APPENDIX D

Shawnigan Research Group (SRG) Information Submissions
May 31, June 08, June 13 & June 21, 2017

Hurst, Nicole ENV:EX

From:	Dave Hutchinson <dave.shawnigan@shaw.ca>
Sent:	Thursday, June 1, 2017 8:13 AM
To:	Downie, AJ ENV:EX
Cc:	Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; 'Sonia Furstenau'; 'Calvin Cook'; 'Bernhard Juurlink'; 'Brent Beach'
Subject:	RE: SRG May 31 Response to CHH Apr 18 As-Built Submission
Attachments:	SRG May 31 Response to MOE re CHH Final Closure.docx

Thanks AJ - I will direct to Mary Miller.

Also, please replace the cover file I sent yesterday with the one attached to this email. I misnamed one of the documents which has been corrected.

Regards,
Dave

-----Original Message-----
From: Downie, AJ ENV:EX [mailto:AJ.Downie@gov.bc.ca]
Sent: May-31-17 5:41 PM
To: Dave Hutchinson
Cc: Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; Sonia Furstenau; Calvin Cook; Bernhard Juurlink; Brent Beach
Subject: Re: SRG May 31 Response to CHH Apr 18 As-Built Submission

Thank you for your submission Dave.

When you drop off the materials in Victoria, please provide them to Mary Miller, with the Regional Operations Branch of the Environmental Protection Division. She will ensure the materials are forwarded as needed.

Cheers,
AJ

AJ Downie
Director, Authorizations - South
Ministry of Environment

Sent from my iPhone

On May 31, 2017, at 4:40 PM, Dave Hutchinson <dave.shawnigan@shaw.ca<mailto:dave.shawnigan@shaw.ca>> wrote:

Hello AJ,

Please find attached the Shawnigan Research Group (SRG) response to the "As-Built" package submitted by CHH/SIRM on April 18th.

There is one MP4 video file which is too large for email. I will also be hand delivering a package including paper copies of the attached documents and will include the video file on a memory stick with that. I intend to deliver the package tomorrow (June 1) to the MOE offices at 2975 Jutland Road in Victoria and will leave it at the front desk addressed it to you. I assume they will forward to you in Nanaimo.

To summarize and reiterate the SRG position; we believe there are problems with the liners and associated infrastructure of the landfill cell and that contaminants are currently leaking into the local environment which present an unacceptable long-term risk to the watershed. This is based on observation of the cell construction and water quality test results.

The SRG and the Shawnigan Residents Association (SRA) are adamant that one or more tests be devised to conclusively determine whether the liners and associated infrastructure are performing as required.

Regards,
Dave Hutchinson

<SRG May 31 Response to MOE re CHH Final Closure.docx> <Landfill Closure Criteria - Brent Beach.docx> <Landfill is Leaking - Bernie Juurlink.docx> <CHH As-Built Documents - Brent Beach.docx> <CHH-SIRM Photos.pptx>

Shawnigan Research Group **May 31, 2017**

Response to MOE re Cobble Hill Holdings "As-Built" submission of April 18, 2017

This document is meant as a cover for several associated documents and files produced by the Shawnigan Research Group (SRG):

1) "Landfill Closure Criteria - Brent Beach.docx"

Summary:

In addition to the failures of this site and of the methods used in its construction, this review highlights many areas in which the site fails to meet the Landfill Criteria for Municipal Solid Waste. For these reasons, the landfill cannot remain on this site. We ask the Minister to amend the Spill Prevention Order "to require the Named Parties to carry out the provisions of Part B" - Contaminated Soil Removal.

2) "Landfill is Leaking – Bernie Juurlink.docx"

Summary:

Before the Ministry of Environment even considers a closure plan for the contaminated soil dumpsite at 460 Stebbings Road, the Ministry must determine whether the site is leaking or not. The base liner was poorly installed, much of the contaminated soil was dripping wet when deposited, and the site was exposed to the fall and winter rains with no, or minimal, cover. The second line of evidence that indicates the site is leaking rests upon comparing the concentration of contaminants in the Ephemeral Stream with Upper Shawnigan Creek upstream of the site.

3) "CHH As-Built Documents - Brent Beach.docx"

Summary:

This project has been characterized by false, misleading and incomplete information from the first Open House in May of 2012. The companies continue to issue the same documents again and again, long after they have been shown to be false, misleading and incomplete. New qualified professionals come to the site and are set off on the wrong track by these documents again and again. MOE must develop a certified set of documents which contain only true, clear and complete information. Only those documents should be available to qualified professionals to become the basis for their reports on this site. There are few if any such documents in the DOX.

4) "CHH-SIRM Photos.pptx"

Summary:

As with the supporting images in Dr. Juurlink's document, the photos in this PowerPoint document are self-explanatory and establish that the construction and operation of this site was unprofessional. They reinforce SRG assertions that the owner/operators are unreliable and that the package of "as-built" specifications submitted on April 18th cannot be relied upon, especially with regard to the construction and composition of the landfill cell and associated infrastructure.

5) "The Professionals .mp4"

Summary:

This six minute video should not be dismissed due to its satirical nature. It is an accurate record of the installation of the base liner for Cell-1C. It is quite apparent that there were significant problems. The MP4 file is too large to email but is provided on a memory stick along with the paper copies of the SRG documents.

Hurst, Nicole ENV:EX

From:	Dave Hutchinson <dave.shawnigan@shaw.ca>
Sent:	Wednesday, May 31, 2017 4:39 PM
To:	Downie, AJ ENV:EX
Cc:	Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; Sonia Furstenau; 'Calvin Cook'; 'Bernhard Juurlink'; Brent Beach
Subject:	SRG May 31 Response to CHH Apr 18 As-Built Submission
Attachments:	SRG May 31 Response to MOE re CHH Final Closure.docx; Landfill Closure Criteria - Brent Beach.docx; Landfill is Leaking - Bernie Juurlink.docx; CHH As-Built Documents - Brent Beach.docx; CHH-SIRM Photos.pptx

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Review - Landfill Closure under Landfill Criteria for Municipal Solid Waste

Introduction

This review considers the contaminated waste pile in the context of the Spill Prevention Order issued March 15, 2017.

In particular, this review notes that the SPO introduces a new set of restrictions on the contaminated waste site. Until this point, the companies operated under their Permit PR-105809 and the Technical Assessment Report on which that permit is based.

The SPO changes the technical basis on which this landfill is assessed. This landfill fails when measured against these new criteria.

Assessment of this landfill is then based on THREE separate measures.

Measure 1 - the "Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016," or LCMSW.

Measure 2 - the rules for quarry reclamation. This landfill has masqueraded as a mine reclamation. We insist that in looking at the closure plan for this site, that closure plan be measured against all the standard rules for mine reclamation. That is, the conformity of the closure plan to a valid mine reclamation plan be determined.

Measure 3 - the end land use, as defined by the Cowichan Valley Regional District bylaws and zoning. Now that the contaminated waste permit has been cancelled, and assuming mine closure and the termination of the Mines permit, the land must be suitable for its end land use. We insist that in looking at the closure plan for this site, that closure plan be determined to produce a site that meets the prescribed end land use.

Spill Prevention Order

On March 15, 2017, Minister of Environment Mary Polak issued AMENDED SPILL PREVENTION ORDER; MO1701. The SPO gave the companies two options: provide a plan to remove the waste by April 30, 2017, or a plan to permanently close the landfill by May 31, 2017. The companies opted to permanently close the landfill.

If the companies "submit a final plan to permanently close the landfill" then this plan "must use the LCMSW for guidance" and "any proposed site-specific alternatives provide an equivalent or better level of environmental protection."
The SPO is clear. The closure plan from the companies is to be based on the LCMSW as the minimum allowed standard.

Physical Location of the Contaminated Waste

The LCMSW place numerous restrictions on the location of landfills. We show that much of the landfill falls outside permitted locations.

Map of the Current Waste Storage Area

The company provided a package of documents, one of which is titled Landfill Lined Cell As-Built, and dated 17 01 30. This is a topographical map of the site using 1 metre contour lines.

I have oriented the map with north at the top (toward Shawnigan Lake).

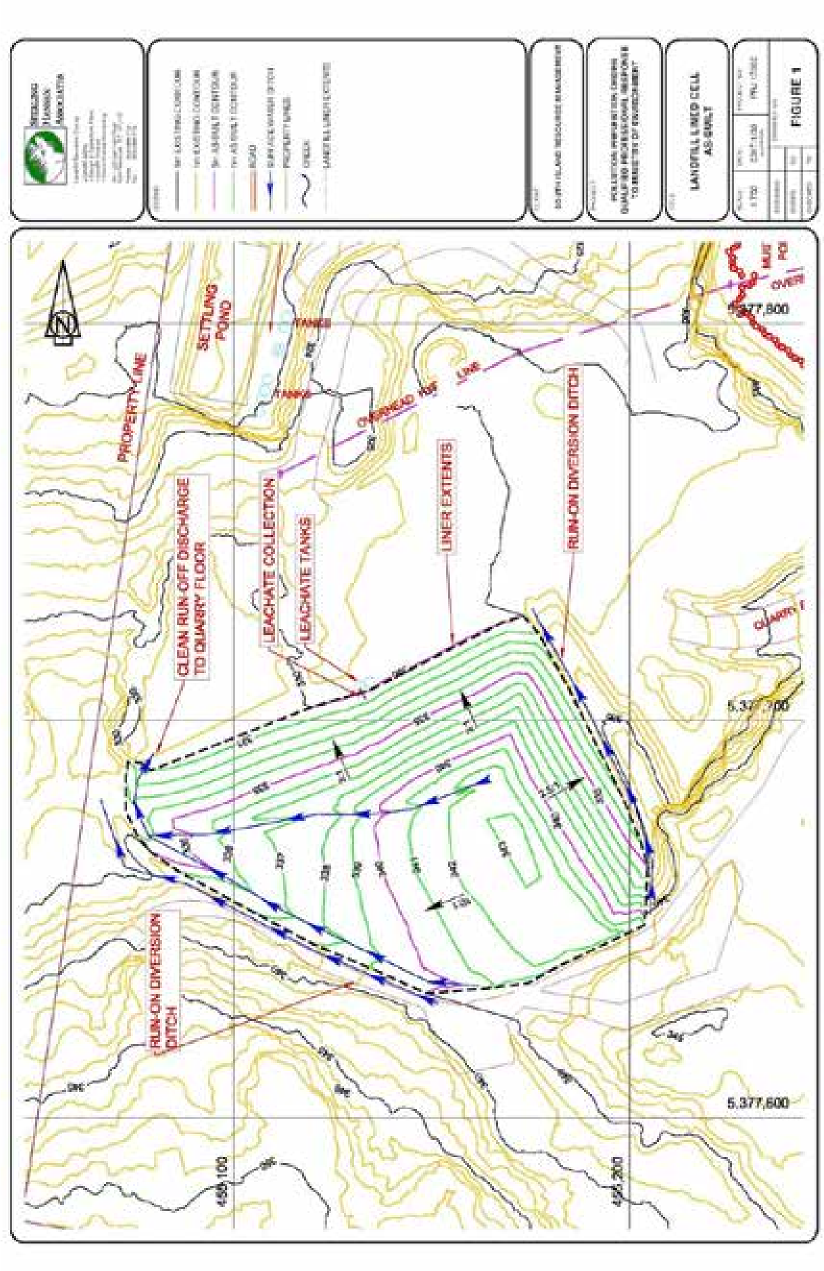


Fig 1

Google Earth Overlay

As usual, I imported this map into Google Earth, using the satellite image dated 16 08 18, and placed it on that image.

Again, north is at the top. Note the slight misalignment between the north on the above map and north according to Google Earth.

Fig 2

Sketchup

I imported this image into Sketchup in order to build a 3D model of the contaminated waste pile.

Again, north is at the top. Here the perspective is from the hill to the south of the waste pile, not the satellite perspective.

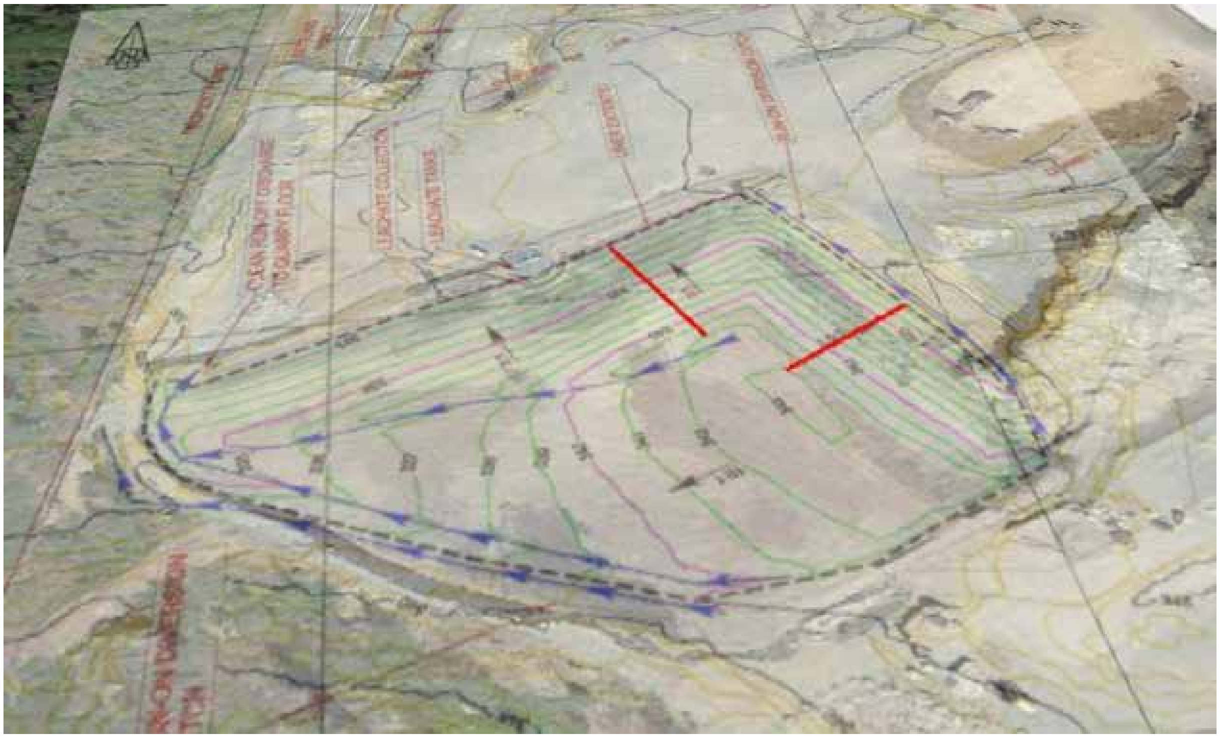


Fig 3

Building the 3D model requires manual tracing of the 1 metre contour lines, then pulling each contour up into position. Here the waste pile is shown in red.

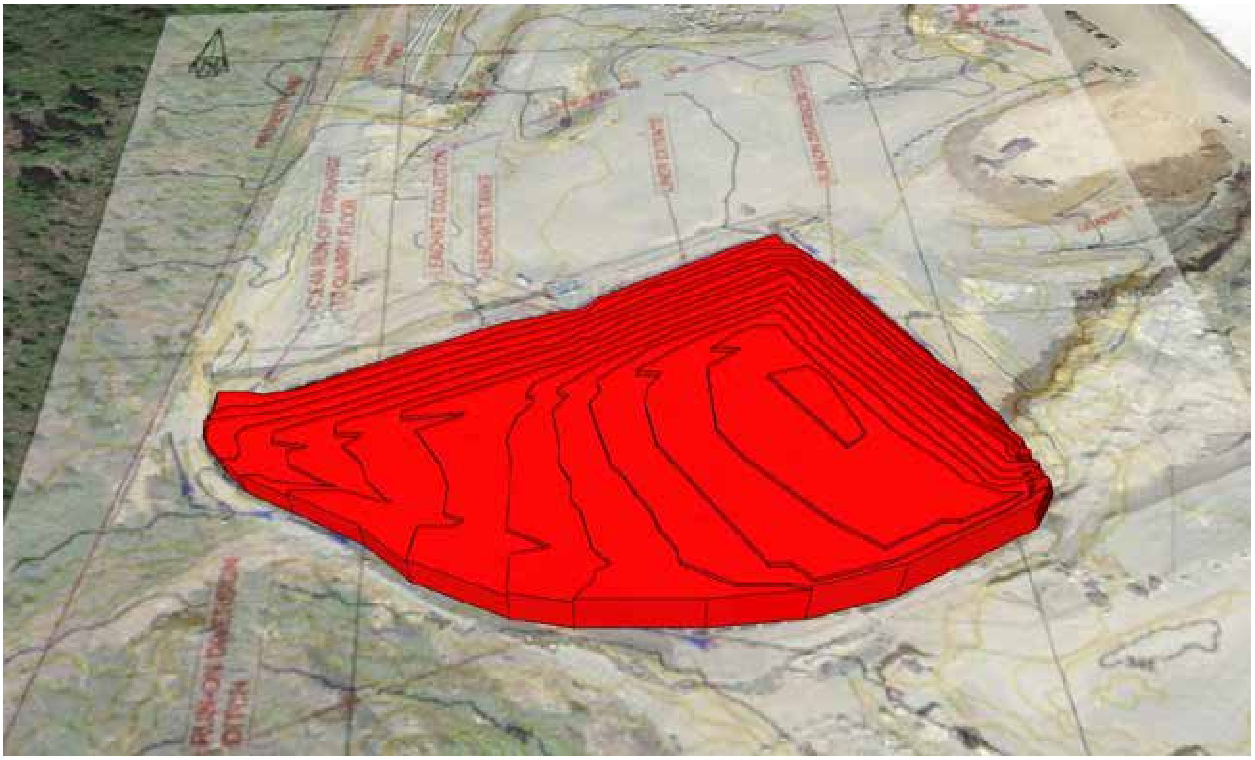


Fig 4

Final Contours

LCMSW Section 5.9 Final Contours, states that "Final contours of the landfill shall be constructed at grades not steeper than 3H:1V." Figure 5.5a makes this clear.

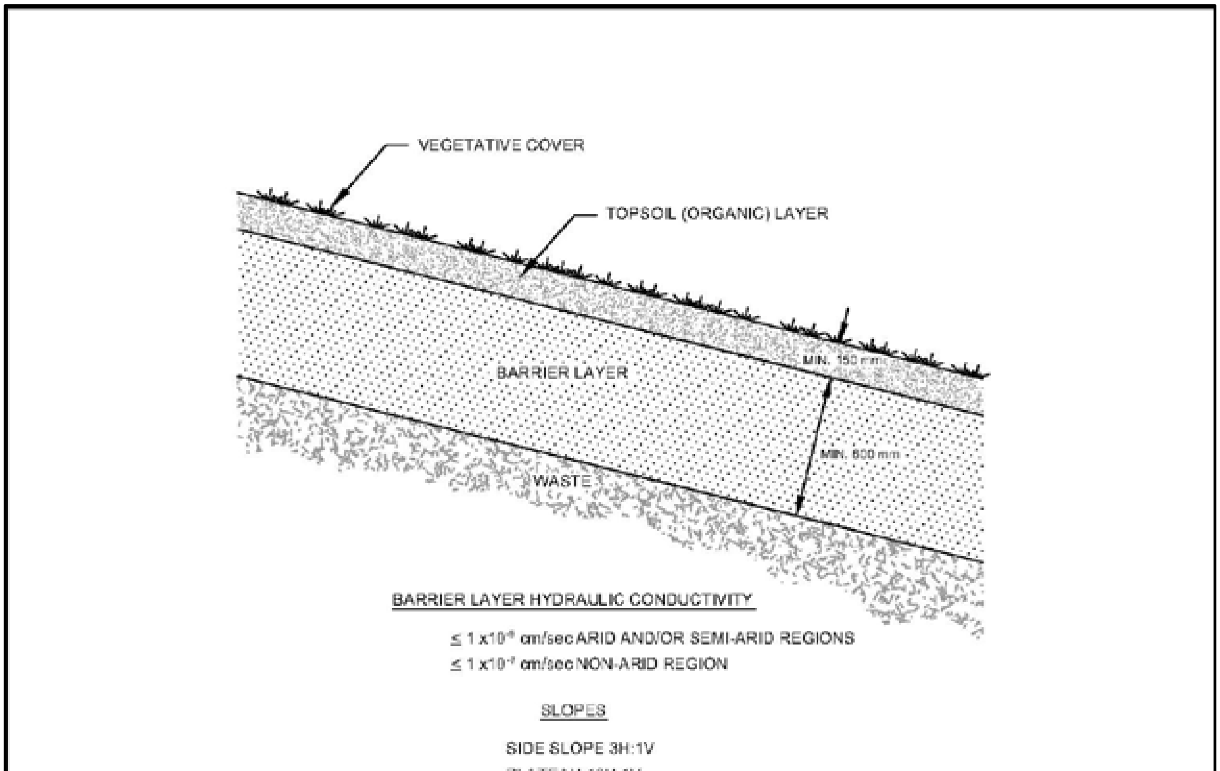


Figure 5.5a
FINAL COVER DETAIL

Fig 5

The map from the companies, Fig 1 above, claims that the slope on the upper left, the northwest facing slope, is 3H:1V, and that the slope to the upper right, the northeast facing slope, is 2.5H:1V. In fact, neither slope meets the requirement for final contours.

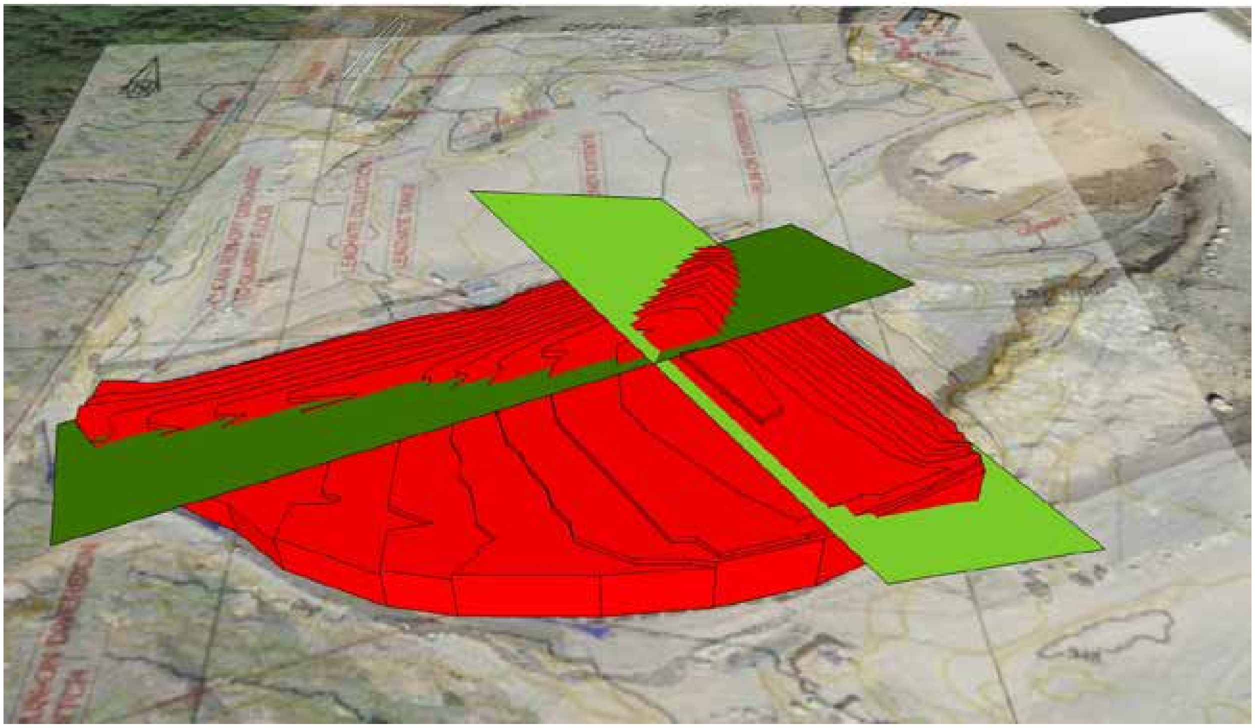


Fig 6

This Sketchup model was adapted from Fig 4 by the addition of a plain with slope 3H:1V through the NW face (dark green), and a second plain with slope 3H:1V through the NE face (pale green). All the waste above the plains must be removed for the waste pile to conform the LCMSW.

Buffer Zone

Section 3.4 of the LCMSW requires that the "buffer zone between the landfill footprint and the landfill site boundary shall be a minimum of 50 m."

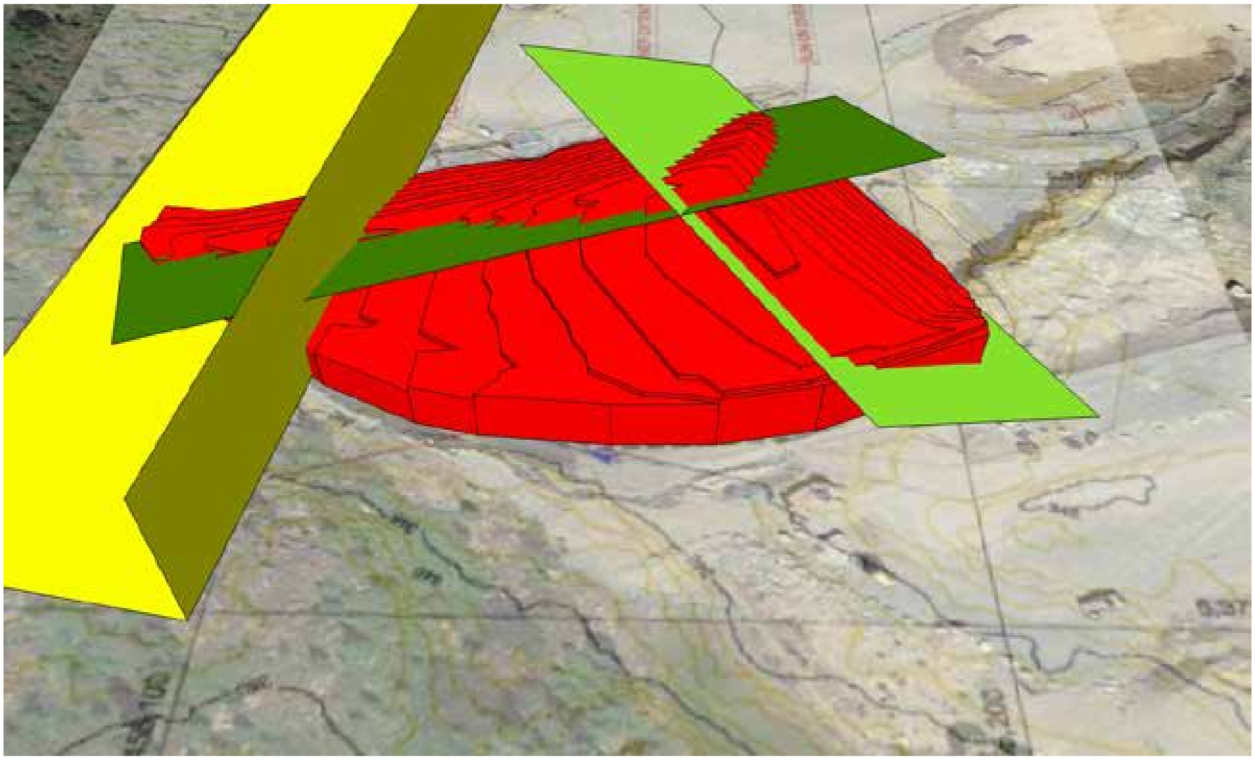


Fig 7

In Fig 7, a yellow buffer 50 m wide with a vertical face has been added. Of course, the face cannot be vertical. Rather, it must satisfy the 3H:1V rule.

Here the new west face of the waste pile is shown. Allowing for the 50 m buffer zone and the 3H:1V slope of the new west face, all the current waste above the yellow face must be removed in order for the remaining waste to meet the LCMSW standard.

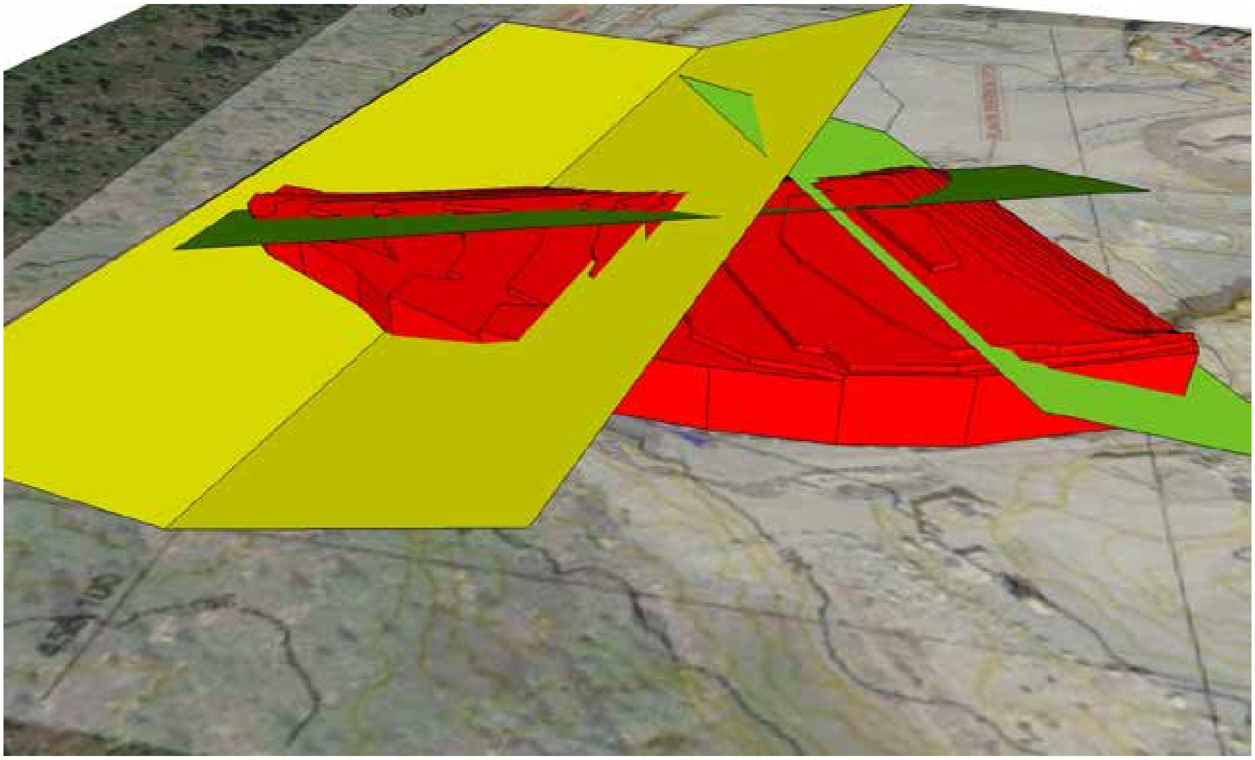


Fig 8

Regional Park

The land to the west of the contaminated waste landfill is a regional park. That is, it is a park owned by the regional district.

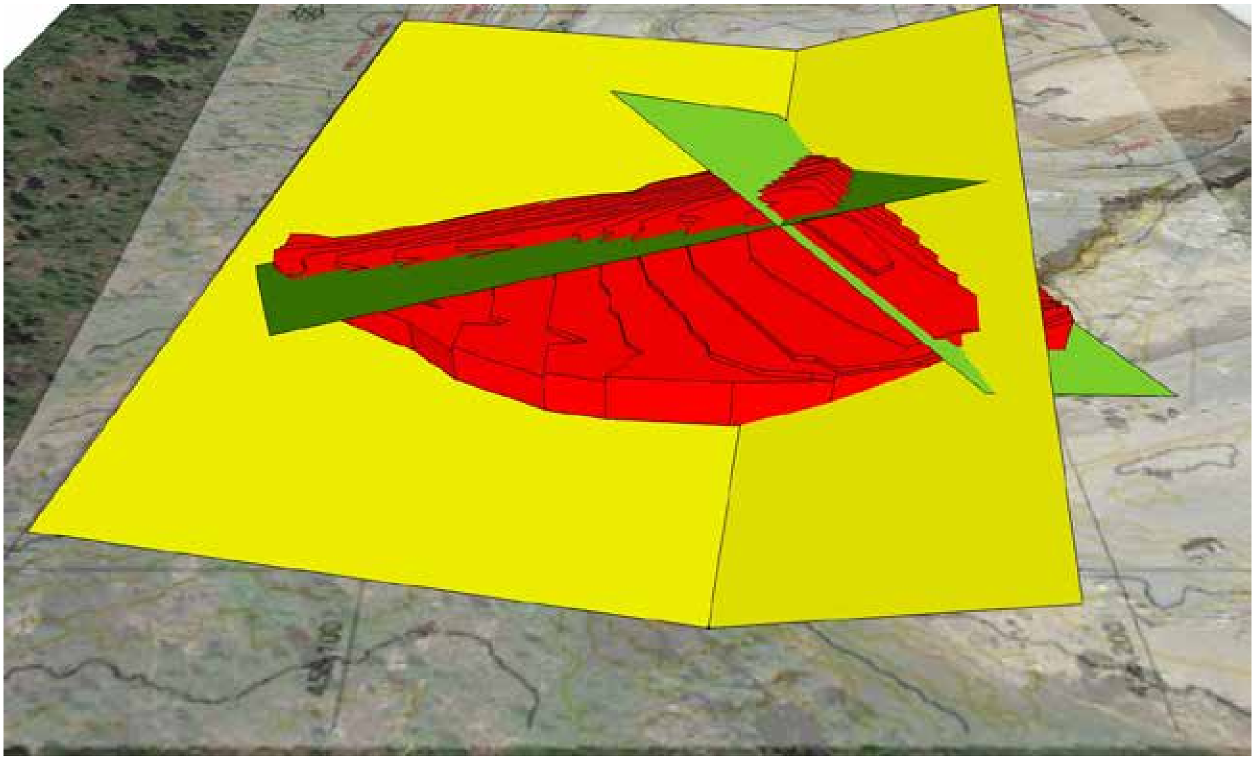


Fig 9

Section 3.8 of the LCMSW, ENVIRONMENTALLY SENSITIVE AREAS, requires of buffer of 100 m of this regional park.

This land to the west of the landfill was made a regional park at the same time as the land on which the landfill sits was sub-divided. That is, the regional park designation precedes the Mine Permit and certainly precedes the Contaminated Waste Permit.

Section 3.8 requires the removal of all of the contaminated waste above the yellow surfaces.

Miscellaneous Contraventions of LCMSW

Surface Water Quality

Section 4.1 of the LCMSW states that "the appropriate water quality criteria must be satisfied at and beyond the landfill site boundary."

Fig 10

The companies have stopped sampling water where water leaves the quarry. Water has been present in the land and has been flowing out of this stream ever since the company pumped the lake dry in the summer of 2015. The lake is clearly fed by ground water and by leachate from the waste pile year round. The lake water runs across the bedrock, through the riprap and out the stream by the settling pond.

Sampling of this water and comparison to the leachate as a method of determining how much of the water in the lake is ground water and how much is leachate must be part of the analysis of the safety of permanent closure of the landfill.

Landfill Base Liner System

Section 5.4 states the "minimum specifications for the primary HDPE geomembrane liner ... thickness of 1.5 mm (60 mil)." The base liner used in this site is only 1.016 mm (40 mil).

While 40 mil is the original specifications for the base liner, we have to follow the changes in the designation of the waste pile over time. Originally, the company was only going to accept dry contaminated waste and only work during the dry season, so the waste would never contain any moisture. It may make sense under those conditions to have a 40 mil base liner.

Originally this location was temporary, since this location is at the mid excavation level of the quarry. When quarrying had achieved the final level, the contaminated waste would be moved to a new final storage area, using an appropriate base liner.

Over time the companies changed the purpose of the current waste pile. What began as a temporary waste pile became a permanent waste pile. This change of status was not accompanied by any change to the base liner.

Their own report, the Landfill Closure Plan, Section 3.2, specifies a 60 mil base liner once the waste in this temporary location is moved to its permanent location. Indeed, that document acknowledges the need to fully comply with Section 5.4 of the LCMSW.

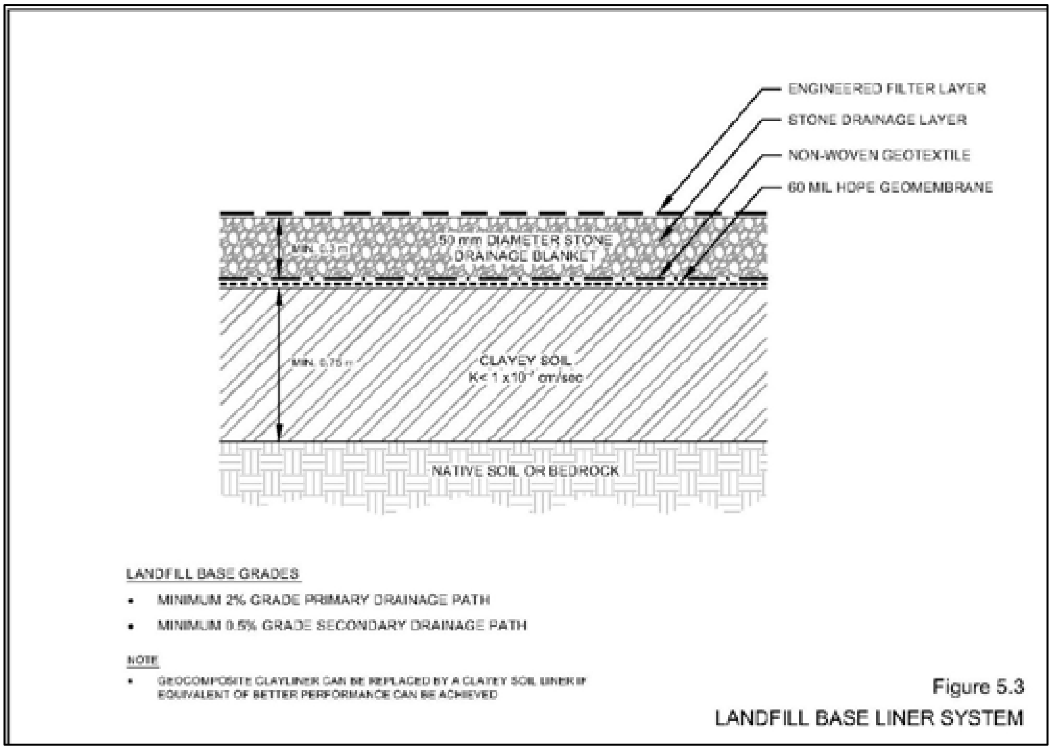


Figure 5.3
LANDFILL BASE LINER SYSTEM

Fig 11

Fig 11 shows the full specification for the "Landfill Base Liner System", as found in Figure 5.3 of the LCMSW. This site lacks the non-woven geotextile above the 60 mil base liner. It also lacks the 50 mm diameter stone drainage blanket layer.

In short, aside from the Clayey Soil on top of the bedrock, this waste pile is entirely non-compliant with the LCMSW.

Leachate Collection System

From LCMSW Section 5.5, Leachate Collection System, "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.".

The current waste pile is over 110 m wide, on the NW face and over 73 m from the NW face to the SE edge. The current waste pile is serviced by a single Leachate Collection pipe along the NW face.

Even if the collection tanks were in the middle of this face - they are not - that would require two runs of 55 m.

At 15 m spacing, there should be 5 runs of leachate collection piping, while there is only one.

The leachate collection system currently on site cannot possibly be compliant with Section 5.5.

Maximum Allowable Leachate Generation Rate

Section 5.8 of the LCMSW, Final Cover Design, requires that the "maximum allowable leachate generation rate shall be identified." We believe the leachate generation level cannot be identified unless the current water content of the waste in the pile has been determined.

Our observations of the waste pile over the time it was being built tell us:

- waste arrived at times in a super saturated condition - water was dripping from the dump trucks;
- much of the waste was at least saturated when it was dumped into the soil containment area, with excavators and workers getting stuck in the just deposited waste
- the operator dumped sludge from the contact water collection pond back into the soil containment area;
- the dump location of the soil containment area at times was a 5m by 3m puddle, several feet deep;
- the entire was pile was effectively uncovered during its entire working life, although occasionally flimsy tarpaulins were stretched across parts of the surface, held in place by tires which were in turn held in place by stakes driven through the tarpaulins, turning the tarpaulins into funnels rather than rain covers.

In order to determine the total leachate expected, as well as the leachate generation rate expected, a rigorous sampling of the waste to determine moisture content is required.

There is no reliable estimate provided in the as-builts we have seen.

Site Security and Fencing

Section 5.10 of the LCMSW requires fencing around the entire landfill.

Fencing has been required both by the mine permit and by the MoE contaminated waste permit. The operators were given a final deadline of September 2016.

To date they have fenced only the western property line. The northern, eastern, and southern property lines remain unfenced.

This is a simple requirement. When ordered to install fencing, the companies failed to comply.

This failure is symptomatic of how these companies operate. They fail to follow the most elementary safety standards until compelled, and then comply only grudgingly.

Worse, the regulators, in both Mines and Environment do not follow up and enforce the orders. Even when given evidence in the form of pictures and videos, Mines and Environment failed to require the operator to install the fencing.

The presence or absence of fencing can be detected by even the least skilled employee.

When even breaches of the permits as evident as this are allowed to continue, is it any surprise that the residents have little faith in the regulators to competently investigate complex issues? If the regulators cannot see that a fence has not been built, can we expect them to be able to detect that the waste pile is leaking?

Landfilling Of Wastes

Section 6.2 of the LCMSW states "Wastes are to be spread in thin layers (0.6 m or less) on the active face and compacted. Normally, 3-5 passes of the compacting equipment over the wastes are sufficient to achieve adequate compaction."

While there was a compactor on site, the nature of the waste - sticky clays for the most part - prevented it used except very briefly. Rather than having the waste spread in thin layers, the waste was dumped by excavators and moved around by excavators. We have pictures of one of the excavators stuck in the contaminated waste.

Site Profile

Section 7.5 of the LCMSW requires that "a landfill property owner complete and submit, to the director, a site profile" "10 days prior to final deposit of waste."

This landfill had its final deposit of waste months ago. Has the Ministry received this "site profile"? The residents of the Shawnigan Lake Community Watershed are keenly interested in obtaining a copy of this "site profile".

We also feel that the "site profile" be made available to the independent Qualified Professionals who have been hired to review the final closure plan for the site.

Leachate Chemistry

Section 9.1 of the LCMSW requires "monitoring of leachate levels within the landfill." It further requires a report on "leachate chemistry" as a basis for estimating "the contaminating lifespan of the landfill at the time of closure." None of this information is in the materials provide by the company to date.

Section 10.3.3 of the LCMSW requires a "Leachate Management Plan" which specifies the "quantity and quality of leachate to be generated at the landfill site during the operational and post-closure periods." This document does not appear in the package of As-builts dated April 17 2017.

Simple provision of records from source sites is insufficient to determine leachate quantity. This site was effectively uncovered the entire time waste was being accepted. Rainfall during that period may well have exceeded 2 metres. On the approximately 8,000 square metres of the waste pile that means up to 16,000 cubic metres of water was added to the water already in the contaminated waste when it arrived on site. Any estimate of leachate quantity less than 16,000 m3 has no basis in fact.

Summary

In addition to the failures of this site and of the methods used in its construction, this review highlights many areas in which the site fails to meet the LCMSW.

For these reasons, the landfill cannot remain on this site.

We ask the Minister to amend the Spill Prevention Order "to require the Named Parties to carry out the provisions of Part B" - **Contaminated Soil Removal.**

The Contaminated Soil Waste Landfill Site Is Leaking

The documents of April 17, 2017 that the Ministry of Environment wishes us to comment upon are full of misinformation and therefore are worthless.

The fear of residents of Shawnigan Lake has always been that the Contaminated Soil Waste Landfill site will contaminate the watershed of Shawnigan Lake. It should be pointed out that Upper Shawnigan Creek the main stream supplying Shawnigan Lake runs through Lot #23 where the Contaminated Soil Waste Landfill site sits. The Ephemeral Stream that drains much of the quarry empties into Shawnigan Creek. Before the Ministry of Environment even considers a closure plan for the contaminated soil dumpsite at 460 Stebbings Road, the Ministry must determine whether the Contaminated Soil Waste Landfill site is leaking or not. As is outlined below examination of the water analyses of the Settling Pond outflow, the Ephemeral Stream and Upper Shawnigan Creek upstream of the Contaminated Soil Waste Landfill site leads to only one conclusion: the Contaminated Soil Waste Landfill site is leaking.

As also noted by Brent Beach, the Ministry has ordered CHH to submit plans according to the specifications "as defined in the **Landfill Criteria for Municipal Solid Waste**, Second Edition, June 2016 (the "LCMSW")". The specifications for the liner in this document is a 60 mil High Density Polyethylene, not the 40 mil linear low density polyethylene that is used in the PEA. Note the PEA 1 all along was intended as a temporary contaminated soil storage unit and was to be moved to a permanent site as quarrying continued. On the liner basis alone, the current landfill, thus, does not meet the requirements of the LCMSW as ordered by the Ministry of Environment. Furthermore, A detailed environmental risk assessment is one of the requirements for the establishment of a municipal landfill site. No such environmental risk assessment was done for the contaminated soil landfill site at 460 Stebbings Road, Shawnigan Lake; indeed, Luc Lachance skillfully read all the regulations regarding landfill sites and pointed out that as there were no regulations for a contaminated soil waste landfill site, there was no necessity to do an environmental risk assessment. Hubert Bunce agreed with this clever skirting of the intent of the regulations. On the basis that no environmental risk assessment was done, the the Stebbings Road contaminated soil waste landfill site does not meet the LCMSW.

Evidence That The Contaminated Soil Waste Landfill Site Is Leaking Contaminants Into The watershed

Note that if left in place the Contaminated Soil Landfill will be there for millennia; hence, it is critical to determine whether it is leaking. All indicators to date indicate the site is leaking. Even if it is not leaking at the moment we must keep in mind that all landfill liners fail, some within a few years and others within a few decades (e.g., Pivato. 2011. Landfill liner failure: An open question for landfill risk analysis. *J. Environmental Protection* **2:** 287-297; Allen. 2001. Containment landfills: The myth of sustainability. *Engineering Geology* **60:** 3-19).

I will start with data supplied by South Island Resource Management (SIRM) to the Ministry and is available on the Ministry Website. Table 1 below shows the dates upon which there were exceedances of the BC Water Quality Guidelines in the outflow of the Settling Pond. Note that the Settling Pond nominally receives non-contact water from Lot #23 as well as contact water that has been 'nominally' cleaned of contaminants. As can be seen in Table 1, there were exceedances on numerous occasions. Using Occam's razor leads to the most likely conclusion that the site is leaking contaminants into the watershed.

There has been no Ministerial requirement for sampling in recent months for reasons that I find baffling.

Table 1: Settling Pond Outflow Exceedances of BC Water Quality Guidelines

October 14, 2016: Iron

October 15, 2016: Toluene

October 20, 2016: Total Suspended Solids, Copper, Iron

October 21, 2016: Total Suspended Solids, Cobalt, Copper, Iron

October 26, 2016: Total Suspended Solids, Chloride, Iron

November 2, 2016: Iron

November 5, 2016: Total Suspended Solids, Copper, Iron

November 9, 2016: Copper, Iron

November 22, 2016: Total Suspended Solids, Copper, Iron

November 24, 2016: Copper, Iron

November 25, 2016, Copper, Iron

November 26, 2016: Copper, Iron

December 11, 2016: Copper

January 18, 2017: Total Suspended Solids, Copper, Iron, Silver, Zinc

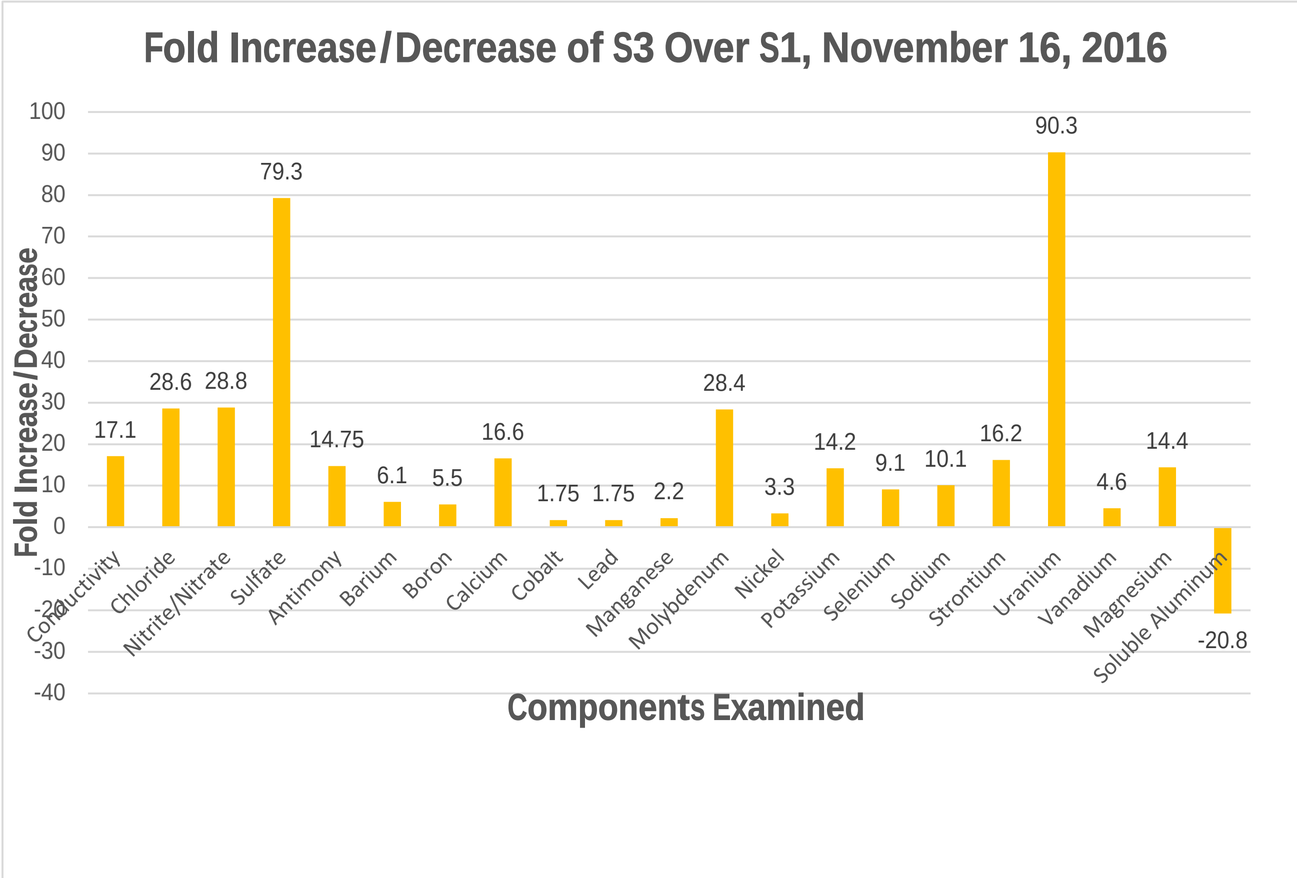
January 19, 2017: Silver

February 15, 2017: Total Suspended Solids, Copper, Iron,

February 16, 2017: Iron

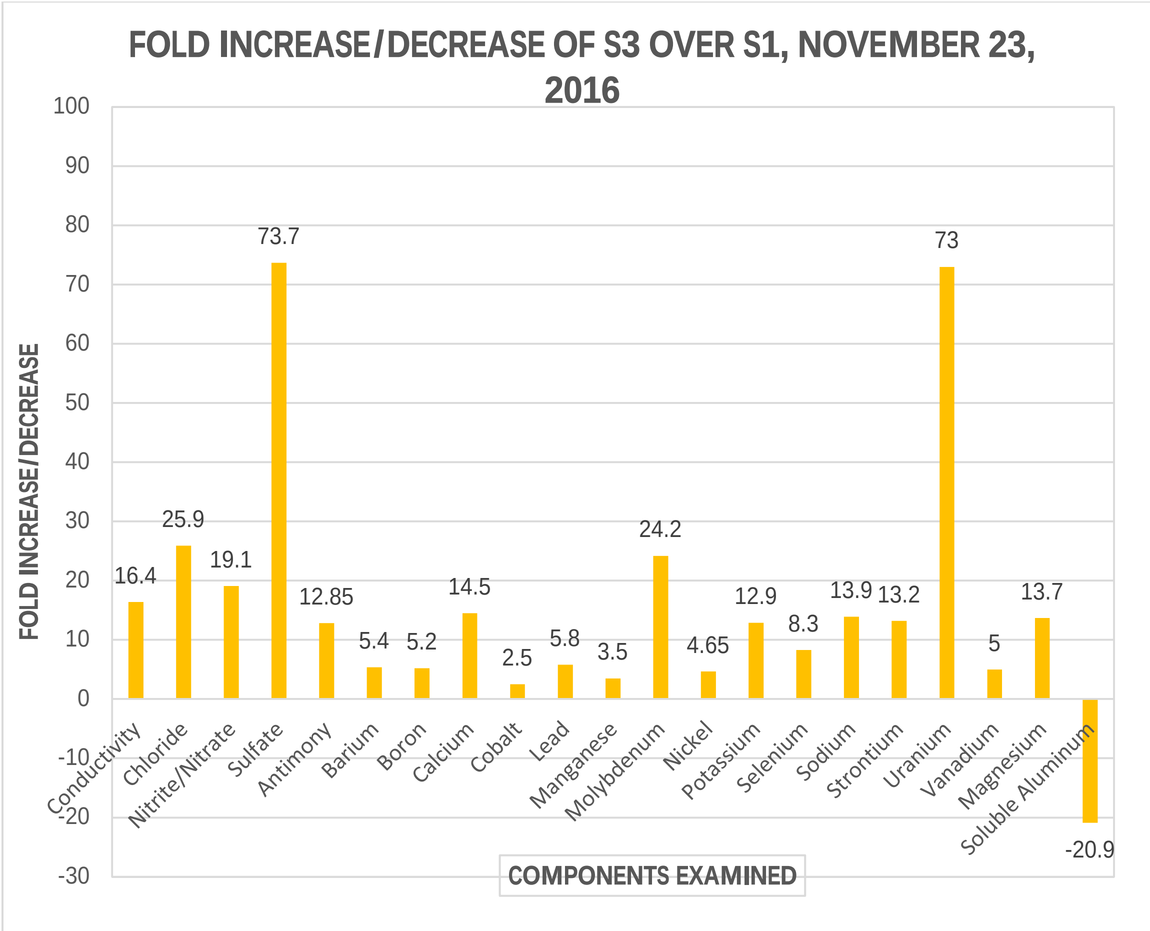
The second line of evidence that indicates the site is leaking rests upon comparing the concentration of contaminants in the Ephemeral Stream (S3) with Upper Shawnigan Creek upstream of the Contaminated Soil Waste Landfill site (S1). These data were collected by Associated Environmental Consultants Inc. for the Ministry. These data are also available on the Ministry website and here are presented in graph format. Note that chloride, sodium, calcium, sulfate and magnesium are elevated in dredgeate. One might expect high levels of antimony, molybdenum, strontium and vanadium in soils where a lot of metal work is being done. Why uranium is so elevated in the Ephemeral stream compared to Shawnigan Creek is somewhat baffling although we know that the Canadian Navy did use depleted uranium for the Phalanx close-in weapons system until 1998. The elevation of these components in the Ephemeral stream can best be explained by the contaminated soil waste landfill site leaking.

Note also that soluble aluminum is about 20-fold lower in the Ephemeral Stream than in Shawnigan Creek. Is this because dredgeate is depleted in soluble aluminum because of long-term exposure to large volumes of seawater that would have leached out much of the soluble aluminum?



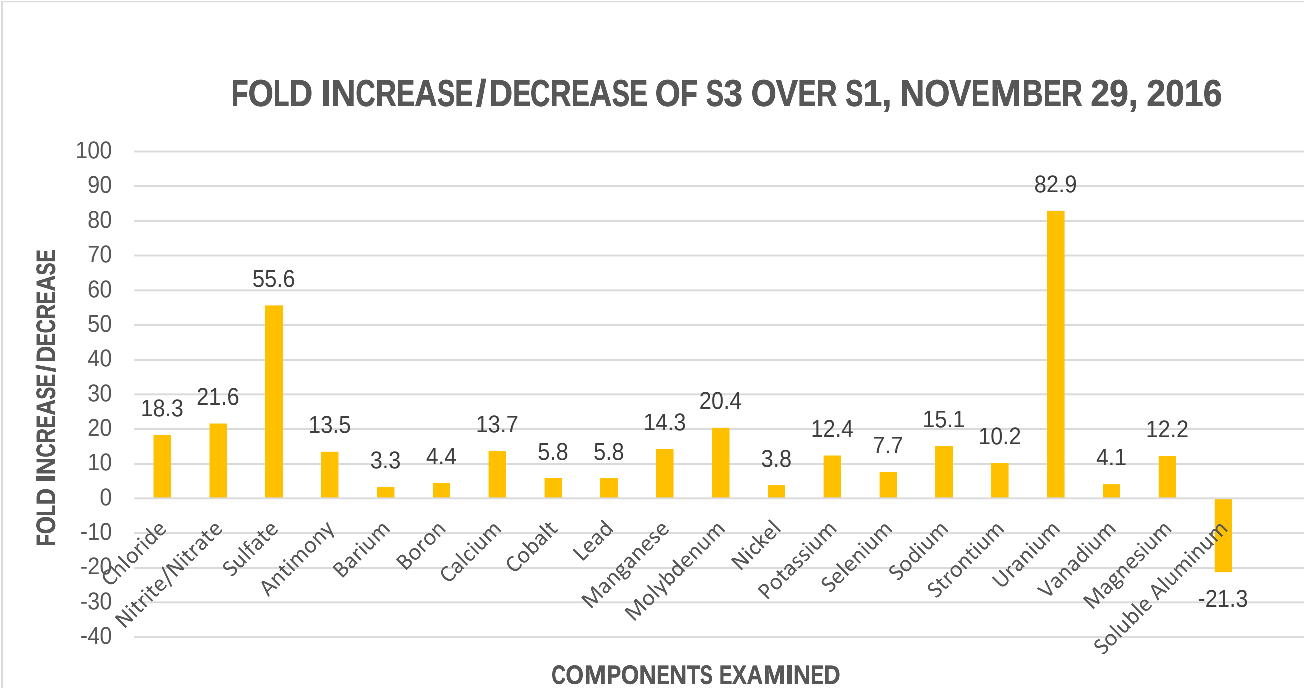
Nota Bene: * Values for Antimony is greater than 14.75, for Boron is greater than 5.5, for Molybdenum is greater than 28.4, for Selenium is greater than 9.1 and for Vanadium is greater than 4.6 because the S1 values were lower than detectable for these elements.

Dissolved Aluminum of the Ephemeral Stream is 0.048 of that of Shawnigan Creek (S3) upstream of Lot 23, i.e., S3 is 20.8 times lower than S3.



Nota Bene: * Values for Antimony is greater than 12.85, for Boron is greater than 5.2, for Molybdenum is greater than 24.2, for Selenium is greater than 8.3 and for Vanadium is greater than 5 because the S1 values were lower than detectable for these elements.

Dissolved Aluminum of the Ephemeral Stream is 0.048 of that of Shawnigan Creek (S3) upstream of Lot 23, i.e., S3 is 20.9 times lower than S3.



Nota Bene: * Values for Antimony is greater than 13.5, for Boron is greater than 4.4, for Molybdenum is greater than 20.4, for Selenium is greater than 7.7 and for Vanadium is greater than 4.1 because the S1 values were lower than detectable for these elements.

Dissolved Aluminum of the Ephemeral Stream is 0.047 of that of Shawnigan Creek (S3) upstream of Lot 23, i.e., S3 is 21.3 times lower than S3.

The Likely Reasons Why The Site Is Leaking So Soon

1) ***Much of the Contaminated Soil Waste was dripping wet when deposited and the site was exposed to the fall and winter rains with no or minimal cover.***

Despite the requirement not to deposit dripping wet soil onto the landfill site, not only was dripping wet soil deposited but often the upper contaminated contact water pond was emptied onto the landfill site. This resulted in more leachate being formed than the leachate collection system could handle (Note Image 1 showing the accumulation of leachate alongside the inner part of the berm (and on top of the leachate collection piping) six weeks after the winter rains had stopped). An hydrovac truck was required to be used (Image 2) to deal with the excess leachate. This excessive leachate created problems in the attempts to weld the liner of PEA 1B to PEA 1C 12 weeks after the winter rains stopped as will be noted below. Furthermore, the untreated leachate, as mentioned, was often dumped back onto the PEA – see Image 2B. A video entitled "The Mixing Bowl" shows how the leachate was moved from the pit at the base of the PEA onto the top of the PEA – this video is available for viewing.

2) ***Poor Installation of the Base Liner***

There was considerable sloppiness in the construction of the base liner of the PEA that ensured that liner failure occurred almost immediately following placement of contaminated soils. The best documented was the construction of PEA 1C; however, we do have one photograph documenting the installation of PEA 1B during the very wet month of November 2015 (Image 3). Welding of seams under such wet conditions is very problematical. Indeed, the westerly berm of PEA 1B shows moisture leaking below the level of the base liner in the first week of May 2016, five weeks since there had been any significant rainfall (Image 4).

Documenting the installation of PEA 1C base liner showed the following problems:

1) Problems linking the base liner of PEA 1C with the base liner of PEA 1B because of moisture problems (Image 5). This was difficult to document since the operators very often had an excavator blocking our view of this clean-up operation. Since this was a dry summer the only source of the moisture was PEA 1B and it is questionable whether the welding was properly done.
2) During the deposition of a sand blanket onto the base liner of PEA 1C, folds were present and the excavator tracks appeared to have caused gouges in the base liner (Images 6, 7 & 8). Cracks were also present in the liner fold (Image 9). At times an excavator dragged the base liner over rip-rap, accounting for some of the gouges and cracks that were present in the base liner – note video entitled "The Professionals". For further details see 'Problematical Aspects of SIRM's Landfill Liner. Part 1'.
3) Because of errors such as the above and because of miscalculations of liner segment sizes multiple patches were required to complete the base liner. Each patch increased leakiness of the liner. Image 10 is but one example of the multiple patches used. For more details see 'Problematical Aspects of SIRM's Landfill Liner. Part 2' for more details.
4) The Leak Collection System was designed not to detect leaks. SIRM's design is shown in Image 11. The fault in the design is that the leak collection perforated pipe that is within the sand blanket below the base liner is located in an elevation above the landfill floor (Images 11 & 12 illustrate this). This requires that water must flow uphill to enter the leak detection piping. The more likely alternate route is for leaks to move laterally through the loose till berm and onto and into the mine floor (see Image 4). More details can be found in the document entitled ''.SIRM's Non-Functional Leak Detection System'.
5) The Cover Liner (which is not 40 mil as stated but is actually 35 ml) also has multiple patches, many of which are coming loose (for example, see Image 14). This seam opening of the cover liner is yet another of the shoddiness of the construction of PEA 1.

SUPPORTING IMAGES

IMAGE 1: Leachate collecting in the trench at the edge of PEA-1B 6 weeks after the winter rains had stopped.

IMAGE 2: The solution when the leachate collection system is overwhelmed by the supersaturated contaminated soil is to suck up the leachate using a hydrovac.

IMAGE 2B: Very often the leachate collected in the upper contact water pond was dumped into a pit at the loading zone of the PEA and then mixed with the contaminated soil. An nice example of a futile cycling event.

IMAGE 3: Photo taken November 17, 2015 during the installation of the base liner of PEA 1B.

IMAGE 4: Photograph taken the first week of May, 2016 after 5 weeks of a dry spell. The westerly face of PEA 1B is shown with wet areas below the base liner covering the berm. The only possible source of this wetness is the contaminated soil landfill site.

IMAGE 5: Because of moisture problems there was difficulty in welding the base liner of PEA 1C with the base liner of PEA 1B. Note the very moist contaminated soil that had to be scooped off the base liner and thrown against the wall of PEA 1B.

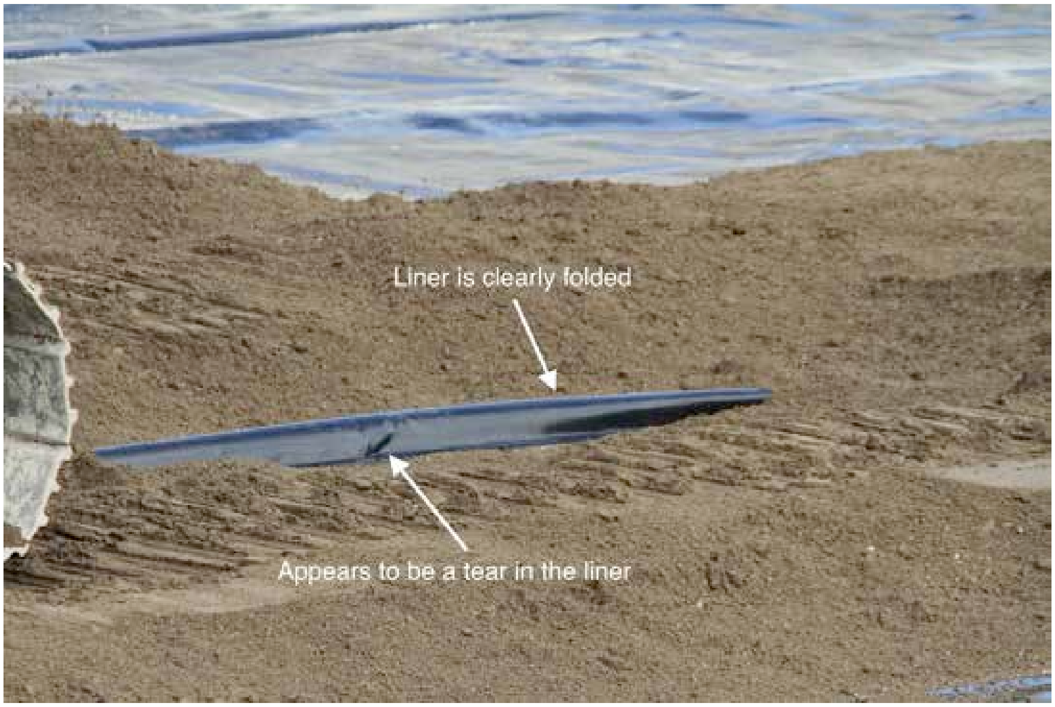


IMAGE 6: Note the base liner fold and an apparent gouge possibly formed by excavator track – see IMAGEs 5 & 6.

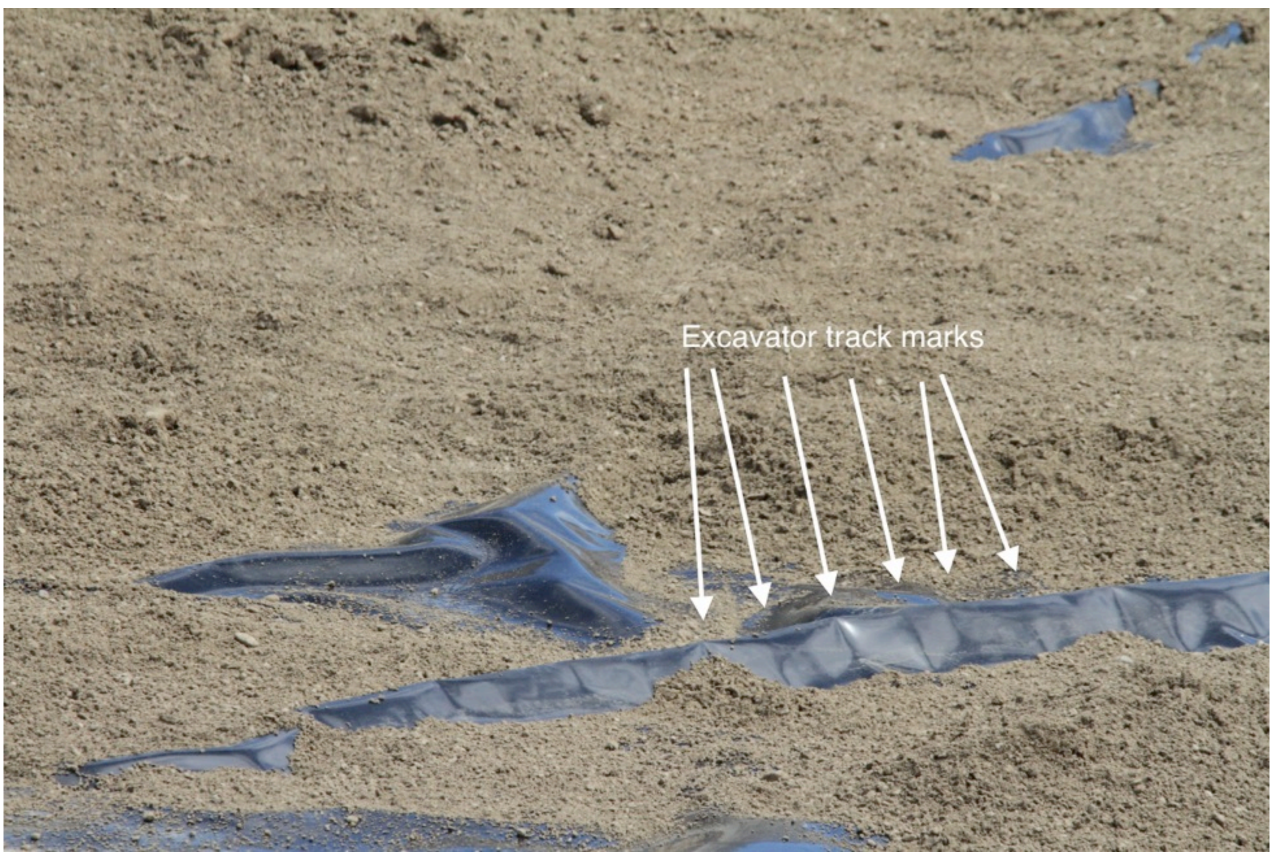


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IMAGE 7: Excavator track marks on base liner of PEA 1C.

IMAGE 8: Note how close this excavator track is to the base liner of PEA 1C.

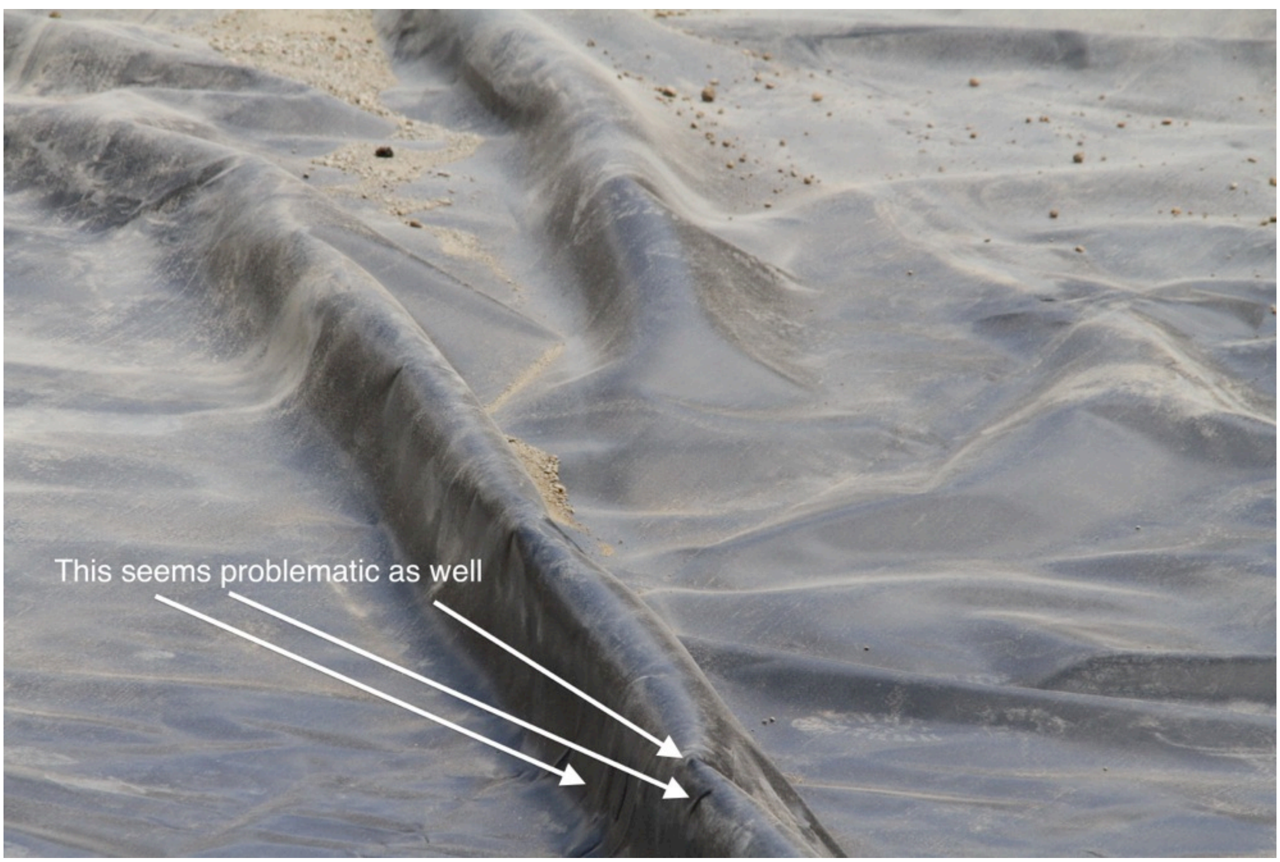


IMAGE 9: Cracks in base liner fold of PEA 1C.

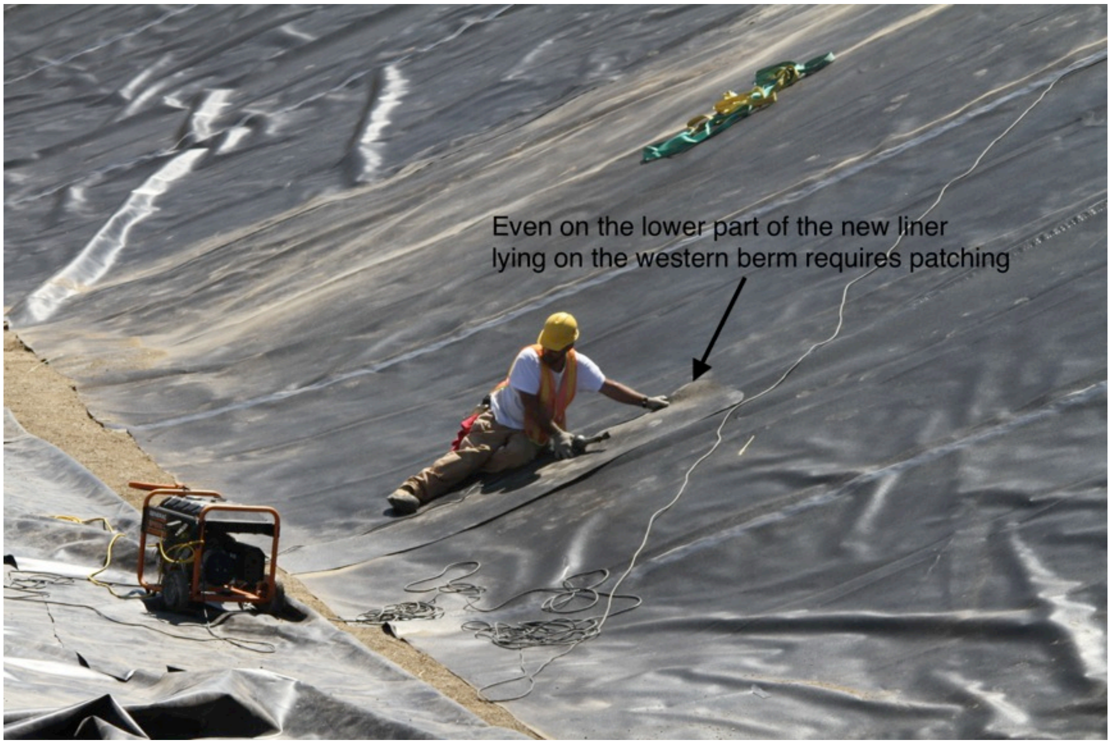


IMAGE 10: One example of a patch required to cover a large gap. Note also the gap between the floor liner and the berm liner that requires patching. An error, one of many, was made in calculating the size of the berm liner.

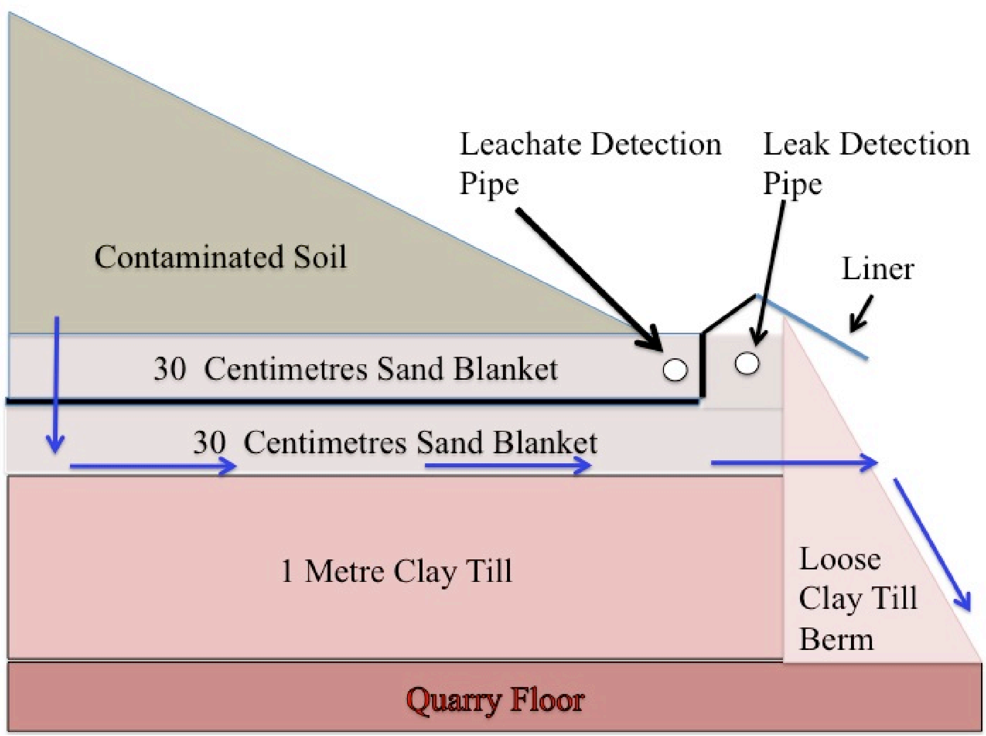


IMAGE 11: The so-called "leak detection system" designed by SIRM. The leaks would have to go **uphill** through sand and course crushed rock to enter the leak detection pipe. The simplest route for leaks is to flow through the

sand blanket below the liner and through the loose clay till berm and from there the leak makes its way ultimately to the Ephemeral Stream. This is the source of the wet patches seen in IMAGE 4.

IMAGE 12: Early stage of installation of the leak collection and leachate collection pipes in PEA 1C. The worker on the right is standing on the PEA 1C floor. It can be seen that the leak collection pipe is well above the floor of PEA 1C.

IMAGE 13: This photo shows a later stage in the installation of the leak collection pipe. One can appreciate that the leak collection pipe is higher than the floor of the landfill site.

IMAGE 14: A few examples of cover liner seams opening. These welds were performed in the wet season and it is no surprise so many seams are opening.

Review - CHH As Built Documents

1 Introduction

On 17 04 18 Cobble Hill Holdings (CHH) submitted a collection of documents (DOX) to the Ministry of Environment (MoE) in support of their decision to Close their Landfill in the quarry at 360 Stebbings Road in the Shawnigan Lake Community Watershed.

These documents were provided to help MoE and it newly hired Qualified Professionals (QPs) determined whether or not the landfill could be safely closed. (Covered and left in perpetuity.)

In the past, documents from CHH and associated companies have been

- false - the information in the document is simply wrong,
- misleading - the information in the document creates a false impression,
- incomplete - the lack of information allows the reader to reach a false conclusion.

This set of documents is no exception.

1.1 Context

After MoE cancelled Permit PR-105809, the Minister issued a spill prevention order which required the landfill to meet the requirements in the Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016. (LCMSW)

Documents intended to support the case for closure of the landfill should indicate that the landfill meets or exceeds the requirements of LCMSW. The As Built documents do not mention LCMSW.

2 Analysis

This analysis is organized by following the figures in LCMSW. For each of the figures, the related documents in the CHH are listed along with their shortcomings.

2.1 Buffer Zones

Figure 5.1 shows the buffer zones required for a landfill.

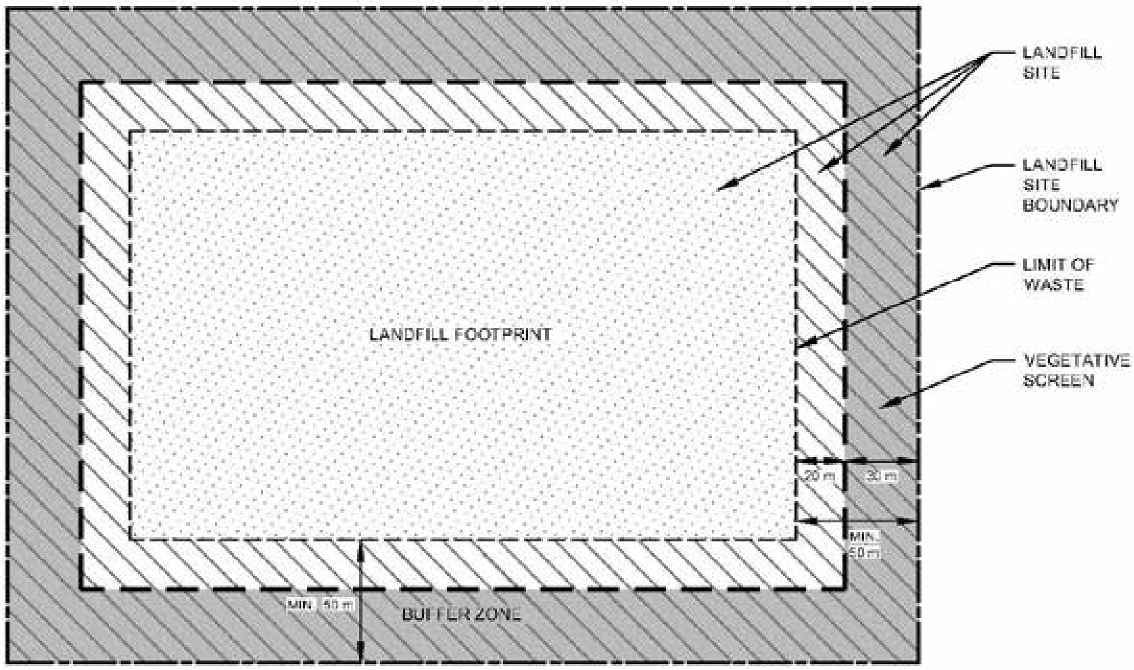


Figure 5.1
ILLUSTRATION OF BUFFER ZONES

No specific mention of any of these buffer zones in DOX.

Review - Landfill Closure under Landfill Criteria for Municipal Solid Waste shows that a large part of the landfill lies in the 50m buffer zone. Refer to that document for an explanation of that contravention of the LCMSW.

2.2 Landfill Slopes

The LCMSW requires that the slopes of the landfill not be too steep. In general, the steepest slope allowed is 3 m horizontal for each 1 m vertical.

Some of the figures in the DOX shows slopes on the landfill. Once shows that the NE face has slope 2.5 H to 1 V. That is, it admits it is non-compliant.

Review - Landfill Closure under Landfill Criteria for Municipal Solid Waste shows the part of the landfill that is non-compliant with this requirement.

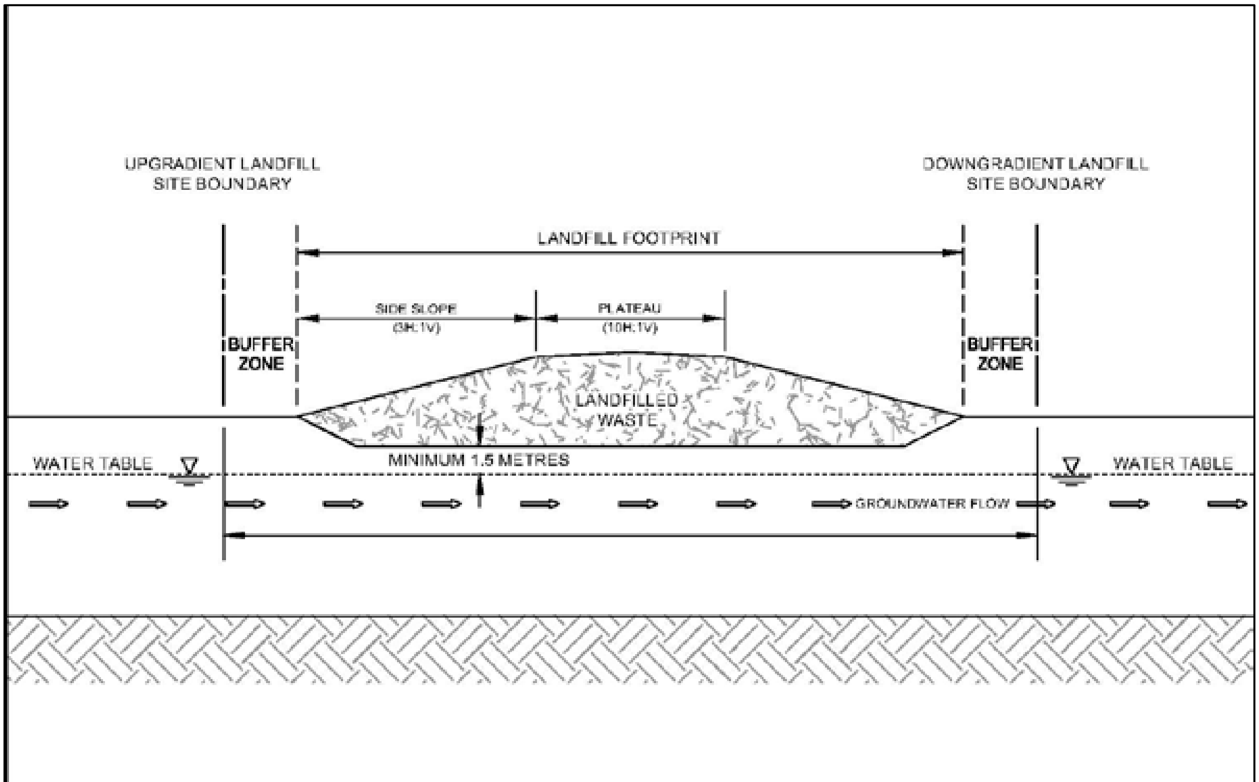


Figure 5.2
LANDFILL CROSS-SECTION SCHEMATIC

2.3 Landfill Base Liner System

The LCMSW has very specific rules about the layers of protection required for a landfill.

2.3.1 CLAYEY SOIL

The DOX has several documents which discuss the bottom layer - the "CLAYEY SOIL". The description is scattered throughout the package, with documents discussing the three separate stages - areas 1A, 1B, and 1C.

The documentation for 1A includes detailed testing (The Levelton tests), which is not provided for area 1B or 1C. The latter two were visually inspected, found wanting, re-inspected, again found wanting, then in the case of area 1C passed based on communications from a principal of the company and an employee of the company.

We have some reports - Sperling Hansen - requiring "continuous Quality Assurance and Quality Control". What we see is a few visits from a QP, when the company has prepared the site for viewing, followed by signoff based on emails from the company.

There is even one document in which the QP states that the purpose of the visit was "to confirm the findings of the Active Earth Engineering Ltd, (AAE) bedrock integrity inspection and risk assessment October 2013."

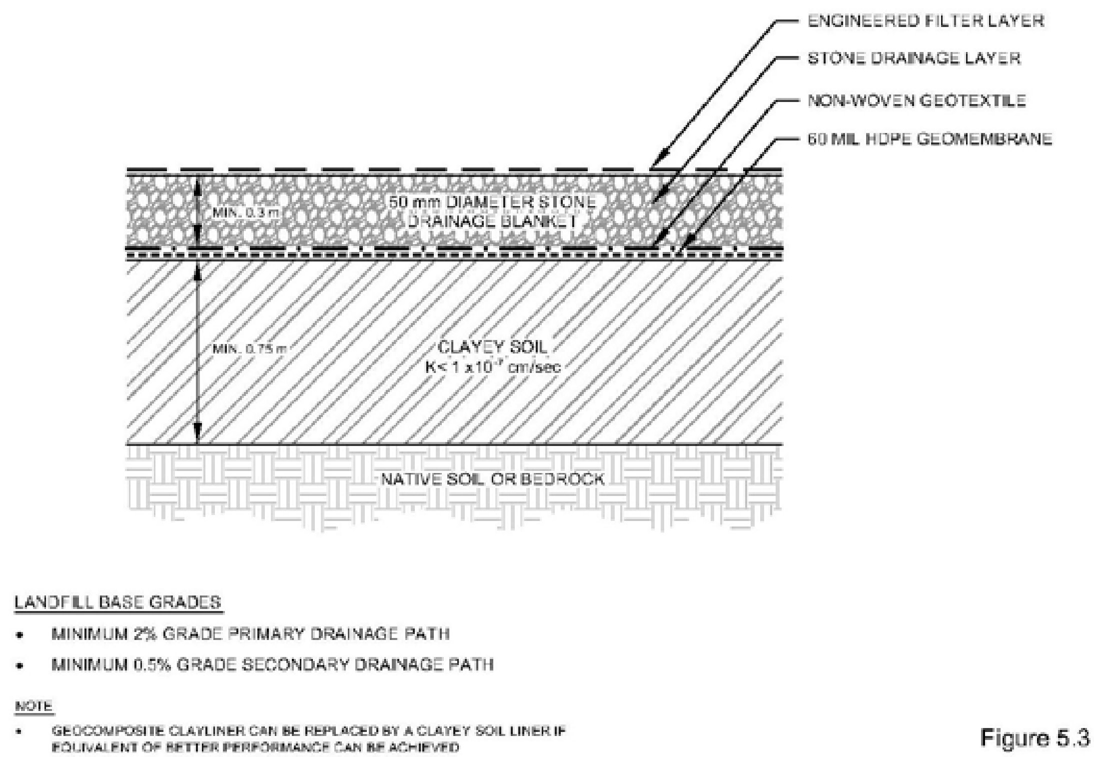


Figure 5.3
LANDFILL BASE LINER SYSTEM

2.3.2 60 mil HDPE Geomembrane

The company used 40 mil HDPE geomembrane throughout.

There any endless pages in the DOX showing manufacturing detail about the 40 mil liner. There is no documentation anywhere in the DOX indicating there was any testing of the liner after installation.

2.3.3 Non-woven Geotextile

There is no mention in the DOX of the use of non-woven geotextile over the geomembrane.

2.3.4 Stone Drainage Layer

There is no mention in the DOX of the use of a stone drainage layer on top of the geomembrane.

2.3.5 Engineered Filter Layer

There is no mention in the DOX of the use of an engineered filter layer over the stone drainage layer.

2.3.6 Summary

While the DOX does contain mention of some spotty testing of the lowest layer, there is no mention of the installation or post installation testing of appropriate layers above that.

2.4 Leachate Collection Pipe

The Leachate Collection pipe locations and lengths are specified in LCMSW.

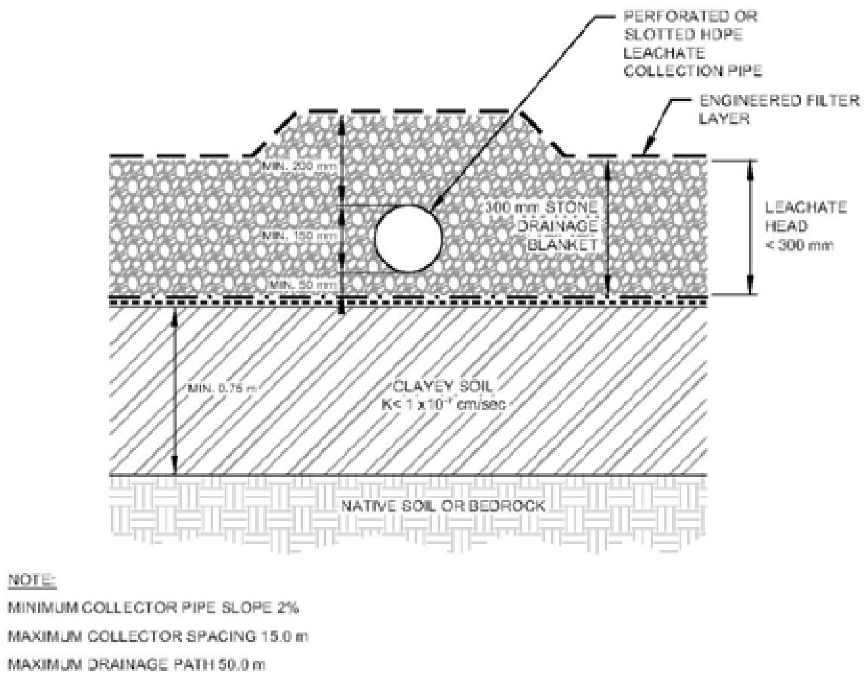


Figure 5.4

LEACHATE COLLECTION PIPE

This figure indicates a maximum length of 50 m and separation of 15 m.

The run of the single pipe is 110 m with the collection tanks in the middle. At least one of the pipes must have a run in excess of 50m.

There is only one leachate collection line, rather than the 5 required by the size of the landfill.

Nowhere in the DOX is there any mention of this requirement.

3 Contaminated Soil Placement As-Built

Pages 129-43 contain a series of diagrams showing what the company claims are the final locations of each of the deliveries of waste material.

	C3	C2	C1	B3	B2	B1	A3	A2	A1
G	FMF	FMF	FMF	HALLO	HALLO	PCT	ENEX/YATES-/1950+	ENEX/YATES-/1950+	ENEX/WP22/1950+
F	PB	PB	PB	HALLO	HALLO	PCT	1950+	1950+	1950+
E		PB	PB	PCT	PCT	PCT	1950+/4-SOIL	1950+4-SOIL	1950+4-SOIL
D		PB	PB	PCT	PCT	PCT	4-SOIL	4-SOIL	4-SOIL
C		PB	PB	PCT	PCT	PCT	4-SOIL	4-SOIL	4-SOIL
B			FMF	PCT	PCT	PCT	4-SOIL	4-SOIL	4-SOIL
A			FMF	PCT	PCT	PCT	4-SOIL	4-SOIL	4-SOIL

This figure, which claims to show the contents of each cell on a 10 m by 10 m grid of the combined soil containment area, applies to the first metre of the waste pile. There are 14 related figures, each purporting to show the contents of each cell in the grid for each layer of the waste pile.

The figure has no engineering stamp.

The figure has no legend connecting squares in the grid to actual deliveries or times of placement.

The suggestion implicit in this series of figures is that the company knows where each delivery was placed. This suggestion is preposterous.

We have watched deliveries of contaminated waste to this site for years. The dump trucks usually simply dump the waste over the side into the waste pile. It is then moved around the existing pile by a series of excavators. There was never any separation vertically between one delivery and the next. One excavator took waste from the dump area and moved it elsewhere in the waste pile. Another excavator moved it further around the pile. There is no way the excavator operators could have known what was new waste and what waste had been in the pile for a day, a week, or a month.

During an earlier stage in waste placement, the operators were adding cementitious material (CM) to the waste. They used two methods. First, the CM was delivered in 1 m3 bags. These bags were shaken over the existing waste pile. The excavators then mixed the waste around. Second, the CM was blown onto the top of the waste from a tanker truck. Again, the excavators mixed the soil and the CM at random.

During the later stages, the excavator dug a trench in the top of the pile and buried newly delivered waste. The trench was excavated the full length the excavator shovel could reach. It certainly reached down at least 3 metres into older waste. This old waste was spread around the top of the pile or over into a new part of the pile. Later this new waste was again excavated from the trench and dumped into area 1C where it was spread by another excavator. Even newer waste was dumped into the trench.

At time one excavator was removing waste from one end of the trench while another was dumping more recently received waste into the other end of the trench.

At other times, silt and leachate from the contact water retention pond was moved to the waste pile and dumped. This leachate represents contaminants from all parts of the pile to that date. Newly arrived waste was dumped into this puddle, absorbing some of the contaminants, then moved into the trench.

4 Leachate Quality and Quantity

There is no attempt to determine how much leachate remains in the waste pile or the contaminants in that leachate.

There is a claim that leachate volumes recovered by the leachate collection system are as little as "50 liters[sic] per day." This statement appears in a cover letter without any engineers stamp. It is without foundation.

The only way to know how much leachate there is in the waste pile that is yet to be released is to test the waste in the pile.

There is no estimate of the contaminant load contained in the waste pile. The only way to discover the contaminant load is through a thorough analysis of the waste in the waste pile.

As a check on contaminant quality, an analysis of contaminants in leachate recovered to date should be made. A comparison of actual contaminants, as determined from the waste itself, to leached contaminants, through analysis of the leachate, must be undertaken to determine what contaminants are quick to leave and which contaminants will only leave over time.

5 Summary

This project has been characterized by false, misleading and incomplete information from the first Open House in May of 2012.

The companies continue to issue the same documents again and again, long after they have been shown to be false, misleading and incomplete.

New qualified professionals come to the site and are set off on the wrong track by these documents again and again.

MoE must develop a certified set of documents which contain only true, clear and complete information. Only those documents should be available to qualified professionals to become the basis for their reports on this site.

There are few if any such documents in the DOX.

CHH-SIRM Photos

by Dave Hutchinson

2015-05-07 Perpetual Pond

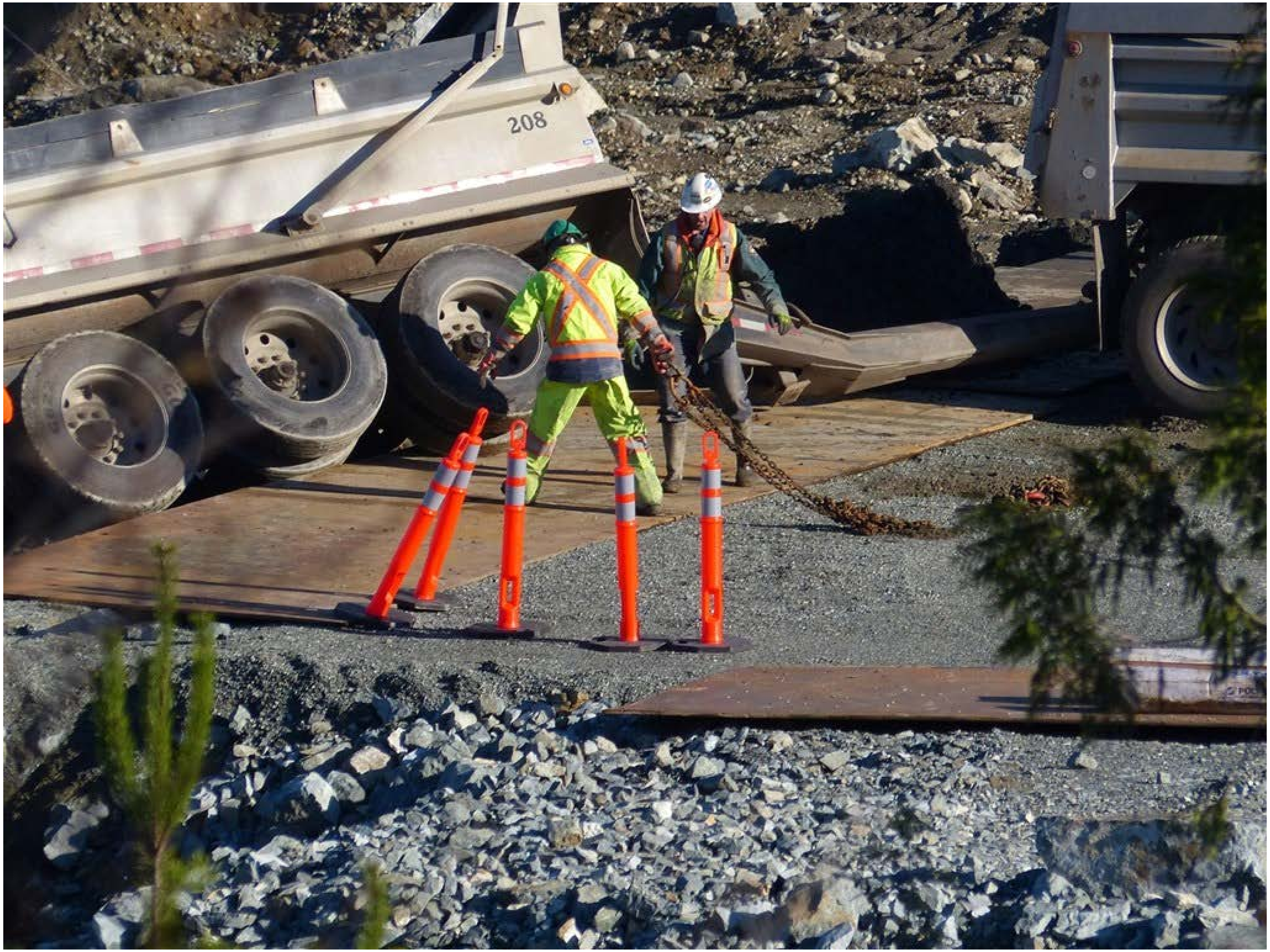
2015-09-27 Fractured Bedrock

2015-11 Stuck in the Muck

2015-11-09 Dumping on Liner

2015-11-13 Saturated Soil

2015-11-19 Truck Mishap



2015-11-19 Truck Mishap2

2015-11-20 Machines on Liner

2015-11-24 Dumping on Liner

2015-11-26 Frozen WTS

2015-12 Aerial Shot

2016-07-10 Aerial of Liquid Dumping

2016-07-10 Aerial of Wet Landfill

2016-10-08 Contact Water Breach

2016-10-09 100,000 Tonnes

2016-10-11 Collection Tanks

2016-10-30 Liner Work

Hurst, Nicole ENV:EX

From:	Dave Hutchinson <dave.shawnigan@shaw.ca>
Sent:	Thursday, June 8, 2017 4:12 PM
To:	Downie, AJ ENV:EX
Cc:	Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; Sonia Furstenau; 'Calvin Cook'
Subject:	SRG June 8 Response to SHA Final Closure Plan for CHH Landfill
Attachments:	1-SRG Summary of SHA Final Closure Plan.docx; 2-SHA Final Closure Plan Review-Beach.docx; 3-SHA Final Closure Plan Review-Juurlink.docx; 4-Cell-1C Liner is Compromised-Hutchinson.pptx; 5-Modern MSW Landfills-Rowe.pdf; 6-Response To Hemmera Review-Juurlink.docx

Hello AJ,

Please find attached the Shawnigan Research Group (SRG) response to the Sperling Hanson Associates "Cobble Hill Landfill Final Closure Plan" of May 31, 2017.

The following points have been copied from the Summary Document:

- **Any consideration of final closure as an option must assume a 2018 implementation.**
- **The SHA request for a June 15, 2017 approval decision should be denied. Any consideration of final closure must be thorough and justified.**
- **The SRG believes a rushed approval would be indefensible and would lead to serious controversy.**
- **Significant portions of the "as-built" specifications are incorrect or misrepresentative.**
- **Unverified declarations made by individuals with obvious conflict of interest must necessarily be viewed as unreliable.**
- **The SHA plan fails to conclusively demonstrate that proposed site-specific alternatives to the LCMSW provide an equivalent or better level of environmental protection.**
- **There is evidence that that the base liner has been irredeemably compromised.**
- **Tests need to be promptly devised to conclusively determine whether the existing base liner and leachate systems are performing as required.**
- **A water quality monitoring regimen needs to be swiftly established which will not only quantify levels of contaminants, but also identify any correlation with contaminants in the landfill.**
- **Any closure plan must include previous commitments related to the quarry/reclamation aspects of the mining operations on both Lot 23 and Lot 21.**
- **Any closure plan must demonstrate compliance with end land use as defined by the Cowichan Valley Regional District zoning bylaw.**

- **The SRG and SRA emphasize that all documented concerns be answered prior to a decision.**

Regards,
Dave Hutchinson

Shawnigan Research Group
SRG Summary of SHA Final Closure Plan

The Shawnigan Research Group (SRG) has provided five documents in response to the "Cobble Hill Landfill Final Closure Plan" dated May 31, 2017, produced by Sperling Hansen Associates (SHA). Also included is one document responding to the May 26 Hemmera Review of the SHA plan..

- **1-SRG Summary of SHA Final Closure Plan.docx (this document)**
- **2-SHA Final Closure Plan Review-Beach.docx**
- **3-SHA Final Closure Plan Review-Juurlink.docx**
- **4-SHA Final Closure Plan Review-Hutchinson.docx**
- **5-Modern MSW Landfills-Rowe.docx**
- **6-Response To Hemmera Review-Juurlink**

Summary:

Any consideration of final closure as an option must assume a 2018 implementation.

The SRG agree with SHA concerns regarding the proposed implementation schedule. SHA is pressuring the Ministry to approve the Final Closure Plan by June 15^{th}. The SRG believes that such a rushed approval would be indefensible and would lead to serious controversy. While a quick decision favouring the removal of the contaminated waste would be welcome, any consideration of final closure must be thorough and justified.

The Ministry of Environment has required that the plan be guided by the "Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016" (LCMSW) and that any proposed site-specific alternatives provide an equivalent or better level of environmental protection. The SHA plan, while recommending some improvements to accessible infrastructure, has been forced to rely on questionable "as-built" documentation along with declarations from owner/operators with regard to the integrity of the underlying structure. The SRG reiterates that significant portions of the "as-built" specifications are incorrect or misrepresentative. Also, unverified declarations by individuals with obvious conflict of interest must necessarily be viewed as unreliable. Given this uncertainty, the SHA plan fails to conclusively demonstrate an equivalent or better level of environmental protection.

The SRG presents evidence that the base liner has been irredeemably compromised. The SRG and the Shawnigan Residents Association (SRA) remain adamant that tests need to be promptly devised to conclusively determine whether the existing base liner and leachate systems are performing as required.

The SRG and SRA insist that an appropriate water quality monitoring regimen needs to be swiftly established which will not only quantify levels of contaminants, but also identify any correlation with contaminants in the landfill. Sampling should include both surface and ground water.

Any final closure process must include confirmation that the Ministry of Energy and Mines will enforce previous commitments related to the quarry/reclamation aspects of the mining operations on both Lot 23 and Lot 21.

Assuming mine closure and the termination of the Mines Permit, the SRG assert that any closure plan must demonstrate compliance with end land use as defined by the Cowichan Valley Regional District zoning bylaw.

The SRG and SRA emphasize that all documented concerns be answered prior to a decision.

Dave Hutchinson June 8, 2017

Review - SHA Final Closure Plan

Introduction

On 17 05 31 Sterling Hansen Associates (SHA) published Cobble Hill Landfill Final Closure Plan.

This is a long, complex document. It claims that, with some changes, the contaminated waste can be left in our Community Watershed.

The SHA consultants visited the site 3 times since late 2016.

To summarize their findings:

> **Everything they could actually see needs to be redone, while everything they could not see, but rather had to rely on documentation from the companies, is just fine.**

The Temporary Encapsulation Area (TEA) - Visible

There is nothing about the visible aspects of the waste pile (TEA) that can remain after closure. The SHA report is merciless:

1. **The cover** - the sloping faces must be replaced with a non-slippery plastic.
2. **The shape** - the sloping faces do not meet the requirements and must be redone.
3. **Leachate collection piping** - will be redone once the sloping faces have been corrected.
4. **Leachate collection tank** - will be replaced with a 5x larger tank.
5. **Tank location and design** - the pit holding the leachate collection and leak detection tanks will be moved and the design enhanced so that it will detect leaks. The piping from the TEA to the tanks will be buried (yes, it can freeze on Vancouver Island).

The Temporary Encapsulation Area (TEA) - Invisible

There are no aspects of the invisible parts of this site that cause them any concern. SHA did not look inside the waste pile. They relied on company reports. As discussed in previous reviews in this series, company reports are false, misleading and incomplete. As a result, the SHA report is simply wrong in many crucial areas.

1. **Water in the waste** - SHA did not measure the water content of the waste. They therefore have no idea how much leachate will be produced over time. In spite of this they make confident prediction on leachate quantity. They have no idea how much the waste will shrink over time. In spite of this they are confident that it will be safe to pave over the site. They base those predictions on data from the companies.

2. **Contaminants in the waste** - SHA did not measure the levels of contaminants in the waste pile. Again, they relied on assurances from the company.

3. **Base liners** - SHA did not, could not, verify the quality of the base liner system. They relied on assurances from the companies that the installation of the base liner system was faultless.

4. **Base liner leaking** - SHA did no testing to compare the contaminants and their levels in the waste (collectively here referred to as the waste DNA) to the contaminants and their levels in the surrounding area. In particular, to the contaminants in water leaving the site. In spite of this they claim the TEA is not leaking.

5. **Leak detection system** - Although the leak detection piping is at the north western toe of the TEA, SHA did not open the liner here to examine the leak detection system. They did not inspect the pipes for blockages. They did not inject test water into the leak detection layer to verify the leak detection system is operational. The leak detection system's failure to collect significant leachate could be due to any combination of causes: bad location of piping, leaks uphill from the pipes that drain all leaks below the leak detection system, plugged pipes, bad pipe installation so pipes go uphill to the collector, ... The most unlikely reason, in my view, is that there is no leaking. SHA passed the leak detection system as fully operational.

6. **Leachate collection system** - Using numbers from the SHA report, the leachate collection system collected .8 m3 per day in February, is estimated to have collected .5 m3 per day in May, is projected to collect only .16 m3 per day by the end of closure (Oct 1 2017). This projection is based on company data and a meaningless analysis. It does not consider the effects of 3 months of sub-zero weather on the waste pile - reducing leachate volume through freezing of the waste which has not yet fully thawed. It is not based on an analysis of the waste itself. It concerns itself with leakage through the top cover, ignoring the thousands of cubic metres of water in the waste. It further ignores the possibility that the leachate collection system is not working. Is slowly filling up with silt and not performing now as it did when first installed.

The Known Unknowns

Before any decision can be made about final closure of the TEA, much more has to be known about the waste itself.

Contaminants

No decision about the safety of leaving this waste in a Community Watershed can be made until a careful analysis of the waste itself determines exactly which contaminants are present and the quantities of each. We cannot rely on the documents produced at the waste source. We must have a thorough analysis of the waste in the waste pile itself. The sample collection process must be peer reviewed and have continuous QAQC.

This will require piercing of the top cover, insertion of sample collection probes, collection of waste samples from all areas of the TEA at all depths, analysis of those samples.

Recommending closure without a clear knowledge of the hazard is foolhardy.

Review - SHA Final Closure Plan

Water Content

These samples can also be used to determine the water content of the TEA. From this we can estimate:

1. leachate volume and
2. TEA shrinkage over time.

The SHA report suggests paving over the TEA so it can be used for industrial purposes. This is asking for sink holes, failed foundations, etc.

Dredgeate Modelling

The SHA report suggests that the waste in the TEA will not produce gas. SHA did not base this claim on any analysis of the waste. It based this claim on representations from the company.

If the dredgeate does produce gas while it gradually breaks down, the volume of the waste will decrease. This again poses problems for any hard surfaces or buildings on the site.

Recommending closure without a careful analysis of the waste in the TEA to satisfy these concerns is foolhardy.

End Land Uses

Closure of the TEA could well leave the property unsuited for any of its uses allowed by zoning.

1. The site contains contaminated waste. The site cannot be sold until the contamination is removed.
2. The site contains waste that could shrink over time. The site cannot be used for industrial purposes for fear of sink holes and failed structures.
3. The site has a very thin soil cover. Any large tree growing on the sloped faces could get blown over with its roots ripping out all the soil and exposing the cap liner. A large fir tree growing on the sloped faces could easily put down roots that would pierce the cap liner. The expert who testified for the CVRD, the former chief mine reclamation officer for BC, said that this site would not be suitable for forestry. The judge at that trial agreed. The lower court decision was overturned on appeal for other reasons. The appeal court decision is on appeal to the Supreme Court. Continuing with a landfill on a property that is not zoned for a landfill, with a pending case before the Supreme Court of Canada undermines the judicial process.

Quarry Closure

SHA is poorly informed about the Quarry and its surrounding area. SHA is nevertheless very confident in its assessment of the site.

1. In Section 2.2 "As of June 2015, the quarry had been operated by South Island Resource Management Ltd." SIRM operated the landfill, not the quarry.

2. In Section 2.2 "then the quarry would have to be reclaimed to meet requirements of the mines act for a total cost north of $10 million" less $5 million for tipping fees for removed

contaminated waste, less $2 million for trucking of that waste, for a total of $3 million for reclamation of the quarry. The bond with mines for reclamation of the quarry if $50,000. The bond with Environment for closure of 1 cell and reclamation of the site is less than $250,000. The estimate of the cost of quarry reclamation is spurious. SHA's ignorance here casts the entire projection into doubt.

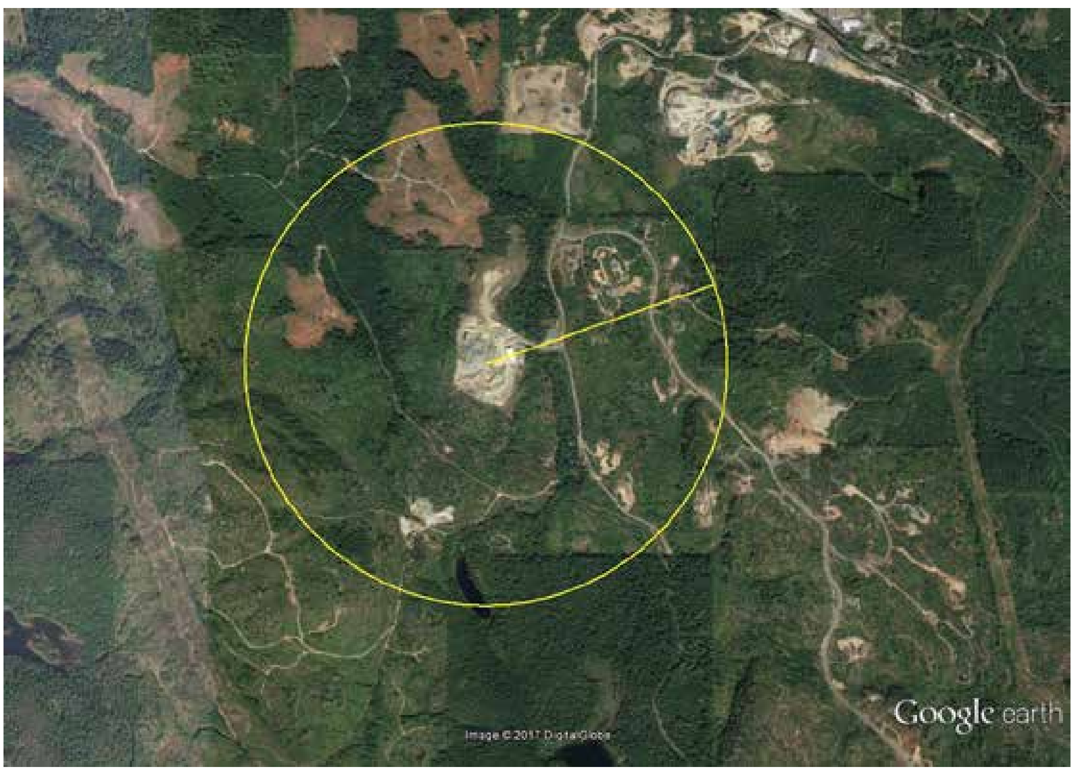
3. Section 2.2.1 "Five rock quarries exist within 1 kilometer of the site." This Google Earth image below with a 1 km circle shows 1 quarry in the neighbourhood of the site, a quarry which is busy a couple of days a year. SHA's confidence in their claims which are false casts the entire report into doubt.

4. Section 2.2.3 "The Quarry permit and Waste Discharge permit are no longer in place." In fact, the quarry permit is still in place.

5. Section 3.1 "Because the plan was to relocate the PEA at some point in the future". So, the TEA became a PERMANENT encapsulation area just by changing the name? SHA has no problem with that.

6. Section 9.4 "As the landfill will be closed, and no further quarrying will take place". The mining permit still exists. Quarrying is still possible. Their subsequent plan is specious.

7. Section 9.5 "As the landfill and quarry are now closed". The landfill is closed, the quarry still has a mining permit.



Review - SHA Final Closure Plan

Mine Reclamation vs Landfill Reclamation

Notwithstanding claims by SHA as outlined in the previous section, the mines permit still exists and the operator could resume quarrying operations.

However, at some point the operator will have to reclaim the quarry.

That reclamation will have to take place with a landfill sitting in the quarry. How will that eventual quarry reclamation affect the works of the reclaimed landfill?

If the operators of the quarry close that quarry next year and reclaim the mine, what will happen to the existing works of the closed landfill?

That SHA reported on closure of the landfill without considering the associated closure of the quarry is an egregious error.

Closure Schedule

The SHA report recommends a decision a closure by Jun 15 2017, a start of the closure operation by Jul 1, 2017, and completion by Oct 1 2017 - **before the rainy season starts.** (Section 10.1)

Like CHH, SIA, and SIRM, SHA appears to be unaware of the extent of the rainy season in our Community Watershed.

Rainfall at the Environment Canada weather station in Shawnigan Lake:

- 2010 sep 114 mm
- 2013 sep 159 mm

Rain at the quarry is typically twice as heavy as at the Shawnigan Lake station weather station (see Section 2.2.5).

Rainfall of 300 mm (almost 1 foot) is possible during September 2017.

The schedule proposed by SHA is therefore completely impractical, since they intend to remove the entire cap liner during the re-capping operation.

Non-Contact Water

The SHA report glosses over the non-contact water issues, effectively ignoring them.

None of the questions raised in the earlier Review of the 16 12 19 Non-Contact Water Study and Review 16 12 19, 17 02 20 Contact and Non-Contact Water Reports are answered by this report.

SHA brushes off contact water as a trifling nuisance that can readily be ignored.

As specialists in Landfills, with apparently little knowledge of quarrying and mine reclamation, this is not surprising. Perhaps they again relied on information from the companies in this area.

Review - SHA Final Closure Plan

Trucking Contaminated Waste

The contaminated waste was brought to this site from around the province. The transportation methods used were approved by Environment as environmentally sound.

The SHA report now deems that movement of contaminated waste is not a safe practice (Section 2.2). "relocating nearly 100,000 tonnes of soil to an alternate facility would introduce another level of environmental impacts including traffic risks associated with 8,000 round trip movements, GHG emissions, dust release, etc. In SHA's professional opinion, managing the waste in place is the environmentally preferred option."
For SHA, it is safer to leave 100,000 tonnes of contaminated waste (they don't know what contaminants are present at what levels) in a landfill whose base liner system has not been tested and may be leaking, than to move that waste using established environmentally safe transportation methods.

More grasping at straws (straw bales) to promote closure of a landfill on property on which a landfill is not a permitted use, all of whose surficial elements must be rebuilt, all of whose hidden components are suspect (but approved without examination), and whose waste material has not been fully characterized as to contaminants, water content, or biological activity.

Buffers

The SHA report makes no mention of the requirements in the "Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016," or LCMSW, for buffers.

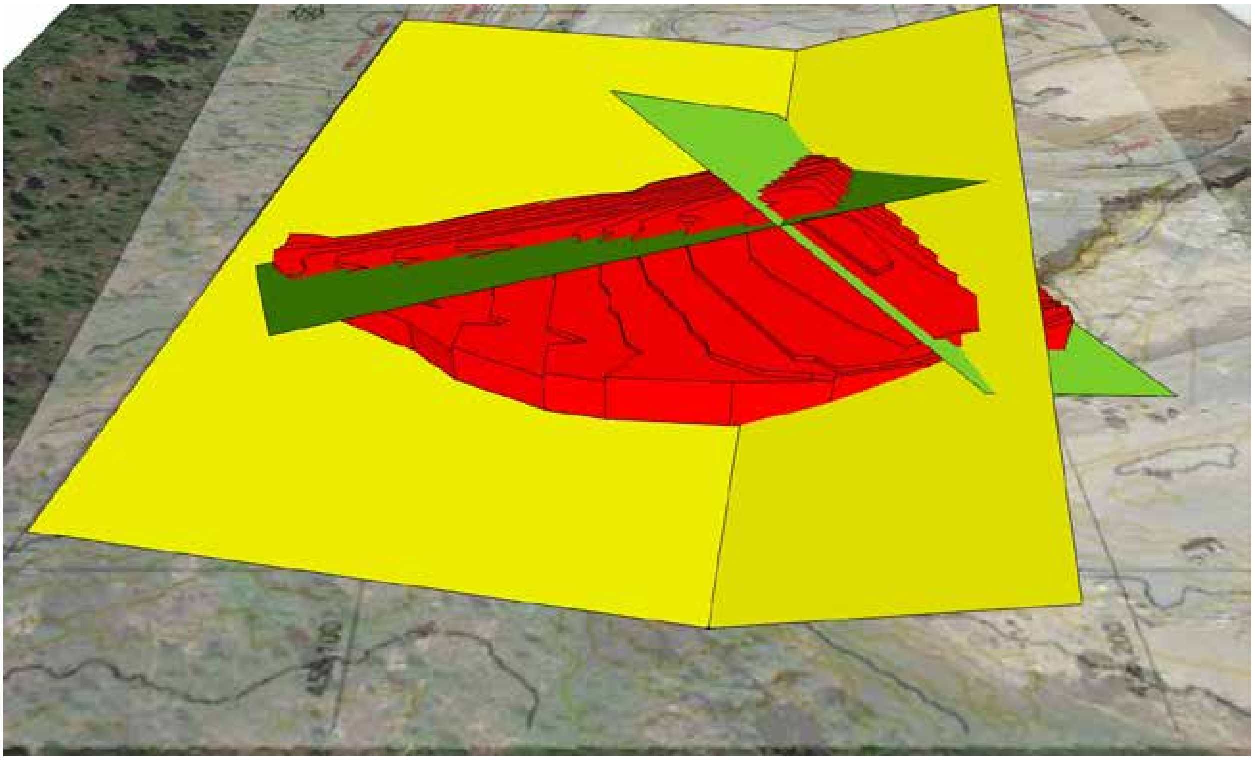
The landfill must be 50 m from the property line.

In addition, where the neighbouring property is a Regional Park, the buffer must be 100 m.

The land to the west of the landfill is owned by the regional district and is a regional park. This land was ceded to the CVRD as part of the subdivision of the area into 10 hectare parcels and re-zoning from Forestry that preceded the purchase of the land and the granting of the mining permit.

Review - SHA Final Closure Plan

The google earth/sketchup model of the landfill (in red) and the buffer required from the CVRD regional park (in yellow) with appropriate slope on the west face, shows that almost the entire landfill sits in the buffer zone and hence violates the LCMSW.



Conclusion

Minister Polak wrote that

Human safety and environmental protection is of paramount importance to the ministry.

At this point in time, the Known Unknowns as so numerous and so complex that they cannot possibly be resolved in time to meet the very aggressive and foolhardy schedule proposed by SHA.

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

FUNDAMENTAL FLAWS IN THE SHA REPORT:

1) The SHA Closure Plan is based upon As-Builts and information supplied by SIRM and CHH. We have presented evidence that such information cannot be relied upon.

2) Another fundamental flaw is that there was no determination if the site is leaking. An examination of the contaminants in the leachate and the Ephemeral stream reveals they have the same footprints. THE SITE IS LEAKING!

The SHA Report refers to Dr. Kerry Rowe's writings; hence, we will also refer to Dr. Rowe, in particular his 2016 paper: R. Kerry Rowe. 2016. Recent Insights regarding the Design and Construction of Modern MSW Landfills. *Eur Asia Waste Management Symposium*, 2-4 May 2016, Istanbul, Turkey.

We also note that: "The closure plan was to be developed following the guidance in the Landfill Criteria for Municipal Solid Waste, 2nd Edition dated June, 2016".

CRITIQUE:

Quotes from the Sperling Hansen Associates Cobble Hill Landfill Final Closure Plan of May 31, 2017
RESPONSE COMMENTS IN BOLD UPPER CASE

P. 11:

HELP modelling was completed for leachate generation, using a safety factor of 1.5.

A SAFETY FACTOR OF 1.5 IS NOT REASSURING.

FURTHER, DR ROWE WRITES (P. 5):
It is common to use the Hydrologic Evaluation of Landfill Performance (HELP) [21] Model for estimating leachate generation. Used correctly it can provide useful results for this purpose. However, it is also frequently used in two problematic ways. The first is the use of the HELP model to calculate leakage through a composite liner with a geomembrane. The common use of HELP only considers the number of holes per hectare and does not consider the effect of wrinkles [12], [22-24]] which will dominate the magnitude of leakage in both a cover and bottom liner [25], [26]. Alternative techniques should be used for modelling leakage through a composite liner [22]. Second is the use of the HELP model to design the capacity of drains (e.g., in a landfill cover) above a composite liner where the numbers people usually calculate may be a reasonable average value but can grossly underestimate the drainage capacity needed in a heavy rainfall event. It is this event that will cause a cover failure. Furthermore, these drains should be designed based on the weathered hydraulic conductivity of the soil above the drain under at least a unit gradient since this will control the capacity needed in a severe rainfall event.

"HELP" MAY NOT BE A SUITABLE WAY OF MODELLING. FURTHER, WE POINT OUT THAT THE BASE LINER WAS VERY WRINKLED (AT LEAST FOR PEA-1C.)

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

P. 11:

Stability Analysis for the re-graded landfill was completed using SLIDE. The proposed design was found to be stable for all static and seismic loading conditions.

I CANNOT IMAGINE THAT 'SLIDE' CALCULATIONS RESULT IN NO ADVERSE EFFECTS ON THE LANDFILL SITE IN CASE OF THE BIG EARTHQUAKE EXPECTED IN THE NOT SO DISTANT FUTURE.

P. 12:

Groundwater Monitoring will be conducted quarterly at three wells up-gradient and down-gradient of the site. Should the results of groundwater testing indicate changes in water chemistry are occurring, the additional existing wells on the site will be re-introduced into the sampling program. As per Hemmera recommendations, a groundwater monitoring program will be established in the seepage blanket, down-gradient of the PEA, consisting of two 3.0 metre deep wells at the landfill toe.

GROUND WATER CHEMISTRY IS ALREADY CHANGED DUE TO LEAKAGE OF THE WASTE PILE. HEMMERA'S SUGGESTION ACTUALLY CAME FROM THE SRG.

P. 12:

However, as the CHHL stopped receiving waste before the new Criteria were released, it is not clear whether this facility should be grandfathered under the post closure care requirements of the 1993 criteria under which the facility was permitted.

THE SRG FINDS THAT THE MINISTRY'S REQUIREMENTS ARE CLEAR AND THE 2016 REQUIREMENTS ARE TO BE MET.

P. 13:

Assuming that MoE can approve this closure plan by June 15th, 2017 works will be initiated by July 1st, 2017 and completed by October 31st, 2017, as specified.

THIS GIVES INADEQUATE TIME FOR THE MINISTRY TO EXAMINE THE SRG'S AND HEMMERA'S RESPONSES TO THE CLOSURE PLAN.

P. 13:

*The Post Closure Monitoring Costs are anticipated to be approximately **$14,865** including:*

THE POST-CLOSURE COSTS ARE BASED UPON AN ASSUMPTION THAT NOTHING UNTOWARD WILL HAPPEN. THIS IS AN UNWARRANTED ASSUMPTION.

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

P. 17:

SHA staff have completed three site visits in total since mid 2016. Based on the site visits and review of numerous documents including Technical Assessment Reports (AEE), Environmental Procedures Manual / Operations, Maintenance and Surveillance Manual (SIRM), Permits and others, SHA has a good understanding of historic site operations, environmental controls and the current state of the site.

WITHOUT THE INPUT OF THE SHAWNIGAN RESEARCH GROUP (SRG), SHA DOES NOT HAVE A GOOD UNDERSTANDING OF THE HISTORIC SITE OPERATIONS, ENVIRONMENTAL CONTROLS AND THE CURRENT STATE OF THE SITE. THE SRG HAS DATA THAT CLEARLY INDICATE THE SITE WAS NOT OPERATED ACCORDING TO THE DOCUMENTS REVIEWED BY SHA.

P. 19:

A quarry permit (No. Q-8-094) was issued in October 2006, amended in April 2009 and again in July 2015.

THE QUARRY PERMIT WAS ALSO AMENDED ON OCTOBER 28, 2015. THIS IS MENTIONED SIMPLY TO POINT OUT ONE OF THE CASES OF SLOPPINESS IN THE REPORT.

P. 19:

As of June 2015, the quarry had been operated by South Island Resource Management Ltd. (SIRM).

THE QUARRY HAS NOT BEEN OPERATED AS OF OCTOBER 2015 – BASED UPON THE ABSENCE OF BLASTING NOTICES SINCE THEN.

P 19:

The double basal liner exceeded the requirements of the 1993 Landfill Criteria."

BUT THIS WAS PART OF THE DESIGN UPON WHICH THE WASTE PERMIT WAS GRANTED.

P. 19:

The encapsulation included a basal lining system and a cap liner composed of 40mil LLDPE Geomembrane.

THE CAP LINER IS ONLY 35 MIL ACCORDING TO MANUFACTURER'S SPECIFICATIONS. AGAIN THIS IS POINTED OUT AS ANOTHER CASE OF SLOPPINESS IN THE REPORT.

FURTHER, FROM ROWE (P. 5):
The stability of the system (e.g., geomembranes, geotextiles, CCLs, drainage system, and nature soils) is an obvious consideration; however, there is an unfortunate tendency for designers to rely on guidance/instruction from the manufacturer/installer without doing basic checks. Checking for an adequate factor of safety against failure during construction, the various stages of landfilling, and after landfill closure is an essential part of the design and is the designer's (not the manufacture's or installer's) responsibility. Even when calculations are performed, mistakes often arise when using geosynthetics due to not considering realistic interface strength both in the short-term and long-term. Testing is required to get short-term strength data and it is

essential that this testing be over the full range of stress conditions expected in the field. Also, if testing is done for one product combination it cannot be assumed that the interface strength would be the same if one or more of the products change. For example, different geomembranes may have different asperity heights or different ways of inducing roughness of the surface that can results in quite different short-term and, potentially, long-term interface properties. Also two GCLs may have the same hydraulic conductivity but substantially different interface characteristics depending on how they are constructed/manufactured. Thus, a design based on testing and specifying one combination of materials may result in a safe design. However, the substitution of even just one alternative material to that specified may result in the design becoming unsafe, unless the change is supported by similar testing and evaluation. The failure envelope of some interfaces may be highly nonlinear. For example, some may have a high interface friction angle at low stress but much lower resistance at higher stresses. Indeed, there can, in some cases, be a failure of some material in shear at high stress. Very careful consideration must be given to what is a reasonable long-term interface strength when that strength relies on either protrusions (e.g., plastic spikes on a geomembrane) or a bond between two components of a material (especially if the bond is due to an adhesive) to provide sufficient interface strength. In considering interface strength, very careful consideration must be given to pore pressures that could reasonably develop at the interface in the very short-term (e.g., a storm event), short-term (e.g., during construction and landfilling), and longer-term (after closure). There are many good papers.

SIRM COMPLETELY RELIED UPON THE MANUFACTURER'S SPECIFICATIONS.

P. 20:

The unexpected cancellation of the CHH Waste Discharge Permit now requires the owner to permanently and securely cap the soil on site or dispose off-site; however, off-site disposal is not a fiscally realistic option. Tipping fees alone would cost at least $5 million, transportation would add another $2 to $3 million and then the quarry would have to be reclaimed to meet requirements of the mines act for a total cost north of $10 million. This level of expenditure is simply beyond the financial capacity of CHH. Furthermore, relocating nearly 100,000 tonnes of soil to an alternate facility would introduce another level of environmental impacts including traffic risks associated with 8,000 round trip movements, GHG emissions, dust release, etc. In SHA's professional opinion, managing the waste in place is the environmentally preferred option.

PUBLIC SAFETY SHOULD BE THE PRIMARY CONSIDERATION, NOT WHETHER CHH MAKES ENORMOUS PROFITS FROM THE CONTAMINATED SOIL WASTE DUMPSITE.

P. 22:

Due to previous quarrying at the site, there are no native soils in the immediate area.

NOT TRUE. THE NATIVE SOILS REMOVED FROM LOT 23 ARE ON THE ADJACENT LOT 21.

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

P.21:

Two residences exist on land located approximately 320 meters southeast of the site.

THERE IS ALSO A RESIDENCE LOCATED NORTH AND EAST OF THE SITE ON THE ADJACENT LOT 21. THIS BIT OF INFORMATION IS ANOTHER EXAMPLE OF WHAT IS DECLARED TO SHA BY CHH IS NOT ALWAYS TRUE – IN THIS CASE A SIN OF OMMISION RATHER THAN COMMISION.

P. 22:

The site is underlain by Wark Gneiss bedrock – a formation composed of massive and gneissic metadiorite, metagabbro, and amphibolites (Active Earth Engineering Ltd., 2012). The site also includes a hard, granitic bedrock exposure.

THE pH OF THE WATER OF SEVERAL OF THE WELLS ON THE SITE IS AROUND 10 INDICATING THAT THERE ARE LIMESTONE INCLUSIONS AS PREVIOUSLY POINTED OUT BY LOWEN. LOWEN'S REPORT WAS COMPLETELY DISPARAGED BY ACTIVE EARTH ENGINEERING AND THE MINISTRY WENT BY ACTIVE EARTH ENGINEERING AND IGNORED THE LOWEN REPORT.

P. 30:

Waste Discharge Permit 105809 does not provide any requirements on the nature of the containment structures.

NOT TRUE. THE WASTE DISCHARGE PERMIT WAS BASED UPON THE DESIGN PROVIDED BY ACTIVE EARTH ENGINEERING.

P. 31:

The 2016 LCMSW stipulates that all new landfills and lateral expansions be sited in areas where the water table is at least 1.5 m below ground. Although this new guidance does not apply, ground water monitoring of the water table undertaken by SIRM has indicated that the water table is consistently several meters below the ground surface.

BUT THE 2016 LCMSW GUIDELINES DO APPLY.

P. 31:

Previous analysis of deep monitoring wells has shown that the potentiometric surface in the confined bedrock aquifer is near the quarry floor (see Active Earth drawing Figure 6, Detailed Cross Section B (at Quarry) 2012-02-21. It is important not to confuse this confined bedrock aquifer piezometric surface with the water table. The water table has consistently been observed several metres below the pit floor when drilling blast holes, according to SIRM representatives.

OUR THOUGHTS ARE THAT SINCE BLASTING HAS OPENED UP FRACTURES RELEASING WATER, THE POTENTIOMETRIC SURFACE BECOMES THE WATER TABLE.

THIS IS SUPPORTED BY ROWE. NOTE P. 3 OF HIS SYMPOSIUM PAPER:
In any case where the water table or potentiometric surface in an underlying aquifer is above the elevation of the lowest point of excavation for the landfill, consideration must be given to potential piping and basal heave.

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

P. 31:

Clay Secondary Liner: *The PEA is lined with a 1 m thick impervious brown marine clay barrier sourced from the Victoria area. This clay contains about 70% fines passing the No. 200 sieve (0.074 mm) with 20 to 30% clay content. Although permeability testing was not conducted on this clay by Golder Associates, grain size analysis was conducted. SHA has used brown marine clay from the Victoria area on other projects at Hartland Landfill and the permeability of that clay, which is likely very similar to the material used at CHH was 2.8x10-8 cm/s. The minimum requirement in the landfill criteria is a 1 m thick clay barrier with a K less than 1x10-7 cm/s or an equivalent geomembrane. Thus the secondary clay liner alone complies with the 1993 Landfill Critiera liner requirement.*

SINCE PERMEABILITY TESTING WAS NOT DONE, WE DO NOT KNOW IF THE CLAY LINER MEETS SPECIFICATIONS! HOW CAN A COMPETENT ENGINEERING FIRM MAKE SUCH AN ASSUMPTION!

P. 31:

40 mil LLDPE Primary Liner: *In addition, the CHHL PEA is lined with a 40 mil geomembrane which serves as the primary liner. The double liner approach adopted by CHH makes the PEA much more secure than most MSW landfills in B.C. that contain far more hazardous wastes. Furthermore, in SHA's opinion, the double liner is equivalent to the liner requirements of the 2016 LCMSW which call for a 60 mil HDPE primary liner and a 750 mm thick compacted clay liner. The CHHL membrane is a little thinner and the clay liner is a little thicker.*

WE DO NOT KNOW THE PERMEABILITY SPECIFICATIONS OF THE CLAY LINER SO THE ABOVE PARAGRAPH IS NONSENSE!

P. 31:

The 2016 LCMSW recommends that a 60 mil HDPE liner be used as the primary geomembrane. This recommendation was made by SHA when originally developing the 2016 LCMSW for the MoE in recognition of research undertaken by Dr. Kerry Rowe which revealed that geomembrane liners tend to deteriorate rapidly when subject to elevated temperatures. This is a particular concern in biologically active landfills that receive typical municipal solid waste, but it is not a concern at CHH landfill because all of the soils placed into PEA are biologically inert soils that will not generate elevated temperatures. Therefore, the primary geomembrane will be subject to far less thermal stress and a 40 mil thickness will be adequate to provide the desired long term performance.

WE DO HAVE HYDROCARBON CONTAMINANTS IN THE LANDFILL; HENCE, IT IS NOT BIOLOGICALLY INERT. IN ADDITION, WITH OCEAN DREDGEATE THERE IS AN ABUNDANCE OF ORGANIC MATERIAL THAT IS NOT BIOLOGICALLY INERT. FURTHERMORE, WE HAVE REDOX-ACTIVE METALS; HENCE, IT IS NOT CHEMICALLY INERT. SUCH REDOX ACTIVE METALS INCREASE THE RATE OF LINER DEGRADATION. A SERVICE LIFE OF IN EXCESS OF 100 YEARS IS NOT ANTICIPATED. BUT EVEN IF THAT WERE THE CASE, WHAT HAPPENS AFTER 100 YEARS?

WE ALSO POINT OUT THAT BECAUSE OF POOR INSTALLATION PROCEDURES THE LINER IS ALREADY LEAKING SO IT DID NOT HAVE A LIFETIME OF EVEN ONE YEAR

P. 32:

Leachate Collection Layer: *The leachate collection layer was constructed of a 300 mm thick sand layer built at 2% grade and with perforated leachate collection pipes. As the PEA has been fully encapsulated and will remain fully encapsulated once the new final cover system is constructed, there will be no new precipitation entering the liner, other than minimum quantities of water through any undetected liner defects. Typically, such infiltration is minimal."*

THE SAND BLANKET ON TOP OF THE LLDPE LINER CERTAIN WAS NOT 300 MM IN PEA-1C AS DOCUMENTED PHOTOGRAPHICALLY. FURTHER THE PERFORATED PIPE WAS INSTALLED ONLY ON THE PERIPHERY OF THE LANDFILL. ALSO, MEMBERS OF THE SRG DID DETECT LINER DEFECTS.

FURTHER ROWE WRITES (P. 6):
As a generalization, leachate drainage layers should have [6]: (i) a coarse relatively uniform gravel layer at least 0.3 m thick; (ii) perforated leachate collection pipes at a regular spacing within the drainage layer itself and the pipe should be such that they can be accessed for inspection and cleaning on a regular basis; (iii) a continuous (usually geotextile) filter/separator above the main drainage gravel layer (but NOT around the pipes [6]); and, (iv) a means of managing any significant perching of leachate above the filter/separator.

THERE WAS NO GRAVEL DRAINAGE LAYER IN THE LEACHATE COLLECTION SYSTEM.

ROWE ALSO WRITES (P. 9):
Significant damage to GCLs and geomembranes has occurred after the drainage layer has been placed because the equipment operating on top of the drainage layer was too heavy.

LARGE EQUIPMENT WAS OPERATING ON TOP OF THE SAND DRAINAGE BLANKET INCLUDING EXCAVATORS AND DUMP TRUCKS.

ROWE ALSO WRITES (P. 6):
Leachate collection systems for MSW landfills must be designed to manage the expected leachate flow in both the short-term (during landfilling) and long-term (post closure). While the actual volume of leachate to be managed is an important consideration it is also the most obvious consideration. Less obvious, although well known for the last 30 years, is the potential impact of biologically induced clogging of the leachate collection system [6-9], [25], [28], [29]. Probably more than any other component of the barrier system, there are right and wrong ways to design a leachate collection system. However, the required design can also be extremely sensitive to the nature of the waste, the thickness of the waste, and the volume of leachate generated per unit area of the landfill. As a generalization, leachate drainage layers should have [6]: (i) a coarse relatively uniform gravel layer at least 0.3 m thick; (ii) perforated leachate collection pipes at a regular spacing within the drainage layer itself and the pipe should be such that they can be accessed for inspection and cleaning on a regular basis; (iii) a continuous (usually geotextile) filter/separator above the main drainage gravel layer (but NOT around the pipes [6]); and, (iv) a means of managing any significant perching of leachate above the filter/separator. The pipe spacing and actual thickness and grading of the gravel will be project specific depending on a number of factors including the size of the landfill, the waste, the leachate characteristics entering the pipe, climate etc. Geonets, geocomposite drainage layers,

and sand are generally not suitable as a drainage layer since in general they will not provide an adequate service life, although there can be some special cases where they can be suitable provided that the case is supported by appropriate data and modelling (e.g., [9], [30-32]). There are sophisticated techniques that can be used for assessing the likely performance of a drainage system [33], although the model is complex and requires an expert user. Rowe and Yu [34] developed a practical method for engineering design that was calibrated against typical North American MSW leachate but may not be suitable for other areas with much different waste streams (e.g., China) and leachate characteristics. The more sophisticated model could be used to develop a similar practical method for other waste streams if sufficient field data were available to do the calibration. With the forgoing as background some of the most common errors in design of which the author is aware are discussed below.

SHA DID NOT ADDRESS POTENTIAL CLOGGING OF THE SAND BLANKET LEAKAGE COLLECTION SYSTEM.

P. 31:

Currently, the amount of seepage being collected daily is averaging about 500 L/day. Over the approximately 1 Ha landfill footprint, this translates to a seepage rate of 1.8 cm/year.

SIRM PREVIOUSLY INFORMED THE MINISTRY THAT THE LEACHATE WAS PRODUCED AT 50 L/DAY. THIS IS YET ANOTHER EXAMPLE OF THE DISINFORMATION ABOUT THE CONTAMINATED SOIL WASTE LANDFILL BEING PROMULGATED BY CHH & SIRM.

P. 32:

A geotextile filter was not installed in the PEA above the sand drainage layer.
Hemmera has raised concerns about this alleged omission. There is no requirement for a filter layer in the 1993 Landfill Criteria. The 2016 LCMSW guidance is for installation of a geotextile filter layer above the drainage blanket, or installation of an engineered graded soil filter.

Based on practical experience with geotextile clogging, SHA's preferred approach to the design of leachate collection systems is to avoid geotextile filter layers and to instead utilize graded soil filters which are less prone to clogging."

HOWEVER, A GEOTEXTILE BLANKET WAS INDICATED IN THE AS-BUILTS AND IS A REQUIREMENT FOR THE 2016 LCMSW GUIDELINES. THIS IS ONE SMALL INDICATOR THAT ONE SHOULD NOT TRUST THE AS-BUILTS. FURTHER, THERE IS NO ENGINEERED GRADED SOIL FILTER.

p. 33:

The pipes will be embedded in 25-50 mm clear round drain rock. The drainage blanket extension will be constructed of 5 – 25 mm clear drain rock isolated from above by a non-woven geotextile filter."

WHY DOES THIS FILTER NOT GET CLOGGED AS ARGUED ABOVE!

Review of Sperling Hanson Associates Final Closure Plan for the CHH Landfill

P. 33:

Leachate collection piping has not been installed in a herringbone fashion within the drainage layer in this case because it was not required in the 1993 Landfill Criteria. The minimum drainage layer requirement in the 1993 Criteria is a 300 mm thick sand drainage layer.

NEVERTHELESS THIS IS NOW A REQUIREMENT.

p. 32:

Furthermore, given that there is no new water entering the PEA there is no opportunity for water to carry the fines into the drainage layer and ultimately into the leachate collection system.

YET TREES WILL BE PLANTED ON TOP OF THE PEA. TREE ROOTS HAVE A REMARKABLE CAPACITY TO OVERCOME BARRIERS. THERE IS NO CONSIDERATION GIVE TO DEFECTS BEING CREATED IN THE COVER LINER BY TREE ROOTS ENABLING WATER TO GET INTO THE PEA.

P. 33:

Furthermore, the 300 mm sand drainage layer has more than enough hydraulic capacity to convey any collected leachate to the landfill toe as the PEA is fully encapsulated with negligible leachate flow."

FIRSTLY, THERE IS NO CONSIDERATION THAT THE SAND DRAINAGE LAYER MAY BE CLOGGED, POSSIBLY EXPLAINING THE DECREASE IN LEACHATE COLLECTION. THERE HAS BEEN NO INVESTIGATION WHETHER THE DRAINAGE SYSTEM IS WORKING.

P. 37:

Provide QP opinion and sign off on the adequacy of the existing cover liner thickness and type (40mil LLDPE smooth non-textured) relative to the use of textured geomembrane or geocomposite equivalent to a 600 mm barrier layer with hydraulic conductivity equal to or less than $1x10^{-7}$ cm/sec as specified in the LCMSW.

THE CURRENT COVER IS ACTUALLY 35 MIL, NOT 40 MIL! THE THICKNESS OF A LINER IS DICTATED BY THE MINIMAL THICKNESS.

P. 38:

The purpose of final closure of any landfill is to put in place the necessary environmental control systems to effectively manage leachate, surface water and landfill gas (not present in this case).

NO GAS IS AN UNWARRENTED ASSUMPTION – THE DREDGEATE HAS LOTS OF ORGANIC MATERIAL THAT SHOULD PRODUCE GAS – IN FACT IN THE DEPTHS OF THE OCEAN THIS ORGANIC MATTER GIVES RISE TO METHANE HYDRATES.

P. 43:

SHA also recommends a 300 mm thick topsoil layer on the slopes to provide flexibility in the type of vegetation implemented long term. An 8 oz non-woven geotextile separation/filter layer will be installed between the topsoil layer and the drainage layer to prevent topsoil particulate from entering the drainage layer. As mentioned previously, the topsoil / vegetative layer should receive hydroseed application directly after installation to promote vegetative growth prior to Fall rain events.

WHY NO CONCERN THAT THIS GEOTEXTILE FILTER WILL CLOG?

P. 67:

The ground surface at the site is an expression of an igneous intrusion of very hard granite bedrock through underlying bedrock known as Wark Gneiss. This hard granite rock, as well as the Wark Gneiss, are the source of materials for the quarry.

THE FACT THAT SOME WELLS HAVE pH OF AROUND 10 INDICATES THERE ARE POCKET OF LIMESTONE AS ALREADY STATED BY LOWEN BUT DISPARAGED BY ACTIVE EARTH ENGINEERING AND THE MINISTRY

P. 68:

Failure scenarios were modeled for both static and seismic (earthquake) conditions for the proposed and existing profiles. The following factors of safety (FOS) for slope failure have been adopted as minimum standards:

- *Static Conditions adjacent to Developed Land and Infrastructure 1.5*
- *Static Conditions adjacent to Undeveloped Land 1.3*
- *Seismic (Earthquake) Loading 1.0*

SUCH LOW FACTORS OF SAFETY ARE NOT REASSURING.

P. 69:

The data indicate that there is no water level mounding acting on the base of the liner, nor is there any perched water table acting within the PEA.

WHAT DATA? THERE ARE NO SUCH DATA.

P. 77:

The MoE may want to revisit whether it is fair and reasonable request to double the post closure period at this time when there is no opportunity to recover those costs, or whether the facility should be grandfathered to a 25 year post closure period.

WITH RESPECT TO FAIRNESS TO THE SHAWNIGAN LAKE RESIDENTS, PERHAPS MoE MIGHT WANT TO REVISIT THE FRAUDULENT BEHAVIOUR DURING THE OBTENTION OF THE PERMIT.

P. 78:

No hazardous waste, liquids, or putrescible material are discharged into the landfill cell.

THEN WHY WAS THE STENCH OFTEN SO OVERWHELMING? THE DREDGEATE CLEARLY CONTAINED PUTRESCIBLE MATERIAL. LEACHATE WAS SOMETIMES DUMPED BACK ONTO THE PEA.

P. 78:

The soils landfilled at the CHL are screened for acceptability by Site staff to ensure the soil is suitable for permanent encapsulation. Unsuitable soils include high debris content or high moisture content and soils that fail verification testing to confirm that the incoming soils are below hazardous waste standards. This screening helps to ensure the soil landfilled in the PEA is essentially inert and considered non-leachable.

THIS MIDDLE STATEMENT IS COMPLETELY NONSENSICAL: DRIPPING WET MATERIAL, OFTEN WITH A PUTRID STENCH, WERE LOADED ONTO THE WASTE PILE.

OTHER PROBLEMS WITH THE CLOSURE PLAN BECOME APPARENT FROM ROWE'S PAPER.

ROWE (P. 11):

Not adequately anchoring/ballasting a placed geomembrane against wind up-lift (Fig. 9). Once up-lifted and folded (e.g., Fig. 9) the geomembrane is compromised and cannot be re-used.

THIS HAPPENED SEVERAL TIMES FOR THE PEA-1C BERM LINER. VIDEO SUBMITTED TO THE MINISTRY AND WE HAVE PHOTOGRAPHS SUBSEQUENT TO THIS WHEN IT HAPPENED SEVERAL TIMES, YET THE GEOMEMBRANE WAS RE-USED.

ROWE (P. 11):

Welding a geomembrane that is not clean and dry at the location of the weld.

WHEN PEA-1B WAS BEING BUILT IT WAS DURING THE RAINY FALL OF 2015. WELDING OF THE BASE LINER COULD NOT HAVE BEEN DONE IN A COMPETENT MANNER. DIRTY MEMBRANE WAS ALSO WELDED DURING THE CONSTRUCTION OF PEA-1C.

ROWE (P. 11):

Covering the geomembrane liner when there are too many wrinkles present (Fig. 10).

THIS WAS DOCUMENTED FOR PEA-1C.

ROWE (P. 12):

While good design and construction are required they are not sufficient, in and of themselves, to ensure good performance. The landfill must also be operated in a manner consistent with the design. A landfill is designed for a given waste stream and mode of operation. If the waste stream or mode of operation is changed, then the design may no *longer be appropriate. Examples of changes that can cause problems include: (i) disposing of liquids (even if they are not hazardous) in a landfill designed for MSW; (ii) accepting reactive waste (e.g., combustion ash or aluminum production waste [53]) into a landfill* designed for MSW; (iii) recirculation of leachate (e.g., for operation of a landfill as a bioreactor) when it was not so designed. … The addition of liquids to the waste (including recirculation of leachate) in a manner not anticipated in the design has resulted in a number of significant stability problems and failures.

LEACHATE WAS RECIRCULATED BACK ONTO THE PEA - WE HAVE PHOTOS AND VIDEOS DOCUMENTATING THIS. FURTHER, COMPONENTS FROM A TANKER LABELLED FLY ASH WERE ADDED.

Evidence that Cell-1C is Compromised

Dave Hutchinson June 8, 2017

Reference is made to a 2016 paper authored by Dr. Kerry Rowe:
"Recent Insights regarding the Design and Construction of Modern MSW Landfills"

Rowe is noted as a leading expert in landfill design and one of the pioneers of geosynthetics:
https://en.wikipedia.org/wiki/R._Kerry_Rowe

Rowe - Figure 9 - Geomembrane that had been picked up and moved by the wind.

"Once up-lifted and folded the geomembrane is compromised and cannot be re-used."

The images below show a portion of the base liner for Cell-1C which was uplifted and folded.

According to Rowe, this liner is compromised and should not have been used.

The SHA “Final Closure Plan” assumes there are no problems with the base liner apart from the choice of material:
“*double textured geomembrane is much preferred and would have been selected by SHA*”

SHA does not question or verify declarations from Active Earth, SIRM and CHH, all who were in a conflict of interest.
Much of the report relies on statements provided by others.

Rowe - Figure 10 - Wrinkles in a geomembrane

"Common problems associated with the installation include covering the geomembrane liner when there are too many wrinkles present"

The image below shows the base liner for Cell-1C being covered with many wrinkles.

According to Rowe (and others), this does not bode well for future performance:

[10]. S. Gudina and R. Brachman, "Physical response of geomembrane wrinkles overlying compacted clay". Journal of Geotechnical and Geoenvironmental Engineering, 132(10): p. 1346-1353, 2006.
[11]. R. W. I. Brachman and S. Gudina, "Geomembrane strains from coarse gravel and wrinkles in a GM/GCL composite liner". Geotextiles and Geomembranes, 26(6): p. 488-497, 2008.
[12]. S. Gudina and R. Brachman, "Geomembrane strains from wrinkle deformations". Geotextiles and Geomembranes, 29(2): p. 181-189, 2011.

EURASIA 2016 WASTE MANAGEMENT SYMPOSIUM

Recent Insights regarding the Design and Construction of Modern MSW Landfills

***R. Kerry Rowe*[1]**

Abstract

The past 30 years have seen very substantial advances in the understanding of how municipal solid waste landfills work as a system and the interactions between the system components. This paper highlights some of these advances with an emphasis on the barrier system. It highlights examples of poor design practice that all too commonly lead to landfill problems. It then examines some common mistakes made in the construction of modern MSW landfills. The paper emphases that while good design and construction are necessary, they are not sufficient. The landfill must also be operated in accordance with the design and while this may seem obvious, many of the most egregious problems and failures can be associated with operations that could quite predicable have been expected to result in a failure but were not understood by those operating the facility. It is concluded that modern landfill can be very effective at containing leachate and landfill gas, but to do so those responsible for design, construction, operations, and closure need to keep up-to-date with advances in available materials and our current understanding of how the barrier system can be best designed and constructed.

Keywords: Construction, Design, Liners, Municipal solid waste landfills, Geosynthetics

1. INTRODUCTION

Landfills and the barrier systems for municipal solid waste (MSW) landfills are now highly regulated in many parts of the world. The quality of regulations, and the level of guidance and technical justification for those regulations, varies substantially from one jurisdiction to another. Some regulations are very prescriptive, while others provided considerable flexibility. Unfortunately, many regulations are quite old (pre-2000) and have not kept pace with advances in materials, changes in waste stream, our current understanding of landfill systems. In 1995, Estrin and Rowe [1] discussed the advantages and limitations of prescriptive regulations and observed that "… prescriptive design may create a situation where for one landfill, the design may be overly conservative while for a second landfill the design may provide no assurance that the long term potential impact of the landfill will be negligible." This is as true today as it was some 20 years ago. Very few regulations provide both rationally based prescriptive regulations combined with flexibility for site specific design that must demonstrate (through modelling) that contaminant impact on any receptor will be below regulatory limits (i.e., will be negligible) for the contaminating lifespan of the landfill. A notable exception in this regard is Ontario Canada's landfill guidelines [2]; however, while these guidelines also offer an excellent list of factors that should be considered in design and construction they provided limited advice, and it is left to the designer and the regulator to ensure that appropriate procedures are followed. It also heavily reflects the fact that it was written in about 1995 and has not been significantly updated in the last 20 years. Unfortunately, it is often not until there is a major problem that regulations are updated. In 2008, hundreds of residents were evacuated from homes around the Cranbourne landfill (Melbourne, Victoria, Australia) due to high methane gas levels detected in some homes a few years after the landfill was closed [3]. This is an excellent example of how problems such as some of those highlighted in this paper can have very unfortunate and expensive consequences. The one positive

[1] Corresponding author: GeoEngineering Centre at Queen's-RMC, Queen's University, Ellis Hall, Kingston ON, Canada K7L 3N6. E-mail: kerry.rowe@queensu.ca

aspect of this case was that it resulted in a substantial updating of Victoria's landfill regulations with the release of a fairly modern regulatory framework in 2010 [4].

While good updated regulations are a starting point for good landfill siting, design, construction and operations/management, they are just that – a starting point. Also essential is good siting, design and construction and operations/management! This implies that the professionals involved understand what they are doing and exercise their responsibilities. Unfortunately, in the author's personal experience reviewing landfill documentation and problems, and based on input from a number of experienced regulators from three continents, often landfills are being designed, constructed, and in some cases operated by people with an inadequate understanding of what is required. Certainly, that appears to have been the case with respect to the Cranbourne Landfilled site cited earlier [5].

The objective of this paper is to highlight some common mistakes made in the design and construction of modern MSW landfills that have been identified by peer reviewers and regulators or as part of a forensic investigation after a failure. The discussion will place particular emphasis on barrier system used below the waste but many of the comments also apply the cover/capping system used above the waste. The mistakes identified herein can be detected by a good peer reviewer or regulator. However, they are sufficiently common that their documentation is considered useful to provide a check list of some things to watch for in the design and construction of modern landfills.

2. COMMON COMPONENTS OF LANDFILL BARRIER SYSTEMS

Modern barrier systems used above the waste and below the waste commonly have two basic components [6]: low permeability liner(s) and drainage layer(s). The low permeability liner is to resist both advective and diffusive transport through the liner (typically contaminants in leachate for the bottom liner and also in the landfill gas in both bottom lines and cover/caps). It also controls the percolation into the waste in a cover/cap. The drainage layer is intended primarily to control the pore pressure above a liner (and sometimes the gas pressure below the liner in a cover/cap). Thus it controls the gradient inducing advective transport (flow) through the liner. To do so, in the bottom of a landfill it collects leachate for treatment and allows monitoring of the leachate volume. For a secondary collection system, it also allows monitoring of leakage through the primary liner.

Drainage layers may be gravel, sand or a geonet/geocomposite. Typically, a leachate collection system will be comprised of a continuous layer of drainage gravel and a network of leachate collection pipes leading to a drainage point (sump). The design of these systems needs to consider the amount of fluid that must be transmitted (demand) and the flow capacity of the drainage layer. Failures may arise due to inadequate assessment of either demand or capacity. Particularly challenging in MSW design is the change in the hydraulic conductivity, and hence the transmissivity or capacity, of the primary leachate drainage layer with time due to biologically induced clogging (e.g., [6-9]). The primary drainage layer is normally separated from the adjacent soil or waste by a suitable geotextile separator/filter. For example, Figure 1 shows the bottom liner of a new landfill cell being constructed adjacent to an existing cell. Shown in the photo are (from the bottom of the photo to the top): multiple layers of coarse gravel (D_{100} = 50 mm; D_{50}=38 mm, D_{10}=25 mm, D_0=19 mm) starting with a 0.3 m thick lower (secondary) leachate collection layer on a natural clayey aquitard; a sewn needle-punched nonwoven (lower) geotextile separator overlain by a 1.2 m thick compacted clay liner (CCL) with a hydraulic conductivity $k < 2x10^{-10}$ m/s; a sewn needle-punched nonwoven (upper) geotextile separator; overlain by gravel 0.45 m-thick at the pipe (not visible here) to 0.15m-thick at the crest of the drainage divide located midway between the leachate collection pipes at 20 m spacing; a sewn needle-punched nonwoven (upper) geotextile filter; and finally a 0.15 m-thick gravel layer upon which select waste is placed.

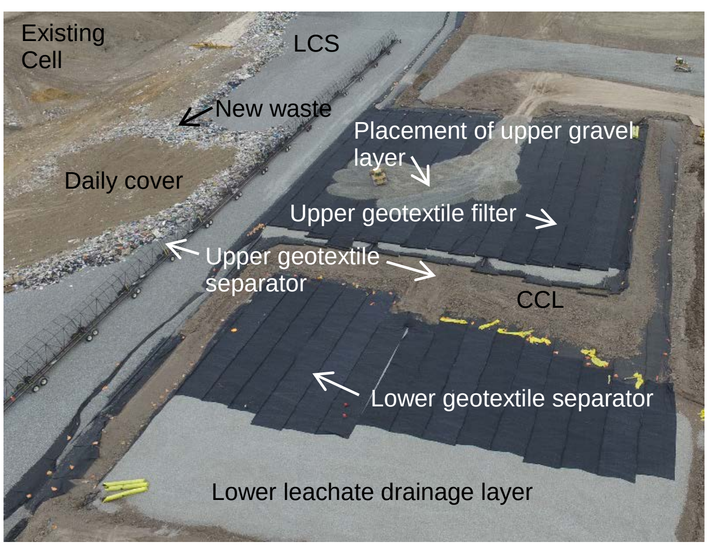


Figure 1. Construction of a multi-layered MSW landfill barrier system

Liners may be a natural low permeability aquitard, a compacted clay liner (CCL, $k < 1x10^{-9}$ m/s), or a composite liner comprised of a geomembrane (usually high density polypropylene, HDPE with a thickness of 1.5 - 3 mm) over either a compacted clay liner or a geosynthetic clay liner [6]. Depending on landfill size, jurisdiction, waste type, and mode of landfill operation there may be a single liner or a double liner with a leak detection (also known as a secondary leachate collection) layer between the two liners. A critical, and often overlooked, aspect of the design of a system with a geomembrane is the protection layer between the drainage layer and the geomembrane. This is critical not only for minimizing the risk of puncture in the short term (i.e., during construction and subsequent placement of the waste), but also to ensuring an adequate service life of the geomembrane [10-14]. Likewise, care needs to be taken with any compacted clay liner below the geomembrane to ensure the CCL does not have stones that will induce either punctures or excessive strains in the geomembrane.

A landfill cover system controls both the ingress of water (which generates leachate) and the egress of landfill gas. The cover may include, from the top down, a vegetative layer, a protective soil layer, a geotextile filter/separator, a drainage layer, a geotextile protection layer (where needed), the liner (CCL, GCL or composite liner), a gas collection layer, and a foundation layer above the waste.

A landfill should not be designed or constructed without a good understanding of the local geology, hydrogeology, and geotechnical conditions. The bottom barrier system (i.e., below the waste) should be designed to take account of and, where possible, advantage of those conditions. Some sites may be particularly well suited to a landfill designed and operated as a hydraulic trap (e.g., [6], [15]), while others may not. Requirements with respect to siting can vary substantially depending on local geological, hydrogeological and geotechnical conditions. Some examples are given below.

In some areas the continuously saturated zone may be well below the bottom of the landfill. If the soil profile involves a lower permeability layer (and/or a perched water level) over a more permeable unsaturated layer then very careful consideration should be given to diffusion of methane and volatile organic compounds (VOCs) in the leachate through the bottom liner and then into the unsaturated zone. Once in the unsaturated zone methane can migrate laterally and potentially migrate into structures well away from the site while VOCs can quickly migrate (in a gaseous phase) and then repartition in to the aqueous phase contaminating groundwater even where there is no physical leakage of leachate.

Some jurisdictions (e.g., Victoria, Australia) have some specific criteria that a landfill should have a minimum of 2 m separation between waste and the long-term groundwater level. Thus, in locations with a high water table, it may be necessary to lower the groundwater below the landfill by use of wells or by installing a separate lower granular layer at the bottom of the liner system (at ≥ 2 m below the waste level) and operate this as a groundwater extraction layer. However, in other jurisdictions (e.g., Ontario, Canada) the same hydrogeological conditions could be seen as an opportunity to enhance the design by operating the site as a hydraulic containment site wherein water flow is induced (at a low rate controlled by the groundwater level, leachate level and liner) into the landfill and in so doing minimizes the risk of outward advection (leakage) while also resisting outward diffusion [6], [15]. In any case where the water table or potentiometric surface in an underlying aquifer is above the elevation of the lowest point of excavation for the landfill, consideration must be given to potential piping and basal heave. While not often considered, hydrofracturing should also be considered. For a low permeability natural clay aquitard, basal stability can be managed by controlling the size of the excavation (taking into account the shear strength that can be developed around the perimeter of a potential failure zone), but then hydrofracturing may become the critical failure mechanism. For example, Rowe and Mabrouk [16] report a case where hydrofracturing occurred through an approximately 14 m thick low permeability aquitard below the bottom of a landfill cell in the absence of any significant basal heave.

3. SOME COMMON MISTAKES IN LANDFILL DESIGN

3.1. Poor design

Some examples of poor practice that all too commonly lead to problems with landfills include:

(1) Designer ignorance of regulatory requirements: Some designers see a prescriptive regulation as being an arrangement of barrier system components to copy into design drawings without: (i) appreciating the reasoning for the materials and their arrangement, (ii) having an understanding of the entire regulation, (iii) understanding the conditions under which the generic designs can be used (e.g., waste stream classification in South Africa [17] or size of landfill in Ontario [2]), or (iv) understanding what represents allowable alternative materials. This lack of understanding and inability to judge the associated performance can be particularly apparent when proposing alternative systems (e.g., replacing an aggregate in a leachate collection system with a geocomposite drain).

(2) Cut and paste designs: It is not unusual to see a design that was used on one project being adopted at another site for another project without adequate consideration being given of the differences between the sites and landfills. These difference may include, inter alia: (i) the type of waste (for example a design suitable for the typical North American MSW waste stream may be totally inadequate for a waste stream in say Egypt or China which has a much higher organic component); (ii) geology, hydrogeology, and geotechnical setting; (iii) the size of the landfill (especially thickness of waste); and (iv) nature, sensitivity, and proximity to receptors.

(3) Cut and paste specifications: Recognizing the evolving availability of materials relevant to landfill design and the differences in designs related to factors such as those cited in (1) above, it is critical that designers check that they are using up-to-date specifications relevant to the specific conditions of their design (don't just recycle specifications over and over on projects).

(4) Inadequate knowledge of materials being used: Geosynthetics are often proposed in designs and, if designed appropriately, they can be very effective. However, too often the designer specifying a particular material has no experience in designing, selecting, and using these materials. Too often they are asking the materials suppliers what to use – however suppliers are suppliers not designers. They cannot, and should not, be expected to be familiar with the subtleties of a particular design which would dictate the choice of a given material or, often more importantly, the combination of materials that form a system. The result of an inadequate understanding and reliance on supplier advice/direction to adopt a particular product or product combination can vary from amusing to disastrous. One recent example, involved the specification of a white coextruded geomembrane covered with a thick geotextile protection layer held down by sand bags without the designer appreciating that the geotextile was particularly prone to UV degradation and could not be left for prolonged exposure without damage or that the geotextile would attract more heat than the white geomembrane and would not only not reduce wrinkles but may actually increase wrinkles under those particular exposure conditions. Another example, involved Supplier A persuading the designers to specify a particular geomembrane (indeed a good and suitable product) which the designer targeted with a particular specification modelled on the product data sheet with emphasis on asperity height. The client then purchased the material by public tender using the designer specification and obtained a product from another country (Supplier B) which met the specification as provided but was of far inferior quality that the product the designer has intended (but not adequately specified) manifest by separation of the textured layer.

(5) Inadequate understanding of the interactions between components of a landfill as a system: As discussed by Rowe [18], there is a need to adopt a systems engineering approach to the design and operation of municipal solid waste landfills. For example, the mode of landfill operation may impact on the design of the barrier system. The design of the leachate collection system may impact the design of the liner, and the interactions between the different components of the system must be considered during design (see [18] for more detail). In a recent example, a designer replaced the prescribed liner system by a liner system, thought by the designer to be equivalent to the standard system, by a thin leachate collection system above an inadequate protection layer over a geocomposite liner (geomembrane plus GCL) directly over a blanket drain but failed to recognize that the capillary break due to the underlying blanket drain prevented prehydration of the GCL before it came into contact with an aggressive MSW leachate, leading to a loss in composite liner performance. This was also an example where poor operations involving storing leachate within the waste cell aggravated the situation.

(6) Designing for phased construction: When designing for implementation/construction in phases, either laterally or vertically, the designer often fails to adequately attend to the detail of the tie in between extensions and lifts. It is extremely easy to make onsite mistakes when waste covers the end of a component so that it is not patently obvious that the tie in of either the liner or the drainage should be continuous. A recent example involved the vertical development of a landfill where once the "floor" area and starter walls were covered with waste, the next phase or lift was to continue with a piggy back liner over historic waste on one side - and the designer and supervisor forgot to install the leachate collection system. This mistake was overlooked by the owner, operator, contractor and designer and it was left to the regulator to discover the error during a site visit.

(7) Terms of reference for peer review: A peer reviewer needs to be able to peer review the entire designer with complete freedom and not be restricted to one aspect of the design (without an appreciation of how that component fits into the system and the full context of environment in which that aspect of the design must perform). A restricted, or worse, misleading terms of reference may negate the value of the peer review even by a very competent peer reviewer. For example, one hazardous waste facility had a double composite liner proposed that not suitable for the waste stream nor temperature of waste. The consultant (in conflict with the regulator) convinced the client/facility owner to have an expert peer review and then defined terms of reference that claimed that a barrier is was allowed to have an average seepage rate of $1x\ 10^{-9}$ m/s which is false for a composite liner - the regulatory standard was that the clay component of a composite liner may not have a hydraulic conductivity greater than $1x10^{-9}$ m/s.

(8) Inadequate consideration of failure mechanisms and testing: The designer should consider all reasonable failure mechanism. For example, the potential for unconsolidated undrained conditions in the clay liner component of a composite liner is often overlooked but can have significant influence on interface shear strength and result in failures such as that in Limpopo, RSA [19].

(9) Inadequate consideration of intrusion in testing and evaluation of composite drains: The entire system in which the drain is to be incorporated must be considered. For example, the composite filter concept used to augment steep slope drainage can be problematic when designers look at individual components (geotextile and spacer) rather than looking at the combined effect. In the case of the HC Landfill RSA the side slope drainage was inadequate and the designer proposed increasing capacity by including a drainage spacer between the geomembrane and geotextile. Testing by the regulator showed that the design assumption of cumulative transmissivity was quiet wrong and that the spacer performance was substantially less than the product data sheet advised [20].

3.2. Site evaluation and consideration of extreme events

Basic site considerations, which are still sometimes overlooked, include not locating a MSW landfill near an airport, in a flood plain, or on unstable ground. Landfill design should include consideration of "extreme" events such as major storms and, where appropriate, earthquakes. In the context of climate change, it should be remembered that storms that have a long return-period, such as 1 in 200 years, are occurring far more frequently than would be expected based on the historic return period.

3.3. Modelling

Given the importance of geological, hydrogeological and geotechnical considerations to overall performance, designs should be conducted in the context of these factors. The use of a fully engineered barrier system does not remove the need to consider these factors. In landfills with steep sidewalls or slopes, particular consideration needs to be given to the stability of the site at all stages during the process of construction, landfilling and after final closure. This applies to both new landfills but equally to the expansion of a landfill either horizontally or vertically. Modelling can play an important role in the understanding of the interactions between the proposed design and the natural system both in terms of the flows that must be managed (i.e., groundwater, storm water, leachate, and landfill gas) and landfill stability. Today there are many computer programs that can be used for modelling (i) groundwater flow, (ii) leachate generation, (iii) contaminant transport through barrier systems and impact on adjacent groundwater, and (iv) basal and slope stability. Problems are generally not due to the software itself but due to users/designers who do not fully understand the limitations of the software or what is required to use the software to obtain meaningful results. Some common problems with groundwater modelling include:

- Failure to understand and/or carefully think through and/or check the input to a model. Inappropriate/wrong input results in wrong output ("garbage in, garbage out") that leads to bad design.
- Failure to calibrate the model to existing conditions before modelling a new landfill or a landfill expansion
- Failure to check the model boundary conditions to ensure they are consistent with observed conditions (e.g., the location potentiometric surface in an underlying aquifer and the elevation of the top of the aquifer).
- Failure to consider the purpose of the modeling and select an appropriate model based on those considerations.
- Failure to allocate sufficient resources (man power and financial) to construct and calibrate the model, and complete sufficient model simulations.
- Failure to understand the limitations of the model, account for these limitations in the design, and communicate these to clients and the public.

It is common to use the Hydrologic Evaluation of Landfill Performance (HELP) [21] Model for estimating leachate generation. Used correctly it can provide useful results for this purpose. However, it is also frequently used in two problematic ways. The first is the use of the HELP model to calculate leakage through a composite liner with a geomembrane. The common use of HELP only considers the number of holes per hectare and does not consider the effect of wrinkles [12], [22-24]] which will dominate the magnitude of leakage in both a cover and bottom liner [25], [26]. Alternative techniques should be used for modelling leakage through a composite liner [22]. Second is the use of the HELP model to design the capacity of drains (e.g., in a landfill cover) above a composite liner where the numbers people usually calculate may be a reasonable average value but can grossly underestimate the drainage capacity needed in a heavy rainfall event. It is this event that will cause a cover failure. Furthermore, these drains should be designed based on the weathered hydraulic conductivity of the soil above the drain under at least a unit gradient since this will control the capacity needed in a severe rainfall event.

The stability of the system (e.g., geomembranes, geotextiles, CCLs, drainage system, and nature soils) is an obvious consideration; however, there is an unfortunate tendency for designers to rely on guidance/instruction from the manufacturer/installer without doing basic checks. Checking for an adequate factor of safety against failure during construction, the various stages of landfilling, and after landfill closure is an essential part of the design and is the designer's (not the manufacture's or installer's) responsibility. Even when calculations are performed, mistakes often arise when using geosynthetics due to not considering realistic interface strength both in the short-term and long-term. Testing is required to get short-term strength data and it is essential that this testing be over the full range of stress conditions expected in the field. Also, if testing is done for one product combination it cannot be assumed that the interface strength would be the same if one or more of the products change. For example, different geomembranes may have different asperity heights or different ways of inducing roughness of the surface that can results in quite different short-term and, potentially, long-term interface properties. Also two GCLs may have the same hydraulic conductivity but substantially different interface characteristics depending on how they are constructed/manufactured. Thus, a design based on testing and specifying one combination of materials may result in a safe design. However, the substitution of even just one alternative material to that specified may result in the design becoming unsafe, unless the change is supported by similar testing and evaluation. The failure envelope of some interfaces may be highly nonlinear. For example, some may have a high interface friction angle at low stress but much lower resistance at higher stresses. Indeed, there can, in some cases, be a failure of some material in shear at high stress. Very careful consideration must be given to what is a reasonable long-term interface strength when that strength relies on either protrusions (e.g., plastic spikes on a geomembrane) or a bond between two components of a material (especially if the bond is due to an adhesive) to provide sufficient interface strength. In considering interface strength, very careful consideration must be given to pore pressures that could reasonably develop at the interface in the very short-term (e.g., a storm event), short-term (e.g., during construction and landfilling), and longer-term (after closure). There are many good papers on interface strength, a particularly relevant one dealing with the strength of GCLs and GCL interfaces is Fox and Stark[27].

Landfill expansion is a topic that requires a paper on its own. Suffice it here to observe that it is especially critical to consider the factors discussed above, and many others, when analyzing the effect of an expansion on stability. A perfectly satisfactory design for the original landfill may have problematic interfaces when there is an expansion which substantially increases the stresses on interfaces (especially those involving geosynthetics). Keep in mind that: (i) the original design interface properties may not be relevant to the higher stresses; (ii) the materials used may not be able to sustain the higher stresses in the long-term; and (iii) the interface strength parameters may degrade with time.

3.4. Leachate collection systems

Leachate collection systems for MSW landfills must be designed to manage the expected leachate flow in both the short-term (during landfilling) and long-term (post closure). While the actual volume of leachate to be managed is an important consideration it is also the most obvious consideration. Less obvious, although well known for the last 30 years, is the potential impact of biologically induced clogging of the leachate collection system [6-9], [25], [28], [29]. Probably more than any other component of the barrier system, there are right and wrong ways to design a leachate collection system. However, the required design can also be extremely sensitive to the nature of the waste, the thickness of the waste, and the volume of leachate generated per unit area of the landfill. As a generalization, leachate drainage layers should have [6]: (i) a coarse relatively uniform gravel layer at least 0.3 m thick; (ii) perforated leachate collection pipes at a regular spacing within the drainage layer itself and the pipe should be such that they can be accessed for inspection and cleaning on a regular basis; (iii) a continuous (usually geotextile) filter/separator above the main drainage gravel layer (but NOT around the pipes [6]); and, (iv) a means of managing any significant perching of leachate above the filter/separator. The pipe spacing and actual thickness and grading of the gravel will be project specific depending on a number of factors including the size of the landfill, the waste, the leachate characteristics entering the pipe, climate etc. Geonets, geocomposite drainage layers, and sand are generally not suitable as a drainage layer since in general they will not provide an adequate service life, although there can be some special cases where they can be suitable provided that the case is supported by appropriate data and modelling (e.g., [9], [30-32]). There are sophisticated techniques that can be used for assessing the likely performance of a drainage system [33], although the model is complex and requires an expert user. Rowe and Yu [34] developed a practical method for engineering design that was calibrated against typical North American MSW leachate but may not be suitable for other areas with much different waste streams (e.g., China) and leachate characteristics. The more sophisticated model could be used to develop a similar practical method for other waste streams if sufficient field data were available to do the calibration. With the forgoing as background some of the most common errors in design of which the author is aware are discussed below.

Drainage layers should have leachate collection pipes (at a regular spacing) that can be inspected and cleaned. Generally, the longer the drainage path to the pipes, the greater the potential problems (other things being equal). Particularly problematic designs involve just strips of granular drainage material (sometimes called French drains or finger drains) leading to a perimeter leachate collection pipe or sump [35]. Generally, placing the pipes in excavated trenches below a drainage layer should also be avoided [35]. It has been known for decades that these designs lead to significant problems but sufficient time has elapsed for people to forget the lessons of the past and they are now repeating the old mistakes.

Generally, it should not be assumed that the leachate being collected is the same as the leachate entering the leachate collection system. With the possible exception of very early in the operation of a landfill cell (i.e., before the development of a significant biofilm on the geotextile or granular filter, drainage media, or pipes) the leachate collected is significantly different from that entering the system. This is because, once a biofilm has developed, the biologically induced process occurring in the leachate collection system can substantially change the leachate within a distance of less than 1m [36] and even more with a longer drainage path to the collection point [32].

Designers are often quick to adopt new geosynthetic products, or new applications, without doing checks/research into either the suitability, or long-term performance of the product. This is particularly true for geocomposites proposed for the drainage layers. While they may be suitable for many applications involving relatively clean water, they should not be considered suitable as the primary drainage layer for a primary leachate collection system unless supported by testing with realistic leachate (leachate collected from a sump is generally NOT suitable - see previous paragraph) at a realistic temperature for a landfill leachate collection system (typically 27-40^{o}C for normal MSW landfill) or calibrated modelling shows that it will provide an adequate service life allowing for biologically induced clogging. While there may be considerable short-term cost savings in replacing a gravel drainage layer below waste with a geocomposite or geonet this will be greatly outweighed by the potential cost of managing a leachate problem in the long-term. Means of controlling the leachate head after a drainage layer has failed, such as leachate extraction wells drilled into the waste, tend to be difficult to maintain and expensive since a large number of wells are usually needed [37]. This is rarely considered by those specifying the replacement.

Project specific factors that often received inadequate consideration include:

- The spacing between leachate collection pipes (which impacts the service life of the system)[2], [8].
- The grades (slopes) of the base, compacted clay layer, leachate drainage layer etc.

- The location of the leachate sumps (generally dedicated sumps should be provided for all new cells).
- The provision of adequate access for video inspection of all pipes and cleaning of all pipes (including a suitable spacing of access points to pipes to allow cleaning of the entire pipe length).
- The method(s) of pumping out leachate from the sump.
- The specifications for the sidewall drainage layer material (a geocomposite drainage material may be suitable in this location is some cases) and the time of placement of this layer (note the problems with leaving a CCL, GCL or composite liner exposed for a prolonged period discussed later in this paper).
- Geotextiles used in the landfill should have adequate tear and puncture strength to have adequate survivability and geotextile seams should be sewn (overlaps and heat-tacked overlaps are not adequate since they tend to open up with the movement of equipment above the layer over the geotextile (e.g., [38]; Figure 2).
- The adequacy of the leachate management system (including the size and design of any leachate pond or holding tank). Capacity calculations should consider the nature of the waste (some waste streams generate large amounts of leachate even in an arid environment), extreme rainfall events, and the adequacy of the free board available in the leachate pond etc. Also the capacity of the treatment facility must be adequate to manage the likely peak volumes and not just an average flow. A landfill should not be used as a leachate storage facility.

Figure 2. Geotextile (GTX) above a secondary leachate collection layer that had been overlapped by 450 mm opened to a maximum of 460 mm due to equipment movement on the overlying layer

3.5. Liners

3.5.1. Compacted clay liners (CCL)

Compacted clay liners have been used in landfills for several decades and much is known about the requirements to obtain a good clay liner (e.g., [6], [39], [40]) dating fifty years back to the classic paper by Mitchell et al. [41]. That said, there are still problems with the design and specification of CCLs today. The most common are a failure of designer to:

- Consider the clay mineralogy and potential for clay-leachate interaction affecting the hydraulic conductivity.
- Specify an appropriate minimum plastic index and minimum percent clay.
- Specify a maximum gravel content (note: this can be especially problematic if the CCL will be covered with a geomembrane).
- Specify lower and upper limits on compaction water content.
- Specify minimum mass of compactor and the need for a kneading compactor (e.g., pad foot).
- Specify compactor foot length exceeding compacted layer thickness (usually need > 150 mm) [38].
- Require prevention of desiccation of compacted clay liners and specify steps that must be taken to meet this requirement.
- Specify covering of the CCL with a suitable insulating layer (usually waste) before it can freeze and identifying steps that must be taken to meet this requirement.

3.5.2. Geosynthetic clay liners (GCL)

Geosynthetic clay liners have many advantages over CCLs and perform very well when appropriately selected, installed, and protected. However, it is important that the designer understands that there are many different GCLs and a similarity in the initial off-the-roll hydraulic conductivity of the GCL with respect to uncontaminated water does not mean they will perform similarly in the field. While having an adequate off-the-roll hydraulic conductivity (typically < $5x10^{-11}$ m/s) is a desirable requirement, this is not the hydraulic conductivity that will generally be mobilized in the field. To perform as designed a GCL generally needs to be adequately hydrated before coming into contact with leachate, and to be protected from desiccation and freezing. Consideration needs to be given to many factors in the design and specification of a GCL either as part of a composite bottom liner or in a cover/cap. Factors that are often overlooked in the design and specifications include:

- Failure to adequately specify that the ground must be sound, relatively uniform (no ruts) and not likely to damage the GCL (e.g., limit of number/size of stones in the subgrade).
- Failure to consider the potential for hydration of a GCL based on the grain size, water content and mineralogy of the soil upon which the GCL is to be placed, and the type of GCL (e.g., [42]).
- Failure to design based on the hydraulic conductivity likely to be mobilized in the field (taking account of hydration, clay-leachate interaction, and applied stress).
- Specifying the use of a coated /laminated GCL without considering whether the coating is to be placed facing up or down. Which way the GCL faces will depend on the intended purpose of the coating. The most common are: (a) to prevent downslope bentonite erosion in composite liners that will be left exposed for some time or to minimize root penetration in applications without a geomembrane – the coating faces up in these cases; (b) to minimize cation exchange effects from a cation rich subsoil or underlying waste – the coating faces down in these cases. Some designers do not even think about why they are using a coating – they use it because "it will help". Yes it can, but how needs to be considered to get best effect. On one recent cover project the contractor (who was given no direction from the designer) randomly placed coating up in some locations and down in other locations depending on whim.
- Specifying the use of geomembrane textured on one side only and not clearly indicating which way the geomembrane is to be placed (texture up or down).
- Failure to specify timely covering of a GCL or composite liner containing a GCL (discussed more in §4.2).

3.5.3. Geomembrane liners (GMB)

Geomembranes, like all materials used in civil engineering, require adequate specifications. Unless there is a regulatory requirement requiring otherwise (e.g., [BEPM 2010]), smooth 1.5 mm HDPE meeting the requirements for GRI-GM13 (2014) can be expected to have a service life in excess of 150 years [MOE 2012] provided that: (i) it is only exposed to normal MSW leachate; (ii) the geomembrane is adequately protected from tensile strains in excess of 5%; and (iii) the liner temperature does not exceed 40^{o}C. The last two points are often overlooked.

The long-term performance of a liner system for a landfill, and especially the geomembrane component, is highly dependent on temperature [25], [26]. The service life of a properly protected geomembrane sheet decreases rapidly from > 150 years at 40^{o}C, to decades at 60^{o}C, to only a few years at 85^{o}C [14]. Temperature becomes even more critical if the geomembrane protection layer is not adequate. For example, a typical geotextile with a mass per unit area of around 600 g/m^2 alone (as is often used in North America) is NOT suitable for protecting the geomembrane from coarse gravel (e.g., that required by [2]). A sand (no gravel) protection layer with a geotextile separator between the sand protection and the gravel drainage layer is best (e.g., [43]), even if adding the sand would mean an increased head on the liner. A geocomposite should not be used as a protection layer at the bottom of a landfill unless tests confirm that the long-term strains induced in the geomembrane are likely to be less than 5% at the anticipated stress level for the proposed foundation, geomembrane and geocomposite.

Essentially all the research into the long-term performance of geomembranes has been on smooth geomembranes. Texturing of a geomembrane can be quite effective at increasing the interface friction; however, very little is known about its effect on the service-life of the geomembrane. In the absence of this data, while textured geomembranes may be needed on side slopes, they should generally be avoided on the base of a landfill.

4. SOME COMMON MISTAKES IN LANDFILL CONSTRUCTION

While there are many factors that can contribute to poor construction, problems can often be traced to simply not following the design specifications or manufacturers guidelines. Two examples: (i) accepting an "alternative" (i.e., usually cheaper) material to that specified in the design when, in fact, it is not really equivalent in overall performance and not therefore really suitable; and (ii) not covering a compacted clay or geosynthetic clay liner (GCL) or a composite liner (geomembrane over a compacted clay or GCL) in a timely manner as is required by good practice and good specifications. Liners that must be left exposed need to be specially designed for the particular exposure conditions. Rowe [44] provided quite an extensive discussion of problems that often arise during construction. These issues will be briefly summarized and a few additional issues will be highlighted below.

An important aspect of ensuring good construction is to have good and independent construction quality assurance (CQA) by experienced and qualified inspectors/auditors. Conformance testing should be performed by an independent laboratory on samples taken by independent inspectors/auditors who are responsible for confirming compliance of construction with the design/specifications. Arrangements whereby a supplier (or contractor) provide the material and the CQA tests (as a package) pose conflict to interest problems.

Design specifications and bid/construction documents must indicate: (i) what types of machinery should, and should not, be used in the construction (including maximum contact pressure); (ii) the restrictions regarding how construction machinery should be operated (i.e., turning and reversing of vehicles should be avoided in certain locations); and (iii) the amount of cover soil to be placed above the liner before any construction equipment can pass over that layer. Significant damage to GCLs and geomembranes has occurred after the drainage layer has been placed because the equipment operating on top of the drainage layer was too heavy.

4.1. Compacted clay liners (CCL)

Although many high quality CCLs have been constructed, this success is related to good design and construction specifications coupled with continuous quality assurance (monitored by an experienced and knowledgeable inspector/auditor. Common causes of problems include:

- Failure to comply with the specifications and the lack of adequate supervision (quality assurance) that allows this to happen.
- A gravel content that is too high (especially critical if the CCL is to be covered by a geomembrane).
- Failure to remove boulders/cobbles/clods larger than 100 mm (Fig. 3).
- Compacting outside the specified water content limits (Fig. 4).
- Compacting in lifts that are too thick for the compaction equipment [38].
- Use of road compaction equipment that is (a) too light and/or (b) has feet too short (e.g., 100 mm) to permit good liner compaction of a 150 mm (compacted) CCL layer (Fig. 5). A compactor that is good for road construction is often not suitable for compaction of a CCL.

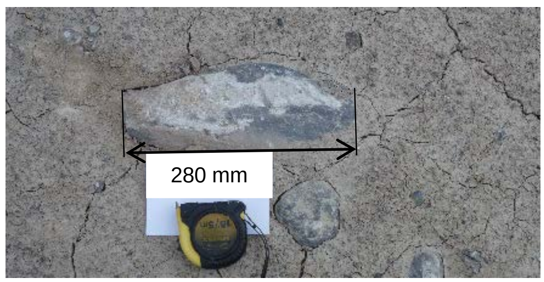


Figure 3. Cobbles of excessive size

Figure 4. Compaction of clayey soil that is too dry (i.e., water content less than optimum +1%)

Figure 5. Equipment with pads that are too small and a mass too small for compacting a typical 150 mm CCL lift

- Allowing clay to desiccate. Even shallow desiccation substantially increases interface transmissivity and potential leakage when the CCL forms part of a composite liner (Fig. 6). Desiccation is particularly problematic if the geomembrane is left exposed to the sun (i.e., without timely covering) since the heating of the geomembrane in the sun increases the risk of desiccation and the presence of the geomembrane hides the desiccation from view. Composite liners with a CCL below the geomembrane need to be covered in a very timely manner by the protection layer and drainage layer. The designer should anticipate if this may not be possible. In that event, a potential solution involves placing a coated GCL between the CCL and the geomembrane. If the slopes will be left exposed for a prolonged period, then the use of a coated GCL (coating facing up) minimizes (but does not eliminate) the risk of problems. Careful consideration also must be given to stability.

Figure 6. Desiccation of a compacted clay liner

4.2. Geosynthetic clay liners (GCL) and geomembranes

Since GCLs and geomembranes are manufactured products, it is somewhat easier to ensure that they meet the specification than for a CCL. However, there are many different types of GCL and geomembranes (even from the same manufacturer) and before they are placed, it is important to check that the material supplied is consistent with that specified. As noted earlier, for a GCL it is not enough to just have the specified hydraulic conductivity and swell index. Depending on the specifics of the application, other important quantities are the mass per unit area of bentonite, the type of bentonite, the type of cover and carrier geotextile, whether it is coated or laminated and if so the nature of the coating/laminate, etc. Common problems associated with the installation include:

- Placing a geomembrane or GCL on a subgrade that has protruding stones, rocks or other objects, and/or is rutted and/or yielding. An inadequate subgrade may compromise the GCL and/or geomembrane performance. A subgrade may be damaged by rainfall events making it wet, soft or eroding it (e.g., Fig. 7) and this must be repaired before liner material is placed. Isolated angular gravel in the subgrade (Figs. 7 & 8) may cause problems for a GCL or geomembrane placed directly over the subgrade [45].

- Placing a GCL and not covering before heavy rain or placing it in wet areas. Premature hydration makes the GCL susceptible to bentonite squeeze-out if subjected to any non-uniform pressure and also shrinkage if it subsequently dries.

Figure 7. Inadequate subgrade for either a GCL or geomembrane (i) too soft (note footprint in upper left), (ii) too irregular, and (iii) too much protruding gravel.

Figure 8. Sharp angular stone in subgrade below where a geomembrane had been place

- Not placing a coated GCL or single side textured geomembrane with the coating or texture the correct way up (what is correct will vary dependent on the design and specifications).
- Not adequately overlapping GCL panels (e.g., 0.3m is recommended). Overlap movements associated with placing overlying materials or due to shrinkage (see below) may compromise the hydraulic seal if the initial overlap is not adequate.
- Driving machinery or pulling equipment directly over the placed liner.
- Not adequately anchoring/ballasting a placed geomembrane against wind up-lift (Fig. 9). Once up-lifted and folded (e.g., Fig. 9) the geomembrane is compromised and cannot be re-used.
- Welding a geomembrane that is not clean and dry at the location of the weld.
- Covering the geomembrane liner when there are too many wrinkles present (Fig. 10).

Figure 9. Geomembrane (GMB) that had been picked up and moved by the wind.

Figure 10. Wrinkles in a geomembrane

- Covering the geomembrane liner when it is in tension due to thermal contraction (e.g., if the geomembrane is welded at a temperature significantly above the current temperature without sufficient accommodation for contraction then bridging (trampolining) will occur at changes in grade that will cause problems if they remain when the geomembrane is covered).

- Placing oversized gravel on the protection layer above the geomembrane. Note that geotextile protection alone is generally not adequate for a coarse (≤ 60 mm) angular gravel drainage. An additional level of protection (e.g., sand) is needed for coarse gravel.

- Not covering a composite liner in a timely manner. An exposed black geomembrane can increase to temperatures of (60-80°C) on a sunny day. If left exposed for a prolonged period of time this can have implications for the service life of the geomembrane. However, the first problems due to exposure are usually related to the evaporation of water from an underlying CCL or GCL, as elaborated below. A CCL covered by a geomembrane is especially prone to damage due to evaporation of moisture causing desiccation of the interface between the CCL and geomembrane, thereby reducing the effectiveness of the composite liner and increasing the leakage through any holes in the geomembrane [26]. The compacted clay liner cannot be expected to self-heal when the liner is eventually covered.

  A GCL covered by a geomembrane is somewhat less susceptible to damage by exposure than a CCL and can be left longer before covering; but how long it can be left will be highly dependent on site conditions and design. A GCL generally uptakes moisture from the subgrade and needs a high level of hydration to have a low hydraulic conductivity. However, if the partially hydrated GCL is subjected to thermal cycles it loses and gains moisture. This process can induce both shrinkage of the GCL panels (e.g., [26], [46], [47]) and a newly identified mechanism whereby evaporation followed by subsequent condensation of water between the geomembrane and GCL causes erosion of bentonite from the GCL at discrete locations [48-52]. These problems can be eliminated by following the GCL manufacturers' recommendation to cover the liner in a timely manner. In situations where this cannot be done, the designer can select GCL products which are much less prone to shrinkage and down-slope erosion[49], [50] than the standard products.

5. OPERATIONS

While good design and construction are required they are not sufficient, in and of themselves, to ensure good performance. The landfill must also be operated in a manner consistent with the design. A landfill is designed for a given waste stream and mode of operation. If the waste stream or mode of operation is changed, then the design may no longer be appropriate. Examples of changes that can cause problems include: (i) disposing of liquids (even if they are not hazardous) in a landfill designed for MSW; (ii) accepting reactive waste (e.g., combustion ash or aluminum production waste [53]) into a landfill designed for MSW; (iii) recirculation of leachate (e.g., for operation of a landfill as a bioreactor) when it was not so designed. A lack of a proper understanding of how a landfill behaves as a system and the consequent lack of consideration of the broader implications of undertaking an activity to address one problem on the overall system performance is too common and has led and to many failures. For example, in the operations of a landfill containing ash and MSW waste, leachate was used as a dust suppressor on the waste surface due to the large volume of ash disposed. This resulted an exothermic reaction that increased the landfill temperature to 67°C for a period of time before it reduced to just over 40°C. This increase in temperature has the potential to substantially reduce the service life of the liner system. The addition of liquids to the waste (including recirculation of leachate) in a manner not anticipated in the design has resulted in a number of significant stability problems and failures.

6. CONCLUSIONS

Modern landfill can be very effective at containing leachate and landfill gas. Unfortunately, the success has also resulted in complacency. To achieve a safe landfill requires good design/specifications, good construction, and good landfill operations by individuals who (i) understand how the system works, (ii) understand how to manage the challenges of construction, and (iii) ensure that the landfill is constructed and operated in accordance with the design. This paper has outlined a number of problems associated with poor design that have been identified by peer reviewers and regulators or as part of a forensic investigation after a failure. The paper then highlighted some common mistakes made in the construction of modern MSW landfills. It is concluded that more attention needs to be paid to items such as those highlighted herein for the design and construction of new landfills and the expansion of existing landfills. In addition to good design and construction, a landfill must also be operated in accordance with the design and many serious problems and failures have been due to decisions and actions made during landfill operations. In particular, since this is still an evolving field, it is important to keep up-to-date with advances in available materials and current knowledge regarding how a landfill barrier system can be best designed and constructed, and how decisions made regarding landfill operations have can affect the landfills long-term performance.

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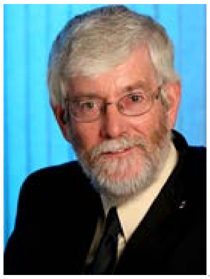
BIOGRAPHY



R. Kerry Rowe *is Professor and Canada Research Chair in Geotechnical and Geoenvironmental Engineering, GeoEngineering Centre at Queen's-RMC, Queen's University, Kingston ON, Canada.*

Rowe received his BSc, BE, PhD and DEng from the University of Sydney, Australia. He worked for 8 years with the Australian Department of Construction before immigrating to Canada where he served as a Professor at Western University for 20 years and for the last 15 years at Queen's University, including 10 years as Vice-Principal for Research, being responsible for all research at the university.

Rowe is a Fellow of the Royal Society (UK), Royal Academy of Engineering (UK), Royal Society of Canada, Canadian Academy of Engineering and a Foreign Member of the US National Academy of Engineering.

He may be contacted at kerry.rowe@queensu.ca.

Missing From Any Of The Reports: The Evidence That The Liner Is Leaking

Bernhard H.J. Juurlink

There is a major disconnect in the Hemmera Report (May 26, 2017) between the Tables in Sections 4.1 and 4.2 and the Recommendations in Section 7. It seems that all the non-compliances between the As-Builts and the construction as well as the non-compliances of the contaminated soil waste PEA with the LCMSW are of little significance: for Hemmera all that is needed are a few cosmetic changes to the PEA or a QP to sign off on the deficiencies. To me this seems to be yet another case where a consultant gives the Ministry the answer the Ministry is looking for.

The elephant in the room that is completely ignored, although brought up by the SRG repeatedly, is the evidence the contaminated soil waste landfill site is leaking contaminants into the watershed. The contamination of the watershed has always been the concern of the Shawnigan Lake residents and the reason there has been opposition to the contaminated soil waste landfill site in the Shawnigan Lake watershed. Hence, it is astonishing this was not part of the Hemmera Report, especially as this was brought up by the SRG in meeting with the Hemmera QPs and the Ministry.

At the request of the SRG the Ministry has had some of the leachate collected in May of 2017 analyzed for contaminants. Comparing the leachate metal data to the metal concentrations found in the Ephemeral Stream on February 16, 2017 and Shawnigan Creek upstream of the contaminated soil waste landfill site on November 29, 2017 leads to the conclusion that the PEA is leaking. It is realized that one cannot directly compare leachate collected in May 2017 to water collected from the Ephemeral Stream in February, 2017; however, it is likely that the composition of the leachate will not vary dramatically over time. Ideally the leachate numbers should be compared to the numbers found in the Ephemeral stream at some time point after collecting leachate. Nevertheless, this is all we have to work with at the moment.

Since the contaminated soil from different locations are located at various levels in the composition of leachate will vary somewhat over time. For example, levels of silver may be episodic whereas dredgeate components such as Na^+ will likely not vary much over time. Movement of contaminants through the surface and subsurface will decrease the concentration of the contaminants and if there is a leak then one would not expect the levels of contaminants to be at the same concentration in the Ephemeral stream as in the leachate being collected. Further, the different components of leachate that leaks will travel through the surface and subsurface at different rates depending upon the chemical nature of the contaminants. Also, some contaminants such as sulfate can be metabolized by bacteria and the concentrations of such will change over time relative to other non-metabolizable contaminants, e.g. Na^+. Hence, one would never expect that the relative concentration of leaked contaminants would be the same near the

PEA compared to a distant site such as the Ephemeral stream; however, one would expect that contaminants that dominate the leachate would be the same as those that dominate in the Ephemeral stream, i.e., one would expect similar foot prints. (We should also keep in mind the amount of rainfall will influence both the concentration of the contaminants as well as their velocity of movement away from the PEA.)

As can be seen in the Table below the footprint of contaminants in the leachate is essentially the same footprint as the contaminants in the Settling Pond outflow and the Ephemeral stream, note the samples have been collected three months apart. **The simplest explanation for similar contaminant footprint in the leachate as in the Settling Pond outflow and the Ephemeral stream is that the PEA is leaking. This interpretation is congruent with the data showing improper installation of the base liner.**

Comparisons of Leachate Values to Settling Pond Outflow, Ephemeral Stream and Shawnigan Creek Upstream of Waste Pile

Unless otherwise indicated units are in micrograms/litre

Item Measured	Fresh Water Standards	Leachate May '17	Feb 16 '17 Weir	Feb 16 '17 Ephemeral Stream	Nov 29 '16 Shawnigan Creek Upstream of Waste Pile
Conductivity uS/cm		11,400	231	236	30.2
Hardness (as $CaCO_3$)		3,730	80.3	89.9	11.4
Turbidity NTUs					
Chloride	150,000 Long-term 600,000 Short-term	3,470,000	16,900	13,100	2,180
Nitrite/Nitrate		1,140	264	408	26.5
Total Dissolved Solids		8,160	144	144	
Total Phosphate					
Sulfate		1,760,000	47,700	49,900	1,370
Total Aluminum	50 Long-term 100 short-term	23.1	985	226	107
Total Antimony		0.59	0.2	0.2	<0.02
Total Arsenic	5	0.76	<0.5	<0.5	0.074

Total Barium		102	9	6	3.25
Total Boron	1,200	444	26	26	<5
Total Cadmium		0.44	<0.01	<0.01	<5
Total Calcium		947,000	28,00	29,800	3,320
Total Chromium		0.71	2	0.8	0.15
Total Cobalt	4 Long-term 110 Short-term	10.1	0.44	0.16	0.0634
Total Copper	<2 Long-term	3.47	3.4	1.5	0.78
Total Iron	1,000 Short-term	1,180	1,020	230	51.7
Total Lead	3 Short-term	<0.1	0.6	0.2	0.02
Total Lithium		2.69	0.7	0.7	<0.5
Magnesium		337,000	4,560	4,590	
Total Manganese	Depends upon hardness of water	24,200	13.3	4.2	743
Total Mercury		<0.02	<0.02	<0.02	2.95
Total Molybdenum	2,000 Short-term	1.58	0.6	0.7	<0.05
Total Nickel		8.29	1.8	0.7	0.187
Total Potassium		27,900	780	590	116
Total Selenium	1 for Long-term 2 for Short-term	0.84	<0.5	<0.5	<0.04
Total Silicon		8,500	4,100	3,400	3,570
Total Silver		0.841	<0.05	<0.05	<0.05
Total Sodium		1,780,000	11,000	8,370	1,760
Total Strontium		5,390	8.4	8.0	12.8
Total Sulfur		698,000	15,000	15,000	1,370
Total Thallium		0.054	<0.02	<0.02	<0.002
Total Uranium	15 Short-term 33 Long-term	3.63	0.26	0.25	0.0079
Zinc	30 Long-term	7.5	4	<4	0.39
Dissolved Aluminum		7.4	7	<5	8.41

Hurst, Nicole ENV:EX

From: Dave Hutchinson <dave.shawnigan@shaw.ca>
Sent: Tuesday, June 13, 2017 4:10 PM
To: Downie, AJ ENV:EX
Cc: Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; 'Sonia Furstenau'; 'Calvin Cook'; 'Bernhard Juurlink'; Brent Beach
Subject: SRG Additional Docs - Jun 13, 2017 re CHH Landfill - WQ Test results etc.
Attachments: 1-SRG Additional Documents - 2017-06-13.docx; 2-Leachate and Water Quality Data Analysis-Juurlink.docx; 3-Maxxam WQ Data 2017-06-12.pdf; 4-Maxxam WQ Data 2017-06-12.xls; 5-SHA Final Closure Plan-Addendum-Beach.docx

Hello AJ,

The Shawnigan Research Group (SRG) is submitting five additional documents to the Ministry of Environment with regard to the Amended Spill Prevention Order: MO1701, concerning the Cobble Hill Holdings Contaminated Waste Landfill:

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- **2-Leachate and Water Quality Data Analysis-Juurlink.docx**
- **3-Maxxam WQ Data 2017-06-12.pdf**
- **4-Maxxam WQ Data 2017-06-12.xls**
- **5-SHA Final Closure Plan-Addendum-Beach.docx**

Summary:

- Water quality samples collected on June 2, 2017, and analysed by Maxxam Laboratories, reaffirm SRG assertions that the landfill is leaking and contaminants are being released into the surrounding environment. The chemical footprint of the contaminants that are elevated in the Ephemeral Stream compared to Shawnigan Creek is almost identical to the May 4th, 2017 leachate chemical footprint.

- Additional observations are also made with regard to:

    1. The pending Supreme Court of Canada appeal by the CVRD of it zoning case against the companies.
    2. Additional evidence that the material in the waste pile is shrinking and the consequences of that.
    3. Areas in which the companies are failing to comply with the Amended Spill Prevention Order.

    These three issues add weight to the arguments against making a decision on final closure of the contaminated waste landfill until these issues are resolved.

Regards,
Dave Hutchinson

Shawnigan Research Group
Additional Documents

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Dave Hutchinson June 13, 2017

Comparisons of Leachate Values to Ephemeral Stream and Shawnigan Creek Upstream of Waste Pile

Unless otherwise indicated units are in micrograms/litre

On June 2, the Shawnigan Residents Association had water samples taken and analyzed by Maxxam. Water samples were taken from Shawnigan Creek upstream of Lot 23, 460 Stebbings Road and from the Ephemeral Stream. The Data are summarized in the Table below.

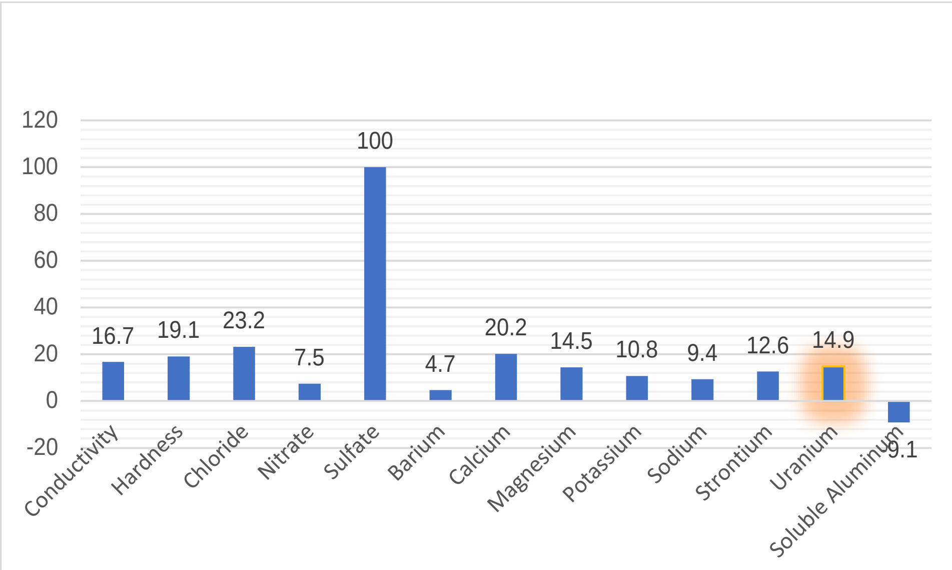
Item Measured	Fresh Water Standards	Leachate May 4, '17	Ephemeral Stream June 2, '17	Shawnigan Creek Upstream of Lot 23 June 2, '17
Conductivity uS/cm		11,400	618	37
Hardness (as $CaCO_3$)		3,730	292	15.3
Chloride	150,000 Long-term 600,000 Short-term	3,470,000	44,000	1,900
Nitrite/Nitrate		1,140	346	46
Sulfate		1,760,000	110,000	1,100
Total Aluminum	50 Long-term 100 short-term	23.1	7.6	43.3
Total Antimony		0.59	<0.5	<0.5
Total Arsenic	5	0.76	0.12	<0.1
Total Barium		102	18.5	3.9
Total Boron	1,200	444	<50	<50
Total Cadmium		0.44	0.015*	<0.01
Total Calcium		947,000	96,900*	4,790
Total Chromium		0.71	<1	<1
Total Cobalt	4 Long-term 110 Short-term	10.1	<0.2	<0.2
Total Copper	<2 Long-term	3.47	1.1	0.52
Total Iron	1,000 Short-term	1,180	12	68

Total Lead	3 Short-term	<0.1	<0.2	<0.2
Total Lithium		2.69	<2	<2
Magnesium		337,000	12.1	0.834
Total Manganese	Depends upon hardness of water	24,200	21.9	17.5
Total Mercury		<0.02	<0.01	<0.01
Total Molybdenum	2,000 Short-term	1.58	1.1	<1
Total Nickel		8.29	<1	<1
Total Potassium		27,900	1,140	106
Total Selenium	1 for Long-term 2 for Short-term	0.84	0.35	<0.1
Total Silicon		8,500	5,350	2,620
Total Silver		0.841	<0.02	<0.02
Total Sodium		1,780,000	17,300	1,840
Total Strontium		5,390	273	21.7
Total Sulfur		698,000	37,100	<3,000
Total Thallium		0.054	<0.01	<0.01
Total Uranium		3.63	1.49	<0.1
Zinc	30 Long-term	7.5	<5	<5
Dissolved Aluminum		7.4	3.3	29.3

The graph on the next page illustrates the components that are significantly elevated in the Ephemeral Stream compared to Shawnigan Creek upstream of the contaminated soil waste landfill site. We see that components high in dredgeate such as chloride, calcium, magnesium, potassium, sodium and sulfate are very much higher in the Ephemeral Stream compared to Shawnigan Creek. These components are also very high in the leachate collected on May 4, 2017. In addition, nitrate, strontium and uranium were significantly higher in the Ephemeral Stream compared to Shawnigan Creek. The components were also very high in leachate. It should be emphasized that uranium increase is an underestimate since the instrumentation was set not to be able to detect less than 0.1 microgram uranium per litre. Prior analysis by Environmental Associates has shown that uranium was around 80 times higher in the Ephemeral Stream compared to Shawnigan Creek.

Total sulfur was also much higher in the Stream than the Creek; however, this sulfur was all contained in sulfate and thus was not included in the graph.

The conductivity measurements simply show the high ion content of the leachate and Ephemeral Stream compared to Shawnigan Creek.



Components that are significantly elevated in the Ephemeral Stream.

Note: 1) that the uranium increase is an underestimate since the Shawnigan Creek value is unknown and simply estimated as <0.1 micrograms/litre and 2) soluble aluminum in the Ephemeral Stream is well below the values in Shawnigan Creek.

The chemical footprint of the contaminants that are elevated in the Ephemeral Stream compared to Shawnigan Creek is almost identical to the May 4th, 2017 leachate chemical footprint. It is noted that SIRM was required by the Ministry to measure the Ephemeral Stream Flow. If the Ministry gives us this information along with the chemical analysis of the Ephemeral Stream on the same date, we could make a reasonable estimate as to the rate of contaminant release by the PEA into the ground water. Such calculations would underestimate contaminant leaks from the PEA since we are convinced not all ground water from the mine area exits Lot 23 via the Ephemeral Stream.

In conclusion, we have data showing that the contaminated soil waste landfill site at 460 Stebbings Road is leaking contaminants into the watershed. If the Ministry provides us with the Ephemeral Stream volume flow data we could provide the Ministry with a reasonable estimate on the rate of PEA release of contaminants into the watershed.

Your C.O.C. #: 525592-01-01

Attention:Calvin Cook

The Shawnigan Residents Association
P.O. Box 443
Shawnigan Lake, BC
Canada V0R 2W0

Report Date: 2017/06/12
Report #: R2395571
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B743204
Received: 2017/06/02, 12:30

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water (1)	2	2017/06/06	2017/06/06	BBY6SOP-00026	SM2320B
Chloride by Automated Colourimetry	2	N/A	2017/06/05	BBY6SOP-00011	SM 22 4500-Cl- E m
True Colour (Single Wavelength) (1)	2	N/A	2017/06/02	VIC SOP-00010	SM 22 2120 C m
Conductance - water (1)	2	N/A	2017/06/06	BBY6SOP-00026	SM-2510B
Fluoride	2	N/A	2017/06/07	BBY6SOP-00048	SM 22 4500-F C m
Glycols in Water by GC/FID (2)	2	N/A	2017/06/08	CAL SOP-00093	EPA 8015D R4 m
Hardness Total (calculated as CaCO3)	1	N/A	2017/06/07	BBY WI-00033	Auto Calc
Hardness Total (calculated as CaCO3)	1	N/A	2017/06/08	BBY WI-00033	Auto Calc
Hardness (calculated as CaCO3)	2	N/A	2017/06/08	BBY WI-00033	Auto Calc
Mercury (Dissolved) by CVAF	2	N/A	2017/06/08	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CVAF	2	2017/06/07	2017/06/07	BBY7SOP-00015	BCMOE BCLM Oct2013 m
EPH in Water when PAH required	2	2017/06/05	2017/06/05	BBY8SOP-00029	BCMOE EPH w 12/00 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	2	N/A	2017/06/08	BBY7SOP-00002	EPA 6020B R2 m
Elements by CRC ICPMS (dissolved)	2	N/A	2017/06/07	BBY7SOP-00002	EPA 6020B R2 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2017/06/02	2017/06/07	BBY7SOP-00002	EPA 6020B R2 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2017/06/02	2017/06/08	BBY7SOP-00002	EPA 6020B R2 m
Elements by CRC ICPMS (total)	1	2017/06/05	2017/06/06	BBY7SOP-00003,	BCLM2005,EPA6020bR2m
Elements by CRC ICPMS (total)	1	2017/06/06	2017/06/07	BBY7SOP-00003,	BCLM2005,EPA6020bR2m
Nitrate + Nitrite (N)	2	N/A	2017/06/03	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA	2	N/A	2017/06/03	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	2	N/A	2017/06/07	BBY6SOP-00010	SM 22 4500-NO3 I m
PAH in Water by GC/MS (SIM)	2	2017/06/05	2017/06/06	BBY8SOP-00021	EPA 8270d R5 m
Total LMW, HMW, Total PAH Calc	2	N/A	2017/06/06	BBY WI-00033	Auto Calc
Filter and HNO3 Preserve for Metals	2	N/A	2017/06/05	BBY7 WI-00004	BCMOE Reqs 08/14
Sulphate by Automated Colourimetry	2	N/A	2017/06/05	BBY6SOP-00017	SM 22 4500-SO42- E m
EPH less PAH in Water by GC/FID	2	N/A	2017/06/06	BBY WI-00033	Auto Calc
Total Suspended Solids (1)	2	N/A	2017/06/08	VIC SOP-00009	Based on SM2540 D E
VOCs, VH, F1, LH in Water by HS GC/MS	2	2017/06/06	2017/06/07	BBY8SOP-00009/11/12	BC Lab Manual 2007
Volatile HC-BTEX	2	N/A	2017/06/07	BBY WI-00033	Auto Calc

Remarks:

Your C.O.C. #: 525592-01-01

Attention:Calvin Cook

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P.O. Box 443
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Canada V0R 2W0

Report Date: 2017/06/12
Report #: R2395571
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B743204
Received: 2017/06/02, 12:30

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

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Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
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Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Victoria
(2) This test was performed by Maxxam Calgary Environmental

Encryption Key

Tanya Eugine
Project Manager
12 Jun 2017 11:14:59

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
BC Env Customer Service, BC Environmental Customer Service
Email: Enviro.CS.BC@maxxam.ca
Phone# (604) 734 7276

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B743204
Report Date: 2017/06/12

The Shawnigan Residents Association

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID			RE7980		RE7981		
Sampling Date			2017/06/02 10:30		2017/06/02 11:00		
COC Number			525592-01-01		525592-01-01		
	UNITS	Criteria	S1	QC Batch	S2	RDL	QC Batch
ANIONS							
Nitrite (N)	mg/L	-	<0.0050	8651532	<0.0050	0.0050	8651532
Calculated Parameters							
Filter and HNO3 Preservation	N/A	-	LAB	8652176	LAB		8652176
Nitrate (N)	mg/L	-	0.046	8649545	0.346	0.020	8649545
Misc. Inorganics							
Fluoride (F)	mg/L	-	0.015	8656333	0.037	0.010	8656340
Alkalinity (Total as CaCO3)	mg/L	10	7.4	8653194	**136**	0.5	8653194
Alkalinity (PP as CaCO3)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Bicarbonate (HCO3)	mg/L	-	9.1	8653194	166	0.5	8653194
Carbonate (CO3)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Hydroxide (OH)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Total Suspended Solids	mg/L	-	<1	8654120	<1	1	8654120
Anions							
Dissolved Sulphate (SO4)	mg/L	-	1.10	8653364	110	0.50	8653364
Dissolved Chloride (Cl)	mg/L	-	1.9	8653344	44	0.50	8653344
MISCELLANEOUS							
True Colour	Col. Unit	-	9	8652807	<5	5	8652807
Nutrients							
Nitrate plus Nitrite (N)	mg/L	-	0.046	8651531	0.346	0.020	8651531
Physical Properties							
Conductivity	uS/cm	-	37	8653193	618	1	8653193

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

GLYCOLS BY GC-FID (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017/06/02 10:30	2017/06/02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	Criteria	S1	S2	RDL	QC Batch
Glycols						
Ethylene Glycol	mg/L	192	<3.0	<3.0	3.0	8653135
Diethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Triethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Tetraethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Propylene Glycol	mg/L	500	<5.0	<5.0	5.0	8653135
Surrogate Recovery (%)						
Methyl Sulfone (sur.)	%	-	81	78		8653135

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		RE7980	RE7981		
Sampling Date		2017/06/02 10:30	2017/06/02 11:00		
COC Number		525592-01-01	525592-01-01		
	UNITS	S1	S2	RDL	QC Batch
Polycyclic Aromatics					
Low Molecular Weight PAH`s	ug/L	<0.10	<0.10	0.10	8649651
High Molecular Weight PAH`s	ug/L	<0.050	<0.050	0.050	8649651
Total PAH	ug/L	<0.10	<0.10	0.10	8649651
Quinoline	ug/L	<0.020	<0.020	0.020	8652080
Naphthalene	ug/L	<0.10	<0.10	0.10	8652080
2-Methylnaphthalene	ug/L	<0.10	<0.10	0.10	8652080
Acenaphthylene	ug/L	<0.050	<0.050	0.050	8652080
Acenaphthene	ug/L	<0.050	<0.050	0.050	8652080
Fluorene	ug/L	<0.050	<0.050	0.050	8652080
Phenanthrene	ug/L	<0.050	<0.050	0.050	8652080
Anthracene	ug/L	<0.010	<0.010	0.010	8652080
Acridine	ug/L	<0.050	<0.050	0.050	8652080
Fluoranthene	ug/L	<0.020	<0.020	0.020	8652080
Pyrene	ug/L	<0.020	<0.020	0.020	8652080
Benzo(a)anthracene	ug/L	<0.010	<0.010	0.010	8652080
Chrysene	ug/L	<0.020	<0.020	0.020	8652080
Benzo(b&j)fluoranthene	ug/L	<0.030	<0.030	0.030	8652080
Benzo(k)fluoranthene	ug/L	<0.050	<0.050	0.050	8652080
Benzo(a)pyrene	ug/L	<0.0050	<0.0050	0.0050	8652080
Indeno(1,2,3-cd)pyrene	ug/L	<0.050	<0.050	0.050	8652080
Dibenz(a,h)anthracene	ug/L	<0.0030	<0.0030	0.0030	8652080
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	0.050	8652080
Calculated Parameters					
LEPH (C10-C19 less PAH)	mg/L	<0.20	<0.20	0.20	8650175
HEPH (C19-C32 less PAH)	mg/L	<0.20	<0.20	0.20	8650175
Ext. Pet. Hydrocarbon					
EPH (C10-C19)	mg/L	<0.20	<0.20	0.20	8652096
EPH (C19-C32)	mg/L	<0.20	<0.20	0.20	8652096
Surrogate Recovery (%)					
O-TERPHENYL (sur.)	%	94	91		8652096
D10-ANTHRACENE (sur.)	%	96	94		8652080
D8-ACENAPHTHYLENE (sur.)	%	99	97		8652080
D8-NAPHTHALENE (sur.)	%	89	79		8652080
D9-Acridine (sur.)	%	61	59		8652080
RDL = Reportable Detection Limit					

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LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		RE7980	RE7981		
Sampling Date		2017/06/02 10:30	2017/06/02 11:00		
COC Number		525592-01-01	525592-01-01		
	UNITS	S1	S2	RDL	QC Batch
TERPHENYL-D14 (sur.)	%	94	92		8652080
RDL = Reportable Detection Limit					

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017/06/02 10:30	2017/06/02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	Criteria	S1	S2	RDL	QC Batch
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	-	14.7	271	0.50	8649574
Elements						
Dissolved Mercury (Hg)	ug/L	-	<0.010	<0.010	0.010	8656120
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	-	29.3	3.3	3.0	8652630
Dissolved Antimony (Sb)	ug/L	20	<0.50	<0.50	0.50	8652630
Dissolved Arsenic (As)	ug/L	5	<0.10	0.11	0.10	8652630
Dissolved Barium (Ba)	ug/L	1000	3.7	18.1	1.0	8652630
Dissolved Beryllium (Be)	ug/L	5.3	<0.10	<0.10	0.10	8652630
Dissolved Bismuth (Bi)	ug/L	-	<1.0	<1.0	1.0	8652630
Dissolved Boron (B)	ug/L	5000	<50	<50	50	8652630
Dissolved Cadmium (Cd)	ug/L	.01	<0.010	0.010	0.010	8652630
Dissolved Chromium (Cr)	ug/L	9	<1.0	<1.0	1.0	8652630
Dissolved Cobalt (Co)	ug/L	.9	<0.20	<0.20	0.20	8652630
Dissolved Copper (Cu)	ug/L	-	0.39	1.09	0.20	8652630
Dissolved Iron (Fe)	ug/L	300	39.5	<5.0	5.0	8652630
Dissolved Lead (Pb)	ug/L	-	<0.20	<0.20	0.20	8652630
Dissolved Lithium (Li)	ug/L	-	<2.0	<2.0	2.0	8652630
Dissolved Manganese (Mn)	ug/L	100	6.1	18.0	1.0	8652630
Dissolved Molybdenum (Mo)	ug/L	-	<1.0	1.1	1.0	8652630
Dissolved Nickel (Ni)	ug/L	25	<1.0	<1.0	1.0	8652630
Dissolved Selenium (Se)	ug/L	1	<0.10	0.37	0.10	8652630
Dissolved Silicon (Si)	ug/L	-	2500	5450	100	8652630
Dissolved Silver (Ag)	ug/L	-	<0.020	<0.020	0.020	8652630
Dissolved Strontium (Sr)	ug/L	-	20.1	254	1.0	8652630
Dissolved Thallium (Tl)	ug/L	1.7	<0.010	<0.010	0.010	8652630
Dissolved Tin (Sn)	ug/L	-	<5.0	<5.0	5.0	8652630
Dissolved Titanium (Ti)	ug/L	100	<5.0	<5.0	5.0	8652630
Dissolved Uranium (U)	ug/L	300	<0.10	1.48	0.10	8652630
Dissolved Vanadium (V)	ug/L	10000	<5.0	<5.0	5.0	8652630
Dissolved Zinc (Zn)	ug/L	30	<5.0	<5.0	5.0	8652630
Dissolved Zirconium (Zr)	ug/L	-	<0.10	<0.10	0.10	8652630
Dissolved Calcium (Ca)	mg/L	4	**4.55**	**87.7**	0.050	8649575
Dissolved Magnesium (Mg)	mg/L	-	0.817	12.6	0.050	8649575

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017/06/02 10:30	2017/06/02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	Criteria	S1	S2	RDL	QC Batch
Dissolved Potassium (K)	mg/L	-	0.096	1.16	0.050	8649575
Dissolved Sodium (Na)	mg/L	-	1.84	17.8	0.050	8649575
Dissolved Sulphur (S)	mg/L	-	<3.0	37.0	3.0	8649575

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980		RE7981		
Sampling Date			2017/06/02 10:30		2017/06/02 11:00		
COC Number			525592-01-01		525592-01-01		
	UNITS	**Criteria**	**S1**	**QC Batch**	**S2**	**RDL**	**QC Batch**
Calculated Parameters							
Total Hardness (CaCO3)	mg/L	-	15.3	8650052	292	0.50	8650052
Elements							
Total Mercury (Hg)	ug/L	-	<0.010	8654963	<0.010	0.010	8654963
Total Metals by ICPMS							
Total Aluminum (Al)	ug/L	-	43.3	8653737	7.6	3.0	8652657
Total Antimony (Sb)	ug/L	20	<0.50	8653737	<0.50	0.50	8652657
Total Arsenic (As)	ug/L	5	<0.10	8653737	0.12	0.10	8652657
Total Barium (Ba)	ug/L	1000	3.9	8653737	18.5	1.0	8652657
Total Beryllium (Be)	ug/L	5.3	<0.10	8653737	<0.10	0.10	8652657
Total Bismuth (Bi)	ug/L	-	<1.0	8653737	<1.0	1.0	8652657
Total Boron (B)	ug/L	5000	<50	8653737	<50	50	8652657
Total Cadmium (Cd)	ug/L	.01	<0.010	8653737	**0.015**	0.010	8652657
Total Chromium (Cr)	ug/L	9	<1.0	8653737	<1.0	1.0	8652657
Total Cobalt (Co)	ug/L	.9	<0.20	8653737	<0.20	0.20	8652657
Total Copper (Cu)	ug/L	-	0.52	8653737	1.10	0.50	8652657
Total Iron (Fe)	ug/L	300	68	8653737	12	10	8652657
Total Lead (Pb)	ug/L	-	<0.20	8653737	<0.20	0.20	8652657
Total Lithium (Li)	ug/L	-	<2.0	8653737	<2.0	2.0	8652657
Total Manganese (Mn)	ug/L	100	17.5	8653737	21.9	1.0	8652657
Total Molybdenum (Mo)	ug/L	-	<1.0	8653737	1.1	1.0	8652657
Total Nickel (Ni)	ug/L	25	<1.0	8653737	<1.0	1.0	8652657
Total Selenium (Se)	ug/L	1	<0.10	8653737	0.35	0.10	8652657
Total Silicon (Si)	ug/L	-	2620	8653737	5350	100	8652657
Total Silver (Ag)	ug/L	-	<0.020	8653737	<0.020	0.020	8652657
Total Strontium (Sr)	ug/L	-	21.7	8653737	273	1.0	8652657
Total Thallium (Tl)	ug/L	1.7	<0.010	8653737	<0.010	0.010	8652657
Total Tin (Sn)	ug/L	-	<5.0	8653737	<5.0	5.0	8652657
Total Titanium (Ti)	ug/L	100	<5.0	8653737	<5.0	5.0	8652657
Total Uranium (U)	ug/L	300	<0.10	8653737	1.49	0.10	8652657
Total Vanadium (V)	ug/L	10000	<5.0	8653737	<5.0	5.0	8652657
Total Zinc (Zn)	ug/L	30	<5.0	8653737	<5.0	5.0	8652657
Total Zirconium (Zr)	ug/L	-	<0.10	8653737	<0.10	0.10	8652657
Total Calcium (Ca)	mg/L	4	**4.74**	8650058	**96.9**	0.050	8650058
Total Magnesium (Mg)	mg/L	-	0.834	8650058	12.1	0.050	8650058

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Maxxam Job #: B743204
Report Date: 2017/06/12

The Shawnigan Residents Association

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980		RE7981		
Sampling Date			2017/06/02 10:30		2017/06/02 11:00		
COC Number			525592-01-01		525592-01-01		
	UNITS	Criteria	S1	QC Batch	S2	RDL	QC Batch
Total Potassium (K)	mg/L	-	0.106	8650058	1.14	0.050	8650058
Total Sodium (Na)	mg/L	-	1.84	8650058	17.3	0.050	8650058
Total Sulphur (S)	mg/L	-	<3.0	8650058	37.1	3.0	8650058

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Maxxam Job #: B743204
Report Date: 2017/06/12

The Shawnigan Residents Association

CSR VOC + VPH IN WATER (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017/06/02 10:30	2017/06/02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	**Criteria**	**S1**	**S2**	**RDL**	**QC Batch**
Volatiles						
VPH (VH6 to 10 - BTEX)	ug/L	-	<300	<300	300	8650061
Chloromethane	ug/L	-	<1.0	<1.0	1.0	8653261
Vinyl chloride	ug/L	-	<0.50	<0.50	0.50	8653261
Chloroethane	ug/L	-	<1.0	<1.0	1.0	8653261
Trichlorofluoromethane	ug/L	-	<4.0	<4.0	4.0	8653261
1,1,2Trichloro-1,2,2Trifluoroethane	ug/L	-	<2.0	<2.0	2.0	8653261
Dichlorodifluoromethane	ug/L	-	<2.0	<2.0	2.0	8653261
1,1-dichloroethene	ug/L	-	<0.50	<0.50	0.50	8653261
Dichloromethane	ug/L	98	<2.0	<2.0	2.0	8653261
trans-1,2-dichloroethene	ug/L	-	<1.0	<1.0	1.0	8653261
1,1-dichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
cis-1,2-dichloroethene	ug/L	-	<1.0	<1.0	1.0	8653261
Chloroform	ug/L	2	<1.0	<1.0	1.0	8653261
1,1,1-trichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,2-dichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
Carbon tetrachloride	ug/L	13	<0.50	<0.50	0.50	8653261
Benzene	ug/L	400	<0.40	<0.40	0.40	8653261
Methyl-tert-butylether (MTBE)	ug/L	-	<4.0	<4.0	4.0	8653261
1,2-dichloropropane	ug/L	100	<0.50	<0.50	0.50	8653261
cis-1,3-dichloropropene	ug/L	-	<1.0	<1.0	1.0	8653261
trans-1,3-dichloropropene	ug/L	-	<1.0	<1.0	1.0	8653261
Bromomethane	ug/L	-	<1.0	<1.0	1.0	8653261
1,1,2-trichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
Trichloroethene	ug/L	20	<0.50	<0.50	0.50	8653261
Chlorodibromomethane	ug/L	-	<1.0	<1.0	1.0	8653261
1,2-dibromoethane	ug/L	-	<0.20	<0.20	0.20	8653261
Tetrachloroethene	ug/L	110	<0.50	<0.50	0.50	8653261
Bromodichloromethane	ug/L	-	<1.0	<1.0	1.0	8653261
Toluene	ug/L	2	<0.40	<0.40	0.40	8653261
Ethylbenzene	ug/L	90	<0.40	<0.40	0.40	8653261
m & p-Xylene	ug/L	-	<0.40	<0.40	0.40	8653261
Bromoform	ug/L	-	<1.0	<1.0	1.0	8653261
Styrene	ug/L	-	<0.50	<0.50	0.50	8653261
o-Xylene	ug/L	-	<0.40	<0.40	0.40	8653261

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

CSR VOC + VPH IN WATER (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017/06/02 10:30	2017/06/02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	**Criteria**	**S1**	**S2**	**RDL**	**QC Batch**
Xylenes (Total)	ug/L	-	<0.40	<0.40	0.40	8653261
1,1,1,2-tetrachloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,1,2,2-tetrachloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,2-dichlorobenzene	ug/L	.7	<0.50	<0.50	0.50	8653261
1,3-dichlorobenzene	ug/L	150	<0.50	<0.50	0.50	8653261
1,4-dichlorobenzene	ug/L	26	<0.50	<0.50	0.50	8653261
Chlorobenzene	ug/L	1.3	<0.50	<0.50	0.50	8653261
1,2,3-trichlorobenzene	ug/L	8	<2.0	<2.0	2.0	8653261
1,2,4-trichlorobenzene	ug/L	24	<2.0	<2.0	2.0	8653261
Hexachlorobutadiene	ug/L	100	<0.50	<0.50	0.50	8653261
VH C6-C10	ug/L	-	<300	<300	300	8653261
Surrogate Recovery (%)						
1,4-Difluorobenzene (sur.)	%	-	100	100		8653261
4-Bromofluorobenzene (sur.)	%	-	82	82		8653261
D4-1,2-Dichloroethane (sur.)	%	-	89	87		8653261

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

GENERAL COMMENTS

Criteria: A compendium of working water quality guidelines for British Columbia 1998 Edition

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
8651531	IW1	Matrix Spike	Nitrate plus Nitrite (N)	2017/06/03		113	%	80 - 120
8651531	IW1	Spiked Blank	Nitrate plus Nitrite (N)	2017/06/03		110	%	80 - 120
8651531	IW1	Method Blank	Nitrate plus Nitrite (N)	2017/06/03	<0.020		mg/L	
8651531	IW1	RPD	Nitrate plus Nitrite (N)	2017/06/03	NC		%	25
8651532	IW1	Matrix Spike	Nitrite (N)	2017/06/03		102	%	80 - 120
8651532	IW1	Spiked Blank	Nitrite (N)	2017/06/03		100	%	80 - 120
8651532	IW1	Method Blank	Nitrite (N)	2017/06/03	<0.0050		mg/L	
8651532	IW1	RPD	Nitrite (N)	2017/06/03	4.4		%	20
8652080	LS2	Matrix Spike	D10-ANTHRACENE (sur.)	2017/06/05		90	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017/06/05		132 (1)	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017/06/05		88	%	50 - 130
			D9-Acridine (sur.)	2017/06/05		60	%	50 - 130
			TERPHENYL-D14 (sur.)	2017/06/05		82	%	60 - 130
			Quinoline	2017/06/05		105	%	50 - 130
			Naphthalene	2017/06/05		82	%	50 - 130
			2-Methylnaphthalene	2017/06/05		91	%	50 - 130
			Acenaphthylene	2017/06/05		92	%	50 - 130
			Acenaphthene	2017/06/05		92	%	50 - 130
			Fluorene	2017/06/05		84	%	50 - 130
			Phenanthrene	2017/06/05		84	%	60 - 130
			Anthracene	2017/06/05		91	%	60 - 130
			Acridine	2017/06/05		78	%	50 - 130
			Fluoranthene	2017/06/05		81	%	60 - 130
			Pyrene	2017/06/05		80	%	60 - 130
			Benzo(a)anthracene	2017/06/05		84	%	60 - 130
			Chrysene	2017/06/05		89	%	60 - 130
			Benzo(b&j)fluoranthene	2017/06/05		91	%	60 - 130
			Benzo(k)fluoranthene	2017/06/05		87	%	60 - 130
			Benzo(a)pyrene	2017/06/05		90	%	60 - 130
			Indeno(1,2,3-cd)pyrene	2017/06/05		86	%	60 - 130
			Dibenz(a,h)anthracene	2017/06/05		86	%	60 - 130
			Benzo(g,h,i)perylene	2017/06/05		84	%	60 - 130
8652080	LS2	Spiked Blank	D10-ANTHRACENE (sur.)	2017/06/05		97	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017/06/05		104	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017/06/05		88	%	50 - 130
			D9-Acridine (sur.)	2017/06/05		60	%	50 - 130
			TERPHENYL-D14 (sur.)	2017/06/05		98	%	60 - 130
			Quinoline	2017/06/05		104	%	50 - 130
			Naphthalene	2017/06/05		86	%	50 - 130
			2-Methylnaphthalene	2017/06/05		91	%	50 - 130
			Acenaphthylene	2017/06/05		93	%	50 - 130
			Acenaphthene	2017/06/05		94	%	50 - 130
			Fluorene	2017/06/05		89	%	50 - 130
			Phenanthrene	2017/06/05		91	%	60 - 130
			Anthracene	2017/06/05		91	%	60 - 130
			Acridine	2017/06/05		79	%	50 - 130
			Fluoranthene	2017/06/05		87	%	60 - 130
			Pyrene	2017/06/05		89	%	60 - 130
			Benzo(a)anthracene	2017/06/05		92	%	60 - 130
			Chrysene	2017/06/05		97	%	60 - 130
			Benzo(b&j)fluoranthene	2017/06/05		95	%	60 - 130
			Benzo(k)fluoranthene	2017/06/05		97	%	60 - 130
			Benzo(a)pyrene	2017/06/05		95	%	60 - 130
			Indeno(1,2,3-cd)pyrene	2017/06/05		94	%	60 - 130
			Dibenz(a,h)anthracene	2017/06/05		92	%	60 - 130

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Benzo(g,h,i)perylene	2017/06/05		95	%	60 - 130
8652080	LS2	Method Blank	D10-ANTHRACENE (sur.)	2017/06/06		99	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017/06/06		100	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017/06/06		76	%	50 - 130
			D9-Acridine (sur.)	2017/06/06		65	%	50 - 130
			TERPHENYL-D14 (sur.)	2017/06/06		98	%	60 - 130
			Quinoline	2017/06/06	<0.020		ug/L	
			Naphthalene	2017/06/06	<0.10		ug/L	
			2-Methylnaphthalene	2017/06/06	<0.10		ug/L	
			Acenaphthylene	2017/06/06	<0.050		ug/L	
			Acenaphthene	2017/06/06	<0.050		ug/L	
			Fluorene	2017/06/06	<0.050		ug/L	
			Phenanthrene	2017/06/06	<0.050		ug/L	
			Anthracene	2017/06/06	<0.010		ug/L	
			Acridine	2017/06/06	<0.050		ug/L	
			Fluoranthene	2017/06/06	<0.020		ug/L	
			Pyrene	2017/06/06	<0.020		ug/L	
			Benzo(a)anthracene	2017/06/06	<0.010		ug/L	
			Chrysene	2017/06/06	<0.020		ug/L	
			Benzo(b&j)fluoranthene	2017/06/06	<0.030		ug/L	
			Benzo(k)fluoranthene	2017/06/06	<0.050		ug/L	
			Benzo(a)pyrene	2017/06/06	<0.0050		ug/L	
			Indeno(1,2,3-cd)pyrene	2017/06/06	<0.050		ug/L	
			Dibenz(a,h)anthracene	2017/06/06	<0.0030		ug/L	
			Benzo(g,h,i)perylene	2017/06/06	<0.050		ug/L	
8652080	LS2	RPD	Quinoline	2017/06/06	NC		%	40
			Naphthalene	2017/06/06	NC		%	40
			2-Methylnaphthalene	2017/06/06	NC		%	40
			Acenaphthylene	2017/06/06	NC		%	40
			Acenaphthene	2017/06/06	NC		%	40
			Fluorene	2017/06/06	NC		%	40
			Phenanthrene	2017/06/06	NC		%	40
			Anthracene	2017/06/06	NC		%	40
			Acridine	2017/06/06	NC		%	40
			Fluoranthene	2017/06/06	NC		%	40
			Pyrene	2017/06/06	NC		%	40
			Benzo(a)anthracene	2017/06/06	NC		%	40
			Chrysene	2017/06/06	NC		%	40
			Benzo(b&j)fluoranthene	2017/06/06	NC		%	40
			Benzo(k)fluoranthene	2017/06/06	NC		%	40
			Benzo(a)pyrene	2017/06/06	NC		%	40
			Indeno(1,2,3-cd)pyrene	2017/06/06	NC		%	40
			Dibenz(a,h)anthracene	2017/06/06	NC		%	40
			Benzo(g,h,i)perylene	2017/06/06	NC		%	40
8652096	IT1	Matrix Spike	O-TERPHENYL (sur.)	2017/06/05		99	%	60 - 140
			EPH (C10-C19)	2017/06/05		97	%	60 - 140
			EPH (C19-C32)	2017/06/05		94	%	60 - 140
8652096	IT1	Spiked Blank	O-TERPHENYL (sur.)	2017/06/05		97	%	60 - 140
			EPH (C10-C19)	2017/06/05		93	%	70 - 130
			EPH (C19-C32)	2017/06/05		93	%	70 - 130
8652096	IT1	Method Blank	O-TERPHENYL (sur.)	2017/06/05		94	%	60 - 140
			EPH (C10-C19)	2017/06/05	<0.20		mg/L	
			EPH (C19-C32)	2017/06/05	<0.20		mg/L	
8652096	IT1	RPD	EPH (C10-C19)	2017/06/05	NC		%	30
8652630	AD5	Matrix Spike [RE7980-08]	Dissolved Aluminum (Al)	2017/06/07		104	%	80 - 120

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Dissolved Antimony (Sb)	2017/06/07		97	%	80 - 120
			Dissolved Arsenic (As)	2017/06/07		96	%	80 - 120
			Dissolved Barium (Ba)	2017/06/07		100	%	80 - 120
			Dissolved Beryllium (Be)	2017/06/07		102	%	80 - 120
			Dissolved Bismuth (Bi)	2017/06/07		95	%	80 - 120
			Dissolved Boron (B)	2017/06/07		99	%	80 - 120
			Dissolved Cadmium (Cd)	2017/06/07		93	%	80 - 120
			Dissolved Chromium (Cr)	2017/06/07		97	%	80 - 120
			Dissolved Cobalt (Co)	2017/06/07		96	%	80 - 120
			Dissolved Copper (Cu)	2017/06/07		96	%	80 - 120
			Dissolved Iron (Fe)	2017/06/07		106	%	80 - 120
			Dissolved Lead (Pb)	2017/06/07		96	%	80 - 120
			Dissolved Lithium (Li)	2017/06/07		103	%	80 - 120
			Dissolved Manganese (Mn)	2017/06/07		93	%	80 - 120
			Dissolved Molybdenum (Mo)	2017/06/07		99	%	80 - 120
			Dissolved Nickel (Ni)	2017/06/07		97	%	80 - 120
			Dissolved Selenium (Se)	2017/06/07		98	%	80 - 120
			Dissolved Silver (Ag)	2017/06/07		99	%	80 - 120
			Dissolved Strontium (Sr)	2017/06/07		NC	%	80 - 120
			Dissolved Thallium (Tl)	2017/06/07		96	%	80 - 120
			Dissolved Tin (Sn)	2017/06/07		94	%	80 - 120
			Dissolved Titanium (Ti)	2017/06/07		92	%	80 - 120
			Dissolved Uranium (U)	2017/06/07		99	%	80 - 120
			Dissolved Vanadium (V)	2017/06/07		97	%	80 - 120
			Dissolved Zinc (Zn)	2017/06/07		97	%	80 - 120
8652630	AD5	Spiked Blank	Dissolved Aluminum (Al)	2017/06/07		107	%	80 - 120
			Dissolved Antimony (Sb)	2017/06/07		97	%	80 - 120
			Dissolved Arsenic (As)	2017/06/07		99	%	80 - 120
			Dissolved Barium (Ba)	2017/06/07		99	%	80 - 120
			Dissolved Beryllium (Be)	2017/06/07		102	%	80 - 120
			Dissolved Bismuth (Bi)	2017/06/07		95	%	80 - 120
			Dissolved Boron (B)	2017/06/07		99	%	80 - 120
			Dissolved Cadmium (Cd)	2017/06/07		96	%	80 - 120
			Dissolved Chromium (Cr)	2017/06/07		101	%	80 - 120
			Dissolved Cobalt (Co)	2017/06/07		99	%	80 - 120
			Dissolved Copper (Cu)	2017/06/07		101	%	80 - 120
			Dissolved Iron (Fe)	2017/06/07		104	%	80 - 120
			Dissolved Lead (Pb)	2017/06/07		96	%	80 - 120
			Dissolved Lithium (Li)	2017/06/07		103	%	80 - 120
			Dissolved Manganese (Mn)	2017/06/07		98	%	80 - 120
			Dissolved Molybdenum (Mo)	2017/06/07		99	%	80 - 120
			Dissolved Nickel (Ni)	2017/06/07		101	%	80 - 120
			Dissolved Selenium (Se)	2017/06/07		98	%	80 - 120
			Dissolved Silver (Ag)	2017/06/07		103	%	80 - 120
			Dissolved Strontium (Sr)	2017/06/07		96	%	80 - 120
			Dissolved Thallium (Tl)	2017/06/07		95	%	80 - 120
			Dissolved Tin (Sn)	2017/06/07		95	%	80 - 120
			Dissolved Titanium (Ti)	2017/06/07		96	%	80 - 120
			Dissolved Uranium (U)	2017/06/07		98	%	80 - 120
			Dissolved Vanadium (V)	2017/06/07		99	%	80 - 120
			Dissolved Zinc (Zn)	2017/06/07		102	%	80 - 120
8652630	AD5	Method Blank	Dissolved Aluminum (Al)	2017/06/07	<3.0		ug/L	
			Dissolved Antimony (Sb)	2017/06/07	<0.50		ug/L	
			Dissolved Arsenic (As)	2017/06/07	<0.10		ug/L	
			Dissolved Barium (Ba)	2017/06/07	<1.0		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Dissolved Beryllium (Be)	2017/06/07	<0.10		ug/L	
			Dissolved Bismuth (Bi)	2017/06/07	<1.0		ug/L	
			Dissolved Boron (B)	2017/06/07	<50		ug/L	
			Dissolved Cadmium (Cd)	2017/06/07	<0.010		ug/L	
			Dissolved Chromium (Cr)	2017/06/07	<1.0		ug/L	
			Dissolved Cobalt (Co)	2017/06/07	<0.20		ug/L	
			Dissolved Copper (Cu)	2017/06/07	<0.20		ug/L	
			Dissolved Iron (Fe)	2017/06/07	<5.0		ug/L	
			Dissolved Lead (Pb)	2017/06/07	<0.20		ug/L	
			Dissolved Lithium (Li)	2017/06/07	<2.0		ug/L	
			Dissolved Manganese (Mn)	2017/06/07	<1.0		ug/L	
			Dissolved Molybdenum (Mo)	2017/06/07	<1.0		ug/L	
			Dissolved Nickel (Ni)	2017/06/07	<1.0		ug/L	
			Dissolved Selenium (Se)	2017/06/07	<0.10		ug/L	
			Dissolved Silicon (Si)	2017/06/07	<100		ug/L	
			Dissolved Silver (Ag)	2017/06/07	<0.020		ug/L	
			Dissolved Strontium (Sr)	2017/06/07	<1.0		ug/L	
			Dissolved Thallium (Tl)	2017/06/07	<0.010		ug/L	
			Dissolved Tin (Sn)	2017/06/07	<5.0		ug/L	
			Dissolved Titanium (Ti)	2017/06/07	<5.0		ug/L	
			Dissolved Uranium (U)	2017/06/07	<0.10		ug/L	
			Dissolved Vanadium (V)	2017/06/07	<5.0		ug/L	
			Dissolved Zinc (Zn)	2017/06/07	<5.0		ug/L	
			Dissolved Zirconium (Zr)	2017/06/07	<0.10		ug/L	
8652630	AD5	RPD [RE7980-08]	Dissolved Aluminum (Al)	2017/06/07	1.1		%	20
			Dissolved Antimony (Sb)	2017/06/07	NC		%	20
			Dissolved Arsenic (As)	2017/06/07	NC		%	20
			Dissolved Barium (Ba)	2017/06/07	0.081		%	20
			Dissolved Beryllium (Be)	2017/06/07	NC		%	20
			Dissolved Bismuth (Bi)	2017/06/07	NC		%	20
			Dissolved Boron (B)	2017/06/07	NC		%	20
			Dissolved Cadmium (Cd)	2017/06/07	NC		%	20
			Dissolved Chromium (Cr)	2017/06/07	NC		%	20
			Dissolved Cobalt (Co)	2017/06/07	NC		%	20
			Dissolved Copper (Cu)	2017/06/07	1.5		%	20
			Dissolved Iron (Fe)	2017/06/07	1.5		%	20
			Dissolved Lead (Pb)	2017/06/07	NC		%	20
			Dissolved Lithium (Li)	2017/06/07	NC		%	20
			Dissolved Manganese (Mn)	2017/06/07	0.92		%	20
			Dissolved Molybdenum (Mo)	2017/06/07	NC		%	20
			Dissolved Nickel (Ni)	2017/06/07	NC		%	20
			Dissolved Selenium (Se)	2017/06/07	NC		%	20
			Dissolved Silicon (Si)	2017/06/07	0.56		%	20
			Dissolved Silver (Ag)	2017/06/07	NC		%	20
			Dissolved Strontium (Sr)	2017/06/07	2.5		%	20
			Dissolved Thallium (Tl)	2017/06/07	NC		%	20
			Dissolved Tin (Sn)	2017/06/07	NC		%	20
			Dissolved Titanium (Ti)	2017/06/07	NC		%	20
			Dissolved Uranium (U)	2017/06/07	NC		%	20
			Dissolved Vanadium (V)	2017/06/07	NC		%	20
			Dissolved Zinc (Zn)	2017/06/07	NC		%	20
			Dissolved Zirconium (Zr)	2017/06/07	NC		%	20
8652657	AD5	Matrix Spike	Total Aluminum (Al)	2017/06/07		114	%	80 - 120
			Total Antimony (Sb)	2017/06/07		104	%	80 - 120
			Total Arsenic (As)	2017/06/07		107	%	80 - 120

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Barium (Ba)	2017/06/07		NC	%	80 - 120
			Total Beryllium (Be)	2017/06/07		105	%	80 - 120
			Total Bismuth (Bi)	2017/06/07		101	%	80 - 120
			Total Boron (B)	2017/06/07		NC	%	80 - 120
			Total Cadmium (Cd)	2017/06/07		103	%	80 - 120
			Total Chromium (Cr)	2017/06/07		99	%	80 - 120
			Total Cobalt (Co)	2017/06/07		96	%	80 - 120
			Total Copper (Cu)	2017/06/07		142 (1)	%	80 - 120
			Total Iron (Fe)	2017/06/07		NC	%	80 - 120
			Total Lead (Pb)	2017/06/07		103	%	80 - 120
			Total Lithium (Li)	2017/06/07		NC	%	80 - 120
			Total Manganese (Mn)	2017/06/07		NC	%	80 - 120
			Total Molybdenum (Mo)	2017/06/07		114	%	80 - 120
			Total Nickel (Ni)	2017/06/07		97	%	80 - 120
			Total Selenium (Se)	2017/06/07		102	%	80 - 120
			Total Silver (Ag)	2017/06/07		105	%	80 - 120
			Total Strontium (Sr)	2017/06/07		NC	%	80 - 120
			Total Thallium (Tl)	2017/06/07		102	%	80 - 120
			Total Tin (Sn)	2017/06/07		109	%	80 - 120
			Total Titanium (Ti)	2017/06/07		94	%	80 - 120
			Total Uranium (U)	2017/06/07		104	%	80 - 120
			Total Vanadium (V)	2017/06/07		100	%	80 - 120
			Total Zinc (Zn)	2017/06/07		112	%	80 - 120
8652657	AD5	Spiked Blank	Total Aluminum (Al)	2017/06/06		108	%	80 - 120
			Total Antimony (Sb)	2017/06/06		101	%	80 - 120
			Total Arsenic (As)	2017/06/06		103	%	80 - 120
			Total Barium (Ba)	2017/06/06		100	%	80 - 120
			Total Beryllium (Be)	2017/06/06		99	%	80 - 120
			Total Bismuth (Bi)	2017/06/06		97	%	80 - 120
			Total Boron (B)	2017/06/06		102	%	80 - 120
			Total Cadmium (Cd)	2017/06/06		105	%	80 - 120
			Total Chromium (Cr)	2017/06/06		101	%	80 - 120
			Total Cobalt (Co)	2017/06/06		99	%	80 - 120
			Total Copper (Cu)	2017/06/06		99	%	80 - 120
			Total Iron (Fe)	2017/06/06		114	%	80 - 120
			Total Lead (Pb)	2017/06/06		96	%	80 - 120
			Total Lithium (Li)	2017/06/06		100	%	80 - 120
			Total Manganese (Mn)	2017/06/06		100	%	80 - 120
			Total Molybdenum (Mo)	2017/06/06		103	%	80 - 120
			Total Nickel (Ni)	2017/06/06		102	%	80 - 120
			Total Selenium (Se)	2017/06/06		103	%	80 - 120
			Total Silver (Ag)	2017/06/06		105	%	80 - 120
			Total Strontium (Sr)	2017/06/06		100	%	80 - 120
			Total Thallium (Tl)	2017/06/06		98	%	80 - 120
			Total Tin (Sn)	2017/06/06		102	%	80 - 120
			Total Titanium (Ti)	2017/06/06		97	%	80 - 120
			Total Uranium (U)	2017/06/06		98	%	80 - 120
			Total Vanadium (V)	2017/06/06		99	%	80 - 120
			Total Zinc (Zn)	2017/06/06		103	%	80 - 120
8652657	AD5	Method Blank	Total Aluminum (Al)	2017/06/06	<3.0		ug/L	
			Total Antimony (Sb)	2017/06/06	<0.50		ug/L	
			Total Arsenic (As)	2017/06/06	<0.10		ug/L	
			Total Barium (Ba)	2017/06/06	<1.0		ug/L	
			Total Beryllium (Be)	2017/06/06	<0.10		ug/L	
			Total Bismuth (Bi)	2017/06/06	<1.0		ug/L	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Boron (B)	2017/06/06	<50		ug/L	
			Total Cadmium (Cd)	2017/06/06	<0.010		ug/L	
			Total Chromium (Cr)	2017/06/06	<1.0		ug/L	
			Total Cobalt (Co)	2017/06/06	<0.20		ug/L	
			Total Copper (Cu)	2017/06/06	<0.50		ug/L	
			Total Iron (Fe)	2017/06/06	<10		ug/L	
			Total Lead (Pb)	2017/06/06	<0.20		ug/L	
			Total Lithium (Li)	2017/06/06	<2.0		ug/L	
			Total Manganese (Mn)	2017/06/06	<1.0		ug/L	
			Total Molybdenum (Mo)	2017/06/06	<1.0		ug/L	
			Total Nickel (Ni)	2017/06/06	<1.0		ug/L	
			Total Selenium (Se)	2017/06/06	<0.10		ug/L	
			Total Silicon (Si)	2017/06/06	<100		ug/L	
			Total Silver (Ag)	2017/06/06	<0.020		ug/L	
			Total Strontium (Sr)	2017/06/06	<1.0		ug/L	
			Total Thallium (Tl)	2017/06/06	<0.010		ug/L	
			Total Tin (Sn)	2017/06/06	<5.0		ug/L	
			Total Titanium (Ti)	2017/06/06	<5.0		ug/L	
			Total Uranium (U)	2017/06/06	<0.10		ug/L	
			Total Vanadium (V)	2017/06/06	<5.0		ug/L	
			Total Zinc (Zn)	2017/06/06	<5.0		ug/L	
			Total Zirconium (Zr)	2017/06/06	<0.10		ug/L	
8652657	AD5	RPD	Total Aluminum (Al)	2017/06/06	16		%	20
			Total Antimony (Sb)	2017/06/06	NC		%	20
			Total Arsenic (As)	2017/06/06	8.8		%	20
			Total Barium (Ba)	2017/06/06	5.9		%	20
			Total Beryllium (Be)	2017/06/06	NC		%	20
			Total Bismuth (Bi)	2017/06/06	NC		%	20
			Total Boron (B)	2017/06/06	3.4		%	20
			Total Cadmium (Cd)	2017/06/06	NC		%	20
			Total Chromium (Cr)	2017/06/06	NC		%	20
			Total Cobalt (Co)	2017/06/06	15		%	20
			Total Copper (Cu)	2017/06/06	20		%	20
			Total Iron (Fe)	2017/06/06	3.1		%	20
			Total Lead (Pb)	2017/06/06	12		%	20
			Total Lithium (Li)	2017/06/06	5.6		%	20
			Total Manganese (Mn)	2017/06/06	11		%	20
			Total Molybdenum (Mo)	2017/06/06	NC		%	20
			Total Nickel (Ni)	2017/06/06	NC		%	20
			Total Selenium (Se)	2017/06/06	NC		%	20
			Total Silicon (Si)	2017/06/06	3.4		%	20
			Total Silver (Ag)	2017/06/06	NC		%	20
			Total Strontium (Sr)	2017/06/06	8.5		%	20
			Total Thallium (Tl)	2017/06/06	NC		%	20
			Total Tin (Sn)	2017/06/06	NC		%	20
			Total Titanium (Ti)	2017/06/06	NC		%	20
			Total Uranium (U)	2017/06/06	NC		%	20
			Total Vanadium (V)	2017/06/06	NC		%	20
			Total Zinc (Zn)	2017/06/06	2.1		%	20
			Total Zirconium (Zr)	2017/06/06	NC		%	20
8652807	J-H	Spiked Blank	True Colour	2017/06/02		91	%	80 - 120
8652807	J-H	Method Blank	True Colour	2017/06/02	<5		Col. Unit	
8652807	J-H	RPD	True Colour	2017/06/02	NC		%	10
8653135	RSA	Matrix Spike [RE7980-11]	Methyl Sulfone (sur.)	2017/06/08		99	%	70 - 130
			Ethylene Glycol	2017/06/08		89	%	70 - 130

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Diethylene Glycol	2017/06/08		93	%	70 - 130
			Triethylene Glycol	2017/06/08		90	%	70 - 130
			Tetraethylene Glycol	2017/06/08		99	%	70 - 130
			Propylene Glycol	2017/06/08		90	%	70 - 130
8653135	RSA	Spiked Blank	Methyl Sulfone (sur.)	2017/06/08		94	%	70 - 130
			Ethylene Glycol	2017/06/08		86	%	70 - 130
			Diethylene Glycol	2017/06/08		86	%	70 - 130
			Triethylene Glycol	2017/06/08		84	%	70 - 130
			Tetraethylene Glycol	2017/06/08		87	%	70 - 130
			Propylene Glycol	2017/06/08		86	%	70 - 130
8653135	RSA	Method Blank	Methyl Sulfone (sur.)	2017/06/08		99	%	70 - 130
			Ethylene Glycol	2017/06/08	<3.0		mg/L	
			Diethylene Glycol	2017/06/08	<5.0		mg/L	
			Triethylene Glycol	2017/06/08	<5.0		mg/L	
			Tetraethylene Glycol	2017/06/08	<5.0		mg/L	
			Propylene Glycol	2017/06/08	<5.0		mg/L	
8653135	RSA	RPD [RE7980-11]	Ethylene Glycol	2017/06/08	NC		%	30
			Diethylene Glycol	2017/06/08	NC		%	30
			Triethylene Glycol	2017/06/08	NC		%	30
			Tetraethylene Glycol	2017/06/08	NC		%	30
			Propylene Glycol	2017/06/08	NC		%	30
8653193	OMA	Spiked Blank	Conductivity	2017/06/06		103	%	90 - 110
8653193	OMA	Method Blank	Conductivity	2017/06/06	1,RDL=1		uS/cm	
8653193	OMA	RPD	Conductivity	2017/06/06	0		%	20
8653194	MM3	Matrix Spike	Alkalinity (Total as CaCO3)	2017/06/06		NC	%	80 - 120
			Alkalinity (PP as CaCO3)	2017/06/06		0	%	N/A
8653194	MM3	Spiked Blank	Alkalinity (Total as CaCO3)	2017/06/06		92	%	80 - 120
8653194	MM3	Method Blank	Alkalinity (Total as CaCO3)	2017/06/06	<0.5		mg/L	
			Alkalinity (PP as CaCO3)	2017/06/06	<0.5		mg/L	
			Bicarbonate (HCO3)	2017/06/06	<0.5		mg/L	
			Carbonate (CO3)	2017/06/06	<0.5		mg/L	
			Hydroxide (OH)	2017/06/06	<0.5		mg/L	
8653194	MM3	RPD	Alkalinity (Total as CaCO3)	2017/06/06	3.8		%	20
			Alkalinity (PP as CaCO3)	2017/06/06	NC		%	20
			Bicarbonate (HCO3)	2017/06/06	3.8		%	20
			Carbonate (CO3)	2017/06/06	NC		%	20
			Hydroxide (OH)	2017/06/06	NC		%	20
8653261	SS9	Matrix Spike	1,4-Difluorobenzene (sur.)	2017/06/07		112	%	70 - 130
			4-Bromofluorobenzene (sur.)	2017/06/07		102	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017/06/07		106	%	70 - 130
			Chloromethane	2017/06/07		108	%	60 - 140
			Vinyl chloride	2017/06/07		112	%	60 - 140
			Chloroethane	2017/06/07		103	%	60 - 140
			Trichlorofluoromethane	2017/06/07		119	%	60 - 140
			Dichlorodifluoromethane	2017/06/07		115	%	60 - 140
			1,1-dichloroethene	2017/06/07		102	%	70 - 130
			Dichloromethane	2017/06/07		103	%	70 - 130
			trans-1,2-dichloroethene	2017/06/07		101	%	70 - 130
			1,1-dichloroethane	2017/06/07		105	%	70 - 130
			cis-1,2-dichloroethene	2017/06/07		104	%	70 - 130
			Chloroform	2017/06/07		105	%	70 - 130
			1,1,1-trichloroethane	2017/06/07		108	%	70 - 130
			1,2-dichloroethane	2017/06/07		104	%	70 - 130
			Carbon tetrachloride	2017/06/07		108	%	70 - 130
			Benzene	2017/06/07		103	%	70 - 130

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Methyl-tert-butylether (MTBE)	2017/06/07		105	%	70 - 130
			1,2-dichloropropane	2017/06/07		102	%	70 - 130
			cis-1,3-dichloropropene	2017/06/07		101	%	70 - 130
			trans-1,3-dichloropropene	2017/06/07		75	%	70 - 130
			Bromomethane	2017/06/07		112	%	60 - 140
			1,1,2-trichloroethane	2017/06/07		105	%	70 - 130
			Trichloroethene	2017/06/07		102	%	70 - 130
			Chlorodibromomethane	2017/06/07		109	%	70 - 130
			1,2-dibromoethane	2017/06/07		105	%	70 - 130
			Tetrachloroethene	2017/06/07		105	%	70 - 130
			Bromodichloromethane	2017/06/07		105	%	70 - 130
			Toluene	2017/06/07		90	%	70 - 130
			Ethylbenzene	2017/06/07		99	%	70 - 130
			m & p-Xylene	2017/06/07		103	%	70 - 130
			Bromoform	2017/06/07		96	%	70 - 130
			Styrene	2017/06/07		106	%	70 - 130
			o-Xylene	2017/06/07		101	%	70 - 130
			1,1,1,2-tetrachloroethane	2017/06/07		105	%	70 - 130
			1,1,2,2-tetrachloroethane	2017/06/07		92	%	70 - 130
			1,2-dichlorobenzene	2017/06/07		91	%	70 - 130
			1,3-dichlorobenzene	2017/06/07		82	%	70 - 130
			1,4-dichlorobenzene	2017/06/07		86	%	70 - 130
			Chlorobenzene	2017/06/07		102	%	70 - 130
			1,2,3-trichlorobenzene	2017/06/07		77	%	70 - 130
			1,2,4-trichlorobenzene	2017/06/07		73	%	70 - 130
			Hexachlorobutadiene	2017/06/07		74	%	70 - 130
8653261	SS9	Spiked Blank	1,4-Difluorobenzene (sur.)	2017/06/07		111	%	70 - 130
			4-Bromofluorobenzene (sur.)	2017/06/07		98	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017/06/07		104	%	70 - 130
			Chloromethane	2017/06/07		104	%	60 - 140
			Vinyl chloride	2017/06/07		107	%	60 - 140
			Chloroethane	2017/06/07		90	%	60 - 140
			Trichlorofluoromethane	2017/06/07		114	%	60 - 140
			Dichlorodifluoromethane	2017/06/07		110	%	60 - 140
			1,1-dichloroethene	2017/06/07		106	%	70 - 130
			Dichloromethane	2017/06/07		100	%	70 - 130
			trans-1,2-dichloroethene	2017/06/07		96	%	70 - 130
			1,1-dichloroethane	2017/06/07		101	%	70 - 130
			cis-1,2-dichloroethene	2017/06/07		100	%	70 - 130
			Chloroform	2017/06/07		100	%	70 - 130
			1,1,1-trichloroethane	2017/06/07		104	%	70 - 130
			1,2-dichloroethane	2017/06/07		97	%	70 - 130
			Carbon tetrachloride	2017/06/07		103	%	70 - 130
			Benzene	2017/06/07		95	%	70 - 130
			Methyl-tert-butylether (MTBE)	2017/06/07		101	%	70 - 130
			1,2-dichloropropane	2017/06/07		98	%	70 - 130
			cis-1,3-dichloropropene	2017/06/07		87	%	70 - 130
			trans-1,3-dichloropropene	2017/06/07		65 (1)	%	70 - 130
			Bromomethane	2017/06/07		125	%	60 - 140
			1,1,2-trichloroethane	2017/06/07		104	%	70 - 130
			Trichloroethene	2017/06/07		97	%	70 - 130
			Chlorodibromomethane	2017/06/07		102	%	70 - 130
			1,2-dibromoethane	2017/06/07		101	%	70 - 130
			Tetrachloroethene	2017/06/07		99	%	70 - 130
			Bromodichloromethane	2017/06/07		99	%	70 - 130

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Toluene	2017/06/07		85	%	70 - 130
			Ethylbenzene	2017/06/07		94	%	70 - 130
			m & p-Xylene	2017/06/07		95	%	70 - 130
			Bromoform	2017/06/07		98	%	70 - 130
			Styrene	2017/06/07		99	%	70 - 130
			o-Xylene	2017/06/07		95	%	70 - 130
			1,1,1,2-tetrachloroethane	2017/06/07		100	%	70 - 130
			1,1,2,2-tetrachloroethane	2017/06/07		93	%	70 - 130
			1,2-dichlorobenzene	2017/06/07		92	%	70 - 130
			1,3-dichlorobenzene	2017/06/07		96	%	70 - 130
			1,4-dichlorobenzene	2017/06/07		85	%	70 - 130
			Chlorobenzene	2017/06/07		96	%	70 - 130
			1,2,3-trichlorobenzene	2017/06/07		76	%	70 - 130
			1,2,4-trichlorobenzene	2017/06/07		73	%	70 - 130
			Hexachlorobutadiene	2017/06/07		75	%	70 - 130
			VH C6-C10	2017/06/07		79	%	70 - 130
8653261	SS9	Method Blank	1,4-Difluorobenzene (sur.)	2017/06/07		100	%	70 - 130
			4-Bromofluorobenzene (sur.)	2017/06/07		80	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017/06/07		87	%	70 - 130
			Chloromethane	2017/06/07	<1.0		ug/L	
			Vinyl chloride	2017/06/07	<0.50		ug/L	
			Chloroethane	2017/06/07	<1.0		ug/L	
			Trichlorofluoromethane	2017/06/07	<4.0		ug/L	
			1,1,2Trichloro-1,2,2Trifluoroethane	2017/06/07	<2.0		ug/L	
			Dichlorodifluoromethane	2017/06/07	<2.0		ug/L	
			1,1-dichloroethene	2017/06/07	<0.50		ug/L	
			Dichloromethane	2017/06/07	<2.0		ug/L	
			trans-1,2-dichloroethene	2017/06/07	<1.0		ug/L	
			1,1-dichloroethane	2017/06/07	<0.50		ug/L	
			cis-1,2-dichloroethene	2017/06/07	<1.0		ug/L	
			Chloroform	2017/06/07	<1.0		ug/L	
			1,1,1-trichloroethane	2017/06/07	<0.50		ug/L	
			1,2-dichloroethane	2017/06/07	<0.50		ug/L	
			Carbon tetrachloride	2017/06/07	<0.50		ug/L	
			Benzene	2017/06/07	<0.40		ug/L	
			Methyl-tert-butylether (MTBE)	2017/06/07	<4.0		ug/L	
			1,2-dichloropropane	2017/06/07	<0.50		ug/L	
			cis-1,3-dichloropropene	2017/06/07	<1.0		ug/L	
			trans-1,3-dichloropropene	2017/06/07	<1.0		ug/L	
			Bromomethane	2017/06/07	<1.0		ug/L	
			1,1,2-trichloroethane	2017/06/07	<0.50		ug/L	
			Trichloroethene	2017/06/07	<0.50		ug/L	
			Chlorodibromomethane	2017/06/07	<1.0		ug/L	
			1,2-dibromoethane	2017/06/07	<0.20		ug/L	
			Tetrachloroethene	2017/06/07	<0.50		ug/L	
			Bromodichloromethane	2017/06/07	<1.0		ug/L	
			Toluene	2017/06/07	<0.40		ug/L	
			Ethylbenzene	2017/06/07	<0.40		ug/L	
			m & p-Xylene	2017/06/07	<0.40		ug/L	
			Bromoform	2017/06/07	<1.0		ug/L	
			Styrene	2017/06/07	<0.50		ug/L	
			o-Xylene	2017/06/07	<0.40		ug/L	
			Xylenes (Total)	2017/06/07	<0.40		ug/L	
			1,1,1,2-tetrachloroethane	2017/06/07	<0.50		ug/L	
			1,1,2,2-tetrachloroethane	2017/06/07	<0.50		ug/L	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			1,2-dichlorobenzene	2017/06/07	<0.50		ug/L	
			1,3-dichlorobenzene	2017/06/07	<0.50		ug/L	
			1,4-dichlorobenzene	2017/06/07	<0.50		ug/L	
			Chlorobenzene	2017/06/07	<0.50		ug/L	
			1,2,3-trichlorobenzene	2017/06/07	<2.0		ug/L	
			1,2,4-trichlorobenzene	2017/06/07	<2.0		ug/L	
			Hexachlorobutadiene	2017/06/07	<0.50		ug/L	
			VH C6-C10	2017/06/07	<300		ug/L	
8653261	SS9	RPD	1,2-dichloroethane	2017/06/07	NC		%	30
			Benzene	2017/06/07	NC		%	30
			Methyl-tert-butylether (MTBE)	2017/06/07	NC		%	30
			1,2-dibromoethane	2017/06/07	NC		%	30
			Toluene	2017/06/07	NC		%	30
			Ethylbenzene	2017/06/07	NC		%	30
			m & p-Xylene	2017/06/07	NC		%	30
			Styrene	2017/06/07	NC		%	30
			o-Xylene	2017/06/07	NC		%	30
			Xylenes (Total)	2017/06/07	NC		%	30
			VH C6-C10	2017/06/07	NC		%	30
8653344	BB3	Matrix Spike	Dissolved Chloride (Cl)	2017/06/05		108	%	80 - 120
8653344	BB3	Spiked Blank	Dissolved Chloride (Cl)	2017/06/05		98	%	80 - 120
8653344	BB3	Method Blank	Dissolved Chloride (Cl)	2017/06/05	<0.50		mg/L	
8653344	BB3	RPD	Dissolved Chloride (Cl)	2017/06/05	3.0		%	20
			Dissolved Chloride (Cl)	2017/06/05	3.2		%	20
8653364	BB3	Matrix Spike	Dissolved Sulphate (SO4)	2017/06/05		NC	%	80 - 120
8653364	BB3	Spiked Blank	Dissolved Sulphate (SO4)	2017/06/05		97	%	80 - 120
8653364	BB3	Method Blank	Dissolved Sulphate (SO4)	2017/06/05	<0.50		mg/L	
8653364	BB3	RPD	Dissolved Sulphate (SO4)	2017/06/05	3.8		%	20
8653737	AD5	Matrix Spike	Total Aluminum (Al)	2017/06/07		107	%	80 - 120
			Total Antimony (Sb)	2017/06/07		99	%	80 - 120
			Total Arsenic (As)	2017/06/07		98	%	80 - 120
			Total Barium (Ba)	2017/06/07		100	%	80 - 120
			Total Beryllium (Be)	2017/06/07		101	%	80 - 120
			Total Bismuth (Bi)	2017/06/07		96	%	80 - 120
			Total Boron (B)	2017/06/07		94	%	80 - 120
			Total Cadmium (Cd)	2017/06/07		103	%	80 - 120
			Total Chromium (Cr)	2017/06/07		97	%	80 - 120
			Total Cobalt (Co)	2017/06/07		94	%	80 - 120
			Total Copper (Cu)	2017/06/07		96	%	80 - 120
			Total Iron (Fe)	2017/06/07		97	%	80 - 120
			Total Lead (Pb)	2017/06/07		97	%	80 - 120
			Total Lithium (Li)	2017/06/07		102	%	80 - 120
			Total Manganese (Mn)	2017/06/07		96	%	80 - 120
			Total Molybdenum (Mo)	2017/06/07		98	%	80 - 120
			Total Nickel (Ni)	2017/06/07		97	%	80 - 120
			Total Selenium (Se)	2017/06/07		97	%	80 - 120
			Total Silver (Ag)	2017/06/07		102	%	80 - 120
			Total Strontium (Sr)	2017/06/07		98	%	80 - 120
			Total Thallium (Tl)	2017/06/07		96	%	80 - 120
			Total Tin (Sn)	2017/06/07		99	%	80 - 120
			Total Titanium (Ti)	2017/06/07		98	%	80 - 120
			Total Uranium (U)	2017/06/07		97	%	80 - 120
			Total Vanadium (V)	2017/06/07		96	%	80 - 120
			Total Zinc (Zn)	2017/06/07		99	%	80 - 120
8653737	AD5	Spiked Blank	Total Aluminum (Al)	2017/06/07		108	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Antimony (Sb)	2017/06/07		99	%	80 - 120
			Total Arsenic (As)	2017/06/07		93	%	80 - 120
			Total Barium (Ba)	2017/06/07		101	%	80 - 120
			Total Beryllium (Be)	2017/06/07		101	%	80 - 120
			Total Bismuth (Bi)	2017/06/07		98	%	80 - 120
			Total Boron (B)	2017/06/07		102	%	80 - 120
			Total Cadmium (Cd)	2017/06/07		97	%	80 - 120
			Total Chromium (Cr)	2017/06/07		92	%	80 - 120
			Total Cobalt (Co)	2017/06/07		92	%	80 - 120
			Total Copper (Cu)	2017/06/07		92	%	80 - 120
			Total Iron (Fe)	2017/06/07		103	%	80 - 120
			Total Lead (Pb)	2017/06/07		99	%	80 - 120
			Total Lithium (Li)	2017/06/07		101	%	80 - 120
			Total Manganese (Mn)	2017/06/07		93	%	80 - 120
			Total Molybdenum (Mo)	2017/06/07		101	%	80 - 120
			Total Nickel (Ni)	2017/06/07		92	%	80 - 120
			Total Selenium (Se)	2017/06/07		101	%	80 - 120
			Total Silver (Ag)	2017/06/07		104	%	80 - 120
			Total Strontium (Sr)	2017/06/07		90	%	80 - 120
			Total Thallium (Tl)	2017/06/07		98	%	80 - 120
			Total Tin (Sn)	2017/06/07		99	%	80 - 120
			Total Titanium (Ti)	2017/06/07		89	%	80 - 120
			Total Uranium (U)	2017/06/07		100	%	80 - 120
			Total Vanadium (V)	2017/06/07		91	%	80 - 120
			Total Zinc (Zn)	2017/06/07		94	%	80 - 120
8653737	AD5	Method Blank	Total Aluminum (Al)	2017/06/07	<3.0		ug/L	
			Total Antimony (Sb)	2017/06/07	<0.50		ug/L	
			Total Arsenic (As)	2017/06/07	<0.10		ug/L	
			Total Barium (Ba)	2017/06/07	<1.0		ug/L	
			Total Beryllium (Be)	2017/06/07	<0.10		ug/L	
			Total Bismuth (Bi)	2017/06/07	<1.0		ug/L	
			Total Boron (B)	2017/06/07	<50		ug/L	
			Total Cadmium (Cd)	2017/06/07	<0.010		ug/L	
			Total Chromium (Cr)	2017/06/07	<1.0		ug/L	
			Total Cobalt (Co)	2017/06/07	<0.20		ug/L	
			Total Copper (Cu)	2017/06/07	<0.50		ug/L	
			Total Iron (Fe)	2017/06/07	<10		ug/L	
			Total Lead (Pb)	2017/06/07	<0.20		ug/L	
			Total Lithium (Li)	2017/06/07	<2.0		ug/L	
			Total Manganese (Mn)	2017/06/07	<1.0		ug/L	
			Total Molybdenum (Mo)	2017/06/07	<1.0		ug/L	
			Total Nickel (Ni)	2017/06/07	<1.0		ug/L	
			Total Selenium (Se)	2017/06/07	<0.10		ug/L	
			Total Silicon (Si)	2017/06/07	<100		ug/L	
			Total Silver (Ag)	2017/06/07	<0.020		ug/L	
			Total Strontium (Sr)	2017/06/07	<1.0		ug/L	
			Total Thallium (Tl)	2017/06/07	<0.010		ug/L	
			Total Tin (Sn)	2017/06/07	<5.0		ug/L	
			Total Titanium (Ti)	2017/06/07	<5.0		ug/L	
			Total Uranium (U)	2017/06/07	<0.10		ug/L	
			Total Vanadium (V)	2017/06/07	<5.0		ug/L	
			Total Zinc (Zn)	2017/06/07	<5.0		ug/L	
			Total Zirconium (Zr)	2017/06/07	<0.10		ug/L	
8653737	AD5	RPD	Total Aluminum (Al)	2017/06/07	NC		%	20
			Total Arsenic (As)	2017/06/07	NC		%	20

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Boron (B)	2017/06/07	NC		%	20
			Total Cadmium (Cd)	2017/06/07	NC		%	20
			Total Chromium (Cr)	2017/06/07	NC		%	20
			Total Cobalt (Co)	2017/06/07	NC		%	20
			Total Copper (Cu)	2017/06/07	NC		%	20
			Total Iron (Fe)	2017/06/07	NC		%	20
			Total Lead (Pb)	2017/06/07	NC		%	20
			Total Manganese (Mn)	2017/06/07	NC		%	20
			Total Molybdenum (Mo)	2017/06/07	NC		%	20
			Total Nickel (Ni)	2017/06/07	NC		%	20
			Total Selenium (Se)	2017/06/07	NC		%	20
			Total Silver (Ag)	2017/06/07	NC		%	20
			Total Zinc (Zn)	2017/06/07	NC		%	20
			Total Copper (Cu)	2017/06/07	2.0		%	20
			Total Silver (Ag)	2017/06/07	1.6		%	20
8654120	JHW	Spiked Blank	Total Suspended Solids	2017/06/08		98	%	80 - 120
8654120	JHW	Method Blank	Total Suspended Solids	2017/06/08	<1		mg/L	
8654120	JHW	RPD	Total Suspended Solids	2017/06/08	2.5		%	20
8654963	EL2	Matrix Spike	Total Mercury (Hg)	2017/06/07		95	%	80 - 120
8654963	EL2	Spiked Blank	Total Mercury (Hg)	2017/06/07		95	%	80 - 120
8654963	EL2	Method Blank	Total Mercury (Hg)	2017/06/07	<0.010		ug/L	
8654963	EL2	RPD	Total Mercury (Hg)	2017/06/07	NC		%	20
8656120	EL2	Matrix Spike [RE7981-09]	Dissolved Mercury (Hg)	2017/06/08		119	%	80 - 120
8656120	EL2	Spiked Blank	Dissolved Mercury (Hg)	2017/06/08		96	%	80 - 120
8656120	EL2	Method Blank	Dissolved Mercury (Hg)	2017/06/08	<0.010		ug/L	
8656120	EL2	RPD [RE7981-09]	Dissolved Mercury (Hg)	2017/06/08	NC		%	20
8656333	BB3	Matrix Spike [RE7980-03]	Fluoride (F)	2017/06/07		103	%	80 - 120
8656333	BB3	Spiked Blank	Fluoride (F)	2017/06/07		106	%	80 - 120
8656333	BB3	Method Blank	Fluoride (F)	2017/06/07	<0.010		mg/L	
8656333	BB3	RPD	Fluoride (F)	2017/06/07	0		%	20
8656340	BB3	Matrix Spike	Fluoride (F)	2017/06/07		106	%	80 - 120
8656340	BB3	Spiked Blank	Fluoride (F)	2017/06/07		106	%	80 - 120
8656340	BB3	Method Blank	Fluoride (F)	2017/06/07	<0.010		mg/L	
8656340	BB3	RPD [RE7981-03]	Fluoride (F)	2017/06/07	2.7		%	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Dennis Ngondu, B.Sc., P.Chem., QP, Supervisor, Organics

David Nadler, AASc, Victoria Operations Manager

Rob Reinert, B.Sc., Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam — A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
Unit 1 - 460 Tennyson Place, Victoria, British Columbia Canada V8Z 6S8 Tel:(250) 385 6112 Toll-free:800-563-6266 Fax:(250) 382 6364 www.maxxam.ca

Chain Of Custody Record

Page of

INVOICE TO:		Report Information		Project Information	
Company Name	#10129 Corporate Client - Maxxam Victoria	Company Name	#34450 SHAWNIGAN RESIDENTS ASSOC. (SRA)	Quotation #	B40228
Contact Name	Corporate Clients	Contact Name	DAVE HUTCHINSON	P.O. #	
Address	Unit 1 - 460 Tennyson Pl	Address	1176 SHAWNIGAN MILL BAY	Project #	
	Victoria BC V8Z 6S8		MILL BAY BC V0R2P2	Project Name	
Phone	(250) 385-6112 x Fax: (250) 382-6364 x	Phone	(250) 882-1843 x Fax:	Site #	
Email		Email	dave.shawnigan@shaw.ca	Sampled By	

Laboratory Use Only	
Maxxam Job #	Bottle Order #:
B743204	525592
Chain Of Custody Record	Project Manager
C#525592-01-01	BC Env Customer Service

Regulatory Criteria

Special Instructions

Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form

Samples must be kept cool (< 10°C) from time of sampling until delivery to maxxam

Turnaround Time (TAT) Required

Please provide advance notice for rush projects

Regular (Standard) TAT ☐
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ______ Time Required: ______ ☐
Rush Confirmation Number: ______ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / (N))	CSR Total Metals in Water with CV Hg	CSR Dissolved Metals in Water with CV Hg	Alkalinity, Anions (F,SO4,Cl,NO2,NO3)	CSR VOC (including BTEX)	EPH in Water by GC/FID	Glycols in Water by GC/FID	LEPH & HEPH with CSR/CCME PAH in Water	Total Suspended Solids	Colour (True), Conductivity		# of Bottles	Comments
1		S1	2017/06/02	10:30 AM				✓	✓	✓	✓	✓	✓	✓	✓	✓			
2		S2	2017/06/02	11:00 AM				✓	✓	✓	✓	✓	✓	✓	✓	✓			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
D. Hutchinson	2017/06/02	12:30PM	DQV N ADLER	June 02/17	12:30	

Lab Use Only		
Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
☐	9, 7, 8	☐ Yes ☒ No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

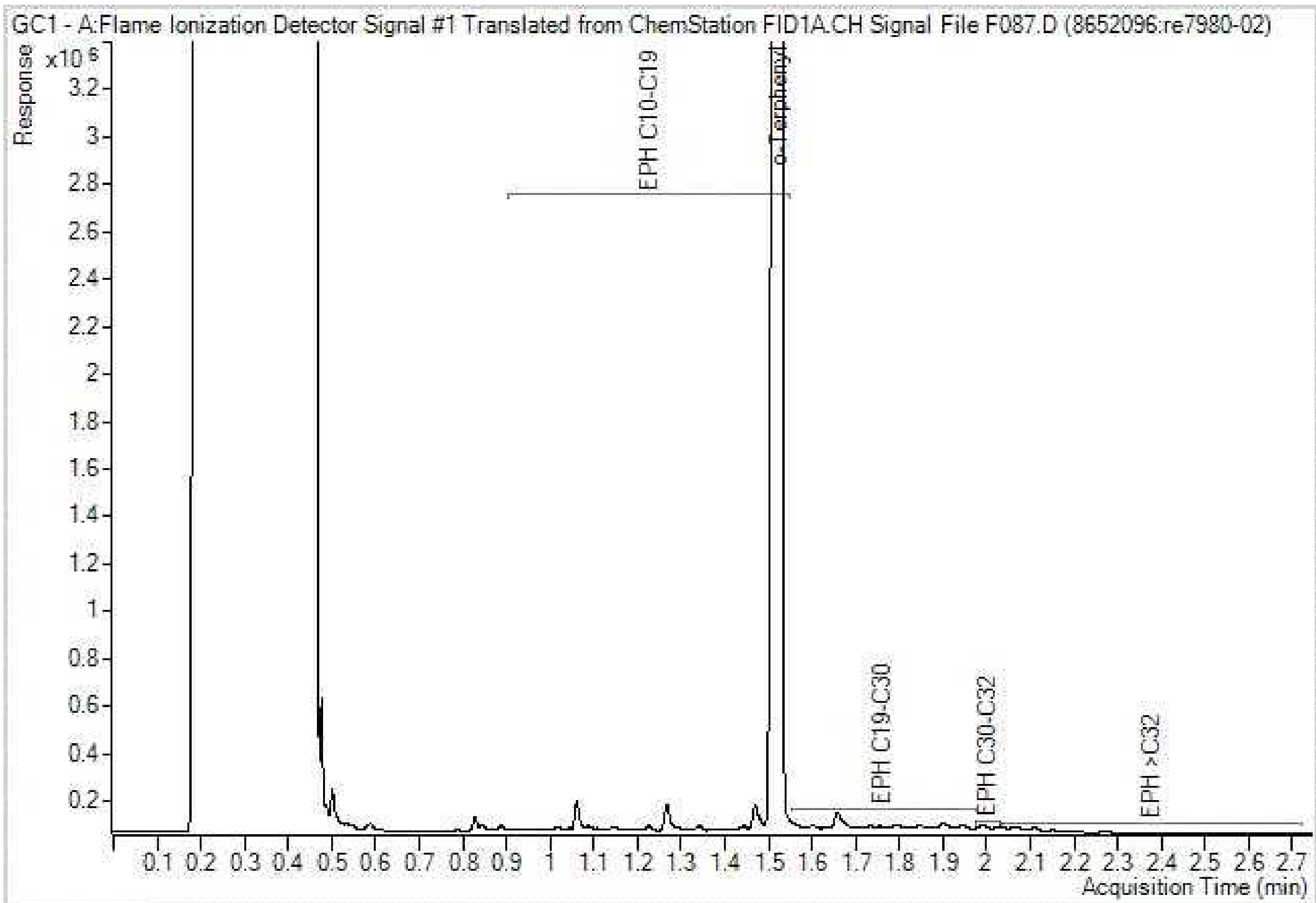
White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam Job #: B743204
Report Date: 2017/06/12
Maxxam Sample: RE7980

The Shawnigan Residents Association
Client ID: S1

EPH in Water when PAH required Chromatogram

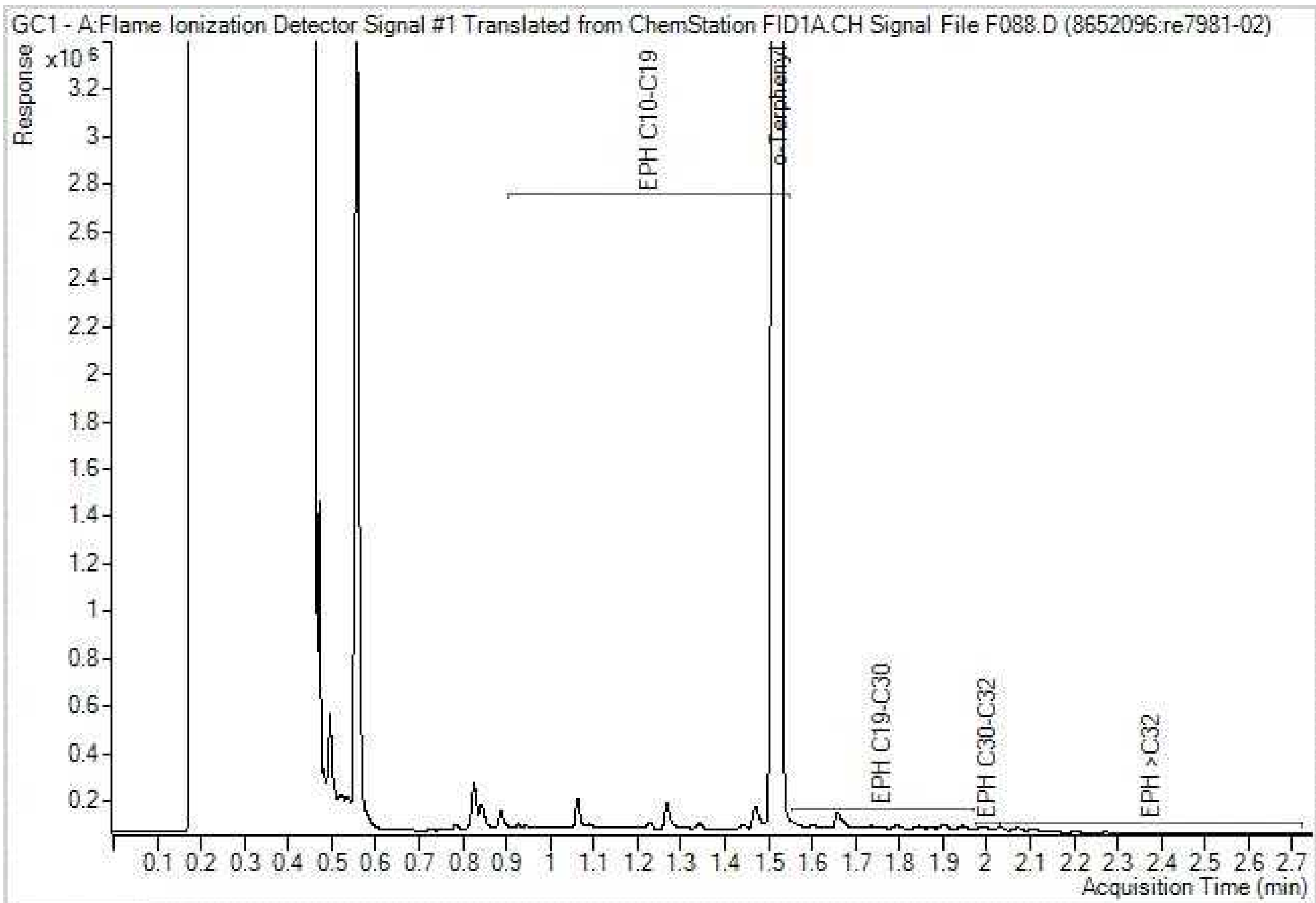


Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

Maxxam Job #: B743204
Report Date: 2017/06/12
Maxxam Sample: RE7981

The Shawnigan Residents Association
Client ID: S2

EPH in Water when PAH required Chromatogram



Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

The Shawnigan Residents Association

Maxxam Job Number: B743204
Report Date: 2017/06/12

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID			RE7980		RE7981		
Sampling Date			2017-06-02 10:30		2017-06-02 11:00		
COC Number			525592-01-01		525592-01-01		
	UNITS	**Criteria**	**S1**	**QC Batch**	**S2**	**RDL**	**QC Batch**
ANIONS							
Nitrite (N)	mg/L	-	<0.0050	8651532	<0.0050	0.0050	8651532
Calculated Parameters							
Filter and HNO3 Preservation	N/A	-	LAB	8652176	LAB		8652176
Nitrate (N)	mg/L	-	0.046	8649545	0.346	0.020	8649545
Misc. Inorganics							
Fluoride (F)	mg/L	-	0.015	8656333	0.037	0.010	8656340
Alkalinity (Total as CaCO3)	mg/L	10	7.4	8653194	**136**	0.5	8653194
Alkalinity (PP as CaCO3)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Bicarbonate (HCO3)	mg/L	-	9.1	8653194	166	0.5	8653194
Carbonate (CO3)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Hydroxide (OH)	mg/L	-	<0.5	8653194	<0.5	0.5	8653194
Total Suspended Solids	mg/L	-	<1	8654120	<1	1	8654120
Anions							
Dissolved Sulphate (SO4)	mg/L	-	1.10	8653364	110	0.50	8653364
Dissolved Chloride (Cl)	mg/L	-	1.9	8653344	44	0.50	8653344
MISCELLANEOUS							
True Colour	Col. Unit	-	9	8652807	<5	5	8652807
Nutrients							
Nitrate plus Nitrite (N)	mg/L	-	0.046	8651531	0.346	0.020	8651531
Physical Properties							
Conductivity	uS/cm	-	37	8653193	618	1	8653193

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Results relate only to the items tested.

The Shawnigan Residents Association

Maxxam Job Number: B743204

Report Date: 2017/06/12

GLYCOLS BY GC-FID (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017-06-02 10:30	2017-06-02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	**Criteria**	**S1**	**S2**	**RDL**	**QC Batch**
Glycols						
Ethylene Glycol	mg/L	192	<3.0	<3.0	3.0	8653135
Diethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Triethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Tetraethylene Glycol	mg/L	-	<5.0	<5.0	5.0	8653135
Propylene Glycol	mg/L	500	<5.0	<5.0	5.0	8653135
Surrogate Recovery (%)						
Methyl Sulfone (sur.)	%	-	81	78		8653135

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Results relate only to the items tested.

The Shawnigan Residents Association

Maxxam Job Number: B743204
Report Date: 2017/06/12

LEPH & HEPH WITH CSR/CCME PAH IN WATER (WATER)

Maxxam ID		RE7980	RE7981		
Sampling Date		2017-06-02 10:30	2017-06-02 11:00		
COC Number		525592-01-01	525592-01-01		
	UNITS	**S1**	**S2**	**RDL**	**QC Batch**
Polycyclic Aromatics					
Low Molecular Weight PAH`s	ug/L	<0.10	<0.10	0.10	8649651
High Molecular Weight PAH`s	ug/L	<0.050	<0.050	0.050	8649651
Total PAH	ug/L	<0.10	<0.10	0.10	8649651
Quinoline	ug/L	<0.020	<0.020	0.020	8652080
Naphthalene	ug/L	<0.10	<0.10	0.10	8652080
2-Methylnaphthalene	ug/L	<0.10	<0.10	0.10	8652080
Acenaphthylene	ug/L	<0.050	<0.050	0.050	8652080
Acenaphthene	ug/L	<0.050	<0.050	0.050	8652080
Fluorene	ug/L	<0.050	<0.050	0.050	8652080
Phenanthrene	ug/L	<0.050	<0.050	0.050	8652080
Anthracene	ug/L	<0.010	<0.010	0.010	8652080
Acridine	ug/L	<0.050	<0.050	0.050	8652080
Fluoranthene	ug/L	<0.020	<0.020	0.020	8652080
Pyrene	ug/L	<0.020	<0.020	0.020	8652080
Benzo(a)anthracene	ug/L	<0.010	<0.010	0.010	8652080
Chrysene	ug/L	<0.020	<0.020	0.020	8652080
Benzo(b&j)fluoranthene	ug/L	<0.030	<0.030	0.030	8652080
Benzo(k)fluoranthene	ug/L	<0.050	<0.050	0.050	8652080
Benzo(a)pyrene	ug/L	<0.0050	<0.0050	0.0050	8652080
Indeno(1,2,3-cd)pyrene	ug/L	<0.050	<0.050	0.050	8652080
Dibenz(a,h)anthracene	ug/L	<0.0030	<0.0030	0.0030	8652080
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	0.050	8652080
Calculated Parameters					
LEPH (C10-C19 less PAH)	mg/L	<0.20	<0.20	0.20	8650175
HEPH (C19-C32 less PAH)	mg/L	<0.20	<0.20	0.20	8650175
Ext. Pet. Hydrocarbon					
EPH (C10-C19)	mg/L	<0.20	<0.20	0.20	8652096
EPH (C19-C32)	mg/L	<0.20	<0.20	0.20	8652096
Surrogate Recovery (%)					
O-TERPHENYL (sur.)	%	94	91		8652096
D10-ANTHRACENE (sur.)	%	96	94		8652080
D8-ACENAPHTHYLENE (sur.)	%	99	97		8652080
D8-NAPHTHALENE (sur.)	%	89	79		8652080
D9-Acridine (sur.)	%	61	59		8652080
TERPHENYL-D14 (sur.)	%	94	92		8652080

RDL = Reportable Detection Limit

Results relate only to the items tested.

The Shawnigan Residents Association

Maxxam Job Number: B743204

Report Date: 2017/06/12

CSR DISSOLVED METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017-06-02 10:30	2017-06-02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	**Criteria**	**S1**	**S2**	**RDL**	**QC Batch**
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	-	14.7	271	0.50	8649574
Elements						
Dissolved Mercury (Hg)	ug/L	-	<0.010	<0.010	0.010	8656120
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	-	29.3	3.3	3.0	8652630
Dissolved Antimony (Sb)	ug/L	20	<0.50	<0.50	0.50	8652630
Dissolved Arsenic (As)	ug/L	5	<0.10	0.11	0.10	8652630
Dissolved Barium (Ba)	ug/L	1000	3.7	18.1	1.0	8652630
Dissolved Beryllium (Be)	ug/L	5.3	<0.10	<0.10	0.10	8652630
Dissolved Bismuth (Bi)	ug/L	-	<1.0	<1.0	1.0	8652630
Dissolved Boron (B)	ug/L	5000	<50	<50	50	8652630
Dissolved Cadmium (Cd)	ug/L	.01	<0.010	0.010	0.010	8652630
Dissolved Chromium (Cr)	ug/L	9	<1.0	<1.0	1.0	8652630
Dissolved Cobalt (Co)	ug/L	.9	<0.20	<0.20	0.20	8652630
Dissolved Copper (Cu)	ug/L	-	0.39	1.09	0.20	8652630
Dissolved Iron (Fe)	ug/L	300	39.5	<5.0	5.0	8652630
Dissolved Lead (Pb)	ug/L	-	<0.20	<0.20	0.20	8652630
Dissolved Lithium (Li)	ug/L	-	<2.0	<2.0	2.0	8652630
Dissolved Manganese (Mn)	ug/L	100	6.1	18.0	1.0	8652630
Dissolved Molybdenum (Mo)	ug/L	-	<1.0	1.1	1.0	8652630
Dissolved Nickel (Ni)	ug/L	25	<1.0	<1.0	1.0	8652630
Dissolved Selenium (Se)	ug/L	1	<0.10	0.37	0.10	8652630
Dissolved Silicon (Si)	ug/L	-	2500	5450	100	8652630
Dissolved Silver (Ag)	ug/L	-	<0.020	<0.020	0.020	8652630
Dissolved Strontium (Sr)	ug/L	-	20.1	254	1.0	8652630
Dissolved Thallium (Tl)	ug/L	1.7	<0.010	<0.010	0.010	8652630
Dissolved Tin (Sn)	ug/L	-	<5.0	<5.0	5.0	8652630
Dissolved Titanium (Ti)	ug/L	100	<5.0	<5.0	5.0	8652630
Dissolved Uranium (U)	ug/L	300	<0.10	1.48	0.10	8652630
Dissolved Vanadium (V)	ug/L	10000	<5.0	<5.0	5.0	8652630
Dissolved Zinc (Zn)	ug/L	30	<5.0	<5.0	5.0	8652630
Dissolved Zirconium (Zr)	ug/L	-	<0.10	<0.10	0.10	8652630
Dissolved Calcium (Ca)	mg/L	4	**4.55**	**87.7**	0.050	8649575
Dissolved Magnesium (Mg)	mg/L	-	0.817	12.6	0.050	8649575
Dissolved Potassium (K)	mg/L	-	0.096	1.16	0.050	8649575
Dissolved Sodium (Na)	mg/L	-	1.84	17.8	0.050	8649575
Dissolved Sulphur (S)	mg/L	-	<3.0	37.0	3.0	8649575

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Results relate only to the items tested.

The Shawnigan Residents Association

Maxxam Job Number: B743204

Report Date: 2017/06/12

CSR TOTAL METALS IN WATER WITH CV HG (WATER)

Maxxam ID			RE7980		RE7981		
Sampling Date			2017-06-02 10:30		2017-06-02 11:00		
COC Number			525592-01-01		525592-01-01		
	UNITS	**Criteria**	**S1**	**QC Batch**	**S2**	**RDL**	**QC Batch**
Calculated Parameters							
Total Hardness (CaCO3)	mg/L	-	15.3	8650052	292	0.50	8650052
Elements							
Total Mercury (Hg)	ug/L	-	<0.010	8654963	<0.010	0.010	8654963
Total Metals by ICPMS							
Total Aluminum (Al)	ug/L	-	43.3	8653737	7.6	3.0	8652657
Total Antimony (Sb)	ug/L	20	<0.50	8653737	<0.50	0.50	8652657
Total Arsenic (As)	ug/L	5	<0.10	8653737	0.12	0.10	8652657
Total Barium (Ba)	ug/L	1000	3.9	8653737	18.5	1.0	8652657
Total Beryllium (Be)	ug/L	5.3	<0.10	8653737	<0.10	0.10	8652657
Total Bismuth (Bi)	ug/L	-	<1.0	8653737	<1.0	1.0	8652657
Total Boron (B)	ug/L	5000	<50	8653737	<50	50	8652657
Total Cadmium (Cd)	ug/L	.01	<0.010	8653737	**0.015**	0.010	8652657
Total Chromium (Cr)	ug/L	9	<1.0	8653737	<1.0	1.0	8652657
Total Cobalt (Co)	ug/L	.9	<0.20	8653737	<0.20	0.20	8652657
Total Copper (Cu)	ug/L	-	0.52	8653737	1.10	0.50	8652657
Total Iron (Fe)	ug/L	300	68	8653737	12	10	8652657
Total Lead (Pb)	ug/L	-	<0.20	8653737	<0.20	0.20	8652657
Total Lithium (Li)	ug/L	-	<2.0	8653737	<2.0	2.0	8652657
Total Manganese (Mn)	ug/L	100	17.5	8653737	21.9	1.0	8652657
Total Molybdenum (Mo)	ug/L	-	<1.0	8653737	1.1	1.0	8652657
Total Nickel (Ni)	ug/L	25	<1.0	8653737	<1.0	1.0	8652657
Total Selenium (Se)	ug/L	1	<0.10	8653737	0.35	0.10	8652657
Total Silicon (Si)	ug/L	-	2620	8653737	5350	100	8652657
Total Silver (Ag)	ug/L	-	<0.020	8653737	<0.020	0.020	8652657
Total Strontium (Sr)	ug/L	-	21.7	8653737	273	1.0	8652657
Total Thallium (Tl)	ug/L	1.7	<0.010	8653737	<0.010	0.010	8652657
Total Tin (Sn)	ug/L	-	<5.0	8653737	<5.0	5.0	8652657
Total Titanium (Ti)	ug/L	100	<5.0	8653737	<5.0	5.0	8652657
Total Uranium (U)	ug/L	300	<0.10	8653737	1.49	0.10	8652657
Total Vanadium (V)	ug/L	10000	<5.0	8653737	<5.0	5.0	8652657
Total Zinc (Zn)	ug/L	30	<5.0	8653737	<5.0	5.0	8652657
Total Zirconium (Zr)	ug/L	-	<0.10	8653737	<0.10	0.10	8652657
Total Calcium (Ca)	mg/L	4	**4.74**	8650058	**96.9**	0.050	8650058
Total Magnesium (Mg)	mg/L	-	0.834	8650058	12.1	0.050	8650058
Total Potassium (K)	mg/L	-	0.106	8650058	1.14	0.050	8650058
Total Sodium (Na)	mg/L	-	1.84	8650058	17.3	0.050	8650058
Total Sulphur (S)	mg/L	-	<3.0	8650058	37.1	3.0	8650058

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Results relate only to the items tested.

The Shawnigan Residents Association

Maxxam Job Number: B743204
Report Date: 2017/06/12

CSR VOC + VPH IN WATER (WATER)

Maxxam ID			RE7980	RE7981		
Sampling Date			2017-06-02 10:30	2017-06-02 11:00		
COC Number			525592-01-01	525592-01-01		
	UNITS	**Criteria**	**S1**	**S2**	**RDL**	**QC Batch**
Volatiles						
VPH (VH6 to 10 - BTEX)	ug/L	-	<300	<300	300	8650061
Chloromethane	ug/L	-	<1.0	<1.0	1.0	8653261
Vinyl chloride	ug/L	-	<0.50	<0.50	0.50	8653261
Chloroethane	ug/L	-	<1.0	<1.0	1.0	8653261
Trichlorofluoromethane	ug/L	-	<4.0	<4.0	4.0	8653261
1,1,2Trichloro-1,2,2Trifluoroethane	ug/L	-	<2.0	<2.0	2.0	8653261
Dichlorodifluoromethane	ug/L	-	<2.0	<2.0	2.0	8653261
1,1-dichloroethene	ug/L	-	<0.50	<0.50	0.50	8653261
Dichloromethane	ug/L	98	<2.0	<2.0	2.0	8653261
trans-1,2-dichloroethene	ug/L	-	<1.0	<1.0	1.0	8653261
1,1-dichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
cis-1,2-dichloroethene	ug/L	-	<1.0	<1.0	1.0	8653261
Chloroform	ug/L	2	<1.0	<1.0	1.0	8653261
1,1,1-trichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,2-dichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
Carbon tetrachloride	ug/L	13	<0.50	<0.50	0.50	8653261
Benzene	ug/L	400	<0.40	<0.40	0.40	8653261
Methyl-tert-butylether (MTBE)	ug/L	-	<4.0	<4.0	4.0	8653261
1,2-dichloropropane	ug/L	100	<0.50	<0.50	0.50	8653261
cis-1,3-dichloropropene	ug/L	-	<1.0	<1.0	1.0	8653261
trans-1,3-dichloropropene	ug/L	-	<1.0	<1.0	1.0	8653261
Bromomethane	ug/L	-	<1.0	<1.0	1.0	8653261
1,1,2-trichloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
Trichloroethene	ug/L	20	<0.50	<0.50	0.50	8653261

Chlorodibromomethane	ug/L	-	<1.0	<1.0	1.0	8653261
1,2-dibromoethane	ug/L	-	<0.20	<0.20	0.20	8653261
Tetrachloroethene	ug/L	110	<0.50	<0.50	0.50	8653261
Bromodichloromethane	ug/L	-	<1.0	<1.0	1.0	8653261
Toluene	ug/L	2	<0.40	<0.40	0.40	8653261
Ethylbenzene	ug/L	90	<0.40	<0.40	0.40	8653261
m & p-Xylene	ug/L	-	<0.40	<0.40	0.40	8653261
Bromoform	ug/L	-	<1.0	<1.0	1.0	8653261
Styrene	ug/L	-	<0.50	<0.50	0.50	8653261
o-Xylene	ug/L	-	<0.40	<0.40	0.40	8653261
Xylenes (Total)	ug/L	-	<0.40	<0.40	0.40	8653261
1,1,1,2-tetrachloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,1,2,2-tetrachloroethane	ug/L	-	<0.50	<0.50	0.50	8653261
1,2-dichlorobenzene	ug/L	.7	<0.50	<0.50	0.50	8653261
1,3-dichlorobenzene	ug/L	150	<0.50	<0.50	0.50	8653261
1,4-dichlorobenzene	ug/L	26	<0.50	<0.50	0.50	8653261
Chlorobenzene	ug/L	1.3	<0.50	<0.50	0.50	8653261
1,2,3-trichlorobenzene	ug/L	8	<2.0	<2.0	2.0	8653261
1,2,4-trichlorobenzene	ug/L	24	<2.0	<2.0	2.0	8653261
Hexachlorobutadiene	ug/L	100	<0.50	<0.50	0.50	8653261
VH C6-C10	ug/L	-	<300	<300	300	8653261
Surrogate Recovery (%)						
1,4-Difluorobenzene (sur.)	%	-	100	100		8653261
4-Bromofluorobenzene (sur.)	%	-	82	82		8653261
D4-1,2-Dichloroethane (sur.)	%	-	89	87		8653261

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit

Results relate only to the items tested.

GENERAL COMMENTS

Criteria: A compendium of working water quality guidelines for British Columbia 1998 Edition

Results relate only to the items tested.

The Shawnigan Residents Association
Attention: Calvin Cook

Report Date: 2017/06/12

Quality Assurance Report
Maxxam Job Number: B743204

QA/QC Bat	Init	QC Type	Parameter	Date Analy	Value	Recovery	UNITS	QC Limits
8651531	IW1	Matrix Spike	Nitrate plus Nitrite (N)	2017-06-03		113	%	80 - 120
8651531	IW1	Spiked Blank	Nitrate plus Nitrite (N)	2017-06-03		110	%	80 - 120
8651531	IW1	Method Blank	Nitrate plus Nitrite (N)	2017-06-03	<0.020		mg/L	
8651531	IW1	RPD	Nitrate plus Nitrite (N)	2017-06-03	NC		%	25
8651532	IW1	Matrix Spike	Nitrite (N)	2017-06-03		102	%	80 - 120
8651532	IW1	Spiked Blank	Nitrite (N)	2017-06-03		100	%	80 - 120
8651532	IW1	Method Blank	Nitrite (N)	2017-06-03	<0.0050		mg/L	
8651532	IW1	RPD	Nitrite (N)	2017-06-03	4.4		%	20
8652080	LS2	Matrix Spike	D10-ANTHRACENE (sur.)	2017-06-05		90	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017-06-05		132 (1)	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017-06-05		88	%	50 - 130
			D9-Acridine (sur.)	2017-06-05		60	%	50 - 130
			TERPHENYL-D14 (sur.)	2017-06-05		82	%	60 - 130
			Quinoline	2017-06-05		105	%	50 - 130
			Naphthalene	2017-06-05		82	%	50 - 130
			2-Methylnaphthalene	2017-06-05		91	%	50 - 130
			Acenaphthylene	2017-06-05		92	%	50 - 130
			Acenaphthene	2017-06-05		92	%	50 - 130
			Fluorene	2017-06-05		84	%	50 - 130
			Phenanthrene	2017-06-05		84	%	60 - 130
			Anthracene	2017-06-05		91	%	60 - 130
			Acridine	2017-06-05		78	%	50 - 130
			Fluoranthene	2017-06-05		81	%	60 - 130
			Pyrene	2017-06-05		80	%	60 - 130
			Benzo(a)anthracene	2017-06-05		84	%	60 - 130
			Chrysene	2017-06-05		89	%	60 - 130
			Benzo(b&j)fluoranthene	2017-06-05		91	%	60 - 130
			Benzo(k)fluoranthene	2017-06-05		87	%	60 - 130
			Benzo(a)pyrene	2017-06-05		90	%	60 - 130
			Indeno(1,2,3-cd)pyrene	2017-06-05		86	%	60 - 130
			Dibenz(a,h)anthracene	2017-06-05		86	%	60 - 130
			Benzo(g,h,i)perylene	2017-06-05		84	%	60 - 130
8652080	LS2	Spiked Blank	D10-ANTHRACENE (sur.)	2017-06-05		97	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017-06-05		104	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017-06-05		88	%	50 - 130
			D9-Acridine (sur.)	2017-06-05		60	%	50 - 130
			TERPHENYL-D14 (sur.)	2017-06-05		98	%	60 - 130
			Quinoline	2017-06-05		104	%	50 - 130
			Naphthalene	2017-06-05		86	%	50 - 130
			2-Methylnaphthalene	2017-06-05		91	%	50 - 130
			Acenaphthylene	2017-06-05		93	%	50 - 130
			Acenaphthene	2017-06-05		94	%	50 - 130
			Fluorene	2017-06-05		89	%	50 - 130
			Phenanthrene	2017-06-05		91	%	60 - 130
			Anthracene	2017-06-05		91	%	60 - 130
			Acridine	2017-06-05		79	%	50 - 130
			Fluoranthene	2017-06-05		87	%	60 - 130
			Pyrene	2017-06-05		89	%	60 - 130
			Benzo(a)anthracene	2017-06-05		92	%	60 - 130
			Chrysene	2017-06-05		97	%	60 - 130
			Benzo(b&j)fluoranthene	2017-06-05		95	%	60 - 130
			Benzo(k)fluoranthene	2017-06-05		97	%	60 - 130
			Benzo(a)pyrene	2017-06-05		95	%	60 - 130
			Indeno(1,2,3-cd)pyrene	2017-06-05		94	%	60 - 130
			Dibenz(a,h)anthracene	2017-06-05		92	%	60 - 130

			Benzo(g,h,i)perylene	2017-06-05	95	%	60 - 130
8652080	LS2	Method Blank	D10-ANTHRACENE (sur.)	2017-06-06	99	%	60 - 130
			D8-ACENAPHTHYLENE (sur.)	2017-06-06	100	%	50 - 130
			D8-NAPHTHALENE (sur.)	2017-06-06	76	%	50 - 130
			D9-Acridine (sur.)	2017-06-06	65	%	50 - 130
			TERPHENYL-D14 (sur.)	2017-06-06	98	%	60 - 130
			Quinoline	2017-06-06 <0.020		ug/L	
			Naphthalene	2017-06-06 <0.10		ug/L	
			2-Methylnaphthalene	2017-06-06 <0.10		ug/L	
			Acenaphthylene	2017-06-06 <0.050		ug/L	
			Acenaphthene	2017-06-06 <0.050		ug/L	
			Fluorene	2017-06-06 <0.050		ug/L	
			Phenanthrene	2017-06-06 <0.050		ug/L	
			Anthracene	2017-06-06 <0.010		ug/L	
			Acridine	2017-06-06 <0.050		ug/L	
			Fluoranthene	2017-06-06 <0.020		ug/L	
			Pyrene	2017-06-06 <0.020		ug/L	
			Benzo(a)anthracene	2017-06-06 <0.010		ug/L	
			Chrysene	2017-06-06 <0.020		ug/L	
			Benzo(b&j)fluoranthene	2017-06-06 <0.030		ug/L	
			Benzo(k)fluoranthene	2017-06-06 <0.050		ug/L	
			Benzo(a)pyrene	2017-06-06 <0.0050		ug/L	
			Indeno(1,2,3-cd)pyrene	2017-06-06 <0.050		ug/L	
			Dibenz(a,h)anthracene	2017-06-06 <0.0030		ug/L	
			Benzo(g,h,i)perylene	2017-06-06 <0.050		ug/L	
8652080	LS2	RPD	Quinoline	2017-06-06 NC		%	40
			Naphthalene	2017-06-06 NC		%	40
			2-Methylnaphthalene	2017-06-06 NC		%	40
			Acenaphthylene	2017-06-06 NC		%	40
			Acenaphthene	2017-06-06 NC		%	40
			Fluorene	2017-06-06 NC		%	40
			Phenanthrene	2017-06-06 NC		%	40
			Anthracene	2017-06-06 NC		%	40
			Acridine	2017-06-06 NC		%	40
			Fluoranthene	2017-06-06 NC		%	40
			Pyrene	2017-06-06 NC		%	40
			Benzo(a)anthracene	2017-06-06 NC		%	40
			Chrysene	2017-06-06 NC		%	40
			Benzo(b&j)fluoranthene	2017-06-06 NC		%	40
			Benzo(k)fluoranthene	2017-06-06 NC		%	40
			Benzo(a)pyrene	2017-06-06 NC		%	40
			Indeno(1,2,3-cd)pyrene	2017-06-06 NC		%	40
			Dibenz(a,h)anthracene	2017-06-06 NC		%	40
			Benzo(g,h,i)perylene	2017-06-06 NC		%	40
8652096	IT1	Matrix Spike	O-TERPHENYL (sur.)	2017-06-05	99	%	60 - 140
			EPH (C10-C19)	2017-06-05	97	%	60 - 140
			EPH (C19-C32)	2017-06-05	94	%	60 - 140
8652096	IT1	Spiked Blank	O-TERPHENYL (sur.)	2017-06-05	97	%	60 - 140
			EPH (C10-C19)	2017-06-05	93	%	70 - 130
			EPH (C19-C32)	2017-06-05	93	%	70 - 130
8652096	IT1	Method Blank	O-TERPHENYL (sur.)	2017-06-05	94	%	60 - 140
			EPH (C10-C19)	2017-06-05 <0.20		mg/L	
			EPH (C19-C32)	2017-06-05 <0.20		mg/L	
8652096	IT1	RPD	EPH (C10-C19)	2017-06-05 NC		%	30
8652630	AD5	Matrix Spike [RE7980-08]	Dissolved Aluminum (Al)	2017-06-07	104	%	80 - 120
			Dissolved Antimony (Sb)	2017-06-07	97	%	80 - 120
			Dissolved Arsenic (As)	2017-06-07	96	%	80 - 120
			Dissolved Barium (Ba)	2017-06-07	100	%	80 - 120
			Dissolved Beryllium (Be)	2017-06-07	102	%	80 - 120
			Dissolved Bismuth (Bi)	2017-06-07	95	%	80 - 120
			Dissolved Boron (B)	2017-06-07	99	%	80 - 120
			Dissolved Cadmium (Cd)	2017-06-07	93	%	80 - 120
			Dissolved Chromium (Cr)	2017-06-07	97	%	80 - 120
			Dissolved Cobalt (Co)	2017-06-07	96	%	80 - 120
			Dissolved Copper (Cu)	2017-06-07	96	%	80 - 120
			Dissolved Iron (Fe)	2017-06-07	106	%	80 - 120
			Dissolved Lead (Pb)	2017-06-07	96	%	80 - 120

			Dissolved Lithium (Li)	2017-06-07	103	%	80 - 120
			Dissolved Manganese (Mn)	2017-06-07	93	%	80 - 120
			Dissolved Molybdenum (Mo)	2017-06-07	99	%	80 - 120
			Dissolved Nickel (Ni)	2017-06-07	97	%	80 - 120
			Dissolved Selenium (Se)	2017-06-07	98	%	80 - 120
			Dissolved Silver (Ag)	2017-06-07	99	%	80 - 120
			Dissolved Strontium (Sr)	2017-06-07	NC	%	80 - 120
			Dissolved Thallium (Tl)	2017-06-07	96	%	80 - 120
			Dissolved Tin (Sn)	2017-06-07	94	%	80 - 120
			Dissolved Titanium (Ti)	2017-06-07	92	%	80 - 120
			Dissolved Uranium (U)	2017-06-07	99	%	80 - 120
			Dissolved Vanadium (V)	2017-06-07	97	%	80 - 120
			Dissolved Zinc (Zn)	2017-06-07	97	%	80 - 120
8652630	AD5	Spiked Blank	Dissolved Aluminum (Al)	2017-06-07	107	%	80 - 120
			Dissolved Antimony (Sb)	2017-06-07	97	%	80 - 120
			Dissolved Arsenic (As)	2017-06-07	99	%	80 - 120
			Dissolved Barium (Ba)	2017-06-07	99	%	80 - 120
			Dissolved Beryllium (Be)	2017-06-07	102	%	80 - 120
			Dissolved Bismuth (Bi)	2017-06-07	95	%	80 - 120
			Dissolved Boron (B)	2017-06-07	99	%	80 - 120
			Dissolved Cadmium (Cd)	2017-06-07	96	%	80 - 120
			Dissolved Chromium (Cr)	2017-06-07	101	%	80 - 120
			Dissolved Cobalt (Co)	2017-06-07	99	%	80 - 120
			Dissolved Copper (Cu)	2017-06-07	101	%	80 - 120
			Dissolved Iron (Fe)	2017-06-07	104	%	80 - 120
			Dissolved Lead (Pb)	2017-06-07	96	%	80 - 120
			Dissolved Lithium (Li)	2017-06-07	103	%	80 - 120
			Dissolved Manganese (Mn)	2017-06-07	98	%	80 - 120
			Dissolved Molybdenum (Mo)	2017-06-07	99	%	80 - 120
			Dissolved Nickel (Ni)	2017-06-07	101	%	80 - 120
			Dissolved Selenium (Se)	2017-06-07	98	%	80 - 120
			Dissolved Silver (Ag)	2017-06-07	103	%	80 - 120
			Dissolved Strontium (Sr)	2017-06-07	96	%	80 - 120
			Dissolved Thallium (Tl)	2017-06-07	95	%	80 - 120
			Dissolved Tin (Sn)	2017-06-07	95	%	80 - 120
			Dissolved Titanium (Ti)	2017-06-07	96	%	80 - 120
			Dissolved Uranium (U)	2017-06-07	98	%	80 - 120
			Dissolved Vanadium (V)	2017-06-07	99	%	80 - 120
			Dissolved Zinc (Zn)	2017-06-07	102	%	80 - 120
8652630	AD5	Method Blank	Dissolved Aluminum (Al)	2017-06-07 <3.0		ug/L	
			Dissolved Antimony (Sb)	2017-06-07 <0.50		ug/L	
			Dissolved Arsenic (As)	2017-06-07 <0.10		ug/L	
			Dissolved Barium (Ba)	2017-06-07 <1.0		ug/L	
			Dissolved Beryllium (Be)	2017-06-07 <0.10		ug/L	
			Dissolved Bismuth (Bi)	2017-06-07 <1.0		ug/L	
			Dissolved Boron (B)	2017-06-07 <50		ug/L	
			Dissolved Cadmium (Cd)	2017-06-07 <0.010		ug/L	
			Dissolved Chromium (Cr)	2017-06-07 <1.0		ug/L	
			Dissolved Cobalt (Co)	2017-06-07 <0.20		ug/L	
			Dissolved Copper (Cu)	2017-06-07 <0.20		ug/L	
			Dissolved Iron (Fe)	2017-06-07 <5.0		ug/L	
			Dissolved Lead (Pb)	2017-06-07 <0.20		ug/L	
			Dissolved Lithium (Li)	2017-06-07 <2.0		ug/L	
			Dissolved Manganese (Mn)	2017-06-07 <1.0		ug/L	
			Dissolved Molybdenum (Mo)	2017-06-07 <1.0		ug/L	
			Dissolved Nickel (Ni)	2017-06-07 <1.0		ug/L	
			Dissolved Selenium (Se)	2017-06-07 <0.10		ug/L	
			Dissolved Silicon (Si)	2017-06-07 <100		ug/L	
			Dissolved Silver (Ag)	2017-06-07 <0.020		ug/L	
			Dissolved Strontium (Sr)	2017-06-07 <1.0		ug/L	
			Dissolved Thallium (Tl)	2017-06-07 <0.010		ug/L	
			Dissolved Tin (Sn)	2017-06-07 <5.0		ug/L	
			Dissolved Titanium (Ti)	2017-06-07 <5.0		ug/L	
			Dissolved Uranium (U)	2017-06-07 <0.10		ug/L	
			Dissolved Vanadium (V)	2017-06-07 <5.0		ug/L	
			Dissolved Zinc (Zn)	2017-06-07 <5.0		ug/L	
			Dissolved Zirconium (Zr)	2017-06-07 <0.10		ug/L	

8652630	AD5	RPD [RE7980-08]	Dissolved Aluminum (Al)	2017-06-07	1.1		%	20
			Dissolved Antimony (Sb)	2017-06-07	NC		%	20
			Dissolved Arsenic (As)	2017-06-07	NC		%	20
			Dissolved Barium (Ba)	2017-06-07	0.081		%	20
			Dissolved Beryllium (Be)	2017-06-07	NC		%	20
			Dissolved Bismuth (Bi)	2017-06-07	NC		%	20
			Dissolved Boron (B)	2017-06-07	NC		%	20
			Dissolved Cadmium (Cd)	2017-06-07	NC		%	20
			Dissolved Chromium (Cr)	2017-06-07	NC		%	20
			Dissolved Cobalt (Co)	2017-06-07	NC		%	20
			Dissolved Copper (Cu)	2017-06-07	1.5		%	20
			Dissolved Iron (Fe)	2017-06-07	1.5		%	20
			Dissolved Lead (Pb)	2017-06-07	NC		%	20
			Dissolved Lithium (Li)	2017-06-07	NC		%	20
			Dissolved Manganese (Mn)	2017-06-07	0.92		%	20
			Dissolved Molybdenum (Mo)	2017-06-07	NC		%	20
			Dissolved Nickel (Ni)	2017-06-07	NC		%	20
			Dissolved Selenium (Se)	2017-06-07	NC		%	20
			Dissolved Silicon (Si)	2017-06-07	0.56		%	20
			Dissolved Silver (Ag)	2017-06-07	NC		%	20
			Dissolved Strontium (Sr)	2017-06-07	2.5		%	20
			Dissolved Thallium (Tl)	2017-06-07	NC		%	20
			Dissolved Tin (Sn)	2017-06-07	NC		%	20
			Dissolved Titanium (Ti)	2017-06-07	NC		%	20
			Dissolved Uranium (U)	2017-06-07	NC		%	20
			Dissolved Vanadium (V)	2017-06-07	NC		%	20
			Dissolved Zinc (Zn)	2017-06-07	NC		%	20
			Dissolved Zirconium (Zr)	2017-06-07	NC		%	20
8652657	AD5	Matrix Spike	Total Aluminum (Al)	2017-06-07		114	%	80 - 120
			Total Antimony (Sb)	2017-06-07		104	%	80 - 120
			Total Arsenic (As)	2017-06-07		107	%	80 - 120
			Total Barium (Ba)	2017-06-07		NC	%	80 - 120
			Total Beryllium (Be)	2017-06-07		105	%	80 - 120
			Total Bismuth (Bi)	2017-06-07		101	%	80 - 120
			Total Boron (B)	2017-06-07		NC	%	80 - 120
			Total Cadmium (Cd)	2017-06-07		103	%	80 - 120
			Total Chromium (Cr)	2017-06-07		99	%	80 - 120
			Total Cobalt (Co)	2017-06-07		96	%	80 - 120
			Total Copper (Cu)	2017-06-07		142 (1)	%	80 - 120
			Total Iron (Fe)	2017-06-07		NC	%	80 - 120
			Total Lead (Pb)	2017-06-07		103	%	80 - 120
			Total Lithium (Li)	2017-06-07		NC	%	80 - 120
			Total Manganese (Mn)	2017-06-07		NC	%	80 - 120
			Total Molybdenum (Mo)	2017-06-07		114	%	80 - 120
			Total Nickel (Ni)	2017-06-07		97	%	80 - 120
			Total Selenium (Se)	2017-06-07		102	%	80 - 120
			Total Silver (Ag)	2017-06-07		105	%	80 - 120
			Total Strontium (Sr)	2017-06-07		NC	%	80 - 120
			Total Thallium (Tl)	2017-06-07		102	%	80 - 120
			Total Tin (Sn)	2017-06-07		109	%	80 - 120
			Total Titanium (Ti)	2017-06-07		94	%	80 - 120
			Total Uranium (U)	2017-06-07		104	%	80 - 120
			Total Vanadium (V)	2017-06-07		100	%	80 - 120
			Total Zinc (Zn)	2017-06-07		112	%	80 - 120
8652657	AD5	Spiked Blank	Total Aluminum (Al)	2017-06-06		108	%	80 - 120
			Total Antimony (Sb)	2017-06-06		101	%	80 - 120
			Total Arsenic (As)	2017-06-06		103	%	80 - 120
			Total Barium (Ba)	2017-06-06		100	%	80 - 120
			Total Beryllium (Be)	2017-06-06		99	%	80 - 120
			Total Bismuth (Bi)	2017-06-06		97	%	80 - 120
			Total Boron (B)	2017-06-06		102	%	80 - 120
			Total Cadmium (Cd)	2017-06-06		105	%	80 - 120
			Total Chromium (Cr)	2017-06-06		101	%	80 - 120
			Total Cobalt (Co)	2017-06-06		99	%	80 - 120
			Total Copper (Cu)	2017-06-06		99	%	80 - 120
			Total Iron (Fe)	2017-06-06		114	%	80 - 120
			Total Lead (Pb)	2017-06-06		96	%	80 - 120

			Total Lithium (Li)	2017-06-06	100	%	80 - 120
			Total Manganese (Mn)	2017-06-06	100	%	80 - 120
			Total Molybdenum (Mo)	2017-06-06	103	%	80 - 120
			Total Nickel (Ni)	2017-06-06	102	%	80 - 120
			Total Selenium (Se)	2017-06-06	103	%	80 - 120
			Total Silver (Ag)	2017-06-06	105	%	80 - 120
			Total Strontium (Sr)	2017-06-06	100	%	80 - 120
			Total Thallium (Tl)	2017-06-06	98	%	80 - 120
			Total Tin (Sn)	2017-06-06	102	%	80 - 120
			Total Titanium (Ti)	2017-06-06	97	%	80 - 120
			Total Uranium (U)	2017-06-06	98	%	80 - 120
			Total Vanadium (V)	2017-06-06	99	%	80 - 120
			Total Zinc (Zn)	2017-06-06	103	%	80 - 120
8652657	AD5	Method Blank	Total Aluminum (Al)	2017-06-06 <3.0		ug/L	
			Total Antimony (Sb)	2017-06-06 <0.50		ug/L	
			Total Arsenic (As)	2017-06-06 <0.10		ug/L	
			Total Barium (Ba)	2017-06-06 <1.0		ug/L	
			Total Beryllium (Be)	2017-06-06 <0.10		ug/L	
			Total Bismuth (Bi)	2017-06-06 <1.0		ug/L	
			Total Boron (B)	2017-06-06 <50		ug/L	
			Total Cadmium (Cd)	2017-06-06 <0.010		ug/L	
			Total Chromium (Cr)	2017-06-06 <1.0		ug/L	
			Total Cobalt (Co)	2017-06-06 <0.20		ug/L	
			Total Copper (Cu)	2017-06-06 <0.50		ug/L	
			Total Iron (Fe)	2017-06-06 <10		ug/L	
			Total Lead (Pb)	2017-06-06 <0.20		ug/L	
			Total Lithium (Li)	2017-06-06 <2.0		ug/L	
			Total Manganese (Mn)	2017-06-06 <1.0		ug/L	
			Total Molybdenum (Mo)	2017-06-06 <1.0		ug/L	
			Total Nickel (Ni)	2017-06-06 <1.0		ug/L	
			Total Selenium (Se)	2017-06-06 <0.10		ug/L	
			Total Silicon (Si)	2017-06-06 <100		ug/L	
			Total Silver (Ag)	2017-06-06 <0.020		ug/L	
			Total Strontium (Sr)	2017-06-06 <1.0		ug/L	
			Total Thallium (Tl)	2017-06-06 <0.010		ug/L	
			Total Tin (Sn)	2017-06-06 <5.0		ug/L	
			Total Titanium (Ti)	2017-06-06 <5.0		ug/L	
			Total Uranium (U)	2017-06-06 <0.10		ug/L	
			Total Vanadium (V)	2017-06-06 <5.0		ug/L	
			Total Zinc (Zn)	2017-06-06 <5.0		ug/L	
			Total Zirconium (Zr)	2017-06-06 <0.10		ug/L	
8652657	AD5	RPD	Total Aluminum (Al)	2017-06-06 16		%	20
			Total Antimony (Sb)	2017-06-06 NC		%	20
			Total Arsenic (As)	2017-06-06 8.8		%	20
			Total Barium (Ba)	2017-06-06 5.9		%	20
			Total Beryllium (Be)	2017-06-06 NC		%	20
			Total Bismuth (Bi)	2017-06-06 NC		%	20
			Total Boron (B)	2017-06-06 3.4		%	20
			Total Cadmium (Cd)	2017-06-06 NC		%	20
			Total Chromium (Cr)	2017-06-06 NC		%	20
			Total Cobalt (Co)	2017-06-06 15		%	20
			Total Copper (Cu)	2017-06-06 20		%	20
			Total Iron (Fe)	2017-06-06 3.1		%	20
			Total Lead (Pb)	2017-06-06 12		%	20
			Total Lithium (Li)	2017-06-06 5.6		%	20
			Total Manganese (Mn)	2017-06-06 11		%	20
			Total Molybdenum (Mo)	2017-06-06 NC		%	20
			Total Nickel (Ni)	2017-06-06 NC		%	20
			Total Selenium (Se)	2017-06-06 NC		%	20
			Total Silicon (Si)	2017-06-06 3.4		%	20
			Total Silver (Ag)	2017-06-06 NC		%	20
			Total Strontium (Sr)	2017-06-06 8.5		%	20
			Total Thallium (Tl)	2017-06-06 NC		%	20
			Total Tin (Sn)	2017-06-06 NC		%	20
			Total Titanium (Ti)	2017-06-06 NC		%	20
			Total Uranium (U)	2017-06-06 NC		%	20
			Total Vanadium (V)	2017-06-06 NC		%	20

			Total Zinc (Zn)	2017-06-06	2.1		%	20
			Total Zirconium (Zr)	2017-06-06	NC		%	20
8652807	J-H	Spiked Blank	True Colour	2017-06-02		91	%	80 - 120
8652807	J-H	Method Blank	True Colour	2017-06-02	<5		Col. Unit	
8652807	J-H	RPD	True Colour	2017-06-02	NC		%	10
8653135	RSA	Matrix Spike [RE7980-11]	Methyl Sulfone (sur.)	2017-06-08		99	%	70 - 130
			Ethylene Glycol	2017-06-08		89	%	70 - 130
			Diethylene Glycol	2017-06-08		93	%	70 - 130
			Triethylene Glycol	2017-06-08		90	%	70 - 130
			Tetraethylene Glycol	2017-06-08		99	%	70 - 130
			Propylene Glycol	2017-06-08		90	%	70 - 130
8653135	RSA	Spiked Blank	Methyl Sulfone (sur.)	2017-06-08		94	%	70 - 130
			Ethylene Glycol	2017-06-08		86	%	70 - 130
			Diethylene Glycol	2017-06-08		86	%	70 - 130
			Triethylene Glycol	2017-06-08		84	%	70 - 130
			Tetraethylene Glycol	2017-06-08		87	%	70 - 130
			Propylene Glycol	2017-06-08		86	%	70 - 130
8653135	RSA	Method Blank	Methyl Sulfone (sur.)	2017-06-08		99	%	70 - 130
			Ethylene Glycol	2017-06-08	<3.0		mg/L	
			Diethylene Glycol	2017-06-08	<5.0		mg/L	
			Triethylene Glycol	2017-06-08	<5.0		mg/L	
			Tetraethylene Glycol	2017-06-08	<5.0		mg/L	
			Propylene Glycol	2017-06-08	<5.0		mg/L	
8653135	RSA	RPD [RE7980-11]	Ethylene Glycol	2017-06-08	NC		%	30
			Diethylene Glycol	2017-06-08	NC		%	30
			Triethylene Glycol	2017-06-08	NC		%	30
			Tetraethylene Glycol	2017-06-08	NC		%	30
			Propylene Glycol	2017-06-08	NC		%	30
8653193	OMA	Spiked Blank	Conductivity	2017-06-06		103	%	90 - 110
8653193	OMA	Method Blank	Conductivity	2017-06-06	1,RDL=1		uS/cm	
8653193	OMA	RPD	Conductivity	2017-06-06	0		%	20
8653194	MM3	Matrix Spike	Alkalinity (Total as CaCO3)	2017-06-06		NC	%	80 - 120
			Alkalinity (PP as CaCO3)	2017-06-06		0	%	N/A
8653194	MM3	Spiked Blank	Alkalinity (Total as CaCO3)	2017-06-06		92	%	80 - 120
8653194	MM3	Method Blank	Alkalinity (Total as CaCO3)	2017-06-06	<0.5		mg/L	
			Alkalinity (PP as CaCO3)	2017-06-06	<0.5		mg/L	
			Bicarbonate (HCO3)	2017-06-06	<0.5		mg/L	
			Carbonate (CO3)	2017-06-06	<0.5		mg/L	
			Hydroxide (OH)	2017-06-06	<0.5		mg/L	
8653194	MM3	RPD	Alkalinity (Total as CaCO3)	2017-06-06	3.8		%	20
			Alkalinity (PP as CaCO3)	2017-06-06	NC		%	20
			Bicarbonate (HCO3)	2017-06-06	3.8		%	20
			Carbonate (CO3)	2017-06-06	NC		%	20
			Hydroxide (OH)	2017-06-06	NC		%	20
8653261	SS9	Matrix Spike	1,4-Difluorobenzene (sur.)	2017-06-07		112	%	70 - 130
			4-Bromofluorobenzene (sur.)	2017-06-07		102	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017-06-07		106	%	70 - 130
			Chloromethane	2017-06-07		108	%	60 - 140
			Vinyl chloride	2017-06-07		112	%	60 - 140
			Chloroethane	2017-06-07		103	%	60 - 140
			Trichlorofluoromethane	2017-06-07		119	%	60 - 140
			Dichlorodifluoromethane	2017-06-07		115	%	60 - 140
			1,1-dichloroethene	2017-06-07		102	%	70 - 130
			Dichloromethane	2017-06-07		103	%	70 - 130
			trans-1,2-dichloroethene	2017-06-07		101	%	70 - 130
			1,1-dichloroethane	2017-06-07		105	%	70 - 130
			cis-1,2-dichloroethene	2017-06-07		104	%	70 - 130
			Chloroform	2017-06-07		105	%	70 - 130
			1,1,1-trichloroethane	2017-06-07		108	%	70 - 130
			1,2-dichloroethane	2017-06-07		104	%	70 - 130
			Carbon tetrachloride	2017-06-07		108	%	70 - 130
			Benzene	2017-06-07		103	%	70 - 130
			Methyl-tert-butylether (MTBE)	2017-06-07		105	%	70 - 130
			1,2-dichloropropane	2017-06-07		102	%	70 - 130
			cis-1,3-dichloropropene	2017-06-07		101	%	70 - 130
			trans-1,3-dichloropropene	2017-06-07		75	%	70 - 130
			Bromomethane	2017-06-07		112	%	60 - 140

			1,1,2-trichloroethane	2017-06-07	105	%	70 - 130
			Trichloroethene	2017-06-07	102	%	70 - 130
			Chlorodibromomethane	2017-06-07	109	%	70 - 130
			1,2-dibromoethane	2017-06-07	105	%	70 - 130
			Tetrachloroethene	2017-06-07	105	%	70 - 130
			Bromodichloromethane	2017-06-07	105	%	70 - 130
			Toluene	2017-06-07	90	%	70 - 130
			Ethylbenzene	2017-06-07	99	%	70 - 130
			m & p-Xylene	2017-06-07	103	%	70 - 130
			Bromoform	2017-06-07	96	%	70 - 130
			Styrene	2017-06-07	106	%	70 - 130
			o-Xylene	2017-06-07	101	%	70 - 130
			1,1,1,2-tetrachloroethane	2017-06-07	105	%	70 - 130
			1,1,2,2-tetrachloroethane	2017-06-07	92	%	70 - 130
			1,2-dichlorobenzene	2017-06-07	91	%	70 - 130
			1,3-dichlorobenzene	2017-06-07	82	%	70 - 130
			1,4-dichlorobenzene	2017-06-07	86	%	70 - 130
			Chlorobenzene	2017-06-07	102	%	70 - 130
			1,2,3-trichlorobenzene	2017-06-07	77	%	70 - 130
			1,2,4-trichlorobenzene	2017-06-07	73	%	70 - 130
			Hexachlorobutadiene	2017-06-07	74	%	70 - 130
8653261	SS9	Spiked Blank	1,4-Difluorobenzene (sur.)	2017-06-07	111	%	70 - 130
			4-Bromofluorobenzene (sur.)	2017-06-07	98	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017-06-07	104	%	70 - 130
			Chloromethane	2017-06-07	104	%	60 - 140
			Vinyl chloride	2017-06-07	107	%	60 - 140
			Chloroethane	2017-06-07	90	%	60 - 140
			Trichlorofluoromethane	2017-06-07	114	%	60 - 140
			Dichlorodifluoromethane	2017-06-07	110	%	60 - 140
			1,1-dichloroethene	2017-06-07	106	%	70 - 130
			Dichloromethane	2017-06-07	100	%	70 - 130
			trans-1,2-dichloroethene	2017-06-07	96	%	70 - 130
			1,1-dichloroethane	2017-06-07	101	%	70 - 130
			cis-1,2-dichloroethene	2017-06-07	100	%	70 - 130
			Chloroform	2017-06-07	100	%	70 - 130
			1,1,1-trichloroethane	2017-06-07	104	%	70 - 130
			1,2-dichloroethane	2017-06-07	97	%	70 - 130
			Carbon tetrachloride	2017-06-07	103	%	70 - 130
			Benzene	2017-06-07	95	%	70 - 130
			Methyl-tert-butylether (MTBE)	2017-06-07	101	%	70 - 130
			1,2-dichloropropane	2017-06-07	98	%	70 - 130
			cis-1,3-dichloropropene	2017-06-07	87	%	70 - 130
			trans-1,3-dichloropropene	2017-06-07	65 (1)	%	70 - 130
			Bromomethane	2017-06-07	125	%	60 - 140
			1,1,2-trichloroethane	2017-06-07	104	%	70 - 130
			Trichloroethene	2017-06-07	97	%	70 - 130
			Chlorodibromomethane	2017-06-07	102	%	70 - 130
			1,2-dibromoethane	2017-06-07	101	%	70 - 130
			Tetrachloroethene	2017-06-07	99	%	70 - 130
			Bromodichloromethane	2017-06-07	99	%	70 - 130
			Toluene	2017-06-07	85	%	70 - 130
			Ethylbenzene	2017-06-07	94	%	70 - 130
			m & p-Xylene	2017-06-07	95	%	70 - 130
			Bromoform	2017-06-07	98	%	70 - 130
			Styrene	2017-06-07	99	%	70 - 130
			o-Xylene	2017-06-07	95	%	70 - 130
			1,1,1,2-tetrachloroethane	2017-06-07	100	%	70 - 130
			1,1,2,2-tetrachloroethane	2017-06-07	93	%	70 - 130
			1,2-dichlorobenzene	2017-06-07	92	%	70 - 130
			1,3-dichlorobenzene	2017-06-07	96	%	70 - 130
			1,4-dichlorobenzene	2017-06-07	85	%	70 - 130
			Chlorobenzene	2017-06-07	96	%	70 - 130
			1,2,3-trichlorobenzene	2017-06-07	76	%	70 - 130
			1,2,4-trichlorobenzene	2017-06-07	73	%	70 - 130
			Hexachlorobutadiene	2017-06-07	75	%	70 - 130
			VH C6-C10	2017-06-07	79	%	70 - 130
8653261	SS9	Method Blank	1,4-Difluorobenzene (sur.)	2017-06-07	100	%	70 - 130

			4-Bromofluorobenzene (sur.)	2017-06-07		80	%	70 - 130
			D4-1,2-Dichloroethane (sur.)	2017-06-07		87	%	70 - 130
			Chloromethane	2017-06-07	<1.0		ug/L	
			Vinyl chloride	2017-06-07	<0.50		ug/L	
			Chloroethane	2017-06-07	<1.0		ug/L	
			Trichlorofluoromethane	2017-06-07	<4.0		ug/L	
			1,1,2Trichloro-1,2,2Trifluoroethane	2017-06-07	<2.0		ug/L	
			Dichlorodifluoromethane	2017-06-07	<2.0		ug/L	
			1,1-dichloroethene	2017-06-07	<0.50		ug/L	
			Dichloromethane	2017-06-07	<2.0		ug/L	
			trans-1,2-dichloroethene	2017-06-07	<1.0		ug/L	
			1,1-dichloroethane	2017-06-07	<0.50		ug/L	
			cis-1,2-dichloroethene	2017-06-07	<1.0		ug/L	
			Chloroform	2017-06-07	<1.0		ug/L	
			1,1,1-trichloroethane	2017-06-07	<0.50		ug/L	
			1,2-dichloroethane	2017-06-07	<0.50		ug/L	
			Carbon tetrachloride	2017-06-07	<0.50		ug/L	
			Benzene	2017-06-07	<0.40		ug/L	
			Methyl-tert-butylether (MTBE)	2017-06-07	<4.0		ug/L	
			1,2-dichloropropane	2017-06-07	<0.50		ug/L	
			cis-1,3-dichloropropene	2017-06-07	<1.0		ug/L	
			trans-1,3-dichloropropene	2017-06-07	<1.0		ug/L	
			Bromomethane	2017-06-07	<1.0		ug/L	
			1,1,2-trichloroethane	2017-06-07	<0.50		ug/L	
			Trichloroethene	2017-06-07	<0.50		ug/L	
			Chlorodibromomethane	2017-06-07	<1.0		ug/L	
			1,2-dibromoethane	2017-06-07	<0.20		ug/L	
			Tetrachloroethene	2017-06-07	<0.50		ug/L	
			Bromodichloromethane	2017-06-07	<1.0		ug/L	
			Toluene	2017-06-07	<0.40		ug/L	
			Ethylbenzene	2017-06-07	<0.40		ug/L	
			m & p-Xylene	2017-06-07	<0.40		ug/L	
			Bromoform	2017-06-07	<1.0		ug/L	
			Styrene	2017-06-07	<0.50		ug/L	
			o-Xylene	2017-06-07	<0.40		ug/L	
			Xylenes (Total)	2017-06-07	<0.40		ug/L	
			1,1,1,2-tetrachloroethane	2017-06-07	<0.50		ug/L	
			1,1,2,2-tetrachloroethane	2017-06-07	<0.50		ug/L	
			1,2-dichlorobenzene	2017-06-07	<0.50		ug/L	
			1,3-dichlorobenzene	2017-06-07	<0.50		ug/L	
			1,4-dichlorobenzene	2017-06-07	<0.50		ug/L	
			Chlorobenzene	2017-06-07	<0.50		ug/L	
			1,2,3-trichlorobenzene	2017-06-07	<2.0		ug/L	
			1,2,4-trichlorobenzene	2017-06-07	<2.0		ug/L	
			Hexachlorobutadiene	2017-06-07	<0.50		ug/L	
			VH C6-C10	2017-06-07	<300		ug/L	
8653261	SS9	RPD	1,2-dichloroethane	2017-06-07	NC		%	30
			Benzene	2017-06-07	NC		%	30
			Methyl-tert-butylether (MTBE)	2017-06-07	NC		%	30
			1,2-dibromoethane	2017-06-07	NC		%	30
			Toluene	2017-06-07	NC		%	30
			Ethylbenzene	2017-06-07	NC		%	30
			m & p-Xylene	2017-06-07	NC		%	30
			Styrene	2017-06-07	NC		%	30
			o-Xylene	2017-06-07	NC		%	30
			Xylenes (Total)	2017-06-07	NC		%	30
			VH C6-C10	2017-06-07	NC		%	30
8653344	BB3	Matrix Spike	Dissolved Chloride (Cl)	2017-06-05		108	%	80 - 120
8653344	BB3	Spiked Blank	Dissolved Chloride (Cl)	2017-06-05		98	%	80 - 120
8653344	BB3	Method Blank	Dissolved Chloride (Cl)	2017-06-05	<0.50		mg/L	
8653344	BB3	RPD	Dissolved Chloride (Cl)	2017-06-05	3.0		%	20
			Dissolved Chloride (Cl)	2017-06-05	3.2		%	20
8653364	BB3	Matrix Spike	Dissolved Sulphate (SO4)	2017-06-05		NC	%	80 - 120
8653364	BB3	Spiked Blank	Dissolved Sulphate (SO4)	2017-06-05		97	%	80 - 120
8653364	BB3	Method Blank	Dissolved Sulphate (SO4)	2017-06-05	<0.50		mg/L	
8653364	BB3	RPD	Dissolved Sulphate (SO4)	2017-06-05	3.8		%	20
8653737	AD5	Matrix Spike	Total Aluminum (Al)	2017-06-07		107	%	80 - 120

			Total Antimony (Sb)	2017-06-07	99	%	80 - 120
			Total Arsenic (As)	2017-06-07	98	%	80 - 120
			Total Barium (Ba)	2017-06-07	100	%	80 - 120
			Total Beryllium (Be)	2017-06-07	101	%	80 - 120
			Total Bismuth (Bi)	2017-06-07	96	%	80 - 120
			Total Boron (B)	2017-06-07	94	%	80 - 120
			Total Cadmium (Cd)	2017-06-07	103	%	80 - 120
			Total Chromium (Cr)	2017-06-07	97	%	80 - 120
			Total Cobalt (Co)	2017-06-07	94	%	80 - 120
			Total Copper (Cu)	2017-06-07	96	%	80 - 120
			Total Iron (Fe)	2017-06-07	97	%	80 - 120
			Total Lead (Pb)	2017-06-07	97	%	80 - 120
			Total Lithium (Li)	2017-06-07	102	%	80 - 120
			Total Manganese (Mn)	2017-06-07	96	%	80 - 120
			Total Molybdenum (Mo)	2017-06-07	98	%	80 - 120
			Total Nickel (Ni)	2017-06-07	97	%	80 - 120
			Total Selenium (Se)	2017-06-07	97	%	80 - 120
			Total Silver (Ag)	2017-06-07	102	%	80 - 120
			Total Strontium (Sr)	2017-06-07	98	%	80 - 120
			Total Thallium (Tl)	2017-06-07	96	%	80 - 120
			Total Tin (Sn)	2017-06-07	99	%	80 - 120
			Total Titanium (Ti)	2017-06-07	98	%	80 - 120
			Total Uranium (U)	2017-06-07	97	%	80 - 120
			Total Vanadium (V)	2017-06-07	96	%	80 - 120
			Total Zinc (Zn)	2017-06-07	99	%	80 - 120
8653737	AD5	Spiked Blank	Total Aluminum (Al)	2017-06-07	108	%	80 - 120
			Total Antimony (Sb)	2017-06-07	99	%	80 - 120
			Total Arsenic (As)	2017-06-07	93	%	80 - 120
			Total Barium (Ba)	2017-06-07	101	%	80 - 120
			Total Beryllium (Be)	2017-06-07	101	%	80 - 120
			Total Bismuth (Bi)	2017-06-07	98	%	80 - 120
			Total Boron (B)	2017-06-07	102	%	80 - 120
			Total Cadmium (Cd)	2017-06-07	97	%	80 - 120
			Total Chromium (Cr)	2017-06-07	92	%	80 - 120
			Total Cobalt (Co)	2017-06-07	92	%	80 - 120
			Total Copper (Cu)	2017-06-07	92	%	80 - 120
			Total Iron (Fe)	2017-06-07	103	%	80 - 120
			Total Lead (Pb)	2017-06-07	99	%	80 - 120
			Total Lithium (Li)	2017-06-07	101	%	80 - 120
			Total Manganese (Mn)	2017-06-07	93	%	80 - 120
			Total Molybdenum (Mo)	2017-06-07	101	%	80 - 120
			Total Nickel (Ni)	2017-06-07	92	%	80 - 120
			Total Selenium (Se)	2017-06-07	101	%	80 - 120
			Total Silver (Ag)	2017-06-07	104	%	80 - 120
			Total Strontium (Sr)	2017-06-07	90	%	80 - 120
			Total Thallium (Tl)	2017-06-07	98	%	80 - 120
			Total Tin (Sn)	2017-06-07	99	%	80 - 120
			Total Titanium (Ti)	2017-06-07	89	%	80 - 120
			Total Uranium (U)	2017-06-07	100	%	80 - 120

			Total Vanadium (V)	2017-06-07	91	%	80 - 120
			Total Zinc (Zn)	2017-06-07	94	%	80 - 120
8653737	AD5	Method Blank	Total Aluminum (Al)	2017-06-07 <3.0		ug/L	
			Total Antimony (Sb)	2017-06-07 <0.50		ug/L	
			Total Arsenic (As)	2017-06-07 <0.10		ug/L	
			Total Barium (Ba)	2017-06-07 <1.0		ug/L	
			Total Beryllium (Be)	2017-06-07 <0.10		ug/L	
			Total Bismuth (Bi)	2017-06-07 <1.0		ug/L	
			Total Boron (B)	2017-06-07 <50		ug/L	
			Total Cadmium (Cd)	2017-06-07 <0.010		ug/L	
			Total Chromium (Cr)	2017-06-07 <1.0		ug/L	
			Total Cobalt (Co)	2017-06-07 <0.20		ug/L	
			Total Copper (Cu)	2017-06-07 <0.50		ug/L	
			Total Iron (Fe)	2017-06-07 <10		ug/L	
			Total Lead (Pb)	2017-06-07 <0.20		ug/L	
			Total Lithium (Li)	2017-06-07 <2.0		ug/L	
			Total Manganese (Mn)	2017-06-07 <1.0		ug/L	
			Total Molybdenum (Mo)	2017-06-07 <1.0		ug/L	
			Total Nickel (Ni)	2017-06-07 <1.0		ug/L	
			Total Selenium (Se)	2017-06-07 <0.10		ug/L	
			Total Silicon (Si)	2017-06-07 <100		ug/L	
			Total Silver (Ag)	2017-06-07 <0.020		ug/L	
			Total Strontium (Sr)	2017-06-07 <1.0		ug/L	
			Total Thallium (Tl)	2017-06-07 <0.010		ug/L	
			Total Tin (Sn)	2017-06-07 <5.0		ug/L	
			Total Titanium (Ti)	2017-06-07 <5.0		ug/L	
			Total Uranium (U)	2017-06-07 <0.10		ug/L	
			Total Vanadium (V)	2017-06-07 <5.0		ug/L	
			Total Zinc (Zn)	2017-06-07 <5.0		ug/L	
			Total Zirconium (Zr)	2017-06-07 <0.10		ug/L	
8653737	AD5	RPD	Total Aluminum (Al)	2017-06-07 NC		%	20
			Total Arsenic (As)	2017-06-07 NC		%	20
			Total Boron (B)	2017-06-07 NC		%	20
			Total Cadmium (Cd)	2017-06-07 NC		%	20
			Total Chromium (Cr)	2017-06-07 NC		%	20
			Total Cobalt (Co)	2017-06-07 NC		%	20
			Total Copper (Cu)	2017-06-07 NC		%	20
			Total Iron (Fe)	2017-06-07 NC		%	20
			Total Lead (Pb)	2017-06-07 NC		%	20
			Total Manganese (Mn)	2017-06-07 NC		%	20
			Total Molybdenum (Mo)	2017-06-07 NC		%	20
			Total Nickel (Ni)	2017-06-07 NC		%	20
			Total Selenium (Se)	2017-06-07 NC		%	20
			Total Silver (Ag)	2017-06-07 NC		%	20
			Total Zinc (Zn)	2017-06-07 NC		%	20
			Total Copper (Cu)	2017-06-07 2.0		%	20
			Total Silver (Ag)	2017-06-07 1.6		%	20
8654120	JHW	Spiked Blank	Total Suspended Solids	2017-06-08	98	%	80 - 120
8654120	JHW	Method Blank	Total Suspended Solids	2017-06-08 <1		mg/L	
8654120	JHW	RPD	Total Suspended Solids	2017-06-08 2.5		%	20
8654963	EL2	Matrix Spike	Total Mercury (Hg)	2017-06-07	95	%	80 - 120
8654963	EL2	Spiked Blank	Total Mercury (Hg)	2017-06-07	95	%	80 - 120
8654963	EL2	Method Blank	Total Mercury (Hg)	2017-06-07 <0.010		ug/L	
8654963	EL2	RPD	Total Mercury (Hg)	2017-06-07 NC		%	20
8656120	EL2	Matrix Spike [RE7981-09]	Dissolved Mercury (Hg)	2017-06-08	119	%	80 - 120
8656120	EL2	Spiked Blank	Dissolved Mercury (Hg)	2017-06-08	96	%	80 - 120
8656120	EL2	Method Blank	Dissolved Mercury (Hg)	2017-06-08 <0.010		ug/L	
8656120	EL2	RPD [RE7981-09]	Dissolved Mercury (Hg)	2017-06-08 NC		%	20
8656333	BB3	Matrix Spike [RE7980-03]	Fluoride (F)	2017-06-07	103	%	80 - 120
8656333	BB3	Spiked Blank	Fluoride (F)	2017-06-07	106	%	80 - 120
8656333	BB3	Method Blank	Fluoride (F)	2017-06-07 <0.010		mg/L	
8656333	BB3	RPD	Fluoride (F)	2017-06-07 0		%	20
8656340	BB3	Matrix Spike	Fluoride (F)	2017-06-07	106	%	80 - 120
8656340	BB3	Spiked Blank	Fluoride (F)	2017-06-07	106	%	80 - 120
8656340	BB3	Method Blank	Fluoride (F)	2017-06-07 <0.010		mg/L	
8656340	BB3	RPD [RE7981-03]	Fluoride (F)	2017-06-07 2.7		%	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

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Introduction

Since my previous Review article, new information has come to light.

This review addresses three topics:

1. The pending Supreme Court of Canada appeal by the CVRD of it zoning case against the companies.
2. Additional evidence that the material in the waste pile is shrinking and the consequences of that.
3. Areas in which the companies are failing to comply with the Amended Spill Prevention Order.

These three issues add weight to the arguments against making a decision on final closure of the contaminated waste landfill until these issues are resolved.

The CVRD Zoning Case

The CVRD case against CHH/SIA on using a contaminated landfill for mine reclamation to override zoning on the quarry land was heard in the BC Supreme Court in the fall of 2015. Justice MacKenzie ruled in favour of the CVRD in March 2016, disallowing the landfill.

The Appeals court decided in favour of CHH/SIA in November 2016.

The CVRD appealed that decision to the Supreme Court of Canada. A decision on whether that appeal will be heard is pending.

The CVRD referral to the Supreme Court of Canada requests an order requiring the removal of the landfill facility.

With this lawsuit pending, it would be improper for Environment to move ahead with a landfill closure plan. Should the CVRD win the case in the Supreme Court of Canada, the closed landfill would still have to be removed.

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Cover Folding

Drone pictures of the Temporary Encapsulation Area (TEA) show that the entire surface has folds. These folds have appeared after the cover was installed. We believe they are growing as the contaminated waste pile continues to shrink. Folding is happening because the waste pile is shrinking through leaching of water and through biological activity in the dredgeate.

Image 1

Image 2


Image 3

We do not know how much the waste pile will finally shrink. Saturated soils can lose as much as 30% of their volume during drying.

If the TEA loses 30% of its volume, the folds will grow much larger than they are today. It will be impossible to put any material on top of the waste pile without compressing those folds flat resulting in cracks in the liner. If the cover is added before shrinking is complete, the folds will still appear. They must because the volume the liner encloses is shrinking. Nothing can prevent continued folding. The liner will go from being 95% effective to 95% ineffective.

We ask that before any decision is made to cap the TEA, tests are conducted on the liner to determine its behaviour when folds are flattened and exposed to pressure. Does the liner material crack and leak?

We note that until the landfill is capped, those folds will not be flattened. The cover liner affords more protection uncovered than covered.

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I urge the consulting engineers to visit the Tervita landfill in the Highlands district of the Capital Regional District. That facility, on land zoned for a landfill, is covered with a liner that has no folds.

Tervita from Mt. Finlayson

Contact Water Management

Recent drone pictures show that hoses are still connected to the leachate collection tank. It is possible that a submerged pump is still present in that tank.

Leachate collection tank, hoses

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The Amended Spill Prevention Order (ASPO) requires that all contact ater be removed directly from the leachate collection tank and trucked from the site.

We ask that the submerged pump be removed from the leachate collection tank. We ask that all hoses be removed.

The leachate collection holding pond on the upper level still contains water. We ask that the contact water holding pond on the upper level be emptied and that water be treated as contact water. We ask that the contact water holding pond be decommissioned, the fencing and piping be removed, the hole be filled in with clean fill.

Contact water holding pond

We further ask that the contact water collection system for the Soil Management Area be replaced by a holding tank similar to the one at the TEA. We ask that water here be treated as contact water under the ASPO.

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Is Delay Safe?

The SHA report notes that the existing cover liner is 95% effective. The greatest danger to the existing cover liner at present is wildlife entering the unfenced quarry and damaging the cover. The quarry was to have been fenced, as demanded by Environment, almost a year ago. To date, only one side of the property is fenced.

Fencing now and a delay of any decision on closure until the Supreme Court case is decided and all the conditions suggests by the Residents groups are satisfied, is the prudent course.

The consequences of leaking from the waste pile continue whether the waste pile is covered or not. Covering the top will not stop leakage from the bottom. In fact, adding extra weight on top of the waste may actually increase the leakage rate.

Summary

This review adds more weight to the arguments against any premature decision on final closure of the contaminated waste landfill.

Hurst, Nicole ENV:EX

From: Dave Hutchinson <dave.shawnigan@shaw.ca>
Sent: Wednesday, June 21, 2017 9:30 AM
To: Downie, AJ ENV:EX
Cc: Zacharias, Mark ENV:EX; McGuire, Jennifer ENV:EX; 'Sonia Furstenau'; 'Calvin Cook'; 'Bernhard Juurlink'; Brent Beach
Subject: SRG Comments re Martin Block June 15 Submission
Attachments: Problem Corner of Cell 1-C - 2016-07-18.jpg; Problem Corner of Cell 1-C - 2016-07-19.jpg; Problem Corner of Cell 1-C - 2016-07-20.jpg

Hello AJ,

Thank you for your email yesterday informing us of the June 15 submission by Martin Block of Cobble Hill Holdings. The Shawnigan Research Group provide the following comments:

1. The April 18, 2017 addendum letter from Brimmell Engineering, affirming the "correct" installation of the Cell-1C liner, contains several inaccurate statements. There was no metre of clay deposited in the corner. The corner was excavated and the rock removed. After this sand was put down, followed by the liner. Also, the date the hammer was used to break up the rock happened July 18, 2016 - not July 19 as stated in the Brimmell addendum. This was documented by Bernie Juurlink who has provided the attached photos from July 18, 19 and 20 (2016) respectively.

2. There appears to be nothing new in the recent documents. None of the drawings have engineer's stamps. The letter, while stamped, relies on the word of two SIRM people, with no engineer's stamp.

3. If the Ministry agrees to Mr. Mizuiks request for a meeting to discuss the "As-Builts", then the Shawnigan Research Group would also like to participate.

Regards,
Dave Hutchinson


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