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CLOSURE PLAN
PENDER HARBOUR LANDFILL
BRITISH COLUMBIA

Prepared for:
SUNSHINE COAST REGIONAL DISTRICT (SCRD)
1975 Field Road
Sechelt, British Columbia
V0N 3A1

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ES 1. EXECUTIVE SUMMARY

This Closure Plan has been prepared in accordance with the design and operation requirements of Landfill Permit PR-01461 issued by the British Columbia Ministry of the Environment on August 23, 1972 for the Pender Harbour Landfill, and in general accordance with relevant British Columbia Ministry of the Environment acts, regulations, and guidance documents.

XCG understands that landfilling will cease at the Site by the end of 2014 and the landfill will be closed in the spring of 2015. The Sunshine Coast Regional District (SCRD) intends to convert the operation to a transfer station.

Key conclusions associated with this Closure Plan include the following:

- Both shallow groundwater and surface water regimes discharge to Meadow Creek at, or near, the Site, so Meadow Creek is the primary receptor for landfill impacts, and the freshwater aquatic life criteria are the most appropriate determination of water quality compliance.
- The compliance location for both surface water and groundwater quality is the down-gradient (south) Site property boundary. Currently, the only monitoring location that is located at the compliance property boundary is groundwater monitoring well Site 5, which represents potential transfer station related impacts to Meadow Creek from groundwater.
- The landfill is performing well and there have been no exceedances of the freshwater aquatic life criteria due to leachate impacts. Based on the existing data, the Site is in compliance.
- A static and dynamic slope stability assessment was undertaken for the east slope of the landfill, deemed to be a critical slope, graded to approximately 1.5 horizontal to 1 vertical. The results of the analysis indicated the following:
    - The landfill is situated on competent materials, and failure of the surficial soils (general bearing failure or liquefaction) was not identified to be of concern.
    - The landfill slope stability analysis resulted in a computed static factor of safety greater than 1.3 and is considered to be within an acceptable range.
    - The results of the pseudo-dynamic analysis indicated that seismic slope displacements would be expressed at approximately the crest of the landfill, with estimated median slope displacements of 10 centimetres. This is less than the typically acceptable limit of 30 centimetres adopted by other approved authorities concerning seismically induced permanent displacements.
    - It is recommended that measures to control surface water be implemented to improve long-term stability, including ditches and pipes to divert water away from the east slope of the landfill.
    - Removal of the existing vegetation on the east slope should be avoided.

The final proposed maximum elevation of the landfill is 50 meters above mean sea level. The proposed final cover system is composed of 0.6 metres of native silty sand (barrier layer with hydraulic conductivity of 1x10^{-4} cm/sec or less) overlain by 0.15 metres of clear stone, overlain by a minimum of 0.30 metres of organic soil (vegetative layer). The topsoil will be hydroseeded to establish native vegetation. The eastern slope of the landfill will be maintained in its current condition (cover and vegetation) to maintain slope stability and mitigate risk of excessive soil erosion.

A lined drainage ditch will be constructed at the top of the existing eastern slope of the landfill to divert surface water runoff from the upper portion of the landfill from flowing onto the steep slope. A perforated stormwater collection pipe will be installed beneath the aforementioned lined drainage ditch to collect stormwater from the drainage layer of the final cover to minimize surface water infiltration into the waste and minimize leachate generation.

The remaining existing environmental controls will be maintained on-site, and rehabilitated as necessary as part of the closure process.

New surface water monitoring locations are proposed at the following locations to allow for compliance, and impacts from the landfill, to be assessed more accurately:

- Upstream to establish background water quality conditions in Meadow Creek.
- Immediately downstream to determine landfill impacts on water quality at the compliance boundary of the Site.
- Downstream Recovery located further downstream to document the extent of the mixing zone and distance required for the discharge from the landfill to assimilate and for water quality to recover to background levels. Based on the experience of the SCRD, the closest accessible location is downstream in Meadow Creek, approximately 1,300 metres southeast of the landfill.

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1. INTRODUCTION

1.1 General

XCG Consultants Ltd. (XCG) was retained by the Sunshine Coast Regional District (SCRD) to prepare a Closure Plan for the Pender Harbour Landfill (Site).

XCG understands that a “Pender Harbour Landfill Closure Plan Report” was prepared by Dayton & Knight Ltd. in 1994. Due to significant changes in site development, maintenance, and monitoring since that time, and the impending closure of the landfill in 2014, a new Closure Plan (Plan) is required.

This report fulfills the closure requirements outlined in subsection 2.6 of Permit PR-01461 issued by the British Columbia Ministry of Environment (MOE) on July 29, 1996 (included as appendix A).

1.2 Site Description

The SCRD owns and manages the Site, which includes a “natural control landfill” used for the disposal of non-hazardous municipal solid waste. The Site services Electoral District A (Egmont and Pender Harbour) of the SCRD, which had a population of approximately 2,678 in 2011 (Statistics Canada, 2012). According to Dayton & Knight Ltd. (1994), the Pender Harbour Landfill has been in operation since the 1960s.

The Site is located approximately 2.75 kilometres northeast of Garden Bay, on Pender Harbour Landfill Site Road off of Garden Bay Road. The legal description of the Site is a Portion of District Lot 4336, Group 1, New Westminster District. A site location map is provided as Figure 1. The Site property is on the North boundary of District Lot 4336 adjacent to District Lot 3677.

The Garden Bay Marine Provincial Park is located approximately 1 kilometre south of the Site, and rural residences are located approximately 550 metres to the southwest and 800 metres to the southeast of the Site (Figure 2).

A gravel road is located along the west side of the landfill (Pender Harbour Landfill Site Road) providing access to Sakinaw Lake, located north of the Site.

As shown on Figure 3, the landfill limit of waste comprises approximately 2.9 hectares of the overall property of approximately 24 hectares. The vegetation outside the developed area of the Site is characterized by dense secondary undergrowth amongst large coast type coniferous trees. In addition to the landfill, existing facilities located at the Site include the following (Figure 3):

- Weigh scale;
- Gate house;
- Recycling;
- Share shed; and
- Leachate treatment wetland.

XCG understands that landfilling will cease at the Site by the end of 2014 and the landfill will be closed in the spring of 2015. The SCRD intends to convert the operation to a transfer station.

1.3 Planning

The following section provides a description of designations and restrictions placed on the Site and surrounding area as part of SCRD planning.

1.3.1 Egmont / Pender Harbour Official Community Plan

Under the SCRD Pender Harbour / Egmont (Electoral Area A) Zoning Bylaw No. 337 (1990) Incorporating Changes to Implement the Pender Harbour / Egmont Official Community Plan, the Site and surrounding area are designated under the following portions of the Pender Harbour / Egmont Official Community Plan.

Land Use and Zoning

As shown on Figure B1 in Appendix B, the Site is designated for industrial land use and is zoned as I-4 Heavy Industrial. This zoning includes landfills, refuse transfer stations, and recycling depots for parcels of land exceeding 5 hectares. As a result, the Site is appropriately zoned for the existing and proposed future land use.

The areas north and west of the Site are zoned as Rural Resource RU-2A. Land, buildings, and structures in the RU-2A zone are to be used for silviculture, wilderness recreation, outdoor natural science education or research, fishing or hunting camp, and auxiliary uses to forest management, but not residential.

The areas south and west of the Site are zoned as Rural Resource RU-2. The area southeast of the Site, greater than 500 metres from the Site, where existing residences are located, is designated as Rural Resource RU-1. Both of these zones include residential land use.

The area southwest of the Site which corresponds with Garden Bay Marine Provincial Park is zoned as Park and Assembly PA-1. Land, buildings and structures in the PA-1 zone are to be used for park, assembly, and fish and wildlife habitat protection areas.

Residential Suitability

This designation indicates areas of varying suitability for settlement purposes based on soil and slope conditions for both bearing capacity of structures and for percolation of septic disposal effluent.

As shown on Figure B2 in Appendix B, the area of the Site west of Pender Harbour Landfill Site Road has a high to moderate constraint for residential suitability.

The area south of the landfill and within 500 metres of the Site has a moderate constraint for residential suitability.

The area south of the Site, more than 500 metres from the Site, has a low constraint for residential suitability. This is the area where existing residences are located.

Areas north of the Site are part of the Sechelt Provincial Forest and have not been designated.

Geotechnical Assessment

This designation indicates areas where geotechnical constraints may exist such as rockfall hazards, flooding, or erosion.

As shown on Figure B3 in Appendix B, the area of the Site west of Pender Harbour Landfill Site Road has a moderate to low geotechnical hazard due to steep upland slope (15 to 30 degrees). The area of the Site northwest of the landfill has a high geotechnical hazard due to steep upland slope (> 30 degrees). Areas north and south of the landfill have not been designated.

Development Permit Area

This designation indicates areas where development permits will be required for environmental and hazardous reasons. As shown on Figure B4 in Appendix B, the area within 30 metres of the top of bank of Meadow Creek is designated as unknown fish presence and Riparian Assessment Area (DPA#1). This designation includes any unmapped stream tributaries that either provide fish habitat or flow to a water body that provides fish habitat. It is important to note that this designation is based on mapping and actual widths will have to be determined on a case by case basis.

1.4 Sensitive Ecosystem Inventory

The Sensitive Ecosystem Inventory (SEI) is a provincial Ministry of the Environment project which systematically identifies and maps rare and fragile ecosystems in a given area. The information is derived from aerial photography, supported by selective field checking of the data. The purpose of the SEI project is to identify remnants of rare and fragile terrestrial ecosystems and to encourage land-use decisions that will ensure the continued integrity of these ecosystems. It is intended for use in a variety of land-use planning processes.

A review of the SEI mapping included in the SCRD Online Property Information System indicates that there are two areas within the Site identified as sensitive ecosystems.

As shown on Figure B5 in Appendix B, a portion of the Meadow Creek tributary that crosses the Site, and is located immediately east of the landfill, is mapped as Wetland Ecosystem.

A portion of the central and north areas of the Site, north of the landfill, is mapped as Woodland Ecosystem.

In addition, the following areas outside the Site are also mapped as sensitive:

- The area west of the Site is mapped as Woodland Ecosystem;
- An area southwest of the Site is mapped as Mature Forest Ecosystem;
- The areas surrounding Meadow Creek downstream of the Site are mapped as Wetland Ecosystem; and
- An area northeast of the Site is mapped as Riparian Ecosystem.

These ecosystems are defined as follows under the SEI.

- Riparian Ecosystems are found on the margins of rivers, streams, lakes and marshes, as well as the floodplains of large rivers and small streams, and in gullies.
- Woodland Ecosystems are open deciduous and mixed deciduous/coniferous forests.
- Wetland Ecosystems have wet soils and moisture dependent plants. They develop where there is daily, seasonal or year-round water that lies at or above the surface, or within the root zone of plants.
- Mature Forest Ecosystems are usually conifer-dominated, occasionally deciduous, dry to moist forests.

Ecosystems identified in a Sensitive Ecosystems Inventory are increasingly valuable as a piece of living history and for the conservation of biodiversity.

1.5 Regulatory Setting

The following provides a summary of the regulatory setting governing closure of the landfill.

1.5.1 Landfill Permit

The Site is operated under Landfill Permit PR-01461 (Landfill Permit) issued by the British Columbia Ministry of Environment (BC MOE) on August 23, 1972. The following amendments have been made since:

- July 29, 1982;
- August 22, 1986 – Permit was changed from a Pollution Control Permit to a Waste Management Permit;
- November 9, 1992 – Permit was upgraded to a Level B Operation;
- December 14, 1993 – Appeal decision of the Deputy Director of Waste Management requiring control of site access, implementation of a water monitoring program, maintenance of site records, reporting provisions and a daily permitted discharge of 7.1 tonnes (16 cubic metres) of municipal solid waste; and
- July 29, 1996 – The most recent amendment and current permit.

Permit PR-01461 is authorized until it is superseded by an operational certificate issued pursuant to the Sunshine Coast Solid Waste Management Plan.

Subsection 2.6 of the Permit PR-01461 regarding the scope of the closure plan states the following:

The SCRD shall review the closure plan, and submit revisions as required for the approval of the Regional Waste Manager. The closure plan shall include details on final elevations, slopes and grading, type and depth of materials used for final cover, maintenance of cover, vegetative cover, management of leachate and landfill gases, surface drainage and interception of groundwater, drawings and profiles of the site, *and proposed use of the site after stabilization. The landfill shall be closed in accordance with the approved closure plan.*

A copy of Permit PR-01461 is included as Appendix A.

1.5.2 Provincial Regulations

The requirements for landfill closure are outlined in the following documentation issued by the BC MOE:

- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (January 1996);
- Landfill Criteria for Municipal Solid Waste (June 1993); and
- Landfill Gas Management Regulation (2008).

1.5.3 Groundwater and Surface Water Quality Criteria

As per the "Landfill Criteria for Municipal Solid Waste" (BC MOE, 1993), the applicable criteria for groundwater and surface water quality are provided in the document entitled "Approved and Working Criteria for Water Quality prepared by the Water Management Division of the Ministry of Environment." This document has been superseded by the document entitled "A Compendium of Working Water Quality Guidelines for British Columbia" (BC MOE, 2006).

1.6 Landfill Performance Assessment

1.6.1 Background

A "Landfill Performance Assessment" was prepared by XCG (2014) to evaluate the existing environmental performance of the Site (performance of the attenuation zone), to identify gaps (if any) in the hydrogeological database for the Site.

The assessment included a focussed review of hydrogeological information, historic investigations, and the environmental monitoring program, as well as recommendations for closure works, environmental controls and post-closure environmental monitoring for the Closure Plan.

1.6.2 Conclusions

The following conclusions were presented as part of the "Landfill Performance Assessment" (XCG, 2014):

1. Geotechnical controls are required to be implemented as part of the final cover design to address slope stability, leachate generation, and down-gradient impacts to groundwater and surface water. These controls will include a 3 to 4-metre wide bench at the top of the existing steep eastern slope and a lined drainage ditch on the bench to divert surface water runoff from the upper portion of the landfill from flowing onto the steep slope. The space for the bench has been maintained in the final waste grades and the bench and drainage ditch will be included in the design of the final cover.

2. The compliance location for both surface water and groundwater quality is the down-gradient (south) Site property boundary. Currently, the only monitoring location that is located at the compliance boundary is groundwater monitoring well Site 5, which represents potential transfer station related impacts to Meadow Creek from groundwater.
3. Both shallow groundwater and surface water regimes discharge to Meadow Creek at, or near, the Site, so Meadow Creek is the primary receptor for landfill impacts, and the freshwater aquatic life Criteria are the most appropriate determination of water quality compliance.
4. The landfill is performing well and there have been no exceedances of the freshwater aquatic life Criteria due to leachate impacts. Based on the existing data, the Site is in compliance.
5. Total metals results for water quality are required to properly assess compliance and to assess the performance of the leachate treatment wetland.
6. Comparing water quality at Site 2 and Site 4 indicates that attenuation is taking place in the down-gradient groundwater contaminant attenuation zone.
7. Comparing water quality at Site 2 and Site 3 indicates that partial nitrification is taking place in the leachate treatment wetland. The basin will likely support conditions for the completion of nitrification, so that nitrate can be available downstream in Meadow Creek for vegetation.

In general, the foregoing indicates that the Site is performing well and in compliance, and the existing environmental controls are performing adequately.

1.6.3 Recommendations

The following recommendations for the Closure Plan were presented in the "Landfill Performance Assessment" (XCG, 2014):

Closure

The design of final cover should address the following:

- Maintain a 3 to 4-metre wide bench at the top of the existing steep slope and construct a lined drainage ditch on the bench to divert surface water runoff from the upper portion of the landfill to the north and south, to stop surface water from flowing onto the steep slope.
- Grade final cover on the top of the landfill so that as much surface water runoff as possible is directed to the north and south and not to the east toward the bench drainage ditch.
- Maintain the existing vegetative cover on the steep slope.

The design of the closure works should include the installation of new piping to replace the potentially existing crushed piping, to convey water from the low point at approximate elevation 45.0 metres above mean sea level (amsl) in the Pender Harbour Landfill Site Road roadside ditch to either the northeast diversion ditch, or the proposed bench ditch.

Post-closure Monitoring

The post-closure monitoring program, as recommended in the "Landfill Performance Assessment" (XCG, 2014), is included as Section 7.4 of the Closure Plan.

2. SETTING

2.1 Topography and Drainage

The landfill is located on the western slope of a small valley and generally slopes from Pender Harbour Landfill Site Road down to the east. The general topography of the Site as well as the surrounding area is illustrated on Figure 3.

As shown on Figure 2, a tributary of Meadow Creek crosses the eastern portion of the Site. The headwater of this tributary of Meadow Creek is located approximately 1,000 metres north of the landfill. The tributary of Meadow Creek flows south and east from the landfill approximately 1,700 metres where it meets with another tributary, then flows 400 metres south where it joins with Myers Creek before discharging to Oyster Bay, approximately 200 metres downstream. The Meadow Creek tributary has been found to flow most of the year (Piteau, 1994).

Surface water runoff mirrors the topography, generally draining from west to east across the Site. As shown on Figure 3, surface water upstream of the Site is collected by a ditch located on the west side of Pender Harbour Landfill Site Road. The south portion of the ditch diverts water south along the west side of Pender Harbour Landfill Site Road. The north portion of the ditch directs water north to a low point at approximate elevation 45.0 metres amsl. The water collected in this low point is conveyed to the east beneath Pender Harbour Landfill Site road and across the landfill via a pipe. This pipe connects to a “clean water” pipe, which is located along the northeast limit of the landfill and conveys “clean water” around the landfill discharging east of the landfill to an intermittent drainage course. It is reported that the pipe crossing the landfill may be crushed. A culvert is located near the north extent of the landfill and directs water from northwest of the Site to the east beneath Pender Harbour Landfill Site road discharging into a ditch. The ditch directs water into the “clean water” pipe noted previously.

Surface water runoff from the landfill is managed as leachate and conveyed by overland flow and a leachate collection ditch located along the northeast and east edges of the landfill, to an engineered wetland. This engineered wetland (leachate treatment wetland) discharges to an intermittent drainage course that runs east for approximately 200 metres where it discharges to Meadow Creek. Based on the topographic survey and visual observations the intermittent drainage course is less than 0.3 metres deep.

As shown on Figure 3, the 2013 topographic survey indicates that in the vicinity of the landfill Meadow Creek flows through a basin. The basin is approximately 4 metres in depth, and is formed between a low point at approximately 18 metres amsl, and a topographical ridge 200 metres south at an approximate elevation of 22 metres amsl. This basin is the local topographic low point which collects water from the surrounding area including the intermittent drainage course, which includes discharge from the leachate treatment wetland and the runoff diverted north of the landfill, as well as runoff from the area south and east of the landfill.

A small portion of the Site consisting of the weigh scale and gate house, and area south of these features, is the only area of the Site that does not drain to the basin. Surface runoff and groundwater from this portion of the Site is conveyed south and east discharging directly to Meadow Creek, south of the basin, near the south property boundary.

As noted previously, the limit of waste is approximately 2.9 hectares in area. As a result, the limit of waste comprises approximately 2 percent of the 148 hectare watershed drained by this tributary of Meadow Creek, upstream and including the Site.

2.2 Climate

Meteorological data for the Pender Harbour region was obtained from the Environment Canada weather station 1043152 at Gibsons Gowers Point. The monthly data for daily average temperature and average precipitation are provided in Table 1. As indicated in Table 1, the average annual precipitation for this region is 1,369.1 millimetres. The meteorological data indicates that the daily minimum average temperature is above 0 degrees Celsius for the entire year, indicating that soil frost is unlikely.

According to the Koppen Climate Classification, Pender Harbour is located in a warm-summer Mediterranean (Csb) type climate. This type of climate experiences warm (but not hot) and dry summers. Winters are rainy and can be mild to chilly. In a few instances, snow can fall on these areas. During the summer months, these regions experience sunny, dry and warm conditions, where almost no rain falls.

As shown on Table 1, the evapotranspiration was estimated for each month using the above noted climatic data and the Thornthwaite and Mather Method (includes daily sunlight correction factor) (Thornthwaite and Mather, 1957). The evapotranspiration results indicate that the months with the highest amount of water available for runoff and infiltration are October, November, December, January, February, and March. Accordingly, these are also the months with the highest potential for leachate generation.

2.3 Geology

The Site is located in the physiographic region referred to as the Georgia Lowlands which is underlain by granitic rocks as well as by inliers of older formations (Holland, 1976). Geologic mapping indicates that locally the Site is underlain by a granodiorite intrusive rock (BCGS, 2013).

A geological mapping study was completed on a number of mining claims which incorporate the north part of the Site. The results of the geological mapping study indicated that, where bedrock was exposed in the north portion of the Site, the bedrock was granodiorite and quartz diorite (Tan, 1978). The geological mapping study also indicated that the area east of the Pender Harbour Landfill Site Road had extensive overburden at ground surface, while the area west of the Pender Harbour Landfill Site road was dominated by bedrock outcrops.

According to the Geological Survey of Canada Surficial Materials of Canada Map 1880A, surficial deposits in the area of the Site are comprised of colluvial blocks, which consist of blocks and rubble with sand and silt derived from crystalline bedrock, medium grained metamorphic substrate, and cemented sandstone (Fulton, 1995).

As per the "Landfill Performance Assessment" (XCG, 2014), the shallow overburden outside of the limit of waste is comprised of the following:

- 0.1 to 1.0 metres of organic soil, which is discontinuous, overlying;
- 0.7 to 1.6 metres of sand and silt, with varying amounts of gravel and clay, sometimes containing a gravel layer, overlying; and
- 1.2 to 2.3 metres of silt and clay, with varying amounts of fine sand, which is discontinuous, overlying bedrock.

During previous investigations and studies, bedrock was found to be located 2.4 to 4.1 metres below ground surface (bgs). In addition, bedrock was reported to be visible in the majority of the surface water diversion ditch located on the west side of Pender Harbour Landfill Site Road and in the base of Meadow Creek.

Stratigraphic logs are not available for monitoring wells Site 4 and Site 5. However, measurements collected during monitoring events indicate that the depth of these wells is 2.1 and 1.8 metres, respectively. It is assumed that these wells were installed at, or near, the overburden / bedrock interface.

A generalized geologic cross-section through the Site, from west to east, is shown on Figure 4. As shown on the geologic cross-section, bedrock is located between 2 to 5 metres bgs in the areas outside the limit of waste. Accordingly, the thickness of the native overburden is also 2 to 5 metres outside the limit of waste.

2.4 Hydrogeology

Regionally, the Site is located within an area that has not been mapped or classified in the British Columbia aquifer classification system. This is likely due to the low number of residences and low groundwater usage in the area.

The area west of the Site around Garden Bay Lake, and the area southeast of the Site, east and south of Oyster Bay, are classified aquifers. The Garden Bay Lake aquifer is #559 and is classified as IIA (moderately developed, high vulnerability) and ranked for hydrogeologic and water use as a 12 in a range of 1 to 25. The Oyster Bay aquifer is #561 and is also classified as IIA (moderately developed, high vulnerability) and ranked for hydrogeologic and water use as a 12 in a range of 1 to 25. The approximate aquifer boundaries are shown on Figure 5.

According to British Columbia water wells records there are four groundwater wells located down-gradient of the Site, between the Site and Oyster Bay, within the same unclassified aquifer area. The location of these water wells is shown on Figure 5. The four water wells are described as follows:

- Water well (tag #70678) is located approximately 780 metres down-gradient of the Site, is completed in bedrock at a depth of approximately 30 metres bgs.

- Water well (tag #95908) is located approximately 1,290 metres down-gradient of the Site, is completed in bedrock at a depth of approximately 49 metres bgs.
- Water well (tag #46735) is located approximately 1,500 metres down-gradient of the Site, is completed in bedrock at a depth of approximately 30 metres bgs.
- Water well (tag #100463) is located approximately 1,570 metres down-gradient of the Site, is completed in bedrock at a depth of approximately 41 metres bgs.

Well records for these wells are included in Appendix C. The well records indicate that the local geology consists of less than 2 metres of overburden and that the zone capable of producing significant groundwater yields is located 30 metres below ground surface in bedrock.

Two temporary piezometers were installed during the investigation for the leachate treatment wetland. Falling head permeameter tests were completed on these temporary piezometers in order to estimate the hydraulic conductivity of the native overburden. Both the temporary piezometers were installed adjacent to, and north of, the leachate treatment wetland, in the native overburden. One temporary piezometer was instrumented in the upper sand and silt soil, and the second temporary piezometer was instrumented in the lower silt and clay soil. The results of the testing estimated that the hydraulic conductivity of the upper sand and silt soil was 5×10^{-4} centimetres per second (cm/sec), and the lower silt and clay soil was 8×10^{-5} cm/sec (Levelton, 1997).

Historic groundwater level measurements in the groundwater monitoring wells indicate the following (Appendix D):

- North of the landfill at monitoring location Site 1, groundwater has been measured from 0.75 to 3.0 metres bgs;
- East (down-gradient) of the landfill and the leachate treatment wetland at monitoring Site 4, groundwater has been measured from ground surface to 1.15 metres bgs. For the most part, the groundwater level at this location is within 0.5 metres of the ground surface.
- Southeast (cross-gradient) of the landfill at monitoring Site 5, groundwater has been measured from 0.09 metres above ground surface to 1.22 metres bgs. For the most part the groundwater level at this location is within 0.5 metres of the ground surface.

The groundwater level fluctuations at Site 5 generally mirror the groundwater level fluctuations at background Site 1. This indicates that the level of the groundwater in the vicinity of Site 5 (i.e. the southeast portion of the Site) is undergoing “natural” fluctuation and is not impacted by the landfill.

Conversely, the groundwater level fluctuations at Site 4 are different from the groundwater level fluctuations at background Site 1. The key difference is that there is much less variability in groundwater levels at Site 4. This indicates that the level of the groundwater down-gradient of the Site is impacted by the landfill and the leachate treatment wetland.

Historic test pits excavated near the east limit of the landfill indicate that groundwater is very close to the ground surface. In addition, historic test pits excavated within the limit of waste indicate that groundwater is located within the landfilled waste, above the overburden / waste interface.

The horizontal groundwater hydraulic gradient between the up-gradient (Site 1) side of the landfill and the down-gradient side of the landfill (leachate treatment wetland) was calculated to be approximately 0.28. The horizontal groundwater hydraulic gradient between the down-gradient side of the landfill (leachate treatment wetland) and the basin was calculated to be 0.018. This indicates that there is a very strong to strong horizontal groundwater hydraulic gradient from west to east across the Site.

A cross-section showing geologic and hydrogeologic conditions is included as Figure 4. The hydrogeologic information and the cross-section confirm that surface water and ground water movement across the Site mirrors the topography, generally draining from west to east.

2.5 Summary

Based on the foregoing it is apparent that surface water and groundwater at the Site flow from west to east towards Meadow Creek. A perched aquifer is located within the overburden created by the underlying bedrock which acts as an aquitard. The perched aquifer is recharged from infiltration of precipitation, and groundwater and surface water discharge from the landfill and leachate treatment wetland. Based on groundwater levels, the perched aquifer persists throughout the year.

Based on the permeable native surface soil, the low intensities of rainfall, and the negligible presence of frozen soil, the majority of rainfall and snowmelt water likely infiltrates to the surface soil. As a result, like most coastal mountain watersheds, overland flow rarely occurs. The perched aquifer discharges to Meadow Creek and provides baseflow for the creek. During periods when the rainfall intensity exceeds the subsurface soil permeability, water passes readily through the surface soil and migrates laterally in the shallow saturated overburden, and overland flow occurs. The lateral migration and overland flow creates stream flow in the intermittent drainage course and Meadow Creek.

The presence of the basin allows subsurface water to accumulate increasing the thickness of the perched water table (saturated zone) and increases the movement of subsurface water downstream in Meadow Creek. Saturated subsurface flow along Meadow Creek may become return flow downstream of the Site. In this case return flow refers to water that infiltrated on-site and discharges downslope.

3. COMPLIANCE AND RECEPTORS

3.1 Potential Receptors

As indicated above, the primary mechanisms for contaminant migration at the Site are groundwater and surface water. Considering the geology of the Site, groundwater impacts are likely restricted to the shallow perched groundwater table. There are currently only four down-gradient groundwater users. These groundwater users are located more than 500 metres from the Site and their wells are completed 30 metres bgs in granite bedrock. In addition, the potential for future groundwater users to be located closer to the Site is limited. As noted previously, the area south of the Site has residential suitability constraints for soil and slopes, and the area around Meadow Creek requires a development permit. Also, under the SEI the area south of the Site and west of Pender Harbour Landfill Site Road is mapped as Mature Forest; while the area south of the Site and east of Pender Harbour Landfill Site Road is mapped as Wetland.

Since both shallow groundwater and surface water regimes discharge to Meadow Creek at, or near, the Site, Meadow Creek is the primary receptor for landfill impacts. According to the Egmont / Pender Harbour Official Community Plan (SCRD, 2009), Meadow Creek is classified as a main fish bearing creek, flowing to the marine sensitive Oyster Bay area. Thus, freshwater aquatic life is the primary receptor within Meadow Creek, and the freshwater aquatic life Criteria are the most appropriate determination of regulatory compliance.

3.2 Compliance Boundary

As indicated in the Landfill Criteria for Municipal Solid Waste (June 1993).

Landfills must not be operated in a manner such that ground or surface water quality in existing or potential future water supply aquifers or surface waters decreases beyond that allowed by the Approved and Working Criteria for Water Quality prepared by the Water Management Division of the Ministry of Environment, or other appropriate criteria, at or beyond the landfill property boundary.

Since both shallow groundwater and surface water regimes discharge to Meadow Creek at, or near, the Site, Meadow Creek is the primary receptor for landfill impacts. As a result, the compliance location for both surface water and groundwater quality is the down-gradient (south) Site property boundary. It is important to note that currently the only monitoring location that is located at the compliance boundary is groundwater monitoring well Site 5.

4. LANDFILL DESIGN

As noted previously, the Site has accepted waste since the 1960s. Effectively, the landfill began operation as an attenuation landfill, with no formal design and operation criteria or performance goals.

As a result, the landfill has performance limitations when compared to an engineered attenuation landfill. The key performance limitations are as follows:

- A limited amount of soil below the base of the landfilled waste to attenuate landfill impacts (less than 5 metres);
- No vertical separation (vertical attenuation zone) between the base of the landfilled waste and the groundwater table, which limits attenuation capability of the limited soil beneath the landfilled waste; and
- A thin saturated overburden layer in the down-gradient groundwater attenuation zone.

However, the landfill also has several advantages over many non-engineered landfills including:

- A relatively small surface area;
- A well graded landform (not flat); and
- Relatively large down-gradient groundwater attenuation zone between the limit of waste and the adjacent surface watercourse.

4.1 Leachate Management

A study completed in 1992 concluded that Meadow Creek was being impacted primarily by iron and manganese from the Site. As a result, environmental controls in the form of a leachate collection and treatment system was designed and implemented to address these impacts.

The collection portion of the leachate collection and treatment system consists of a leachate interception ditch along the east and northeast limit of waste at the base of the landfill slope, and a leachate collection pipe and “clean water” diversion pipe constructed along the northeastern limit of waste at the base of the landfill slope. The leachate interception ditch collects leachate that seeps from the landfill as well as impacted runoff from the landfill, and conveys it to the leachate treatment wetland. The leachate collection pipe is a perforated pipe located below ground surface, which collects impacted shallow groundwater and directs it to the leachate treatment wetland. The “clean water” pipe collects surface water runoff from upstream of the landfill and conveys it east to the intermittent drainage course.

Treated leachate is discharged from the leachate treatment wetland to the intermittent drainage course where it mixes with the diverted “clean water” from the diversion ditch and flows to the basin.

The main components of the leachate treatment wetland are as follows (Reid Crowther & Partners Ltd., 1997):

- Sedimentation Forebay Pond: Designed to settle out coarse sediments and to distribute flow evenly into the treatment marsh cell. A portion of metals adsorbed onto sediment and organic debris is settled out.
- Treatment Marsh Cell: Aerobic water column with anaerobic muck, for precipitating metals, particularly iron and manganese. Biofilms on plant stems and detritus are effective in complexing some metals.
- Infiltration Trench with Dolomitic Limestone: Adsorption of metal onto surfaces, maintains biofilter film which treats sulphates, increases hardness of water which mitigates toxicity of some metal ions.
- Riparian Treatment Cell: Soil microbe and plant uptake of metal ions, particularly copper, selenium, and zinc.

The primary purpose of the design was to optimize treatment of the target pollutants, including aluminum, cadmium, copper, iron, manganese, selenium, and zinc. The area of the leachate treatment wetland was limited due to the available space. Significant seasonal variations in treatment effectiveness were not anticipated, since the removal of metals employs physical transformations that are relatively independent of above freezing temperatures. Predicted percentage removal rates, as a proportion of inflow concentration were aluminum 75, cadmium 75, copper 85, manganese 80, iron 80, selenium 85, and zinc 85.

4.2 Landfill Gas Management

No active or passive landfill gas (LFG) management controls currently exist at the Site.

5. GEOTECHNICAL INVESTIGATION

5.1 Background

The landfill is characterized by a steep (approximately 1.5 horizontal to 1 vertical) eastern slope, currently heavily vegetated with bushes, shrubs, and trees.

XCG understands that a "Slope Stability Assessment" (Piteau Associates, 1994) has historically been completed for the Site. The following recommendations for geotechnical controls were included:

1. As part of the design of final cover, maintain a 3 to 4-metre wide bench at the top of the existing steep slope and construct a lined drainage ditch on the bench to divert surface water runoff from the upper portion of the landfill from flowing onto the steep slope. The objective is to reduce infiltration (leachate generation) and erosion of the steep slope.
2. Fill a portion of the steep slope north of the leachate treatment wetland.
3. Regrade the peak of the landfill in the south.
4. Construct a buttress at the base the steep slope at the south end of the landfill (south of the leachate treatment wetland).
5. Establish a vegetative cover over the slope.

Items 2 through 5 were completed previously. The space for the bench has been maintained in the final waste grades and the bench and drainage ditch will be included in the design of final cover.

5.2 Geotechnical Investigation

An updated geotechnical investigation (Appendix E) was carried out at the Site by Braun Geotechnical Ltd. (Braun) in November 2013 with a focus on closure of the landfill. The objective of the investigation was to assess the following:

- Landfill slope stability;
- Existing cover on east landfill slope; and
- Stratigraphy and geotechnical properties of the shallow overburden at the location of the proposed transfer station.

The investigation consisted of 10 test pits, excavated to depths of approximately 1.1 to 3.4 metres bgs. TP13-01 to 13-04, 13-08, and 13-09 were excavated on the existing east slope of the landfill, TP13-10 was excavated within the sand filter adjacent to the leachate treatment wetland, and TP13-05 to 13-07 were excavated within the recycling area. A site plan showing the test pit locations and the test pit logs are included in Appendix E.

5.2.1 Existing Cover

Based on the results of the test pit program, the cover on the eastern slope of the landfill is generally composed of loose to compact sand fill with some gravel and silt and occasional cobbles and boulders, with thicknesses ranging from 0.5 metres to more than 2.9 metres.

5.2.2 Landfill Slope Stability

A static and dynamic slope stability assessment was undertaken for the east slope of the landfill, deemed to be the critical slope, graded to approximately 1.5 horizontal to 1 vertical. The results of the analysis indicated that the landfill is situated on competent materials, and failure of the surficial soils (general bearing failure or liquefaction) was not identified to be of concern.

The landfill slope stability analysis resulted in a computed static factor of safety greater than 1.3 and is considered to be within an acceptable range. The results of the pseudo-dynamic analysis indicated that seismic slope displacements would be expressed at approximately the crest of the landfill, with estimated median slope displacements of 10 centimetres. This is less than the typical acceptable limit of 30 centimetres adopted by other approved authorities concerning seismically induced permanent displacements.

The results of the landfill slope stability analysis indicate that the highest risk of instability to the landfill would result from the removal of existing vegetation which would reduce the veneer stability and likely result in short-term erosion of the cover. Any significant short-term erosion could not only compromise the cover, but would result in significant impacts to the leachate treatment wetland. Further it is noted that regrading the steep east slope is not practical due to the geometry of the waste mass and close proximity to the leachate treatment wetland. As such, it is recommended that measures to control surface water be implemented to improve long-term stability, including ditches and pipes to divert water away from the eastern slope of the landfill. Removal of existing vegetation on the east slope should be avoided.

6. CLOSURE

6.1 Design Criteria

The following design criteria were taken into account to prepare this Plan (Table 2):

- Maximum 3 horizontal to 1 vertical slope (33 percent), except on existing east slope, as presented in Section 5.2 above;
- Minimum slope at final closure of 10 percent;
- Maximum access road grade of 8 percent;
- Minimize leachate generation; and
- Address surface water control to reduce run-on from upstream areas, to reduce leachate generation.

6.2 Final Waste Contours

The final contours presented on Figure 6 were developed based on the following:

- Maximize surface water run-off, thereby reducing the amount of infiltration into the landfill area and consequently minimizing leachate generation;
- Minimize the amount of waste to be relocated;
- Minimize disturbance of the east slope; and
- Limit the amount of make-up grading material required to in fill areas of the landfill where the existing side-slopes are too shallow.

The final contour plan presented on Figure 6 includes filling all areas necessary to achieve minimum final landfill slopes of 10 percent. The existing east slope of the landfill varies in slope from approximately 1.9 horizontal to 1 vertical, with localized areas as steep as 0.8 horizontal to 1 vertical. As presented in Section 5.2, it is recommended that this slope and existing vegetation not be disturbed to maintain slope stability.

The final proposed maximum elevation of the landfill is 50 metres above mean sea level, and assumes landfilling ceases at the Site in 2014.

6.3 Final Cover

As indicated in the "Landfill Performance Assessment" (XCG, 2014), the current landfill performance with respect to down-gradient water quality is in compliance with the Permit prior to placement of final cover. Therefore, the performance criteria for the final cover are as follows:

- Reduce the leachate generation rate to ensure the continued compliance with respect to groundwater quality;
- Meet the performance criteria of the final cover detailed in the Landfill Criteria;
- Make use of locally available cover materials where possible to allow for ease of construction; and

- Provide adequate protection against burrowing animals.

The proposed cover system will be composed of 0.6 metres of native silty sand (barrier layer with hydraulic conductivity of $1x10^{-4}$ cm/sec or less) overlain by 0.15 metres of clear stone, overlain by a minimum of 0.30 metres of organic soil (vegetative layer), as illustrated in Figure 7. The topsoil will be hydroseeded to establish native vegetation.

The performance of the proposed cover system was analyzed using the Hydrological Evaluation of Landfill Performance (HELP) Model (USACE, 1997). The performance (i.e. leachate generation potential) of the Landfill Criteria prescribed cover system (1 metre of low permeability 10^{-5} cm/s soil) was compared to the proposed cover system. The results of this analysis are summarized in Table 3. Data output from the HELP model runs are included as Appendix F. Based on the analyses, the proposed cover system exceeds the performance of the low permeability soil and will provide a suitable cover system using local materials (native gravel and silty sand).

As discussed in Section 5.2, it is recommended that the eastern slope of the landfill be maintained in its current condition (cover and vegetation) to maintain slope stability and mitigate risk of excessive soil erosion.

6.4 Soil Balance

6.4.1 Soil Requirements

The quantity of native soil required to construct the barrier layer is estimated to be 4,800 cubic metres. This volume is based on the placement of 0.6 metres of native soil in the areas highlighted on Figure 6.

The quantity of clear stone required to construct the drainage layer is estimated to be 1,200 cubic metres. This volume is based on the placement of 0.15 metres of clear stone in the areas highlighted on Figure 6.

The volume of organic soil required to construct the vegetated organic layer is approximately 2,400 cubic metres. This volume is based on the placement of 0.30 metres of organic soil in the areas highlighted on Figure 6.

6.4.2 Soil Availability

Currently there are no available on-site stockpiles or borrow pits for native soil, gravel, or organic soil. Soil and aggregate will need to be acquired from local sources.

6.5 Proposed Leachate and Surface Water Management Strategy

As indicated in the "Landfill Performance Assessment" (XCG, 2014), the current performance of the down-gradient attenuation zone is adequate. In addition, as noted in Section 6.3, the final closure works (i.e. final cover system) will reduce leachate generation rates, further improving down-gradient groundwater quality. Therefore, the existing leachate and surface water management controls are deemed effective and will be maintained post-closure.

The leachate interception ditch along the east and northeast limit of waste at the base of the landfill slope will continue to collect leachate seeps and impacted runoff from the landfill and will convey these to the leachate treatment wetland. The existing perforated leachate collection pipe will collect impacted groundwater and direct it to the leachate treatment wetland (Figure 6).

As recommended in the "Slope Stability Assessment" (Piteau Associates, 1994), a lined drainage ditch will be constructed at the top of the existing eastern slope of the landfill to divert surface water runoff from the upper portion of the landfill from flowing onto the steep slope. The lined drainage ditch will divert water south and north, to spillways that will outlet to the existing leachate collection ditch located along the northeast and east edges of the landfill, to ultimately discharge to the leachate treatment wetland (Figure 6).

A perforated stormwater collection pipe will be installed beneath the aforementioned lined drainage ditch. The perforated pipe will collect stormwater from the drainage layer of the final cover to minimize surface water infiltration into the waste and minimize leachate generation. The stormwater collection pipe will divert water south and north, to the aforementioned spillways. A typical cross-section showing the perforated stormwater collection pipe is included on Figure 7.

Surface water upstream of the Site will continue to be collected by the ditch located on the west side of Pender Harbour Landfill Site Road, as follows (Figure 6):

- The south portion of the ditch will continue to divert water south along the west side of Pender Harbour Landfill Site Road;
- The central portion of the ditch will direct water north to the low point at approximate elevation 45.0 metres amsl. A new pipe will be installed to replace the existing crushed pipe, to convey stormwater to the east beneath Pender Harbour Landfill Site Road and across the landfill to the existing "clean water" pipe located along the northeast limit of the landfill; and
- The north portion of the ditch will continue to direct water north to an existing culvert that directs water to the east beneath Pender Harbour Landfill Site Road to discharge into an existing ditch. The ditch will direct water into the existing "clean water" pipe noted previously.

Stormwater from the "clean water" pipe will discharge to the existing ditch that bypasses the leachate treatment wetland and outlets to the intermittent drainage course, as indicated on Figure 6.

6.6 Landfill Gas Management

6.6.1 Potential Receptors

Receptors are generally defined and grouped based upon risk type. The risks can broadly be categorized as: exposure to combustible gases, asphyxiation potential, and ecotoxicity. On a site-specific basis, the following receptor types were identified which could potentially be adversely impacted by LFG:

- Buildings;

- Manholes; and
- Vegetation.

There are currently several on-site buildings located at the Site (Figure 3). These include the scale house and share shed. These buildings are located approximately 40 metres from the limit of waste. XCG understands that the SCRD is considering converting the recycling facility into a transfer station at the Site once the landfill is closed; it is unknown at this time whether these buildings will be maintained on-site during the post-closure period.

It is noted that any other buildings (residences) are located more than 500 metres from the Site. In addition, the potential for future residences to be located closer to the Site is limited. As noted previously, the area south of the Site has residential suitability constraints for soil and slopes, and the area around Meadow Creek requires a development permit. Also, under the SEI the area south of the Site and west of Pender Harbour Landfill Site Road is mapped as Mature Forest; while the area south of the Site and east of Pender Harbour Landfill Site Road is mapped as Wetland.

The potential for LFG to displace oxygen can result in health and safety issues with respect to accessing confined spaces (i.e., manholes).

The ability of LFG to displace oxygen in the soil matrix in the vadose zone can result in vegetative stress which can adversely affect agricultural lands, landfill cover systems, and screening vegetation. It is noted that no evidence of vegetative stress on the landfill cover or the screening vegetation has historically been evidenced at the Site.

6.6.2 LFG Migration Potential Assessment

XCG understands that LFG migration monitoring has not been previously conducted at the Site.

As discussed in Section 2.3, the surficial soils in the vicinity of the Site primarily consist of organic soil overlying sand and silt, with varying amounts of gravel and clay. The depth to bedrock is shallow, with the thickness of the overburden averaging between 2 and 5 metres in the vicinity of the Site. Surficial soils are reported to have hydraulic conductivities in the range of 5×10^{-4} to 8×10^{-5} cm/sec (Levelton, 1997).

As discussed above, the scale house and the share shed are the only two buildings in close proximity to the landfill. As part of the geotechnical investigation (Braun, 2014), three test pits (TH13-05, 13-06, and 13-07) were excavated in the northeast corner of the recycling area. The test pits indicated that the shallow overburden in the recycling area is comprised of sand and gravel fill to approximately 1.5 metres bgs, underlain by dense sand and gravel. Although the sand and gravel fill is a potential conduit for LFG, based on the absence of a confining layer above, and the distance (approximately 40 metres) from the landfill, migration of LFG to the scale house or share shed is unlikely.

As presented in Section 2.2, meteorological data indicates that the daily minimum average temperature for the Site is above 0 degrees Celsius for the entire year, indicating that soil frost is unlikely. The absence of frost or frozen soil conditions allows for the venting of LFG and diminishes the potential for LFG migration.

Groundwater levels in the vicinity of the Site have been reported as being very close to surface, with a maximum depth to groundwater recorded at approximately 3 metres bgs.

As presented above, the existing cover on the eastern landfill slope is composed of approximately 90 centimetres of sand and gravel. This higher permeability cover will allow for venting of LFG, diminishing the potential for lateral LFG migration.

Based on the above, the risk of LFG migration to the scale house and share shed, originating from the landfill is deemed to be low.

6.6.3 LFG Regulation

As per the Landfill Gas Management Regulation (2008), an owner or operator of a regulated landfill must ensure that a qualified professional conducts an LFG generation assessment of the landfill:

- If the quantity of municipal solid waste in place at the site is 100,000 tonnes or more; and/or
- If the quantity of municipal solid waste received for disposal into the landfill reaches or exceeds 10,000 tonnes per year.

Historic and future waste tonnages for the Site can be found in Table 4. These waste tonnages were estimated based upon the following factors:

- It was assumed that landfilling commenced at the Site in 1960;
- Tonnages of waste for the years of 1996 to 2013 were provided by the SCRD;
- The Site service area, Electoral District A (Egmont and Pender Harbour) of the SCRD, accounts for approximately 10.5 percent of the total population of the SCRD;
- Historic and future population growth is estimated to average 1.0 percent per year; and
- Prior to 1996 and after 2013, it was estimated that the landfill service population would generate a rate of 0.45 tonnes of solid waste per person per year (based on an average generation rate for 1996 to 2013).

As per the historic and current waste data presented in Table 4, the landfill contains a total of an estimated 54,000 tonnes of waste in place, and receives approximately 1,400 tonnes per year. Both of these criteria are below the above-noted regulatory thresholds. As a result, a LFG generation assessment is not required by the Landfill Gas Regulation.

6.6.4 Post-Closure LFG Management Strategy

Based on the above, the risk to on-site buildings from LFG migration originating from the landfill is deemed to be low. It is noted however, that if on-site buildings are maintained or additional buildings added during the post-closure period as part of the future potential transfer station development, the need for LFG monitoring and/or controls should be reassessed.

7. POST-CLOSURE CARE

The following section provides procedures and protocols for the inspection and care of the Site.

7.1 Post-Closure Use

The duration of the post-closure care period is a function of the contaminating lifespan of the landfilled waste. However, the minimum regulatory post-closure period is 25 years. Land use during the post-closure care period, during which time the landfill will generate contaminants at concentrations that may have an unacceptable impact if discharged to the surrounding environment, should be limited and closely monitored. The rationale for this limited/controlled land use during the post-closure period is to ensure that the surrounding environment is not adversely impacted. Hence, land use, during the post-closure care period, should take into account the following considerations:

- Minimize impacts to the vegetative cover (optimized evapotranspiration potential);
- Minimize soil erosion;
- Minimize infiltration through the cover system (e.g., prohibit the use of irrigation on the cover system);
- Minimize the external loading to the cover system which could result in differential settlement, thereby requiring significant mitigative measures to re-establish adequate drainage;
- Minimize external loading which could result in slope instability;
- Minimize potential direct exposure of the public to waste; and
- Avoid buried utilities, manholes, and other below grade infrastructure within the limit of waste to reduce the potential for lateral landfill gas migration and/or risks associated with asphyxiation or the accumulation of combustible gases.

XCG understands that the SCRD is planning on potentially using a portion of the Site (outside of the limit of waste) as a transfer station and resource recovery centre. Due to the steep final slopes and dense vegetation comprising most of the closed landfill, XCG recommends that the landfill be maintained as a passive use area during the post-closure period to minimize impacts to the final cover, to reduce maintenance requirements, and to avoid the liability associated with public access.

7.2 Inspection and Record Keeping

During the post-closure care period, the Site will be routinely inspected at a minimum of twice annually (May and November). In addition to routine inspections, the Site will be inspected following any major storm event (1 in 2 year return storm event or 50 millimetres of precipitation in a 24-hour period) or natural disaster. The inspection will include the following:

- Final cover;

- Ditches;
- Culverts and pipe inlets/outlets;
- Buffer zones;
- Fencing and Site security;
- Access and maintenance roads; and
- Environmental monitoring infrastructure.

An inspection summary sheet is included as Appendix G.

If the inspection results indicate any problems or damage, necessary steps will be taken, as presented herein, to ensure that proper maintenance is completed to address problems and repair damage.

Records of the inspections and any maintenance procedures carried out throughout the post-closure period will be maintained.

7.3 Maintenance

7.3.1 Final Cover

The long-term maintenance of the final cover will consist of regular inspections, primarily for surface erosion, differential settlement, and vegetative health. These conditions, if left to deteriorate could lead to failure of the final cover, resulting in increased leachate generation, accelerated erosion, and potential exposure of the underlying waste.

Erosion Control

Erosion control can be considered with respect to long-term and short-term measures. Long-term erosion control strategies generally involve the establishment of a vegetative mat as an integral component of the final cover system.

Short-term erosion control measures generally include such elements as silt fencing or straw bales to reduce sediment loading to the surrounding environment while final vegetation is establishing. In the event that erosion issues develop (e.g. rill erosion associated with channelized surface water runoff), or other mitigative measures require that a portion of the cover system be replaced, temporary erosion control measures should be implemented to reduce the generation of sediment. At a minimum, erosion control will include the installation of silt fencing or straw bales, installed in such a manner as to prevent the migration of sediment from the remediated cover area until such a time as vegetation is re-established.

Vegetative Cover

The vegetative cover should be maintained to ensure complete coverage over the landfill. Measures should be taken to ensure that damage to the final cover is minimized (e.g. limiting vehicular access to establish maintenance roads and limiting activities which could disturb vegetation in wet conditions).

In regions of the landfill where vegetation is poorly developed/established, additional vegetation shall be established (as Site access permits) to ensure that the evapotranspiration potential of the final cover system is optimized.

In the event of loss of vegetation due to erosion (e.g. rill erosion of landfill side-slopes), remedial measures should be undertaken to repair the eroded final cover and re-vegetate the cover area as indicated above. A specification for an appropriate native seed mixture, indigenous to the Pender Harbour area is presented in Appendix H. Temporary erosion control measures, as prescribed above, should also be implemented until vegetation is established.

In the event of localized vegetative stress on the landfill, temporary soil gas probes could be driven into the soil cover to determine if landfill gas is the cause of the stress. Based upon an evaluation of the cause of the stress, appropriate mitigation measures would be undertaken to permit vegetation to be re-established.

Cracking

Cracking of the cover system is generally associated with either the desiccation of the upper cover soil (localized shrinkage) or differential settlement. Desiccation of the upper cover system can be a seasonal occurrence. Typically, these minor cracks in the cover system are isolated to the topsoil layer and will “heal” when the moisture content of the soil matrix increases during periods of precipitation.

Cracking can also be associated with differential settlement due to the variable waste thickness, rate of decay, composition, and compaction. Differential settlement results in the development of stresses within the final cover and, in the case of a soil, results in deep cracks. In the event that differential settlement is found to be impacting the integrity of the final cover, a repair of the cover system should be evaluated. Such a repair would include the local excavation of the cracked region, placement, re-compaction, and re-vegetation of the cover system.

Slope Failure

As indicated herein, the risk of general slope failure is low as per the “Geotechnical Report” (Braun, 2014). It is recommended however, that measures to control surface water be implemented to divert water away from the eastern landfill slope, and that removal of the existing vegetation on the eastern landfill slope be avoided.

If slope failure is discovered within the limit of waste, a case-specific evaluation should be undertaken to establish the cause of the failure and recommend appropriate remedial measures.

Settlement

Municipal solid waste settles significantly once landfilled due to decomposition of the waste. The rate of decomposition depends on temperature, moisture, and the composition of the waste, and can continue for many years after Site closure. Settlement of a least 10 percent of the final height of landfill can be expected.

In the event that settlement limits positive drainage, remedial measures should be undertaken to re-establish adequate grades (typically 1 to 2 percent) to promote surface water runoff. Minor regrading (less than 1.0 metres of fill) will generally involve stripping off existing topsoil and clear stone and placing additional native soil. Topsoil and clear stone will then be replaced to the original thickness. Immediate seeding of the topsoil will be undertaken with temporary erosion control measures, as presented above, until vegetation is re-established.

In the event that major regrading is required (fill heights greater than 1.0 metres), an evaluation will be completed prior to undertaking remedial measures. Due to the compressibility of the waste mass and the mass of additional soil, the potential exists for additional soil to further exacerbate the differential settlement. Hence, major regrading efforts should be reviewed on a case by case basis.

7.3.2 Leachate Management

The landfill is a "natural control landfill", and as such was not originally constructed with an engineered liner or leachate collection system. Therefore, the primary task associated with leachate management is the regular inspection of the final cover for evidence of leachate surface seeps and maintenance of the leachate collection pipes and ditches.

In the event that leachate seepage is identified, remedial measures will be immediately undertaken to contain the seepage in order to prevent impacts to surface watercourses, and affect repair to the final cover in the area where seepage is observed.

In the event that leachate seepage has impacted surface watercourses, temporary controls, such as berming, should be implemented to prevent the migration of the impacted surface water downstream. Where possible, the impacted surface water should be redirected to the landfill by excavating a vertical channel into the waste mass and allowing the leachate to infiltrate into the waste.

If the leachate seepage is deemed to be substantial or chronic, prior to repairing the cover system, a vertical stone drain should be installed immediately up-gradient of the seep (Figure 7). This vertical stone drain is constructed by excavating through the uppermost lift of waste and the underlying soil (e.g. fire break or interim cover layer), to the underlying waste. This will provide a hydraulic connection to lower lifts of waste and allow the perched leachate to dissipate and prevent further seepage. The excavation is then backfilled with coarse stone to ensure the hydraulic connection to underlying waste is maintained upon completion of the remedial measures. The cover is then restored using un-impacted soil and regraded to pre-seepage contours.

At a minimum, the perforated leachate collection piping will be video inspected every five years. Maintenance could include removal of accumulated sediment, or flushing with high pressure water.

7.3.3 Surface Water Management

The long-term maintenance of the surface water ditches, pipes, and spillways will consist mainly of inspection for erosion, sediment build-up, blockages, and ponding due to differential settlement.

The perimeter landfill ditches will be repaired by filling and grading eroded areas or by removing sediment, debris, or any other blockages from within the ditches, as required (at a minimum when the capture capacity of the ditch has been decreased by one third). Particular attention will be paid to avoid disturbance of the natural vegetative growth (i.e. reeds and cattails). It is anticipated that the frequency of maintenance for ditches, to remove accumulated sediments, will occur approximately every five years during the post-closure period.

Ponding observed due to differential settlement will be dealt with by the placement of native soil, clear stone and topsoil to match the original grades of the final cover, as discussed above.

The manholes will be inspected for excessive sediment accumulation and the presence of debris and/or decaying vegetation.

At a minimum, the stormwater management piping and catch basins will be video inspected every five years. Maintenance could include removal of accumulated sediment, or flushing with high pressure water.

7.3.4 Buffer Zones

Buffer zones should generally be vegetated with native species and should be self-supporting. As such, with the exception of potential remedial measures to address landfill derived impacts, maintenance should generally not be required. In the event of landfill derived impacts (i.e. vegetative stress associated with landfill gas, sediment accumulation or leachate seepage) an assessment of the cause of the impact should be undertaken and appropriate measures undertaken.

7.3.5 Fencing and Site Security

All fencing and gates should be maintained. If fencing/gates are found to be damaged or in disrepair, then the existing fence/gate should be repaired or replaced as needed to ensure the protection of the Site’s environmental controls. The need for existing fencing and/or additional fencing should be reviewed on an annual basis.

7.3.6 Access Roads

On-site access roads shall be repaired should any erosion, rutting, or potholes occur. Snow clearing of the access road shall be performed on an as-required basis.

7.3.7 Environmental Monitoring Infrastructure

Existing groundwater monitoring wells should remain in place and operational throughout the post-closure care period of the landfill. Monitoring wells should be inspected at the time of monitoring for proper operation, and any broken valves or fittings should be replaced immediately. Should existing or any new monitoring wells be damaged beyond repair or abandoned during the post-closure care period, then they will be decommissioned as soon as reasonably possible.

In the event of ponding or surface water accumulation at the base of a monitoring well installation, remedial measures shall be undertaken to regrade the area and re-establish vegetative cover immediately. Alternatively, consideration can be given to decommissioning the monitoring well and installing a replacement in an adjacent location which will not be impacted by surface water.

7.4 Post-Closure Monitoring Program

The post-closure environmental monitoring program will continue at the Site, during the post-closure care period, until the waste mass is no longer generating contaminants at concentrations that may have an unacceptable impact if discharged to the surrounding environment.

The monitoring program shall be reviewed, with respect to groundwater, surface water, and soil gas monitoring, on an annual basis as part of the annual environmental monitoring report. Based upon the performance of the landfill, the program will be amended (either increasing or decreasing the scope of the monitoring program) as deemed necessary to mitigate any potential environmental risk during the post-closure care period.

The post-closure monitoring program, presented herein, is as per the recommendations of the "Landfill Performance Assessment" (XCG, 2014).

7.4.1 Locations

The existing five monitoring locations will continue to be monitored as part of the post-closure monitoring program. These locations include:

- Site 1 – A groundwater monitoring well located north of the landfill which represents background groundwater quality.
- Site 2 – A surface water sampling location in the forebay of the leachate treatment wetland, which essentially represents leachate quality and influent quality (to the treatment wetland).
- Site 3 – A surface water sampling location in the intermittent drainage course, approximately 50 metres east and downstream of the leachate treatment wetland, which represents the quality of effluent from the leachate treatment wetland, after it mixes with surface water diverted around the landfill.
- Site 4 – A groundwater monitoring well located near the intermittent drainage course, approximately 100 metres east of the landfill, which represents water quality at the approximate midpoint of the contaminant attenuation zone.
- Site 5 – A groundwater monitoring well located near the south property boundary, approximately 250 metres southeast of the landfill, which represents water quality down-gradient of the transfer station.

New surface water monitoring locations should be implemented at the following locations to allow for compliance, and impacts from the landfill, to be assessed more accurately:

- Upstream to establish background water quality conditions in Meadow Creek. The proposed location is shown on Figure 8 and should be located at an elevation above 23.0 metres amsl.

- Immediately downstream to determine landfill impacts on water quality at the compliance boundary of the Site. The proposed location is shown on Figure 8.
- Downstream Recovery located further downstream to document the extent of the mixing zone and distance required for the discharge from the landfill to assimilate and for water quality to recover to background levels. According to the SCRD, the closest accessible location is approximately 1,300 metres southeast of the landfill. The proposed location is shown on Figure 8.

The exact monitoring locations will have to be determined in the field based on safety and accessibility.

7.4.2 Regulatory Criteria

As part of the post-closure monitoring program, the groundwater and surface water analytical data is assessed with respect to the British Columbia Approved and Working Criteria for Water Quality, 2011 Edition, for freshwater aquatic life (hereinafter referred to as Criteria).

7.4.3 Parameters

The post-closure monitoring program will consist of water level monitoring for the groundwater monitoring wells, as well as the collection and laboratory analyses of water samples from all groundwater and surface water monitoring locations.

The groundwater and surface water samples will be analyzed for the following chemical parameters:

- pH;
- Electrical conductivity;
- Chemical oxygen demand (COD);
- Nitrate and nitrite;
- Ammonia;
- Dissolved chloride;
- Alkalinity;
- Dissolved organic carbon (DOC);
- Turbidity;
- Total Kjeldahl Nitrogen (TKN);
- Sulfate;
- Dissolved iron;
- Dissolved aluminum; and
- Total metals scan.

It is noted that all historic metals analyses have been completed for dissolved metals, yet all Criteria for metals, with the exception of aluminum and iron, are for total metals. Therefore, it is recommended that both dissolved and total metals be analysed for a transitionary period of two years, at which time the dissolved metals analysis will be discontinued.

7.4.4 Frequency

It is recommended that the monitoring frequency be twice annually in the spring (April or May) and fall (October or November).

7.4.5 Trigger Level Contingency Plan

The monitoring program should include a trigger level contingency plan to address unexpected and/or anomalous results, or results that exceed the applicable Criteria. Trigger levels will be established based on the first two years of post-closure monitoring results once baseline values have been established. Exceedance of trigger levels will prompt contingency measures, as follows:

Tier 1	Regular groundwater and surface water monitoring Trigger: Water quality non-compliance of fresh water quality life Criteria at the proposed compliance surface water monitoring (immediately downstream) location, as compared to regulatory criteria and upstream background surface water quality. The SCRD is notified and options for proceeding are discussed.
Tier 2	At a minimum, and with the approval of the SCRD, duplicate samples are collected at the location where the non-compliance was indicated to confirm exceedance. Trigger: The SCRD is notified of the results. If the exceedance is confirmed, Tier 3 is initiated.
Tier 3	Evaluation of the nature of impacts to determine if they are related to the landfill, what are the associated risks, and the requirement and timeline for mitigation measures.

7.4.6 Mitigation Measures

In the selection and implementation of mitigation measures it is important to ensure that the mitigation measures being considered are compatible with the Site setting and all the existing systems at the Site. This means that priority should be given to enhancing and optimizing existing attenuation mechanisms and environmental controls. Enhancing and optimizing existing attenuation mechanisms and environmental controls will minimize the impact that construction of mitigation measures can have on the on-site and downstream environment.

The importance of minimizing the impact to the on-site and downstream environment at the Site is specifically emphasized by the planning information. As noted in Sections 1.3 and 1.4:

- The area along the Meadow Creek tributary is considered a Riparian Assessment Area;
- The basin is considered to be a Wetland Ecosystem; and

- The majority of the remainder of the Site is considered a Woodland Ecosystem.

As a result, consideration of mitigation measures for the Site should avoid intrusive mitigation measures and focus on enhancing and optimizing existing attenuation mechanisms and environmental controls.

Mitigation measures will be considered if a Tier 3 noncompliance consisting of confirmed landfill impacts at the Immediately Downstream or Downstream Recovery surface water monitoring locations takes place.

Mitigation measures to be considered may include (in no particular order):

- No further action and continued reliance on attenuation and the leachate treatment wetland;
- Water quality investigation to determine the scope of the landfill impacts on the on-site and downstream environment;
- Maintenance of the leachate treatment wetland;
- Establishment of a downstream (off-site) mixing zone;
- Regular biologic monitoring (macroinvertebrate and/or fish surveys, species replacement index, drowning index, productivity index) to determine if the water quality is altering or having an adverse effect on the on-site and downstream environment;
- Line the Pender Harbour Landfill Site Road roadside ditch with low permeability soil to reduce infiltration and leachate generation; and
- Enhancement or enlargement of leachate treatment wetland.

7.5 Reporting

7.5.1 Annual Environmental Monitoring Report

An annual environmental monitoring report will be prepared for each calendar year. The report will include, at a minimum: a summary of the annual monitoring program, monitoring results and interpretation, and conclusions and recommendations.

8. REFERENCES

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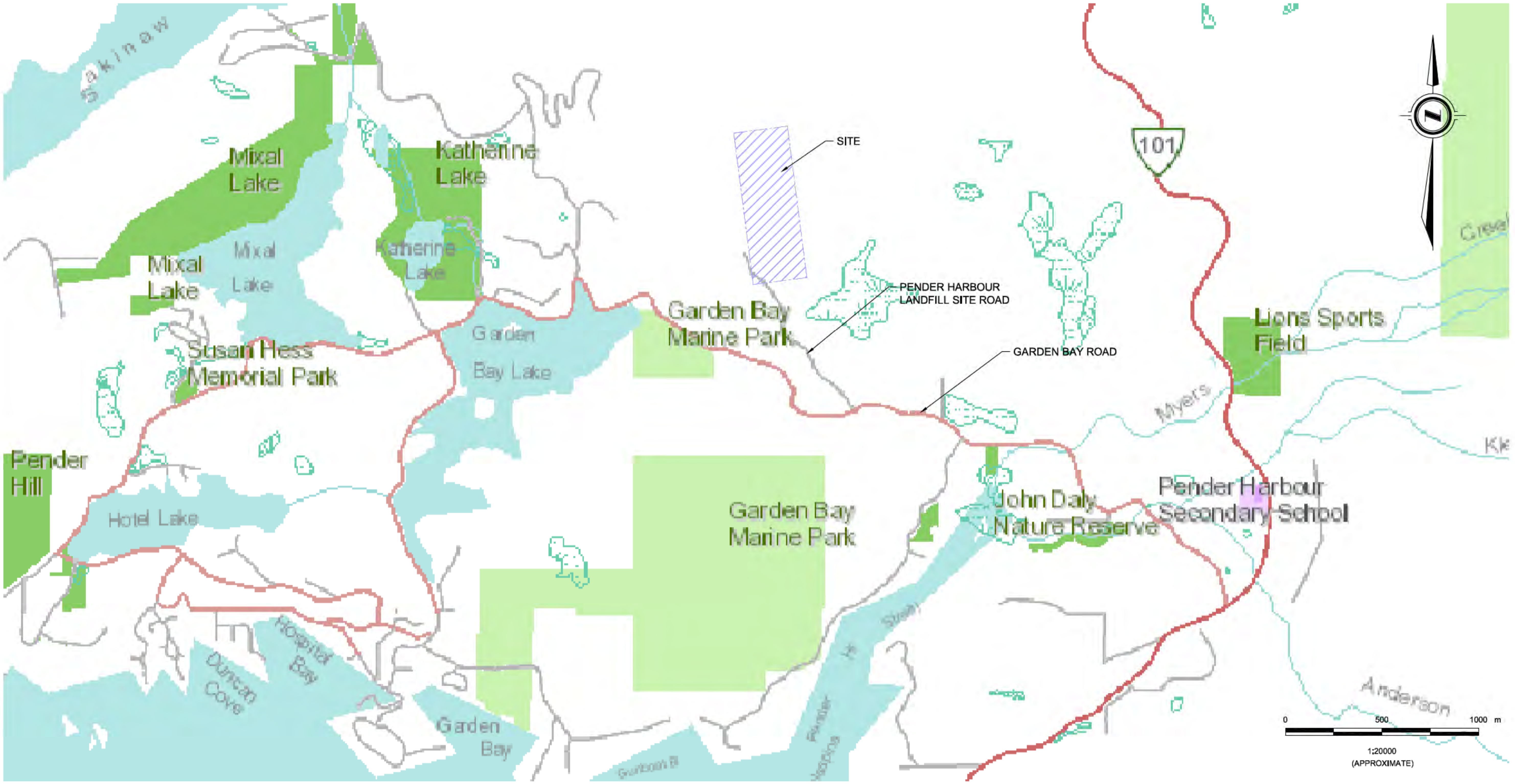
FIGURES



(file: R421110205002FIG1.dwg)

SITE LOCATION MAP

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	1

LEGEND

- ── CREEK
- ─ ─ PROPERTY BOUNDARY
- ▨ LIMIT OF WASTE
- ─ ─ DISTANCE FROM SITE
- ■ RESIDENCE

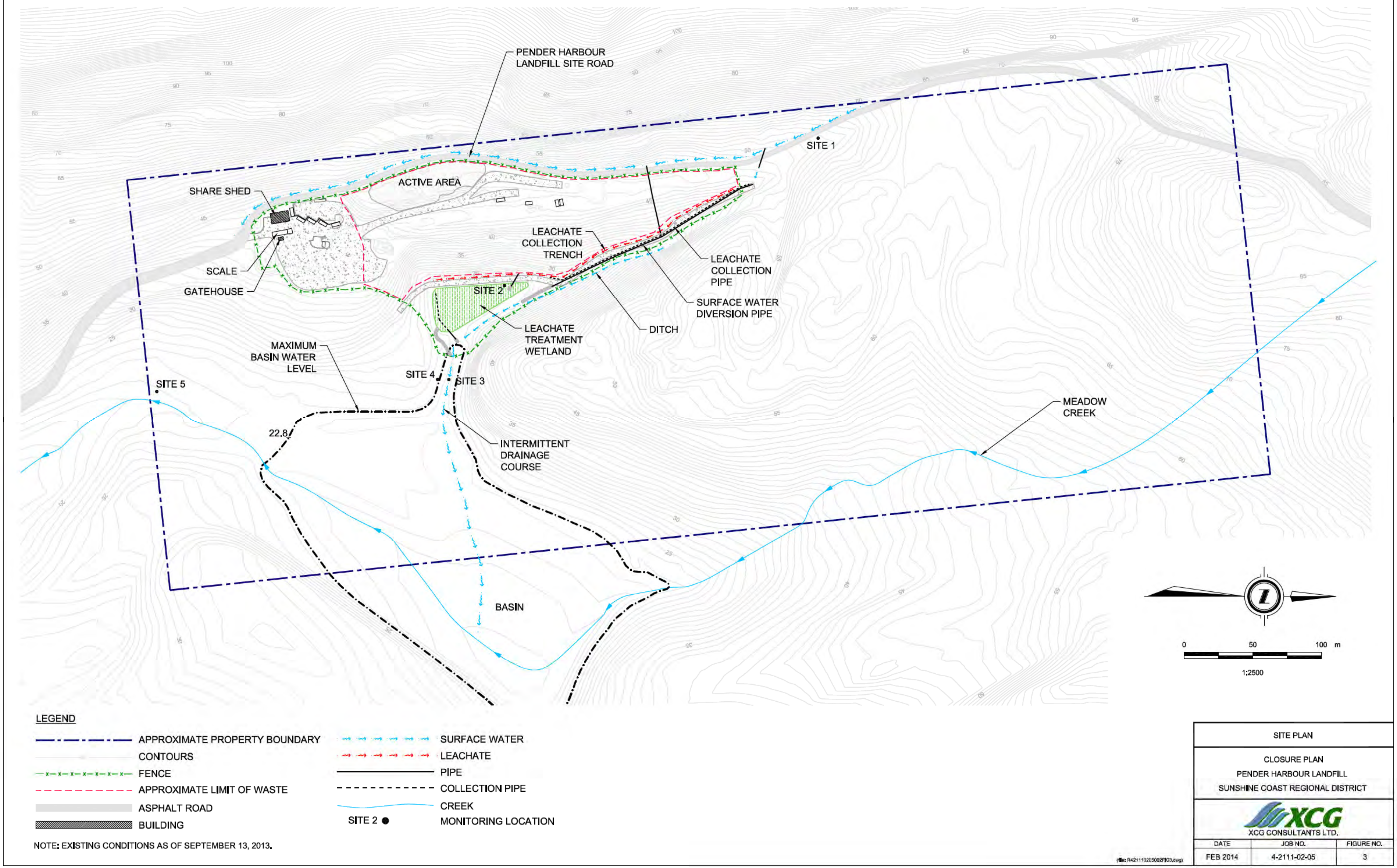
SITE AND SURROUNDING AREA

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	2

(file: R421110205002FIG02.dwg)



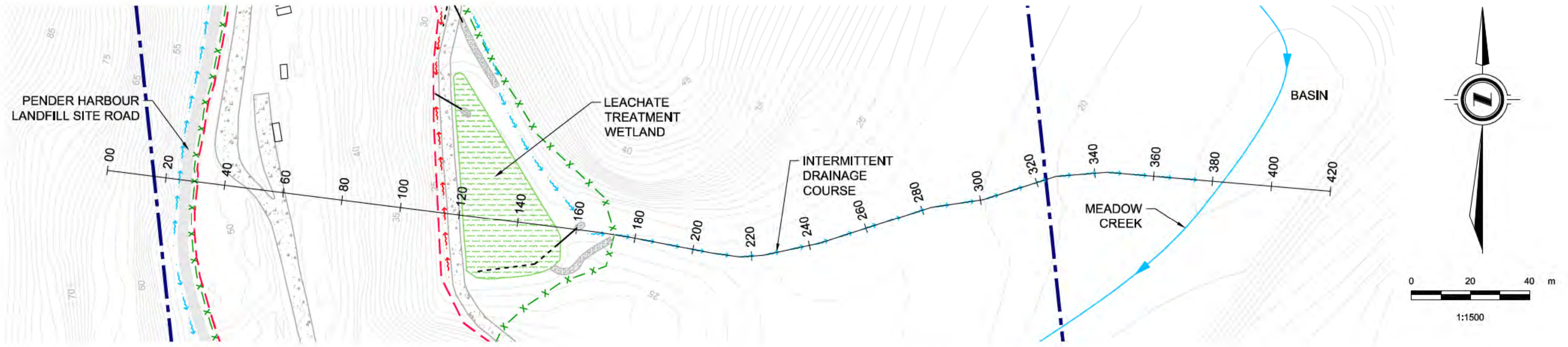
NOTE: EXISTING CONDITIONS AS OF SEPTEMBER 13, 2013.

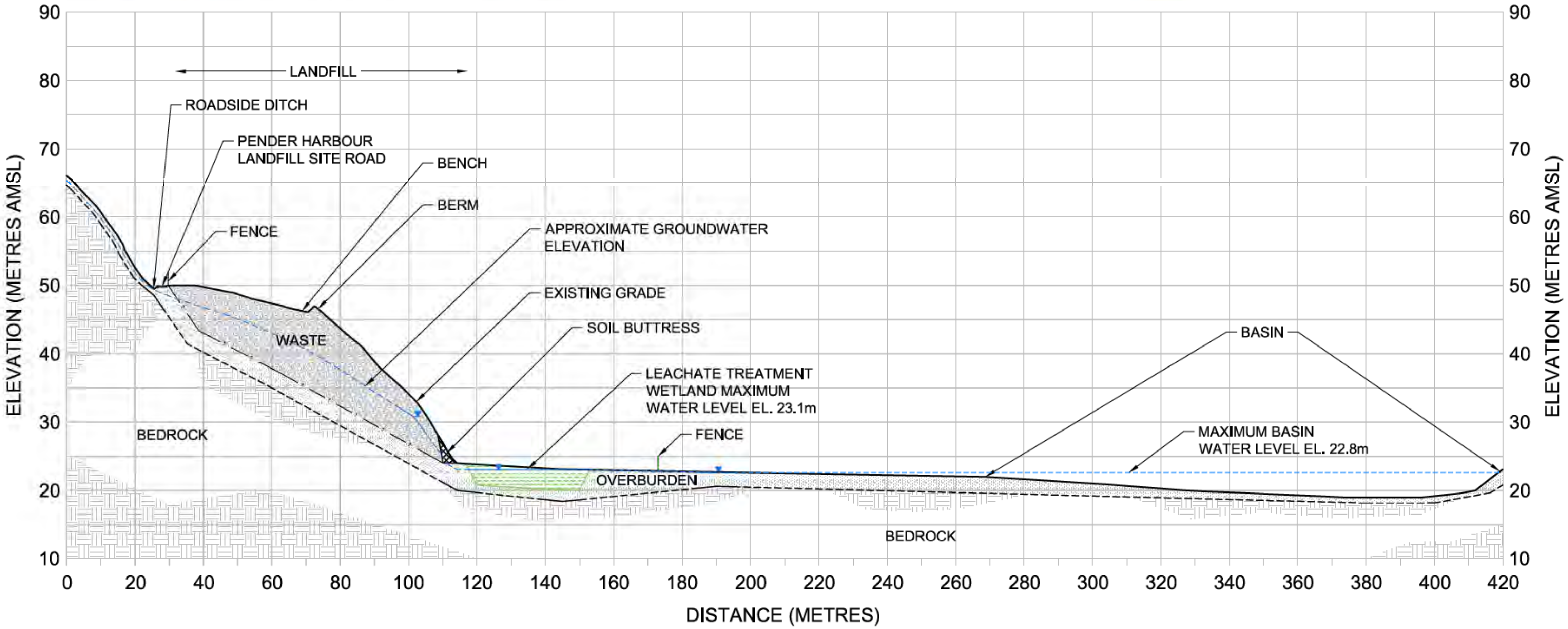
SITE PLAN

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	3





LEGEND

- · - · - APPROXIMATE PROPERTY BOUNDARY
EXISTING CONTOURS
—x—x—x— FENCE
– – – – APPROXIMATE LIMIT OF WASTE
▬ ASPHALT ROAD
▨ BUILDING
→ → → SURFACE WATER
→ → → LEACHATE
——— PIPE
- - - - COLLECTION PIPE
〰 CREEK

NOTE: EXISTING CONDITIONS AS OF SEPTEMBER 13, 2013.

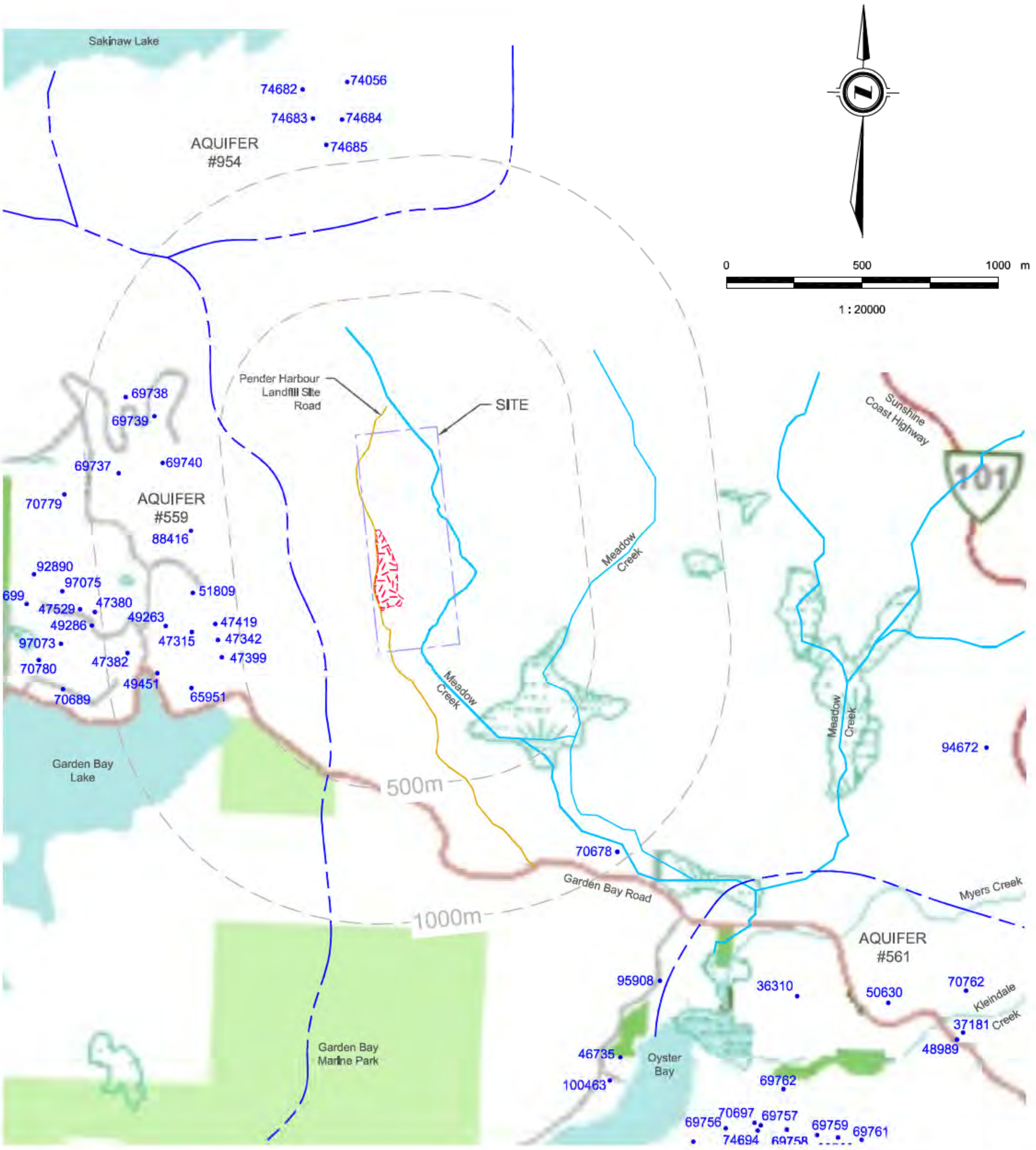
(file: R421110205002FIG04.dwg)

CROSS-SECTION

LANDFILL CLOSURE
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	4



LEGEND

CREEK

PROPERTY BOUNDARY

LIMIT OF WASTE

DISTANCE FROM SITE

AQUIFER BOUNDARY

•74684 WATER WELL

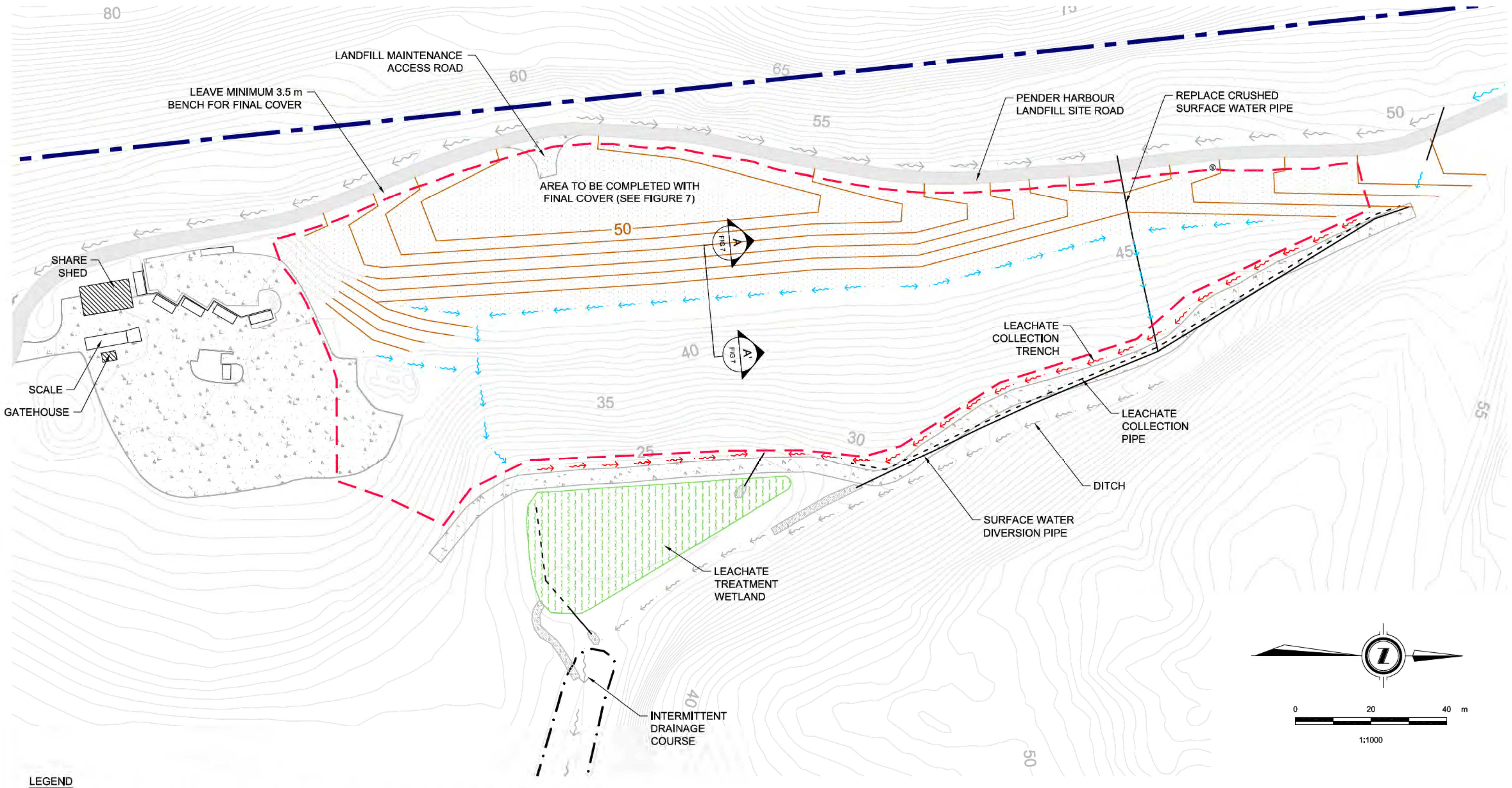
(file: R421110205002FIG05.dwg)

WATER WELLS AND AQUIFER BOUNDARIES

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	5



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING CONTOURS
- PROPOSED CONTOURS
- APPROXIMATE LIMIT OF WASTE
- ASPHALT ROAD
- GRAVEL ROAD
- BUILDING
- EXISTING SURFACE WATER
- PROPOSED SURFACE WATER
- LEACHATE
- PIPE
- COLLECTION PIPE
- CREEK

NOTE: EXISTING CONDITIONS AS OF SEPTEMBER 13, 2013.

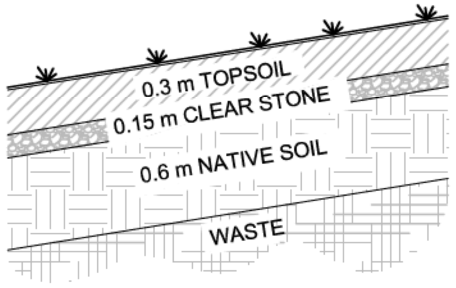
(file: R421110205002FIG6.dwg)

FINAL CONTOURS

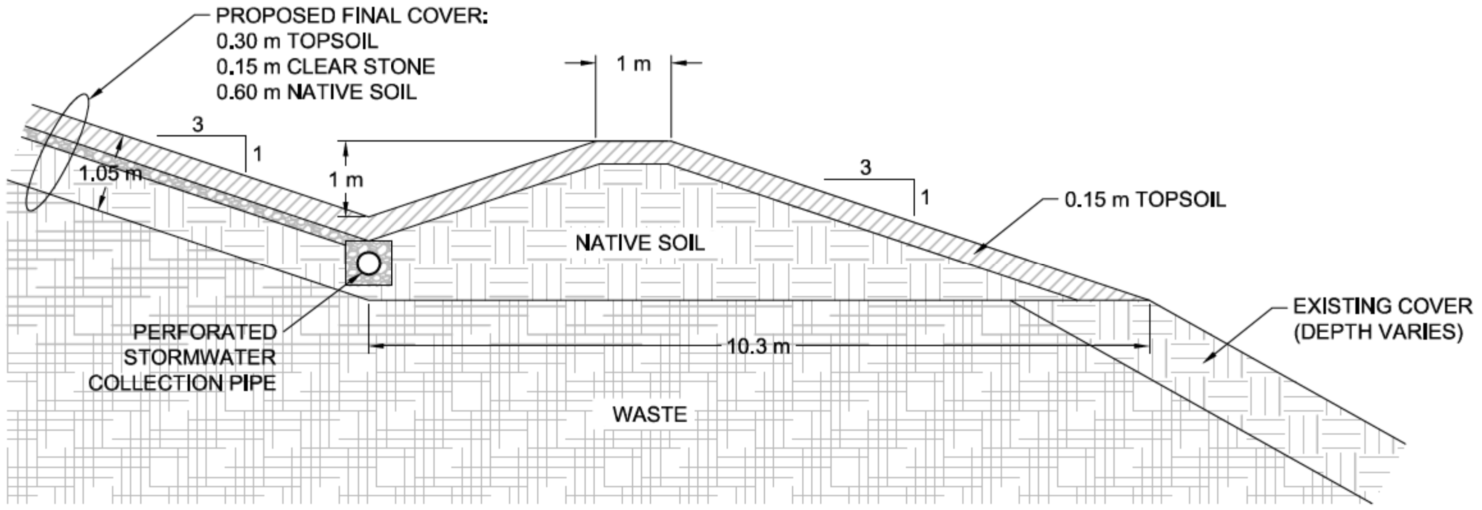
CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

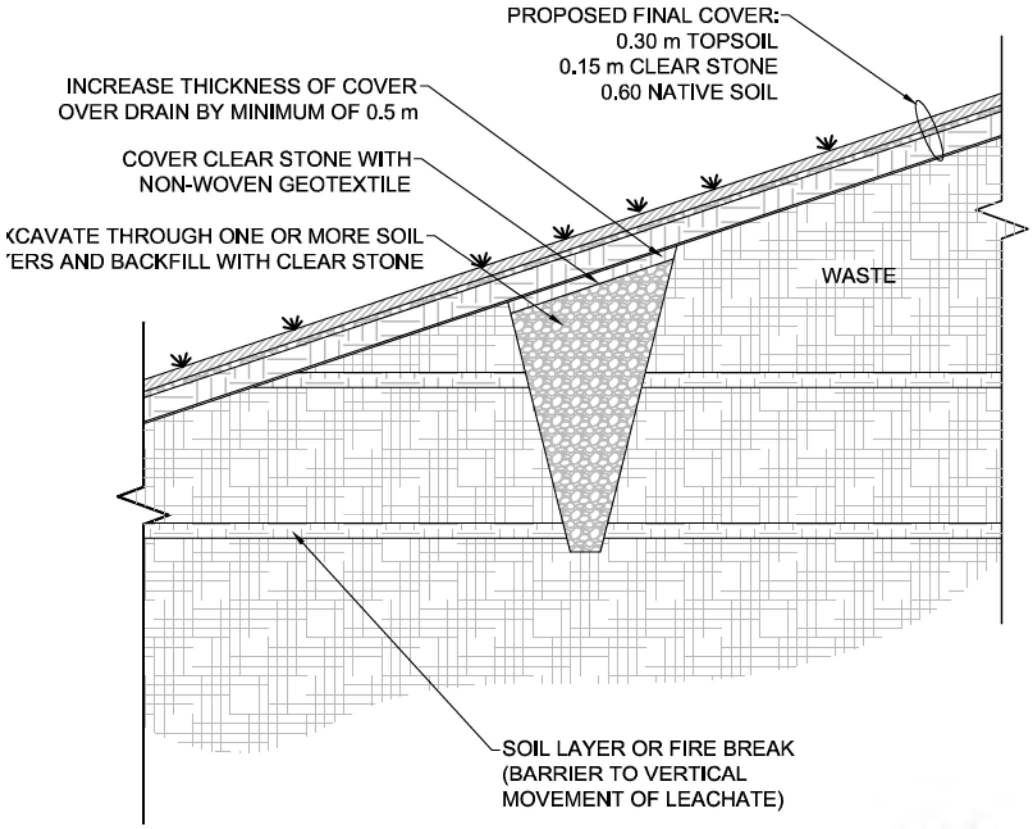
DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	6



DETAIL ① FINAL COVER
N.T.S. FIG 6



SECTION Ⓐ SURFACE WATER DIVERSION DITCH
N.T.S. FIG 6



DETAIL ② LEACHATE SEEP REPAIR
N.T.S.

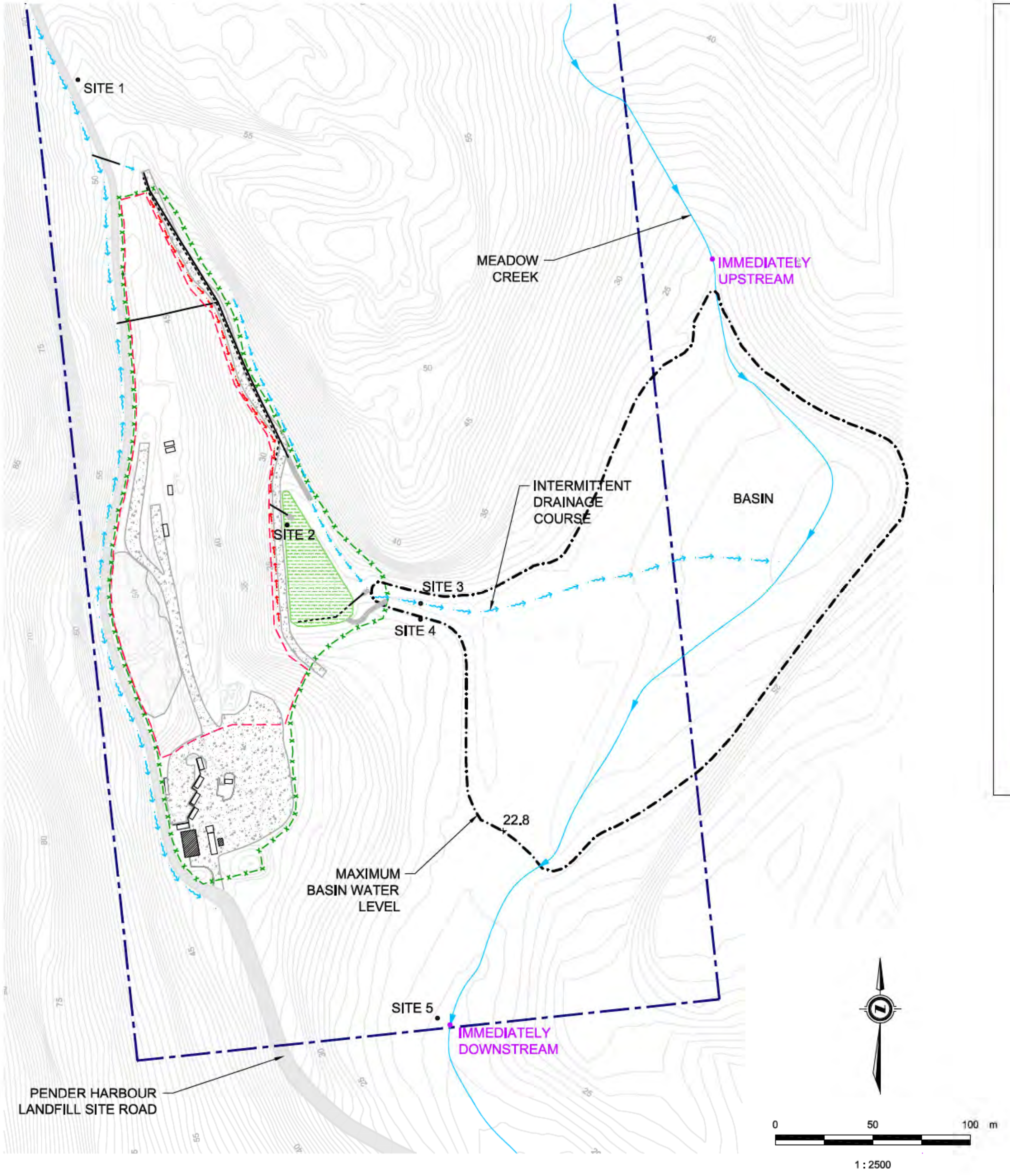
(file: R421110205002FIG06.dwg)

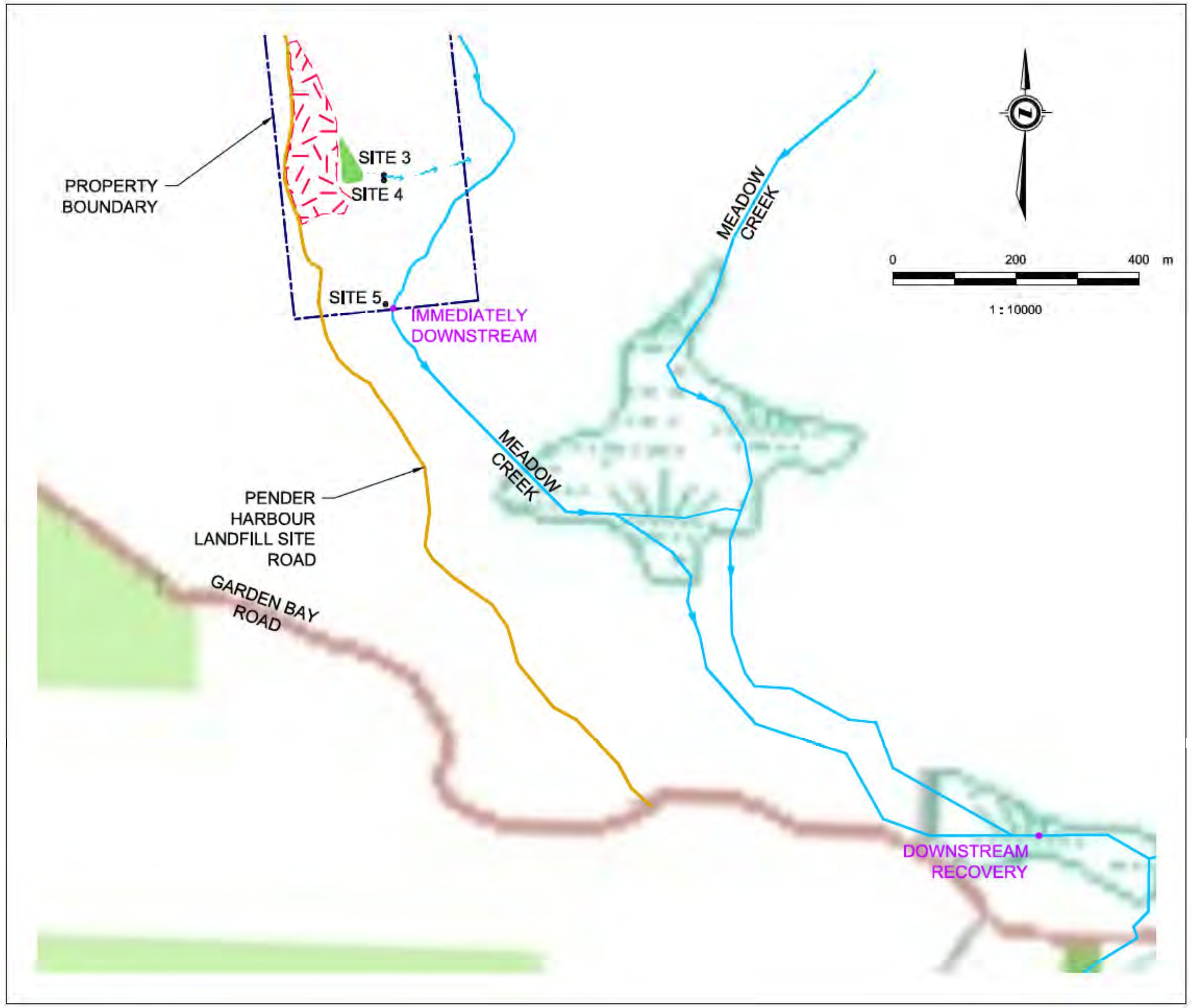
COVER DETAILS

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG
XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	7





LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- CONTOURS
- FENCE
- APPROXIMATE LIMIT OF WASTE
- ASPHALT ROAD
- BUILDING
- SURFACE WATER
- LEACHATE
- PIPE
- COLLECTION PIPE
- CREEK
- SITE 2 ● EXISTING MONITORING LOCATION
- IMMEDIATELY UPSTREAM ● PROPOSED MONITORING LOCATION

NOTE: EXISTING CONDITIONS AS OF SEPTEMBER 13, 2013.

(file: R421110205002FIG08.dwg)

PROPOSED MONITORING LOCATIONS

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	8

TABLES

Table 1 Climate Normals

Month	Daily Average Temperature (Celsius)	Rainfall (mm)	Snowfall (mm)	Average Total Precipitation (mm)	Evapotranspiration (mm)	Net Precipitation (mm)
January	3.7	156.7	14.3	171.0	11.0	160.0
February	5.0	131.9	10.2	142.1	18.1	124.0
March	6.7	120.2	4.2	124.4	29.0	95.4
April	9.2	92.7	0.5	93.1	47.8	45.3
May	12.3	80.8	0	80.8	73.8	7.0
June	14.8	67.2	0	67.2	96.0	-28.8
July	17.3	46.4	0	46.4	111.5	-65.1
August	17.6	45.6	0	45.6	103.5	-57.9
September	14.8	61.9	0	61.9	75.0	-13.1
October	10.4	133.3	0.5	133.8	43.3	90.5
November	6.2	206.7	2.9	209.7	20.7	189.0
December	3.8	180.2	13.1	193.2	10.8	182.4
Annual	10.2	1323.6	45.7	1,369.2	640.5	728.7

Note:

1. Source: Environment Canada, Climate ID 1043152 (1971-2000).

Table 2 Landfill Design Criteria Summary

Item	Criteria
Site Area	Permitted Area = 24 hectares
Waste Footprint Area	Existing area footprint =1.7 hectares
	Proposed area footprint = 1.7 hectares
Maximum Final Grade (horizontal:vertical)	Final contours 3H:1V [1]
Minimum Final Grade	Final contours: 10 percent
Minimum Ditch Grade	0.5 percent
Final Cover	0.30 metres vegetated organic soil
	0.15 metres clear stone
	0.60 metres silty sand (native soil)
Maximum access road grade	8 percent

Notes:

1 - Not considering eastern slope, which will remain at existing grade as per recommendations from "Preliminary Geotechnical Report" (Braun, 2014).

Table 3 Infiltration Rate Summary

Cover Type	Model	Slope (%)	Infiltration Rate (mm/yr)
Existing East Slope Cover	HELP	56%	866
MOE Cover	HELP	10%	783
MOE Cover	HELP	33%	781
Proposed Final Cover	HELP	10%	684
Proposed Final Cover	HELP	33%	657

Note:

1. Hydrological Evaluation of Landfill Performance (HELP) Model (USACE, 1997)

Table 4 Waste Data

Year	SCRD Population ^{1,2}	Pender Harbour Service Population ^{3}	Tonnes per Person per Year ^{5}	Tonnes of Waste ^{4}	Total Waste Landfilled (tonnes)
1960	13,393	1,406	0.45	633	633
1961	13,527	1,420	0.45	639	1,272
1962	13,663	1,435	0.45	646	1,918
1963	13,799	1,449	0.45	652	2,570
1964	13,937	1,463	0.45	659	3,228
1965	14,077	1,478	0.45	665	3,893
1966	14,217	1,493	0.45	672	4,565
1967	14,360	1,508	0.45	678	5,244
1968	14,503	1,523	0.45	685	5,929
1969	14,648	1,538	0.45	692	6,621
1970	14,795	1,553	0.45	699	7,320
1971	14,943	1,569	0.45	706	8,026
1972	15,092	1,585	0.45	713	8,739
1973	15,243	1,601	0.45	720	9,459
1974	15,395	1,617	0.45	727	10,187
1975	15,549	1,633	0.45	735	10,922
1976	15,705	1,649	0.45	742	11,664
1977	15,862	1,666	0.45	749	12,413
1978	16,021	1,682	0.45	757	13,170
1979	16,181	1,699	0.45	765	13,935
1980	16,343	1,716	0.45	772	14,707
1981	16,506	1,733	0.45	780	15,487
1982	16,671	1,750	0.45	788	16,274
1983	16,838	1,768	0.45	796	17,070
1984	17,006	1,786	0.45	804	17,873
1985	17,176	1,804	0.45	812	18,685
1986	17,348	1,822	0.45	820	19,505
1987	17,666	1,855	0.45	835	20,339
1988	18,379	1,930	0.45	868	21,208
1989	19,212	2,017	0.45	908	22,116
1990	20,497	2,152	0.45	968	23,084
1991	21,337	2,240	0.45	1,008	24,092
1992	22,209	2,332	0.45	1,049	25,142
1993	23,270	2,443	0.45	1,100	26,241
1994	24,267	2,548	0.45	1,147	27,388
1995	24,945	2,619	0.45	1,179	28,566
1996	25,745	2,703	0.55	1,479	30,045
1997	26,093	2,740	0.40	1,107	31,152
1998	26,201	2,751	0.41	1,138	32,290
1999	26,129	2,744	0.39	1,073	33,362
2000	25,924	2,722	0.40	1,097	34,459
2001	25,920	2,722	0.40	1,084	35,543
2002	26,109	2,741	0.43	1,169	36,712
2003	26,400	2,772	0.46	1,280	37,993
2004	26,593	2,792	0.52	1,448	39,440
2005	27,341	2,871	0.48	1,379	40,820
2006	27,959	2,936	0.53	1,561	42,380
2007	28,590	3,002	0.53	1,590	43,970
2008	29,201	3,066	0.47	1,441	45,411
2009	29,586	3,107	0.46	1,439	46,850
2010	28,971	3,042	0.44	1,349	48,199
2011	30,376	3,189	0.36	1,157	49,355
2012	30,589	3,212	0.36	1,155	50,510
2013	30,895	3,244	0.36	1,160	51,670
2014	31,204	3,276	0.45	1,474	53,144

Notes:

1. Historic (1986 - 2012) population data from BC Stats.
2. Population growth (1960 to 1985 and 2013 - 2014) estimated to be 1 percent.
3. Service population for Pender Harbour Landfill estimated to be 10.5 percent of total SCRD population.
4. Waste tonnages (1996 - 2013) provided by the SCRD.
5. Per capita waste generation (1960 - 1985 and 2014) assumed to be 0.45 tonnes per year.

APPENDIX A

LANDFILL PERMIT PR-01461

PROVINCE OF
BRITISH COLUMBIA

Environmental Protection
15326 - 103A Avenue
Surrey, British Columbia
V3R 7A2
Telephone: (604) 582-5200

MINISTRY OF ENVIRONMENT,
LANDS AND PARKS

PERMIT
PR-01461

Under the Provisions of the Waste Management Act

SUNSHINE COAST REGIONAL DISTRICT
5477 Wharf Road
Sechelt, British Columbia
V0N 3A0

is authorized to discharge refuse to the land located in Pender Harbour, British Columbia, and is subject to the conditions listed below. Contravention of any of these conditions is a violation of the *Waste Management Act* and may result in prosecution.

The discharge under the permit is authorized until the permit is superceded by an operational certificate issued pursuant to the Sunshine Coast Solid Waste Management Plan, approved by the Minister of Environment, Lands and Parks on June 14, 1996.

1. AUTHORIZED DISCHARGE

1.1 This subsection applies to the discharge of refuse to a controlled landfill serving **Electoral Area A of the Sunshine Coast Regional District.** The site reference number for this discharge is E213874.

1.1.1 The maximum authorized rate of discharge is 7.1 tonnes per day. The authorized discharge period is continuous.

Date Issued: August 23, 1972
Date Amended: JUL 29 1996
(most recent)

H.G. Maxwell
H.G. Maxwell
Assistant Regional Waste Manager

1.1.2 The components of the discharge are those typical of municipal refuse, and selected materials specifically authorized by the Regional Waste Manager. Materials specifically excluded from discharge are (i) special wastes, (ii) semi-solid wastes and organic sludges, such as those arising from sewage treatment plants, septic tanks and holding tanks, and (iii) the following specified recyclable materials:

a. used white goods,
b. auto hulks,
c. used tires,
d. used lead acid batteries,
e. gypsum wallboard, and
f. other materials which may be designated by the Regional Waste Manager when alternatives to disposal become available.

1.1.3 The authorized works are those associated with a landfill operation, and include a fence with locking gate to control access, fire protection equipment, leachate control works and surface water diversionary works. The landfill is located approximately as shown on the attached Site Plan A.

1.1.4 The legal description for the location of the point of discharge is the Portion of District Lot 4336, Group 1, New Westminster District, and unsurveyed adjacent lands.

2. GENERAL REQUIREMENTS

2.1 Maintenance of Works

The permittee shall inspect the authorized works regularly and maintain them in good working order. Notify the Regional Waste Manager of any malfunction of these works.

2.2 Emergency Procedures

In the event of an emergency which prevents compliance with a requirement of this permit, that requirement will be suspended **for such time as the emergency exists** or until otherwise directed by the Regional Waste Manager provided that:

a. Due diligence was exercised in relation to the process, operation or event which caused the emergency and that the emergency occurred notwithstanding this exercise of due diligence;

b. The Regional Waste Manager is immediately notified of the emergency; and

c. The emergency condition is being corrected with due diligence.

Notwithstanding a, b, and c above, the Regional Waste Manager may require the operation to be suspended to protect the environment while the situation is corrected.

H.G. Maxwell
H.G. Maxwell
Assistant Regional Waste Manager

2.3 Site Preparation and Restoration

Provision of fencing, site access, vehicle safety barriers, surface water diversionary works, leachate control works, firebreaks and site restoration as required, shall be carried out to the satisfaction of the Regional Waste Manager.

2.4 Landfill Operation

All refuse shall be confined to the smallest practical area and reduced to the smallest practical volume at the operating face of the landfill. The permittee shall apply a minimum 0.15 m of suitable cover material on all exposed solid waste not less than three times each week that municipal solid waste is discharged at the landfill.

2.5 Operating Plan

The permittee shall review the operating plan to determine whether it reflects current practices at the landfill, and submit revisions as required for approval of the Regional Waste Manager. The operating plan shall include details on mitigating the effects of the leachate on the environment, operational improvements to the site, and management of special wastes and recyclable materials. The landfill shall be operated in accordance with the approved operating plan.

2.6 Closure Plan

The permittee shall review the closure plan, and submit revisions as required for approval of the Regional Waste Manager. The closure plan shall include details on final elevations, slopes and grading, type and depth of materials used for final cover, maintenance of cover, vegetative cover, management of leachate and landfill gases, surface drainage and interception of groundwater, drawings and profiles of the site, and proposed use of the site after stabilization. The landfill shall be closed in accordance with the approved closure plan.

2.7 Access Control

The permittee shall maintain a fence with locking gate to control access to the site by the public. An attendant shall be at the landfill whenever the gate is open. Duties of the attendant shall be in accordance with the approved operating plan.

2.8 Wildlife Nuisance

The discharge authorized by Subsection 1.1 is one of concern because of the possibility of a nuisance or hazard being caused by bears or other animals attracted to the site. Additional works may be required or other operating instructions may be issued by the Regional Waste Manager if such problems arise.

H.G. Maxwell

H.G. Maxwell
Assistant Regional Waste Manager

Date Issued: August 23, 1972
Date Amended: JUL. 29 1996
(most recent)

2.9 Management of Recyclable Materials

Areas shall be set aside at the landfill site for the collection and storage of recyclable materials. These facilities shall be designed and operated in a manner acceptable to the Regional Waste Manager to prevent the discharge of leachate, control vectors, and minimize nuisance conditions such as odours and wind-blown litter. Recyclable materials shall be removed from the landfill site regularly, and the amounts accumulated shall be limited to the maximum which can be properly managed at the site.

3. MONITORING AND REPORTING REQUIREMENTS

3.1 Discharge and Recyclable Materials Monitoring

The permittee shall maintain records, for inspection, of the quantity of waste received at the landfill by management destination at the site, such as landfilling and recycling. The quantity of recyclable materials removed from the site shall be recorded. Records shall be in tonnes.

3.2 Surface Water Monitoring

3.2.1 Grab Sampling

The permittee shall obtain grab samples of surface water **once each three months** at the following locations: (A) upstream of the landfill, (B) leachate detention pond at the toe of the landfill, and (C) 100 metres downstream from the toe of the landfill. Sampling locations are located approximately as shown on the attached Site Plan A. Proper care should be taken in sampling, storing and transporting the samples to adequately control temperature and avoid contamination, breakage, etc.

3.2.2 Analyses

Obtain analyses of the samples for the following:

pH
nitrate and nitrite nitrogen, mg/L
specific conductivity, µmhos/cm
chemical oxygen demand, mg/L
chloride, mg/L
iron (dissolved), mg/L

Date Issued: August 23, 1972
Date Amended:
(most recent) JUL 29 1996

H G Maxwell
H.G. Maxwell
Assistant Regional Waste Manager

3.3 Monitoring Procedures

3.3.1 Sampling

Sampling shall be carried out in accordance with the procedures described in "Field Criteria for Sampling Effluents and Receiving Waters", April 1989, 17 pp., or by suitable alternative procedures as authorized by the Regional Waste Manager.

Copies of the above manual are available from the Environmental Protection Division, Ministry of Environment, Lands and Parks, 777 Broughton Street, Victoria, British Columbia, V8V 1X5, and are also available for inspection at all Environmental Protection Offices.

3.3.2 Chemical Analyses

Analyses are to be carried out in accordance with procedures described in the latest version of "BRITISH COLUMBIA ENVIRONMENTAL LABORATORY MANUAL for the Analysis of Water, Wastewater, Sediment and Biological Materials (March 1994 Permittee Edition)", or by suitable alternative procedures as authorized by the Regional Waste Manager.

A copy of the above manual may be purchased from the Queens Printer Publications Centre, 2nd Floor, 563 Superior Street, Victoria, British Columbia, V8V 4R6 (1-800-663-6105). A copy of the manual is also available for review at any Environmental Protection Program Office.

3.3.3 Quality Assurance

All data analyses required to be submitted by the permit shall be conducted by a laboratory acceptable to the Regional Waste Manager. At the request of the manager, the permittee shall provide the laboratory quality assurance data, associated field blanks, and duplicate analysis results along with the submission of data required under Subsection 3.2 of the permit.

3.4 Reporting

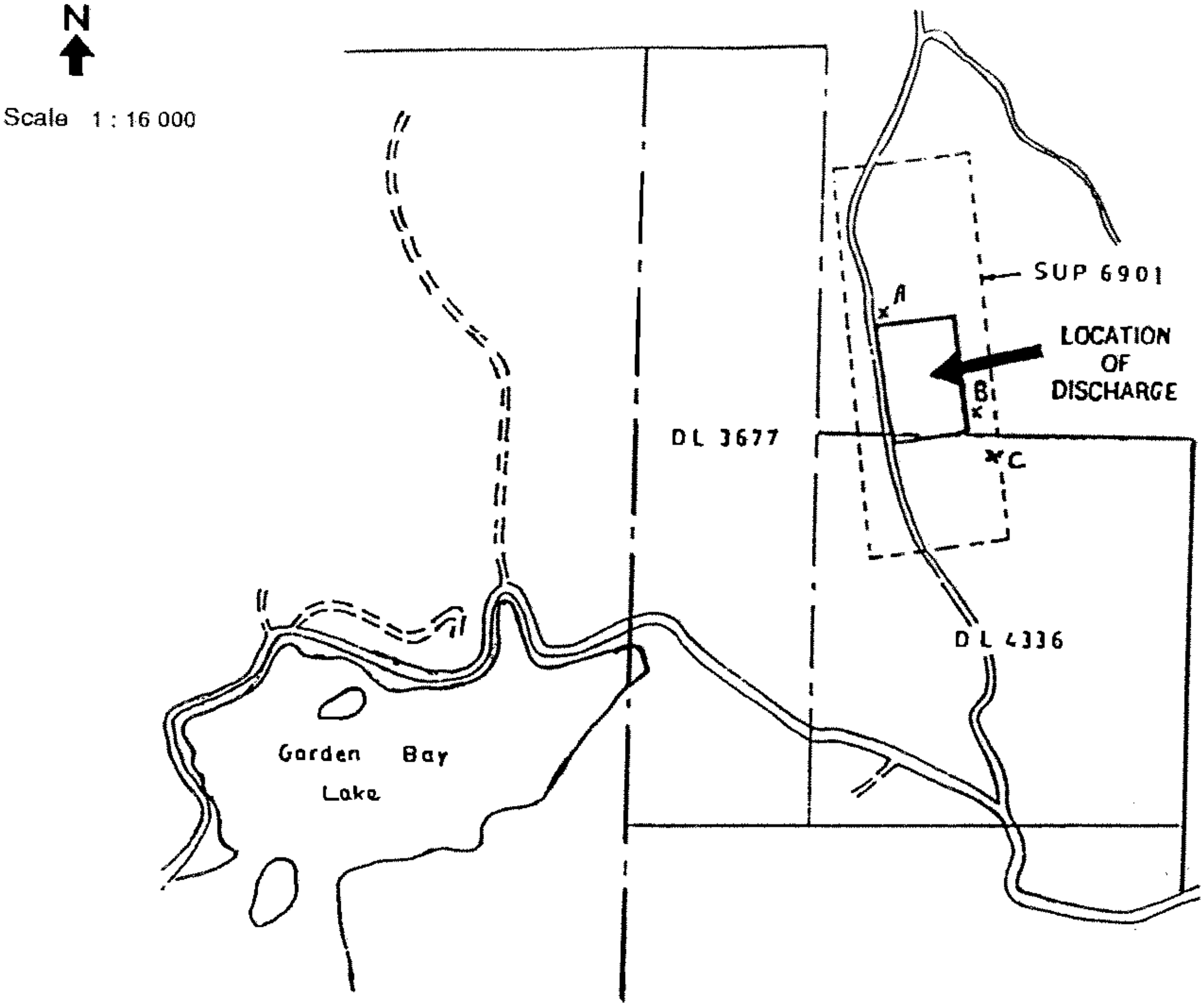
Maintain data of analyses and flow measurements for inspection and submit the data, suitably tabulated, to the Regional Waste Manager for the previous **six months.** The first reporting period ends **December 31, 1996.** All reports shall be received by the manager within 31 days of the end of the reporting period.

H.G. Maxwell
H.G. Maxwell
Assistant Regional Waste Manager

PROVINCE OF
BRITISH COLUMBIA

Environmental Protection

SITE PLAN

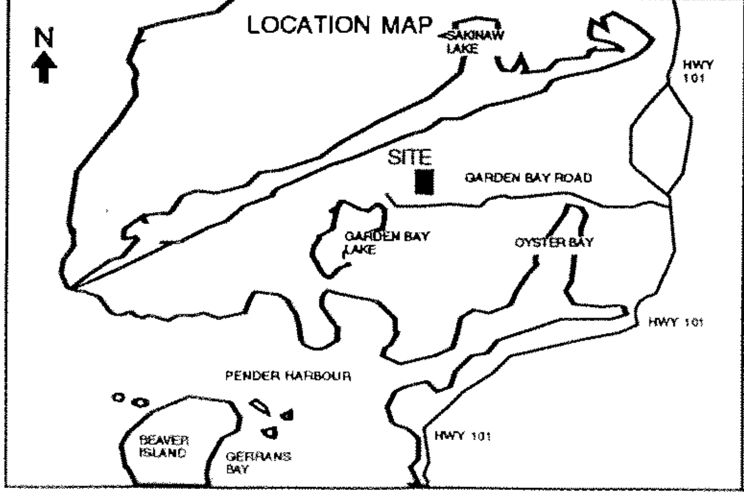


A: Groundwater monitoring site.
B, C: Surface water monitoring sites.

LEGAL DESCRIPTION:

Portion of District Lot 4336, Group 1, New Westminster District and unsurveyed adjacent lands.

LOCATION MAP



For Office Use Only

Site Plan A

Permit PR-01461

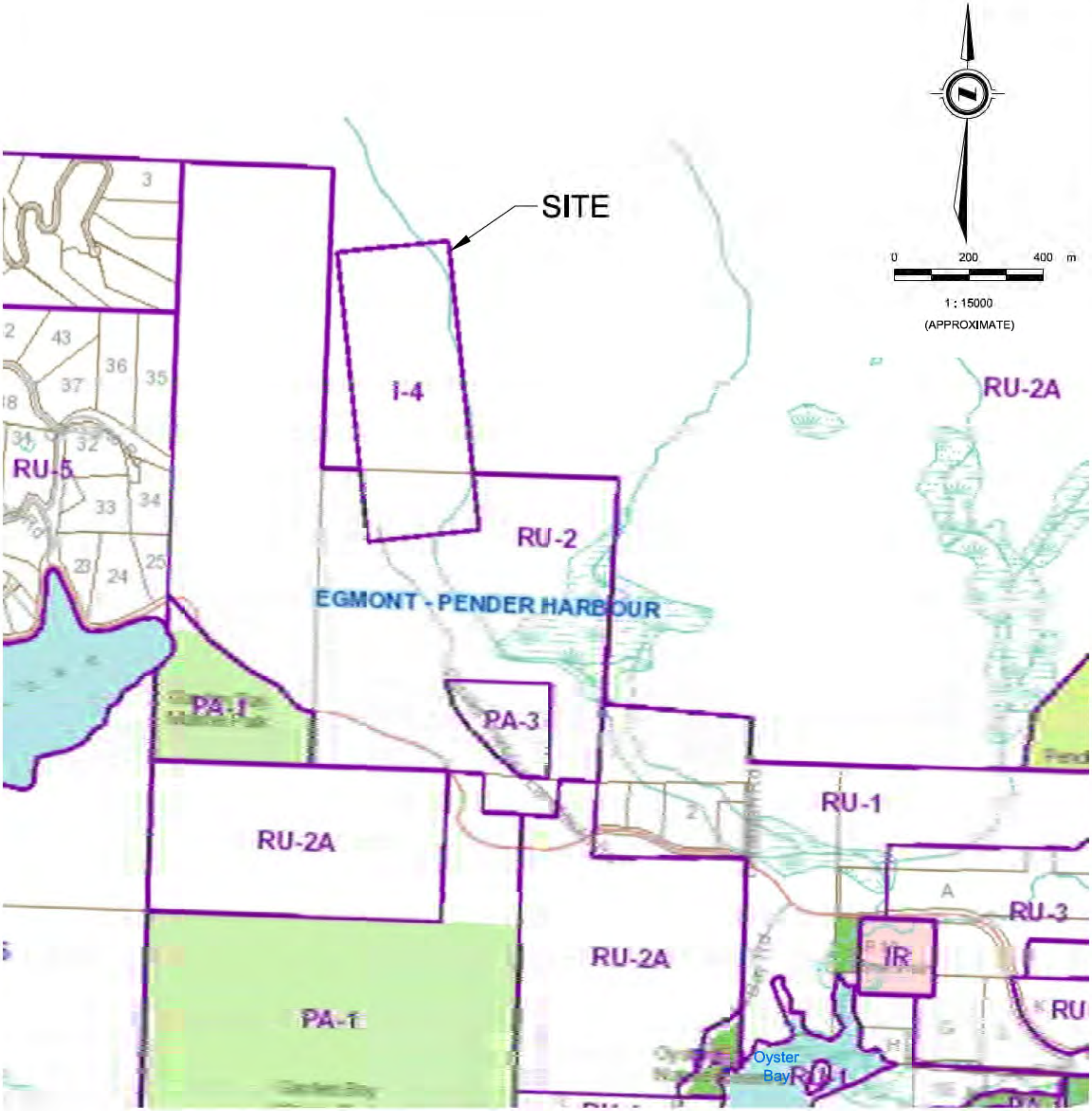
JUL 29 1996

Date

Assistant Regional Waste Manager

APPENDIX B

PENDER HARBOUR / EGMONT COMMUNITY PLAN FIGURES



I-4	HEAVY INDUSTRIAL
RU-2A	RURAL RESOURCE
RU-2	RURAL RESOURCE
RU-1	RURAL RESOURCE
PA-1	PARK & ASSEMBLY

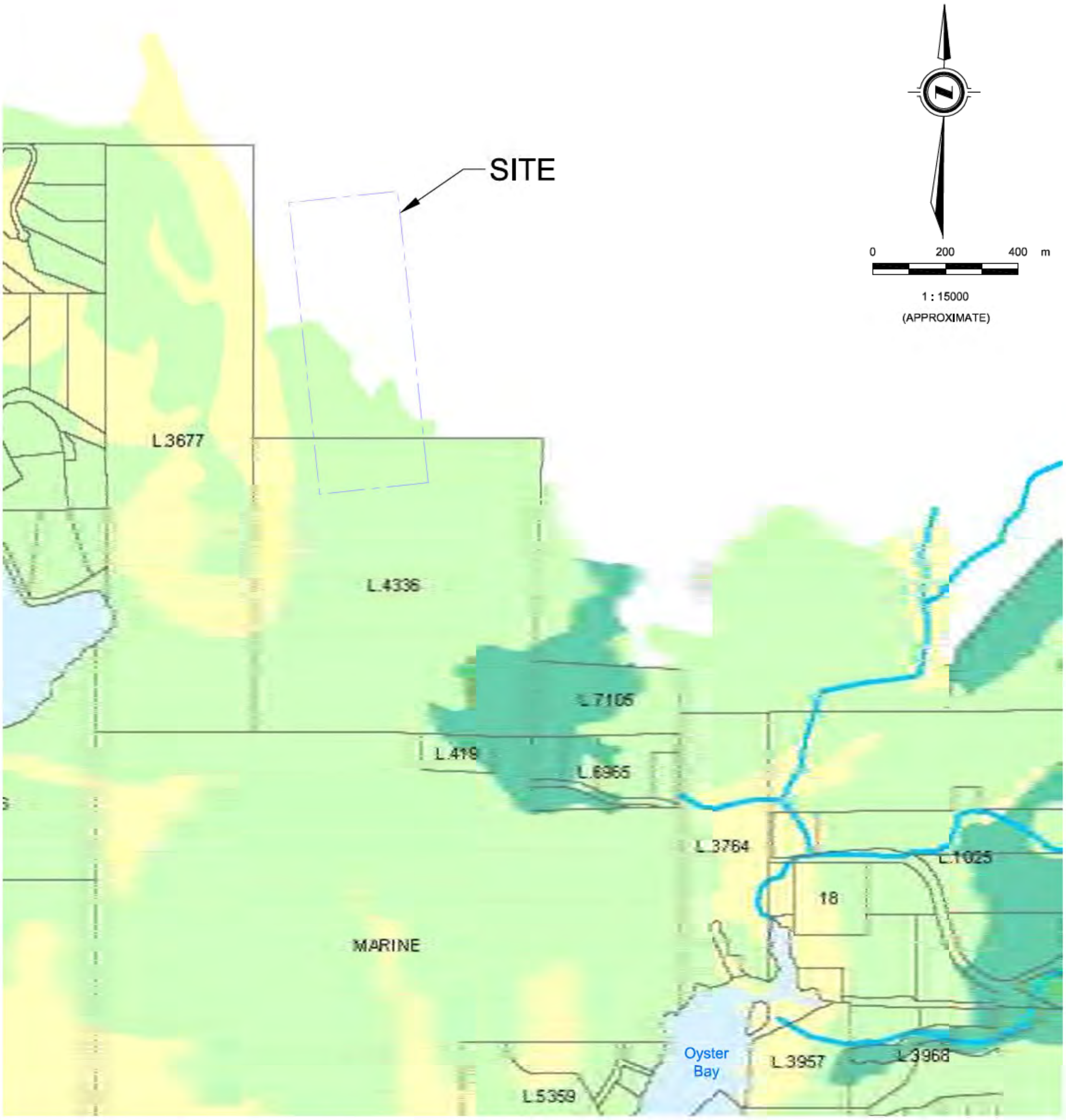
LAND USE AND ZONING

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	B1

(file: R421110205001FIGA01+.dwg)



🟨 High Constraint

🟩 Moderate Constraint

🟩 Low Constraint

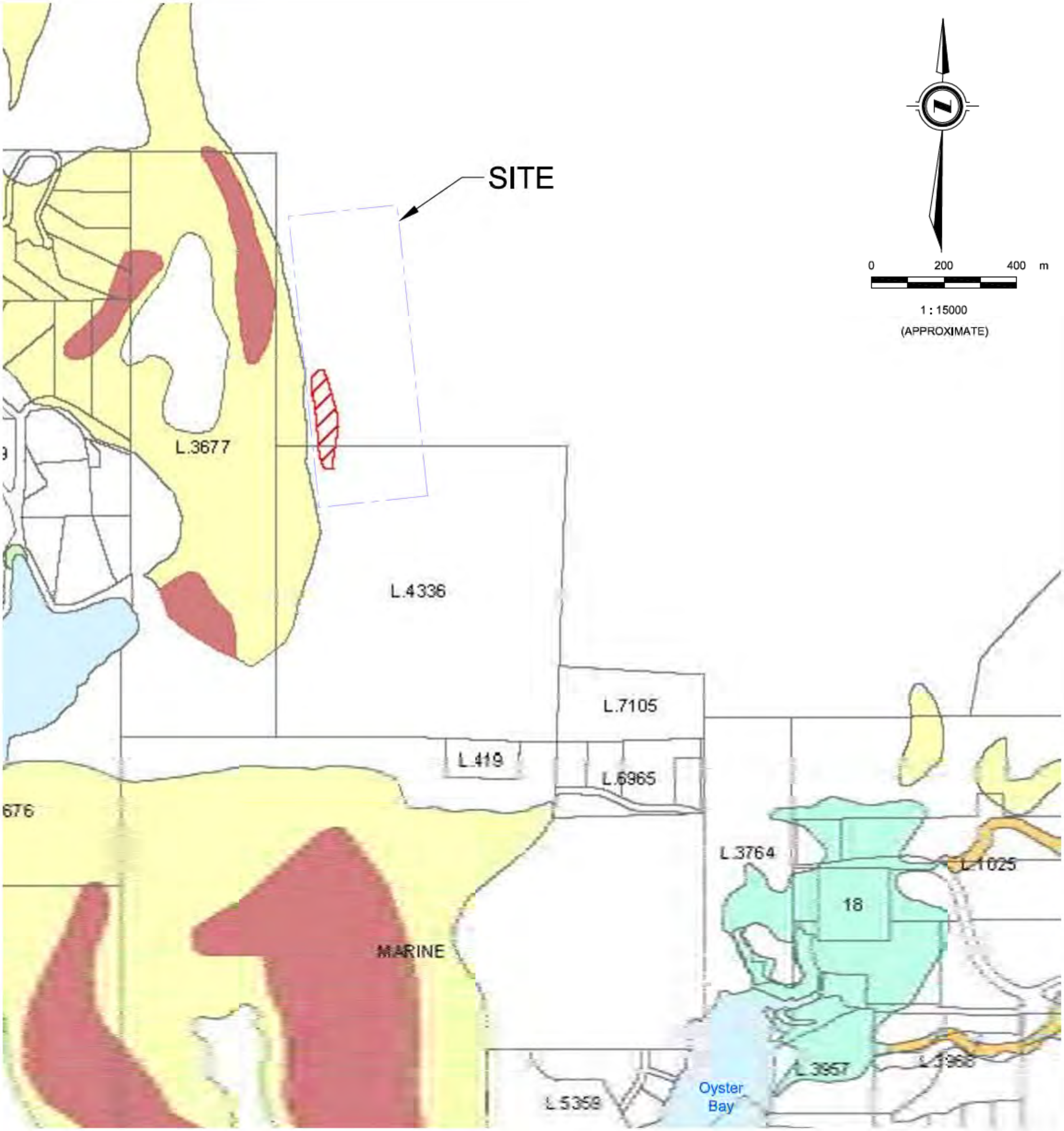
RESIDENTIAL SUITABILITY

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	B2

(file: R421110205001FIGA01+.dwg)



GAA4 - STEEP UPLAND SLOPE HAZARD

🟨 Moderate to Low Probability - 15 - 30 Degree Slope

🟥 High Probability > 30 Degree Slope

GAA7 - PENDER LANDFILL

▨ Pender Landfill

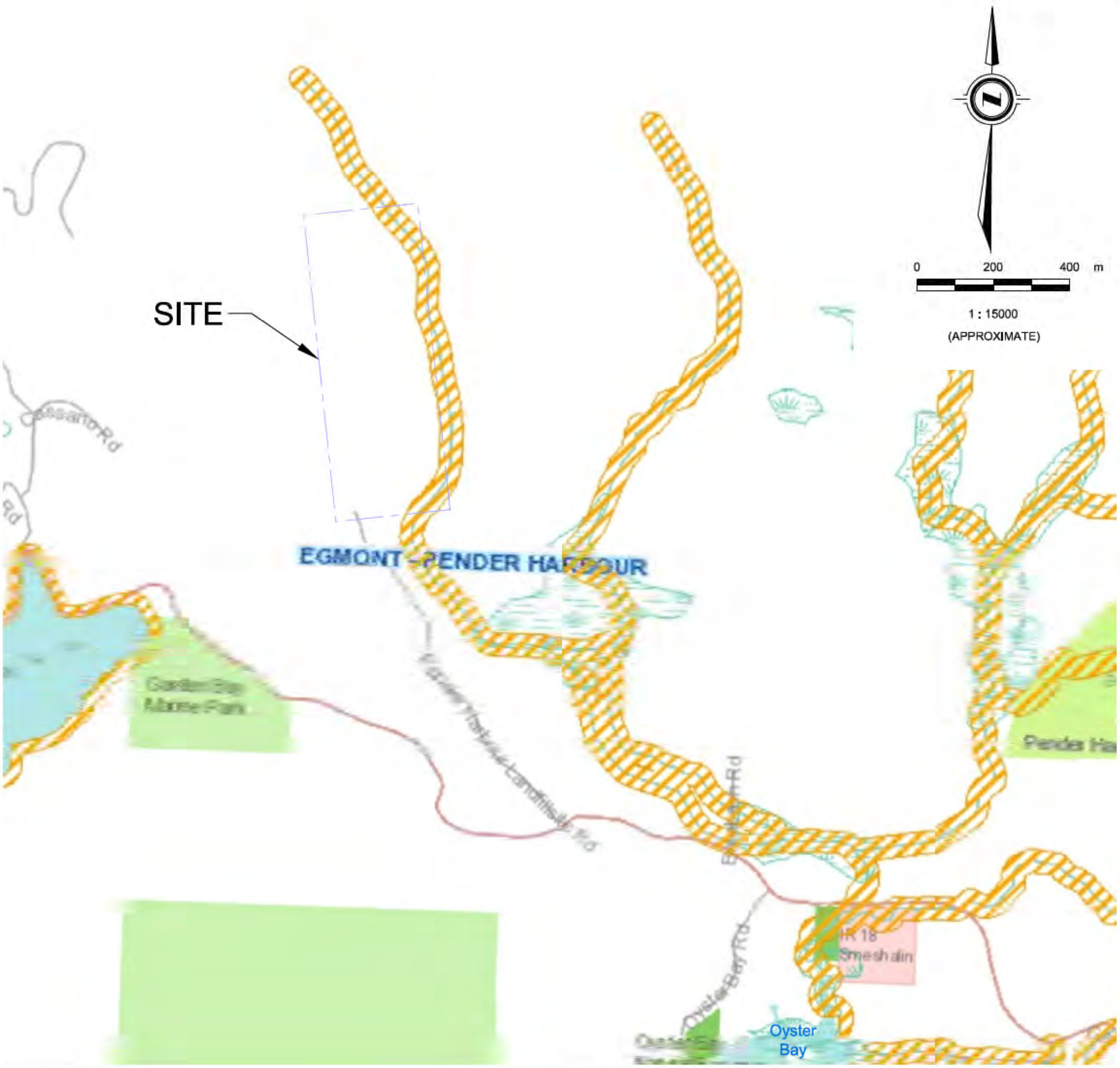
(file: R421110205001FIGA01+.dwg)

GEOTECHNICAL ASSESSMENT

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	B3



▨ RIPARIAN ASSESSMENT AREA

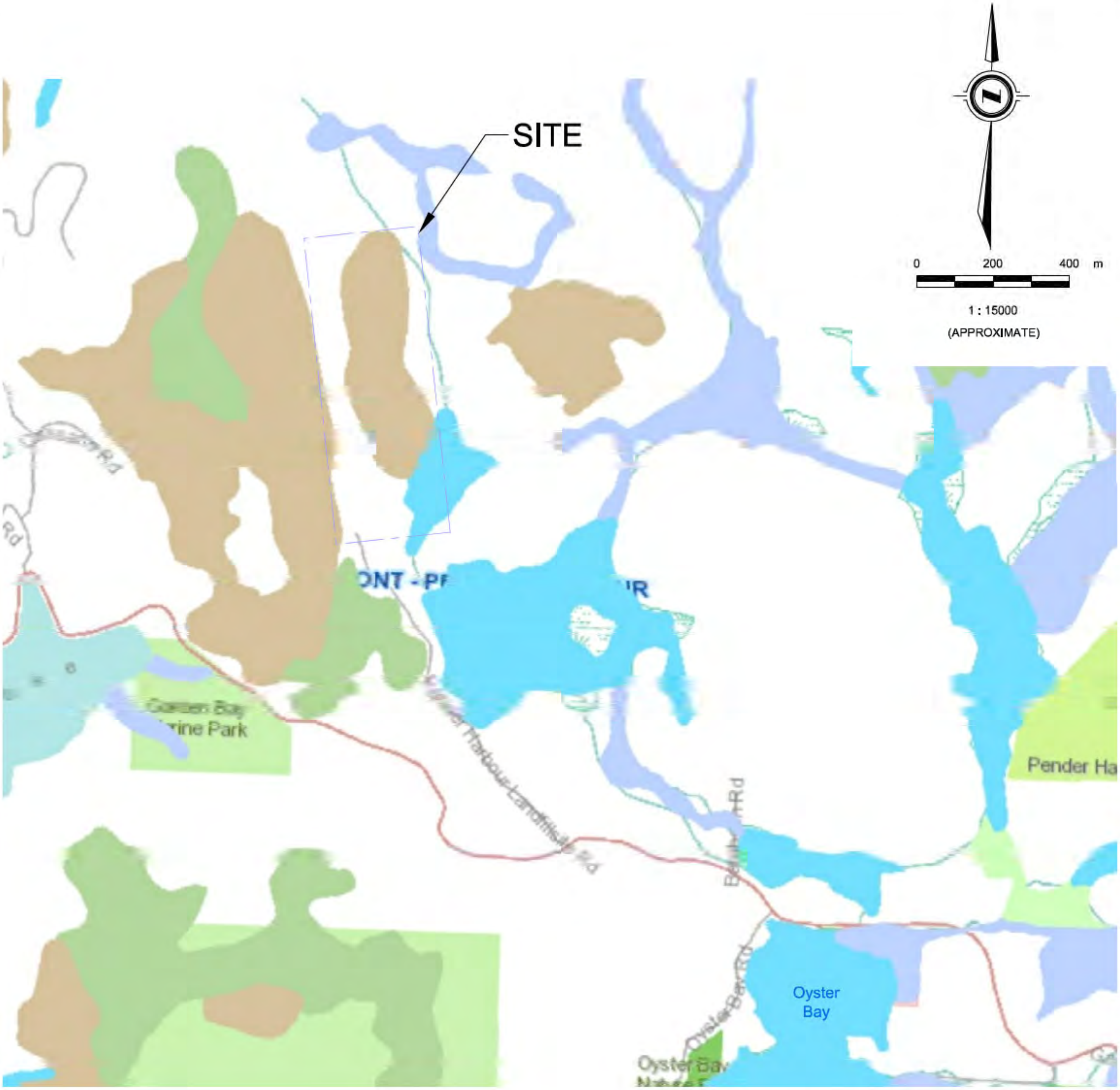
DEVELOPMENT PERMIT AREA

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

(file: R421110205001FIGA01+.dwg)

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	B4



🟫 WOODLAND ECOSYSTEM

🟦 WETLAND ECOSYSTEM

🟩 MATURE FOREST ECOSYSTEM

SENSITIVE ECOSYSTEM INVENTORY

CLOSURE PLAN
PENDER HARBOUR LANDFILL
SUNSHINE COAST REGIONAL DISTRICT

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
FEB 2014	4-2111-02-05	B5

(file: R421110205001FIGA01+.dwg)

APPENDIX C

WATER WELL RECORDS

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 70678

Owner: MACDONALD ROSS

Address: 5653 GARDEN BAY RD

Area:

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot: 6965 Plan: 19816 Lot: 2
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): 092G061133 Well: 4

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Well Use:
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: inches
Casing drive shoe:
Well Depth: 120 feet
Elevation: feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: 4 feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Construction Date: 1986-05-12 00:00:00

Driller: Nor-West Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 1.5 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Development Method:
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM): N

Water Utility: N
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material:
Method:
Depth (ft):
Thickness (in):

WELL CLOSURE INFORMATION:
Reason For Closure:

Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
CASING .7 TO 9.3,

LITHOLOGY INFORMATION:

From 0 to 4 Ft. SANDY BROWN SOIL

From 4 to 70 Ft. GRANITE WITH SOME CRACKS

From 0 to 0 Ft. 1 1/2 GPM at 104-112 FEET

From 104 to 112 Ft. GRANITE WITH SOME WATER

From 112 to 120 Ft. GRANITE

From 70 to 104 Ft. HARD GRANITE

- Return to Main
- Return to Search Options
- Return to Search Criteria

Report 1 - Detailed Well Record

Well Tag Number: 95908

Owner: Grainge

Address: 13468 Oyster Bay Road

Area: Garden Bay

WELL LOCATION:

Land District

District Lot: Plan: Lot:

Township: Section: Range:

Indian Reserve: Meridian: Block:

Quarter:

Island:

BCGS Number (NAD 27): 092G061133 Well:

Class of Well: Water supply

Subclass of Well: Domestic

Orientation of Well: Vertical

Status of Well: New

Well Use:

Observation Well Number:

Observation Well Status:

Construction Method:

Diameter: inches

Casing drive shoe: Y

Well Depth: 160 feet

Elevation: 62 feet (ASL)

Final Casing Stick Up: 12 inches

Well Cap Type: steel

Bedrock Depth: 18 feet

Construction Date: 2009-09-10 00:00:00

Driller: Nor-West Drilling

Well Identification Plate Number: 31001

Plate Attached By: Wayne Phips

Where Plate Attached: on casing

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: 10 (Driller's Estimate) U.S. Gallons per Minute

Development Method: Air lifting

Pump Test Info Flag: N

Artesian Flow:

Artesian Pressure (ft):

Static Level: 20 feet

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag: N

Field Chemistry Info Flag:

Site Info (SEAM):

Water Utility:

Water Supply System Name:

Water Supply System Well Name:

SURFACE SEAL:

Flag: Y

Material: Bentonite clay and cement mixture

Method: Poured

Depth (ft): 18 feet

Lithology Info Flag: Y

File Info Flag: N

Sieve Info Flag: N

Screen Info Flag: N

Site Info Details:

Other Info Flag:

Other Info Details:

Thickness (in): 1.5 inches

Liner from To: feet

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe
0	19	6	Steel	Y

GENERAL REMARKS:
WELL RECORD SUBMITTED THROUGH EWELLS.

LITHOLOGY INFORMATION:

```
From     0 to    16 Ft.      broken grey  granite

From    16 to   140 Ft.      some fractures grey  granite

From   140 to   160 Ft.    10 U.S. Gallons per Minute some fractures grey  granite
```

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 46735

Owner: BOB LETROY

Address: OYSTER BAY RD

Area: GARDEN BAY

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot: 5359 Plan: 13419 Lot: 2
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): 092G061133 Well: 1

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Well Use: Unknown Well Use
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 6.5 inches
Casing drive shoe:
Well Depth: 100 feet
Elevation: 0 feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: feet
Lithology Info Flag:

Construction Date: 1980-12-04 00:00:00

Driller: Ken's Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 8 (Driller's Estimate) U.S. Gallons per Minute
Development Method:
Pump Test Info Flag:
Artesian Flow:
Artesian Pressure (ft):
Static Level: 2 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag:
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag:
Material:
Method:
Depth (ft):

File Info Flag:

Sieve Info Flag:

Screen Info Flag:

Site Info Details:

Other Info Flag:

Other Info Details:

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
GOOD SUPPLY. GOOD QUALITY.

LITHOLOGY INFORMATION:

From 0 to 5 Ft. Overburden.

From 5 to 12 Ft. Casing-bedrock

From 12 to 35 Ft. 1 GPM

From 35 to 55 Ft. 2,5-3 GPM

From 55 to 85 Ft. 8 GPM

From 85 to 90 Ft. 10 GPM

From 90 to 100 Ft. Total Depth.

- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 100463

Owner: PARE

Address: 13366 OYSTER BAY ROAD

Area: PENDER HARBOUR

WELL LOCATION:
NEW WESTMINSTER Group 1 Land District
District Lot: 5359 Plan: 11301 Lot: 1
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): 092G061133 Well: 5

Class of Well: Water supply
Subclass of Well:
Orientation of Well: Vertical
Status of Well: New
Well Use:
Observation Well Number:
Observation Well Status:
Construction Method:

Diameter: inches
Casing drive shoe: N N
Well Depth: 150 feet
Elevation: feet (ASL)
Final Casing Stick Up: 12 inches
Well Cap Type:
Bedrock Depth: 1 feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 1996-05-24 00:00:00

Driller: Tri-K Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 3 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material: Bentonite clay
Method:
Depth (ft):
Thickness (in):
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

```
-1                        20                        null                      Steel                     N
20                        150                       6                         Open hole                 N
```

```
GENERAL REMARKS:
 PITLESS:  WELDED, NEW


LITHOLOGY INFORMATION:

From     0 to     4 Ft.   SOIL, BROKEN BEDROCK

From     4 to   150 Ft.   PREDOMINANTLY LIGHT BLUE/GREEN    vari-coloured  volcanic

From     4 to    90 Ft.   SOLID HARD FORMATION

From    90 to    95 Ft.   BROKEN AREA - TRACES OF FELDSPAR .5 Gallons per Minute (U.S./Imperial) WATER

From    95 to   115 Ft.   CHANGES IN ROCK

From   117 to       Ft.   FRACTURE 1.5 Gallons per Minute (U.S./Imperial) WATER INCREASED

From   135 to       Ft.   FRACTURE 3 Gallons per Minute (U.S./Imperial) TOTAL WATER; DRILLED 150 FT WITH 20 FT OF CASING INSTALLED
```

- Return to Main

- Return to Search Options
- Return to Search Criteria

APPENDIX D

HISTORIC GROUNDWATER ELEVATION DATA

Table D1 Historic Depths to Groundwater

Monitoring Well	Groundwater Elevation (mbgs)																			
	Sep-94	Dec-94	Mar-95	Jun-95	Nov-95	Dec-95	Mar-96	Jun-96	Sep-96	Jan-97	Apr-97	Jun-97	Oct-97	Jan-98	May-98	Jul-98	Oct-98	Dec-98	Mar-99	Sep-99
Site 1	2.395	1.635	1.54	1.795	1.315	0.745	1.615	1.645	1.705	0.945	1.575	1.695	1.295	1.445	1.535	1.615	1.695	1.515	0.935	1.635
Site 4									0.37	0.12	0.26	0.28	0.2	0.19	0.2	0.28	0.28	0.24	0.12	0.33
Site 5									0.21	-0.09	0.12	0.21	0.15	0.11	0.2	0.24	0.26	0.19	0.07	0.34

Notes:
mbgs - Metres below ground surface

Table D1 Historic Depths to Groundwater

Monitoring Well	Groundwater Elevation (mbgs)																			
	Dec-99	May-00	Jun-00	Sep-00	Dec-00	Mar-01	Jul-01	Sep-01	Dec-01	Jun-02	Oct-02	Feb-03	Mar-03	Sep-03	Mar-04	Dec-04	Mar-05	Feb-06	May-06	Sep-06
Site 1	1.395	1.395	1.485	2.065	1.42	1.48	1.63	2.06	1.6	1.6	2.58	2.1	2.2	2.41	1.5	1.3	1.53	1.165	1.615	2.615
Site 4	0.12	0.12	0.18	0.28	0.24	0.24	0.27	0.28	0.12	0.26	0.26	0.14	0.14	0.28	0.13	0.18	0.58	0.22	0.15	0.26
Site 5	-0.09	0.43	0.17	0.24	0.12	0.16	0.24	0.33	0.07	0.24	0.57	0.11	1.22	0.68	0.18	0.08	0.24	0.03	0.32	0.75

Notes:
mbgs - Metres below ground surface

Table D1 Historic Depths to Groundwater

Monitoring Well	Groundwater Elevation (mbgs)																				
	Nov-06	Apr-07	Jul-08	Sep-08	Oct-08	Nov-08	Apr-09	Jul-09	Dec-09	Mar-10	Aug-10	Sep-10	Dec-10	Mar-11	Aug-11	Oct-11	Dec-11	Apr-12	Aug-12	Nov-12	Dec-12
Site 1	1.165	2.195	1.795	2.995	1.565	1.755	1.495	2.005	1.575	2.195	1.725	1.635	1.295	1.435	1.555	1.635	1.295	1.465	1.575	1.205	1.635
Site 4	0.2	0.09	0.08	0.28	0.17	0.15	0.23	0.66	0.07	0.15	0.48	0.17	0.03	0.07	0.19	0.16	0.06	0.05	1.15	0.07	0.01
Site 5	0.05	0.11	0.36	0.3	0.21	0.17	0.19	0.39	0.07	0.13	0.33	0.23	0.07	-0.04	0.35	0.3	0.06	0.1	0.29	-0.04	0.03

Notes:
mbgs - Metres below ground surface

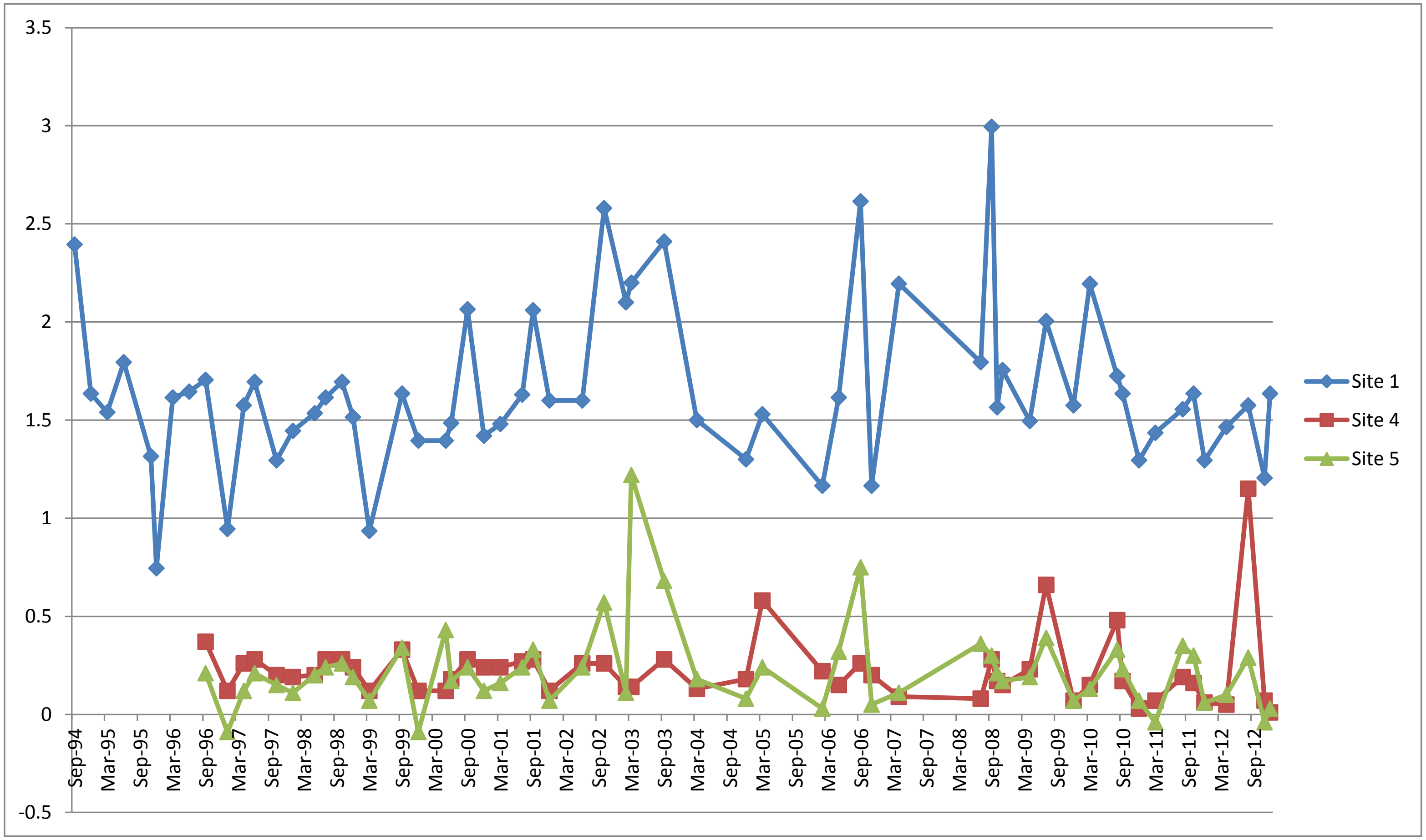


Figure D1 Historic Depths to Groundwater

APPENDIX E

GEOTECHNICAL INVESTIGATION

Foundations,
Excavation &
Shoring
Specialists

Braun Geotechnical
110 – 19188 94th Ave
Surrey, BC
V4N 4X8
Tel: 604-513-4190
Fax: 604-513-4195
info@braungeo.com

www.braungeo.com

Foundations

Excavation &
Shoring

Slope Stability

Natural Hazards

Pavement Design
and Management

Reinforced Soil
Walls and Slopes

Professional Engineers and Geoscientists of BC MEMBER

February 6, 2014

Our File: 13-5996

Via email: Michel@xcg.com

XCG Consultants Ltd.
10455 84th Avenue
Edmonton, Alberta
T6E 2H3

Attention: Michel Lefebvre, M.Sc., P.Eng.

Re: Geotechnical Report
Pender Harbour Landfill Slope Stability Assessment

1.0 INTRODUCTION

As requested, Braun Geotechnical Ltd. has carried out a geotechnical exploration and slope stability assessment for the above referenced project. The geotechnical work has been performed in general accordance with the Braun Geotechnical Fee Estimate dated August 23, 2013 (reference no. P13-3994).

The geotechnical work scope included a test pit exploration and provision of this geotechnical report with comments and recommendations pertaining to slope stability of the existing Municipal Solid Waste (MSW) mass. The slope assessment work has been carried out in general accordance with the Landfill Criteria for Municipal Solid Waste (June 1993).

Note that the slope stability assessment is based on an assumption that the MSW mass is not bottom lined (i.e. no clay/geocomposite liner).

The scope of services was limited to the evaluation of geotechnical characteristics of the site with respect to slope stability, and no consideration has been given to any environmental issues.

2.0 SITE AND PROJECT DESCRIPTION

The subject site is the existing Pender Harbour Landfill located in Medeira Park, BC. The site is irregularly shaped with maximum overall dimensions of approximately 355 by 135m. The site is located at the toe of an approximately 120m high bedrock controlled slope that is inclined at approximately 2H:1V (Horizontal to Vertical).

The western portion of the site is comprised of a benched, upper, relatively flat terrace like area. At the time of report preparation, active landfilling was taking place on the northern portion of the upper area. Existing office/gatehouse, scale, recycling and bin areas were located on the southern portion of the upper area. After closure, the southern area will be used as a transfer station, and waste will be trucked off site. The transfer station would include collection bins placed adjacent to a new elevated roadway.

The east side of the site slopes down approximately 23m at 1.9H:1V, with localized areas as steep as 0.8H:1V. An approximately 7m wide sand road/berm is located at the toe of slope, with a pond located immediately to the east.

It is understood that a slope stability assessment was required for the proposed landfill closure. Contours of the existing landfill were provided in the Aero Geometrics Ltd. drawing "13144-SCRD-Pender-Harbour-Landfill-Plan," dated September 13, 2013, attached for reference.

The critical section used for the slope stability assessment is also attached for reference (Dwg. 13-5996-02).

3.0 DESK STUDY INFORMATION & SITE WALKOVER

The Desk Study phase of geotechnical services was non-intrusive in nature, and involved update and review of available geological and geotechnical information and update and review of available historical aerial photographs.

The following geotechnical comments based on the desk study information are provided:

- A review of historical government air photos available for most decades dating back to 1947 were reviewed. Obvious visible features and/or tones to indicate past or incipient onsite slope movements were not observed on the photographs.
- Obvious visible features and/or tones to indicate past or incipient offsite slope movements in the immediate vicinity of the study site and considered to have potential for having an impact on or be impacted by the study site were not observed on the photographs.
- Initial clearing and development of the subject site occurred between 1972 and 1978 based on the air photos.

A site walkover review was carried out on October 30, 2013, with a follow-up site walkover review on November 14, 2013. The following geotechnical comments based on the site walkover review are provided:

- Bedrock outcrops were observed immediately west of the subject site, on the natural east facing slope.
- An approximately 7m wide roadway was observed at the toe of the MSW mass. It is understood from discussions with onsite personnel that the roadway is a sand filter.
- A pond was observed immediately east of the sand filter.
- Mr. Don White of Indian Isle Construction was interviewed on site on November 14, 2013. It is understood that Mr. White has been involved with work on the site since the early stages of landfilling. Based on discussions with Mr. White, it is understood that the natural material within the pond area was sub-excavated, and replaced with silty fill material. It is also understood that the preferred method of landfilling was to construct a maximum 2m high berm using granular fill followed by placement of MSW behind the berm. For the subsequent stage of landfilling, a granular fill berm would be constructed offset from lower berm, and MSW would be placed behind it.

4.0 SUBSURFACE EXPLORATION

Ten test pits (TP13-01 to TH13-10) were excavated on November 14, 2013 using a tracked excavator and operator supplied by the client. The test pits were excavated to depths of approximately 1.1 to 3.4m. TP13-01 to -04, -08 and -09 were excavated on the existing MSW mass slope, TP13-10 was excavated within the existing sand filter at the toe of the MSW mass slope, and TP13-05 to TP13-07 were excavated within the south portion of the upper terrace area in order to determine the approximate extent of existing fill. The approximate test pit locations are shown on the attached location plan (Dwg. 13-5996-01). The soil conditions were logged in the field and representative samples were retrieved for further classification.

5.0 SOIL AND GROUNDWATER CONDITIONS

The results of the test pits are summarized on the enclosed test pit logs. The logs provide complete, detailed descriptions of the soils encountered in the exploration and should be used in preference to the generalized summary given below.

MSW Mass Area

Test pits in the upper portion of the MSW mass area (TP13-01 to -04) generally encountered a relatively thin near surface organics zone underlain by sand, and MSW at depth. The organics zone typically comprised sandy organics with some silt and occasional rootlets, and was absent in TP13-03 and -04. Loose to compact sand fill with some gravel and silt, and occasional cobbles and boulders was encountered below to depths of 0.5 to 2.1m. Occasional zones of MSW were encountered throughout the organics and sand fill layers. MSW with variable mineral fill content was encountered below to the extent of the test pits. Groundwater was not encountered in test pits in this portion of the site.

Test pits in the lower portion of the MSW mass area (TP13-08 and -09 at the bottom of the east slope) generally encountered loose to compact sand with some gravel, silt and occasional cobbles and boulders to a depth of 2.4m at TP13-09 and to the bottom of the test pit at TP13-08. The sand fill included zones of MSW at TP13-08, and near surface zones of organics at TP13-09. Very dense silty sand to very stiff sandy silt was encountered below 2.4m at TP13-09. Static groundwater was encountered within TP13-08 at a depth of 2.6m. Sidewall seepage was encountered within TP13-09 at a depth of 2.4m.

Proposed Transfer Station Area

Test pits in the proposed transfer station area (TP13-05 to -07) generally encountered sand and gravel fill over MSW or very dense Till-Like soils. The sand and gravel fill was typically compact and contained trace to some silt, and occasional cobbles and asphalt fragments. The fill was mixed with MSW from 0.3 to 1.1m at TP13-05. Very dense Till-Like soils were encountered below 1.1m at TP13-06 and -07. Groundwater was not observed in the open test pits in this portion of the site.

Sand Filter Area

Test pit TP13-10 in the sand filter area located at the base of the east slope generally encountered loose to compact sand with trace to some silt and gravel, and occasional cobbles and boulders from surface to the depth of the test pit at 2.0m. A static groundwater level was observed at 1.2m depth at the time of exploration.

The subsurface conditions described above were encountered at the test pit locations only. Subsurface conditions at other locations could vary. Groundwater levels and near-surface run-off flows are expected to fluctuate seasonally, and with drainage conditions.

6.0 SLOPE STABILITY ASSESSMENT

6.1 General

The purpose of the slope stability assessment was to evaluate the stability of the MSW mass for static and seismic loading conditions. The slope assessment was based on the available site information, the site walkover review, and findings from the test pit exploration, as well as topographic information provided by XCG Consultants.

The findings of the exploration indicate that subsurface condition in the MSW mass slope area consist of varying depths of organic/mineral fill overlying MSW, over natural compact to very dense/very stiff soils. Obvious visible evidence to suggest immediate stability concerns with the existing slope was not revealed during the assessment.

However, it is considered that some localized shallow sloughing requiring maintenance may occur within the surficial fill soils, especially under periods of extended rainfall.

6.2 Factor of Safety Discussion

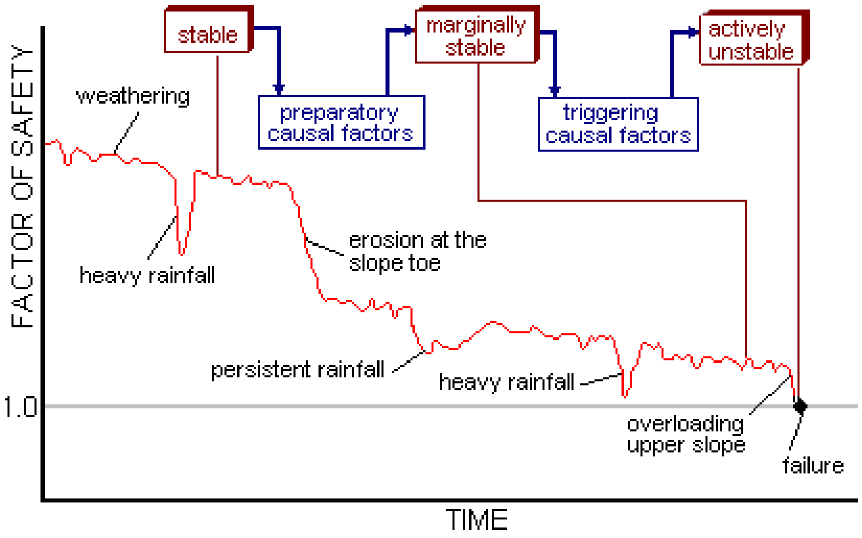
Current BC Building Code (2012) requires a clear and simple distinction between stable and unstable slope conditions for structures, expressed as a computed value of the factor of safety. Further, the current BC Building Code requires that slope performance under both static and seismic conditions be addressed as part of foundation design.

Minimum acceptable factors of safety are presented in the building code reference document 1991 BC Mine Dump Guidelines and 2006 Canadian Foundation Engineering Manual, and indicate that for slopes in static condition the factor of safety should be at least 1.3.

The minimum factor of safety indicated above has been adopted for this assessment. Further, based on information provided by XCG Consultants, the seismic hazard probability with a 10% probability of exceedance in 50 years (~1:475 return period) has been adopted for consideration in the seismic slope stability assessment for the MSW mass.

Calculated factors of safety only present a baseline (or 'snapshot') assessment of slope conditions at the time of analysis, and may not present an accurate representation of slope conditions over the long term. The following diagram is provided for illustration:

Influence Factors on Slope Stability (after Popescu, 1994)



Preparatory Causal Factor – factor that makes the slope susceptible to movement (ie. tend to place the slope in a marginally stable state).

Triggering Causal Factor – factor that initiates slope movement (ie. tend to place the slope from a marginally stable state to an actively unstable state).

Site slopes are considered stable in the condition where the margin of stability is sufficiently large to withstand all reasonably foreseeable destabilizing forces. Slopes are considered marginally stable if they will fail at some time in the future in response to foreseeable destabilizing forces that reach a certain level of activity. Slopes are considered actively unstable if they are undergoing intermittent movement or on-going creep caused by destabilizing forces.

Man-made processes with potential to negatively impact the stability of slopes and/or promote erosion include, but may not be limited to the following:

- Excavations into the slope or slope toe areas
- Water leakage from waterlines
- Excessive vibration from heavy machinery, such as compaction equipment or pile drivers
- Defective maintenance of slope drainage systems
- Loading of slopes and/or slope crests (fill, structures, etc.)
- Construction of ponds, pools, or other water retention structures with potential for uncontrolled leakage
- Unexpected changes to groundwater flow regimes due to development in the area.

Natural processes with potential to negatively impact the stability of the steep site slopes include, but may not be limited to the following:

- Extended periods of seasonally wet weather
- Storm events with exceptionally high rainfall intensity and duration
- Erosion of slope toe areas
- Earthquake events
- Removal of slope vegetation cover by disease or fire.

6.3 Slope Stability Analysis

Static analyses to assess stability of the slope were run using the limit equilibrium software, SLIDE (RocScience, 2007) based on the subsurface conditions encountered during the test pit exploration and estimated bottom of MSW elevations.

The soil parameters used in the assessment are provided in the table below:

Material	**Soil Type**	**Soil Strength Parameters**		
		Unit Weight (kN/m3)	*Internal Friction Angle*	*Cohesion (kPa)*
1.	Organics	16	28°	1.5
2.	Granular Fill	20	35°	1.5*
3.	MSW	12	30°	1
4.	Very Dense/Very Stiff SAND/SILT	20	38°	1
5.	SAND Berm	18	34°	0
6.	Pond Material	18	25°	1
7.	Bedrock**			

*Apparent cohesion intercept.
**Bedrock considered an infinite strength material in analysis.

As indicated above, an apparent cohesion intercept of 1.5 kPa was used for the sandy organics/granular fill zone in the analysis due to negative pore water pressure in unsaturated soils (Rinaldi and Gasagli 1999).

The analyses indicated the computed static factor of safety is greater than 1.3 and is considered to be within an acceptable range.

Pseudo-dynamic analysis to assess stability under seismic loading conditions was also carried out. A design horizontal acceleration of 0.194g associated with an earthquake event with a return period of 1 in 475 years (10% probability in 50 years) was used for the pseudo-dynamic analysis. Seismic slope deformation was estimated using updated procedures for estimating earthquake-induced deviatoric slope displacements per Bray and Travasarou, 2007.

The findings of the analysis indicate that seismic slope displacements would be expressed at approximately the crest of the MSW mass slope. The estimated median permanent slope displacements along the slip surface resulting from design seismic loading were in the order of 10cm. This is less than the typical acceptable limit of 30cm adopted by other approving authorities concerning seismically induced permanent displacements.

Results of the analysis are attached for static, seismic, and yield acceleration loading conditions.

7.0 GEOTECHNICAL CONSIDERATIONS

7.1 Maximum Contact Pressure

Based on a maximum MSW mass height of approximately 24m, a maximum surcharge of approximately 300kPa under confined conditions is anticipated. The underlying native very dense/very stiff sand/silt soils encountered are considered capable of supporting the maximum anticipated contact pressure under confined conditions.

The natural underlying soils are classified as “Competent: highly competent bedrock or soil of equal or greater strength than the dump materials, and which is insensitive to pore pressure generation or strength reduction due to loading” (British Columbia Mine Waste Rock Pile Research Committee “Mined Rock and Overburden Piles Investigation and Design Manual – Interim Guidelines,” dated May 1991). Further, the underlying soils are not considered susceptible to liquefaction and/or stain softening under seismic loading conditions.

7.2 Differential Settlements

Differential settlement of the underlying natural subgrade soils over time is anticipated to be negligible relative to differential settlements typically experienced in MSW. Based on reference information provided by XCG Consultants, typical average settlement of the waste mass of 11 percent of the overall depth can be expected (McBean et al, 1995). As such, the impact of any potential minor differential settlement of the surficial soils is deemed to be negligible and not anticipated to adversely impact landfill infrastructure.

7.3 Control of Surface Water

It is considered that the most likely risk of instability to the MSW mass is that resulting from uncontrolled surface water and rising groundwater. Measures to control surface water should be implemented to improve long term stability and may include installation of ditches and pipes to catch water from adjacent and areas above such that it circumvents the MSW mass. In addition, the active landfill area may be graded to allow water to run off and reduce infiltration into the landfill and/or the area may be capped with relatively low permeability soil.

7.4 Surficial Vegetation

The MSW mass slope is currently heavily vegetated. Maintaining the vegetation is considered an important aspect of surficial stability (i.e. cohesion due to surficial organics was included in the stability analyses). Removal of existing vegetation should be avoided. If any areas are cleared, they should be immediately re-vegetated. After closure, the active area should also be capped as required, and vegetated.

8.0 CLOSURE

This report is prepared for the exclusive use of XCG Consultants Ltd. and their designated representatives and may not be used by other parties without the written permission of Braun Geotechnical Ltd. The Sunshine Coast Regional District may also rely on the findings of this report.

The use of this assessment report is subject to the conditions on the attached Report Interpretation and Limitations sheet. The reader's attention is drawn specifically to those conditions, as it is considered essential that they be followed for proper use and interpretation of this report.

We hope the above meets with your requirements. Should any questions arise, please do not hesitate to contact the undersigned.

Yours truly,
Braun Geotechnical Ltd.

PROFESSIONAL
PROVINCE OF
H. DHILLON
39484
BRITISH COLUMBIA
ENGINEER

Feb 11/2014

Harman Dhillon, P.Eng.
Geotechnical Engineer

Braun Geotechnical Ltd.

Sonny Singha, P.Eng.
Geotechnical Engineer

Encl: Report Interpretation and Limitation
Location Plan
Test Pit Logs
Critical Section
Select SLIDE (RocScience 2007) output (3)
Aero Geometrics Ltd. drawing "13144-SCRD-Pender-Harbour-Landfill-Plan," dated September 13, 2013

X:\2013 Projects\13-5996 Pender Harbour Landfill\Report 13-5996 2014-01-14.docx

REPORT INTERPRETATION AND LIMITATIONS

1. STANDARD OF CARE

Braun Geotechnical Ltd. (Braun) has prepared this report in a manner consistent with generally accepted engineering consulting practices in this area, subject to the time and physical constraints applicable. No other warranty, expressed or implied, is made.

2. COMPLETENESS OF THIS REPORT

This Report represents a summary of paper, electronic and other documents, records, data and files and is not intended to stand alone without reference to the instructions given to Braun by the Client, communications between Braun and the Client, and/or to any other reports, writings, proposals or documents prepared by Braun for the Client relating to the specific site described herein.

This report is intended to be used and quoted in its entirety. Any references to this report must include the whole of the report and any appendices or supporting material. Braun cannot be responsible for use by any party of portions of this report without reference to the entire report.

3. BASIS OF THIS REPORT

This report has been prepared for the specific site, development, design objective, and purpose described to Braun by the Client or the Client's Representatives or Consultants. The applicability and reliability of any of the factual data, findings, recommendations or opinions expressed in this document pertain to a specific project at described in this report and are not applicable to any other project or site, and are valid only to the extent that there has been no material alteration to or variation from any of the descriptions provided to Braun. Braun cannot be responsible for use of this report, or portions thereof, unless we were specifically requested by the Client to review and revise the Report in light of any alterations or variations to the project description provided by the Client.

If the project does not commence within 18 months of the report date, the report may become invalid and further review may be required.

The recommendations of this report should only be used for design. The extent of exploration including number of test pits or test holes necessary to thoroughly investigate the site for conditions that may affect construction costs will generally be greater than that required for design purposes. Contractors should rely upon their own explorations and interpretation of the factual data provided for costing purposes, equipment requirements, construction techniques, or to establish project schedule.

The information provided in this report is based on limited exploration, for a specific project scope. Braun cannot accept responsibility for independent conclusions, interpretations, interpolations or decisions by the Client or others based on information contained in this Report. This restriction of liability includes decisions made to purchase or sell land.

4. USE OF THIS REPORT

The contents of this report, including plans, data, drawings and all other documents including electronic and hard copies remain the copyright property of Braun Geotechnical Ltd. However, we will consider any reasonable request by the Client to approve the use of this report by other parties as "Approved Users." With regard to the duplication and distribution of this Report or its contents, we authorize only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of this Report by those parties. The Client and "Approved Users" may not give, lend, sell or otherwise make this Report or any portion thereof available to any other party without express written permission from Braun. Any use which a third party makes of this Report – in its entirety or portions thereof – is the sole responsibility of such third parties. BRAUN GEOTECHNICAL LTD. ACCEPTS NO RESPONSIBILITY FOR DAMAGES SUFFERED BY ANY PARTY RESULTING FROM THE UNAUTHORIZED USE OF THIS REPORT.

Electronic media is susceptible to unauthorized modification or unintended alteration, and the Client should not rely on electronic versions of reports or other documents. All documents should be obtained directly from Braun.

5. INTERPRETATION OF THIS REPORT

Classification and identification of soils and rock and other geological units, including groundwater conditions have been based on exploration(s) performed in accordance with the standards set out in Paragraph 1. These tasks are judgemental in nature; despite comprehensive sampling and testing programs properly performed by experienced personnel with the appropriate equipment, some conditions may elude detection. As such, all explorations involve an inherent risk that some conditions will not be detected.

Further, all documents or records summarizing such exploration will be based on assumptions of what exists between the actual points sampled at the time of the site exploration. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of and accept this risk.

The Client and "Approved Users" accept that subsurface conditions may change with time and this report only represents the soil conditions encountered at the time of exploration and/or review. Soil and ground water conditions may change due to construction activity on the site or on adjacent sites, and also from other causes, including climactic conditions.

The exploration and review provided in this report were for geotechnical purposes only. Environmental aspects of soil and groundwater have not been included in the exploration or review, or addressed in any other way.

The exploration and Report is based on information provided by the Client or the Client's Consultants, and conditions observed at the time of our site reconnaissance or exploration. Braun has relied in good faith upon all information provided. Accordingly, Braun cannot accept responsibility for inaccuracies, misstatements, omissions, or deficiencies in this Report resulting from misstatements, omissions, misrepresentations or fraudulent acts of persons or sources providing this information.

6. DESIGN AND CONSTRUCTION REVIEW

This report assumes that Braun will be retained to work and coordinate design and construction with other Design Professionals and the Contractor. Further, it is assumed that Braun will be retained to provide field reviews during construction to confirm adherence to building code guidelines and generally accepted engineering practices, and the recommendations provided in this report. Field services recommended for the project represent the minimum necessary to confirm that the work is being carried out in general conformance with Braun's recommendations and generally accepted engineering standards. It is the Client's or the Client's Contractor's responsibility to provide timely notice to Braun to carry out site reviews. The Client acknowledges that unsatisfactory or unsafe conditions may be missed by intermittent site reviews by Braun. Accordingly, it is the Client's or Client's Contractor's responsibility to inform Braun of any such conditions.

Work that is covered prior to review by Braun may have to be re-exposed at considerable cost to the Client. Review of all Geotechnical aspects of the project are required for submittal of unconditional Letters of Assurance to regulatory authorities. The site reviews are not carried out for the benefit of the Contractor(s) and therefore do not in any way effect the Contractor(s) obligations to perform under the terms of his/her Contract.

7. SAMPLE DISPOSAL

Braun will dispose of all samples 3 months after issuance of this report, or after a longer period of time at the Client's expense if requested by the Client. All contaminated samples remain the property of the Client and it will be the Client's responsibility to dispose of them properly.

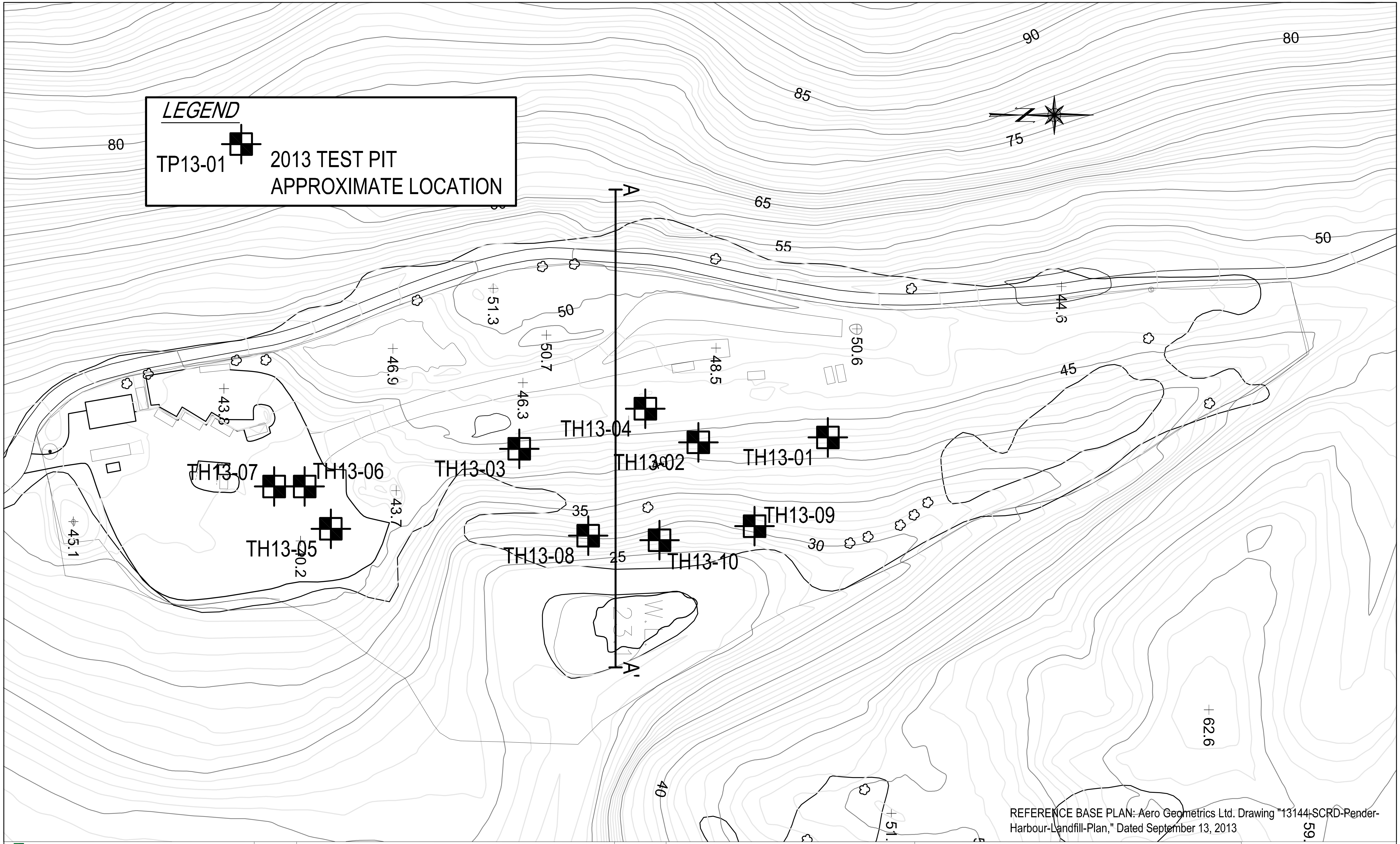
8. SUBCONSULTANTS AND CONTRACTORS

Engineering studies frequently requires hiring the services of individuals and companies with special expertise and/or services which Braun Geotechnical Ltd. does not provide. These services are arranged as a convenience to our Clients, for the Client's benefit. Accordingly, the Client agrees to hold the Company harmless and to indemnify and defend Braun Geotechnical Ltd. from and against all claims arising through such Subconsultants or Contractors as though the Client had retained those services directly. This includes responsibility for payment of services rendered and the pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. These conditions apply to specialized subconsultants and the use of drilling, excavation and laboratory testing services, and any other Subconsultant or Contractor.

9. SITE SAFETY

Braun Geotechnical Ltd. assumes responsibility for site safety solely for the activities of our employees on the jobsite. The Client or any Contractors on the site will be responsible for their own personnel. The Client or his representatives, Contractors or others retain control of the site. It is the Client's or the Client's Contractors responsibility to inform Braun of conditions pertaining to the safety and security of the site – hazardous or otherwise – of which the Client or Contractor is aware.

Exploration or construction activities could uncover previously unknown hazardous conditions, materials, or substances that may result in the necessity to undertake emergency procedures to protect workers, the public or the environment. Additional work may be required that is outside of any previously established budget(s). The Client agrees to reimburse Braun for fees and expenses resulting from such discoveries. The Client acknowledges that some discoveries require that certain regulatory bodies be informed. The Client agrees that notification to such bodies by Braun Geotechnical Ltd. will not be a cause for either action or dispute.



REFERENCE BASE PLAN: Aero Geometrics Ltd. Drawing "13144-SCRD-Pender-Harbour-Landfill-Plan," Dated September 13, 2013

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Rev.	Description	Date

Client: XCG CONSULTANTS LTD.

Project: PENDER HARBOUR LANDFILL
PENDER HARBOUR, BC

Title: LOCATION PLAN

Project no.	Drawn	Design	Checked	Date	Scale	Drawing no.
13-5996	HD	HD	SS	January 16, 2013	1:1000	13-5996-01

Test Hole Log: TP13-01

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

Depth		Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft 0 m		○	dark-brown, damp, loose sandy ORGANICS, trace to some silt, occasional rootlets, occasional municipal solid waste (ORGANIC FILL)	S1		
1 2		○	brown, damp, loose to compact SAND, some gravel, trace to some silt, occasional cobbles and boulders, occasional municipal solid waste (FILL)	S2		
3 1 4 5 6 2 7 8 9 3 10 11			moist, loose MUNICIPAL SOLID WASTE mixed with grey to brown, variable, SAND, some gravel, some silt, with occasional silty zones (MSW)			
12 13 4			End of Test Pit @ 3.4m			

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP01
Page: 1 of 1

Test Hole Log: TP13-02

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

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Depth		Sample	Soil Description	Sample #	Water Cont.	Remarks
			dark-brown, damp, loose sandy ORGANICS, trace to some silt, occasional rootlets, occasional municipal solid waste (ORGANIC FILL)			
			brown, damp, loose SAND, some gravel, some silt, occasional cobbles and boulders, occasional municipal solid waste (FILL)			
			moist, loose MUNICIPAL SOLID WASTE, trace to some variable mineral fill, includes zones of variable mineral FILL with some municipal solid waste up to 0.5m thick (MSW)			
			End of Test Pit @ 2.4m			

ft: 0 1 2 3 4 5 6 7 8 9 10 11 12 13
m: 0 1 2 3 4

Equipment: Tracked Excavator
Sampling Method: Lump Sample
Datum: Ground Surface
Water Depth: Not Encountered
Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP02
Page: 1 of 1

Test Hole Log: TP13-03

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

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Depth ft	Depth m		Sample	Soil Description	Sample #	Water Cont.	Remarks
0	0			dark grey-brown, damp, loose SAND, some silt, some gravel, some organics (ORGANIC FILL)			
1							
2				grey-brown, damp, loose SAND, some gravel, trace to some silt, occasional municipal solid waste (FILL)			
3	1						
4			○		S1		
5							
6	2						
7				damp, loose, MUNICIPAL SOLID WASTE mixed with brown to grey-brown SAND, some gravel, some silt (MSW)			
8							
9							
10	3			End of Test Pit @ 3.0m			
11							
12							
13	4						

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP03
Page: 1 of 1

Test Hole Log: TP13-04

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

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Depth			Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft	0 m			brown, damp, loose SAND, some silt, some organics, occasional roots, occasional municipal solid waste (FILL)			
1 2 3	1			grey to grey-brown, variable, damp, loose SAND, some gravel, some silt, occasional cobbles and boulders, occasional organics, occasional municipal solid waste (FILL)			
4 5 6	2			moist to wet, loose, MUNICIPAL SOLID WASTE mixed with grey to brown, variable, SAND, some gravel, some silt, with occasional silty zones (MSW)			
7 8 9 10 11 12 13	3 4			End of Test Pit @ 2.1m			

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP04
Page: 1 of 1

Test Hole Log: TP13-05

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

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Depth		Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft 0 m			grey-brown, damp, compact SAND and GRAVEL, trace silt (FILL)			
1 ft			dark-grey, damp to moist, compact SAND, some gravel, trace to some silt, occasional cobbles, mixed with municipal solid waste (MSW)			
3 ft 1 m			End of Test Pit @ 1.1m			
4 ft 5 ft 6 ft 2 m 7 ft 8 ft 9 ft 10 ft 3 m 11 ft 12 ft 13 ft 4 m						

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP05
Page: 1 of 1

Test Hole Log: TP13-06

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

BRAUN GEOTECHNICAL LTD.

Depth		Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft 0 m 1 2			grey, damp, compact 150mm minus SAND and GRAVEL, trace to some silt, occasional cobbles, occasional asphalt, occasional municipal solid waste (FILL)			
3 1			brown, damp to moist, loose SAND, some organics, some roots			-Inferred to be original organic horizon and/or organic waste
4			grey, damp to moist, very dense SAND, some gravel, some silt, occasional cobbles and boulders (TILL-LIKE)			
5 6 2 7 8 9 3 10 11 12 13 4			End of Test Pit @ 1.5m			

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP06
Page: 1 of 1

Test Hole Log: TP13-07

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

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Depth			Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft	0 m		○	grey, damp, compact 150mm minus SAND and GRAVEL, trace to some silt, occasional cobbles, occasional asphalt (FILL)	S1		
1							
2			○		S2		
3				brown, damp to moist, loose SAND, some organics, some roots			-Inferred to be original organic horizon and/or organic waste
	1			rust-brown, damp, compact SAND, some gravel, trace to some silt			
4				grey, damp to moist, very dense SAND, some gravel, some silt, occasional cobbles and boulders (TILL-LIKE)			
				End of Test Pit @ 1.3m			
5							
6							
	2						
7							
8							
9							
	3						
10							
11							
12							
13							
	4						

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Not Encountered

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP07
Page: 1 of 1

Test Hole Log: TP13-08

File: 13–5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

BRAUN
GEOTECHNICAL LTD.

Depth ft	Depth m		Sample	Soil Description	Sample #	Water Cont.	Remarks
0	0		○	grey to brown, damp, loose SAND, some gravel, some silt, occasional cobbles and boulders, occasional silty zones, includes occasional zones of MUNICIPAL SOLID WASTE mixed with variable FILL up to 600mm thick (MSW)	S1		
1							
2			○		S2		
3							
	1						
4							
5							
6							
	2						-seepage encountered at 2.0m (~600mm depth on east (downslope) side.
7							
8							▽ Water Level (at time of exploration)
9				-wet below 2.6m			
	3			End of Test Pit @ 2.9m (~1.5m on east downslope) side of pit).			
10							
11							
12							
13							
	4						

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: 2.6m

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP08
Page: 1 of 1

Test Hole Log: TP13-09

File: 13-5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

BRAUN
GEOTECHNICAL LTD.

Depth		Sample	Soil Description	Sample #	Water Cont.	Remarks
0 ft 0 m			dark-brown, damp, loose sandy ORGANICS, trace to some silt, occasional rootlets, occasional municipal solid waste (ORGANIC FILL)			
			rust-brown, damp, loose SAND, some gravel, trace to some silt with occasional municipal solid waste (FILL)			
			dark-brown, moist, loose sandy ORGANICS, some silt, occasional roots and rootlets			
			rust brown, damp, compact SAND, some silt, occasional cobbles and boulders, occasional rootlets			
		○		S1		
			grey-brown, brown mottled, moist, very dense silty SAND to very stiff sandy SILT, trace to some gravel, occasional cobbles			-seepage encountered at 2.4m (~900mm depth on east (downslope) side).
		○		S2		
			End of Test Pit @ 3.4m (~1.9m on east downslope) side of pit).			

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: Seepage @ 2.4m

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP09
Page: 1 of 1

Test Hole Log: TP13-10

File: 13–5996
Project: PENDER HARBOUR LANDFILL
Client: XCG CONSULTANTS LTD.
Location: PENDER HARBOUR, BC

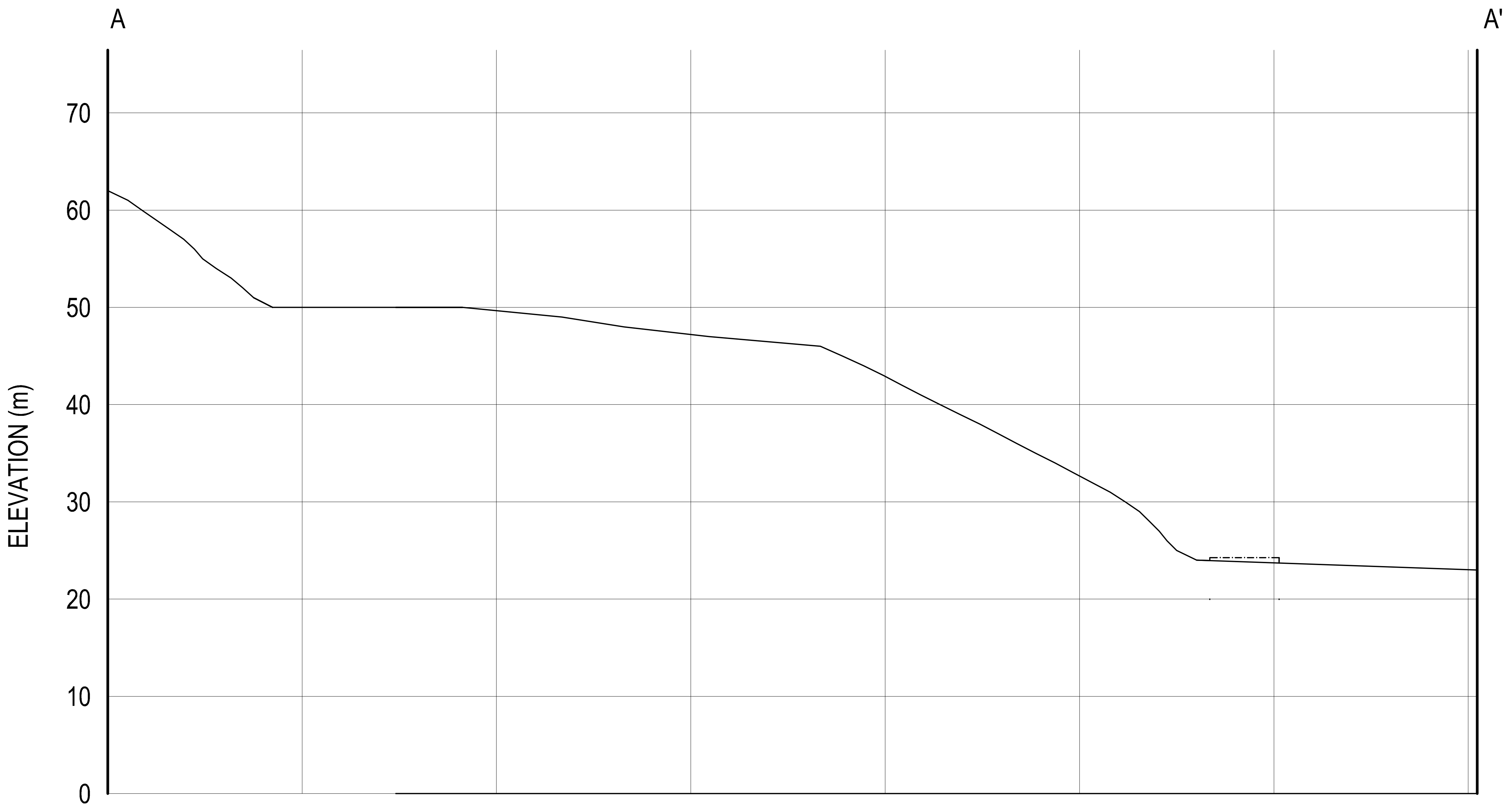
BRAUN
GEOTECHNICAL LTD.

Depth ft	Depth m		Sample	Soil Description	Sample #	Water Cont.	Remarks
0	0			grey to grey-brown, damp, loose to compact SAND, trace to some gravel, trace to some silt, occasional cobbles and boulders (FILL)			
1							
2							
3	1						
4				-wet below 1.2m			▽ Water Level (at time of exploration) -sidewall sloughing at 1.2m.
5							
6	2			End of Test Pit @ 2.0m			-test pit terminated due to sidewall sloughing.
7							
8							
9							
10	3						
11							
12							
13	4						

Equipment: Tracked Excavator
Sampling Method: Lump Sample

Datum: Ground Surface
Water Depth: 1.2m

Logged By: HD
Exploration Date: November 14, 2013
Dwg No.: 13-5996-TP10
Page: 1 of 1



BRAUN
GEOTECHNICAL LTD.

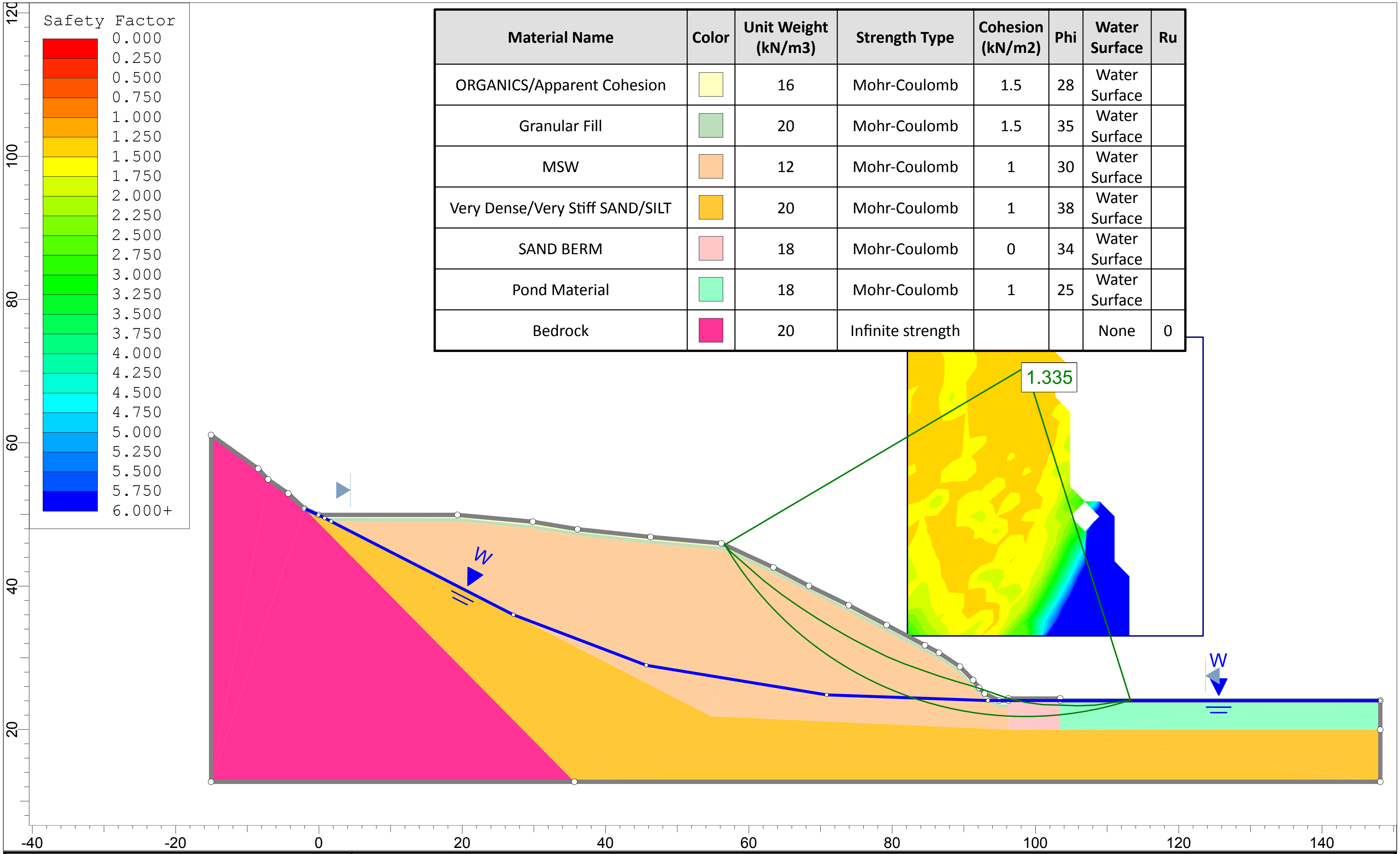
Rev.	Description	Date

Client
XCG CONSULTANTS LTD.

Project
PENDER HARBOUR LANDFILL
PENDER HARBOUR, BC

Title
CRITICAL SECTION

Project no.	Drawn	Design	Checked	Date	Scale	Drawing no.
13-5996	HD	HD	SS	January 16, 2013	1:500	13-5996-02



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Ru
ORGANICS/Apparent Cohesion	🟨	16	Mohr-Coulomb	1.5	28	Water Surface	
Granular Fill	🟩	20	Mohr-Coulomb	1.5	35	Water Surface	
MSW	🟧	12	Mohr-Coulomb	1	30	Water Surface	
Very Dense/Very Stiff SAND/SILT	🟨	20	Mohr-Coulomb	1	38	Water Surface	
SAND BERM	🟥	18	Mohr-Coulomb	0	34	Water Surface	
Pond Material	🟩	18	Mohr-Coulomb	1	25	Water Surface	
Bedrock	🟪	20	Infinite strength			None	0

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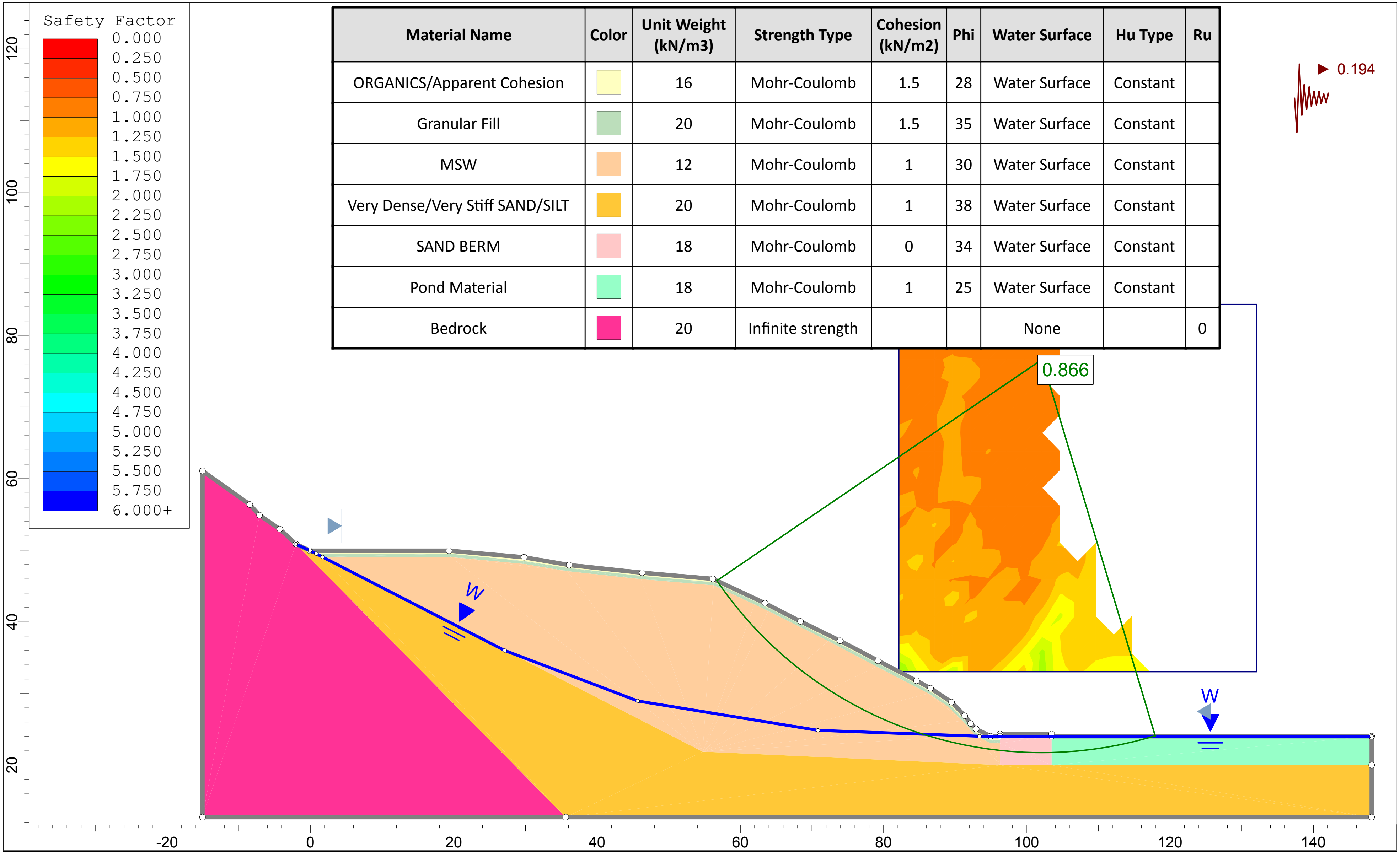
GEOTECHNICAL LTD.

SLIDEINTERPRET 6.013

Project	Pender Harbour Landfill		
Analysis Description	Slope Stability Assessment		
Drawn By HD	*Scale* 1:750	*Company*	
Date 1/06/14, 4:16:43 PM		*File Name* Pender Harbour Landfill Static.slim	

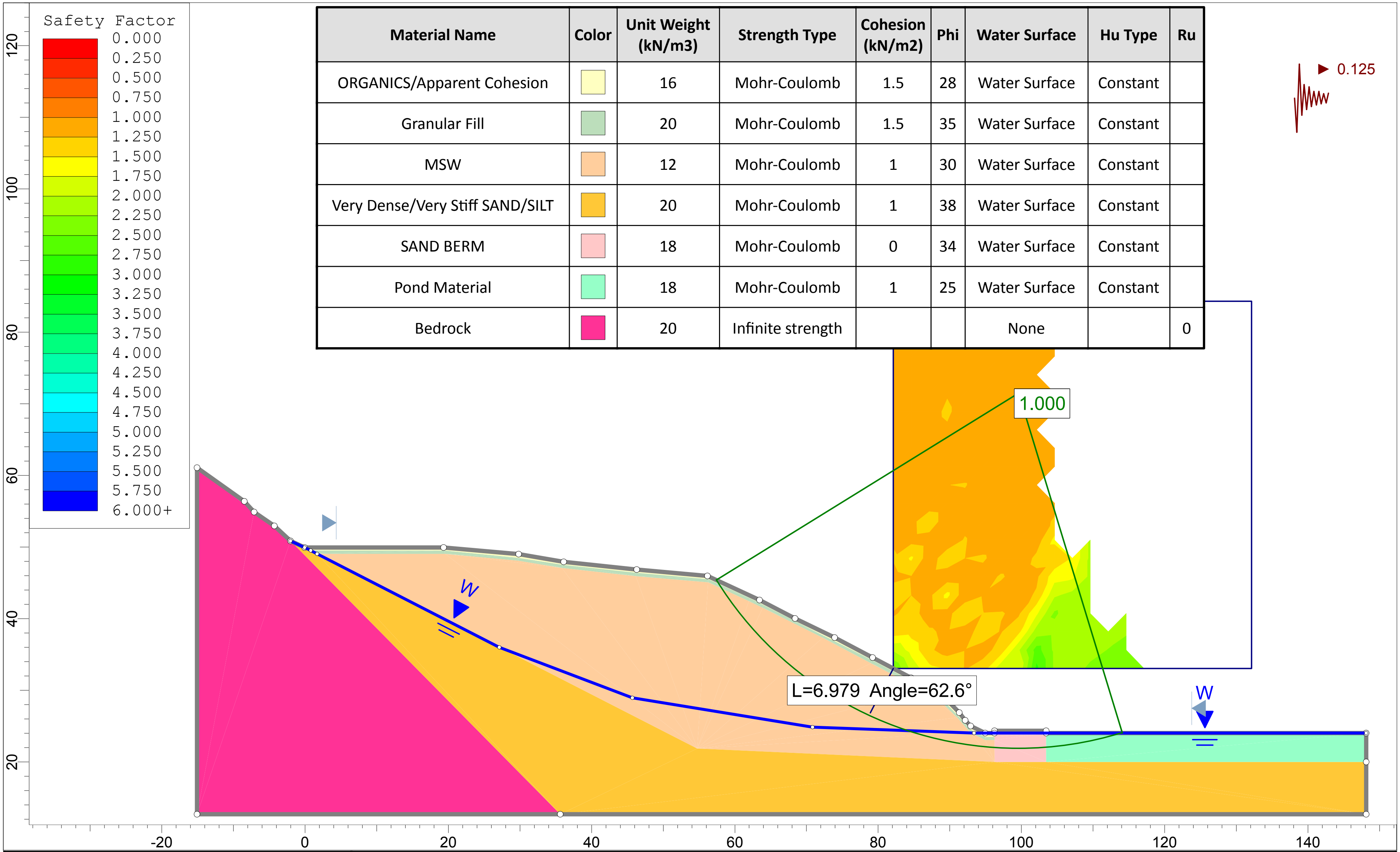


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Hu Type	Ru
ORGANICS/Apparent Cohesion	🟨	16	Mohr-Coulomb	1.5	28	Water Surface	Constant	
Granular Fill	🟩	20	Mohr-Coulomb	1.5	35	Water Surface	Constant	
MSW	🟧	12	Mohr-Coulomb	1	30	Water Surface	Constant	
Very Dense/Very Stiff SAND/SILT	🟧	20	Mohr-Coulomb	1	38	Water Surface	Constant	
SAND BERM	🟥	18	Mohr-Coulomb	0	34	Water Surface	Constant	
Pond Material	🟩	18	Mohr-Coulomb	1	25	Water Surface	Constant	
Bedrock	🟪	20	Infinite strength			None		0

BRAUN
GEOTECHNICAL LTD.

SLIDEINTERPRET 6.013

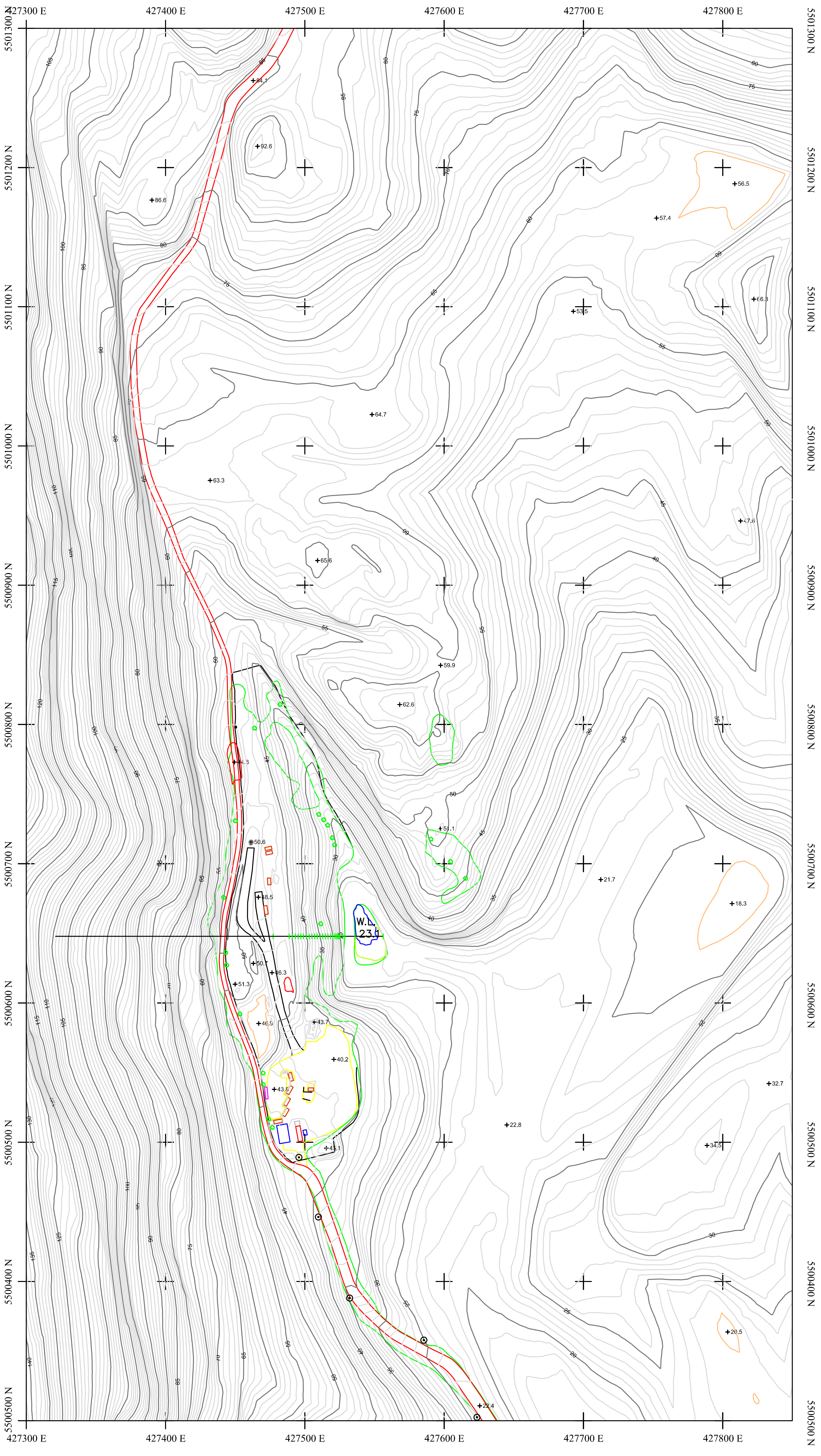
Project	Pender Harbour Landfill
Analysis Description	Slope Stability Assessment
Drawn By	HD
Scale	1:750
Company	
Date	1/06/14, 4:16:43 PM
File Name	Pender Harbour Landfill PGA.slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Hu Type	Ru
ORGANICS/Apparent Cohesion	🟨	16	Mohr-Coulomb	1.5	28	Water Surface	Constant	
Granular Fill	🟩	20	Mohr-Coulomb	1.5	35	Water Surface	Constant	
MSW	🟧	12	Mohr-Coulomb	1	30	Water Surface	Constant	
Very Dense/Very Stiff SAND/SILT	🟧	20	Mohr-Coulomb	1	38	Water Surface	Constant	
SAND BERM	🟥	18	Mohr-Coulomb	0	34	Water Surface	Constant	
Pond Material	🟩	18	Mohr-Coulomb	1	25	Water Surface	Constant	
Bedrock	🟪	20	Infinite strength			None		0

BRAUN
GEOTECHNICAL LTD.
SLIDEINTERPRET 6.013

Project	Pender Harbour Landfill
Analysis Description	Slope Stability Assessment
Drawn By	HD
Scale	1:750
Company	
Date	1/06/14, 4:16:43 PM
File Name	Pender Harbour Landfill kY.slim



sclogo.jpg

Sunshine Coast
Regional District

1975 Field Road,
Sechelt, BC
V0N 3A1

Pender Harbour
Landfill

Date of Photo: September 13, 2013

1:2000

50m 0 25m 50m

CONTOUR INTERVAL : 1 METER

N

Legend

Building - Commercial
Concrete - Pad
Contour Index
Contour Inter
Contour Index Dep
Contour Inter Dep
Ditch
Fence
Guardrail
Pole-Utility
Road Double Gravel
Road Paved
Road Rough
Road Shoulder
Road Single Gravel
638.7 Spot Height
Stream Intermittant
Tank
Trail
Wall - Retaining
Wall

Projection UTM Zone 10

Datum NAD83

NTS Mapsheet: 92F/09

Job Number: 13144

AERO GEOMETRICS LTD.
TERMINAL CITY CLUB TOWER
#209 837 West Hastings St.
Vancouver, B.C.   V6C 3N6
Telephone: (604) 408-8740
Toll Free 1-855-AeroGeo
manager@aerogeo.com
www.aerogeo.com

G:\13142-RDN\AGL-2013-.jpg

APPENDIX F

HELP MODEL OUTPUTS

```
♀
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************



PRECIPITATION DATA FILE:    C:\HELP3\data4.D4
TEMPERATURE DATA FILE:      C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\MOE10.D10
OUTPUT DATA FILE:           C:\HELP3\MOE10.OUT


TIME:  15:53     DATE:   1/27/2014



******************************************************************************

     TITLE:  Pender Harbour Landfill - MOE Cover (10%)

******************************************************************************



     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                  =     15.00   CM
           POROSITY                   =      0.5010 VOL/VOL
           FIELD CAPACITY             =      0.2840 VOL/VOL
           WILTING POINT              =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3800 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                   LAYER  2
                                   --------
```

```
                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  15
    THICKNESS                     =    100.00   CM
    POROSITY                      =      0.4750 VOL/VOL
    FIELD CAPACITY                =      0.3780 VOL/VOL
    WILTING POINT                 =      0.2650 VOL/VOL
    INITIAL SOIL WATER CONTENT    =      0.4750 VOL/VOL
    EFFECTIVE SAT. HYD. COND.     =  0.170000003000E-04 CM/SEC




           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
           FAIR STAND OF GRASS, A SURFACE SLOPE OF 10.%
           AND A SLOPE LENGTH OF  100. METERS.

   SCS RUNOFF CURVE NUMBER            =     82.30
   FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE =      1.0000 HECTARES
   EVAPORATIVE ZONE DEPTH             =     15.0    CM
   INITIAL WATER IN EVAPORATIVE ZONE  =      5.699  CM
   UPPER LIMIT OF EVAPORATIVE STORAGE =      7.515  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE =      2.025  CM
   INITIAL SNOW WATER                 =      0.000  CM
   INITIAL WATER IN LAYER MATERIALS   =     53.199  CM
   TOTAL INITIAL WATER                =     53.199  CM
   TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR




            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           Pender Harbour        British Columbia

        STATION LATITUDE                         =  49.23 DEGREES
        MAXIMUM LEAF AREA INDEX                  =   2.50
        START OF GROWING SEASON (JULIAN DATE)    =    130
        END OF GROWING SEASON (JULIAN DATE)      =    270
        EVAPORATIVE ZONE DEPTH                   =  15.0  CM
        AVERAGE ANNUAL WIND SPEED                =  13.00 KPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  76.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  58.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  48.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  78.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    SPOKANE             WASHINGTON

            NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
```

```
      171.0       142.1       124.4        93.1        80.8        67.2
       46.4        45.6        61.9       133.8       209.7       193.2


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
        3.7         5.0         6.7         9.2        12.3        14.8
       17.3        17.6        14.8        10.4         6.2         3.8


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON
                    AND STATION LATITUDE  =  49.23 DEGREES




*******************************************************************************

            AVERAGE MONTHLY VALUES (MM) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               161.02   141.15   126.22    79.66    91.99    51.67
                          48.07    52.24    63.15   103.39   247.70   172.32

    STD. DEVIATIONS       54.77    50.51    51.25    40.58    57.02    36.46
                          44.94    36.56    31.48    64.29   117.26    70.95

  RUNOFF
  ------
    TOTALS                12.535    5.745    3.968    2.291    1.351    0.774
                           2.419    0.987    0.672    3.620   51.853   16.348

    STD. DEVIATIONS       21.968    8.730    9.954    5.988    2.549    2.085
                           6.588    3.729    1.739    5.599   58.847   23.742

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                20.032   24.949   52.888   59.135   64.594   47.975
                          33.406   41.702   43.144   27.133   20.950   17.192

    STD. DEVIATIONS        3.328    3.891    6.138   15.723   29.191   31.546
                          24.042   25.135   20.817   11.711    4.521    3.344

  PERCOLATION/LEAKAGE THROUGH LAYER  2
  ------------------------------------
    TOTALS               134.6686 120.0539  75.6304  24.7572  25.3409   7.5084
                          12.7706   7.7894  17.9906  61.3738 155.1971 140.5376

    STD. DEVIATIONS       51.5854  44.4825  44.1234  23.5069  33.0349  13.4244
```

```
                          18.5884   9.9069  14.7294  50.3556  54.9213  55.2654


-------------------------------------------------------------------------------
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  2
  -------------------------------------
    AVERAGES                 1.0996   1.2102   0.5574   0.2401   0.2042   0.0682
                             0.1406   0.0582   0.1318   0.5047   2.0151   1.1113

    STD. DEVIATIONS          0.7778   0.7651   0.5241   0.3848   0.3421   0.1656
                             0.2530   0.1581   0.1870   0.5007   1.0729   0.7872

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                         MM                CU. METERS     PERCENT
                              --------------------    -----------    ---------
 PRECIPITATION                1338.59    ( 190.105)      13385.9     100.00

 RUNOFF                        102.563   ( 62.3809)       1025.63      7.662

 EVAPOTRANSPIRATION            453.102   ( 51.6906)       4531.02     33.849

 PERCOLATION/LEAKAGE THROUGH   783.61841 (135.14670)      7836.184    58.54037
   LAYER  2

 AVERAGE HEAD ON TOP             6.118 (    1.638)
   OF LAYER  2

 CHANGE IN WATER STORAGE        -0.688   (  0.9901)         -6.88     -0.051
*******************************************************************************


♀
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                  (MM)      (CU. METERS)
                                               ----------    ------------
      PRECIPITATION                            156.60          1566.000

      RUNOFF                                   113.111         1131.1129

      PERCOLATION/LEAKAGE THROUGH LAYER  2      16.836514       168.36514

      AVERAGE HEAD ON TOP OF LAYER  2          146.295

      SNOW WATER                               250.07          2500.6606


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.5010
```

```
      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1350

*******************************************************************************



♀
*******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   20
    ----------------------------------------------------------------------
                    LAYER          (CM)         (VOL/VOL)
                    -----         ------        ---------
                      1            4.3228         0.2882

                      2           47.5000         0.4750

                  SNOW WATER       0.000

*******************************************************************************
*******************************************************************************
```

```
♀
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                  USAE WATERWAYS EXPERIMENT STATION                        **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\data4.D4
TEMPERATURE DATA FILE:      C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\MOE33.D10
OUTPUT DATA FILE:           C:\HELP3\MOE33.OUT


TIME:  10:33     DATE:   2/ 4/2014


*******************************************************************************

     TITLE:  Pender Harbour Landfill - MOE Cover (33%)

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   9
           THICKNESS                   =    15.00   CM
           POROSITY                    =     0.5010 VOL/VOL
           FIELD CAPACITY              =     0.2840 VOL/VOL
           WILTING POINT               =     0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.3755 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------
```

```
                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  15
      THICKNESS                   =    100.00   CM
      POROSITY                    =      0.4750 VOL/VOL
      FIELD CAPACITY              =      0.3780 VOL/VOL
      WILTING POINT               =      0.2650 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.4750 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.170000003000E-04 CM/SEC




              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
             FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
             AND A SLOPE LENGTH OF  100. METERS.

   SCS RUNOFF CURVE NUMBER             =     82.90
   FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE  =      1.0000 HECTARES
   EVAPORATIVE ZONE DEPTH              =     15.0    CM
   INITIAL WATER IN EVAPORATIVE ZONE   =      5.633  CM
   UPPER LIMIT OF EVAPORATIVE STORAGE  =      7.515  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.025  CM
   INITIAL SNOW WATER                  =      0.000  CM
   INITIAL WATER IN LAYER MATERIALS    =     53.133  CM
   TOTAL INITIAL WATER                 =     53.133  CM
   TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR



               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             Pender Harbour        British Columbia

        STATION LATITUDE                       =  49.23 DEGREES
        MAXIMUM LEAF AREA INDEX                =   2.50
        START OF GROWING SEASON (JULIAN DATE)  =    130
        END OF GROWING SEASON (JULIAN DATE)    =    270
        EVAPORATIVE ZONE DEPTH                 =  15.0  CM
        AVERAGE ANNUAL WIND SPEED              =  13.00 KPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  76.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  58.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  48.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  78.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    SPOKANE             WASHINGTON

               NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
```

```
      171.0       142.1       124.4        93.1        80.8        67.2
       46.4        45.6        61.9       133.8       209.7       193.2


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
        3.7         5.0         6.7         9.2        12.3        14.8
       17.3        17.6        14.8        10.4         6.2         3.8


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON
                    AND STATION LATITUDE  =  49.23 DEGREES




*******************************************************************************

            AVERAGE MONTHLY VALUES (MM) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               161.02   141.15   126.22    79.66    91.99    51.67
                          48.07    52.24    63.15   103.39   247.70   172.32

    STD. DEVIATIONS       54.77    50.51    51.25    40.58    57.02    36.46
                          44.94    36.56    31.48    64.29   117.26    70.95

  RUNOFF
  ------
    TOTALS                12.899    5.820    4.137    2.369    1.550    0.852
                           2.557    1.014    0.770    3.842   52.419   16.370

    STD. DEVIATIONS       21.934    8.735   10.033    5.993    2.866    2.175
                           6.712    3.670    1.896    5.631   58.365   23.559

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                20.033   24.951   52.917   59.153   64.760   47.949
                          33.370   41.685   43.148   27.129   20.951   17.198

    STD. DEVIATIONS        3.329    3.890    6.132   15.741   29.273   31.496
                          24.050   25.095   20.822   11.676    4.522    3.348

  PERCOLATION/LEAKAGE THROUGH LAYER  2
  ------------------------------------
    TOTALS               134.2920 119.8762  75.3561  24.7311  25.1084   7.3214
                          12.6421   7.7667  17.9173  60.9355 155.0483 140.4099

    STD. DEVIATIONS       51.4018  44.6509  43.6938  23.3678  32.7680  12.9044
```

```
                           18.3791   9.9448  14.6282  50.1521  55.0122  55.5869


-------------------------------------------------------------------------------
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  2
  -------------------------------------
    AVERAGES              1.0789   1.1663   0.5550   0.2303   0.1991   0.0628
                          0.1373   0.0591   0.1304   0.5114   2.0081   1.1066

    STD. DEVIATIONS       0.7517   0.7108   0.5168   0.3736   0.3322   0.1398
                          0.2468   0.1606   0.1827   0.4978   1.0392   0.7715

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                         MM             CU. METERS     PERCENT
                              --------------------     ----------    ---------
 PRECIPITATION                1338.59    ( 190.105)      13385.9     100.00

 RUNOFF                        104.601   ( 61.8945)       1046.01      7.814

 EVAPOTRANSPIRATION            453.244   ( 51.5843)       4532.44     33.860

 PERCOLATION/LEAKAGE THROUGH   781.40485 (135.55943)      7814.048    58.37500
   LAYER  2

 AVERAGE HEAD ON TOP             6.038 (    1.498)
   OF LAYER  2

 CHANGE IN WATER STORAGE        -0.655   (  0.9841)         -6.55     -0.049
*******************************************************************************


♀
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                  (MM)       (CU. METERS)
                                               ----------    ------------
      PRECIPITATION                            156.60          1566.000

      RUNOFF                                   112.946         1129.4598

      PERCOLATION/LEAKAGE THROUGH LAYER  2      16.819019       168.19019

      AVERAGE HEAD ON TOP OF LAYER  2          145.103

      SNOW WATER                               250.07          2500.6606


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.5010
```

```
      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1350

******************************************************************************



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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   20
    ----------------------------------------------------------------------
                    LAYER          (CM)         (VOL/VOL)
                    -----         ------        ---------
                      1           4.3228          0.2882

                      2          47.5000          0.4750

                   SNOW WATER     0.000

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******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\data4.D4
TEMPERATURE DATA FILE:      C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\EX-56.D10
OUTPUT DATA FILE:           C:\HELP3\EX-56.OUT


TIME:  10:36     DATE:   2/ 4/2014


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     TITLE:  SECHELT LANDFILL - EXISTING FINAL COVER (56%)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   3
           THICKNESS                   =     90.00   CM
           POROSITY                    =      0.4570 VOL/VOL
           FIELD CAPACITY              =      0.0830 VOL/VOL
           WILTING POINT               =      0.0330 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2184 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                   GENERAL DESIGN AND EVAPORATIVE ZONE DATA
```

```
              ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE # 3 WITH A
             GOOD STAND OF GRASS, A SURFACE SLOPE OF 56.%
             AND A SLOPE LENGTH OF  100. METERS.

   SCS RUNOFF CURVE NUMBER              =    54.20
   FRACTION OF AREA ALLOWING RUNOFF     =   100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =     1.0000 HECTARES
   EVAPORATIVE ZONE DEPTH               =    30.0    CM
   INITIAL WATER IN EVAPORATIVE ZONE    =     5.159  CM
   UPPER LIMIT OF EVAPORATIVE STORAGE   =    13.710  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE   =     0.990  CM
   INITIAL SNOW WATER                   =     0.000  CM
   INITIAL WATER IN LAYER MATERIALS     =    19.655  CM
   TOTAL INITIAL WATER                  =    19.655  CM
   TOTAL SUBSURFACE INFLOW              =     0.00   MM/YR



               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             Pender Harbour        British Columbia

        STATION LATITUDE                         =  49.23 DEGREES
        MAXIMUM LEAF AREA INDEX                  =   2.50
        START OF GROWING SEASON (JULIAN DATE)    =    130
        END OF GROWING SEASON (JULIAN DATE)      =    270
        EVAPORATIVE ZONE DEPTH                   =  30.0  CM
        AVERAGE ANNUAL WIND SPEED                =  13.00 KPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  76.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  58.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  48.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  78.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    SPOKANE             WASHINGTON

               NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 171.0       142.1       124.4        93.1        80.8        67.2
  46.4        45.6        61.9       133.8       209.7       193.2


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    SPOKANE             WASHINGTON

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
   3.7         5.0         6.7         9.2        12.3        14.8
  17.3        17.6        14.8        10.4         6.2         3.8
```

```
         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON
                    AND STATION LATITUDE  =  49.23 DEGREES




*******************************************************************************

            AVERAGE MONTHLY VALUES (MM) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               161.02   141.15   126.22    79.66    91.99    51.67
                          48.07    52.24    63.15   103.39   247.70   172.32

    STD. DEVIATIONS       54.77    50.51    51.25    40.58    57.02    36.46
                          44.94    36.56    31.48    64.29   117.26    70.95

  RUNOFF
  ------
    TOTALS                 0.041    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.687    0.000

    STD. DEVIATIONS        0.182    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    2.670    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                19.811   24.696   51.193   60.702   70.533   56.354
                          35.359   45.744   43.222   27.802   20.545   16.877

    STD. DEVIATIONS        3.339    3.869    6.035   13.492   26.883   30.325
                          25.439   27.136   21.041    9.408    4.619    3.191

  PERCOLATION/LEAKAGE THROUGH LAYER  1
  ------------------------------------
    TOTALS               147.4562 129.3495  88.3820  41.0743  23.9460  16.9964
                          12.5911   8.4644   8.7961  44.3403 184.6242 160.1297

    STD. DEVIATIONS       55.5554  41.9214  46.6295  28.2290  21.9266  12.1571
                          11.0477   9.8858  10.2218  41.5522  92.1018  73.0677

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                       MM              CU. METERS     PERCENT
                              --------------------     -----------   ---------
 PRECIPITATION                1338.59    ( 190.105)      13385.9     100.00

 RUNOFF                          0.728   (  2.6648)          7.28      0.054
```

```
 EVAPOTRANSPIRATION              472.839   ( 57.5967)      4728.39     35.324

 PERCOLATION/LEAKAGE THROUGH     866.15051 (170.75362)      8661.505    64.70594
   LAYER  1

 CHANGE IN WATER STORAGE          -1.122   (  1.2155)       -11.22     -0.084

*******************************************************************************


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******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                    (MM)      (CU. METERS)
                                                 ----------    ------------
      PRECIPITATION                                156.60         1566.000

      RUNOFF                                        11.899         118.9911

      PERCOLATION/LEAKAGE THROUGH LAYER  1          86.530495      865.30493

      SNOW WATER                                   250.07         2500.6606

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.2975

      MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0330

******************************************************************************


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                 FINAL WATER STORAGE AT END OF YEAR   20
    ----------------------------------------------------------------------
                  LAYER         (CM)         (VOL/VOL)
                  -----        ------        ---------
                    1          17.4105         0.1934

                 SNOW WATER       0.000

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******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\data4.D4
TEMPERATURE DATA FILE:      C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\FIN33.D10
OUTPUT DATA FILE:           C:\HELP3\FIN33.OUT


TIME:  10:46     DATE:   2/ 4/2014


******************************************************************************

     TITLE:  Pender Harbour Landfill - Final Cover (33%)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                 =     30.00   CM
           POROSITY                  =      0.5010 VOL/VOL
           FIELD CAPACITY            =      0.2840 VOL/VOL
           WILTING POINT             =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.3310 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  21
   THICKNESS                   =     15.00   CM
   POROSITY                    =      0.3970 VOL/VOL
   FIELD CAPACITY              =      0.0320 VOL/VOL
   WILTING POINT               =      0.0130 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.0320 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC
   SLOPE                       =     33.00   PERCENT
   DRAINAGE LENGTH             =     50.0    METERS


                            LAYER  3
                            --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  10
   THICKNESS                   =     60.00   CM
   POROSITY                    =      0.3980 VOL/VOL
   FIELD CAPACITY              =      0.2440 VOL/VOL
   WILTING POINT               =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.3980 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
          AND A SLOPE LENGTH OF  100. METERS.

SCS RUNOFF CURVE NUMBER             =     82.90
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.0000 HECTARES
EVAPORATIVE ZONE DEPTH              =     30.0    CM
INITIAL WATER IN EVAPORATIVE ZONE   =      9.930  CM
UPPER LIMIT OF EVAPORATIVE STORAGE  =     15.030  CM
LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.050  CM
INITIAL SNOW WATER                  =      0.000  CM
INITIAL WATER IN LAYER MATERIALS    =     34.290  CM
TOTAL INITIAL WATER                 =     34.290  CM
TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          Pender Harbour        British Columbia

     STATION LATITUDE                        =  49.23 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   2.50
     START OF GROWING SEASON (JULIAN DATE)   =    130
```

```
             END OF GROWING SEASON (JULIAN DATE)    =    270
             EVAPORATIVE ZONE DEPTH                 =  30.0  CM
             AVERAGE ANNUAL WIND SPEED              =  13.00 KPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  76.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  58.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  48.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  78.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      171.0       142.1       124.4        93.1        80.8        67.2
       46.4        45.6        61.9       133.8       209.7       193.2


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
        3.7         5.0         6.7         9.2        12.3        14.8
       17.3        17.6        14.8        10.4         6.2         3.8


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON
                    AND STATION LATITUDE  =  49.23 DEGREES




*******************************************************************************

            AVERAGE MONTHLY VALUES (MM) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               161.02   141.15   126.22    79.66    91.99    51.67
                          48.07    52.24    63.15   103.39   247.70   172.32

    STD. DEVIATIONS       54.77    50.51    51.25    40.58    57.02    36.46
                          44.94    36.56    31.48    64.29   117.26    70.95

  RUNOFF
  ------
    TOTALS                 9.890    5.514    3.918    1.541    1.559    0.844
                           1.935    0.648    0.716    3.972   29.835   11.845
```

```
    STD. DEVIATIONS       12.730    4.789    7.290    3.158    3.099    2.141
                           4.419    2.066    1.827    4.958   30.966   14.362

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                19.630   24.510   54.158   79.984   81.795   62.204
                          42.337   48.926   47.526   29.402   20.091   16.633

    STD. DEVIATIONS        3.252    3.806    4.880   13.913   32.091   34.365
                          28.848   29.277   23.888    9.121    4.509    3.136

  LATERAL DRAINAGE COLLECTED FROM LAYER  2
  ----------------------------------------
    TOTALS                15.0260  13.9930   7.0079   1.5818   0.8740   0.0222
                           0.3605   0.0187   0.1087   3.5853  23.2622  15.8760

    STD. DEVIATIONS       10.9952   9.3541   7.0287   3.2138   2.7557   0.0594
                           1.1040   0.0622   0.2028   4.1401  15.4842  10.4972

  PERCOLATION/LEAKAGE THROUGH LAYER  3
  ------------------------------------
    TOTALS               121.8623 106.7439  70.7929  17.3840   9.3385   1.2997
                           2.8733   1.0366   4.3149  44.2236 148.9921 128.5390

    STD. DEVIATIONS       44.9479  36.6414  36.8919  21.6204  20.6344   3.1661
                           6.9630   2.8980   7.7332  40.1449  62.9560  51.1649


-------------------------------------------------------------------------------
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES               0.0586   0.0626   0.0341   0.0086   0.0041   0.0006
                           0.0015   0.0003   0.0019   0.0185   0.0735   0.0615

    STD. DEVIATIONS        0.0259   0.0280   0.0201   0.0116   0.0093   0.0014
                           0.0037   0.0008   0.0033   0.0170   0.0339   0.0257

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                       MM              CU. METERS     PERCENT
                              --------------------     -----------   ---------
 PRECIPITATION                1338.59    ( 190.105)      13385.9     100.00

 RUNOFF                         72.215   ( 34.3266)        722.15      5.395

 EVAPOTRANSPIRATION            527.195   ( 63.7222)       5271.95     39.384

 LATERAL DRAINAGE COLLECTED     81.71623 ( 26.03346)       817.162    6.10463
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH   657.40094 (120.37112)      6574.009    49.11127
   LAYER  3
```

```
 AVERAGE HEAD ON TOP              0.271 (    0.056)
   OF LAYER  3

 CHANGE IN WATER STORAGE          0.068   (  1.0557)          0.68      0.005

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                     (MM)      (CU. METERS)
                                                  ----------   ------------
      PRECIPITATION                               156.60         1566.000

      RUNOFF                                       78.748         787.4828

      DRAINAGE COLLECTED FROM LAYER  2             21.72838       217.28377

      PERCOLATION/LEAKAGE THROUGH LAYER  3         40.343197      403.43198

      AVERAGE HEAD ON TOP OF LAYER  3               9.264

      MAXIMUM HEAD ON TOP OF LAYER  3              13.964

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                   0.0 METERS

      SNOW WATER                                  250.07         2500.6606


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.3775

      MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.1350

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

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                   FINAL WATER STORAGE AT END OF YEAR   20
    ----------------------------------------------------------------------
                    LAYER         (CM)          (VOL/VOL)
                    -----        ------         ---------
                      1         10.0664           0.3355

                      2          0.4800           0.0320
```

```
                     3            23.8800          0.3980

                SNOW WATER        0.000

**********************************************************************************
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******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\data4.D4
TEMPERATURE DATA FILE:      C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\FIN10.D10
OUTPUT DATA FILE:           C:\HELP3\FIN10.OUT


TIME:  10:52     DATE:   2/ 4/2014



******************************************************************************

     TITLE:  Pender Harbour Landfill - Final Cover (10%)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
           THICKNESS                  =     30.00   CM
           POROSITY                   =      0.5010 VOL/VOL
           FIELD CAPACITY             =      0.2840 VOL/VOL
           WILTING POINT              =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3162 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                   LAYER  2
                                   --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  21
   THICKNESS                    =     15.00   CM
   POROSITY                     =      0.3970 VOL/VOL
   FIELD CAPACITY               =      0.0320 VOL/VOL
   WILTING POINT                =      0.0130 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.0377 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.300000012000     CM/SEC
   SLOPE                        =     10.00   PERCENT
   DRAINAGE LENGTH              =     50.0    METERS



                          LAYER  3
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  10
   THICKNESS                    =     60.00   CM
   POROSITY                     =      0.3980 VOL/VOL
   FIELD CAPACITY               =      0.2440 VOL/VOL
   WILTING POINT                =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.3980 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC



            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
           FAIR STAND OF GRASS, A SURFACE SLOPE OF 10.%
           AND A SLOPE LENGTH OF  100. METERS.

 SCS RUNOFF CURVE NUMBER              =     82.30
 FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =      1.0000 HECTARES
 EVAPORATIVE ZONE DEPTH               =     30.0    CM
 INITIAL WATER IN EVAPORATIVE ZONE    =      9.487  CM
 UPPER LIMIT OF EVAPORATIVE STORAGE   =     15.030  CM
 LOWER LIMIT OF EVAPORATIVE STORAGE   =      4.050  CM
 INITIAL SNOW WATER                   =      0.000  CM
 INITIAL WATER IN LAYER MATERIALS     =     33.933  CM
 TOTAL INITIAL WATER                  =     33.933  CM
 TOTAL SUBSURFACE INFLOW              =      0.00   MM/YR



             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           Pender Harbour        British Columbia

     STATION LATITUDE                        =  49.23 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   2.50
     START OF GROWING SEASON (JULIAN DATE)   =    130
```

```
             END OF GROWING SEASON (JULIAN DATE)    =    270
             EVAPORATIVE ZONE DEPTH                 =  30.0  CM
             AVERAGE ANNUAL WIND SPEED              =  13.00 KPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  76.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  58.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  48.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  78.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      171.0       142.1       124.4        93.1        80.8        67.2
       46.4        45.6        61.9       133.8       209.7       193.2


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
        3.7         5.0         6.7         9.2        12.3        14.8
       17.3        17.6        14.8        10.4         6.2         3.8


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    SPOKANE             WASHINGTON
                    AND STATION LATITUDE  =  49.23 DEGREES




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            AVERAGE MONTHLY VALUES (MM) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               161.02   141.15   126.22    79.66    91.99    51.67
                          48.07    52.24    63.15   103.39   247.70   172.32

    STD. DEVIATIONS       54.77    50.51    51.25    40.58    57.02    36.46
                          44.94    36.56    31.48    64.29   117.26    70.95

  RUNOFF
  ------
    TOTALS                 7.690    4.006    2.897    1.010    1.179    0.733
                           1.718    0.572    0.546    3.215   25.597    9.330
```

```
   STD. DEVIATIONS        10.945     3.441     5.761     2.059     2.576     1.919
                           4.065     1.957     1.387     4.298    27.203    11.989

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 19.657    24.545    54.213    79.691    81.276    61.905
                          41.656    48.762    47.542    29.685    20.149    16.676

   STD. DEVIATIONS         3.248     3.808     4.829    14.170    31.980    34.265
                          28.249    29.372    23.790     9.337     4.517     3.151

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
   TOTALS                 12.7430   11.1855    5.8048    1.2992    0.9934    0.0290
                           0.4109    0.1623    0.2184    4.2147   20.1693   13.1167

   STD. DEVIATIONS         7.1779    6.6707    4.8925    2.3115    2.8921    0.0964
                           0.9930    0.7127    0.5331    4.5502   11.9414    8.9938

 PERCOLATION/LEAKAGE THROUGH LAYER  3
 ------------------------------------
   TOTALS                126.9330  109.8967   73.1554   17.0948    9.9003    1.4858
                           3.5122    1.3935    4.0695   44.7300  157.4219  134.2816

   STD. DEVIATIONS        49.9778   40.7871   39.9679   21.9313   21.1135    3.6793
                           7.9983    4.4003    7.4302   41.0669   68.5417   54.5954


-------------------------------------------------------------------------------
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES                0.1520    0.1530    0.0835    0.0207    0.0138    0.0015
                           0.0048    0.0020    0.0051    0.0580    0.1918    0.1559

   STD. DEVIATIONS         0.0590    0.0582    0.0464    0.0263    0.0303    0.0033
                           0.0113    0.0070    0.0096    0.0531    0.0847    0.0710

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                         MM                 CU. METERS    PERCENT
                                --------------------        ----------   ---------
 PRECIPITATION                  1338.59    ( 190.105)        13385.9     100.00

 RUNOFF                           58.491   ( 29.1503)          584.91      4.370

 EVAPOTRANSPIRATION              525.757   ( 63.7802)         5257.57     39.277

 LATERAL DRAINAGE COLLECTED       70.34703 ( 18.79745)         703.470     5.25529
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH     683.87445 (127.84819)        6838.745    51.08897
   LAYER  3
```

```
 AVERAGE HEAD ON TOP              0.702 (    0.132)
   OF LAYER  3

 CHANGE IN WATER STORAGE          0.125   (  0.9863)         1.25      0.009

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
    ------------------------------------------------------------------------
                                                  (MM)       (CU. METERS)
                                               ----------    ------------
      PRECIPITATION                            156.60          1566.000

      RUNOFF                                    71.389          713.8912

      DRAINAGE COLLECTED FROM LAYER  2          13.52845        135.28447

      PERCOLATION/LEAKAGE THROUGH LAYER  3      48.982105       489.82104

      AVERAGE HEAD ON TOP OF LAYER  3           19.573

      MAXIMUM HEAD ON TOP OF LAYER  3           25.761

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                0.6 METERS

      SNOW WATER                               250.07          2500.6606


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4558

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1350

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

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                   FINAL WATER STORAGE AT END OF YEAR   20
     ----------------------------------------------------------------------
                    LAYER          (CM)         (VOL/VOL)
                    -----         ------        ---------
                      1           9.6896          0.3230

                      2           0.6142          0.0409
```

```
                      3           23.8800         0.3980

                  SNOW WATER       0.000

*******************************************************************************
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APPENDIX G

INSPECTION SUMMARY SHEET

Table G1 Post-Closure Inspection Checklist

Name: ____________________

Date: ____________________

Final Cover	**Yes**	**No**	**Comments**
Is there evidence of erosion?			
Is there evidence of rill erosion or channelling?			
Are there visible depressions?			
Are there signs of vegetative stress?			
Is there ponding water?			
Is there exposed refuse?			
Are there cracks in the final cover?			
Are there signs of settlement or subsidence?			
Are there signs of slope failure?			
Leachate Management	**Yes**	**No**	**Comments**
Are there signs of leachate seeps?			
Surface Water Management	**Yes**	**No**	**Comments**
Is there sediment accumulation in any swales?			
Are there blockages in any ditches?			
Are there blockages in any culverts?			
Are vegetated swales in poor condition?			
Buffer Zones	**Yes**	**No**	**Comments**
Are there signs of vegetative stress?			
Is there evidence of sediment accumulation?			
Are there signs of leachate impacts or seeps?			
Fencing and Site Security	**Yes**	**No**	**Comments**
Is the perimeter fencing in poor condition?			
Is there evidence of illegal dumping?			
Are any signs missing or damaged?			
Are the gates left unlocked when Site is closed?			
Access and Maintenance Roads	**Yes**	**No**	**Comments**
Are asphalt surfaces in poor repair?			
Are granular surfaces in poor repair?			
Environmental Monitoring	**Yes**	**No**	**Comments**
Are any well casings unlocked or unsecured?			
Are any well casings damaged or tampered with?			
Is there any ponding around the well casings?			

APPENDIX H

NATIVE SEED MIXTURE SPECIFICATION

NATIVE SEED MIXTURE SPECIFICATIONS

The vegetation seed mix should be composed of species native to the Pender Harbour area. Combination of seed shall, in general, meet the following criteria (for placement before September):

Specie	% by Weight	% by Seed
Creeping Red Fescue	15%	14.88%
Hard Fescue	10%	12.90%
Slender Wheatgrass	13%	4.13%
Perennial Ryegrass	20%	9.52%
Dahurian Wild Ryegras	15%	2.83%
Orchardgrass	6%	6.78%
Timothy	4%	9.92%
Canada Bluegrass	5%	15.77%
Red Top	1%	10.91%
White Clover	1.5%	2.23%
Single Cut Red Clover	8%	4.92%
Alsike Clover	3.5%	5.21%

Combination of seed shall, in general, meet the following criteria (for placement in September or after):

Specie	% by Weight	% by Seed
Creeping Red Fescue	5%	14.08%
Annual Ryegrass	23%	10.59%
Tall Fescue	10%	10.30%
Timothy	1.5%	8.93%
Orchardgrass	4%	9.89%
Kentucky Bluegrass	1%	9.85%
Red Top	0.5%	11.43%
Dahurian Wild Ryegrass	10%	3.64%
Single Cut Red Clover	7%	9.01%
Alsike Clover	3%	9.37%
Fall Rye	35%	2.92%