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BC Ministry of Environment  
Environmental Protection Division  
2080 Labieux Road  
Nanaimo, BC V9T 6J9

**Attn: AJ Downie, Regional Director - Authorizations South**

Dear Mr. Downie,

**Re: Independent Review of Engineering Design for the Shawnigan Lake Landfill, 460 Stebbings Road.**

Hemmera Envirochem Inc. was retained by the BC Ministry of Environment (BC MoE) Regional Operations Branch in Nanaimo to review the submitted As-Built plans and specifications and the Final Closure Plan, and to provide comments, conclusions and recommendations focusing on the engineering design, construction and stability of the landfill to assist BC MoE in making a determination of the adequacy of the landfill, leachate collection and storage works, and the post-closure inspection, operation, and maintenance and environmental monitoring program, to prevent an escape or spill of leachate into the environment during the post-closure period. The Shawnigan Lake Landfill is owned by Cobble Hill Holdings Ltd. (CHH) and is located at 460 Stebbings Road, near Shawnigan Lake, BC (Site).

Mr. Brant Dorman, P.Eng., CSAP and Mr. Paul Webb, P.Geo., CSAP of Hemmera have reviewed documents related to the Shawnigan Lake Landfill at the Site further to a revised Spill Prevention Order for the landfill issued on March 15, 2017. Contaminated soil and ash were placed in the Permanent Encapsulation Area landfill facility (the "PEA") as part of a reclamation plan for a quarry site. The review was completed to assess, where possible, the level of representation of "As-Built" documentation as well as conformance of the landfill with 2016 2<sup>nd</sup> Edition Landfill Criteria for Municipal Solid Waste (LCMSW) a BC MoE guidance document.

Concerns documented by local residents as part of the information package provided were reviewed in order to guide and focus the technical document review, and were taken into consideration when preparing the conclusions and recommendations of this report. Preparation of written responses to concerns were considered outside of the work scope.

This Work was performed under contract between Hemmera Envirochem Inc. (Hemmera) and BC Ministry of Environment (Client), dated May 3, 2017 (Contract). This Report has been prepared by Hemmera, based on work conducted by Hemmera, for sole benefit and use by BC Ministry of Environment. In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable criteria, guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

This report is a preliminary product that presents the findings of the initial phase of document review pertaining to the Shawnigan Lake landfill closure. This first phase includes review and comment of background documents including the documentation package prepared for the construction of the Encapsulation Cell. This documentation package includes as-built reports, and drawings, by qualified professionals, QA/QC documentation, submissions from local residents, and other technical documentation and correspondence. Portions of the submitted background documentation were not reviewed where that portion of the facility is no longer needed following closure.

A second phase of the project will review and comment on the Final Closure Plan, which is to be submitted at a later date. Upon receipt and review of the Final Closure Plan, a second report will be prepared.

## **1.0 BACKGROUND**

BC MoE issued Permit PR- 105809 to Cobble Hill Holdings Ltd. (CHH) for the Shawnigan Lake Landfill at 460 Stebbings Road on August 21, 2013, authorizing discharge of refuse from contaminated soil treatment facility to the landfill. The Permit PR- 105809 was canceled on February 23, 2017.

The permit allowed for soil treatment on site; however, in accordance with CVRD municipal bylaws no soil treatment was conducted on site. A covered soil management area (SMA) was used as a staging area for incoming soils.

The permit allowed for discharge of non-Hazardous Waste contaminated soils and ash into engineered lined landfill cells. Contaminants permitted included hydrocarbons, styrene, methyl tertiary butyl ether (MTBE), volatile petroleum hydrocarbons, light and heavy extractable petroleum hydrocarbons, polycyclic aromatic hydrocarbons, chlorinated hydrocarbons, phenolic substances, chloride, sodium, glycols, metals, dioxins, and furans. The permit also allowed for effluent to be discharged from the site.

On March 15, 2017, Amended Spill Prevention Order MO1701 (SPO) was issued after the Permit PR-105809 was cancelled. The SPO requires that:

- The landfill is covered completely with weighted and secured impermeable cover;
- Leachate generated at the Facility is collected and transported to an off-site facility that is authorized to treat and/or dispose of the leachate;
- All works for the collection and temporary storage of Leachate generated at the Facility are inspected regularly and maintained in good working order; and
- Records of the volumes of Leachate collected, stored and transported are maintained and submitted to the director.

Under the SPO, by April 17, 2017 the landfill operators must submit to the Ministry complete "As-Built" plans and specifications of the existing Facility, including the landfill base liner system, leachate collection system (LCS), leak detection system, landfill, slopes, impermeable cover, leachate storage works, tanks, pipes, pumps, leachate storage pond, soil management area and wheel wash area including details, layers, cross-sections, inspections, photos, quality assurance/quality control and testing results for the works.

## **2.0 AS-BUILT PLANS AND SPECIFICATIONS DOCUMENTATION**

South Island Resource Management (SIRM) submitted a binder containing "As-Built" plans and specifications of the existing Facility to Cobble Hill Holdings for submission to BC MoE pursuant to the SPO. The plans and specifications were to include details, layers, cross-sections, inspections, photos, quality assurance/quality control, and testing results for the Facility works.

### **2.1 REVIEW OF AS-BUILT PLANS**

The cover letter for the binder package dated April 18, 2017 (a 1-day extension was accepted by the MoE) addresses points a) through f) of Section 1 of the March 17, 2017 letter issued by the BC MoE, *Re: Input from Ministry staff to be addressed and responded to as part of Final Closure Plan pursuant to the amended Spill Prevention Order (SPO) issued by Minister Polak on March 15, 2017*. A summary of the SIRM responses to the issues raised in the March 17, 2017 MoE letter are provided in Table A below along with reviewer comments.

**Table A Responses to Issues Raised in March 17, 2017 MOE Letter**

Issue Raised in March 17, 2017 MOE Letter	Summary of SIRM Response	Reviewer Comments
<p>a) Previous information referred to a seepage blanket above the bedrock (e.g. Active Earth Engineering Ltd. Seepage Blanket Details, dated December 10, 2013; Environmental Appeal Board decision of March 20, 2015 (para 491 etc.); SHA Feb 2017 closure plan (section 3.2)). The WSP Feb 2017 Review (page iv), states that “As built drawings for the PEA do not clearly indicate if a seepage blanket was installed”.</p>	<ul style="list-style-type: none"> <li>• The Seepage Blanket was clearly indicated in the October 2013 <i>Bedrock Integrity Inspection and Risk Assessment</i> report prepared for Cell 1, certified by a Qualified Professional.</li> <li>• <i>Test Pit Location Plan (binder pg 16)</i> shows that test pits were excavated through the Seepage Blanket for the entirety of Cell 1.</li> <li>• Excavation through the Seepage Blanket for the westward construction of Cell 1 was documented in the <i>Bedrock Integrity Inspection and Risk Assessment</i> report dated May 05, 2016</li> <li>• The above documents use the term “expansion” for Cells 1B and 1C, these cells were built on the original Cell 1 footprint shown on the <i>Test Pit Location Plan</i></li> </ul>	<ul style="list-style-type: none"> <li>• The Active Earth Engineering Figure 2 “As-Built of Permanent Encapsulation Area Cell 1, Cross Section A-A’ included in the binder Section 3 does not indicate a Seepage Blanket between the compacted clay basal layer and the underlying bedrock.</li> <li>• <i>Bedrock Integrity Inspection and Risk Assessment</i> reports prepared by Active Earth Engineering Ltd. (Oct 2013) and Brimmell Engineering Ltd. (May 2016) do not discuss or evaluate the presence of a Seepage Blanket, however the Active Earth report does indicate that the rock surface is covered with blast rock debris with thicknesses up to 2m thick.</li> <li>• The supplied photos appear to indicate the presence of rock debris in the test pit walls.</li> </ul>
<p>b) Ministry Inspection Record 27734 dated August 11, 2016, indicated that actual construction of the landfill cell(s) differed from submitted As-Built plans and specifications (e.g. base liner anchor trench was not installed/complete), and requested that accurate As-Built plans and specifications of the facility including cross-section details of the landfill cells be submitted (e.g. “SIRM will submit accurate As-Built cross-section details for PEA Cells 1A, 1B and 1C, certified by a QP, including all details (e.g. leak detection works, all layers, anchor trenches, etc.)”).</p>	<ul style="list-style-type: none"> <li>• Anchor trenches are not utilized in the completed closed cells. These trenches are used during the preliminary construction of the cell and base liner placement, the anchor trench ensures that the base liner is held in place at the top of the slope during soil deposit.</li> <li>• Sperling Hansen Associates letter of January 30, 2017 indicates that the top and bottom liner layers of Cell 1 are welded seams of multiple liner sections brought together to make one integral lined cell which ensures that the liners are held in place.</li> <li>• During the construction of Cell 1, the liner was weight supported at the top of the slope with concrete lock blocks, an alternate method of holding a liner in place, when rock prevented the excavation of the trench dam.</li> </ul>	<ul style="list-style-type: none"> <li>• Photos taken during construction (08/03/2016) show that boulders and stakes were also used to anchor the liner during construction.</li> <li>• It is agreed that the as-built plans do not show the anchor trenches accurately.</li> <li>• The alternate methods used to anchor the liner during installation appear to have been appropriate. The liner extends to the crest of the Cell 1.</li> </ul>

Issue Raised in March 17, 2017 MOE Letter	Summary of SIRM Response	Reviewer Comments
<p>c) Brimmell Engineering Ltd. letter re: As-Built for Encapsulation Cell 1C, dated July 4, 2016 (page 2) states: "The narrow, southerly end of the Encapsulation Cell 1C site has yet to be finalized due to a problem with outcropping bedrock on the west side (photo). This report will be updated when the south end has been finalized. Until this is done the contaminated fill is to be kept back at least 1.5 m from the existing south end of the LLDPE liner, and sloped up to the north at 1.5:1."</p>	<ul style="list-style-type: none"> <li>• April 18, 2017 addendum to Brimmell Engineering Ltd. letter dated July 4, 2016 provided in binder (pg. 111). Report concludes that construction of Cell 1C meets Permit standards.</li> <li>• Report photos show outcropping removed and Cell construction.</li> </ul>	<ul style="list-style-type: none"> <li>• Updated As-Built for Encapsulation Cell 1C report by Brimmell Engineering Ltd. April 2017 addresses this concern.</li> <li>• Qualified Professional did not carry out site reviews during preparation of this area and relied on statements provided by others.</li> <li>• The dates provided in the report appear to be typo errors as they refer to dates in July 2017.</li> </ul>
<p>d) The WSP Feb 2017 Review states "The size of the Contact Water Pond surveyed in June 2016 is smaller than the as-built size in the Active Earth documents." (page iv).</p>	<ul style="list-style-type: none"> <li>• Sperling Hansen are currently developing the Final Closure Plan which is anticipated to include removal of the Contact Water Pond. The Permanent Encapsulation Area is currently generating 50 litres of leachate per day which is anticipated to be collected into tanks that protect against receiving water from the weather.</li> <li>• The WSP draft report dated Feb 20, 2017 assumed a catchment area that included the wheel wash and future ongoing operations. Due to cancellation of the Permit, the wheel wash has been eliminated and the Soil Management Area is covered and does not currently produce contact water. The only contact water being produced is from the PEA Cell 1, and is estimated to be 50 litres per hour. We understand that some calculation discrepancies exist and are being rectified.</li> </ul>	<ul style="list-style-type: none"> <li>• The SIRM response appears to be appropriate.</li> </ul>

Issue Raised in March 17, 2017 MOE Letter	Summary of SIRM Response	Reviewer Comments
<p>e) The SIRM letter dated March 9, 2017, and SHA letter dated January 30, 2017 (pages 3 &amp; 5), indicates that the geomembrane cover installation is not fully complete and that additional detailed welding of patches, tie-in to the basal liner, pipe penetration boots, 3rd party review and QA/QC testing, and final inspection/completion report, as well as reinstalling the 'tire-chain' securing system on the crest and side slopes, are required.</p>	<ul style="list-style-type: none"> <li>• Sperling Hansen Associates are actively working on the Final Closure Plan with Cobble Hill Holdings in conjunction with the Facility Operator who have been working to complete the actions stated in the SHA January report. Plans are being prepared to permanently close the Soil Management Area, proposing to deposit the remaining soil in the SMA to the PEA. The remaining activities stated in the Sperling Hansen Associates report will also be completed under the Final Closure Plan.</li> </ul>	<ul style="list-style-type: none"> <li>• The cover has been welded to the basal liner as of May 2017. The remaining items are expected to be completed as indicated.</li> <li>• SIRM plan to open up the geomembrane cover to place the contaminated soil from SMA in the landfill once the final closure plan is approved</li> </ul>
<p>f) The SHA January 30, 2017 letter (page 4) also indicates "SIRM constructed an additional contact water lined storage pond near the Water Treatment Plant onsite. The new pond adds approximately 75m3 of storage capacity for contact water."</p>	<ul style="list-style-type: none"> <li>• The additional pond was built as a contingency measure as part of the Ministry of Environment Pollution Prevention Order 108608.</li> <li>• The additional pond was not utilized. The liner has been removed and the remaining hole has been structurally backfilled.</li> </ul>	<ul style="list-style-type: none"> <li>• The additional pond has been removed from the site and was outside the review scope.</li> </ul>

The submitted documentation binder is organized into the following sections:

1. Site Plans for 460 Stebbings Road, Lot 23

This section includes a Quarry mine plan and Electrical distribution plan

2. Permanent Encapsulation Area – Cell 1

This section contains an Active Earth Engineering Ltd. report dated July 2015 and an Addendum dated August 2015 that describe the construction of the landfill Encapsulation Cell 1, with figures showing plan and cross section views. As-built report describes the various layers used to encapsulate the landfill soils, including

- native bedrock subbase,
- minimum 1m compacted clay placed above the bedrock. Surface of the clay is sloped approximately 2% to the north.
- 0.3 m sand drainage and protection layer overlying the clay that drains to a 4-inch header along the north side of the cell then into a 2,500 gallon tank,
- a single panel (no field welds) 40 mil LLDPE liner. Liner is underlain by geotextile on the berm slopes on the south and east sides of Cell 1.
- second 0.3 m sand protection and leachate drainage layer overlying the liner that drains to a 4-inch header along the north side of the cell then into a 2,500 gallon tank.

The attachments to the July 2015 report are included in Section 4 of the binder.

The Addendum report provides clarifications to the As-built report and a summary of the QA/QC completed during the cell construction. No corrections to the original report were required. The QA/QC measures employed during the base liner system included:

- Bedrock Integrity assessment;
- Grain size analysis of the clay used for the base liner;
- Proctor testing of clay sources and field density testing to confirm appropriate compaction of the base liner;
- Visual inspection, hand measurement and survey to confirm appropriate thickness and slope of the base liner;
- Inspection and approval of sand used for leak detection and leachate collection blankets to confirm free draining properties and appropriateness for liner protection;
- Direction for liner installation procedures and visual inspection of deployed liner for any potential damage;
- Review of supplier QA/QC report that documents liner integrity testing;
- No field welds were utilized for encapsulation Cell 1 liner; and
- Leak detection and leachate collection piping systems were visually inspected during construction.

No dates specifying when the above QA/QC measures were completed or observed were provided in the report. Dates that the Proctor testing, Grain Size analysis, and field density testing were completed are provided on the attached Levelton reports included in Section 4 of the binder. The cross section for the Cell contains details of the cell toe design showing the leachate collection and detection system piping and details of an anchor trench for the 40-mil liner (indicated to be blue) at the top of the berm.

3. Rock Integrity Seepage Blanket – Cell 1

This section contains an Active Earth report dated December 2013 that describes changes to the Encapsulation area to include a Seepage Blanket that is expected to provide a passive drainage pathway for any groundwater seepage that may occur into the base of the quarry pit. The seepage blanket consists of 6-inch minus crushed rock placed to fill depressions in the final quarry surface. Any groundwater that enters the seepage blanket is considered non-contact water. The report indicates that monitoring the presence/absence of groundwater flow and quality within the seepage blanket is not necessarily warranted. The report describes seven failures that must occur for the landfill soils to impact the groundwater within the seepage blanket.

An Active Earth report dated October 2013 describes test pitting that was completed to inspect the bedrock integrity below Cell 1. Ponding of water in the test pits was stated to be indicative of the bedrock surface to be low-permeability and relatively unfractured.

A Brimmell Engineering Ltd. report dated May 2106 describes the results of two test pits to assess the integrity of bedrock below the proposed westward expansion of Cell 1.

4. Cell 1 Phase A – As-Built Quality Assurance & Quality Control

This section contains plans, photographs, tank specifications, liner testing documentation, and clay base layer grain size and compaction data from the Active Earth Engineering Ltd. report dated July 2015 and addendum dated August 2015 that describe the Phase A construction of the landfill Encapsulation Cell 1. A Levelton Consultants Ltd. field review report dated April 16, 2014 describes inspection of the bedrock slopes on the west and south sides of Cell 1. Reports prepared by Levelton Consultants Ltd. in April 2014 are provided including Proctor Test reports, Grain Size Analysis reports, and Field Density reports completed in April 2014 are provided.

5. Cell 1 Phase B – As-Built Quality Assurance & Quality Control

This section contains a Brimmell Engineering Ltd. report dated November 2015 that describes the site preparation for the landfill expansion and density testing. The report does not specify that the site preparation work described in the report was monitored during completion by a Qualified professional, with the exception of October 25<sup>th</sup> density testing. A field report dated Oct 27, 2015 describes a review that concluded the initial clay thickness was insufficient, a subsequent inspection on Nov 4 2015 indicated that additional clay had been added and compaction was acceptable. Notably, the clay layer is not described to extend up the slope to the south, or if geotextile or sand protection was placed on the slope below the liner. The liner is indicated to have been hot-welded to Cell 1A liner, and based on inspection at several locations the welds were found to be thorough. The date of the liner weld inspection was not provided. Site plans, liner testing documentation, and clay base layer grain size and compaction data are included.

6. Cell 1 Phase C – As-Built Quality Assurance & Quality Control

This section contains a Brimmell Engineering Ltd. report dated July 2016 that describes the site preparation for the 1C westward landfill expansion and density testing. Golder Associates completed the density testing on behalf of Brimmell, and the dates of the testing of 1st to 4th 0.25m lifts are indicated in the Compaction Testing reports. The dates of the construction inspections were not provided; however, photos of the preparation are provided. The clay layer is described to extend up the slope to the west, and a “lift” (no nominal thickness indicated) of sand protection was placed on the slope above the clay and below the liner. Use of geotextile is not indicated. The liner is indicated to have been hot-welded to Cell 1A liner (should be the Cell 1B liner). The south west corner of the Cell was not completed at the time of the inspection due to a bedrock outcrop. Site plans, photographs, liner testing documentation, and clay base layer compaction data are included. Photographs of an area in the southeast portion of Cell 1C where a liner fold over was planned appear to indicate that the liner extended over the liner covering Cell 1B.

An updated As-Built for Encapsulation Cell 1C was provided by Brimmell Engineering Ltd. dated April 2017 further to the July 2016 report. The report states that the Qualified Professional did not carry out site reviews during preparation of this area (following removal of bedrock outcrop) and relied on statements provided by others. The dates provided in the report appear to be typo errors as they refer to dates in July 2017.

7. Cell 1 – Contaminated Soil Placement As-Built

This section contains a schematic of the source of soils placed on a 10m by 10m grid within the various 1m thick lifts of the Permanent Encapsulation Area cells 1A to 1C.

8. Cell 1 – Closure Report, Quality Assurance, and Quality Control

This section contains a Sperling Hansen Associates (SHA) report dated January 2017 that describes the findings of two site inspections completed during and after the installation of the impermeable cover on the soil landfill cell. Inspection of the sand cushion layer below the liner and liner weld quality control testing was completed on site. The cover liner was welded to the basal liner to minimize the entry of rainfall into the PEA cell. However, SHA indicates in the report that several tasks were outstanding, including detail welding of patches and tie-in to the basal liner and pipe boots as well as seam QA/QC testing and documentation. Site plans and liner testing documentation are included.

In the report, SHA also presents the status of tasks the required immediate action based on MoE concerns outlined in the Pollution Prevention Order.

9. Soil Management Area - Soil Management Area location on Site Plan

Not within scope of review.

10. Contact Pond – Contact Pond location on Site Plan / Water Management System

Not within scope of review.

## **2.2 REVIEWER COMMENTS REGARDING AS-BUILT PLANS**

### **2.2.1 Permanent Encapsulation Area – Cell 1**

The cross section (Figure 2) provided in the package only shows north - south orientation and is inaccurate (e.g shows anchor trenches that were not installed, and does not show the presence of the seepage blanket). A perpendicular cross section in the west-east direction was not provided.

A cross section in the west-east direction would be expected to show details of the connections between the three phases of construction where the liner, leak detection, and leachate collection systems between the three phases of construction were joined. For example, the plan and cross section documentation appears to lack details regarding the presence of berms between the cell expansion phases, however berms are shown along the west and north sides of Cell 1B in the plan view Figure 1 for the Cell 1 Phase B documentation, as well as along the north edge of Cell 1C (shown on Figure 1 for the Cell 1C to be located between the leachate and leak detection piping and the main cell area). The berms between the cell expansion phases are apparent in photographs of the Cell 1 construction.

While photographs of the construction are provided, the reporting would also be expected to include details and records of the construction monitoring events carried out to confirm the as-built construction.

### **2.2.2 Rock Integrity Seepage Blanket – Cell 1**

This section contains documentation that is provided to describe the as-built construction of the Seepage Blanket underlying the clay liner below Cell 1. The two supporting reports that were included contained information pertaining to the integrity of the bedrock surface and did not discuss the presence or specifications of the seepage blanket. Photos appear to show that the material used to level the Cell 1 area of the quarry contains 6 inch minus blast rock material. No as-built specifications, design documents, or construction monitoring records for the seepage blanket were provided in the package.

The Active Earth report dated December 2013 describes seven failures that must occur for the landfill soils to impact the groundwater within the seepage blanket, and it is agreed that the clay basal liner would be expected to maintain a separation between the seepage blanket and potential contact water from the PEA. Monitoring of the water quality and assessment of the hydrogeologic properties within the seepage blanket appear warranted to confirm the performance of the clay basal liner.

### **2.2.3 Cell 1 – Closure Report, Quality Assurance, and Quality Control**

The Sperling Hansen Associates (SHA) report dated January 2017 indicates that several tasks were outstanding before the PEA liner completion could be signed off. Of the outstanding tasks, detail welding of patches, pipe boots, as well as seam QA/QC testing and documentation appear to remain outstanding.

There are no pipe boots evident in the cover liner as would be expected near the clean-outs for the leachate detection and collection piping systems. One section of piping that included what appears to be a liner pipe boot (cut out of the liner and looking similar to skirting around the pipe) was present on the ground outside near the collection tanks on May 18, 2017.

Comments regarding other aspects of the as-built landfill construction are provided below:

"As-Built" Aspect	Reviewer Comments
landfill base liner system	No geotextile added between sand bedding above clay layer and above sand bedding above base liner for avoiding LCS plugging by fines.
leachate collection system	No geotextile above sand layer to prevent plugging by fines. Cross-section detail needed to show how collector pipe is configured at cell junctions where photos show berms. Is there a means to demonstrate cover integrity? Are leachate flows recorded continuously to demonstrate temporal leachate production changes?
leak detection system	Landfill toe leak detection collector pipe should be keyed into clay layer to intercept all leakage. Detailed as-built cross-sections and photos during and after construction should be provided. Record leakage flow continuously to assess temporal changes.  Since approximately November 2016 when the cover liner was installed and welded to the basal geomembrane, any precipitation that collects along the upper portions of Cell 1 is expected to infiltrate between the clay berm and the geomembrane, and accumulate within the leak detection sand layer. The leak detection system has not identified any flow from the sand layer to date.
landfill slopes	Cross-section figures from West to East showing berms between sub cells, landfill toe liner and leakage and leachate collection completion details not provided.
landfill impermeable cover	Cover liner placed, however proposed closure clay and soil protection layers not yet added.
leachate storage works: tanks, pipes, pumps, leachate storage pond	Review of pumps and storage pond not within scope of this review as leachate accumulations in the collection tank to be removed for off-site disposal on a regular basis. Leachate tank cover is cracked and open to elements. On May 18, 2017, the water level in the tank was near (within approximately 95%) to the level where the tank could overflow.
soil management area and wheel wash area	Review of this area not within scope as these features are not expected to be present in final closure.

### 3.0 ADDITIONAL DOCUMENTS REVIEWED

Electronic document files were provided for review to guide and focus the technical review of As-built plans and specifications, and were taken into consideration when preparing the conclusions and recommendations of this report.

**CHH info from SRA reps.pdf** – “Documentation of Evidence That the Contaminated Soil Landfill Site Is Already Contaminating the Watershed Area”

Document provides data and photos as apparent evidence for:

1. Exceedances of the BC Aquatic & Drinking Water standards at the Ancillary Discharge from the Settling Pond
2. The many-fold increase of contaminants measured in the Ephemeral Stream compared to Shawnigan Creek upstream of the contaminated soil landfill site
3. Installation of a Leak Detection system designed not to detect leaks and evidence that the liner system was already leaking prior to the installation of Cell 1C.
4. Poor liner installation procedures and evidence that liner welds are already coming apart.

#### Local Resident Concerns

The information package provided to Hemmera by BC MoE contained PDF and E-mail documents received by the BC MoE from local residents documenting concerns they have raised regarding the landfill construction. The documents provided from local residents are listed in **Appendix A** along with a brief summary of the content.

Of note, an e-mail dated 07 13 2016 from Hutchinson titled *FW SIASIRM operational issues re MOE Permit 105809* contains information regarding liner issues, leak detection system, and dumping prior to cell completion. There are photos of Cell 1C construction showing the berm between Phases 1B and 1C. Based on water accumulations evident in the photos that are expected to be able to drain off through the leachate collection layer, it appears that there is the potential that >0.3m of hydraulic head could be present in some areas of Cell 1C.

#### Previous As-builts to March 2017

The information package provided to Hemmera by MoE also contained previous as-built PDF and E-mail documents that had been submitted to the MoE. These are listed in **Appendix B** along with a brief summary of the content. Several of these documents were included again in the submitted As-Built binder and are included in the Section 2.1 review.

## **Feb 2017 WSP & SHA Reports**

### **1) 2017-02-20 SHA Closure Report**

This report prepared by Sperling Hansen Associates in February 2017 presents a landfill closure plan for the site. The report addresses comments received on the October 2013 Closure Plan. It is noted that the updates were prepared prior to the cancellation of the permit and assumed continued operation of the landfill, as such sections regarding continued soil landfilling and quarrying operations are no longer pertinent.

**Climate Station:** WSP and SHA used different climate stations as representation of the landfill site.

- In the updated closure plan, SHA used Lake Cowichan weather station data for the climate section and leachate generation modeling. SHA had initially used the Shawnigan Lake weather station as it is closest to the site, updated to be consistent with WSP.

**Cost Estimates:** SHA did not fully address all outlined Post Closure Costs.

- SHA updated Closure Costs to reflect 2016 2nd Edition Landfill Criteria.

**Post Closure Period:** Post Closure period was not in accordance with 2nd edition landfill criteria.

- SHA updated the post closure period and provided proposed rationale.

**Surface/Stormwater Conveyance:** 2nd Edition Landfill Criteria does not allow for water diversion beneath the landfill footprint.

- SHA provides proposed justification that this does not apply to the design of the Cobble Hill Landfill.

**Geomembrane:** SHA report cited a 40 mil geomembrane basal liner was to be used rather than 60 mil.

- SHA has updated the report to include a geosynthetic clay liner (GCL) overlain by a 60mil geomembrane recommendation in the basal layer design.

In the report, SHA recommends that clean groundwater collected within the seepage blanket layer (below the landfill basal layers) be kept separate from the other surface water collection systems to enable testing of the groundwater for contamination from soil fill cells. The leachate collection strategy also recommends that a monitoring program be put in place to test any groundwater seepage draining from under the landfill to ensure no leakage of the basal liner system is occurring.

It is also noted in the report that the landfill is not a Municipal Waste Landfill and the gas generation rate for the types of waste being landfilled is expected to be slow, as such landfill gas will be monitored but is not deemed to be of great concern at the site.

## 2) 2017-02-20 WSP Report No. 161-16816-00

This report is a draft Addendum Review of Contact and Non-Contact Water Management Systems prepared by WSP Canada Inc. in February 2017 for MoE review. The scope of the report included:

Review of the Contact Water System as-built drawings, operational records, and test data for the whole system including:

- Contact Water Pond,
- Permanent Encapsulation Area (PEA),
- Soil Management Area (SMA),
- Wheel Wash Area,
- Leak Detection system, and
- Leachate collection system

Hydrotechnical Comment Review:

- Hydrogeological Investigation
- Seepage Blanket Review
- Settling Pond
- Contact Water Pond
- Lake Cowichan IDF Data/ 200 Year Event

As the landfill PEA is to be closed with no future effluent discharge, the majority of the Contact Water System and Hydrotechnical Comment Review are no longer applicable and was not reviewed.

Of note, the following were identified in the report:

- The size of the Contact Water Pond is smaller than the as-built size in Active Earth documents and is not large enough to handle the contact water that would be generated by a 200 year storm with snow melt.
- The PEA has not been covered with 0.66 m of soil as required in the current EMP/OMC. This protects the cover barrier liner from puncture by fly rock or ungulates as well as increase the life of the liner.
- The underlying bedrock was inspected for fractures containing water and none were identified.
- During construction of the cells the basal clay layer was tested for particle size distribution and compaction tested to confirm greater than 90% standard proctor before covering with sand.
- The LLDPE base liner was joined at the factory, and joint test documentation was included with the as-built documentation.

- The base liner of Cell 1B was hot welded in the field to the Cell 1A liner to form a continuous base. Cell 1C base liner was hot welded to Cell 1B liner.
- Original designs included a layer of crushed rock over the bed rock to form a “seepage blanket” to level the underlying bedrock. However, the as-built reports indicate that between 1-3 m of clay was placed over the bedrock.
- WSP completed a review of a December 10, 2013 Seepage Blanket Details letter. Uncertainty in the seepage blanket construction was anticipated to be addressed through the shallow subsurface flow investigation.

WSP concluded in the PEA Leachate Collection section:

- PEA design is effective and appropriate for storing contaminated soils that do not contain incompatible chemicals for the lifespan of the LLDPE liner.
- Leachates generated from within the PEA are captured by the leachate collection system
- The leak detection system design should be effective for detecting leaks
- Monday to Friday inspections of the leachate and leak detection pipe inspection ports and reservoirs ensure that any blockages are cleared relatively quickly

Daily inspection reports on the leak detection and leachate reservoirs allow the operators to monitor the volume of leachate that is collected in the PEA before pumping to the contact water pond.

### Previous Photos

Additional photos were also provided to Hemmera by MoE in order to assist in the review of technical documents and other submissions.

Folder Name	Photo Summary	Reviewer Comments
2015-04-10 Site Visit	Photo 1: Looking downstream. Sample point circled. Photo 2: Looking upstream towards discharge point Photo 3: Treatment plant and empty settling pond. Discharge point circled. Photo 4: Discharge point to ephemeral tributary Photo 5: Typical water sample Photo 6: Soil management area	Not pertinent to review scope / material as these features are not expected to be present in final closure.
2015-07-10 Site Visit	11 photos of facility	Not pertinent to review material
2015-11-13 complaint photos	2015-11-13 photo provided by Sonia Furstenau ponded water 2015-11-13 photo provided by Sonia Furstenau running water off site of SIA 2015-11-13 photo provided by Sonia Furstenau soil excavation 2015-11-13 video from Sonia Furstenau of running flow from SIA	Not pertinent to review material

Folder Name	Photo Summary	Reviewer Comments
2016-03-07 photos	3 photos of settling pond berms, Cement Ash Dust containment in SMA, new SMA roof	Not pertinent to review material
2016-05-30	8 photos – Settling pond, SMA, Containment pond	Not pertinent to review material
2016-07-21 Site Visit photos	6 photos – 4 of SMA bulge and 2 of Cell 1C filling	SMA photos not pertinent to review material.
2016-08-03 Photos	Hunse – 35 photos McCurdy – 67 photos Morrow - 32 photos	Various photos of the SMA and filling of Cell 1C Photos show liner damage from excavator at top (above filling height) of Cell 1C, construction of leachate collection at Cell 1C, sand layer below fill on slope of Cell 1C, ditching above Cell 1C, settling pond, ephemeral stream, ponded water in quarry, truck wheel wash, water treatment equipment, leachate containment pond

## 4.0 COMPARISON TO LANDFILL CRITERIA

### 4.1 COMPARISON TO 1993 LANDFILL CRITERIA (IN EFFECT AT TIME OF LANDFILL CONSTRUCTION)

The 1993 Landfill Criteria document states that landfills are to be designed to minimize environmental impact and risk and to ensure compliance with the Performance Criteria and must be carried out by qualified professionals.

The design criteria identify two types of landfills:

- "natural control landfills" which utilize the attributes of the site's natural setting (e.g. low permeability soils) to control emissions such as leachate or landfill gas and
- "engineered landfills" which use engineered systems (e.g. leachate and gas collection systems) to compensate for inadequacies in the natural abilities of the site to restrict off-site environmental impacts.

As the Permanent Encapsulation Area includes a leachate containment/collection/disposal system, the criteria below for engineered landfills were considered to apply during the construction of the landfill.

Criteria for Engineered Landfill	Compliant?	Reviewer Comments
The minimum liner specification for leachate containment systems is a 1 metre thick, compacted soil liner with a hydraulic conductivity of $1 \times 10^{-7}$ cm/s or less.	Yes	1 – 3 metre thick clay basal layer installed.
Geomembranes, or composite liners (consisting of a geomembrane and a soil layer) which provide the same level of leachate containment are acceptable equivalents.	Yes	40 mil LLDPE liner installed between 0.3 metre thick sand drainage/protection layers over clay layer

Criteria for Engineered Landfill	Compliant?	Reviewer Comments
Minimum bottom slopes of the liner are to be 2 percent on controlling slopes and 0.5 percent on the remaining slopes.	Yes	Quarry base sloped 2% to North.
Minimum specifications for leachate collection systems are a 0.3 metre thick sand drainage layer having a hydraulic conductivity of $1 \times 10^{-2}$ cm/s or greater.	Yes	0.3 metre thick sand drainage/protection layer installed over clay layer
The drainage layer is to be designed with appropriate grades and collection piping so that the leachate hydraulic head on the liner does not exceed 0.3 metre at any time.	Undetermined	Photographs of Cell 1C construction appear to show water collecting in west side of cell. Water should drain to leachate collection system.

#### 4.2 COMPARISON TO 2016 LANDFILL CRITERIA

2016 Landfill Criteria	Compliant?	Reviewer Comments
<b>LANDFILL BASE DESIGN</b>		
The landfill base shall be placed in stable soils or rock, with a minimum distance of 1.5 m above groundwater at all times.	Seasonally may not be compliant.	AEE Geotech report PDF pg 45, Figure 3 shows water tables above base of landfill.
The landfill base soils shall not be subject to consolidation that could result in differential settlement under the applied waste and cover soil loading.	Yes	Compacted to appropriate specifications.
The landfill base shall be graded to provide a minimum 2 % grade for the primary drainage path (leachate collection piping) and minimum 0.5 percent for the secondary drainage path (drainage blanket).	Yes	Seepage layer and clay base graded 2% to north.
The maximum drainage path in the drainage blanket to a leachate collection pipe shall be 50 m.	No	65.91 m for Cell 1A.
Geologic inspection of the landfill base by a Qualified Professional.	Yes	AEE and Brimmell completed bedrock integrity assessments of the landfill base.
<b>LANDFILL BASE LINER</b>		
The landfill base liner shall comprise a primary High Density Polyethylene (HDPE) geomembrane liner and a secondary compacted clay liner or Geosynthetic Clay Liner (GCL).	Yes	Geomembrane liner used composed of LLDPE (more pliant than HDPE) Secondary compacted clay liner present.
Continuous QA/QC inspection by a Qualified Professional during geomembrane installation and subsequent coverage is required to limit occurrence of undetected defects.	No	AEE and Brimmell infrequently on site during construction, however records of continuous QA/QC inspection by a Qualified Professional were not provided in the as-builts.
Each seam should be individually tested using non-destructive methods.	Yes	Seam testing has passed inspection to date.
Leak detection survey should be performed on HDPE geomembrane after it has been backfilled to locate areas that may have been damaged during material placement.	No	Survey not completed, however leak detection layer will potentially allow this to occur.

2016 Landfill Criteria	Compliant?	Reviewer Comments
The minimum specifications for the primary HDPE geomembrane liner are:		
<ul style="list-style-type: none"> <li>• HDPE geomembrane thickness of 1.5 mm (60 mil).</li> </ul>	No	LLDPE liner is 40 mil
<ul style="list-style-type: none"> <li>• Service life of 100 years at expected operating temperatures</li> </ul>	Possible	Not specified. Once covered, it is not unreasonable to expect this service life can be achieved.
<ul style="list-style-type: none"> <li>• HDPE geomembrane should be installed to meet or exceed industry standard QA/QC programs for material manufacture and installation.</li> </ul>	Yes	Manufacturer seam and material testing to date has passed inspection. AEE provided visual inspection of deployed liner for any potential damage as part of installation QA/QC
<ul style="list-style-type: none"> <li>• Consideration is to be given to the requirement for texturing and asperity size of the primary geomembrane to ensure stability of the fill in all circumstances, including earthquake loading.</li> </ul>	No	No texturing of the membrane observed.
The specifications for the secondary compacted clay liner are:		
<ul style="list-style-type: none"> <li>• Soil containing minimum 25 percent clay and minimum 60 percent silt and clay by weight.</li> </ul>	Yes	Grain size analysis completed on basal layer.
<ul style="list-style-type: none"> <li>• A minimum compacted thickness of 750 mm. Thickness is to be measured perpendicular to the slope.</li> </ul>	Yes	Clay has 1.0 to 3.0 m nominal thickness
<ul style="list-style-type: none"> <li>• Compacted hydraulic conductivity of <math>1 \times 10^{-7}</math> cm/sec or less.</li> </ul>	Unknown	The clay has been shown to be compacted to 90% Proctor, however the hydraulic conductivity of the clay layer was not measured.
<ul style="list-style-type: none"> <li>• Organic carbon content of at least 0.1 percent.</li> </ul>	Unknown	Not specified
<ul style="list-style-type: none"> <li>• Clay structure and permeability to remain stable when exposed to leachate.</li> </ul>	Unknown	Not specified in as-built package, however not expected to be unstable.
<b>LEACHATE COLLECTION SYSTEM</b>		
A leachate collection system is to be constructed above the landfill base liner. The leachate collection system is to provide a free draining layer that allows for collection of leachate and eliminates the buildup of a leachate head on the landfill base liner.	Yes and Maybe	0.3m of free draining sand installed above geomembrane liner. Construction photos show accumulations of water in Cell 1C that appear to suggest that some portions of the liner may build up leachate head.
The leachate collection system is to be designed to minimize clogging and allow for maintenance of the leachate collector pipes.	No	Photos show clean outs installed at the ends and T- connectors, however no pipe access points are evident in the current cover liner - site inspection shows cleanouts absent.

2016 Landfill Criteria	Compliant?	Reviewer Comments
<p>Minimum design requirements for a leachate collection system are:</p>		
<ul style="list-style-type: none"> <li>The leachate collection system shall be constructed of a continuous 0.3 m thick stone drainage blanket with perforated or slotted collector pipes with protective geotextile layers. Composite solutions which provide a proven equivalent hydraulic conductivity and mechanical protection are acceptable alternatives.</li> </ul>	Yes	<p>Sand drainage layer installed rather than stone drainage blanket. No protective geotextile layer installed.</p> <p>Sand drainage layer performance is expected to be similar to stone drainage blanket, geotextile would add extra protection but fines ingress will be more.</p>
<ul style="list-style-type: none"> <li>The stone drainage blanket shall be constructed of 50 mm diameter clear stone with minimal fines or equivalent. The stone shall be chemically stable and inert rock.</li> </ul>	No	<p>Sand drainage layer installed rather than stone drainage blanket. Sand is expected to be chemically stable.</p>
<ul style="list-style-type: none"> <li>A non-woven geotextile shall be placed on top of the geomembrane liner prior to placement of the stone drainage blanket to protect the geomembrane liner against puncture.</li> </ul>	No	<p>Sand drainage layer installed rather than stone drainage blanket, sand provides some protection.</p>
<ul style="list-style-type: none"> <li>An engineered filter layer shall be placed above the clear stone drainage blanket to maintain separation of the waste from the clear stone and to minimize the potential for ingress of fines into the stone drainage blanket.</li> </ul>	No	<p>Sand layer partially meets these criteria, but will allow fines in.</p>
<ul style="list-style-type: none"> <li>Perforated or slotted HDPE leachate collector pipes shall be placed within the stone drainage blanket. Steps should be taken to prevent entry of air into drainage pipes.</li> </ul>	No	<p>Leachate collector pipes tied into header not installed.</p>
<ul style="list-style-type: none"> <li>Leachate collector pipes are to be installed at a lateral spacing that provides a maximum spacing of 15 m and maximum drainage path of 50 m.</li> </ul>	No	<p>Leachate collector pipes tied into header not installed.</p>
<ul style="list-style-type: none"> <li>The collector pipes shall be sized to handle leachate flows based on site-specific leachate generation calculations but shall be a minimum 150-mm-diameter in all cases.</li> </ul>	No	<p>Leachate collector pipes tied into header not installed.</p>
<ul style="list-style-type: none"> <li>The pipe wall thickness shall be designed based on the site-specific loadings from the mass of the waste and final cover soils.</li> </ul>	No	<p>Leachate collector pipes tied into header not installed, pipe wall thickness not specified.</p>
<ul style="list-style-type: none"> <li>The collector pipes shall be installed at a minimum slope of 2 percent along primary leachate flow paths.</li> </ul>	No	<p>Leachate collector pipes tied into header not installed.</p>
<ul style="list-style-type: none"> <li>Clean outs are to be provided at each end of the leachate collector pipes.</li> </ul>	No	<p>Clean outs on leachate collector pipe header not installed, not currently accessible through liner.</p>

2016 Landfill Criteria	Compliant?	Reviewer Comments
<ul style="list-style-type: none"> <li>The collector pipes shall drain to a collection header and sump to allow for the removal of collected leachate. Leachate shall be removed to maintain a leachate head of less than 0.3 m at any point on the landfill base liner.</li> </ul>	Yes and Maybe	<p>No leachate collector pipes installed, only sand layer. Leachate collector pipe header installed.</p> <p>Leachate may be present at a head of &gt;0.3m in some areas of landfill. Construction photos show accumulations of water in Cell 1C that appear to suggest that some portions of the liner may build up leachate head.</p>
<ul style="list-style-type: none"> <li>Continuous QA/QC inspection shall be carried out during installation by a Qualified Professional during the construction of the leachate collection system.</li> </ul>	No	<p>Continuous inspection by QP not indicated; QP inspections infrequent and not well documented in the as-built documents...</p>
<ul style="list-style-type: none"> <li>The collected leachate shall be managed in accordance with the approved Leachate Management Plan.</li> </ul>	No	<p>No leachate management plan provided. Leachate is currently pumped from tank on regular basis for off-site disposal</p>
<b>SURFACE WATER MANAGEMENT WORKS</b>		
Surface water management works are to:		
<ul style="list-style-type: none"> <li>Convey and direct surface water runoff away from the active operation area within the landfill footprint to minimize surface water contact with waste.</li> </ul>	Yes	<p>Meets Criteria. Ditching around PEA to divert surface run-off</p>
<ul style="list-style-type: none"> <li>Minimize potential for on-site erosion and sediment loading to downstream water courses.</li> </ul>	Yes	<p>Discharge to rock quarry.</p>
<ul style="list-style-type: none"> <li>Control peak flows from the landfill to minimize the downstream flood risk.</li> </ul>	N/A	<p>Outside of review scope</p>
<ul style="list-style-type: none"> <li>Prevent surface water run-on onto the landfill footprint.</li> </ul>	Yes	<p>Meets Criteria. Ditching around PEA to divert surface run-off away. South and highest edge of the PEA requires an anchor trench to divert run-on away from landfill footprint.</p>
Surface water management works shall be designed in accordance with the following criteria.		
<ul style="list-style-type: none"> <li>All components of a surface water management system, including stormwater retention ponds, are to be designed to promote settling of sediment and infiltration of retained storm water for groundwater recharge where possible.</li> </ul>	No	<p>Outside of review scope</p>
<ul style="list-style-type: none"> <li>Ponds are to be designed with low flow control structures and high flow overflow spillways.</li> </ul>	No	<p>Outside of review scope</p>
<ul style="list-style-type: none"> <li>Surface water ditches and retention ponds shall be designed for the control and retention of a 1:100-year, 24-hour storm event.</li> </ul>	Yes	<p>Closure Plan Design to capture all surface water and route it to local streams.</p>
<ul style="list-style-type: none"> <li>The design shall make allowances for additional water that may result from snow melt and from prolonged multi-day precipitation events.</li> </ul>	Yes	<p>Leachate generation estimated using HELP model that accounts for snowmelt.</p>

2016 Landfill Criteria	Compliant?	Reviewer Comments
<ul style="list-style-type: none"> <li>Surface water runoff generated from active areas of the landfill (i.e., areas that are not capped with final or interim cover but containing waste) shall be managed as leachate. Run-on diversion ditches and other control structures are to be used where required to minimize clean surface water contact with active waste disposal areas.</li> </ul>	N/A	<p>Landfill is capped and permit revoked. No more waste accepted.</p> <p>Soils currently in SMA area are proposed to be placed in the landfill during final closure.</p>
<ul style="list-style-type: none"> <li>All ditch surfaces are to be armoured with appropriate protection for expected flow velocities (i.e., rip rap, erosion control matting, or vegetative cover) to prevent erosion of ditch bottom and side slopes</li> </ul>	Yes	Current ditching adjacent to landfill meets criteria
<ul style="list-style-type: none"> <li>All ditches are to maintain a minimum 1 percent grade to prevent sedimentation and maintain hydraulic design capacity. Ditches shall be designed to accommodate localized settlement (no grade reversals).</li> </ul>	No	Not mentioned/specified in as-builts or preliminary SHA Closure Plan design.
<ul style="list-style-type: none"> <li>Erosion control measures are to be used to prevent active erosion of channel slopes and surfaces that contribute to run-off. Common erosion control measures include loose straw, hydro-seed, erosion control blankets and straw wattles, amongst others.</li> </ul>	N/A	Preliminary SHA Closure Plan design meets criteria. Not currently installed.
<ul style="list-style-type: none"> <li>Mid slope drainage ditches/swales shall be constructed on the final cover surface as required to intercept run-off and prevent erosion of final cover soils. The recommended spacing of such ditches is every 15 m (vertical separation).</li> </ul>	N/A	Not currently installed. SHA presents typical design and recommends analysis of ditches in final design.
<b>LANDFILL GAS MANAGEMENT WORKS</b>		
<p>As per the requirements of the Landfill Gas Management Regulation, landfill owners must design, construct, and operate landfill gas management facilities in accordance with the BC Landfill Gas Management Facilities Design Guideline.</p>	N/A	<p>Preliminary SHA Closure Plan design has considered LFG, but since no municipal waste is present no LFG will be generated. A VOC monitoring program is included in the Closure Plan.</p>
<b>FINAL COVER DESIGN</b>		
<p>The final cover is to achieve the following objectives:</p>		
<ul style="list-style-type: none"> <li>Prevent exposure of humans and/or wildlife to MSW.</li> </ul>	N/A	Final cover design and installation not complete.
<ul style="list-style-type: none"> <li>Control infiltration of precipitation.</li> </ul>	Yes	SHA letter of January 2017 estimates that the capped landfill cell (PEA) is shedding 95% of precipitation
<ul style="list-style-type: none"> <li>Minimize the uncontrolled release of methane to the atmosphere.</li> </ul>	N/A	Final cover design and installation not complete.

2016 Landfill Criteria	Compliant?	Reviewer Comments
<ul style="list-style-type: none"> <li>Limit erosion and release of sediment to surrounding surface waters.</li> </ul>	N/A	Final cover design and installation not complete.
<ul style="list-style-type: none"> <li>Control the release of odours.</li> </ul>	N/A	Final cover design and installation not complete.
<ul style="list-style-type: none"> <li>Minimize oxygen infiltration and fire risk.</li> </ul>	N/A	Final cover design and installation not complete. Minimal fire risk due to landfilled material.
<ul style="list-style-type: none"> <li>The final cover shall be compatible with the end use planned for the landfill site.</li> </ul>	No	Final cover design and installation not complete. No end-use stated in any documents.
<p>The minimum final cover shall consist of a barrier layer, providing a maximum hydraulic conductivity of <math>1 \times 10^{-5}</math> cm/sec for landfill sites located in arid and semi-arid regions and <math>1 \times 10^{-7}</math> cm/sec for landfill sites located in non-arid regions</p>	N/A	Final cover design and installation not complete.
<p>The final cover barrier layer shall have a minimum compacted thickness of 0.6 m measured perpendicular to the slope with a minimum 0.15 m topsoil layer capable of establishment and sustained growth of the vegetative cover.</p>	No	1.0m thick final cover barrier not completed to date.
<p>The final cover system is to be designed to ensure the maximum allowable leachate generation rate is not exceeded but will allow for waste stabilization during the post-closure period.</p>	Maybe	Final cover design and installation not complete. Proposed design exceeds minimum requirements. Current liner will partially achieve this.
<p>Hydrologic modeling of the "final cover" performance using the applicable climatic setting for the landfill site shall be completed to demonstrate the final cover stability under design storm conditions and consistency with the Leachate Management Plan</p>	N/A	Final cover design and installation not complete.
<p>A lower permeability barrier layer or the addition of a textured geomembrane or geo-composite equivalent may be required to control leachate generation rates</p>	N/A	Final cover design and installation not complete. Current liner may achieve this; however the liner is not textured.
<b>FINAL CONTOURS</b>		
<p>Final contours of the landfill shall be constructed at grades not steeper than 3H:1V (33 %).</p>	No	The final cover is not in place. Subject to the additional soil placement from the SMA. The final design contours should be 3H:1V
<p>The recommended design criteria for the top plateau of the landfill is a slope not less than 10H:1V (10 %) for cover systems using a soil barrier layer. The grade for the top plateau can be reduced up to 25H:1V (4%) for cover systems using a durable geomembrane or composite barrier layer with an overlying drainage layer above the final landfill side slope.</p>	No	The final cover is not in place, and grade subject to the additional soil placement from the SMA.

2016 Landfill Criteria	Compliant?	Reviewer Comments
Surface water control benches to intercept surface water run-off shall be provided on the landfill final contours every 15 m vertical or less. Benches shall be graded in a way that will effectively convey surface water run-off from the landfill refuse via ramps, down-chutes, or spillways and shall account for anticipated settlement.	No	Final cover design and installation not complete. The final cover is not in place, contours subject to the additional soil placement from the SMA.
SITE SECURITY AND FENCING	No	Quarry operations to be maintained. West, southwest and south perimeter fence absent.
ACCESS ROADS	n/a	Quarry operations to be maintained
VECTOR AND WILDLIFE MANAGEMENT AND NUISANCE CONTROLS	No	Quarry operations to be maintained. West, southwest and south perimeter fence absent. Deer tracks on northwest berm on May 18, 2017.

## 5.0 DISCUSSION

This section will first discuss our review of the as-built plans, after which we will provide our comment on local resident concerns and photos. Finally, items requiring further clarification with respect to the 2016 BC Landfill Criteria are discussed. Some of our comments are based on the previously submitted Closure Plan that was submitted for the operating landfill, which is now not applicable. Based on Mr. Dorman's and Mr. Webb's review of the information provided regarding the PEA closure, there are several items worthy of discussion. Overall, we observed a general lack of detail in documents provided with respect to PEA construction and undocumented and apparently infrequent Qualified Professional inspection and review. While some aspects of the landfill design exceed the minimum requirements of the Landfill Criteria such as the proposed clay cap of 1.0m thickness, other aspects such as no geotextile above the sand leachate drainage layer will likely reduce the leachate collection system effectiveness over time.

### 5.1 AS-BUILT PLANS

The as-built plans were significantly different than what was observed in the field and often contradicted information presented in provided reports. The As-Built package does not appear to be complete, up to date, and accurately reflect current conditions at the existing Facility

Based on our site inspection and report review, the as-built cross-sections provided do not represent actual conditions. There is no seepage blanket shown in the AEE Cell 1 cross-section and no details regarding the as-built construction of the seepage blanket are provided. The as-built shows the Leak and Leachate Collection System (LCS) with clean-outs, but they were absent (possibly covered by the liner) during our site inspection. With no east-west cross section provided, base liner connection details between cells cannot be reviewed. There is no geotextile above the sand leachate collection layer above the clay base to minimize fines migration into the LCS.

Anchor trenches shown on the as-builts were not present at the site. Because there is no anchor trench, storm water has the potential to infiltrate into the leakage detection system. The leakage detection system collector pipe may not be situated to intercept all leakage drainage layer liquids. CHH stated that no liquids have been collected in the leak detection system to date. Of note, the leakage detection system piping connecting to the storage tank was not connected during our May 18, 2017 site visit and the leachate tank was at 95% capacity, which causes us to question the quality and frequency of routine site inspections by the proponent and QP. During our site visit, the cap liner integrity is in question as evidenced by patch welded seams coming apart and what appear to be silicone used to seal some of the patches rather than welding.

The provided info does not include evidence of leakage tests completed. With the leakage detection layer present, there is a capability to complete these tests before capping the PEA.

## **5.2 LOCAL RESIDENT CONCERNS AND PHOTOS**

Our review of local resident's concerns revealed that some of their observations differed with respect to documents provided by CHH. We have considered this information during the course of our work. The local residents will be providing further objective information with direct comparisons to the items of concern.

## **5.3 2016 BC LANDFILL CRITERIA FOR MUNICIPAL SOLID WASTE**

The focus of our work centred on conformance with the 2016 BC Landfill Criteria for Municipal Solid Waste (LCMSW – a ministry guidance document). We have discussed various aspects of the LCMSW with respect to the PEA closure information as follows:

### **5.3.1 Landfill Base Design**

Several items were absent in the landfill base design. During landfill base construction, there was no leachate collection piping added running down the slopes to connect with the leachate collector header at the slope toe. The landfill base shall be a minimum 1.5m above groundwater always, yet according to AEE's Geotech report, the groundwater table is above the landfill base, at least seasonally. The drainage path in the LCS sand layer, at 65.9m, is greater than the maximum 50m stipulated in the LCMSW.

### **5.3.2 Landfill Base Liner**

Several items regarding the liner did not meet the LCMSW while some information was not provided. Instead of the base liner being High Density Polyethylene (HDPE, 60 mil) geomembrane, a Linear Low Density Polyethylene (LLDPE, 40 mil) geomembrane was used. Instead of continuous Qualified Professional (QP) inspection during geomembrane installation, AEE and Brimmell were infrequently on site during construction. No leak detection survey was completed prior to or after filling. Membrane

texturing consideration was absent, although earthquake loading was assessed. The LCMSW states the organic carbon content, hydraulic conductivity, and leachate stability of the compacted clay liner. No information for these was provided.

### **5.3.3 Leachate Collection System and Leakage Detection System**

There are a few differences between the LCMSW and the as-built Leachate Collection System (LCS). There was no geotextile added above the sand drainage layer, which may collect fines from the landfilled waste. No LCS collector pipes, or continuous QP inspection during installation. No formal leachate management plan provided. Leachate may be present at a head of >0.3m in some areas of landfill. Construction photos show accumulations of water in Cell 1C that appear to suggest that some portions of the liner may build up leachate head.

The leakage detection system collector pipe does not appear to be properly located to intercept leakage liquids. Since approximately November 2016 when the cover liner was installed and welded to the basal geomembrane, any precipitation that collects along the upper portions of Cell 1 is expected to infiltrate between the clay berm and the geomembrane, and accumulate within the leak detection sand layer. However, the leak detection system has not identified any flow from the sand layer to date.

### **5.3.4 Surface Water Management Works**

Surface water drainage from the PEA appeared generally adequate to direct flow away from the soil pile. The anchor trench is absent, and if installed would be expected to reduce or eliminate surface water ingress into the leakage detection system. Once the final clay and organic soil cap is added, the design should include armoured drainage channels and ditches at a minimum 1% grade to accommodate settlement causing grade reversals.

### **5.3.5 Final Cover Design, Contours, Security and Vectors**

Our review of the preliminary Closure Plan for the operating landfill revealed the following shortcomings. There was no end use explicitly stated for the site. The Closure Plan must have final cover constructed at a slope of 3H:1V. The western and southern fence were absent, which would allow trespassers and wildlife to freely roam on to the PEA.

## **6.0 CONCLUSIONS**

Based on all the information provided and reviewed there appears to be several short-comings of the work completed in the design, construction, operation and oversight during the entire process. Although some aspects of the PEA exceed minimum requirements, many details are missing and are required to ensure the facility is designed, constructed and operated to minimize any risks to the environment.

Major deficiencies include: lack of continuous QP oversight of the entire LCS and leakage detection system construction and testing, as well as membrane cover repair and integrity check.

Minor deficiencies include missing geotextile over sand LCS, adequate cover liner weighting, lack of anchor trenches and no formal leachate management plan provided.

## 7.0 RECOMMENDATIONS

In the context of avoiding any leaks or spills of leachate to the environment, and for the landfill PEA closure to more closely conform with the 2016 LCMSW (a ministry guidance document), in our professional opinion the following items must be completed:

1. Ensure the leak detection system collector piping at the landfill slope toe has been adequately keyed into the clay layer such that it captures all potential leakage and non-contact infiltration from the surface of the underlying clay barrier.
2. Based on current construction, confirm that there are provisions in place to minimize non-contact water from entering the leakage detection system. For example, the base liner could be notched into the clay on the east, south and west sides of the PEA.
3. Reinstate leak detection tank piping and measure volumes collected. Correlate with rainfall events. Provide leakage water chemistry each time the leak detection tank is emptied.
4. Have a QP document and inspect the LCS and leak detection system.
5. Provide a complete set of as-built cross-sections (North – South & East-West) for each cell including down and across the base liner slopes, as well as confirmation of the clay liner extent southwards. Provide details showing the connections between cells 1A, 1B and 1C to confirm as-built construction.
6. Provide QP opinion and sign-off on the difference in base liner thickness, material, and expected life span relative to the use of 40mil LLDPE vs 60 mil HDPE in the LCMSW.
7. Provide QP opinion and sign-off on the adequacy of not installing geotextile above the sand drainage layer to minimize fines intrusion into the leachate collection system.
8. Meter leachate flow into the leachate collection tank so that it can be correlated to precipitation data to assess and confirm cover integrity. Demonstrate that there is no correlation between rainfall events and leachate production due to cover liner leaks. Collect a sample for leachate chemistry before each tank is emptied.
9. Provide QP opinion and sign-off on the adequacy of the existing cover liner thickness and type (40 mil LLDPE smooth non-textured) relative to the use of textured geomembrane or geocomposite equivalent to a 600 mm barrier layer with a hydraulic conductivity  $\leq 1 \times 10^{-7}$  cm/sec as specified in the LCMSW. As well, the use of smooth non-textured geo-membrane should be re-evaluated before the final cover is started.
10. Have continuous QP inspection and documentation of all work completed on the PEA closure.
11. Design and install a representative groundwater monitoring program in the seepage blanket down-gradient of the PEA that will remain intact following final cover completion. Compare chemistry results to up-gradient background, leachate, and leak detection system water monitoring results to assess liner integrity.

Implementing the preceding recommendations will increase adequacy of the works to prevent the escape of leachate into the environment during the post-closure period and minimize the potential for environmental risk.

We have appreciated the opportunity to work with you on this project and trust that this report meets to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

Report prepared by:  
Hemmera Envirochem Inc.

**ORIGINAL SIGNED  
AND STAMPED**

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*This document represents an electronic version of the original hard copy document, sealed, signed and dated by Paul Webb, P.Geo., CSAP and Brant Dorman, P.Eng., CSAP and retained on file. The content of the electronically transmitted document can be confirmed by referring to the original hard copy and file. This document is provided in electronic format for convenience only. Hemmera Envirochem Inc. shall not be liable in any way for errors or omissions in any electronic version of its report document.*

## Appendix A - Files Containing Local Resident Concerns

File Name	PDF	E-mail	Reviewer Comments
2016-05-05 Juurlink	X		Document presents photos taken May 4th, 2016
2016-05-09 1431 SIRM comments FW water seepage		X	E-mail attachments: Encapsulation Design Section.pdf Photo 1 W berm looking S 6May2016.jpg
2016-05-23 Juurlink Fw Liner leaks at 460 Stebbings Road		X	E-mail attachments: Landfill liner failure.pdf
2016-05-23 Juurlink Landfill liner failure	X		Photos of suspected leakage and "yellow exudate"
2016-06-08 1128 SIRM to MOE RE water seepage		X	Update on status of the seepage - no seepage occurred until rain Source was non-contact groundwater trapped within the outer berm soil. Leak detection separate from the leachate collection
2016-06-13 Juurlink	X		MoE response to Mr. Juurlink e-mail of 05-05 (May 5).
2016-06-14 Hutchinson FW Apparent liner failure of the Shawnigan contaminated soil landfill		X	E-mail and responses re: Apparent liner failure of the Shawnigan contaminated soil landfill
2016-06-14 Hutchinson FW SIA saturated soil stockpile		X	Confirmation of draining in north direction
2016-06-15 1410 SIRM to MOE RE clean material coming on site		X	Response to MoE e-mail <i>clean material coming on site</i>
2016-06-15 1618 MOE to SIRM RE clean material coming on site		X	MoE response to above e-mail <i>clean material coming on site</i>
2016-06-26 Juurlink	X		Immediate inspection required of improper liner installation at 460 Stebbings
2016-06-27 1230 Hutchinson to MOE re SIA SIRM operational issues		X	SMA liquid draining. Containment Pond sludge transferred to the Encapsulation Cell.
2016-06-27 1319 MEM comments re Hutchinson FW SIA SIRM operational issues		X	Comments re: SIA/SIRM operational issues re MoE Permit 105809
2016-07-06 MEM to MOE seepage results		X	Results of soil sample from seepage area- exceeds Protocol 4 background for mercury, but less than Schedule 7
2016-07-13 Hutchinson FW SIA SIRM operational issues re MOE Permit 105809		X	Documents regarding Liner Issues, Leak Detection System, Dumping prior to cell completion Good photos of Cell 1C construction showing berm between 1B and 1C
2016-07-13 Hutchinson July 12 Mtg re Waste Permit 105809 (Shawnigan)		X	2 aerial photos attached – one shows water ponding in west side of Cell 1C, should be draining through sand layer to leachate collection. potential slope or drainage layer issue.
2016-07-13 Hutchinson Violation of Section 1.3.2 of Permit 105809 (Shawnigan)		X	SMA sediment placed in PEA violation

File Name	PDF	E-mail	Reviewer Comments
2016-07-14 Juurlink More liner problems		X	There is no geotextile fabric above and below the LLDPE liner as required The liner is covered by sand with no intervening geotextile fabric. Berm liner is not anchored by an anchor trench
2016-07-19 1359 SIRM to MEM SMA perimeter soil sample results		X	SMA perimeter soil sample results - not relevant to review scope
2016-07-28 MOE LH to SIRM TG Regarding Alleged Concerns for Discussion		X	Above liner, SMA, disposal concerns forwarded to SIRM
2016-08-08 MOE ADM to JUURLINK RE Second paper and other Lot No23 matters including the Ministry of Energy Mines		X	MoE Response to 2026 07 14 Juurlink e-mail with attachment Documentation Of Liner Installation Errors.pdf and photos
2017-03-03 2004 Fwd MOE WQ Study Community Response Mar 3 2017 - Docs from B. Juurlink L. Gregory		X	MoE WQ Study Community Response
2017-03-27 1216 Beach to MOE Non-contact Report and Addendum		X	Shawnigan Research Team review of the WSP Non-contact water report and addendum is complete and may be found at <a href="http://brentatthefocus.blogspot.com/2017/03/review-of-16-12-19-contact-water-study.html">http://brentatthefocus.blogspot.com/2017/03/review-of-16-12-19-contact-water-study.html</a>
2017-04-07 1636 Beach to MOE Contact Water Report and Addendum		X	Completed a review of the WPS documents as they relate to contact water - see blog. To summarize, documents make it clear that the consultants were given false, misleading and incomplete information on which to base their reports.
2017-04-10 1541 Beach to MOE Landfill arguments		X	Initial comments on final landfill slopes not meeting reclamation objectives
2017-04-24 1744 Beach to MOE Landfill Closure Reports		X	review completed of the Landfill Closure Plans - see blog
Fwd 2017-03-04 SIA One week after shut down		X	Photos of landfill areas

## Appendix B - Previous As-builts to March 2017

Report #	File Name	PDF	E-mail	Reviewer Comments
1	2013-10-10 2.4 - Bedrock Integrity - Cell 1	X		AE excavates 6 testpits to assess bedrock integrity. Inspection revealed no discernable water bearing or open fractures in bedrock. Pondered water supports low permeability bedrock and lack of fractures. Piezometric pressures above pit bottom with upward hydraulic gradients. Testpit inspections were consistent with previous investigations. This testing was completed in addition to 1993 Landfill Criteria requirements, but complies with 2016 Landfill Criteria and HWR.
2	2013-10-22 4.1 & 4.2 Closure Plan and Security Posting	X		Landfill cap design comprising 30 mil LLDPE liner, 1.0 m thick $1 \times 10^{-7}$ m/s hydraulic conductivity or lower compacted soil layer. Meets 1993 Landfill Criteria requirement.
3	2013-10-24 AEE Geotechnical Assessment	X		Assessed geotechnical aspects of landfill area prior to construction. 1993 Not relevant to Closure Plan compliance.
4	2013-10-29 As Built - Soil Management Area	X		Summarized design of SMA. Not relevant to Closure Plan compliance.
5	2013-12-06 As-Built - Water Management System	X		Summarized Water Management system in place during soil handling and filling activities. Not relevant to Closure Plan compliance.
6	2013-12-09 AEE Core Drilling Report MW13-4 & 13-5	X		Summarized Core Drilling and Testing Results. Not relevant to Closure Plan compliance.
7	2013-12-10 AEE Seepage Blanket Design Report FINAL	X		Summarized Seepage Blanket design before soil acceptance to landfill. Not relevant to Closure Plan compliance.
8	2013-12-10 AEE SIA Seepage Blanket Design Report FINAL	X		Summarized Seepage Blanket design before soil acceptance to landfill. Not relevant to Closure Plan compliance.
9	2013-12-12 Letter from MoE to SIA_CHH re. Supporting Docs	X		MoE letter stating additional requirements under Permit PR-105809. Not relevant to Closure Plan compliance.
10	2014-03-20 AEE Revised Base Liner Cell 1	X		Soil Containment Area Base Liner Revised Design. Not relevant to Closure Plan compliance.
11	2014-05-21 As Built Sed Control Pond	X		Sediment Control Pond As-Built. Not relevant to Closure Plan compliance.
12	2015-05-01 water treatment plant commissioning report	X		Water Treatment Plant Commissioning Plan summary during landfill operation. Not relevant to Closure Plan compliance.
13	2015-07-30 Cell1_As-Built_PR105809_Q-8-094	X		Shows Cell 1 liner construction prior to filling. Confirms Cell 1 holding cell construction meets 1993 Landfill Criteria.
14	2015-08-28 As Built Reports_Cell 1A_reduced	X		AE specifically stated that their Cell 1 design met compliance with MEM and MoE permits.

Report #	File Name	PDF	E-mail	Reviewer Comments
15	2015-08-28 Cell1_QAQC Addendum_Q-8-094	X		AE specifically stated that their Cell 1 design met compliance with MEM and MoE permits.
16	2015-11-13 Cell_1_Extension_as built	X		Cell 1B As-Built showing compliance with 1993 Landfill Criteria. Base liner welded to Cell 1A liner.
17	2015-11-18 1100 FW As-Built Additional Cell 1 Liner		X	Email to MoE with 2015-11-13 Cell_1_Extension_asbuilt attached. Not relevant to Closure Plan compliance.
18	2015-11-18 1121 FW Attachment Cell 1 initial as-built		X	Email to MoE with Reports # 13,14 attached, Not relevant to Closure Plan compliance.
19	2016-01-29 SIRM to MOE WTS backup	X		Email to MoE of Water Treatment System backup confirmation. Not relevant to Closure Plan compliance.
20	2016-02-04 As Built sed pond		X	CAD version of Sediment Control Pond Design. Not relevant to Closure Plan compliance.
21	2016-02-05 MOE to CHH FW SIRM Water Treatment System Back-up		X	MoE Response to Email #19. Not relevant to Closure Plan compliance.
22	2016-02-05 MOE to CHH WTS backup	X		MoE Letter Response to Report Not relevant to Closure Plan compliance.
23	2016-02-29 As-Built Quantum Eng. SMA Roof Completion Report	X		SMA Roof Details. Not relevant to Closure Plan compliance.
24	2016-03-02 SIRM to MOE WTS backup	X		WTS Information to MoE. Not relevant to Closure Plan compliance.
25	2016-03-17 0925 SIRM to MOE Water Treatment System Back-up		X	Email to MoE with Report #24. Not relevant to Closure Plan compliance.
26	2016-05-05 1441 SIRM Bedrock Integrity Inspection and Risk Assessment Report		X	Email with Report #27 attached. Not relevant to Closure Plan compliance.
27	2016-05-05 Brimmell Eng Bedrock Report	X		Confirms bedrock integrity. Not relevant to Closure Plan compliance.
28	2016-07-04 1216 SIRM Cell 1C As-Built		X	Email to MEM with Report #27 and 30. Not relevant to Closure Plan compliance.
29	2016-07-04 Brimmell PEA Cell 1C As-Built	X		Report for Cell 1C showing compliance with 1993 Landfill Criteria.
30	2016-07-04 SIRM PEA Cell1C liner letter	X		Confirmation of no liner Damage letter to MoE confirming compliance with Closure Plan.
31	2016-07-06 MEM to MOE TAR and liner construction		X	MEM observance of no geotextile added between the sand and the liner. Further information provided to justify. Relevant to Closure Plan compliance.
32	2016-07-06 SIRM TAR and liner construction		X	Email and Report MEM sends to MoE (Report #31) Relevant to Closure Plan compliance.

Report #	File Name	PDF	E-mail	Reviewer Comments
33	2016-07-15 Brimmell Eng SMA ret wall geotech letter	X		SMA. Not relevant to Closure Plan compliance.
34	2016-08-03 as-built for SMA cover		X	Quantum SMA Cover Install Confirmation. Not relevant to Closure Plan compliance.
35	2016-08-03 SMA lock block letter		X	SMA. Not relevant to Closure Plan compliance.
36	2017-03-09 SIRM to MOE & SHA As-Built info final cover	X		Detailed description of how SIRM addressed contact water release and landfill closure. Directly relevant to Closure Plan compliance.
37	2017-03-22 CHH to MOE info submission	X		Summary of All Reports delivered to MoE. Not relevant to Closure Plan compliance.