

# Westside Landfill Conceptual Closure Plan

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## 1 Introduction

The Regional District of Central Okanagan's (RDCO) region is naturally divided into two geographic areas by Lake Okanagan. On the west side of Lake are the municipalities of Westside and Peachland, as well as the RDCO's West Electoral Area. Municipalities on the east side of Lake Okanagan include Kelowna, Lake County, and RDCO's East Electoral Area.

The Westside Landfill primarily services residents and businesses on the west side of Lake Okanagan, and is expected to remain in operation for the next one to three years. When the Westside Landfill closes, 35,000 to 40,000 tonnes of solid waste will be directed each year to the City of Kelowna's Glenmore Landfill.

In preparation for the eventual closure of the Westside Landfill, CH2M HILL was retained by RDCO to identify closure requirements and outline a conceptual plan for the closure. Ultimately, the scope of work for this assignment included:

- Providing a summary of current provincial requirements related landfill closure;
- Reviewing historical waste tonnages accepted at the Westside Landfill;
- Generating an existing surface contour plan based on recent RDCO topographical survey data;
- Outlining options for landfill capping, landfill gas management, and surface water management systems, and identifying post-closure monitoring requirements; and
- Reviewing and updating the proposed final contour plan contained in "Westside Landfill Operations and Closure Plan" (1993).

## 2 Background

### 2.1 Site Description

The Westside Landfill site is located approximately 2.5 km north of Westbank, and 325 m west of Shannon Lake, within the boundaries of the recently formed Westside District Municipality. The 16.7 ha parcel of land on which the facility is situated on is owned by RDCO, and is zoned for “community facilities” in accordance with Bylaw 1050. The landfill property is adjacent to, but falls outside of, an agricultural land reserve to the north. Access to the site is from the southwest via Asquith Road.

The Westside Landfill began operations in late 1960’s, and currently operates under Operational Certificate PR12217 issued by British Columbia Ministry of the Environment (BCMOE). This permit was issued in 1997 to replace the site’s original operating permit issued in 1973.

Day-to-day operation of the landfill and associated recycling facility is contracted out to a private contractor, but is overseen by RDCO staff. RDCO also has an agreement in place with a separate contractor which allows the latter to bring hydrocarbon contaminated soils to the site for remediation.

As shown in Exhibit 1, the landfill is situated on the western slope of the Okanagan Valley. It is bordered on the north and west by steep slopes, bedrock outcrops, and flat open benches that are typical of the Okanagan Valley. Development in these directions is limited and consists mainly of single-family residences, and thus much of the area remains covered with vegetation (primarily mature pine and fir trees). Lands to the south and east have been developed for residential or agricultural purposes, and are generally lower in elevation, gradually sloping towards Shannon Lake to the east or Okanagan Lake to the south.

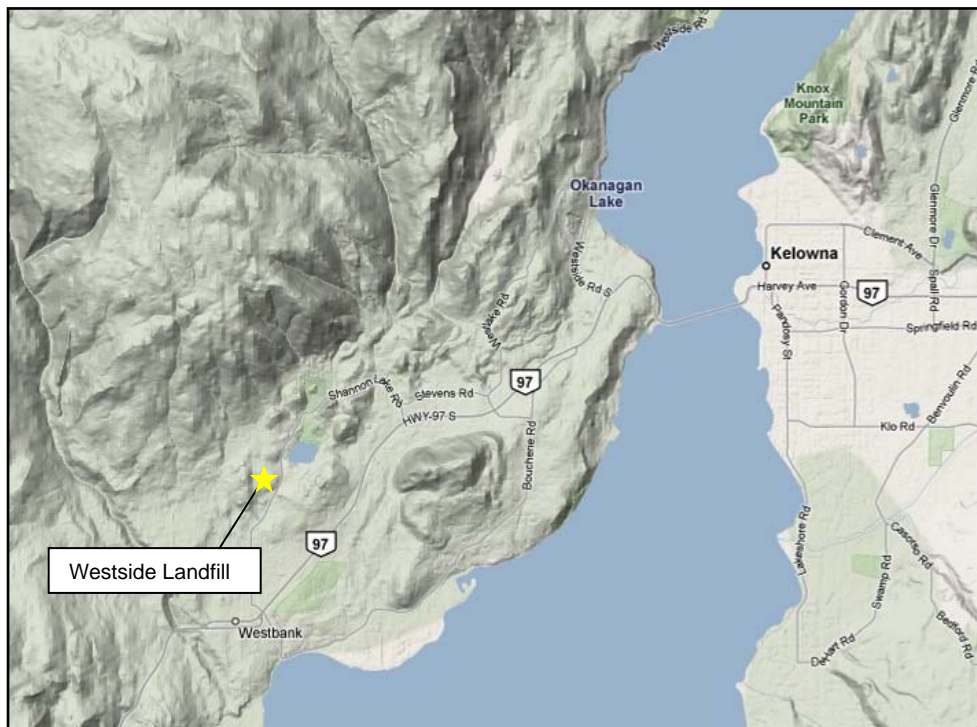


EXHIBIT 1: OKANAGAN VALLEY TERRAIN MAP

The landfill site has been developed to a height approximately 20m above the surrounding landscape. The existing contours of the landfill site are shown in Exhibit 2.

The climate of the region is semi-arid, with rainfall in the order of 340 mm per year, 263 mm of which falls as rain. Historically, the peak periods for precipitation are in the winter months (i.e., November through January) and in June.

## 2.2 Hydrogeology

Detailed investigations of soil and groundwater conditions at the site have been completed by Golder Associates on behalf of RDCO. This information has been summarized in various reports prepared by Golder Associates for RDCO.

## 2.3 Waste Quantities

Waste accepted at the Westside Landfill originates from communities and businesses along the west side of Lake Okanagan, from as far north as North Westside Road, and south to Peachland.

Residential and commercial waste receipts for the year 2007 are summarized in Exhibit 3. Demolition, land clearing and construction (DLC) waste quantities are also summarized in Exhibit 3. In recent years, there has been an increase in the amounts of DLC waste as well as clean soils accepted at the Westside location.

## 3 Existing Closure Plan

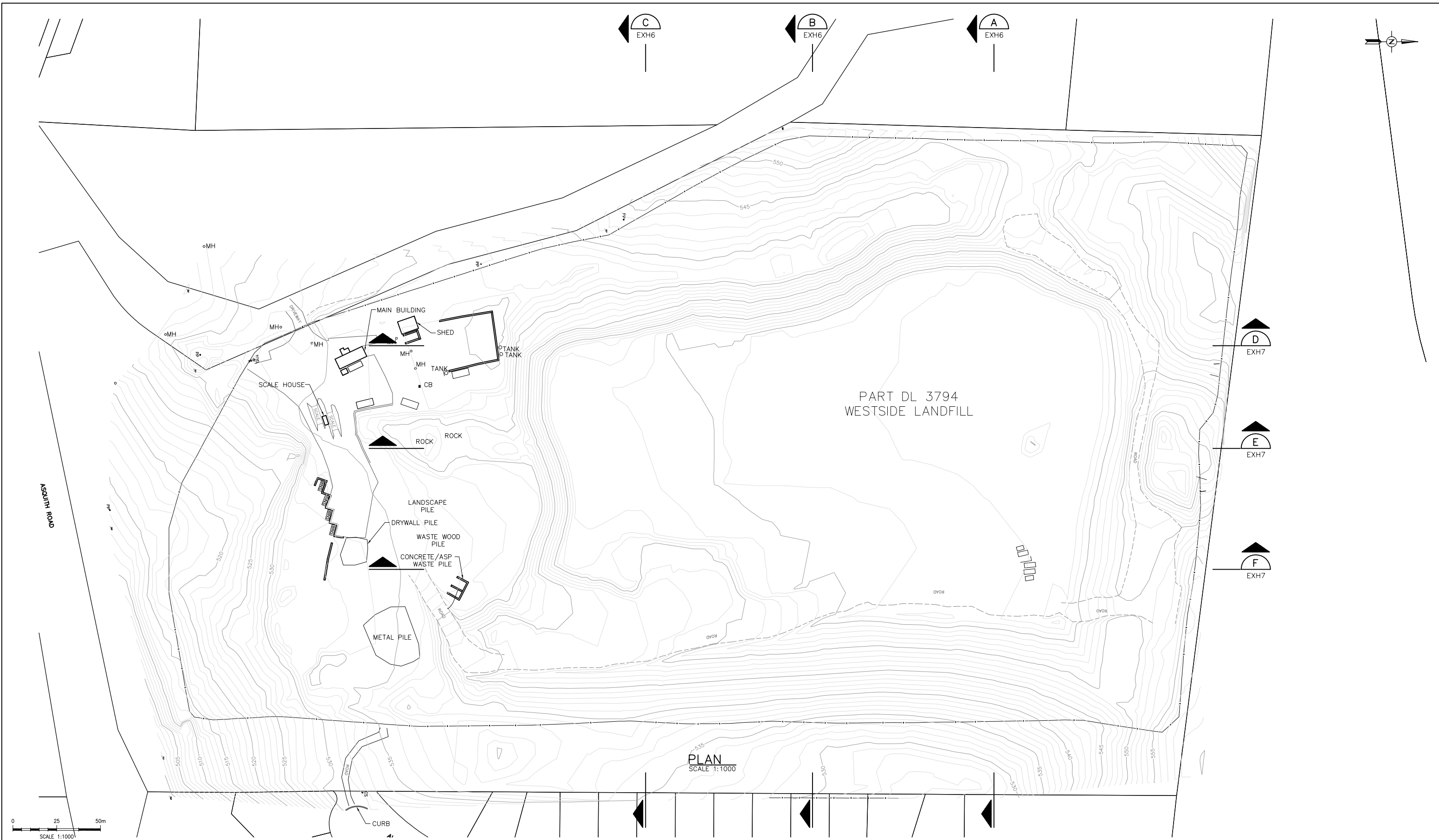
The existing closure plan is contained in the “Westside Landfill Operations and Closure Plan” prepared in 1993 (Reid Crowther and Partners, 1993). This document also outlined operating requirements, waste reduction strategies, and control measures for leachate and landfill gas.

A contour map for the landfill at closure was contained within the 1993 plan. This contour map, shown in Exhibit 4, was developed based on slope stability considerations as well as surface water drainage, setback requirements, and the maximum desired elevation of the landfill. The final contours were based on maximum side slopes of 4H:1V, and maximum top surface slopes of 4%.

The design criteria and quality assurance requirements for a capping system were outlined in the plan and were based on provincial regulatory requirements. The recommended system consisted of a 1 metre thick “barrier layer” constructed of compacted clayey or silty clay soil with a permeability of less than  $1 \times 10^{-5}$  cm/s. This would be overlain by a 150 mm layer of topsoil to sustain vegetation. The type of vegetation cover was not specified by the Plan, other than it should consist of native species that are not deep-rooting.

The possibility of an irrigation system being needed was identified in the plan, both to help establish and maintain vegetation in the topsoil layer, and to maintain an equilibrium moisture content in the barrier layer.

Landfill gas management requirements were not outlined in the 1993 Operations and Closure Plan as preliminary measurements taken at the time showed negligible quantities of gas. However, the Operations and Closure Plan did indicate that landfill gas should continue to be monitored over a longer period to determine whether the installation of a collection system was necessary as part of closure of the site.



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**REGIONAL DISTRICT OF CENTRAL OKANAGAN**

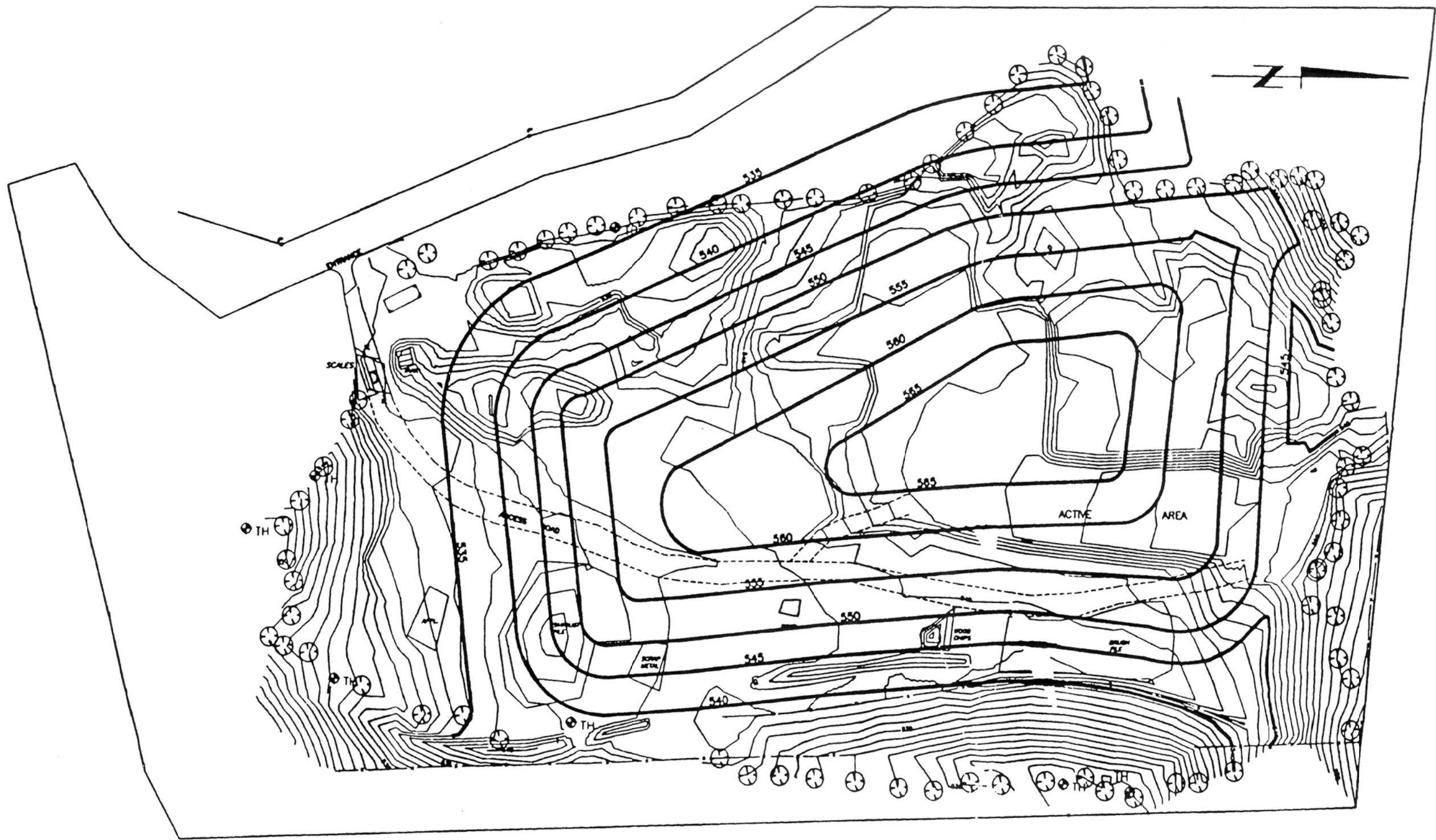
**WESTSIDE LANDFILL CONCEPTUAL CLOSURE PLAN**

EXHIBIT 2  
EXISTING CONTOURS

DATE	2008.10.21	SCALE	1:1000
DRAWN	SES	REV. NO.	
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DRAWING NO.	EXHIBIT 2		

**Exhibit 3**  
**Westside Landfill 2007 Waste Quantities**

Type	Name	January	February	March	April	May	June	July	August	September	October	November	December	Total
DLC	Construction Waste	578.845	989.830	891.665	731.175	615.460	1,132.435	1,598.040	612.205	739.315	604.985	808.760	402.960	9,705.675
<b>DLC Total</b>		<b>578.845</b>	<b>989.830</b>	<b>891.665</b>	<b>731.175</b>	<b>615.460</b>	<b>1,132.435</b>	<b>1,598.040</b>	<b>612.205</b>	<b>739.315</b>	<b>604.985</b>	<b>808.760</b>	<b>402.960</b>	<b>9,705.675</b>
Commercial	Community Clean-Up (Garbage)	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	Commercial	654.835	660.880	651.800	684.295	994.270	1,071.960	1,148.940	1,242.145	887.355	891.500	846.505	671.030	10,405.515
Commercial	RD No Charge	424.865	336.965	387.175	397.980	509.790	417.245	489.060	539.070	505.960	473.710	396.710	364.720	5,243.250
Commercial	RD Parks (Charge)	5.235	17.080	30.610	5.800	17.770	15.760	12.040	8.420	4.180	2.820	12.860	6.810	139.385
Commercial	Waste Management	0.105	-	0.015	0.980	0.050	0.875	-	1.335	0.710	0.665	-	0.055	4.790
Commercial	LAK Irrigation & Charities	0.565	0.085	0.065	4.745	0.320	0.095	0.200	0.180	0.180	0.120	0.365	0.150	7.070
<b>Commercial Total</b>		<b>1,085.605</b>	<b>1,015.010</b>	<b>1,069.665</b>	<b>1,093.800</b>	<b>1,522.200</b>	<b>1,505.935</b>	<b>1,650.240</b>	<b>1,791.150</b>	<b>1,398.385</b>	<b>1,368.815</b>	<b>1,256.440</b>	<b>1,042.765</b>	<b>15,800.010</b>
Recyclables	Community Clean-Up (Metal)	-	-	-	-	-	-	-	-	2.205	0.945	-	-	3.150
Recyclables	Clean Cardboard	-	-	-	-	-	-	-	-	-	-	-	-	-
Recyclables	Concrete & Asphalt	2.630	36.470	56.695	56.560	91.600	47.450	37.560	49.950	55.130	17.405	24.735	5.835	482.020
Recyclables	Clean Lumber	97.665	136.235	187.590	225.470	348.400	289.010	277.315	293.300	244.925	247.845	212.465	93.370	2,653.590
Recyclables	Recycled Metal	492.410	-	-	-	-	-	-	530.190	176.055	-	-	-	1,198.655
Recyclables	Recycled Tires	-	-	12.585	-	17.490	-	-	93.190	9.325	-	9.920	-	142.510
Recyclables	Recycled Drywall	52.330	52.010	125.135	71.075	46.620	110.385	76.095	100.080	76.985	51.935	76.695	-	839.345
Recyclables	Propane Tanks	-	-	1.130	-	-	1.910	-	-	-	2.445	-	-	5.485
Recyclables	Cardboard Over 1 Cubic Meter	-	-	-	-	-	-	-	-	-	-	-	-	-
Recyclables	Drywall	56.720	67.050	97.435	81.275	81.640	83.180	60.950	59.090	57.635	67.830	59.675	44.850	817.330
Recyclables	Drywall Flat Rate - 1 Sheet	1.900	3.150	6.150	6.300	5.200	2.750	3.650	3.250	3.600	1.850	3.400	4.100	45.300
<b>Recyclables Total</b>		<b>703.655</b>	<b>294.915</b>	<b>486.720</b>	<b>440.680</b>	<b>590.950</b>	<b>534.685</b>	<b>455.570</b>	<b>1,129.050</b>	<b>625.860</b>	<b>390.255</b>	<b>386.890</b>	<b>148.155</b>	<b>6,187.385</b>
Residential	Self-haul Residential	130.915	189.605	242.985	215.785	239.663	326.105	385.855	314.565	340.250	313.595	244.485	144.450	3,088.258
Residential	Peachland	87.660	68.500	78.340	86.650	88.146	90.410	99.290	110.520	82.620	89.490	71.360	69.135	1,022.121
Residential	PL Pilot Project - Garbage	-	-	-	-	-	-	-	-	-	3.445	6.280	2.470	12.195
Residential	PL Pilot Project - Yard Waste	-	-	-	-	-	-	-	-	-	-	1.360	0.395	1.755
Residential	North Westside Transfer Station	12.785	9.155	32.885	28.090	37.645	35.205	36.500	38.000	33.570	23.415	29.645	13.265	330.160
Residential	Traders Cove	5.415	5.590	8.610	16.145	11.965	10.695	17.215	16.465	9.785	11.720	10.275	6.335	130.215
Residential	Area I - Joe Rich	-	-	-	-	-	-	-	-	-	-	-	-	-
Residential	RDCO Pilot Project - Garbage	-	-	-	-	-	-	-	-	5.585	9.635	6.380	3.115	24.715
Residential	RDCO Pilot Project - Yard Waste	-	-	-	-	-	-	-	-	2.460	4.995	3.970	1.055	12.480
Residential	Residential Bags	115.380	102.180	224.220	340.140	398.220	233.400	206.370	203.130	174.690	201.300	159.000	122.580	2,480.610
Residential	Flat Rate Minimum	-	-	-	0.200	-	-	-	-	-	-	-	-	0.200
Residential	Garbage Tags	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Residential Total</b>		<b>352.155</b>	<b>375.030</b>	<b>587.040</b>	<b>687.010</b>	<b>775.639</b>	<b>695.815</b>	<b>745.230</b>	<b>682.680</b>	<b>648.960</b>	<b>657.595</b>	<b>532.755</b>	<b>362.800</b>	<b>7,102.709</b>
Special Waste	Car Wash Waste	-	-	-	-	-	-	-	-	-	-	-	-	-
Special Waste	Clean Fill	8,494.975	5,620.705	4,347.715	6,212.620	1,149.495	8,532.720	9,367.720	7,700.745	8,585.770	8,219.185	5,729.640	2,206.995	76,168.285
Special Waste	Grit	-	44.415	69.330	30.000	463.510	205.450	98.685	59.800	24.755	250.040	181.795	-	1,427.780
Special Waste	Bio-Solids	-	-	-	-	-	-	-	-	-	-	-	-	-
Special Waste	Grease Waste	45.325	64.555	34.475	75.690	49.145	50.550	76.470	82.715	78.415	124.330	90.030	87.395	859.095
Special Waste	Contaminated Soil RL+	68.945	96.125	1,711.420	1,040.905	492.145	43.955	-	322.060	1,206.865	481.920	-	3.570	5,467.910
Special Waste	Contaminated Soil - CL+	-	2.965	1,102.640	104.495	209.740	140.725	-	-	-	303.420	314.225	-	2,178.210
Special Waste	Contaminated Soil - SW	-	-	-	-	103.535	-	-	-	-	123.595	-	-	227.130
<b>Special Waste Total</b>		<b>8,609.245</b>	<b>5,828.765</b>	<b>7,265.580</b>	<b>7,463.710</b>	<b>2,467.570</b>	<b>8,973.400</b>	<b>9,542.875</b>	<b>8,165.320</b>	<b>9,895.805</b>	<b>9,502.490</b>	<b>6,315.690</b>	<b>2,297.960</b>	<b>86,328.410</b>
Yard Waste	Peachland Yard Waste Pick-Up	-	-	28.490	20.310	17.920	-	-	-	-	17.065	41.520	-	125.305
Yard Waste	Joe Rich Yard Waste Pick-Up	-	-	-	-	-	-	-	-	-	-	-	-	-
Yard Waste	Westside Yard Waste Pick-Up	-	-	89.945	112.810	67.470	-	-	-	-	153.110	158.225	-	581.560
Yard Waste	Winfield Yard Waste Pick-Up	-	-	-	-	-	-	-	-	-	-	-	-	-
Yard Waste	Clean Brush	27.055	45.065	151.405	251.725	308.740	158.610	192.655	146.240	90.255	120.430	59.805	32.845	1,584.830
Yard Waste	Free Brush	0.645	4.625	16.070	10.620	4.060	5.940	9.930	7.270	5.725	5.465	6.050	-	76.400
Yard Waste	Grinding Sales	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Yard Waste Total</b>		<b>27.700</b>	<b>49.690</b>	<b>285.910</b>	<b>395.465</b>	<b>398.190</b>	<b>164.550</b>	<b>202.585</b>	<b>153.510</b>	<b>95.980</b>	<b>296.070</b>	<b>265.600</b>	<b>32.845</b>	<b>2,368.095</b>
Other	Unknown Name	-	-	-	-	-	-	0.030	-	-	-	-	-	0.030
Other	Clean Metal	22.800	12.285	35.650	19.120	10.870	30.715	24.075	24.480	27.880	34.385	11.565	4.605	258.430
Other	Recycled Mixed Garbage	6.710	8.275	22.370	50.865	64.820	30.350	37.900	29.250	34.240	23.400	16.730	7.450	332.360
Other	Clean Material Need Separating	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	Recycle Removal	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	Landfill Fees E-14 Sec 1A4	31.770	5.880	37.430	30.450	8.830	13.810	6.940	6.145	-	5.780	23.630	13.725	184.390
Other	Unknown Name	-	-	-	-	-	123.390	-	-	-	-	-	-	123.390
<b>Other Total</b>		<b>61.280</b>	<b>26.440</b>	<b>95.450</b>	<b>100.435</b>	<b>84.520</b>	<b>198.265</b>	<b>68.945</b>	<b>59.875</b>	<b>62.120</b>	<b>63.565</b>	<b>51.925</b>	<b>25.780</b>	<b>898.600</b>
<b>Grand Total</b>		<b>11,418.485</b>	<b>8,579.680</b>	<b>10,682.030</b>	<b>10,912.275</b>	<b>6,454.529</b>	<b>13,205.085</b>	<b>14,263.485</b>	<b>12,593.790</b>	<b>13,466.425</b>	<b>12,883.775</b>	<b>9,618.060</b>	<b>4,313.265</b>	<b>128,390.884</b>



Surface water controls recommended in the Operations and Closure Plan consisted of drainage ditches constructed along the toe of the landfill side slopes that are integrated with the final capping layer. The ditching network would convey water to two points (i.e., on the eastern and southern boundaries) and then offsite into regional watercourses.

The Operations and Closure Plan indicated that the best use of the site would be for passive recreational uses such as a picnic area or playground. It also suggested that the landfill entrance area could remain as a recycling depot and transfer station following closure of the landfill operation.

This post-closure land use recommendation was based on the review of the Westbank Official Community Plan of the day, as well as the physical constraints posed by landfill development. For example, the ultimate shape of the final contours ruled out any uses that require flat surfaces such as sports field or golf courses. The construction of buildings and other structures on the site is limited by the fact that the landfill surface will continue to settle during the post-closure period as solid wastes further degrade. Finally, the integrity of the landfill cap must be maintained, which limits the choice of vegetation to shallow-rooting species.

## 4 Regulatory Requirements

The umbrella statute governing waste management in British Columbia is the provincial *Environmental Management Act*, which is administered by the Ministry of Environment (BCMOE) and under which specific regulations, guidelines, and standards have been issued. With respect to the development and closure of landfills, the primary criteria are outlined in BCMOE's *Landfill Criteria for Municipal Solid Waste* (BCMOE, 1993) hereinafter referred to as *Criteria*.

### 4.1 Closure Plan

Section 8 of the *Criteria* provides specific requirements on the preparation and submission of Closure Plans for landfills, as well as design criteria and requirements for long-term management after the site has been closed. As a minimum, the Closure Plan must include:

- Anticipated total waste volumes and tonnage and life of the landfill (i.e., closure date);
- A topographic plan showing the final elevation contours of the landfill and surface water diversion and drainage controls;
- Design of the final cover, including the thickness and permeability of barrier layers and drainage layers, and information on topsoil, vegetative cover, and erosion prevention controls;
- Procedures for notifying the public about the closure and about alternative waste disposal facilities;
- Rodent and nuisance wildlife control procedures;
- Proposed end use of the property after closure;
- A plan for monitoring groundwater, surface water and landfill gas, and erosion and settlement for a minimum post-closure period of 25 years;

- A plan and accompanying design for the collection, storage, and treatment/use of LFG for a minimum of 25 years; and
- A plan for operation of any required pollution abatement engineering works, such as leachate collection and treatment systems, for a minimum post-closure period of 25 years.
- An estimated cost, updated annually, to carry out closure and post-closure activities for a minimum period of 25 years.

#### 4.2 Final Grading, Cover, and Drainage

Design criteria for final cover systems at closed landfills are outlined in Section 6 of the *Criteria*. As a minimum, BCMOE requires:

- A 1 m thick barrier layer constructed of compacted, low-permeability soil material (i.e. permeability  $< 1 \times 10^{-5}$  cm/s);
- A 0.15 m topsoil layer overtop the barrier layer, in which approved vegetation is established;
- landfill side slopes less than 33% prevent erosion and scouring;
- top slopes greater than 4% (but less than 33%) to encourage drainage;

The *Criteria* also specify that completed portions of the landfill are to be progressively covered, and the cover must be installed within 90 days of landfill closure

#### 4.3 Ground and Surface Water Quality Impairment

BCMOE requires that all landfills be operated such that groundwater or surface water quality in aquifers and surface water bodies at or beyond the landfill's property boundary does not decrease beyond specified numerical criteria.

Assessment of water quality is normally done relative to specific assessment criteria contained in the landfill's approval or the "Approved Water Quality Guidelines" published by BCMOE (BCMOE, 2006). The appropriate criteria for a site will be specified by BCMOE following their review of existing and potential future uses of the ground and surface water resources.

In the situation where criterion for a particular parameter has not been addressed by BCMOE, it may be possible to use criteria from another jurisdiction. This will require review and approval by BCMOE.

#### 4.4 Landfill Gas Management

Landfill gas (LFG) can pose health and safety risks as well as contributing to greenhouse gas emissions. Through the *Criteria*, BCMOE has established assessment and performance standards for LFG emissions from municipal landfills<sup>1</sup>.

The *Criteria* contain performance criteria for LFG at all landfill sites, which require that combustible gas concentrations should not be allowed to exceed the lower explosive limit in soils at the property boundary, or 25% of the lower explosive limit at or in on- site or off- site

<sup>1</sup> During the course of preparing this conceptual closure plan, BCMOE released a "Policy Intentions Paper" and received comments on a proposed new Landfill Gas Regulation. When it comes into force, the requirements of this regulation will need to be considered as part of the development of the Detailed Closure Plan for Westside Landfill.

structures. These standards have been developed to control potential accumulation of LFG and resulting health and safety issues.

Recovery and management of LFG is not required by BCMOE if the total amount of waste contained in the landfill is less than 100,000 tonnes. However, if the amount of in-situ waste exceeds this amount, BCMOE requires that an assessment of potential LFG emissions be completed in accordance with the methodology outlined in the *Criteria*. Normally, non-methane organic compounds (NMOCs) are used during the assessment,

If the completed assessment indicates that the emission rate of NMOCs is expected to exceed 150 tonnes per year, the installation and subsequent operation of a LFG recovery and management system is mandatory.

When it is necessary to install a LFG recovery and management system, recovering energy from the LFG, incineration or flaring are recommended by BCMOE. Direct venting of LFG to the atmosphere must be avoided to reduce odours and greenhouse gas emissions. If a LFG recovery system is deemed necessary, the landfill owner should be prepared to operate the system for a minimum of 25 years following closure of the landfill.

#### 4.5 Post-Closure Monitoring

During the operating life of the landfill, it is necessary to have programs in place to monitor ground and surface water, landfill gas emissions, and ambient air quality. Site specific situations may also require that vegetation and soils be assessed and monitored.

It is expected that groundwater, surface water and landfill gas monitoring programs will continue following closure of the landfill. Additionally, monitoring of settlement of the landfill, and erosion of the final cover and drainage system is also required. Post closure monitoring results and the associated interpretation by a qualified professional are to be reported on an annual basis.

Post-closure monitoring programs are required to continue for a minimum of 25 years.

#### 4.6 Building and Structures

The *Criteria* recommend that the construction of buildings and other structures on landfills containing putrescible wastes not be undertaken for a minimum period of 25 years after closure. This is due to concerns about combustible gas and excessive settlement.

In the event that buildings or structures are to be constructed, it will only be considered and/or authorized by BCMOE following completion of an investigation and preparation of a report by a qualified professional. The report is to be submitted to BCMOE and approval received prior to any construction activities being initiated.

#### 4.7 Additional Requirements

In addition to the Closure Plan, the *Criteria* also requires a closure fund be established and approved by BCMOE to pay for closure and post-closure costs, and that covenants be placed on the property's land title stating it was used for landfilling.

## 5 RDCO Requirements and Constraints

In addition to the Criteria developed by BCMOE for all landfills, there are a number of site specific requirements and constraints that affect the closure of the Westside Landfill. These are outlined in the following sections.

### 5.1 Westside Landfill Operating Certificate PR 12217

The Westside Landfill's first operating permit was first issued in 1973. In May of 1997, BCMOE replaced this with a new Operational Certificate (i.e. PR 12217) which contained significantly more details related to operational and closure requirements.

Much of the contents of the existing Operational Certificate (OC) mirror the *Criteria*, including requirements related to groundwater and surface water impairment, landfill gas management, access roads, supervision, and signage. The OC also contains site specific requirements for water quality sampling and analysis, fencing, measurement of waste density, and acceptance/management of hydrocarbon contaminated soils.

With respect to closure of the landfill, the OC includes specific requirements for the submission of an operations and closure plan (Section 2.4), outlines minimum requirements for a final cover system (Section 2.11), requires the establishment of a "closure fund" (Section 3.9), limits the development of buildings and structures at the landfill (Section 3.11) and requires monitoring and operation of any needed LFG and leachate control systems through the post-closure period (Sections 3.12 and 3.13). As with other aspects of the OC, these conditions mirror the contents of the *Criteria*.

### 5.2 Westside OCP

The Westside Official Community Plan (OCP) was adopted as Schedule A to Bylaw 1050 in February of 2005, and was further revised in December of 2007. The OCP contains a number vision statements and objectives related to future land use, infrastructure and recreational needs, protection of sensitive ecosystems and agricultural resources. These visions and objectives, together with a series of supporting policies, guide future growth in Westside and provide the framework on which land use decisions are made.

The OCP contains a number of guiding principles and objectives that impact or otherwise provide guidance to the closure of the Westside site and its subsequent use. These are outlined below.

- Lands in the vicinity of the Westside Landfill are designated for a mix of low density single and multifamily residential, park and open space, and agricultural uses.
- The OCP encourages that developments retain minimum amounts of hillsides as mature forested landscape.
- Neighbourhood Plans for new developments must include planning for parks, open space and pedestrian corridors.
- Development should provide for an overall inter-connectivity of open space, parks, and watercourses, and maintain and protect natural linkages to prevent isolation of ecosystems.
- Open spaces, ravines, steep slopes and sensitive ecosystems should be protected.

- The use of native vegetation to reclaim disturbed areas is encouraged, as is the use and management of topsoil specifically designed for water retention purposes.
- Voluntary habitat conservation and restoration should be encouraged.
- Public awareness of good environmental stewardship practices should be raised.
- Environmental stewardship should be promoted through ongoing education on ways to reduce, reuse and recycle resources.

### 5.3 Westside Parks and Recreation Master Plan

The Westside Parks and Recreation Master Plan (WPRMP) was completed in 2000. It was undertaken to analyze existing recreational resources, identify recreational needs of area residents, and guide the planning and development of new leisure services.

The WPRMP laid out a scheme for organizing parks and open spaces into a classification system consisting of Community Parks, Athletic Parks, Neighbourhood Parks, Waterfront Parks, Open Spaces, and Linear Parks. The WPRMP further contained guidelines for each classification that outlined function, allocation, and size.

The WPRMP specifically identified the Westside Landfill site as the potential site for a new Community Park that would serve residential development in the Shannon Lake and Smith Creek areas. It recommended that a portion of the completed landfill site be designated for passive community park use, and that the landfill's closure plan be updated to reflect this use. While it was not specific about the particular form the future park should take, it did provide typical examples of community park concepts, such as plazas, memorials, gardens, sport courts, picnic areas, performance space, exhibition space, water spray park, playgrounds, washrooms and tourism attractions. Sport fields, of a lower standard than athletic sport fields, were also identified as being included in passive community parks, provided the use thereof does not conflict with the other uses of the park.

### 5.4 RDCO Solid Waste Management Plan

An update to the region's Solid Waste Management Plan (SWMP) was completed in 2006 and approved by the RDCO Board and the Councils of the City of Kelowna and District's of Lake Country and Peachland. The SWMP was subsequently approved by BCMOE in early 2008.

The SWMP outlines a number of short and long term initiatives that would augment existing waste management programs. Many of these initiatives are targeted at implementing the concept of "zero waste", and diverting materials from disposal in landfills.

There is no specific mention of the Westside Landfill closure or post-closure in the SWMP aside from the implementation of best practices and adherence to the *Criteria*.

However, the SWMP may indirectly impact closure/post-closure plans through its recommendations to encourage further recycling, collection of e-waste, and capture of yard waste for composting. These program enhancements may drive the need for long-term drop-off or transfer facilities at the Westside site to maintain or improve services in the area.

## 6 Conceptual Closure Plan

Based on the review of background information, the responses from a telephone survey of area residents and stakeholder consultation to date, this Conceptual Closure Plan has been prepared for further consideration. It is expected that this concept plan will be updated to reflect feedback from a broader stakeholder consultation process, and that a Detailed Closure Plan will be developed that contains detailed engineering designs.

### 6.1 Waste Quantities

RDCO records for the years 2000 through 2007 indicate that approximately 186,500 tonnes of waste were placed in the landfill. Records for the years prior to 2000 are not readily available. However an estimate of overall insitu waste quantities can be made based on the landfill footprint and its height above grade, and expected waste densities and soil cover usage. Using this methodology, it is estimated that in the order of 1,200,000 m<sup>3</sup> of waste and soil has been placed in the landfill site since it first opened, which would correspond to approximately 450,000 to 500,000 tonnes (based on an average waste density of 0.5 tonne/m<sup>3</sup> and a waste to cover ratio of 4:1).

### 6.2 Grading Plan and Final Contours

The proposed final contours for the landfill site are presented on Exhibit 5. Cross-sections of the proposed final contours are provided in Exhibits 6 and 7. These contours represent the top of intermediate cover prior to the installation of the final cover system. Side slopes have been established at 3 (horizontal) to 1 (vertical) ratio, whereas the crest of the landfill is sloped at a minimum of 4%.

The peak of the landfill has been set at an elevation of approximately 560 mASL, and offset from the centre of the landfill footprint to better blend into the existing topography around the landfill site. The crest of the landfill surface maintains a gentle slope to the south and east before tying into the steeper (i.e. 3 to 1) side slopes. Slopes on the north and west sides of the landfill crest are less gradual.

Adjustments to these final elevations and slopes are expected to be made during the detailed design stage based on feedback obtained from RDCO and BCMOE personnel, and through the public consultation process.

### 6.3 Proposed End Use

The end use plan developed for the Westside Landfill in 1993 indicated that the best use of the site would be for passive recreational uses for most of the site, but retaining recycling and transfer station operations at the south end. This end use plan has subsequently been recommended in the Westside Parks and Recreation Master Plan, and incorporated on a conceptual basis into RDCO's informal planning for the site.

The selection of the specific passive recreational use(s) for the site depends upon a number of factors, including final topography of the site, anticipated settlement, LFG generation, the nature of adjacent land uses, and regulatory criteria. A number of acceptable uses for the site fall within the guidelines for community parks as outlined in the WPRMP. These include hiking and walking trails, on and off leash dog-parks, and open space.

There are a number of potential uses that fall within the community parks guidelines that should be avoided. For example, buildings (e.g. washrooms, field buildings) and other large structures (e.g. skateboard ramps) should not be constructed on a landfill for at least 25 years after closure due to settlement and the potential for accumulation of landfill gas around foundations. Facilities that involve the installation of subsurface infrastructure (e.g. water lines for a spray park), should also be avoided as utility trenches can provide conduits for landfill gas migration, and may require extensive design modifications to the barrier layer design.

Development that requires installation of foundations or other supports below ground should be done with caution and in a manner that preserves the integrity of the final cover system. This would include fences, signs, decks and viewing platforms, playground equipment,

Any activity that contributes significantly to erosion would not be compatible with the end use of the site. This would include allowing ATV or other off-road vehicles to access the property, or construction of mountain bike or equestrian trails.

Based on the various constraints imposed by the landfill development, closure requirements, and the guidance provided by the WPRMP, the conceptual end use for the site is as “natural open space”. The intent of the conceptual closure plan is to mimic the grasslands that naturally occur on the upper slopes of the Okanagan Valley, and create a low-maintenance community or regional park.

Native shrubs would be dispersed in pockets through the open spaces to break up open spaces and slopes, and also to serve as a visual screen to monitoring wells and LFG vents. A network of gravel walking trails would also be installed, leading to viewpoints on the upper slopes that overlook Shannon Lake and Lake Okanagan. Non-obtrusive interpretive displays would be installed at the viewpoints and at other locations outlining the restorative efforts at the site.

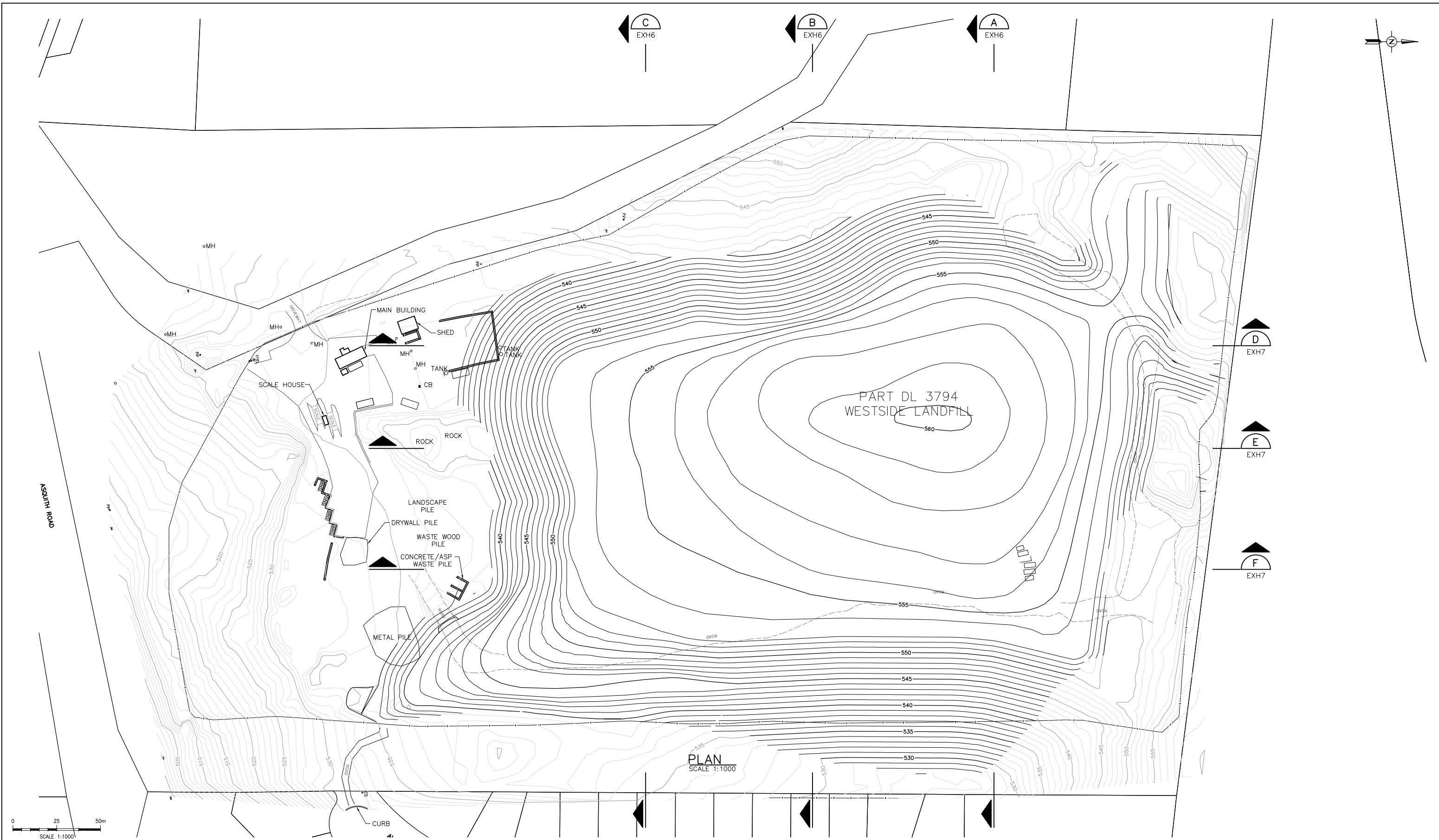
#### 6.4 Landfill Gas Assessment

An assessment of landfill gas generation rates is in the process of being completed by Golder Associates in accordance with the *Criteria*. Preliminary information from the assessment indicates that despite the quantities of waste within the landfill cell, landfill gas concentrations are low. Based on these preliminary results, it is unlikely that an active LFG recovery and management system will be required following the closure of the site. However, in light of planned future development in the area, consideration should be given to the installation of a passive system along the north and east perimeter of the landfill footprint as a precautionary measure. Depending upon the type and extent of future development in the landfill entrance area, a passive LFG system may also be required in this area.

#### 6.5 Barrier Layer

The barrier layer that is required by the *Criteria* as part of the final cover system overtop the completed landfill serves several purposes, including:

- enclosing wastes to prevent wildlife attraction and control odours and litter;
- control and management of LFG; and
- preventing precipitation from entering the landfill and contributing to leachate generation.



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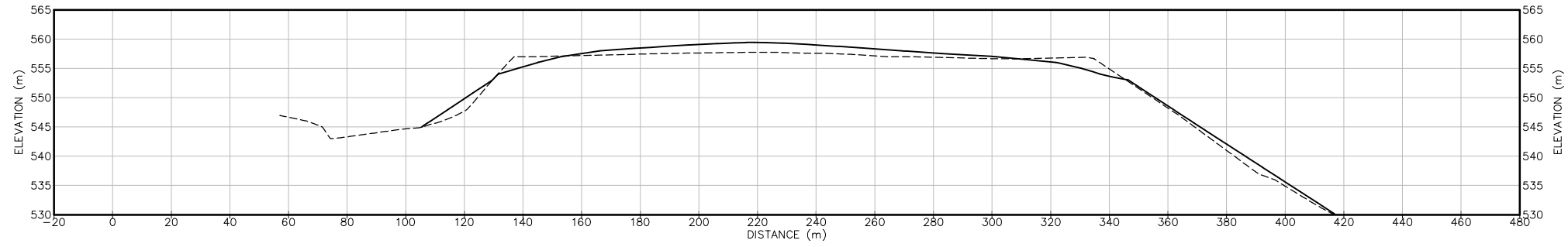
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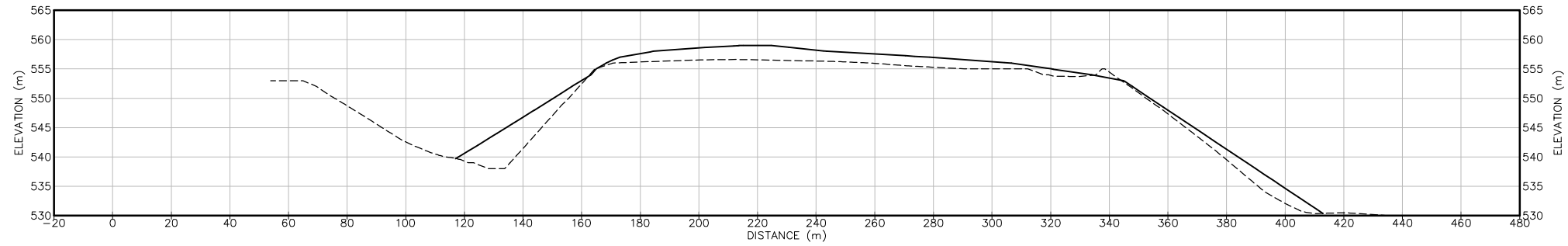


REGIONAL DISTRICT OF CENTRAL OKANAGAN  
 WESTSIDE LANDFILL CONCEPTUAL CLOSURE PLAN  
 EXHIBIT 5  
 REVISED FINAL CONTOUR PLAN

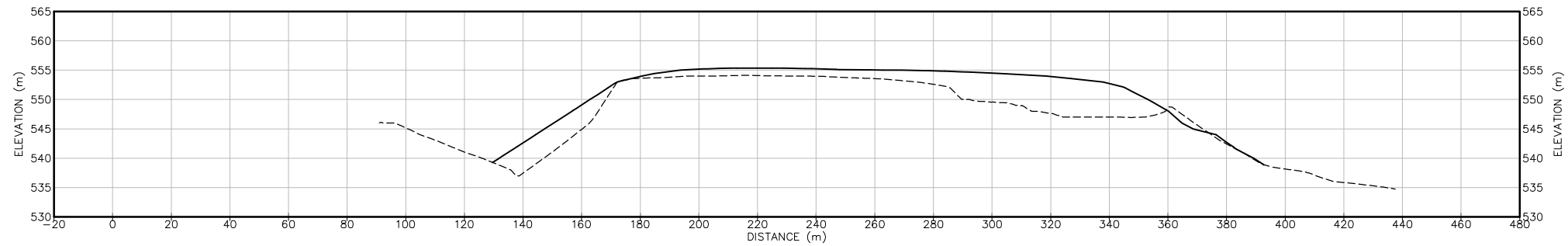
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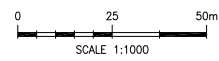
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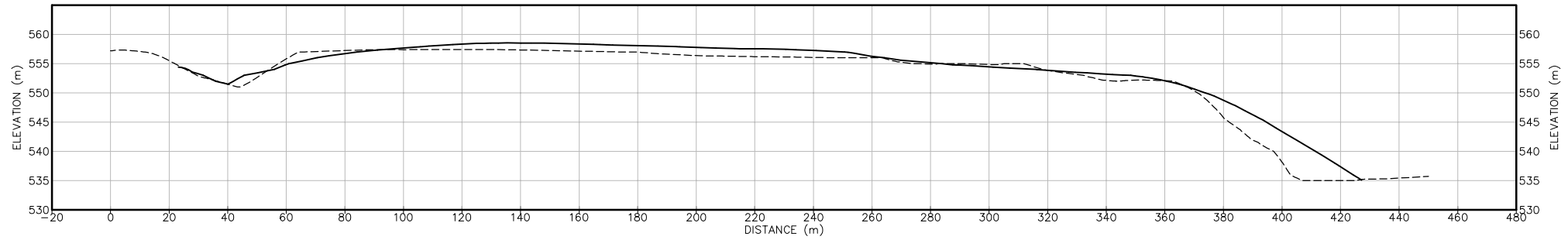
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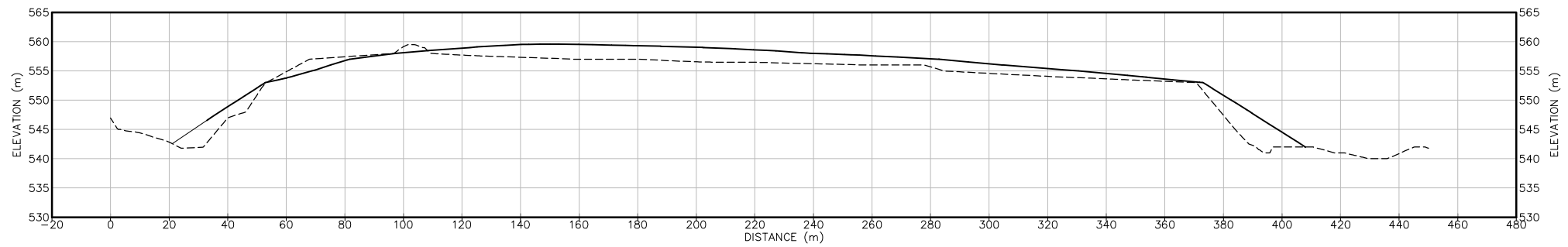


**REGIONAL DISTRICT OF CENTRAL OKANAGAN**  
  
**WESTSIDE LANDFILL CONCEPTUAL CLOSURE PLAN**  
  
EXHIBIT 6  
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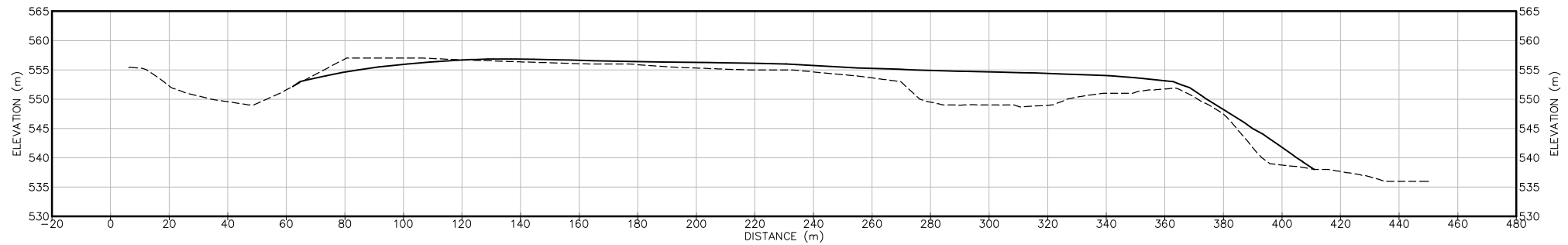
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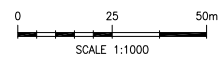
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REGIONAL DISTRICT OF CENTRAL OKANAGAN

**WESTSIDE LANDFILL CONCEPTUAL CLOSURE PLAN**

EXHIBIT 7  
SECTIONS

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Three types of barrier layers are generally considered for use when closing municipal landfills.

- **Compacted Soil:** Compacted soil barriers are typically constructed from natural, low-permeability soil materials, usually clay or silty clay. The soil can be amended with bentonite to further reduce its permeability, but this increases material handling requirements and construction costs.

These barriers are constructed in 150 to 200 mm lifts to form a final cover layer with a thickness of 600 mm to 1,000 mm. The performance of a compacted clay lining is highly dependent upon the quality of construction and on the suitability of the soil used to construct the lining. Also, compared to their geosynthetic counter parts, clay soils are also more susceptible to damage from dessication, repeated freeze-thaw cycles and cracks forming as a result of landfill subsidence.

A typical cross-section of a compacted soil cover system is presented in Exhibit 8.

- **Geosynthetic Clay Membrane:** A geosynthetic clay membrane (GCM) is a manufactured composite system, consisting of a thin layer of dehydrated clay powder sandwiched between two geosynthetic backing carrier materials. The carrier materials typically consist of two geotextile layers (woven, nonwoven, or a combination of both). The clay component of a GCM is typically 7 to 10 mm thick and generally consists of bentonite which has a very low permeability. Following installation, the dehydrated clay material becomes moist and swells, creating the barrier layer.

Manufacturers typically require that the GCM layer be covered with a soil layer with thickness of at least 15 cm. In practice, a soil cover of 30 cm is more common. Also, the GCM needs to be covered with a soil layer immediately following its installation. If the GCM becomes overly wet, say from a rainstorm, the clay swells in an uneven manner and it may not properly self-seam.

- **Geomembrane:** Geomembranes are manufactured “impervious” sheets of plastic or rubber-like materials. Common materials used in geomembrane barriers include high density polyethylene (HDPE), low density polyethylene (LDPE), Polypropylene (PP), and Modified Bitumen Membranes.

These sheets are manufactured and prefabricated in a factory and transported to the job site in rolls, where placement and additional (field) seaming are performed to complete the job. Membrane systems are typically protected by a manufacturer’s warranty, provided that the manufacturer’s installation specifications and QA/QC procedures are followed.

Some of the materials used to construct geomembranes are vulnerable to exposure from ozone, ultraviolet light, and temperature extremes, and thus they require soil be placed overtop to protect against atmospheric exposure. This does not pose problems in landfill capping applications as regulations require topsoil be placed overtop the barrier layer. However, the low friction coefficient of the geomembrane can make placement of the covering soil layer difficult on steep side slopes, where the soil has a tendency to slide downward under gravitational forces. Geomembranes with textured surfaces (i.e. high friction coefficient) are available for use in these situations. It is also a common design practice to incorporate a drainage layer above the geomembrane to provide a flow path for

infiltration, thereby reducing the risk of slope failure. A typical cross-section of a geomembrane cover system is presented in Exhibit 9.

When assessing the appropriateness of a capping system for an application, designers must consider a number of factors. In addition to material and installation costs, this includes permeability of the barrier, strength and flexibility, puncture resistance, impacts of low temperatures, and resistance to chemical and biological degradation.

Reclamation and closure work completed to date at the Westside Landfill (i.e., along the east perimeter) has been based on the use of compacted soil as a barrier layer. This type of material is appropriate for a site where LFG will not be actively recovered, will allow for easy tie-ins to existing reclaimed areas, and avoids the issues involved with installing geomembrane barriers on side slopes.

It is therefore proposed that the use of a compacted soil barrier, as shown in Exhibit 8, continue to be used for closure of the remaining portions of the Westside Landfill provided that:

- the compacted soil barrier is designed and constructed to meet the performance specifications contained in the *Criteria*; and
- modeling of the landfill site's water balance (using the USEPA's Hydrologic Evaluation of Landfill Performance model) completed as part of the Detailed Closure Plan verifies the suitability of the compacted soil barrier system.

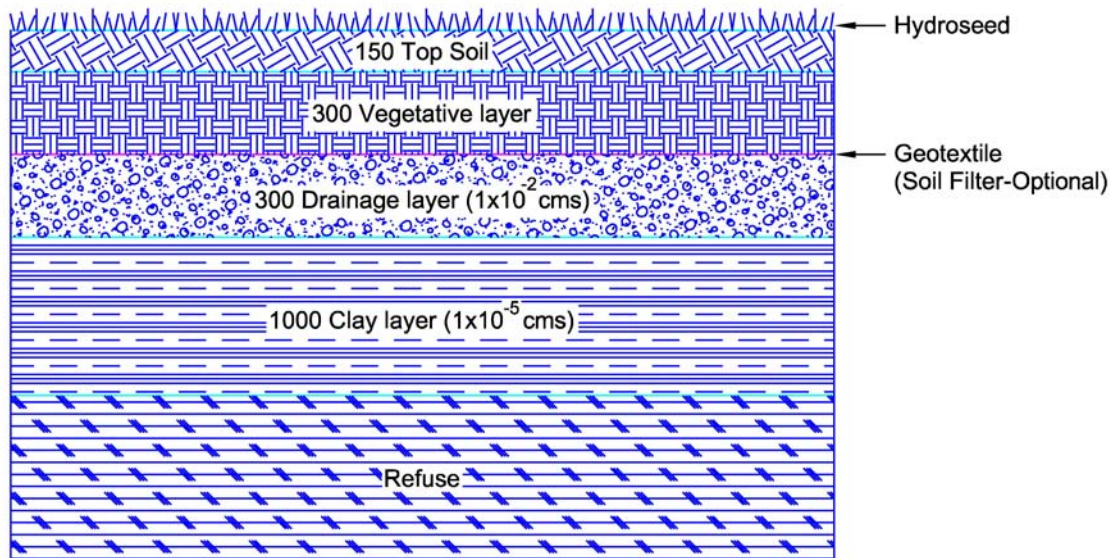
It is further proposed that the impermeability of existing barrier layers be verified through field measurements to ensure appropriate quality assurance records exist. In the event that sufficient quantities of suitable soil are not available at the time of construction, a geomembrane barrier could be utilized on the top slopes of the landfill site.

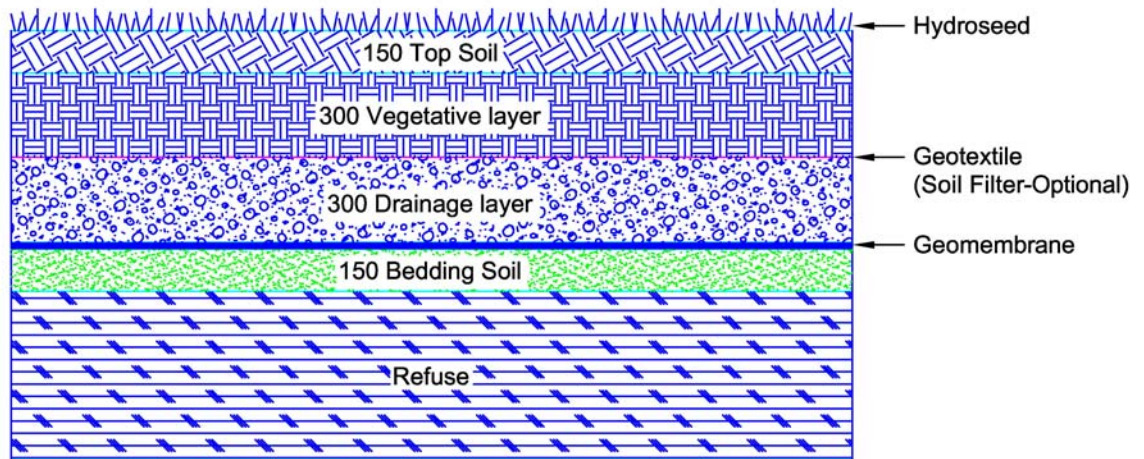
## 6.6 Topsoil and Vegetation Cover

The *Criteria* requires that a topsoil layer with a minimum thickness of 150 mm be placed overtop the barrier layer. For the Westside site, this thickness is appropriate when combined with an underlying 300 mm vegetative layer. It is further proposed that the topsoil and vegetative layers be amended with compost. This will result in the soils having a higher water holding capacity than native soils alone. The water holding capacity would provide a "reservoir" for surface water, from which the established vegetation could draw upon. This will decrease irrigation requirements during the post-closure period, and is consistent with the objectives of the OCP to use topsoil specifically designed for water retention purposes.

Integrated with the use of the manufactured topsoil would be the construction of low berms across slopes to slow run-off, and installation of erosion control blankets at key locations. Both of these measures would be constructed of coarser compost to assist with erosion control.

Following installation of the manufactured topsoil layer, it would be seeded with selected species of grasses that are native to the area, and that are consistent with the end use concept. The selection of specific species would also be based on their ability to withstand drought conditions so as to minimize long term irrigation requirements.





Pockets of shallow-rooting shrubs would be installed to break up the open spaces, and also to provide a visual screen to any residual infrastructure (e.g. monitoring wells, LFG vents). Conceptually, the shrubs would be installed in “beds” created by increasing the topsoil and vegetative layers overtop the barrier layer to a combined depth of 0.75m to 1 m.

## 6.7 Stormwater Management

A key requirement of the closure plan and associated designs is the control of surface water run-on from adjacent properties, and run-off from the site itself.

Surface water run-on has been controlled through grading and use of existing contours. The final contours are such that run-off from adjacent properties and roadways will flow around and away from the landfill site.

Surface water run-off from the landfill footprint would be managed through a combination of the topsoil and vegetative layers overtop the impermeable barrier layer, and drainage controls at the northeast and southwest corners of the footprint. As previously outlined, the higher water holding capacity of the topsoil and vegetative layer will create a reservoir from which site vegetation can draw upon.

Drainage controls consisting of check dams, dry detention ponds and vegetated channels will serve to slow and temporarily detain run-off water in areas adjacent to the landfill footprint before it is released into offsite surface water infrastructure. The goal is to cause the hydrological run-off curve from the landfill site to lag behind that of adjacent areas, which in turn will reduce the burden on downstream surface water control systems.

## 6.8 Erosion Protection and Monitoring

Due to the steepness of the side slopes, care needs to be taken to prevent run-off from scouring the final topsoil layer and creating “rills” in the surface that could ultimately lead to damage of the barrier layer.

The construction of erosion controls from natural organic materials is proposed for the site, rather than using metal culverts or traditional silt fences, geogrids, and erosion control blankets constructed from synthetic materials. Specific erosion controls that would be incorporated into the reclamation of the site would include low compost berms installed as check dams in drainage courses and along the tops and sides of slopes to slow run-off, and filter strips to reduce offsite migration of sediment and suspended solids.

Regular inspection of the landfill surface will be required, and any areas of the final cover layer observed to be eroding will need to be repaired with replacement fill and re-compacted.

## 6.9 Post-Closure Monitoring and Care

Following the closure of the landfill and installation of the final cover and associated infrastructure, it will be necessary to continue regular monitoring programs to determine if the landfill is negatively affecting local groundwater and surface water quality or creating other nuisance condition. Ongoing inspection and maintenance of engineering controls (e.g. final cover system, drainage ditches) will also be required during the post-closure period.

The monitoring program will include groundwater, surface water, and landfill gas monitoring as follows:

- Groundwater level monitoring will be conducted quarterly (i.e. spring, summer, fall, winter) to assess seasonal water table conditions for at least two years following closure of the site. Groundwater sampling will be conducted at all monitoring wells quarterly for at least two years following closure of the site. Sampling will be conducted at three month intervals corresponding to the end of each season to assess the extreme water table conditions.
- Surface water sampling will be conducted at all surface water sampling locations quarterly for at least two years following closure of the site.
- Groundwater and surface water samples will be analyzed for a range of organic and inorganic parameters to provide an assessment of quality. Analytical results will be compared to results from upgradient samples, and to the Approved Water Quality Guidelines (BCMOE, 2006) to determine compliance. Water quality data will be also be evaluated by trend analysis of concentrations over time to determine if long-term trends in water quality are evident.
- Monitoring of landfill gas will be carried out on a quarterly basis by measuring gas concentrations in probes established around the landfill perimeter. Measurement of methane, carbon dioxide, and oxygen concentrations should be taken quarterly.
- Monitoring is expected to continue until it can be demonstrated that the landfill is not impacting the environment. If after three years or more, the monitoring data has consistently shown that there are no significant impacts, then the monitoring program will be re-evaluated and a revised monitoring plan submitted to the BCMOE for approval. Revisions might include reducing sampling frequency, reducing the number of wells tested, eliminating some testing parameters, or discontinuing the monitoring program altogether. In any case, the monitoring will continue in accordance with the current plan until such time as approval is received for changes to the monitoring program.
- Inspection of the final cover system will be carried out on a quarterly basis. Any damage to the final cover system resulting from settlement or erosion will be repaired.

#### 6.10 Post-Closure Contingency

Contingency plans may be required if the monitoring results or trend analysis indicates impacts on groundwater or surface water quality. Appropriate contingency plans would be developed, taking into consideration the design of the various closure systems, as part of developing the Detailed Closure Plan.

#### 6.11 Rodent and Wildlife Control

The main risk associated with rodent and wildlife controls are expected to be burrowing rodents. It is expected that the design of the final cover system will provide a deterrent to burrowing rodents. However, it is recommended that the surface of the landfill be monitored for signs of burrowing and that repairs be undertaken as required. Excessive burrowing may necessitate RDCO to employ some form of pest management.

While bears are present in the area, capping the landfill is expected to isolate the waste enough to deter bears from feeding on buried waste. The future levels of human activity and residential development around the site is expected to be a further deterrent.

It is proposed that bear activity be monitored for the two years following closure of the landfill to verify this anticipated behavior. If monitoring data supports it, the electric fence around the reclaimed portion of the landfill site can be removed. The portion of electric fencing surrounding the transfer station operation would remain in place.

### 6.12 Settlement Monitoring

It is recommended that several settlement monuments be established at the site to monitor the extent and rate of settlement during the post-closure period. Monuments can be constructed by securely fastening a stiff post to a sturdy base plate. The base plate should be large enough to provide an adequate foundation and should be constructed from a material that will not degrade within the landfill. The post should be stiff enough to prevent excessive bending under lateral pressures.

It is suggested that the end of the monument post be threaded to permit extensions in case the landfill is redeveloped. Any extensions to the monuments should be well documented, including a survey of the monument immediately before and after the extension is made.

The monuments should be surveyed once a year using a method with a horizontal and the vertical accuracy of at least 1 cm. A clear mark should be established on the crest of each monument to identify where the measurement is to be taken.

## 7 References

BCMOE; *British Columbia Approved Water Quality Guidelines*, 2006 Edition; August, 2006.

Reid Crowther and Partners; *Westside Landfill Operations and Closure Plan*; July, 1993.

BCMOE, *Landfill Criteria for Municipal Solid Waste*; January, 2005.