T: 604.439.9922 F: 604.439.9189	SCALE: AS SHOWN	GEOCELL COVER	
PROJECT DATE:				



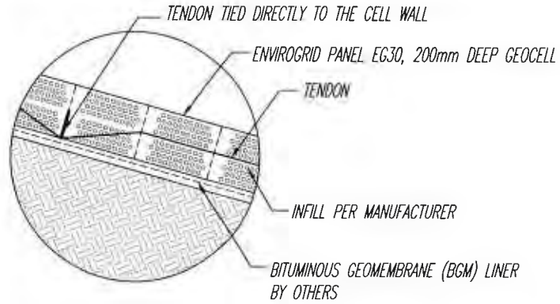
SECTION A
SCALE 1:200



DETAIL A
SCALE 1:40



SECTION B
SCALE 1:200



DETAIL B
N.T.S.

ORIGINAL PAPER SIZE 11"x17"

REFERENCE:

GEOPACIFIC
VANCOUVER KAMLOOPS CALGARY
1779 W. 75th Avenue
Vancouver, B.C. V6P 6P2
P. 604.439.0922
F. 604.439.9189

DATE: MAY 4, 2018		
DRAWN BY: M.S.	APPROVED BY: M.X.L.	REVIEWED BY: M.X.L.
SCALE: AS SHOWN		

UNION BAY WASTE COAL PILE
UNION BAY, B.C.
GEOCELL - SECTION A, B, DETAIL A, B

FILE NO.: 9422
DWG. NO.: G-2

REVISIONS:
A. AUGUST 23, 2019 - New Keystone dwg.
B.
C.

moffatt & nichol

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March 4, 2020

Keystone Environmental
#320 - 4400 Dominion Street
Burnaby, BC
Canada V5G 4G3

Attn: Ms. Zahra Pirani, M.Eng., P.Eng. – Project Engineer

Subject: **Union Bay Coal Pile Green Shores Design**

Dear Zahra:

The alternatives for soft shoreline protection at the Union Bay Coal Pile were developed based on available site information, and the summary of the metocean conditions described in the "Union Bay Coal Pile Shoreline Protection Design" document (BOD) dated April 2018, prepared by Moffatt & Nichol.

1. BASIS OF DESIGN

The level of protection for the proposed facility was designated for an Annual Exceedance Probability (AEP) of 0.5%. The AEP is the percentage risk probability associated with a given return period, e.g. AEP = 0.5% corresponds to a return period of 1/0.005 = 200 years. The Ministry Standards, MOE (2011), requires us to design for the 200-year storm condition.

The design and performance of the facilities assumes that a regular inspection and maintenance program is implemented to repair damage and deterioration which is normal for structures exposed to the marine environment.

The original design for shoreline protection was a riprap structure that was to be located along the east and north facing shorelines, and section of the waste pile located along Hart Creek along the west side of the pile.

2. CLIMATE CHANGE ADAPTIVE STRATEGY

Sea level rise was considered in the design by adhering to the Ministry guidelines. These require a sea level change of 1 metre to be considered. The design water level was therefore assumed to include a 1-metre rise in sea level. The ministry guidelines also require an average return period (ARP) of 200 years to be considered for storm surge, combined with sea level rise.

Based on the current outlook, a 1-metre rise in sea level is projected to occur by 2100. As climate science evolves, the projections of future sea level rise are likely to be adjusted. The projections may

also be adjusted up e.g. if field measurements indicate that sea level rise is accelerating, i.e. departing from a linear trend; or e.g. adjusted down if emissions are curbed significantly worldwide.

As far as sea level rise remains below 1 metre, the project is designed for a combined storm surge and sea level rise of (1.25+1.0 = 2.25 metres). If sea level rise progresses beyond 1 metre, the project still retains some level of resilience to storm exposure and wave action.

Table 2-1 quantifies the level of resilience the design has for sea level rise above 1 metre. As sea level rises above the 1 metre design objective, the design would become increasingly sensitive to the magnitude of storm events and associated wave exposure. For example, if the mean sea level were to rise to 1.1 metres, the design total water level would be met with a storm surge having a return period of 75 years. At the extreme end of the scale, if sea level were to rise to 1.5 metres (a 50% increase above 1.0 metres), storm surge recurring annually would produce the same total water level as assumed for the current design.

Table 2-1: Sea Level Rise Resilience.

Sea Level Rise (m)	% increase	ARP (years)
< 1.0	-	> 200
1.0	0%	200
1.1	10%	75
1.2	20%	35
1.3	30%	15
1.4	40%	7
1.5	50%	1

This illustrates that the current design is highly resilient out to around year 2100. If sea level rises beyond that point, the project would still remain fairly resilient to the increase in mean sea level.

A rise in sea level to 1.5 meres is currently projected to occur by 2150, which is a significant time horizon from present day. What the future specifically holds in terms of sea level rise is as yet largely unknown and is more of a matter of timing of when, as opposed to a set amount.

This in turn means that the timeline over which to accommodate and adapt to sea level rise is quite reasonable, because the projected rise is fairly gradual. If the typical time horizon needed to plan, fund, and construct a project is around 10 years, it is possible to define a trigger point as to when such planning should commence.

As sea level rise progresses, the indication is that the design would transition to a need for an increasing level of maintenance – to repair damage after significant storm events.

In this state, it becomes a gamble each successive year as to how each winter storm and wave exposure turns out. These are random events, so there is a certain probability of having say a 1-year, 5-year or 10-year storm in a given winter. While events with strong wind and wave exposure can be expected to occur together with storm surge, tides are generally independent of these processes. If a

storm event were to peak on a low tide, the exposure of the shoreline to wave action would be diminished. Conversely, one can also argue that because a storm unfolds over a number of hours to days, it will at some point coincide with a high tide.

Figure 2-1 illustrates this effect for example tides predicted for January and February. It can be seen that the envelope of the highest tides ranges from about 4.7 to 5.2 metres relative to Chart Datum (CD). The intermediate high tides range from 3.2 to 4.7 m CD. The indication is that the variation of the highest tides can be on the order of 0.5 metres. The variation of the highest tides being about 40% relative to the design storm surge of 1.25 metre, and 50% relative to the design sea level rise of 1 metre shows that tides do play a significant role in the outcome of the total water level during the passage of a storm. A modest decrease in the tide level can therefore reduce the magnitude of what would otherwise have been e.g. a 100-year storm.

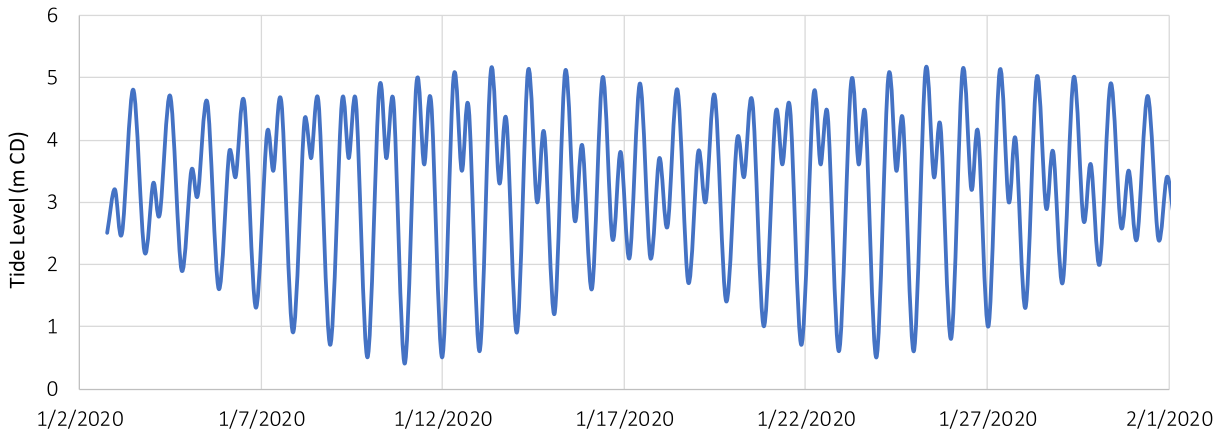


Figure 2-1: Example tides for January, February – Denman Island.

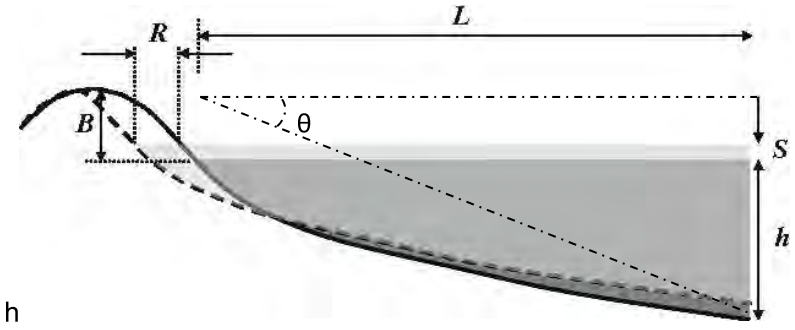
2.1. Shoreline Changes

There are several different ways sea-level rise can affect shorelines. Along shorelines subject to wave action, the typical response of the shoreline to sea-level rise is to recede inland. This happens as the shoreline profile rebalances itself around the new higher mean sea level. This effect was described in 1962 by Per Bruun and is known as the Bruun Rule. In order to maintain the same beach slope, upland material is eroded and shifted to the below water portion of the profile. In undeveloped areas the effect may be pronounced recession of the shoreline. If there is an insufficient supply of sediment available to raise the shoreline profile in tow with sea-level rise, the result can be accelerated erosion and deepening of the coastal waters. This in turn allows larger waves to impact the shore which further exacerbates erosion.

The Bruun Rule relates shoreline erosion to sea level rise through the following relationship:

$$R = \frac{S \cdot L}{h + B} = \frac{S}{\tan \theta}$$

Where R is the shoreline recession (Figure 2-2), S is the amount of sea-level rise, L is the horizontal extent of the shoreline zone where active sediment transport occurs, B is the beach and dune height above mean sea level, and h is the closure depth beyond which significant sediment transport does not occur, θ is the average slope of the active profile.



h

Figure 2-2: Schematic of Bruun Rule.

The Bruun Rule states that shoreline erosion caused by sea level rise is a function of the average slope of the active shoreline profile; further, an increase in sea level produces shoreline recession to achieve an equilibrium of the mass-balance of the shore profile.

Table 2-2 summarizes estimates of shoreline recession due to projected sea level rise. In the table, slopes of 1V:2H and 1V:4H are representative of shore protection structures which fix the location of the shoreline. The loss of shoreline for these is therefore directly proportional to the slope. The 1V:12H slope is representative of the back beach, the 1V:60H slope is representative of the beach profile along the eastern shore of the coal pile, while the 1V:125H slope is representative of the deposition plateau fronting Hart Creek along the shoreline on the northern side of the coal pile.

Table 2-2: Estimates of Shoreline Recession due to Sea Level Rise.

Profile Slope	1V:2H	1V:4H	1V:12H	1V:60H	1V:125H
Active Extent (m)	12.5	25.0	75.0	374.8	780.9
Sea Level Rise (m)	0.0	0.0	0.0	0.0	0.0
0.1	0.2	0.4	0.8	3.8	8.0
0.2	0.4	0.8	1.5	7.7	16.0
0.3	0.6	1.2	2.3	11.5	24.0
0.4	0.8	1.6	3.1	15.4	32.0
0.5	1.0	2.0	3.8	19.2	40.1
0.6	1.2	2.4	4.6	23.1	48.1
0.7	1.4	2.8	5.4	26.9	56.1
0.8	1.6	3.2	6.2	30.8	64.1
0.9	1.8	3.6	6.9	34.6	72.1

Profile Slope	1V:2H	1V:4H	1V:12H	1V:60H	1V:125H
1.0	2.0	4.0	7.7	38.5	80.1

This analysis predicts that the least impacts will occur in areas with shore protection and greater impacts will be seen in areas with mild slopes. However, the above analysis assumes that conditions are static, which is a reasonable assumption for shore protection structures, but not for Hart Creek, which has a continuous output of sediment to the shoreline area. The sediment output from Hart Creek will mean that the shoreline recession will be less than what is projected in Table 2-2. Whether sediment output from the creek can keep up with sea level rise will depend on the rate of the rise.

Climate change adaptation strategies must address the need to limit shoreline erosion of the coal pile and protect the upland remediation work to be completed as part of the overall project. Strategies such as avoidance and retreat are considered unacceptable due to increased risks associated with exposing coal material to the site environmental habitat.

Construction of a revetment structure along the east-facing reach of shoreline that is most exposed to storm waves can continue to provide protection as the changes to sea levels occur. If improvements (such as larger stone or higher crest elevation) to the revetment are needed in order to address increased wave exposures, the work can be accomplished, while leaving the existing structure in place.

3. REVIEW OF SOFT SHORELINE ALTERNATIVE

The project design was revisited for a soft shoreline protection alternative that would follow the Stewardship Centre BC Green Shores Guide for Coastal Development. The shoreline was divided into three reaches, based on the exposure to environmental conditions.

The east facing shoreline is exposed to significant wave action and is recommended to remain as a riprap structure. Significant wave heights along the east shoreline are estimated to range from 0.92 m to 1.57 m in a 200-year storm event. The significant wave height is a statistical average of the 1/3 of the largest waves. Over the course of a storm event, waves rolling in on the shore will present as a highly scattered wave field composed of a wide range of waves of varying heights. The largest waves that will occur during the storm will be about two times the significant wave height. The largest waves will therefore be between 1.8 and 3.1 metres in height. Wave action of this magnitude categorizes as a severe wave exposure. Only a manmade structure or shore protection e.g. in the form of large rock would be able to withstand this level of wave exposure.

The only low-profile type of solution that could potentially work would be a beach, but there are a number of reasons why a beach cannot be incorporated along this shoreline. For one, the level of the beach would have to be high enough that wave action during the highest tides will be prevented from reaching the toe of the coal pile. A beach profile, e.g. consisting of sand will have a slope between 1:10 and 1:100. This in turn means that a large-scale fill operation would be needed in order to establish a beach along the eastern shoreline. However, the wave exposure along this shoreline is

such that waves arrive at an angle to the shoreline, which produces longshore transport of sediment (sand) out of the shoreline area. Any sand-sized material placed for a beach should therefore be expected to disappear within a relatively short amount of time, perhaps within one to two winters depending on the severity of winter storms and the amount of beach material placed. A shoreline protection scheme of this type cannot be functional without an accompanying program of regular maintenance with resupply of sand to the beach. In the present case, this type of solution is not deemed viable for the east-facing shoreline. Retaining a beach-type concept, the size of material that can remain stable without being transported out of the area would be cobble-sized material. The riprap shore protection as designed, meets Green Shores principles of preventing pollutants from entering the aquatic environment by preventing erosion of the coal pile.

Figure 3-1: Scarps developed from storm waves along east-facing shoreline

For the north facing shoreline, a cobble blanket type green shores solution is feasible to meet the desired level of protection for the environmental exposures (waves and currents) and designed to provide shore protection as well as meet the green shores guidance. The north shoreline is slightly more resilient to wave action than the eastern shoreline due largely to the direction of wave approach to shore. The shoreline profile is very wide and flat in this area and receives much of the coarser sediments from Hart Creek, which helps offset loss of sediments due to wave erosion. During storm conditions and high-water levels due to storm surge and/or high tides, the wave exposure along the northern shoreline can be nearly as severe as for the eastern shoreline. The recommended solution that can provide a stable protection of the shoreline is a cobble beach type protection. The shore protection as designed, meets Green Shores principles of preventing pollutants from entering the aquatic environment by preventing erosion of the coal pile. A cobble beach also meets Green Shores principles to maintain access to the public.

To enhance constructed habitat along the north facing shoreline, a layer of sand/pea gravel mix can be placed on the cobble below the high-water mark. The sand/pea gravel mix would provide habitat requirements for forage fish such as Pacific sand lance and surf smelt. The stability of such a layer would be governed by the interaction between coastal processes (e.g. water levels, wind-waves and passing vessel wakes) and shoreline morphology (nearshore elevation profile and size/gradation of the shoreline substrate). Often times, major erosion of shoreline occurs when a storm event coincides with a high tide event. The existing north-facing stretch of the shoreline is currently comprised mainly of sand and gravel material at a slope of approximately 12H:1V in the intertidal range. Inspection of

historical aerial photographs and recent ground photos of the shoreline do not reveal signs of significant shoreline changes and suggests that the shoreline is currently stable (in equilibrium with the wave environment). Without a detailed stability analysis for the proposed fill, it is hard to predict performance of this layer exposed to extreme storm events. However, presence of gravel and other fine material along the shoreline and relatively stable status of shoreline indicates that this material would be dynamically stable on the shoreline for typical (e.g. 5-yr) wave events. Littoral material from the adjacent east facing shore can also provide a source of sediments along the shore during northward transport, which can supplement the placed sand/pea gravel layer with natural occurring sediments in this more protected area of the shoreline.

Figure 2: July 2018 aerial view of project vicinity at low tide (Ref: Google Earth)

The cobble beach design meets Prerequisite 4 – Conservation of Coastal Sediment Processes by not interfering with or impeding the natural processes. The primary source of sediment to the area is the sediment load from Hart Creek, which will continue to supply and nourish the shoreline area. (See Figure 2 for aerial view of area.) The natural action of water and sediment movement is therefore preserved and able to support a natural shoreline and maintain habitat function and diversity along the shoreline. It should be noted, however, that in this regard, Hart Creek is chiefly a conveyance medium for the sediment load. If upland sediment output decreases for any of a number of reasons, sediment output from Hart Creek will likewise decline. It should be noted that the coal pile itself cannot be considered a source of sediment due to the contaminated nature of the substrate material. Capping of the coal pile meets Green Shores principles by preventing pollutants from entering the aquatic environment.

For the west side of the coal pile, Hart Creek meanders along the toe of the coal pile, at times located nearby the limits of the property to the west of the pile.

Observed site conditions along Hart Creek indicate the impact of high creek flows have eroded the existing banks. As shown in the pictures below, the existing banks appear to consist of a wide range of materials, from gravel and cobbles, to native soils.

Figure 3: Hart Creek, looking South (Union Bay Coal Pile on left side); photograph taken June 2019

Figure 4: Hart Creek, looking North (Union Bay Pile on right side); photograph taken June 2019

The estimated drainage area of Hart Creek is approximately 28.7 km². Discharge data from MOE (1995) is summarized in Table 1.

Table 3-1: Hart Creek Discharge Data

Hart Creek Mean Monthly and Mean Annual Discharge (litres/sec)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
2,899	2,790	2,368	1,963	2,112	1,358	20	17	23	1,929	3,065	3,303	1,837

For the Hart Creek shoreline, evaluation of soft shoreline design alternatives also considered the level of design and associated maintenance and repair. As described above, the Hart Creek mean annual discharge rate is 1,837 litres/second; the largest discharge rates occurring in the winter with values as large as 3,300 litres/second. Due to the close proximity of the creek to the adjacent property to the west, it is recommended that shoreline improvement would be located such that the existing creek flow cross sectional area be maintained.

The designated flood level for the Hart Creek area was determined to be +4.0m GD as described in the BOD.

4. RECOMMENDATION

Review of the site photographs from June 2019 and the need to provide the level of protection to prevent erosion of the coal waste pile during high creek flows, and flood levels, the shoreline treatment along Hart Creek would remain as a riprap structure. The elevation of the riprap would be a minimum of +4m GD to address the designated flood level. The slope protection along Hart Creek would be constructed such that the original cross section of the creek is maintained.

This letter should be appended to the BOD for the project shoreline protection design. Please contact me if there are any questions.

Sincerely,

MOFFATT & NICHOL

Paul Hoo

Paul Hoo, P. Eng.
Project Manager

REFERENCES

MOE (1995). Nile Creek to Trent River. Water Allocation Plan. Province of British Columbia. Ministry of Environment, Lands and Parks, Vancouver Island Region. January 1995.

MOE (2011a). Guidelines for Management of Coastal Flood Hazard Land Use. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Project No. 143111, Revision Number 0. BC Ministry of Environment. Ausenco, Sandwell, 27 January, 2011.

MOE (2011b). Draft Policy Discussion Paper. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Project No. 143111, Revision Number 0. BC Ministry of Environment. Ausenco, Sandwell, 27 January, 2011.

MOE (2011c). Sea Dike Guidelines. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Project No. 143111, Revision Number 0. BC Ministry of Environment. Ausenco, Sandwell, 27 January, 2011.

Section 82 Removed for Ease of Reading

Shoreline protection devices

83. *Justification*

Shoreline protection devices can threaten the ecological and physical integrity of the shoreline. These areas have high ecological and aesthetic values and may contain unstable slopes subject to erosion and land slip. Due to their physical and biological characteristics and situation, these devices need to be carefully managed in order to avoid potential negative impacts to the shoreline.

These development permit guidelines will promote sound shoreline protection device design to protect the natural environmental values and prevent erosion and destabilization of the shoreline. Shoreline stabilization should be limited to that necessary to prevent damage to existing, newly constructed or established uses on adjacent upland properties.

Exemption

When seeking approval to install, replace or repair a shoreline protection device in a shoreline protection device development permit area, an applicant is not required to apply for a separate aquatic environmentally sensitive development permit.

Area

The shoreline protection devices development permit area applies to all those lands adjacent to the any watercourse, river or lake including the Strait of Georgia. Any application for the installation of new shoreline protection devices or repair of shoreline protection devices falls within shoreline protection device development permit area.

Guidelines

Where an applicant proposes the installation, replacement or repair of a shoreline protection device under these guidelines, the design of the device shall contribute to shoreline resiliency by following soft shore (e.g. "Greenshore") principles:

- Conserve or restore natural coastal or riparian processes (e.g. sediment transfer);
- Maintain habitat function and diversity;
- Prevent pollutants from entering the aquatic or riparian environment;
- Avoid or reduce cumulative impacts on the shoreline environment, including coastal or riparian processes.

All proposals shall incorporate design elements that contribute to coastal resiliency by protecting or restoring natural coastal processes and habitat. Except when a hardened shoreline is proposed (i.e. based on the findings of a qualified professional that shoreline hardening is required to protect life and/or a principal building), shoreline protection device development permits can be approved under delegated authority. Proposals to harden a shoreline, including replacement and/or maintenance of an existing hard shoreline with similar hard design elements shall require board approval of the development permit.

General conditions

(a) Shoreline protection devices shall be located within the property line on the upland side of the natural boundary of the Strait of Georgia as depicted on a recent British Columbia land surveyor's certificate;

(b) The installation of new, or the repair of an existing, shoreline protection devices outside of the property line shall require federal and provincial government approval;

(c) Where a shoreline protection device is proposed on or adjacent to a steep slope a geotechnical report must be provided as per the steep slope development permit area requirements

(d) New flat faced cast-in-place concrete walls and lock block walls shall not be permitted;

(e) New revetment walls (rip rap) shall not be permitted

Design considerations

Any shoreline protection device construction or maintenance works shall be in accordance with the following design guidelines:

(a) All new shoreline protection devices shall apply the "softest" measures possible (such as biotechnical slope stabilization) that will still provide satisfactory protection;

(b) Integrate greenshore approaches where possible

Information requirements

Development permits issues under the shoreline protection device development permit area will be subject to the condition and recommendations based on the required professional reports and studies. The following information is require:

(a) A recent survey completed by a British Columbia land surveyor is required. The survey shall include:
   i. the location of the present natural boundary;
   ii. the location of any existing shoreline structures; and
   iii. elevations showing the top of bank and toe of the bank.

(b) Applicant shall submit a report and detailed design of the shoreline protection device prepared by and sealed by an engineer, qualified to carry out shoreline protection device designs. The information shall include an assessment and recommendations with regard to the following:
   i. Necessity of the proposed shoreline protection device;

ii. Evaluation of potential negative impacts to the natural environment and to adjacent properties, and recommendations to mitigate any potential negative impacts;
iii. Description of the construction details, materials and methods to be used; and
iv. Inspection details of the proposed works to be conducted by an engineer qualified to carry out shoreline protection device design.

(c) A bio-physical assessment is required. The assessment report must be prepared by a qualified environmental professional. The assessment must include:
i. a site plan;
ii. written summary of proposed development works;
iii. a review of development alternatives that have been considered;
iv. inventories of the existing environmentally sensitive feature(s);
v. assessments of the environmental impact of the proposed development;
vi. identify all proposed protective measures;
vii. identify measures to preserve, protect, restore or enhance identified ESA impacted by the development;
viii. identify measures to control drainage or erosion, and to protect banks.; and,
ix. recommendations for the for mitigation, restoration and protection of habitat during and after construction.

(d) A landscape plan is required where disturbance or alteration of the native vegetation within the development permit area is proposed. The plan shall provide a re-vegetation and restoration strategy and a quote for the full cost of materials and labour for the works to the satisfaction of the CVRD officers.

(e) Shoreline protection devices within the vicinity of known and/or potential archaeological sites, will require an archaeological assessment prior to the installation. The provincial archaeology branch is responsible for maintaining and distributing archaeological information and deciding if site alteration permits need to be issued to allow installation to take place within known and/or potential sites.

(f) A post development report is required from the qualified environmental professional and/or registered professional biologist confirming that the shoreline protection device and associated restoration measures has been constructed in compliance with the engineer's report and bio-physical assessment

Construction and phasing

(a) All machinery and vehicles involved in the installation of new shoreline protection devices or repair of an existing shoreline protection device shall be located entirely on the upland portion of a property. If machinery must access the construction site via the foreshore to install proposed works, the engineer shall provide the following information:

i. Confirmation of how access is going to be achieved and any required permissions (for example, if through an adjacent property, permission from the property owner; if through a beach access, permission from the provincial government; if machinery is traversing the foreshore; permission from the federal government); and

ii. Confirmation that the machinery will not adversely impact the beach environment.

(b) Confirmation that the regional district will be informed of the timing of the proposed works and advised of the name of selected contractor(s) who will do the work in compliance with the engineer's report. The timing of works shall consider fisheries and wildlife sensitive periods (such as late summer bird migration and pacific herring spawn). The development permit may specify a permitted "window" as recommended within the engineer's report or by another level of government.

Steep slopes development permit area (Hazardous Conditions)

84.

Section 84 Removed for Ease of Reading