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Hartland Landfill

Operating & Environmental Monitoring 2016 Annual Report

Operational Certificate 12659

Parks & Environmental Services | Environmental Protection

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HARTLAND LANDFILL
OPERATING & ENVIRONMENTAL MONITORING 2016 ANNUAL REPORT

EXECUTIVE SUMMARY

Hartland Landfill is owned and operated by the Capital Regional District (CRD) and is located about 14 km northwest of Victoria. It is the only sanitary landfill in the capital region, serving nearly 400,000 people. The operation is a multi-purpose facility providing recycling; household hazardous waste collection; a salvage area; yard and garden waste collection and processing; controlled waste disposal; and landfill services to commercial and residential customers.

The facility operates under an approved Solid Waste Management Plan and Operational Certificate 12659 issued by the BC Ministry of Environment (MOE). An authorization is in place for the Hartland Landfill to deposit waste asbestos. The site has a BC Generator number 15394 and is a registered Return Collection Facility. This annual report is requirement of the Hartland Operational Certificate and is intended for internal and external CRD stakeholders and regulators including the BC MOE. The report compiles data regarding total waste tonnages, landfill lifespan, closure funding, operational and construction related activities in 2016, and environmental monitoring program results.

In 2016, the Hartland Landfill received a total of 146,704 tonnes of waste, including 134,167 tonnes of general refuse and 12,537 tonnes of controlled waste. The controlled waste tonnage includes 2,875 tonnes of asbestos. Based upon comparison of surface elevation data and planned final contours in the *Hartland Landfill Phase 2 Long Term Leachate Management Plan* (Sperling Hansen Associates, June 2007) the estimated remaining capacity[1] is 4,916,468 cubic metres, compared to 5,115,000 cubic metres in 2015. It is estimated that there has been approximately 7,030,827 tonnes of municipal waste deposited at the site at the end of 2016. The estimated landfill capacity will be reached in 33 years.

Since 1985, over $40 million has been invested in capital works, environmental controls and general site improvements.

Summary of Capital Projects Completed in 2016:

- Airspace/Aggregate Production
- Interim cover, Phase 2, Cell 2 (southeast face)
- Gas and Leachate Collection Infrastructure – 175 and 179 mASL lifts
- Microtunnel cleaning and retrofit
- Landfill Criteria Conformance Assessment
- Environmental Inventory – Hartland North Aggregate Storage
- Phase 2 East Toe Berm Upgrades
- Phase 2, Cell 3 Underdrain and Liner System
- Conceptual Landfill Capacity Study, Aggregate Management Plan and Stockpile Design
- Replacement of Commercial Scale Decks
- Hydrogeological Conceptual Model of North Ridge (draft)
- Overview of Landfill Gas Utilization Options and Technologies

Summary of Operational Activities for 2016:

- Annual Invasive Species Control
- Execution of Landfill Operations, Mechanical Services, Security and Vector Control Contracts
- Water System Upgrades
- Landfill Gas Engine Rebuild
- 2016 Waste Composition Study
- Waste Discharge Permit Revisions
- Design, Operations and Closure Plan Update
- Hartland Biennial Open House

1 Estimated capacities for 2015 and 2014 are rounded values to thousandths

Hartland Landfill employs a number of control measures to prevent or reduce effects on groundwater, surface water and air. An environmental monitoring program is in place to assess the effectiveness of these controls and to confirm regulatory compliance. Monitoring data is reported between April 1, 2016 and March 31, 2017. The monitoring program confirms that for 2016/2017 the regulatory requirements were met and effective measures are in place to mitigate environmental impacts and to contain leachate prior to discharge to the sanitary sewer.

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1.0 INTRODUCTION

Hartland Landfill is owned and operated by the Capital Regional District (CRD) and is located about 14 km northwest of Victoria. It is the only sanitary landfill in the capital region, serving a population of nearly 400,000 people. The operation is a multi-purpose facility providing recycling; household hazardous waste collection; a salvage area; yard and garden waste collection and processing; controlled waste disposal; and landfill services to commercial and residential customers.

This report represents the amalgamation of 3 historically separate documents (i.e., Hartland Operations Annual Report; Environmental Program Annual Report; Landfill Gas Annual Report) and is intended for a diverse audience including: BC Ministry of Environment (MOE); CRD internal staff, CRD committee and board members; and the public. The data compiled herein is required to meet internal requirements and BC regulatory requirements per Section 3.2 of the Operational Certificate. As required by the Operational Certificate, this report summarizes the following:

- waste tonnages
- remaining landfill lifespan
- post closure funding
- 2016 operations activities
- 2016 construction contract related activities, and
- 2016–2017 environmental monitoring program results

2.0 SITE OVERVIEW

Hartland Landfill is located in the Tod Creek watershed, in the bedrock highlands of the Gowland Range, northwest of Victoria. The terrain is moderately rugged with relief of up to 446 m in the area. Undeveloped CRD property (about 320 ha in total) lies to the west and south of the landfill site. Mount Work Regional Park also lies to the west. Willis Point Road borders the site to the north, and beyond that is a Department of National Defense rifle range. Private residential properties are located to the east and southeast of the landfill.

The landfill is situated in a north-south trending bedrock saddle with Mount Work to the west and an unnamed bedrock ridge to the east. The crest of the landfill forms a drainage divide between the Heal Creek drainage basin to the north and the Killarney Creek drainage basin to the south.

Filling with waste commenced at the site in the 1950s. The site was owned and operated by a private company until 1975 when the property was purchased by the CRD. The landfill is currently owned and operated by the CRD and is the primary solid waste disposal site for the 13 member municipalities of the capital region. Landfilling equipment and operation is conducted by private companies under contract and direction of CRD staff.

The Hartland Landfill site is divided into 2 distinct areas referred to as Phase 1 and Phase 2. Initially, waste was deposited in Phase 1, which reached capacity in 1996 and was capped in 1997. Phase 2 is currently receiving waste. Filling of Phase 2, Cell 1 was completed in 2004. Subsequently, the filling of Cell 2 was completed in 2016 and its interim closure is in progress. Cell 3 was prepared in the summer of 2016 and became active in September 2016.

Leachate and surface runoff from the active landfill areas are directed to 2 leachate lagoons at the north end of the landfill. The leachate is then transported by a pipeline to the northwest trunk sewer system and ultimately, the Macaulay Point deep ocean outfall. Leachate discharge to sewer is authorized by RSCP Waste Discharge Permit SC97.001 and is subject to the CRD Sewer Use Bylaw.

The CRD initiated a surface water and groundwater monitoring program for the landfill in 1983. Annual monitoring reports have been prepared and issued by Gartner Lee and AECOM since 1988. The present Hartland monitoring program is required under the Amended Operational Certificate #12659 issued by the BC MOE and last amended January 21, 2013.

3.0 REGULATORY SETTING

The Hartland Landfill operates in accordance with an approved Solid Waste Management Plan (SWMP). The original SWMP was approved by the MOE in 1989 and has been amended as required. A revision to the plan commenced in 2012. In addition to the SWMP, the landfill operates in accordance with the following:

- Amended Operational Certificate (#12659) approved by the BC MOE, last amended on January 21, 2013.
- Authorization to Dispose of Hazardous Waste Asbestos at the Hartland Landfill approved by the BC MOE on July 23, 2012.
- Waste Discharge Permit SC97.001 issued by the CRD Regional Source Control Program (RSCP), last amended on April 4, 2016, and subject to the CRD Sewer Use Bylaw.
- Waste generation in accordance with the Hazardous Waste Regulation under BC Generator number 15394.
- Environmental monitoring programs are regulated by the British Columbia Contaminated Sites Regulation (BC CSR)[2].
- Landfill gas is regulated by the Landfill Gas Management Regulation and various provincial guidelines and criteria. In April 2012, CRD submitted the Hartland Landfill Gas Management Plan in accordance with the Landfill Gas Regulation requirements.

3.1 BC Landfill Criteria Revised

In June 2016, the BC MOE Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016 (revised Landfill Criteria) was released. The Landfill Criteria reflect BC MOE expectations regarding the standards for municipal landfills in BC and provide guidance to landfill owners, operators and consultants on environmentally sound landfilling practices and procedures. Although the Landfill Criteria are guidelines, they are legally enforceable at Hartland Landfill because they are incorporated into the Hartland Operational Certificate. The revised criteria is prescriptive in nature and has many new requirements, however, modified practices and exceptions are allowable if supported by technical justification and formally approved. Several requirements are automatically exempted in existing landfills until vertical or horizontal expansion is proposed.

Many aspects of Hartland's design and operation are already compliant; however, a preliminary review identified some conformance requirements for Hartland under the status quo (i.e., no expansion). These non-conformance issues are typically technical assessments (e.g., hydrologic model), administrative reporting updates (e.g., Design, Operations and Closure Plan Update upgrade) or capital improvements (e.g., landfill fire management). Many of these initiatives are already in the planning stages and have been included in the Hartland 5-year Capital Plan. Specifically, the criteria requires submission of a Landfill Criteria Conformance Review and related upgrading plan during the next SWMP review or within 5 years of issuance of the Landfill Criteria. This conformance review is in progress.

3.2 BC Contaminated Site Regulation – Upcoming Revisions

In October 2016, the BC MOE published the Stage 10 (Omnibus) amendments to the BC CSR and related consequential amendments to other related regulations. Following a 12-month transition period, these changes will come into effect on November 1, 2017. The Omnibus amendment updated over 8,500 environmental quality standards, many of which are applied against groundwater and surface water quality data at Hartland. Additionally, several new emerging contaminants are now regulated.

The current report regarding 2016/2017 Hartland environmental data does not include comparison to the Omnibus amendments because they are not yet applicable. However, CRD staff are currently evaluating the potential impact of the Stage 10 (Omnibus) amendments including the applicability of newly regulated emerging contaminants at Hartland. This assessment is in progress and will continue through 2017.

2 BC Contaminated Sites Regulation (BC CSR), BC Reg. 375/96 including amendments up to BC Reg. 184/2016 July 19, 2016.

4.0 WASTE VOLUMES AND AIR SPACE CONSUMPTION

In 2016, the Hartland Landfill received a total of 146,704 tonnes of waste, including 134,167 tonnes of general refuse and 12,537 tonnes of controlled waste. The controlled waste tonnage includes 2,875 tonnes of asbestos. The following section reports annual statistics landfill airspace and waste tonnages. The waste tonnages reported hereafter differ slightly from those above, as beneficial use material is included in the airspace and tonnage calculations. Additionally, survey reporting periods in Table 1 and Table 2 varies from the calendar year.

4.1 Monthly Waste Tonnage and Airspace Data

Monthly surveys are conducted by the CRD Environmental Engineering Division at the following key locations: active landfilling (waste), active asbestos (asbestos), and daily cover aggregate storage (daily cover). Elevation surveys document changes in airspace volume and support quality control, design conformance assessment, and ongoing landfilling optimization. The following Tables 1–3 summarize waste volumes and airspace consumption for each key location for 2016.

Table 1 Monthly Volume of Airspace Consumed at the Active Landfilling Location

Material	Date	Days	Weight Received[1] (Tonnes)	Weight/day (tonnes/day)	Airspace Consumed (m^3/day)	Total airspace consumed[2] (m^3)
Waste	Dec 30 – Feb 1	25.5	12,396	486	480	12,249
	Feb 2 – Mar 2	23	10,792	469	478	10,983
	Mar 3 – Apr 4	23.5	11,957	509	733	17,228
	Apr 5 – May 2	22	11,067	503	671	14,767
	May 3 – Jun 2	24	13,106	546	725	17,395
	Jun 3 – Jul 4	23.5	12,696	540	795	18,680
	Jul 5 – Aug 3	23	12,734	554	830	19,091
	Aug 4 – Sept 2	24	13,035	543	803	19,264
	Sept 3 – Oct 4	23.5	12,645	538	772	18,144
	Oct 5 – Nov 4	24	12,718	530	815	19,560
	Nov 5 – Dec 1	20	10,546	527	774	15,479
	Dec 2 – Jan 4	24.5	11,721	478	640	15,692
	Total	**281**	**145,413[1]**			**198,532**
	Average		**12,118**	**519**	**699**	**16,544**

Notes:

[1] Reported tonnages include beneficial use material and controlled waste (except asbestos) and, therefore, differ slightly from the officially reported weights/volumes [per the BC MOE requirements where beneficial use and controlled waste (except asbestos) are excluded]. Additionally, volumes may vary due to differing periods (survey vs calendar year).

[2] Includes daily cover volumes

Table 2 Monthly Volume of Airspace Consumed at the Asbestos Location

Material	Date	Days[2]	Weight Received (Tonnes)	Weight/day (tonnes/day)	Airspace Consumed (m^3/day)	Total airspace consumed (m^3)[1]
Asbestos	Dec 30 – Feb 1	23	257.09	11.2	59.26	1,363
	Feb 2 – Mar 2	21	224.89	10.7	52.86	1,110
	Mar 3 – Apr 4	21	172.07	8.2	34.52	725
	Apr 5 – May 2	20	274.46	13.7	62.40	1,248
	May 3 – Jun 2	22	180.29	8.2	45.05	991
	Jun 3 – Jul 4	21	206.48	9.8	55.19	1,159
	Jul 5 – Aug 3	21	198.37	9.4	57.55	1,209
	Aug 4 – Sept 2	22	252.44	11.5	47.81	1,052
	Sept 3 – Oct 4	21	158.52	7.5	39.45	829
	Oct 5 – Nov 4	22	429.98	19.5	83.46	1,836
	Nov 5 – Dec 1	18	150.64	8.4	49.98	900
	Dec 2 – Jan 4	22	394.63	17.9	75.92	1,670
	Total	**254**	**2,900**			**14,092**
	Average		**242**	**11.3**	**55**	**1,174**

Note:
[1] Includes daily cover volumes
[2] Asbestos is accepted Monday to Friday, whereas waste is accepted Monday to Saturday

Table 3 Monthly Volume of Airspace Consumed at the Aggregate Storage Locations[1]

Material	Date	Operating Days	Volume/day (m^3/day)	Daily cover used (m^3)
Daily Cover	Dec 30 – Feb 1	25.5	120	3,067
	Feb 2 – Mar 2	23	114	2,625
	Mar 3 – Apr 4	23.5	117	2,755
	Apr 5 – May 2	22	167	3,683
	May 3 – Jun 2	24	148	3,560
	Jun 3 – Jul 4	23.5	243	5,719
	Jul 5 – Aug 3	23	147	3,375
	Aug 4 – Sept 2	24	160	3,830
	Sept 3 – Oct 4	23.5	123	2,894
	Oct 5 – Nov 4	24	150	3,602
	Nov 5 – Dec 1	20	198	3,965
	Dec 2 – Jan 4	24.5	226	5,531
	Total	**280.5**	**1913**	**44,606**
	Average	**23.375**	**160**	**3,717**

Note:
[1] Aggregate was used from both Hartland North and Toutle Valley in 2016

4.2 Daily Cover Aggregate Usage

Daily cover material is summarized separately for the active landfilling and active asbestos areas. The average daily cover usage of 160 m^3/day of daily cover is segregated to the 2 areas based upon the following:

- load capacity is 10 m^3, so on average 16 loads are used daily
- 13.6 loads (85%) were transported to the active landfilling location
- 2.4 loads (15%) were transported to the active asbestos location

Therefore, the volume of daily cover used in each location can be calculated, as shown in Table 4.

Table 4 Daily Cover Volumes

Aggregate used for Daily Cover		Volume (m^3)
Total daily cover used		44,606
Daily cover used for waste	(85%)	37,915
Daily cover used for asbestos	(15%)	6,691

4.3 Waste Volume/Density – Active Landfilling Area

Annual waste density for 2016 was calculated at 910 kg/m^3, while total waste volume was 160,617 m^3, as shown in Table 5.

Table 5 Waste Volume Calculations

2016 Waste Volumes	Volume
Total airspace consumed by waste (m^3)	198,532
Volume of daily cover (m^3)	37,915
Volume of waste (m^3)	160,617
Tonnage of waste landfilled (tonnes)	145,413
Waste/daily cover ratio[1]	4.24
Waste density (tonnes/m^3)[2]	0.91

Notes:
[1] Waste:cover ratio = waste landfilled (m^3)/total daily cover (m^3)
[2] Waste density = waste received (tonnes)/waste volume received (m^3)

4.4 Waste Volume/Density – Active Asbestos Location

The annual tonnage of asbestos received and proportionate daily cover used in the active asbestos location is shown in Table 6. Asbestos density is much lower than waste density due to lack of compaction.

Table 6 Asbestos Volume Calculations

2016 Asbestos Volumes	Volume (m^3)
Total airspace consumed by asbestos	14,091
Volume of daily cover (m^3)	6,691
Volume of asbestos (m^3)	7,400
Tonnage of asbestos landfilled (tonnes)	2,900
Asbestos/daily cover ratio[1]	1.11
Asbestos density (tonnes/m^3)[2]	0.39

Notes:
[1] Asbestos:cover ratio = asbestos landfilled (m^3)/total daily cover (m^3)
[2] Asbestos density = asbestos received (tonnes)/asbestos volume received (m^3)

4.5 Uncertainties

Daily cover aggregate use for side-slopes is considerable because of daily cover requirements for exposed perimeters at the active landfilling and asbestos locations (daily cover thicknesses of at least 0.35 m required). As such, estimates may vary somewhat from actual ratios.

4.6 Quality Control

Hartland's target compaction density is at least 850 kg/m^3 (0.85 tonnes/m^3). Compaction test are performed to support the landfill operations and to verify compaction. Five different compaction tests were completed throughout 2016 at random locations throughout Hartland's recently landfilled areas. The results are shown in Table 7.

Table 7 2016 Compaction Tests

LANDFILL COMPACTION TEST REPORT 2016
TESTS SUMMARY

Contract:	Operation of Hartland Landfill Jan 2014 to June 2016
Client:	CRD - Hartland Landfill
Project Manager:	Kyle Teschke
Contractor:	Chew Excavating
Superintendent:	Mike Flynn
Date:	Wednesday, July 12, 2017

	Date Completed	Density (T/m3)
Compaction Test No.1	May 31, 2016	1.09
Compaction Test No.2	July 27, 2016	0.94
Compaction Test No.3	October 6, 2016	1.05
Compaction Test No.4	November 7, 2016	1.06
Compaction Test No.5	January 13, 2017	1.05
	Average	**1.04**

4.7 Air Space Consumption

Comparison volumes of airspace consumed, weight received, and daily cover used in the active landfilling and active asbestos locations are shown in Table 8.

Table 8 Airspace Consumption

Material	Airspace Consumed (m^3)	% of Total	Weight Received (tonnes)	% of Total	Daily Cover Used (m^3)	% of Total
Waste	160,617	95.6%	145,413	98.0%	37,915	85%
Asbestos	7,400	4.4%	2,900	2.0%	6,691	15%
Total	**168,017**	**100%**	**148,313**	**100%**	**44,606**	**100%**

It is shown that 95.6% of Hartland's total airspace was consumed for waste which required 85% of the daily cover used. Conversely, 4.4% of Hartland's total airspace was consumed for asbestos which required 15% of the daily cover used.

4.8 Design Conformance

Hartland Landfill is designed to be constructed in a series of cells. Each cell is divided into a series of lifts, which are progressively filled with waste. Throughout 2016, the Phase 2, Cell 2, 179 m lift was completed, and the 182 m and 185 m lifts were constructed from January until September, at which time filling commenced in the Phase 2, Cell 3, 143 m lift. Filling within the Phase 2, Cell 2, 179 m, 182 m and 185 m lifts was completed as designed.

5.0 REMAINING SITE LIFE

Annual planemetric surveys are conducted over the Hartland Landfill site. Survey data is used to define surface elevation. The 2016 survey was conducted in summer of 2016. Space use calculations are derived from the planemetric data and compared to the final contours associated with a filling plan prepared in the *Hartland Landfill Phase 2 Long Term Leachate Management Plan* (Sperling Hansen Associates, June 2007). These calculations estimate that the remaining capacity[3] is 4,916,000 cubic metres, compared to 5,115,000 cubic metres in 2015. It is estimated that there has been approximately 7,030,827 tonnes of municipal waste deposited at the site at the end of 2016. The estimated landfill capacity will be reached in 33 years. A landfill capacity study commenced in late 2014 to assess remaining capacity and evaluate landfill expansion options.

6.0 CLOSURE AND POST-CLOSURE FUND

A requirement of the Operational Certificate is a closure and post-closure fund to meet or exceed the estimated closure and post-closure costs with a reasonable contingency. At the end of 2016, the closure/post-closure fund was $8,444,499.

3 Estimated capacities for 2015 and 2014 are rounded values to thousandths

7.0 2016 ACTIVITIES (OPERATIONS AND CAPITAL)

7.1 Operations

The following is a brief summary of 2016 operations activities at the landfill.

- **Annual Invasive Plant Species Control:** Invasive species control continued with removal of some species and spraying of others with herbicide.

- **Execution of Landfill Operations, Mechanical Services, Security and Vector Control Contracts:** Throughout 2016, staff executed and managed contracts for on-site security, seasonal bird control, and provided direction to landfill operations contractor. The 2016 landfill operations contract was procured via a competitive public process and included an incentive bonus for high compaction rates to ensure landfill air space is managed effectively.

- **Kitchen Scraps Ban:** Kitchen scraps have been fully banned from disposal since January 2015. In 2016, segregated kitchen scraps from municipal and private haulers were collected and transported off site under a third-party processing contract. This waste stream is used to produce both green energy and compost.

- **Water System Upgrades (Potable and Fire Protection):** Through 2016, site water servicing was evaluated and upgraded. The potable water service line and meter were upgraded to improve flow rates. As a result of the 2015 active face fire, fire protection water sources were evaluated in coordination with the local municipality and fire emergency service providers. Fire protection planning continued throughout 2016.

- **Landfill Gas Engine Rebuild:** Following an August 2015 engine failure, the landfill gas utilization plant power generating engine underwent a major rebuild in 2016. In accordance with the regulations, and to minimize environmental discharges during power plant downtime, landfill gas is destroyed using the ground flare.

- **2016 Waste Composition Study:** The 2016 waste composition study provides an accurate snapshot of waste composition. The study confirms regional trend of decreasing waste generation per capita and documented the success of various waste diversion initiatives, including organics. The data is used in landfill gas modelling and to prepare educational materials.

- **Waste Discharge Permit Revisions:** In winter 2015/2016, Hartland and Environmental Protection staff revised the RSCP waste discharge permit to reflect operational changes (including the addition of domestic waste from site administrative operations into the leachate collection system). These changes, as well as administrative and source description updates, and the exclusion of chlorinated phenols in discharge sampling, have been finalized.

- **Design, Operations and Closure Plan Update:** In February 2016, CRD staff updated the Design, Operations and Closure Plan Update (last submitted in 2005). Completion of the Design, Operations and Closure Plan Update continued through 2016. Landfilling activities have not changed substantially since 2005.

- **Hartland Open House:** Hartland hosted an open house in June 2016 to promote public awareness about landfill operations and activities. This biennial CRD event features site tours, access to landfill experts, and educational displays focusing on recycling, environmental monitoring, compost education and watershed management.

7.2 Capital Works

Since 1985, over $40 million has been invested in capital works, environmental controls and general site improvements. The annual budget is approximately $3 million and the following capital projects completed/commenced in 2016:

- **Airspace/Aggregate Production and Hartland North Aggregate Storage Area Preparation:** To prepare for opening of Phase 2, Cell 3, drilling, blasting and hauling aggregate and shot rock from the northwest side of the landfill took place in 2016. It is estimated that approximately 30,000 cubic metres were removed and stored on site for operational use. At the very end of 2016, phased construction of a new aggregate storage area commenced with the clearing of vegetation. Other aspects of construction will continue through 2017.

- **Interim Landfill Cover – Phase 2, Cell 2 (South East Face):** Interim cover was placed on southwest face of Phase 2, Cell 2 as required in the Landfill Criteria for Municipal Solid Waste to reduce leachate generation by shedding precipitation and improves landfill gas capture. Hartland interim closures include a gravel layer overlain by a synthetic cover.

- **Gas and Leachate Collection Infrastructure:** Combined landfill gas and leachate collectors continued to be installed in Phase 2, Cell 2 in 2016. Wellheads, valves, condensation traps, monitoring points and piping are installed and commissioned to convey landfill gas to the gas plant and leachate to the storage lagoons. The 175 m and 179 m lift collectors were installed in 2015/2016.

- **Microtunnel Cleaning and Retrofit:** In 2016, the CRD conducted design and planning for retrofit of the microtunnel chamber. The retrofit will allow for safe access for annual flushing and cleaning of the microtunnel. Unobstructed operation of the microtunnel is critical to leachate containment at the landfill.

- **Landfill Criteria Conformance Assessment:** A conformance assessment respecting the Revised Landfill Criteria commenced in 2016. The Revised Landfill Criteria requires submission of a Landfill Criteria Conformance Review and related Upgrading Plan during the next SWMP review or within 5 years of issuance of the Landfill Criteria. This conformance assessment is in progress.

- **Environmental Inventory – Hartland North Aggregate Storage:** To support planning for future aggregate storage needs (approximately 280,000 m^3 over the life of the landfill), an environmental inventory was completed in 2015/2016 for potential future aggregate storage areas in Hartland North.

- **Phase 2, East Toe Berm Upgrades:** An aggregate toe berm was added to Phase 2 (east) to improve for seismic stability as Phase 2 top elevation was raised in accordance with recommendations in the Seismic Stability Assessment Update Report (2015).

- **Phase 2, Cell 3 Underdrain and Liner System:** In accordance with Hartland filling plans, Phase 2, Cell 3 was constructed and use commenced in fall 2016. Cell 3 includes new leachate containment (i.e., the Toutle Drain) and gravity flow conveyance infrastructure, which discharges directly into the upper leachate lagoon.

- **Conceptual Landfill Capacity Study, Aggregate Management Plan and Stockpile Design:** The CRD procured a conceptual landfill capacity study to support long term planning and to identify options for extending the landfill capacity. The study was supplied measures for increased efficiency (on a per tonne basis). The aggregate management plan and stockpile design will identify appropriate locations to store the rock, ensure that the stockpiles are accessible, stable, and that the run-off is contained.

- **Replacement Commercial Scale Decks:** Replacement of the aged automated commercial scale decks was completed due to identified structural issues.

- **Leachate Control Verification of North Purge Well System:** In March and April 2016, the CRD documented the extent of the drawdown cone resulting from the north purge well system. The test used pressure transducers to measure well responses to variable north purge well pumping and scenarios. The tests will be repeated in the future.

- **Hydrogeological Conceptual Model of North Ridge (Draft):** Hydrogeological data was collected to determine whether the groundwater flow divide located beneath the bedrock ridge located north of the Phase 2 landfill is prominent and persistent enough to continue restricting northward leachate migration during future landfill development activities. Hydrogeologic pumping tests were conducted and a hydrogeological conceptual model was compiled.

- **Overview of Landfill Gas Utilization Options and Technologies:** Currently, just over half of the landfill gas captured on site is utilized for energy production. In 2016, consultants were retained to provide an overview of the landfill gas utilization at Hartland and conduct a high-level technical assessment of current utilization technologies deemed viable at Hartland Landfill. Technologies were assessed based on current landfill gas feedstock, access to markets, maturity of the technology and applications at similar landfill sites.

8.0 2017 PLANS (OPERATIONS AND CAPITAL)

8.1 Planned 2017 Operations Projects

- **Bylaw Amendments:** An increase in tipping fee for out-of-region asbestos and kitchen scraps will come into effect January 2017.

- **Hartland Open House:** Hartland will host an open house in June 2018 to promote public awareness about landfill operations and activities. The event includes site tours, access to landfill experts, and educational displays.

- **Annual Invasive Plant Species Control:** Invasive species control will continue with removal of some species and spraying of others with herbicide.

- **Continuation of Security, Bird Control and Landfill Operations Contracts:** Ongoing management of CRD contractors, including security, bird control, operations and kitchen scraps management.

- **Water System Upgrades (Fire Protection):** Fire protection planning will continue throughout 2017.

- **Demolition and Renovation Waste Management:** To improve health and safety, and reduce potential hazardous materials exposure, the CRD has developed a new screening process for residential demolition loads and a supporting outreach campaign. All building demolition and renovation wastes will be screened similar to the existing commercial screening process. As a result, consistent and prescriptive rules will apply to all building demolition wastes. Exposure monitoring for dust and asbestos will continue on the site.

8.2 Planned 2017 Capital Projects

- **Airspace/Aggregate Production and Aggregate Storage Area Preparation:** Design of airspace/ aggregate activities planned for the slope north of Phase 2, Cell 3 will occur in 2017. Construction of the new aggregate storage area in Hartland North will continue with removal of cleared trees and surface soil.

- **Interim Landfill Cover – Phase 2, Cell 2 (South East Face):** Interim cover placement will continue on Phase 2, Cell 2 as required in the Landfill Criteria for Municipal Solid Waste to reduce leachate generation by shedding precipitation and improving landfill gas capture. Hartland interim closures include a gravel layer overlain by a synthetic cover.

- **Gas and Leachate Collection Infrastructure:** Combined landfill gas and leachate collectors will continue to be installed as landfilling progresses. Well heads, valves, condensation traps, monitoring points and piping are installed and commissioned to convey landfill gas to the gas plant and leachate to the storage lagoons. The Phase 2, Cell 2, 171 m, 175 m, and 179 m lifts collectors are expected to be activated in 2017. Gas and leachate collectors in the 183 m lift (the top lift) in Phase 2, Cell 2 will await interim closure design and installation. As waste placement allows throughout 2017, the Phase 2, Cell 3 gas and leachate collector design and installations are expected to occur in lifts 151 m, 155 m, and 159 m.

- **Microtunnel Cleaning and Retrofit:** A retrofit of the microtunnel chamber will occur in summer/fall 2017. The retrofit will allow for safe access for annual flushing and cleaning. Unobstructed operation of the microtunnel is critical to leachate containment at the landfill.

- **Landfill Criteria Conformance Assessment:** A conformance assessment that commenced in 2016 will continue through 2017.

- **Monitoring Network Upgrades:** Ongoing upgrades to the environmental monitoring network will continue through 2017. Planned works include a weir and automated flow measurement along the new Phase 2, Cell 3 leachate collector (Toutle Drain); automated water/leachate level monitoring device upgrades, and monitoring well decommissioning and/or replacements, as needed.

- **Detailed Phase 2 Filling Plan:** In 2017/2018, the CRD will commence detailed filling plan design for an approximate 20-year timeframe. The plan will include detailed cell-by-cell sequencing and engineering, infrastructure design for landfill gas, leachate and surface water management, quarry and aggregate design, progressive closure design, and other infrastructure design (i.e., power, roads, etc.).

- **Airspace/Aggregate Production:** Drilling, blasting, and hauling aggregate will continue, as required, to support airspace production in accordance with the filling plans.

- **Planning for Hartland North Residual Treatment Facility:** Hartland Landfill will work with CRD and external entities in planning for the future residual treatment facility at Hartland North to support ongoing Hartland activities and maintenance of environmental controls.

- **Odour Pilot Study:** In the absence of complaints, limited data is available regarding odour potential at Hartland Landfill. An odour monitoring pilot study will be used to design future monitoring and mitigation protocols that support ongoing Revised Landfill Criteria compliance. The project will document baseline odour data using a variety of methods and evaluate odour monitoring options.

- **Design Commercial Scale Decks – Hartland North:** Design of automated commercial scales for Hartland North will be prepared in 2017. The scales will support both Hartland Landfill and the future residual treatment facility.

- **Hartland North Preliminary Water Balance:** A preliminary water balance will be commissioned for the Hartland North area to build on the hydrogeologic conceptual model of this area. The model and this water balance support a fulsome understanding of the groundwater flow divide and its long-term viability during future landfill development activities.

- **Leachate Geochemical Review:** Leachate geochemistry will be evaluated to identify mechanisms contributing to recent biofouling of the leachate conveyancing infrastructure and decreased flow rates. The document will identify preliminary mitigation and prevention alternatives.

9.0 2016–2017 ENVIRONMENTAL MONITORING

CRD staff monitor landfill gas, groundwater, surface water and leachate quality to ensure the effectiveness of management activities and confirm regulatory compliance. Based on monitoring conducted in 2016[4], the program continues to provide data needed to:

- meet Operational Certificate requirements;
- identify potential impacts of landfill operations, if any;
- plan environmental mitigation, if required; and
- measure the effectiveness of control measures.

The key findings of the landfill gas, groundwater, surface water and leachate monitoring program presented here are referenced from the following:

- Hartland Landfill Groundwater, Surface Water, Leachate Monitoring Program Annual Report (April 2016 to March 2017), AECOM Canada Ltd. (AECOM) – Appendix A

- Hartland Landfill – Landfill Gas Monitoring, Annual Report, 2016, Parks & Environmental Services, Environmental Protection, CRD, October 2017 – Appendix B

9.1 Landfill Gas Monitoring Program

Decomposition of refuse creates landfill gas; the composition and amount of gas generated varies based on factors such as amount, type and age of waste, as well as environmental conditions, such as moisture content. Peak gas generation occurs during the first 1 to 3 years after disposal. Landfill gas is primarily composed of methane and carbon dioxide with small amounts of water vapour, oxygen, nitrogen and trace gases. Trace gases include hydrogen sulphide, ammonia, nitrous oxide, volatile organic compounds and chlorofluorocarbons. Initially, decomposition of waste is an aerobic process and produces mainly carbon dioxide. As oxygen is depleted, the decomposition occurs under anaerobic conditions.

Landfill gas management is dictated by a variety of BC regulations (including the BC Landfill Gas Management Regulation), design guidelines, criteria, Hartland-specific management plans, and WorkSafeBC. The BC Landfill Gas Management Regulation requires landfills generating more than 1,000 tonnes per year of methane to develop landfill gas management plans that targets 75% collection efficiency in 4 years. A plan was completed for Hartland Landfill and submitted to the MOE in April 2012 with an implementation target of the end of 2016.

Since the 1990s, Hartland Landfill has implemented a system to assess and control fugitive landfill gas emissions. The objective of these controls is ultimately to reduce emissions, ensure staff health and safety, and comply with regulations. Since the implementation of the Landfill Gas Management Regulation in 2010 landfill gas collection and/or management program at Hartland now includes gas generation modelling, gas collection infrastructure installation and maintenance, and operation of a landfill gas beneficial use facility. Additionally, the landfill gas program monitors the effectiveness of the collection infrastructure through a variety of monitoring programs.

Landfill gas generated in the landfill is drawn under vacuum to the gas plant where it is directed to a generator and/or to a flare. The gas is then conditioned (cleaned) and methane and oxygen content is measured. Excess gas is fed back to a candlestick flare, while the ground flare is only used during extended generator downtime. The landfill gas collection system is designed to reach 75% collection efficiency as per the Landfill Gas Management Facilities Design Guidelines. The CRD is in the process of implementing the plan.

4 Monitoring calendars vary such that the landfill gas ‘year’ is January to December, but the groundwater, surface water and leachate ‘year’ is April to March.

To monitor the effectiveness of the landfill gas collection infrastructure, Hartland Landfill has implemented a 4-component monitoring program. In 2016, the monitoring program confirmed that landfill gas was maintained within the landfill and results were within specified criteria or regulatory limits.

The main components of the landfill gas system at Hartland include collection infrastructure, gas generation modelling, and gas utilization. The effectiveness of the landfill gas system is monitored by the CRD GeoEnvironmental Program as follows:

1. **Collection and utilization system monitoring:** To evaluate changes in gas quality over time, and evaluate data for gas collection and gas utilization to assess collection efficiency and total emissions from the landfill.

2. **Subsurface perimeter and building foundation probe monitoring:** Quarterly monitoring to assess the potential for subsurface landfill gas migration at the eastern landfill boundary and at on-site buildings for compliance with criteria, and for worker and public health and safety. Monitoring is required by the BC MOE Landfill Criteria for Municipal Solid Waste.

3. **Ambient grid and hot spot monitoring:** Twice annual monitoring to verify the effectiveness of cover and landfill gas collection systems and identify areas of concern where landfill gas is being released to the atmosphere for protection of worker and public health and safety.

4. **Landfill Gas Speciation:** Speciation is conducted bi-annually to assess the composition of gas with regard to volatile organic compounds, sulphur gases and typical landfill gases in order to calculate ambient dilution concentrations for health and safety and infrastructure integrity purposes. Speciation was last completed in 2015 and the next monitoring event is scheduled for 2017.

9.1.1 Gas Generation

In 2016, Hartland Landfill generated 7,979 tonnes of methane, based on the MOE provided gas generation model. As required, the MOE gas generation model is updated annually with waste quantity and composition data to enable annual calculation of collection efficiency and greenhouse gas emissions. An organics diversion program and ban took effect in January 2015. Continued diversion of a large portion of highly decomposable waste stream from the landfill is expected to result in a decrease in overall gas production.

9.1.2 Gas Collection and Utilization

In 2016, the gas collection system consisted of 74 vertical wells, 57 horizontal wells, for a total of 131 wells. Twelve new horizontal wells were installed in completed lifts in Phase 2. The top 8 collecting wells accounted for close to 40% of the total volume of gas collected. The well field was balanced monthly in 2016, as recommended by the Landfill Gas Management Facilities Design Guidelines.

Total fugitive greenhouse gas emissions generated from the landfill for 2016 are estimated at 75,939 tonnes CO_2. This represents an increase from 2015 quantities, but a 27% decrease since the implementation of the Landfill Gas Management Plan in 2012. It is expected that fugitive greenhouse gas emissions will continue to decline due to improvements in gas extraction infrastructure. As noted, overall gas production is expected to decline with continued waste diversion initiatives (e.g., kitchen scraps, etc.).

The CRD has implemented the conceptual design in the plan with limited filling plan changes. In 2016, landfill gas collection efficiency was 61.8%. Modelled methane generation was 1,579 scfm and of that, an average of 1,009 scfm was captured through the gas plant. Current landfill gas collection efficiencies are within estimated ranges according to the Landfill Gas Management Plan.

9.1.3 Gas Monitoring and Compliance Summary

Numerous monitoring programs are in place to evaluate the performance of landfill gas system. Table 9 has been prepared to summarize the results of these monitoring programs, whether the results comply with requirements, actions taken to address non-compliance, and recommendations.

Table 9 Landfill Gas Compliance Summary 2016

Program	Compliance Location	Criteria	Findings	Actions	Recommendations
Perimeter Probe Monitoring	Probes GP-1A, 1B, 2A, 2B, 3A, 3B, 11A, 11B, 12A and 12B	Methane in subsurface soil must not exceed the Lower Explosive Limit (BC Landfill Criteria for Municipal Solid Waste)	No exceedances. Low risk of subsurface gas migration to adjacent properties.	None	Continue quarterly monitoring.
Building Foundation Probe Monitoring	Probes GP- 4A, 5A, 6A, 6B, 7A, 7B, 8A, 9A, 13A, 14A, 17A, 18A	Maximum 1.0% methane in any on-site facility (BC Landfill Criteria for Municipal Solid Waste). Maximum 1% methane inside buildings (Landfill Gas Management Facility Design Guidelines).	No exceedances. Low risk of subsurface gas migration to adjacent building.	None	Continue quarterly monitoring.
Ambient Grid Monitoring	N/A	100 ppm Total Hydrocarbon as methane (CRD internal guideline).	3 grid locations >100 ppm No cover system failures suspected in the closed area of Phase 1.	Investigated hot spots, mitigated were possible.	Continue biannual monitoring.
Hot Spot Monitoring	N/A	1,000 ppm Total Hydrocarbon as methane (CRD internal guideline).	No new hot spots >1,000 ppm, No hot spots removed. Currently 21 locations for hot spot investigation.	Added new locations of hot spots to the monitoring program.	Continue biannual monitoring. Investigate remediation measures.
Well Field Monitoring and Balancing	N/A	Monitor monthly. Oxygen <3% - gas optimization and reduction of fire potential	Monitoring completed monthly; oxygen did not exceed 3%.	Well field monitoring has been scheduled monthly for 2017.	Continue monthly monitoring at minimum.
Gas Speciation (2015)	N/A	N/A	Undiluted landfill gas exceeded WorkSafeBC criteria for methane, carbon dioxide, hydrogen sulfide, vinyl chloride and benzene; however, ambient concentrations are likely well below WorkSafeBC limits due to dilution with ambient air.	None	Conduct speciation of landfill gas in 2017.
Gas Collection	N/A	75% gas collection efficiency target by the end of 2016 as per Landfill Gas Management Plan.	Gas collection efficiency was estimated at 61.8%, based on the MOE gas generation model.	None	Continue to implement the gas management plan.

9.2 Groundwater Quality Monitoring Program

Engineered controls at Hartland Landfill collect and contain leachate to reduce or eliminate potential effects to groundwater and surface water quality. Since 1990, the leachate has been captured and contained on site and discharged via pipeline to the sanitary sewer.

Groundwater and surface water monitoring stations on the Hartland Landfill property and specific off-site locations have been monitored since 1983. The purpose of the groundwater and surface water monitoring program is to assess impacts of landfill processes and operations on water quality and to assess compliance with water quality standards at the property boundary. In addition to this, leachate, generated by the infiltration of precipitation through the municipal waste, is also monitored for flow and quality. Monitoring data is collected to assess the potential for effect of landfill processes on groundwater and surface water resources. The annual monitoring program has 3 main components:

1. Groundwater monitoring on site and at selected off-site domestic wells
2. Surface water monitoring at on-site and off-site locations
3. Leachate quality and flow monitoring

Hartland Landfill has an extensive network of groundwater wells to monitor conditions immediately adjacent to the Phase 1 and Phase 2 areas, and at points adjacent to the landfill property boundary. Groundwater elevations are routinely monitored in approximately 120 well locations to understand the direction of groundwater flow within the landfill property. Groundwater quality is monitored at groundwater well locations to evaluate and identify changes in water chemistry that may be attributed to landfill processes and operations and, specifically, the effect of landfill leachate on groundwater resources. In addition, 12 privately owned, domestic drinking water wells within a 2-km radius of Hartland Landfill are monitored.

Groundwater quality is assessed against BC CSR numerical standards for the protection of drinking water and aquatic life. This represents a change, as the data was previously compared against only the BC Water Quality Guidelines[5]. Current water quality is generally similar to previous years, though when compared to the new standards, site conditions have improved.

In February 2016, AECOM conducted an evaluation of the annual sampling program. The majority of the monitoring program remained unchanged; however, the following minor recommendations have been implemented:

- Elimination of a few select monitoring locations from the groundwater monitoring program where duplicate, adjacent locations were continued and/or long term data indicated no water quality concerns;
- Select parameters were removed from the routine groundwater sampling analytical package where long term data indicates no water quality concerns; and
- Quarterly groundwater, surface water, and leachate level monitoring at most locations throughout the landfill with continuous automated water level monitoring at select location.

9.2.1 Results

Of over 120 wells at Hartland, 34 groundwater monitoring wells are Boundary Compliance Monitoring Locations including wells at locations 4, 18, 20, 21, 28, 29, 30, 31, 39, 41, 42, 50, 53, 55, 56, 57, 71, 72, 73. Groundwater quality data collected between April 1, 2016 and March 31, 2017 indicated that the boundary stations were in compliance with BC CSR standards. The results of the 2016–2017 program were similar to those measured in recent years and showed improvement in several areas. The results of groundwater monitoring for each of the landfill boundary areas are presented in the following sections.

[5] BC Approved Water Quality Guidelines and the Compendium of Working Water Quality Guidelines

Phase 1

Groundwater flow was consistent with historical trends. Groundwater flow directions in the Phase 1 area were primarily to the north, and most of the northward flowing groundwater was captured by the leachate containment and collection system. At the south end of Phase 1, a groundwater divide corresponding with a bedrock high influences the groundwater flow. North of this divide, groundwater flows to the north. South of the divide, groundwater flows south and is intercepted by the leachate containment and collection system.

The water quality data south of Phase 1 confirms that leachate containment has successfully controlled leachate impacts. Water level and quality monitoring in this area should continue to confirm ongoing effectiveness of leachate containment and identify any changes in the extent or magnitude of leachate impacts.

North of the Landfill

Groundwater quality in boundary compliance locations north of the landfill met the applicable BC CSR groundwater standards. Groundwater quality in this area is stable or improving based upon statistical analysis. Improvements are considered related to the effective operation of the north purge well system including recent improvements.

Table 10 Groundwater Quality Compliance Summary North of the Landfill (2016–2017)

Well	Exceedances	# of Exceedances	5-year Trend
20-1-1	none	-	Stable
20-1-2	none	-	Decreasing conductivity, ammonia, sulphate
21-1-1	none	-	Decreasing sulphate
21-1-2	none	-	Decreasing sulphate
21-2-1	none	-	Stable
28-1-0	none	-	Stable
29-1-1	none	-	Decreasing conductivity chloride
29-1-2	none	-	Decreasing conductivity chloride
30-1-1	none	-	Decreasing conductivity chloride, decreasing ammonia
30-1-2	none	-	Decreasing conductivity chloride
31-1-1	none	-	Increasing ammonia
31-1-2	none	-	Decreasing chloride
39-1-1	none	-	Increasing ammonia
39-2-1	none	-	Decreasing sulphate and chloride
53-1-1	none	-	Decreasing sulphate

Concentrations of groundwater quality in other Phase 1 wells were consistent with previous years. Leachate impacts continued in areas within or immediately adjacent to the landfill (e.g., monitoring well 58-1-0). Impacted groundwater in this area is collected by the north purge well system. In fall 2015, the CRD and AECOM identified options for augmenting leachate collection in the area west of the lower leachate lagoon (e.g., near monitoring well 40-1-1). To augment the leachate collection near 40-1-1, a pump was installed in an existing well (P9) located west of the existing purge well system (P7 and P8). Performance of P9 is routinely assessed through drawdown testing.

Continued operation of the north purge well system will reinforce leachate collection and containment and to contribute to water quality improvements. Augmentation of the north purge well system is recommended to further reduce the persistent presence of these leachate indicator parameters in groundwater in this area.

Wells along Willis Point Road met the BC CSR standards, but continued to show road salt-related impacts.

South of Phase 1

To the south of the Phase 1 groundwater divide, groundwater flows towards the south. A number of leachate containment measures have been installed in this area since the mid-1980s. The containment system in this area is composed of a grout curtain, a clay berm, a shallow toe drain and 5 purge wells which, in combination, obstruct and intercept southward-flowing leachate. The leachate is then directed to the leachate collection system.

Water quality in the boundary compliance stations south of Phase 1 met the BC CSR standards. Consistent with the previous reporting periods, leachate indicator parameter concentrations indicate some leachate influence in this area; however, 5-year concentration trends are improving. Potential leachate migration is being addressed through continued optimization and maintenance of the south leachate purge well system.

As shown in Table 11, leachate indicator parameter trends indicate that concentrations are generally either stable or decreasing.

Table 11 Groundwater Quality Compliance Summary South of the Landfill (2016–2017)

Well	Exceedances	# of Exceedances	Trend
04-3-1	none	-	Decreasing conductivity, sulphate, chloride, increasing ammonia
04-4-1	none	-	Decreasing chloride, increasing ammonia
07-1-0	none	-	Decreasing sulphate
71-1-1	none	-	Decreasing conductivity, chloride, sulphate
71-2-1	none	-	Decreasing chloride, sulphate, increasing ammonia
71-3-1	none	-	Stable
72-1-1	none	-	Increasing chloride
72-3-1	none	-	Stable
73-1-1	none	-	Decreasing conductivity, sulphate
73-2-1	none	-	Decreasing conductivity, sulphate
73-3-1	none	-	Decreasing conductivity, sulphate

East of Phase 1

Similar to previous years, water quality east of Phase 1 met BC CSR standards for the reporting period (as shown in Table 12). A slightly elevated ammonia concentration in well 18-2-2 and 17-1-2 in December 2016 is not likely due to leachate, but should be confirmed through continued monitoring. Water quality in this area should continue to be closely monitored, as groundwater movement in this area is directed from east to west, preventing off-site leachate migration to the east. The 2016–2017 data collected in wells east of Phase 1 confirmed that leachate is effectively contained on site in this area.

Table 12 Groundwater Quality Compliance Summary East of the Landfill (2016–2017)

Well	Exceedances	# of Exceedances	Trend
18-1-1	none	-	Stable
18-2-1	none	-	Decreasing chloride
18-2-2	none	-	Stable

Phase 2

In the Phase 2 area, immediately west of Phase 1, groundwater flow is directed inward toward the base of the former Heal Lake, where leachate is collected by an underdrain system and discharged to the leachate lagoons. This area of the leachate collection and containment system is known as the Phase 2 basin. Because the groundwater flow is directed inward toward the basin, it is considered a hydraulic trap. Leachate and water levels are monitored in Phase 2 to ensure that the hydraulic trap is maintained. The 2016–2017 data indicate that the hydraulic trap functioned effectively throughout the year.

Automated leachate level monitoring has traditionally been conducted within the refuse in Phase 2. That monitoring equipment failed in 2014 and should be replaced by 2019 to ensure appropriate leachate and landfill operational activities.

North of Phase 2 and North of the Hartland North Pad

Groundwater quality met BC CSR standards at all boundary compliance locations north of Phase 2, including locations north of the Hartland North pad.

In the vicinity of the Hartland North pad, northwest of Phase 2, groundwater results indicate that over the past 7 years, impacts from historical composting activities have been reduced and impacts from aggregate stockpiling on the Hartland North pad have stabilized or are decreasing. Improvements since 2012 are largely attributed to the aggregate cover system installed in January 2012. Continued monitoring is warranted to confirm ongoing improvements and efforts should be made to reduce infiltration by maintain temporary covers.

Table 13 Groundwater Quality Compliance Summary North of the Hartland North Pad (2016–2017)

Well	Exceedances	# of Exceedances	Trend
41-1-1	Manganese (DW)[1]	2	Decreasing conductivity, sulphate
42-1-1	none	-	Decreasing chloride, sulphate
55-1-1	none	-	Decreasing conductivity, chloride, sulphate
56-1-1	none	-	Decreasing conductivity, chloride, sulphate
57-1-1	none	-	Decreasing conductivity, chloride, sulphate

Notes:
[1] The drinking water standard for manganese is an aesthetic objective

Commencing in 2015/2016, the CRD initiated 2 special studies in the Hartland North area to improve understanding of the groundwater flow divide located beneath the bedrock ridge located north of the Phase 2 landfill. These studies support a fulsome understanding of the groundwater flow divide and its long-term viability during future landfill development activities. The studies were performed to determine whether the Hartland North groundwater flow divide is prominent and persistent enough to continue restricting northward leachate migration during future landfill development activities. AECOM conducted hydrogeological pumping tests and prepared a hydrogeological conceptual model and SLR commenced a preliminary water balance.

The AECOM report indicated that bedrock discontinuities (i.e., faults) are a significant factor contributing to the large fluctuations in groundwater elevations observed beneath the north ridge. The bedrock discontinuities and precipitation variations result in a weaker flow divide in summer and stronger more prominent divide during higher winter elevations. AECOM recommended a preliminary water balance to better understand the weaker flow divide periods in summer. Additionally, given the influence of fractures, AECOM recommended that future quarrying in this area be managed to minimize potential for blast-enhanced fracturing that could have negative impacts on hydraulic properties and be conducted under direction from a specialized blasting professional.

To augment the AECOM hydrogeologic model, SLR's preliminary water balance for the Hartland North area was designed to model the effects of climate changes, infiltration and construction activities on groundwater elevations. This work is ongoing.

9.3 Domestic Well Monitoring Program

Since the 1980s, the CRD has performed routine sampling and analysis of domestic wells in the vicinity of the landfill that are used as the primary source of drinking water. In 2016, water quality data was collected from 13 domestic wells located within a 2-km radius of the landfill on July 19, 2016. The sampling program included single samples and 1 replicate sample which were analyzed for general water quality parameters and total metals.

The number of wells included in the program has gradually been reduced as municipal water became available and residents chose to connect to the municipal supply system. Most of the domestic wells near Hartland Landfill are situated southeast of the landfill and are bedrock wells drilled to depths of 30 to 120 metres.

Laboratory analytical results were compared to the BC Approved Water Quality Guidelines (2010 edition) where available and Guidelines for Canadian Drinking Water Quality (2008) where they are more stringent.

9.3.1 Results

The 2016 domestic well water quality met applicable drinking water quality guidelines, with the exception of a few exceedances of aesthetic targets for iron and/or manganese. The iron and manganese concentrations in excess of drinking water guidelines occur occasionally, but these guidelines are aesthetic targets and are not human health objectives or leachate indicators. Iron and manganese concentrations in wells 53 and 38, respectively, exceeded the aesthetic targets. The results are consistent with background conditions and indicate that landfill leachate is not affecting any of the 13 domestic wells sampled.

9.4 Surface Water Monitoring Program

Hartland Landfill is located within the Tod Creek watershed. Drainage south of the landfill is directed toward Killarney Lake and Prospect Lake, discharging to Tod Creek. Drainage north of the landfill flows northeasterly within Heal Creek to Durrance Creek, discharging to Tod Creek, and ultimately, to Tod Inlet. Surface water is monitored to ensure that it is not adversely affected by landfill operations.

The monitoring program includes approximately 23 sites within the landfill, at the property boundary and within each of the major off-site drainages. Five of these stations are considered boundary compliance monitoring stations. These stations are concentrated north and south of the landfill where creeks flow from the landfill property to off-site locations. Water quality results are compared to the BC Approved and Working Water Quality Guidelines (BC WQG) for Freshwater Aquatic Life.

9.4.1 Results

Surface water quality data collected in 2016–2017 confirmed that nearby surface water bodies, Tod Creek, Durrance Lake, Durrance Creek and Killarney Lake are not impacted by leachate and have not been for many years.

Surface water samples collected in this monitoring program typically met the BC WQG-MAC[6] and or BC WQG 30-day average values. Occasional exceedances for a select parameters were reported at 2 of the compliance locations. Elevated concentrations are considered related to seasonal impacts (rain events or dry low-flow conditions). Decreasing concentration trends were reported for the 5 compliance locations. The CRD has addressed sample variation during low flow stream conditions and has implemented increased leachate containment near the lower lagoon. These efforts are expected to improve surface water quality.

6 BC WQG MAC are the maximum concentration of a parameter that should not be exceeded at any time.

Table 14 Surface Water Quality Compliance Summary (2016–2017)

Location	Exceedances	# of Exceedances	Trend
SW-N-05	none	-	Decreasing conductivity, sulphate
SW-N-16	Total & Dissolved Iron	1	Stable
SW-N-41s1	Total Iron, TSS	1	Decreasing conductivity, nitrate, sulphate
SW-N-42s1	none	-	Decreasing conductivity, chloride, sulphate
SW-S-04	none	-	Decreasing conductivity, chloride / Increasing ammonia

9.5 Leachate Management and Monitoring Program

Leachate is produced from the percolation of precipitation and groundwater through the decomposing refuse in the landfill. At Hartland Landfill, leachate is managed through landfill design, input monitoring, contaminant treatment, if required, and routine monitoring.

9.5.1 Leachate Management

Typically, leachate inputs do not vary; however, during this reporting period, operational changes resulted in the redirection of organic receiving area and administrative building domestic wastes into the leachate collection system. The aged on-site septic system was abandoned in November 2015. As a result, the CRD RSCP waste discharge permit was amended to reflect the new inputs.

At Hartland, 2 leachate treatment options (aeration and bioxide treatment) are available to mitigate sulphide concentrations which occasionally exceed the CRD RSCP waste discharge permit limits. Since May 2014, leachate stored in the lower lagoon is continuously aerated. Bioxide infrastructure is maintained to mitigate sulphide concentrations, but was last active from May to July 2014, when the aeration process was being initiated and tested. Bioxide treatment has not been necessary since the aeration process was implemented.

9.5.2 Leachate Monitoring

A routine leachate monitoring program is conducted to:

- document leachate discharge volumes and flow rates to the sanitary sewer;
- characterize the physical and chemical constituents in the leachate; and
- verify compliance with the CRD RSCP waste discharge permit at the point of discharge.

Automated monitoring of the volume of leachate discharged is maintained on the CRD SCADA system and provides a basis for measuring flow rates to the sanitary sewer and leak detection. Monthly leachate samples are collected to verify compliance with the RSCP waste discharge permit. Routine and annual leachate testing includes analysis of a variety of chemical parameters (e.g., nutrients, mineral oil and grease, organic compounds, metals and chlorinated compounds).

Results

The total leachate discharged during the reporting period was 423,971 m^3. The average leachate flow over the period April 1, 2016 to March 31, 2017 was 13.44 L/s, which is slightly greater than the previous reporting year's average flow of 11.23 L/s. Leachate generation rates vary with annual precipitation rates and the precipitation values for 2016–2017 were greater than in 2015–2016.

Leachate quality at the point of discharge to the leachate pipeline was in compliance with the RSCP waste discharge permit throughout the reporting period.

Hartland Landfill leachate continues to report low contaminant levels compared to other typical municipal waste landfills.

9.6 Summary of Environmental Monitoring Recommendations

The environmental monitoring program at Hartland Landfill provides a valuable foundation to evaluate the effectiveness of the control measures, assess potential impacts of Hartland Landfill and support landfill management and operations by providing information to staff, managers and committees.

- Overall, the monitoring programs conducted at Harland Landfill (landfill gas, groundwater, surface water, domestic wells and leachate) confirm that regulatory requirements are met and are critical to the successful management of Hartland Landfill. Monitoring programs are routinely optimized through a continuous improvement program that evaluates data, sampling techniques and quality. As required to meet regulations, the annual monitoring program results will continue to be reviewed and interpreted by qualified professionals experienced in assessing the impacts of landfill leachate at large municipal landfills similar to Hartland Landfill.
- Landfill gas monitoring programs should continue (i.e., quarterly perimeter probes, quarterly building foundation probes, bi-annual ambient grid, hot spot monitoring and speciation) to measure and ensure regulatory compliance. Landfill gas collection efficiency (utilization) for 2016 was 61.8%. Continued monthly well field balancing is necessary to optimize gas collection. Gas speciation is recommended for 2017 to enable tracking of gas composition changes.
- The environmental monitoring program and data should be evaluated against the Revised Landfill Criteria and the BC CSR Stage 10 (Omnibus) amendments to determine if monitoring program changes are warranted to continue meeting regulatory requirements.
- Operation of the north and south purge well systems effectively controls and contains leachate and should be continued, including planned optimization and maintenance activities. 2016 optimization efforts have had beneficial results. The extent of the drawdown cone should continue to be validated routinely and additional optimization implemented if warranted.
- Recently malfunctioning monitoring equipment should be replaced by 2019 to allow for evaluation of leachate mounding in Phase 2.
- Aggregate stockpiles should be stored within the leachate containment area or covered to protect downgradient surface water quality. Water quality downgradient of aggregate stockpile areas should continue to be closely monitored to confirm the effectiveness of cover systems.
- Leachate flow and chemistry should continue to be monitored to inform landfill management and operational decisions and to comply with the RSCP waste discharge permit. Leachate treatment should be implemented on an as-needed basis to periodic sulphide concentration spikes, and monitoring should be conducted to demonstrate the effectiveness of the leachate treatment. Additionally, aeration system in the lower lagoon should continue to be operated as a cost-effective way to limit sulphide formation during storage of leachate.
- Future landfill planning should include a detailed hydrogeological evaluation to ensure that proposed works will not compromise the integrity of leachate containment.

10.0 CONCLUSIONS

The CRD Hartland Landfill and recycling facility provides recycling; household hazardous waste collection; a salvage area; yard and garden waste collection and processing; controlled waste disposal; and landfill services to commercial and residential customers. The facility operates under an approved SWMP and BC MOE Operational Certificate 12659. This report is intended for internal and external CRD stakeholders and regulators including the BC MOE. The report compiles data regarding total waste tonnages, landfill lifespan, closure funding, operational and construction related activities in 2016 and environmental monitoring program results.

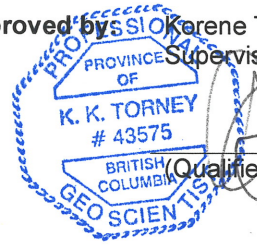
In 2016, the Hartland Landfill received a total of 146,704 tonnes of waste[7], including 134,167 tonnes of general refuse and 12,537 tonnes of controlled waste. The controlled waste tonnage includes 2,875 tonnes of asbestos.

The Harland landfill monitoring programs confirm that regulatory requirements are met and provide critical data that supports successful management of the landfill. Based upon the monitoring program, effective measures are in place to ensure environmental impacts are mitigated and leachate is effectively controlled and contained on site prior to discharge to the sanitary sewer.

7 Reported tonnages and calculated volumes (cubic metres) are based upon landfill actual weigh scale data.

11.0 REPORT SIGNOFF

Certified/Approved by: Karene Torney, P.Geo., PMP
Supervisor, GeoEnvironmental Programs



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