OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE

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OLIVER, BRITISH COLUMBIA

JUNE 2010
REF. NO. 049846 (04)

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EXECUTIVE SUMMARY

This Operation and Closure Plan (O&C Plan) has been prepared by Conestoga-Rovers & Associates (CRA) on behalf of the Regional District of Okanagan Similkameen (RDOS) in conjunction with the "Hydrogeological Assessment, Oliver Landfill Site, Oliver, British Columbia" (CRA, June 2009), to support development of the Oliver landfill. The development of the Oliver Landfill is being sought to provide future landfill capacity for the Town of Oliver and surrounding service area. This O&C Plan has been prepared in accordance with the performance and operational requirements of draft Operational Certificate No. PR-15280 for the Oliver Landfill as well as the British Columbia Ministry of Environment (BC MOE) document "Landfill Criteria for Municipal Solid Waste" (Landfill Criteria), dated June 1993.

The Oliver Landfill (Site) is located on a 13.8 hectare property approximately six kilometres southeast of the Town of Oliver, British Columbia. The Site currently consists of a 4.3 hectare "waste discharge area" and a 4.4 hectare designated "buffer zone". The Site operates as a natural attenuation sanitary landfill and is authorized to discharge refuse and store recyclables from municipal, commercial and light industrial sources.

The placement of waste reportedly commenced in the late 1970's along the east edge of the property, against the bedrock-overburden interface. Landfill development progressed along the bedrock-overburden interface towards the northern and subsequently the western extremity of the area enclosed by the bedrock outcropping (EBA, 2001). Refuse has been placed off-Site within a small gully north of the property boundary with an approximate area 0.1 hectares (ha) encroaching on the adjacent lands. Cover material was excavated in the mid 1980's from a borrow pit area in the northwest portion of the Site. In the early 2000's, cover material was excavated from a borrow pit area located centrally in the Site to an elevation of approximately 380 m above mean sea level (AMSL).

In 2001, the maximum thickness of deposited waste was reported to be approximately 15 m in the central portion of the refuse limits and decreased to approximately 7 m along the northeast and northwest extremities of the area enclosed by the bedrock outcropping. Since 2001, refuse placement has occurred in the former central borrow pit area and is currently being placed in the northeast quadrant of the Site as shown on (Drawing C-01). Based on 2007 contour information, the maximum refuse thickness in the central portion of the refuse limits is now estimated at 16 m (top of deck elevation 396 m AMSL minus elevation of former central borrow pit area base of 380 m AMSL).

The development plan for the Site consists of the discharge of waste into four cell areas or Stages located over and adjacent to the existing landfilled area (Drawing C-02). Stage construction and waste placement will occur on a progressive basis, generally progressing from east to west on the existing landfill footprint and then from the borrow area north. This layout and development sequence provides for waste placement to final grades and the progressive construction of final cover commencing in the northeast portion of the landfill as the active landfilling portion of the Site reaches final contours. The layout and development sequence also facilitates the development of the surface water management system (i.e., perimeter ditching).

Detailed assessment of the leachate and landfill gas (LFG) generation potential for the fully developed Site was undertaken as part of this O&C Plan. Modeling of the leachate generation and natural attenuation capacity for the developed landfill indicate that the expanded landfill will be able to continue to operate in compliance with the BC MOE Landfill Criteria and that the groundwater quality at and beyond the property boundary will respect the BC MOE's published water quality criteria. This analysis predicted that the landfill gas generation rate would be low, with an estimated peak LFG production of 177.5 m^3 per hour (approximately 510 tonnes of methane per year). Based on this assessment, there is no regulatory requirement for a LFG collection system to be installed at the Site.

Due to the nature of the sub-surface material present at the landfill, the majority of surface water generated at the Site infiltrates directly into the ground. As such, no surface waterways have been identified to enter, exit, or exist on the Site. As no downstream receiving environment (and subsequent receptors) exists under existing conditions, with respect to surface flow, surface water runoff at the Site was modeled for the post-closure scenario only. A Site-specific stormwater management system has been designed to manage and control storm water runoff from the Site. The engineered system consists of perimeter infiltration ditching and a provision for a contingency stormwater infiltration pond. These mechanisms will ensure that adequate stormwater quality and quantity control is achieved to minimize environmental impacts from stormwater runoff and discharge from the Site.

Groundwater monitoring is currently being undertaken at the Site. An updated Environmental Monitoring Program prepared in accordance with the "Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills", January 1996, has been developed for the Site as part of the O&C Plan which will address both operational and post-closure conditions. Three new groundwater monitoring well locations have been identified for inclusion in the Environmental Monitoring Program which will allow effective and reliable assessment of the Site performance and identify any environmental impacts that may occur as a result of landfilling operations at the Site. These wells are monitored as part of the Environmental Monitoring Program and if groundwater is encountered water samples will be collected and analyzed for leachate indicators.

In conclusion, the proposed development of the Oliver Landfill will enable the existing Site to continue to service the Town of Oliver and surrounding service area for approximately 40 years. Based on the assessments and modeling undertaken as part of this O&C Plan, the proposed development of the Oliver Landfill will not result in any adverse environmental impacts and will allow the Site to operate in compliance with the Operational Certificate (OC) conditions and the BC MOE Landfill Criteria.

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1.0 INTRODUCTION

Conestoga-Rovers and Associates (CRA) was retained by the Regional District of Okanagan-Similkameen (RDOS) to prepare an Operation and Closure (O&C) Plan for the Oliver Landfill, as per CRA's proposal, entitled "Request for Proposal: Hydrogeological Assessment Operations/Closure Plan Revision", dated June 2007.

The purpose of this O&C Plan, in conjunction with the "Hydrogeological Assessment, Oliver Landfill Site, Oliver, British Columbia" (Hydrogeological Assessment) (CRA, June 2009) is to support the engineered development of the Oliver Landfill (hereinafter referred to as the "Site"). The O&C Plan provides a detailed design that optimizes the Site capacity, ensures development of the Site within compliance of the applicable regulatory requirements and provides for progressive closure as the Site develops. This O&C Plan has been prepared in accordance with the performance and operational requirements of the draft Operational Certificate 15280. This O&C Plan has also been developed in general accordance with the British Columbia Ministry of Environment (BC MOE) document entitled, "Landfill Criteria for Municipal Solid Waste", dated June 1993 (hereinafter called the "Landfill Criteria").

1.1 SITE DESCRIPTION

The Oliver Landfill, operated by the RDOS, is located approximately six kilometers southeast of the Town of Oliver, British Columbia, within the Regional District Okanagan-Similkameen, as illustrated in Figure 1.1.

The Site is owned by the RDOS and the properties adjacent to the Site include land owned by the Osoyoos First Nation (Indian Reserve No. 1) to the east and privately-owned land to the north, south and west. The legal description of the Site is recorded as Lot 2450s, Similkameen Division of Yale District, Plan 14590, except Plan 31702. The Site has a total area of approximately 13.8 hectares, which consists of a 4.3 hectare "waste discharge area" and a 4.4 hectare designated "buffer zone".

The Site is accessed from Black Sage Road via Sibco Landfill Road which enters at the southwest corner of the property. Approximately 3 hectares of the Site, immediately north of the Site entrance, is currently being used by an adjacent landowner for feedlot cattle pens. Land use of the surrounding area is predominantly horticulture and agriculture, with vineyards, orchards and the cattle feedlot to the south and west of the property. The land to the north and east of the Site is undeveloped.

1.2 SITE HISTORY AND REGULATORY SETTING

Landfilling commenced at the Site in approximately in 1979 as a natural control site under Permit PR 04911 (Permit) issued on February 17, 1978 and subsequently amended on July 22, 1993. A draft Operational Certificate 15280 (OC) has been prepared for the Site and is currently under regulatory review. Copies of the Permit and draft OC are provided in Appendix A.

The Site is authorized to discharge municipal solid waste (MSW) and other wastes by the Director of Waste Management, as defined in the *Environmental Management Act*, from the Town of Oliver and Electoral Area C of the RDOS at a maximum discharge rate of 12,000 tonnes per year. The Site currently landfills approximately 6,000 tonnes of refuse a year. The Site is approved to store and manage hazardous wastes as defined in the Hazardous Waste Regulation subject to conditions stipulated in the draft OC. Historical operations included septic lagoons and authorized open burning which were discontinued in the late 1990's.

1.2.1 REGULATORY ACTS AND GUIDELINES

The following documents are applicable to landfill design, operations, monitoring, and closure requirements and were referenced in preparation of this O&C Plan:

- Environmental Management Act
- Landfill Criteria for Municipal Solid Waste, BC MOE, June 1993 (hereinafter referred to as the "Landfill Criteria")
- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills, BC MOE, January 1996 (hereinafter referred to as the "Environmental Monitoring Guidelines")
- Landfill Gas Management Regulation, BC MOE, December 2008 (hereinafter referred to as the "LFG Regulation")
- Landfill Requirements for Poultry Processing and Slaughter Waste Final Report (PPSWR), Sperling Hansen Associates, February 2007
- Bovine Spongiform Encephalophathy Manual of Procedures (MOP), Canadian Food Inspection Agency (CFIA), Section 4.1, July 2008

This O&C Plan, as presented herein, has been developed in accordance with these documents.

1.2.2 LANDFILL OPERATIONAL CERTIFICATE

A draft OC has been prepared for the Site and is currently under regulatory review. A copy of the draft OC is included in Appendix A.

1.3 REPORT OBJECTIVE

The primary objectives of this O&C Plan are to provide an effective long-term site progressive development/closure design and an operating manual for landfill site operators as required by the draft OC.

The strategies to minimize future development costs, minimize impacts to the environment, and address public concerns of the O&C Plan are as follows:

- Identify opportunities to obtain additional capacity and additional soil borrow within the existing landfill footprint
- Minimize the extent of the cell development required outside the existing landfill footprint, which will minimize long-term leachate generation and, in-turn minimize the size of the required contaminant attenuation zone
- Develop a final contour plan that will maximize surface water runoff, maximize Site capacity within the proposed development footprint and address the potential for visual impacts
- Develop a surface water management plan that will recharge the ground water at key locations which, in-turn will aid in maximizing the Site attenuation capacity and mitigate the potential for surface water discharge compliance issues
- Develop a long-term environmental monitoring program that will provide early warning of potential impact concerns (i.e., sentinel well, trigger levels)

Utilizing the above strategies will allow for development of effective, long-term Site operation and fill-management systems and processes for the Site. With the above strategies in mind, the O&C Plan objectives are as follows:

- Meet the requirements of the existing draft OC including:
    - Anticipated total waste volumes and tonnages for landfill life
    - Topographic plan showing the final elevation contours with surface water diversion and drainage controls
    - Final cover design
    - Public notification procedures
    - Rodent and nuisance wildlife control procedures
    - Proposed end use of property after closure
    - Plan and schedule for monitoring groundwater, surface water, landfill gas, erosion and settlement for a minimum of 25 years after closure
- Provide an operating manual for the Landfill Operator
- Identify key infrastructure components/projects associated with continued Site operation, expansion, and progressive closure
- Estimate incremental airspace availability
- Integrate and optimize daily operations
- Integrate and optimize existing landfill gas, leachate, groundwater, and surface water monitoring locations
- Outline cell expansion strategies and progressive closure development and maintenance
- Establish water quality and landfill gas monitoring requirements
- Summarize and record the design concept for the Site

2.0 SITE PHYSICAL SETTING

The Hydrogeological Assessment was prepared to facilitate the development of the O&C Plan by addressing the following key elements:

- Assessment of existing geological and hydrogeological conditions
- Identification and characterization of existing landfill operation-related impacts
- Determination of the attenuation capacity of the Site
- Technical feasibility of Specified Risk Material (SRM) disposal

The above-listed objectives of the Hydrogeological Assessment were investigated with the findings utilized in developing this O&C Plan. The following presents a summary of the Site physical setting based on the Hydrogeological Assessment.

2.1 PHYSIOGRAPHY

The Site is situated within the Interior Plateau along the main trench of the Okanagan Valley between the Okanagan Highland to the east and the Thompson Plateau to the west. The Site is part of the Thompson-Okanagan Plateau eco-region, as well as the Bunchgrass biogeoclimatic zone, which is characterized by warm, dry climate conditions, primarily grassland and shrub-steppe ecosystems, and diverse wildlife.

Grasses form the dominant vegetation cover with drought tolerant shrubs and forbs common throughout the region. Ponderosa pine and Douglas-fir forests occur primarily on steep rocky soils, on gravelly terraces, and in cool, moist ravines. Characteristic wildlife includes a variety of birds, reptiles, amphibians, and mammals.

2.2 CLIMATE

The Site is located in a semiarid environment within the rain shadow of the Coast and Cascade mountains and is one of the warmest and driest areas in BC. The regional climate is characterized by relatively low annual precipitation and high potential for evapotranspiration.

Environment Canada climate data measured at Oliver STP (Climate ID: 1125766) was used to characterize the local climate. The Oliver STP climate station is presently active and located approximately 6 km north of the Site at an elevation of 297 m above mean sea level (AMSL). The mean annual temperature is approximately 9.9°C with a summer (June, July, and August) mean temperature of 20.5°C and a winter (January, February, and December) mean temperature of -0.7°C. The local mean annual precipitation is approximately 319 mm. Peak periods of precipitation occur in early winter and June, but overall precipitation is low. Peak snowpack is seldom greater than 50 cm and many areas in the region are without snow for most of the winter. Frost penetrates most soils to a depth of approximately 0.5 m.

Moisture from local precipitation is likely to accumulate in the soils during the early spring when temperatures are cooler and evapotranspiration is less intense; however, by late June drought conditions prevail in most of the region's upland area. Recharge from precipitation in the area is not anticipated to be significant, however may be augmented seasonally by surface water run-off from the adjacent bedrock outcrops.

Climate data for the Oliver STP climate station is presented in Table 2.1.

2.3 SITE TOPOGRAPHY AND DRAINAGE

The regional topography is generally characterized by a broad plateau described as a gently rolling upland of low relief (Holland, 1964) with low elevation basins. The Site is located within the Okanagan Basin which runs north to south and drains into the Columbia River System within the United States.

The Okanagan River and its tributaries, along with long narrow lakes occupy the valley floor. During the Pleistocene epoch, glacial melt water that flowed down the valley formed river-cut terraces at elevations between 290 to 335 m AMSL that are now presently represented as discontinuous remnants. The valley bottom ranges in elevation from 275 to 550 m AMSL and in width from 3 to 16 km.

The landfill is situated at an elevation of approximately 400 m AMSL along the toe of a bedrock slope which dips to the south and west. The southwest quadrant of the Site is gently sloping at an elevation of approximately 380 m AMSL and forms part of a terrace on the east bank of the Okanagan River.

Surface water on-Site generally drains to the southwest. There are currently no formal stormwater management control systems in place since historically there is very little surface water runoff due to the low annual precipitation and high soil permeability.

The nearest significant water body to the Site is the Okanagan River situated approximately 1.6 km to the west and approximately 100 m lower in elevation than the landfill. The Okanagan River has been significantly modified by flood control dams, channelization, and river flow containment dykes.

2.4 SITE GEOLOGY

The geology of the Site is derived from Site-specific stratigraphic data collected through investigations conducted in August 1998 and October 2007 as summarized in the following sections.

2.4.1 ON-SITE FILL STRATIGRAPHY

The placement of waste reportedly commenced in the late 1970's along the east edge of the property, against the bedrock-overburden interface. Landfill development progressed along the bedrock-overburden interface towards the northern and subsequently the western extremity of the area enclosed by the bedrock outcropping (EBA, 2001). Refuse has been placed off-Site within a small gully north of the property boundary with an approximate area 0.1 ha encroaching on the adjacent lands.

Cover material was excavated in the mid 1980's from a borrow pit area in the northwest portion of the Site. In the early 2000's, cover material was excavated from a borrow pit area located centrally in the Site to an elevation of approximately 380 m AMSL. Both former borrow pit areas have been backfilled with refuse with the exception of a portion of the former central borrow pit area located at the toe of refuse.

In 2001, the maximum thickness of deposited waste was reported to be approximately 15 m in the central portion of the refuse limits and decreased to approximately 7 m along the northeast and northwest extremities of the area enclosed by the bedrock outcropping. Since 2001, refuse placement has occurred in the former central borrow pit area and is currently being placed in the northeast quadrant of the Site as shown on Drawing C-01.

The existing limit of refuse is approximately 43,300 m^2 as outlined on Drawing C-01. Based on 2007 contour information, the maximum refuse thickness in the central portion of the refuse limits is now estimated at 16 m (top of waste elevation 396 m AMSL minus elevation of former central borrow pit area base of 380 m AMSL).

2.4.2 ON-SITE OVERBURDEN GEOLOGY

On a regional scale, the Okanagan Valley was subject to intense glaciation during the Pleistocene epoch that formed a deep, basin-shaped trough oriented in a general north-south direction and subsequently filled with a thick sequence of unconsolidated glacial drift (Nasmith, 1962). On a smaller scale, the northeast quadrant of the landfill property is situated in a bedrock depression filled with glacial deposits. The borehole investigations indicate that the overburden stratigraphy in the vicinity of the Site varies in thickness from 0 m where bedrock outcrops are located to 119 m (MW08-2) along the southern property boundary. The overburden material is composed of glacial outwash sand deposits generally underlain by finer grained glacial-lake deposits. Sand deposits are primarily poorly sorted and fine grained with inter-layered gravels and silt material. The underlying finer grained deposits are primarily silts, ranging in content from 45 to 60 percent, interlayered with varying amounts of clay and fine sands.

Overburden thickness generally increases to the south and west along the property limits. Overburden thickness increases by approximately 95 m over a distance of 60 m, indicating a significant drop-off in bedrock elevation south of the existing toe of refuse. Stratigraphy information indicates the overburden thickness increases by approximately 75 m in a westerly direction over a distance of 120 m.

2.4.3 BEDROCK

The Geological Survey of Canada maps indicate the bedrock in the vicinity of the Site belongs to the Shuswap Complex and consists mainly of banded gneiss, crystalline schists, and less altered strata derived mainly from sedimentary rocks (Map 538A). Prominent bedrock outcrops are located diagonally from the northwest to southeast corner of the Site. The bedrock outcrops rise some 25 to 40 m, generally slope to the west and south, and have rounded and lightly fractured features.

Four on-Site borehole locations (MW98-1, MW08-1, MW08-2, and MW08-3) have been advanced to the bedrock surface with elevations ranging from approximately 260 to 404 m AMSL. The existing limits of refuse are inferred to be situated within a local bedrock depression with a bedrock trough located between the exposed bedrock areas, in the vicinity of the existing toe of the limit of refuse based on the surrounding bedrock outcrops and bedrock surface encountered at MW08-1 at a depth of 23 m below ground surface (approximately 358 m AMSL).

2.5 SITE HYDROGEOLOGY

The movement of groundwater at the Site is assumed to be controlled by the spatial variation in bedrock and/or surficial deposit permeability, as well as by topographic relief. The general groundwater direction is to the west, towards the Okanagan River; however, insufficient Site information is available to confirm this assumption. Recharge from the Site area to the main aquifer unit in the valley bottom is most likely to occur via the following pathways:

- **Perched Water Table** – infiltrating water will move vertically downward through the highly permeable sand unit until it intercepts the low permeability silt unit, resulting in a saturated lens being formed above the silt unit. Water will then flow along a downhill gradient to the top of the silt unit toward the aquifers in the valley bottom.
- **Aquitard** – infiltrating water will move vertically downward through the highly permeable sand unit and enter the low permeability silt unit. The silt unit may be permeable enough to allow groundwater flow toward the aquifers in the valley bottom, but not permeable enough to permit significant quantities of ground water to migrate.

The water table thickness above the silt unit ranges from 0.2 (MW08-2) to 1.5 (MW98-2) m based on existing field measurements. No data is available to determine the water table within the silt unit, thus it is unclear at this time if the water in the sand unit is perched or if the sand and silt units are hydraulically connected. The linear groundwater flow velocity was estimated for both stratigraphic units using the modified Darcy Equation for the sand and silt units as follows:

$$V = \frac{Ki}{n}$$

where:

V = linear groundwater velocity (m/year)
K = hydraulic conductivity (cm/s) (10^{-3}cm/s for sand, 10^{-4}cm/s for silt)
i = hydraulic gradient (m/m) (0.07 based on field data)
n = porosity (%) (25%)

The resultant groundwater velocity calculated for the Site ranged from 0.88 m/year in the silt unit to 92 m/year in the sand unit. A resultant travel time of 11 to 1000 years is approximated for groundwater underlying the Site to travel and reach the main aquifer located approximately 1 km west of the landfill assuming flow in the fine sand and silt units respectively.

2.6 LOCAL RESOURCE USAGE

Services provided by the British Columbia Ministry of Energy, Mines and Petroleum Resources were used to investigate the geological resource usage in the study area. No MINFILE or mineral tile records were found within close proximity of the Site.

The Town of Oliver's main source of municipal water is groundwater supplied from twelve water wells. Four of the water supply wells, Blacksage Wells 1 through 3 and Miller Road Well, are located approximately 1.6 km downgradient of the Site. A groundwater monitoring program is currently conducted by the Town of Oliver.

Water demands for the rural area of Oliver are supplied from surface water during the irrigation season and groundwater at other times. It is understood that the adjacent feedlot and vineyard operations divert water from the Okanagan River.

Investigation of the subsurface features within the region identified one aquifer located downgradient of the Site within sand and gravel material (BC Water Resource Atlas). Aquifer No. 254, located approximately 1 km south of the Site, is classified as IA (high productivity, high vulnerability, and moderate demand components). Aquifer No. 254 is primarily unconfined and underlies the eastern portion of the Town of Oliver, extending from Tuc-El-Nuit Lake, along both the west and east site of the Okanagan River, to Osoyoos Lake (Golder, 2005).

3.0 DESIGN CONSIDERATIONS

The following section presents a summary of the considerations and criteria used to prepare the design portion of this report.

3.1 LANDFILL DESIGN CRITERIA

The following design criteria are based on the results of the Hydrogeological Assessment and the Landfill Criteria:

- Maximum final cover gradient - 4H: 1V (25 percent)
- Minimum final cover gradient - 20H: 1V (5 percent)
- Maximum access road gradient – 10H:1V (10 percent)
- Maximum refuse lift height of 3 metres
- Apparent waste density of 0.6 tonnes per cubic metre
- Minimum 0.15 metres of daily cover material or approved equivalent
- Waste to daily cover material ratio of 6:1
- Downgradient buffer zone of 50 m or greater
- Evapotranspirative final cover with a minimum of 1 m evapotranspirative zone depth
- Progressive closure of the Site to minimize leachate generation

All aforementioned design parameters meet or exceed the requirements stipulated by the Landfill Criteria.

3.2 WASTE CHARACTERISTICS

Waste discharged at the Site is authorized under Permit PR 04911 and guided by the draft OC (Appendix A). The draft OC allows the discharge of waste to land from municipal, commercial, light industrial and institutional sources.

The waste however must not include any of the following without prior authorization from the Regional Manager, Environmental Protection:

- Hazardous waste other than those specifically authorized in the *Hazardous Waste Regulation*
- Bulk liquids and semisolid sludges which contain free liquid
- Liquid or semisolid wastes including septage, black water, sewage treatment sludge, etc.
- Automobiles, white goods, other large metallic objects and tires
- Biomedical waste as defined in the document *Guidelines for the Management of Biomedical Waste in Canada* (CCME, February 1992)
- Dead animals and slaughter house, fish hatchery and farming wastes or cannery wastes and byproducts (this is further discussed in Section 14.0)

3.2.1 WASTE DENSITY

Apparent waste density represents the mass (tonnes) of waste that can be disposed in each cubic metre of landfill airspace. Efficient landfill compaction techniques employed at well-operated landfill sites can typically attain an apparent waste density in the range of 0.6 to 1.0 tonnes of waste per cubic metre of air space consumed depending on the rate of waste placement, compactive effort and the type of daily cover.

For the purpose of estimating Site life, an apparent density of 0.6 tonnes per cubic metre has been used which is considered a conservative assessment of the existing Site landfilling activities, as tarp covers are used when possible and daily cover soil use is minimal. Refuse at the Site is compacted utilizing a 345 Rex Trashmaster compactor, which, when used appropriately, would provide sufficient compactive effort to achieve the assumed apparent waste density of 0.6 tonnes per cubic metre.

3.2.2 WASTE TONNAGE

The total amount of materials received in 2005 was 7,102 tonnes and in 2006 was 7,373 tonnes. Excluding composted/recycled materials, the amount of waste landfilled was approximately 6,034 tonnes in 2005, 6,000 tonnes in 2006 and 6,380 tonnes in 2007.

The future annual waste tonnage (the tonnage of waste the Site will receive on an annual basis in the future), has been estimated using historical data collected from the Site records. Projected waste disposal rates, presented in Table 3.1, are based upon the following elements:

- Historical waste disposal data provided by the RDOS
- Population forecast discussed in Section 3.3
- No annual increase or decrease in per capita waste disposal rates

3.2.3 WASTE DIVERSION

A number of waste diversion procedures are currently undertaken at the Site, these include the diversion of the following:

- Agricultural plastic
- Asphalt roofing
- Agricultural tree stumps
- Batteries
- Concrete
- Freon units
- Masonry
- Metals
- Propane tanks
- Tires
- Tree stumps
- Wood and branches
- Yard and garden waste
- Blue bag recycling
- Cardboard
- Glass
- Gypsum
- E-waste
- Used oil
- Household hazardous wastes

- Plastics 1 to 7 except Styrofoam

3.3 POPULATION FORECAST

Based on data obtained from BC Stats, the population of the Site service area was estimated to be 8,279 in 2006. For the purpose of this report, an annual population growth estimate of 0.7 percent was utilized. The population data utilized for estimating future annual waste tonnage is presented in Table 3.1.

4.0 SITE DESIGN

4.1 LANDFILL FOOTPRINT

Based upon the Hydrogeological Assessment the development and final closure of the landfill shall be limited to the existing footprint to the north, east and west and to 50 metres from the southern property boundary. As presented on Drawing C-01, the existing landfill footprint (limit of refuse) covers a total area of approximately 1.3 hectares. As part of the proposed Site development, it is planned to extend this footprint area to cover a total final area of 5.16 hectares, as presented in Drawings C-02. The proposed footprint expansion extends the footprint south towards the southern property boundary.

Expanding the existing landfill footprint will significantly extend the Site life of the landfill. A detailed development plan and analysis has been undertaken to efficiently utilize the expanded footprint.

Expanding the landfill footprint area will result in increased leachate generation caused by stormwater infiltration over the larger area of waste; however it is proposed that with improved Site management, progressive Site closure and an evapotransporative final cover design, that the increase in leachate generation will be minimized. In addition, predictive contaminant transport modeling of the expanded footprint has been completed to verify adverse impacts to groundwater quality at the Site boundary should not occur.

4.2 BUFFER ZONES

The purpose of the buffer zones is to facilitate the implementation of environmental controls, to provide sufficient land to locate operating facilities, and to buffer adjacent lands from landfilling operations (e.g., visual impacts). In addition, the subsurface aquifer beneath the buffer area can also serve to provide natural attenuation of the landfill leachate.

The Landfill Criteria stipulates that the following minimum buffer zone distances must be maintained from the limit of refuse,

- To any property boundary - 50 metres (presented on Figure 4.1)
- To the nearest residence, water supply well, water supply intake, hotel, restaurant, food processing facility, school, church or public park – 300 metres (presented on Figure 4.1)
- To an airport utilized by commercial aircraft – 8 kilometres
- To any surface water body - 100 metres
- To an unstable area – 100 metres
- Outside the 200 year floodplain

The operation of buffer zones less than that specified above may be authorized by the Regional Manager, Environmental Protection however 15 metres is the absolute minimum.

Current buffer zones of 50 metres or greater exist to the south and west of the limit of refuse. On the eastern and northern property boundaries historical waste is within 15 m of the property boundaries in some areas and should be removed or left in place pending agreement during Stage 1 of Site development. The landfill footprint expansion designed as part of the O&C Plan has been developed to retain a 50 metre buffer zone downgradient of landfill footprint. One residence is located within 300 metres of the proposed landfill footprint. The Environmental Monitoring Program includes groundwater and landfill gas monitoring between the residence and the landfill footprint.

4.3 SLOPE STABILITY

All proposed final slopes for the landfill are consistent with the Landfill Criteria guidelines.

The slopes of the landfill final cover will be a maximum of 4H:1V, and a minimum of 20H:1V which will promote surface water runoff and drainage, and minimize surface soil erosion.

5.0 FINAL COVER

5.1 FINAL COVER MODELLING

Due to the nature of the soils readily available and the climatic conditions in the area of the Oliver landfill, it is proposed that an evapotranspiration (ET) final cover system be used. Evapotranspiration cover systems utilize soils with a high capacity to store water resulting from precipitation events, thus enabling transpiration (through vegetation) and evaporation processes to remove water from the cover soil during periods between precipitation events. Although low permeability cover systems are accepted as a standard landfill cover, the concept of ET covers is gaining acceptance in the regulatory community as they provide opportunities for improved performance and lower construction costs in certain situations.

Assessment of a final cover system is based on the ability of the cover to minimize percolation of water into the refuse, therefore minimizing the leachate generation at the Site. The cover system must be sufficiently permeable in order for landfill gas to migrate up through the soil layers of the landfill surface. Under the Landfill Criteria guidelines, the approval of an alternative final cover which does not have a low permeability barrier layer may be approved based on an assessment of the leachate generation potential of the Site. The proposed cover system must be an integral part of the leachate management system ensuring the cover system and corresponding leachate generation are appropriately managed.

In order to assess the performance of the proposed ET cover system, hydraulic modeling using the Environmental Policy Integrated Climate (EPIC) model was completed. EPIC has the capacity to more accurately represent the complex variables contributing to the overall water balance of a site and in particular the ET by assessing the Site and the associated influences more specifically, such as wind velocities, precipitation trends and in-depth soil profiling. EPIC model input parameters are presented in Table 5.1.

5.2 MODEL RESULTS

EPIC model results are summarized in Table 5.2 and show no percolation below the root zone. Based on the results obtained using the EPIC model, the use of an ET final cover at the Oliver landfill is a viable option. Due to the arid conditions at the Site, an ET cover would be effective at minimizing the percolation into the landfill mass. It is noted that for long duration storm events, the percolation may increase over that predicted by the model if the moisture capacity of the soil layer is exceeded, resulting in increased infiltration through the soil layers.

5.3 EVAPOTRANSPIRATIVE COVER

There are two forms of ET cover systems typically used for the final cover of municipal landfills; capillary-barrier and monolithic barrier. Selection of which ET cover to use is based on Site specific details. At the Oliver Site, it is proposed to use a capillary barrier ET cover as available on-Site soils are more appropriate for this system. Capillary-barrier ET covers consist of a finer-grained soil layer overlying a coarser-grained soil layer. These layers function by using the differences in the unsaturated hydraulic properties of the two layers. During unsaturated conditions, percolation down into the lower coarser-grained layer is minimized as the capillary forces hold the water in the upper finer-grained layer, however once the soils near the interface of the two layers approaches saturation the water will move more quickly through the lower coarser-grained layer and into the waste below.

The capillary-barrier ET cover system consists of three soil layers:

- *Topsoil and vegetative cover layer* - Pasture/range vegetation cover planted on a 0.15 m layer of compost/fine mulch soil
- *Blended Soil Layer* - 1.0 m of compost/fine mulch soil
- *Sand* - 0.5 m of compacted sandy soils

The proposed ET soil layers at the Oliver Site will be constructed from a compost blend, and will consist of two sub-layers: a 0.15 m thick layer dedicated to plant establishment on the cover surface and a second 1.0 m thick layer as a dedicated moisture storage layer.

It is proposed to blend the manufactured soils on-Site from a mix of organic compost or fine mulch and the available on-Site sandy soils. The compost component will be sourced on-Site from a wood and yard waste composting/mulching facility.

The manufactured soil blend will have a final organic matter content of approximately 10 percent. This blend will be achieved by mixing approximately 1.5 parts compost to 1 part soil (volumetric basis), which is equivalent to 1 part compost to 3.5 parts soil on a mass basis. This blend ratio was selected to maximize the ET potential in the top soil layers, while still creating an effective, nutrient-rich bedding material that promotes plant establishment and growth and therefore maximizing the plant transpiration potential.

An important characteristic of compost soil blends relevant to the Site and the ET cover design is the effect that the compost blending has on a soil's stability and moisture retention capacity. Studies have identified that a key benefit of adding organic matter to soil is an increase in the overall water storage capacity of the soil (Kirchhoff, Malina and Barrett, 2002). The porosity and aggregation of the soils is also increased, which respectively promotes plant root development and helps stabilize the soils against erosion.

The sandy soil in the compost soil blend mix and for the sand layer is sourced from the excavation of the borrow area. Based on analytical results of soil samples collected as part of the Hydrogeological Assessment, the sandy soil has the following properties:

- Sand content: approximately 91%
- Silt and Clay content: approximately 9%

5.4 VEGETATIVE COVER LAYER

The function of the vegetative cover layer is to achieve the following objectives:

- Maximize ET of moisture from the soil cover material
- Stabilize the cover system against erosion by wind and water
- Minimize percolation through the final cover
- Enhance the aesthetics of the Site
- Create low-maintenance self-sustaining ecosystems

The vegetative cover will be established by hydroseeding the top soil cover layer. The hydroseeding seed-blend will be a mixture of both warm and cool season native species. Selecting native species specific to the region is important to ensure that the greatest possible plant survival rate is achieved while selecting warm and cool season species will ensure that the plant-water uptake and transpiration is maximized throughout the year which is essential for the effectiveness of the ET cover.

Generally, when hydroseeding, a combination of seed mixture, fertilizer blend, tackifier and wood fibre mulch should be applied. The ratio of this mixture composition and the specific additive requirements are seasonally dependant. The following outlines a typical hydroseeding application blend:

- 80 kg/ha seed mixture
- 160 kg/ha fertilizer blend (18-18-18)
- 50 kg/ha guar gum tackifier
- 200 kg/ha wood fibre mulch

5.5 FINAL CONTOURS

The final contours for the final cover system are presented in Drawing C-03. The final contour grades are based upon the optimization of the net available airspace of the landfill while minimizing the potential for slope failure, promoting surface water runoff and protecting the final cover soils from erosion. The final contour grades range from 4H:1V to 20H:1V. These slopes are consistent with the Landfill Criteria guidelines which stipulate that the final cover grades must be constructed with slopes between 4 percent to 33 percent (25H:1V to 3H:1V).

The maximum proposed side slope of 4H:1V was selected to allow for practical landfill development with respect to Site operations and maintenance. The minimum proposed top slope of 20H:1V was selected to allow for future differential settlement and to ensure that a sufficient slope would be maintained in the long-term to promote runoff. The final top of refuse elevation will be 415 m AMSL. This elevation is based upon the geometric constraints of the landfill footprint.

5.6 DAILY AND INTERMEDIATE COVER

For landfills accepting municipal solid waste, daily cover fulfills a number of functions which include: minimizing erosion of landfilled waste, minimizing blowing litter, reducing odours, discouraging vector and vermin activity, and improving vehicular access to the active disposal area. Soil used for the daily and intermediate cover may be a 'low quality' soil, which is typically unsuitable for final cover, preferably granular and free draining in order to ensure a hydraulic connection throughout the waste mass.

On-Site sandy soils will be excavated as part of the proposed landfill development and will be used as daily cover.

As specified in the Landfill Criteria, daily cover, or approved alternate cover system, shall be placed on the working face of the landfill at the end of each working day to cover exposed refuse. Daily cover shall be comprised of a 0.15 m thick layer of soil, or approved alternative (e.g., tarps). This results in a waste to daily cover ratio of approximately 6 to 1 (volumetric ratio).

Intermediate cover is constructed by placing an additional 0.15 m of soil on top of a previously-placed 0.15 m of daily cover. The Landfill Criteria stipulates that intermediate cover is to be placed over areas of the landfill that will be inactive for periods exceeding 30 days. When returning to continue filling of the intermediate covered area, the intermediate cover (the top 0.15 m of soil) is to be excavated and reused for daily cover or future intermediate cover. As such, the volume of the intermediate cover does not constitute a demand in the soil balance calculations.

6.0 LANDFILL VOLUMES

6.1 TOTAL SITE VOLUME

Based on the proposed final contours, presented in Drawing C-03, the total remaining Site capacity for waste and daily cover is estimated to be 545,938 m^3. The remaining Site capacity is based on a final top of refuse elevation of 415 m AMSL.

6.2 SOIL VOLUMES

6.2.1 SOIL REQUIREMENTS

The following section provides an estimate of the soil requirements for completing landfilling of the landfill stages and the closure of the Site. The soils required include daily and final cover material. A summary of the soil requirements for the Site is provided in Table 6.1.

Daily cover soil requirements were estimated at a ratio of 6 parts waste to 1 part daily cover soil (volumetric ratio). Based on the estimated air space available for waste and daily cover (545,938 m^3), the total volume of daily cover soil required is calculated to be 78,000 m^3.

The final cover soil requirements were estimated for a final cover surface area of 67,500 m^2. The soil requirements to complete the final cover are: 10,125 m^3 of topsoil underlain by 27,000 m^3 of soil from the borrow area mixed with 40,500 m^3 of mulch, underlain by 33,750 m^3 of sandy soil from the borrow area.

6.2.2 SOIL AVAILABILITY

At present, all daily and intermediate soil cover is sourced from a borrow area located to the south of the existing limit of refuse. Soil samples were collected from boreholes drilled south of the limit of refuse as part of CRA's Hydrogeological Assessment. Samples were submitted for soil property analysis (grain size, total organic carbon, cation exchange capacity) to characterize the surficial soils. Borrow area soil sample analysis indicated that the material sourced from this area is a silty sand and is suitable for the construction of an ET cover system.

Any suitable material (i.e., free of cobbles, boulders, organic material, etc.) excavated from the borrow area excavation will be used for daily and intermediate cover. Based on field observations, it is estimated that all the excavated material is acceptable for use as cover material. The volume of soil available from the soil borrow area is approximately 135,240 m^3 of soil. An additional 3,510 m^3 of soil will be secured from on-Site and/or approved off-Site sources to meet final cover requirements in 2049. Topsoil will be secured from on-Site and/or approved off-Site sources.

6.3 SITE LIFE

The total airspace available for waste and daily cover is calculated to be approximately 545,938 m^3. A summary of airspace consumption, with respect to each stage of the development plan is presented in Table 6.2.

Based upon the population projection discussed in Section 3.3, 6,000 tonnes of waste landfilled in 2006, a growth rate of 0.7 percent, a waste to cover ratio of 6:1, and an apparent waste density of 0.6 tonnes/m^3, the Site is estimated to reach design capacity in 2050. Note, the remaining capacity and estimated Site life shall be reviewed annually as part of the Annual Operations and Monitoring Report submission described in Section 13.4.

7.0 SITE DEVELOPMENT

This section presents an overview of the Site development plan from existing conditions, illustrated in Drawing C-01, through to proposed final closure contours illustrated in Drawing C-03.

The objectives of the Site development plan include the following:

- Provide a phased filling plan
- Divert surface water runoff away from the limits of refuse
- Minimize leachate generation
- Minimize daily cover consumption
- Minimize wind impacts (litter control)
- Minimize area of active working face

7.1 DEVELOPMENT

The development plan for the Site consists of the discharge of waste into four Stages located over and adjacent to the existing landfilled area (Drawing C-04). The Site development plan is based on the existing conditions contour plan, which was generated from the 2007 Aero Geometrics survey.

Stage construction and waste placement will occur on a progressive basis, generally progressing from east to west on the existing landfill footprint and then from the borrow area north. This layout and development sequence provides for waste placement to final grades and the progressive construction of final cover commencing in the northeast portion of the landfill as the active landfilling portion of the Site reaches final contours. The layout and development sequence also facilitates the progressive development of the surface water management system (i.e., perimeter ditching). As waste placement to final grades and construction of final cover advances to the west, the perimeter ditching will also be progressively extended to receive surface water run-off from the completed final cover areas, as detailed in Section 8.3.1.

To minimize potential leachate generation from the waste placement slope as it is advanced, intermediate cover will be maintained over the entire waste placement slope except for the area of the active working face.

The size of the active working face will be controlled to an area of approximately 100 m^2. Daily cover soil will be applied to the active working face at the end of each day as described in Section 5.6. The active working face will traverse back and forth across the waste placement slope as the slope advances in a eastern direction during Stages 1 to 3 and then in a northern direction during Stage 4 to Closure.

The Site development plan is presented graphically in four Stages on Drawing C-05 to Drawing C-08. The borrow area side walls will be excavated at a slope of 2H:1V to a total depth of 365 AMSL. This excavation will be undertaken to increase the capacity of Site as well as to source daily and intermediate cover soil material. It will be necessary to advance the perimeter ditching downgradient of the active landfill face prior to commencement of base excavation and waste placement.

The area surrounding the active landfilling face will be graded toward the waste placement slope to contain stormwater runoff from the active working face (leachate) for infiltration into the waste and landfill base at the toe of the waste face.

Details of the development stages for the proposed Site development plan are presented on Drawings C-05 through C-08.

The four stages of development are described further in the following sections.

7.1.1 STAGE 1 DEVELOPMENT

Stage 1 represents the development of the first landfilling stage, as presented on Drawing C-05. The existing access road will be relocated to the perimeter of the soil borrow area. During Stage 1 development, soil excavation will be undertaken south of the Stage 1 area, as required. Large cobbles and boulders will be separated from the soil material and stockpiled in the area west of the borrow area footprint. Excavated soil material suitable for on-Site use will be stockpiled to fulfill cover soil requirements. Waste placement during Stage 1 development will generally progress from west to east. Final cover will be constructed on the northern side slopes of Stage 1 area completed to final grades, as shown on Drawing C-05. Approximately 14,400 m^2 (21 percent) of the landfill will receive final cover during Stage 1. Daily cover, tarps are typically used on weekdays for most of the year, weather permitting. Soil is used as daily cover on weekends and in adverse weather conditions during weekdays. Daily, interim and final cover soil requirements for Stage 1 will be obtained from the on-Site borrow area.

During Stage 1 development, the perimeter access road will be constructed around the southern limit of the soil borrow area. Perimeter berming and infiltration ditching will be advanced around the Stage 1 area to control surface water runoff and promote infiltration as placement of final cover progresses. Details of the perimeter road and storm water ditch are shown on Drawing C-9. During Stage 1 waste within the 15 m northern and eastern buffer area will be excavated and placed in the active face or left in place pending agreement.

During Stage 1 the public waste drop-off area will developed at the entrance to the Site and the public will no longer have access to the active landfill face (This is further discussed in Section 12.3).

7.1.2 STAGE 2 DEVELOPMENT

Stage 2 represents the development of the second landfilling stage, as presented on Drawing C-06. Waste placement during Stage 2 development will generally progress from southwest to northeast. Excavated soil material suitable for on-Site use will be stockpiled to fulfill cover soil requirements. Large cobbles and boulders will be separated from the soil material and stockpiled in the area west of the soil borrow area. Final cover will be constructed on the side and top slopes of Stage 2 completed to final grades, as shown on Drawing C-06. Approximately 11,500 m^2 (17 percent) of the landfill will receive final cover during Stage 2. Extension to the existing perimeter fence to incorporate the new development area will be undertaken at the beginning of Stage 2 development, as presented on Drawing C-06. Daily cover, tarps are typically used on weekdays for most of the year, weather permitting. Soil is used as daily cover on weekends and in adverse weather conditions during weekdays. Daily, interim and final cover soil requirements for Stage 2 will be obtained from the on-Site borrow area.

MW08-01 will be decommissioned during Stage 2 as excavation of the borrow soil area progresses.

7.1.3 STAGE 3 DEVELOPMENT

Stage 3 represents the development of the third landfilling stage, as presented on Drawing C-07. Waste placement during Stage 3 development will generally progress from west to east. During Stage 3 development, complete excavation of the soil borrow area will be undertaken in advance of waste placement. Large cobbles and boulders will be separated from the soil material and stockpiled west of the Stage 3 area. Excavated soil material suitable for on-Site use will be stockpiled west of the Stage 3 development area to fulfill final cover soil requirements. Final cover will be constructed on the side and top slopes of a portion of Stage 3 completed to final grades, as shown on Drawing C-07. Approximately 18,800 m^2 (28 percent) of the landfill will receive final cover during Stage 3. Daily cover, tarps are typically used on weekdays for most of the year, weather permitting. Soil is used as daily cover on weekends and in adverse weather conditions during weekdays. Daily, interim and final cover soil requirements for Stage 3 will be obtained from the on-Site borrow stockpile. An access road will be constructed along the western perimeter of the Stage 3 area, as shown on Drawing C-07.

7.1.4 STAGE 4 DEVELOPMENT AND FINAL CLOSURE

Stage 4 represents the development of the fourth and final landfilling stage, as presented in Drawing C-08. Waste placement during Stage 4 development will generally progress from west to east. Final cover will be constructed on the side and top slopes of Stage 4 and the remaining portion of Stage 4 completed to final grades, as shown on Drawing C-08. Approximately 22,800 m^2 (34 percent) of the landfill will receive final cover during Stage 4. Daily cover, tarps are typically used on weekdays for most of the year, weather permitting. Soil is used as daily cover on weekends and in adverse weather conditions during weekdays. Daily, interim and final cover soil requirements for Stage 4 will be obtained from the on-Site soil stockpile area west of the landfill footprint.

7.2 WASTE PLACEMENT

The following waste placement practices will be implemented to facilitate Site development, optimize airspace utilization and reduce water infiltration into the refuse mass:

- Compact waste to achieve a minimum apparent waste density of 0.6 tonnes/m^3 or greater
- Achieve final stage contours as soon as possible
- Place final cover on areas which have reached final contours
- Place intermediate cover on disposal areas which will remain inactive for more than 30 days
- Remove interim cover for reuse prior to resumption of landfilling in order to promote hydraulic connection between the refuse lifts and optimize airspace

- Divert surface water runoff from the landfill and the active filling area to minimize infiltration and subsequent leachate generation

8.0 WATER RUNOFF MANAGEMENT PLAN

8.1 OBJECTIVES

The objective of a Water Runoff Management Plan (WRMP) is to minimize the impact of surface water runoff from the landfill on the receiving environment. This objective can be achieved by taking into account the following design criteria:

- Collect and convey surface water runoff from the landfill cover to minimize the potential for surface ponding
- Minimize surface water run-on into the active fill area to reduce leachate generation
- Control surface runoff flows to reduce the potential for on-Site erosion and consequential sediment loading to the downstream receiving water courses
- Maintain as closely as possible the natural predevelopment surface water flow pattern to off-Site receptors
- Preserve the existing natural drainage patterns
- Promote groundwater recharge

This WRMP is equivalent to a typical Surface Water Management Plan (SWMP) but has been renamed to avoid conflicting with the Solid Waste Management Plan.

8.2 HYDROLOGIC MODEL

Hydrologic modeling was undertaken to quantify peak surface water runoff flows and volumes, which were then used to design the surface water management systems for the landfill development.

The hydrological model used to represent the Site was the "Hydrologic Engineering Centre – Hydrologic Modelling System" Version 3.3 (HEC-HMS). This model was developed by the U.S. Army Corps of Engineers to simulate the precipitation – runoff process of dendritic watershed systems. Within the HEC-HMS model, there are a number of different recognized hydrologic and hydraulic methods the user may use to represent the various catchment characteristics and meteorological conditions occurring at a site. The methods used to represent the Oliver Landfill are outlined in detail in the following sections.

The input parameters required to run a HEC-HMS model are divided into three categories; Basin Models, Meteorologic Models and Control Specifications.

8.2.1 BASIN MODELS

Basin Models are constructed to represent the layout of the overall catchment. The basin model used for the Site consisted of a series of sub-basins (sub-catchment areas), reaches (the drainage ditch systems), junctions (the convergence of two ditch systems) and a sink (the final surface runoff discharge point). For each of these components, specific details which affect the collection and conveyance of surface runoff are entered.

Two basin models were developed for the Oliver Landfill surface water evaluation; an existing conditions model and a post-closure model.

To assess the runoff generation from and flow through a sub-basin, 'Loss', 'Transform' and 'Baseflow' methods were identified. For all of the sub-basins, a 'Soil Conservation Service (SCS) Curve Number' loss method was selected to represent the water losses. This method implements the curve number methodology for incremental losses and it computes the incremental precipitation during a storm by recalculating the infiltration volume at the end of each time interval. The curve numbers selected for each of the sub-basins were chosen based on the soil type underlying the catchment and the condition of the ground surface vegetation coverage.

A 'Kinematic Wave' transform method was selected to represent the surface water conveyance across and off all the sub-basins. This method uses a series of planes, sub-collectors and channels to represent the different drainage pathways that the surface water runoff from the Site will travel.

There is no baseflow within the catchment of the Site, consequently no Base Flow Model analysis was used for the Oliver Landfill model.

The basin model parameters used in the HEC-HMS simulation are presented in Table 8.1.

8.2.2 EXISTING CONDITIONS CATCHMENT

The existing conditions catchment is defined as the current landfilled footprint and those areas upstream which contribute surface water flow onto the Site. The catchment encompasses an area of approximately 9.6 hectares, of which approximately 4.5 hectares is land located up gradient of the existing landfill Site.

For the purpose of evaluating the surface water flows, the existing conditions basin model was divided into three sub-basins; 101, which contains the entire existing landfill footprint and the majority of the up gradient contributing area, and 102 and 103, which contain perimeter catchments that will contribute to on-Site surface water flows. For the purpose of the model it was assumed that any surface water flows in the Existing Conditions model flow as overland flows with no channel infrastructure.

8.2.3 POST-CLOSURE CATCHMENT

The post-closure catchment is defined as the final landfilled footprint and those areas upstream which contribute surface water flow onto the Site. The closed catchment encompasses an area of approximately 12.1 hectares. For the purpose of evaluating the surface water flows, the catchment is divided into 4 sub-basins; 201 which contains the majority of the upstream catchment area (approximately 6.9 hectares) and 202, 203, and 204 which contain the landfilled footprint (approximately 5.2 hectares).

Surface water run-off from the post-closure catchment is managed by perimeter ditching, as detailed in Section 8.3.

The post-closure catchment area and sub-basin boundaries are presented on Figure 8.1.

8.2.4 METEORLOGIC MODEL

The 'Frequency Storm' precipitation method was used in the HEC-HMS model for the Site. This method is a reliable design tool when sizing the surface water management system components to match the flows and/or volumes generated from specific storm events. For this method, HEC-HMS generates a synthetic storm of a known probability from statistical data and applies it to the Site.

The HEC-HMS model was run for two design storm events; the 25 year and 100 year 24-hour duration storms. The 25 year design storm was selected to evaluate the necessary storage capacity of a stormwater management pond (if required), while the 100 year design storm event was modeled to evaluate the necessary sizes of the perimeter ditching systems and overland flow paths.

The frequency storm precipitation data input for the model is presented in Table 8.2, this data was derived from the Intensity Duration Frequency Curve for Oliver Climate

Station (No. 1125766) (Appendix B). This curve was developed by Environment Canada based on rain gauge data collected for the period between 1973 and 1997.

No consideration of ET or snowmelt was applied to the model as only short-duration flow analysis was being assessed for the Site.

8.2.5 CONTROL SPECIFICATIONS

The control specifications for the HEC-HMS model specify the period that the simulation will be run and the time interval between simulation computations.

As the model simulation is only for short-duration frequency storm events, the precipitation occurring is not seasonal dependant and therefore any short-duration period could be selected to run the model. For the purpose of the modeling simulation, all storm events were run for a three day period and were evaluated at 10 minute intervals. Table 8.2 presents the HEC-HMS control specifications used.

8.2.6 MODEL RESULTS

For the Site, the total peak flow rate and the total volume of stormwater runoff from each of the sub-basin catchments was evaluated to size the various surface water management components.

A summary of the HEC-HMS model results are presented in Table 8.3 and 8.4, while the complete hydrologic modeling output for the post-closure conditions is provided in Appendix C.

8.3 SURFACE WATER MANAGEMENT COMPONENTS

Due to the semi-arid nature of the Site, with a uniquely low rainfall and relatively even precipitation distribution throughout the year, the engineered surface water management system requirements to manage the surface water runoff for the Site are minimal.

The engineered surface water management system will consist of a perimeter surface water drainage ditch system which will convey and store surface water run-off and capture sediment along the perimeter of the landfill. The ditch system will also double as an infiltration/evaporation trench.

8.3.1 EXISTING CONDITION AND POST-CLOSURE PEAK FLOW MATCHING

Surface water management at the Site is being conducted entirely within the landfill property boundary with no proposed surface water discharges from the Site. Consequently, no matching of off-Site surface water flows (between the Existing Conditions model and the Post-Closure model) need to be undertaken.

8.3.2 PERIMETER DITCHING

Perimeter ditching around the post-closure landfilled area is designed to collect, convey and store all surface runoff from the closed landfill surface and from the upstream sub-catchment areas. The two ditch systems, the western ditch alignment and the eastern ditch alignment, are designed for the surface runoff flows for all events up to the 100 year 24-hour duration storm event and shall be constructed to meet the following criteria:

- Rip rap channel armoring when ditch grades exceed 5 percent (3" to 6" nominal diameter)
- Minimum depth of 0.6 m
- Minimum grade slope of 1 percent
- Maximum flow velocity 3 m/s

Drainage ditch slope gradients should be between 1 percent through 5 percent. In sections along the Oliver Landfill perimeter, the ditch gradient will exceed these design grades. In these locations, additional erosion protection measures will need to be implemented e.g., woven geotextile fabric or concrete channel lining. The level of extra protection required will depend on the length and slope grade of the ditch section.

One extremely steep sections of ditching has been specifically identified (refer to Drawing C-03). This section of ditching will require a down-chute to be constructed to effectively convey the water.

Specific sections of the perimeter ditching system also provide surface water storage capacity and will be managed as infiltration/evaporation trenches. Due to low precipitation at the Site, only small volumes of surface water runoff will be generated during the 100-year 24-hour duration storm event, consequently, capacity to contain the runoff from all storms up to the 100-year event will be incorporated into the ditch design. Water contained in the ditches will then either evaporate or infiltrate.

8.3.3 SURFACE WATER INFILTRATION POND

A portion of land in the southwest corner of the Site is allocated for stormwater management contingency purposes. This area, as shown on Drawing C-03, may be utilized in the future to construct a stormwater infiltration pond in the event that on-Site flows exceed the capacity of the perimeter infiltration/evaporation ditching. The size of the contingency stormwater infiltration pond area is approximately 350 m^2 and should be constructed with 3:1 side slopes with a base elevation set at 1.8 m below ground surface.

8.3.4 STORMWATER INTERCEPTOR BERMS

Stormwater interceptor berms will be constructed on the active landfill face to direct surface flows away from the exposed waste. These interceptor berms will isolate the active face from surface runoff derived from portions of the landfill with intermediate and final cover in-place, effectively minimizing leachate generation.

8.3.5 SWALES

To ensure channelization of surface water runoff and associated erosion does not occur on the closed landfill surface, mid-slope swales will be constructed on the side slopes to create sub-slope lengths of a maximum of 30 m. Swales help reduce soil erosion when installed along the contours of long slopes as they shorten the slope length; thus reducing runoff water velocity and trapping dislodged soil particles.

On slope grades of 4H:1V, the swales will be spaced at 30 m intervals down the slope face following the contour line.

8.3.6 RAINWATER HARVESTING

Review of the landfill operations identified that there is not currently a water source at the Site. Due to the nature of the topography of the Site and the annual rainfall distribution, rainwater harvesting at the Site may be considered. Harvested rainwater could be used for dust control on-Site or to aid in composting.

Rainwater harvesting would incorporate the installation of a rainwater tank and fill pipe. It is anticipated that the fill pipe for the tank would be connected to the western ditch down-chute.

From the model, it was estimated that approximately 250 m^3 of surface water runoff is generated annually from the two sub-basins up gradient of the western down-chute. On a monthly basis, the volume generated from these catchments ranges between 13.5 m^3 to 28 m^3.

9.0 LEACHATE MANAGEMENT

9.1 GENERAL OVERVIEW

Leachate is generated as a result of water which has infiltrated into the landfill waste mass. BC MOE defines leachate as any liquid, and suspended materials which it contains, which has percolated through or drained from a MSW disposal facility (BC MOE, 1996).

Principal factors affecting the composition of leachate include the following (McBean et al., 1995):

- Waste composition
- Age of waste
- Landfill operations
- Climatic conditions
- Hydrogeological conditions
- Conditions within the landfill (e.g., chemical and biological activities, temperature, pH, and redox conditions)

Landfill leachate is a complex chemical mixture of organic and inorganic compounds produced from waste materials by a combination of physical, chemical, and biochemical processes. Physical processes, related to leachate generation, involve the flushing and dissolution of water as it percolates through the waste material. Chemical processes, including ion exchange, sorption/desorption, and change in pH, contribute to leachate production by enhancing the mobilization of various leachate constituents. Biological processes contribute to leachate production via the degradation of organic constituents into simpler and more mobile compounds.

The principal factors governing the quantity of leachate generated at a MSW landfill include the following:

- Moisture addition
- Thickness of waste layer
- Compaction and permeability of waste mass
- Slope, thickness, and permeability of daily and final cover

Moisture addition to a landfill can arise from a number of possible sources (McBean et al., 1995):

- Water present in waste mass when landfilled
- Percolation of water through the landfill surface
- Lateral flow through sides
- Upgradient flow from the bottom

Water entering the landfill is retained within the waste by surface tension and capillary pressure until the waste reaches field capacity, which is defined as the point at which the force of gravity on the leachate overcomes the forces retaining the leachate (El-Fadel et. al., 2002). In general, waste is placed with water content below field capacity, hence percolation and inflow are considered to be the principle sources of water infiltration for leachate generation. The specific moisture content of the waste at field capacity varies with the waste composition, density, and porosity. The heterogeneous nature of the waste and channelling of leachate through paths of low hydraulic resistance causes leachate generation prior to the waste mass reaching field capacity, however, it can be expected that leachate flow rates will increase once field capacity has been reached.

9.1.1 LEACHATE CHEMICAL COMPOSITION

The mass of waste stored in a MSW landfill represents a finite source of pollutants. The mass of pollutants available for leaching is largely a function of the physio-chemical nature of the waste, the extent of waste stabilization, and the volume of infiltration into the landfill (Lu et al., 1984). As a result, the leachate composition may be significantly impacted by not only the above-stated factors, but also key elements of the landfill design and operations.

Landfill leachate is typically composed of a number of constituents, which generally include the following:

- Organics
- Nitrogen
- Phosphates
- Heavy metals
- Dissolved solids

9.1.2 LEACHATE GENERATION LIFE-CYCLE

Leachate composition will vary over time as conditions within the waste material change. Biological activity is the major influence affecting leachate chemistry. Biological degradation involves three distinct phases, which can occur simultaneously and have varying impacts on leachate chemistry. These phases include the following:

- Aerobic phase
- Anaerobic phase
- Methanogenic phase

The initial biodegradation phase occurs under aerobic conditions resulting in the partial degradation of organic components in the waste material. The aerobic decomposition results in high carbon dioxide (CO_2) concentrations, a rapid increase in temperature, a lowering of pH, and high chemical oxygen demand (COD), biochemical oxygen demand (BOD), and specific conductance levels in leachate.

As the availability of oxygen is limited, the organic material will undergo anaerobic decomposition in the second phase producing high concentrations of organic acids, ammonia, hydrogen, and CO_2. The production of organic acids and CO_2 lowers the pH in the leachate, typically between 5.5 and 6.5. An aggressive leachate is produced enhancing the dissolution of inorganic constituents including iron (Fe), magnesium (Mg), zinc (Zn), and calcium (Ca). This phase is also characterized by high levels of BOD, COD, and specific conductance.

In the third phase of biological degradation, organic acids are consumed by methanogenic bacteria producing methane and CO_2. A stable leachate is produced, characterized by a pH between 7 and 8, and low BOD levels. Inorganic constituents such as sulphate, chloride, iron, sodium, and potassium, however, can continue to leach and dissolve for a prolonged period of time.

Upon closure, conventional landfills generally experience a decrease in "strength", or chemical concentration, of the leachate over time as a result of "wash-out" (i.e., tendency of contaminants to be transported away from the Site by infiltrating water) (Reinhart, 1995). Table 9.1 presents typical leachate concentration trends as a function of time.

9.1.3 LEACHATE INDICATOR PARAMETERS

A number of leachate parameters could potentially be utilized as indicators of leachate derived impacts. Typically a leachate sample is collected on-Site for characterization and identification of contaminants of concern (COC). Leachate characteristics identified by the Solid Waste Association of North America (SWANA) provided in Table 9.2 can be considered.

As chemicals are transported in landfill leachate, their concentrations can be reduced or attenuated by a variety of processes including dilution, dispersion, sorption, ion exchange, and biological degradation. An indicator parameter of landfill derived impacts should be a chemical which is subject to minimal attenuation so that it can signal the early movement of a leachate plume. Chloride is a preferred indicator parameter as it is usually present in landfill leachate at elevated concentrations and is attenuated only by dilution and dispersion.

9.1.4 POTENTIAL IMPACTS

Impacts associated with leachate are generally associated with one or more of the following:

- Environmental impacts affecting groundwater
- Environmental impacts affecting surface water
- Odour issues
- Mounding in waste mass, which may impede cover/vegetation generation, LFG collection activities, and result in slope stability issues

Typical leachate constituents can be organized into four categories: common inorganic cations, heavy metals, organic matter, and specific organic compounds originating from household or industrial chemicals present in relatively low concentrations, including aromatic hydrocarbons, phenols, and chlorinated aliphatics (Christensen et al., 1989). These substances are with time washed out of the landfill by water infiltrating through the cover of the landfill. The effect of uncontrolled discharge of leachate into the environment is one of the most significant impacts associated with MSW landfill operations.

The build up of water within the waste mass creates a pressure gradient that can increase the amount of leachate which discharges into the ground underneath the landfill. In addition, mounding that is severe enough to raise the water table within the landfill, such that it intercepts the slopes of the landfill, will cause leachate breakouts at these points on the slope. This can be detrimental to human and environmental well being, as well as being a source of unpleasant odours.

Leachate management and control of contaminant release remains an ongoing priority at landfills due to contaminants such as chlorides, ammonia, and organic matter, which continue to exist in the leachate for decades. Therefore, leachate control systems must continue to be monitored for years after the waste has been placed and covered.

9.2 LEACHATE GENERATION

The generation of leachate is dependent on a number of factors including the amount of precipitation, cover system design, and Site development (e.g., areas of cells, areas of exposed waste, areas completed with final cover, etc.).

Precipitation which falls onto a landfill surface will travel one of four hydrologic pathways; surface runoff, ET, infiltration or soil moisture storage. When estimating leachate generation within a landfill, it is generally assumed that all precipitation that infiltrates through the landfill cover will become leachate. Computer modeling is the most common method used to estimate the amount of water entering the landfill mass via percolation. Hydrologic Evaluation of Landfill Performance (HELP) model simulations completed in the Hydrogeological Assessment estimated percolation rates between 28 to 53 millimeters per year per meter squared (mm/yr m^2) under daily cover design and 9 to 29 mm/yr m_2 under intermediate cover design. The current limit of refuse generates an estimated 375 to 1,250 m^3 of leachate a year, assuming intermediate cover placement. Post-closure leachate generation at the Site is estimated at 270 m^3/yr considering the final development footprint and the final cover described in Section 5.0. Leachate generation rates are relatively low compared to other landfills in BC.

9.3 ATTENUATION

An attenuation evaluation was completed as part of the Hydrogeological Assessment to determine the fate and transport of landfill derived contaminants as follows:

- Select soils sample collected on-Site during the field investigation program were submitted to the laboratory for grain size, cation exchange capacity (CEC), and fraction organic carbon analysis. Analytical results indicate the soils within the sand and the silt stratigraphy units underlying the Site are within the lower end of the expected range for similar soil types and generally have low affinity for cation exchange; however, filtration, oxidation/reduction, precipitation, and biological degradation process can still occur at the base of the landfill and/or in the vadose zone to reduce contaminant levels.

- Based on VLEACH modeling results, it would take approximately 23 years for chloride concentrations to begin impacting groundwater below the Site assuming a 20 m thick vadose zone at an infiltration rate of 28 mm/year. Steady state conditions would be reached after approximately 40 years. With placement of an ET final cover, leachate impacts would likely not occur below the 20 m thick vadose zone for over 200 years due to the reduced infiltration rate.
- In the saturated zone, the dilution attenuation factors range from 5 to 7 for Scenario A and from 40 to 56 for Scenario B throughout the proposed development stages assuming dilution from water percolating in the buffer zone and underlying groundwater. Modeling results indicate sufficient attenuation occurs to maintain compliance with respect to water quality at the property boundary.

Based on the above, sufficient natural attenuation is provided by the physical setting of the Site and the use of best management practices can ensure that the most cost effective means are used to protect the environment and public health from the adverse impacts of waste disposal.

9.4 LANDFILL BASE

The Oliver landfill is an unlined, natural attenuation landfill. Soil samples collected at the Site indicate the soil beneath the landfill base is composed of silty sand. Section 6.1.1 of the Landfill Criteria for Municipal Solid Waste (June 1993) states there must be a low permeability layer (hydraulic conductivity of 1×10^{-6} cm/s or less) at least 2 m thick underlying the bottom-most waste cell. Exemptions are considered based on the potential for leachate generation, unsaturated depth, permeability, and attenuation capacity of the Site. In addition, the landfill base must be 1.2 m above the seasonal high water table.

Soil that would meet the requirements of the Landfill Criteria is not readily available in the area of the Site. As demonstrated in Section 9.3, the Site conditions support a natural attenuation design for the landfill. The buffer zone, in addition to the natural attenuation capabilities of the Site, is anticipated to provide sufficient protection against leachate impacts to groundwater quality. A progressive landfilling and closure strategy is used in Site development to minimize leachate generation rates.

The depth to the seasonal high water table from the expanded landfill base is at minimum estimated to be 23 m and is compliant with the Landfill Criteria.

9.5 LEACHATE SEEPAGE

Should leachate seepage be identified, the Site Operator will repair the cover in the area of the seepage immediately.

Leachate seepage will be addressed as an operation and maintenance issue. Leachate seepage in active areas will be managed by redirecting the seepage into the landfilled waste. This will be accomplished by excavating in the area of seepage through the uppermost lift of waste, to the underlying lift. This will provide a hydraulic connection to lower lifts of waste and allow the perched leachate to dissipate and prevent further seepage. Leachate seepage in completed areas (final cover) will be dealt with by excavating in the area of seepage through the uppermost lift of waste, to the underlying lift. The excavation will then be backfilled with stone drainage media to ensure an unobstructed vertical hydraulic connection to underlying waste. This will provide a hydraulic connection to lower lifts of waste and allow the perched leachate to dissipate and prevent further seepage. The excavated seepage area will then be completed with final cover, utilizing clean soil and completed with topsoil and vegetation, as weather permits.

9.6 LEACHATE MANAGEMENT STRATEGY

Section 4.1 of the of the Landfill Criteria for Municipal Solid Waste (June 1993) states that water quality must not be degraded below acceptable levels (based on Approved and Working Criteria for Water Quality) at or beyond the property boundary.

Hydraulic conductivity evaluation of the underlying soils suggests leachate mounding at the Site would be minimal. No leachate accumulation has been observed on-Site during inspection events. Should clogging of the base occur a minimal leachate mound may result. The Site attenuation evaluation indicates that leachate volumes generated by the waste mass will not degrade water quality above acceptable limits.

The depth to the seasonal high water table from the expanded landfill base is at minimum approximately 23 m and is compliant with the Landfill Criteria. This depth was based on historical water level data and is consistent with data collected from the Site (CRA, March 2008).

The data indicates that the Site can continue to operate as a "natural control" landfill without significant environmental impacts. The existing property boundary and attenuation capacity of the Site is anticipated to provide sufficient buffer against detrimental impacts to water quality and maintain compliance at the property boundary. The progressive closure strategy used in Site development will reduce leachate generation rates. Water quality monitoring will be conducted to ensure surface water and groundwater quality is not degraded above acceptable levels at the property boundary. If monitoring results indicate a long-term degradation in water quality approaching the Landfill Criteria concentrations, contingency measures would be implemented.

10.0 LANDFILL GAS MANAGEMENT

10.1 LANDFILL GAS OVERVIEW

Landfill gas is produced by the biological decomposition of wastes placed in a landfill. LFG composition is highly variable and depends upon a number of Site-specific conditions including solid waste composition, density, moisture content, and age. The specific composition of LFG varies significantly from landfill to landfill and even from place to place within a single landfill; However, LFG is typically comprised of methane (approximately 50 percent by volume) and carbon dioxide (approximately 50 percent by volume). LFG may also contain nitrogen (N_2), oxygen (O_2), and trace quantities of other gases (such as hydrogen sulfide (H_2S), mercaptans, etc.). In addition to the above methane-related LFG constituents, non-methane organic compounds (NMOCs) such as vinyl chloride, may also be generated and emitted at a landfill.

Due to its composition, the presence of LFG may create explosive, suffocating, and toxic conditions. LFG management may be required to control potential impacts relating to the release of LFG to the atmosphere and migration of LFG through the soil surrounding the Site.

The release of LFG into the air may contribute to odours in the vicinity of the Site and addition of greenhouse gases into the atmosphere. LFG odours are primarily a result of the presence of hydrogen sulfide and mercaptans. These compounds may be detected by sense of smell at very low concentrations (0.005 and 0.001 parts per million for hydrogen sulfide and mercaptans, respectively). It is generally recognized that the impacts related to these compounds are nuisance odours.

Migration of LFG through the soil poses two primary concerns that are related to the build-up of gases within or below structures near the landfill site. Firstly, accumulation of LFG in a subsurface structure (i.e., basement, buried chambers, etc.) may expose those required to enter the structure, to an oxygen deficient environment which may be created by the presence of LFG. Secondly, accumulation of LFG in low-lying areas or within buildings introduces the risk of an explosion if a source of ignition is present.

10.2 LANDFILL GAS PRODUCTION

10.2.1 LFG GENERATION MODEL

The LFG generation potential for the Site was estimated using a LFG generation model. Although a number of models are available for estimating rates of LFG production, the accepted industry standard is a first-order kinetic model, which relies on a number of basic assumptions regarding Site-specific conditions. This model is used to predict the variation of LFG generation rates as a function of time for a typical unit mass of MSW. The LFG generation rate curve is then applied to the history of MSW placement at the Site to produce estimates of LFG production over specified time periods.

The Scholl Canyon model, a first-order kinetic function, is the accepted industry standard model to evaluate LFG production and emission rates for the purpose of assessing potential LFG impacts.

The Scholl Canyon model is used to estimate LFG production over time as a function of the LFG generation constant (k), the methane generation potential (L_o), historic filling records, and future projections for waste filling rates. Typical values of k range from 0.006 per year for dry sites to 0.07 per year for wet sites. Depending upon the regional precipitation and waste composition, production of LFG may continue for more than 50 years after closure and can result in methane generation potential ranging from approximately 10 m^3 to 350 m^3 of methane per tonne of waste.

The formula for the Scholl Canyon model can be expressed as follows:

$$Q_T = \sum_{t=1,n} 2L_O k M_t e^{-kt}$$

Where:

Q_T	=	total LFG emissions (50 percent CH_4 and 50 percent CO_2 by volume)
k	=	LFG generation constant ($year^{-1}$)
L_o	=	methane generation potential (m^3 CH_4 / tonne of waste)
M	=	mass of waste (tonnes) placed in year t
t	=	time in years

10.2.2 LFG PRODUCTION ASSESSMENT

As discussed in Section 10.2.1, the Scholl Canyon model was used to estimate the LFG production at the Site. The LFG production estimate is based on the following factors:

- Study timeframe
- Waste quantification
- Waste characteristics
- Model input parameters

For the purpose of this study it is assumed that filling at the Site commenced in 1979 and will continue to the end of 2050. The estimated closing date of 2050 is based upon the air space capacity presented in Section 6.1.

LFG generation parameters (k and L_0) provided in the Landfill Gas Generation Assessment Procedure Guidance (LFG Assessment Guidance)(CRA, 2009) were utilized for this evaluation. The use of this approach to modeling LFG production was selected to compare annual methane production with the Landfill Gas Regulation threshold of 1,000 tonnes of methane per year.

The methane generation potentials (L_o) of 20, 120 and 160 m^3 of methane per tonne of waste were used for relatively inert waste, moderately decomposable waste, and decomposable waste respectively. Precipitation at the Oliver landfill is below 500 mm per year therefore the LFG generation constants (k) of 0.01, 0.02, and 0.05 yr-1 were selected for relatively inert waste, moderately decomposable waste, and decomposable waste respectively.

A conservative estimate of waste characterization was completed based on scalehouse data. As waste characterization data for the Oliver landfill service area is not available it was assumed that all mixed waste received at the Site is decomposable. This assumption likely over estimates LFG generation and was used as an upper bound. A lower bound was estimated by classifying mixed waste as one third relatively inert, one third moderately decomposable and one third decomposable.

10.2.3 LFG PRODUCTION RESULTS

The LFG production assessment indicates that the peak LFG production is estimated at approximately 129 to 176 m^3 per hour (371 to 505 tonnes of methane per year) subsequent to Site closure.

Results of the estimated LFG production rate rates are presented in Tables 10.1 and 10.2. The LFG generation model results are presented in Figure 10.1.

10.2.4 POTENTIAL LANDFILL GAS IMPACTS

Due predominantly to pressure gradients, LFG migrates through either the landfill cover or adjacent soil and enters the atmosphere. Impacts related to LFG are largely dependent upon the pathway by which the gas is exposed to humans or introduced into the environment.

The generation and presence of LFG can result in adverse impacts related to either air emissions or sub-surface migration. Adverse air emissions issues include the following:

- Greenhouse gas (GHG) issues
- Health and toxic effects issues
- Creation of nuisance odours

Global warming is caused by increased concentrations of GHG's such as carbon dioxide and methane, in the atmosphere. These gases permit solar radiation to pass through the atmosphere while absorbing part of the infrared radiation that is reflected back from the Earth's surface. Methane is a potent GHG, which has twenty-one times the global warming potential of carbon dioxide. LFG represents approximately 27 percent of Canada's anthropogenic methane production and is, therefore, a significant contributor to total GHG emissions.

LFG has the potential to create toxic conditions or cause asphyxiation. In a confined space, LFG will displace oxygen in the area thereby creating an oxygen deficient atmosphere. Health effects associated with LFG exposure are generally related to trace gases such as vinyl chloride. Some trace compounds in LFG are toxic at high exposure concentrations while other trace compounds are considered carcinogenic over long-term exposure.

The release of LFG into the atmosphere may contribute to odours in the vicinity of the landfill. As described in Section 10.1, LFG odours are caused primarily by the hydrogen sulphide and mercaptans (thiol) compounds, which are present in trace quantities in LFG.

Potential sub-surface LFG migration impacts include the following:

- Explosive hazard
- Vegetative stress

The risk of explosion occurs when the concentration of methane in air exceeds its Lower Explosive Limit (LEL). Due to the fact that the LEL of methane is approximately 5 percent by volume in air, only a small proportion of LFG (containing approximately 50 percent methane by volume) is necessary to create explosive conditions. This risk is present in confined spaces with limited ventilation.

Vegetative stress is a sign of LFG migration through the subsurface and occurs due to the displacement of oxygen in the soil and the resultant oxygen deprivation of the plant roots. Deterioration of vegetation on or near landfills may be both an aesthetic and a practical issue. In areas where vegetative cover is diminished, erosion of the cover may occur. This may result in a "cascade" effect resulting in increased LFG emissions.

The assessment of the LFG migration potential requires a basic understanding of the fundamentals and processes involved in the decomposition of solid waste. Depending upon the proportions of the two major constituents of LFG (CO_2 and CH_4), it can either be lighter or heavier than air and therefore may accumulate in structures or low lying areas. Should there be a continuous source of LFG, the hazard may be significant given that methane is explosive in the range between approximately 5 to 15 percent by volume in air.

Medium to coarse grained soils tend to act as preferential pathways for migration of LFG while fine grained, clayey or water bearing soils tend to impede the movement of LFG. Granular bedding materials and pipelines in underground service corridors may also provide preferential pathways for LFG migration. The landfill cover system may have a significant impact on the potential for LFG migration.

LFG migration from the refuse is influenced primarily by pressure, diffusion, and permeability. Impacts of LFG are largely dependent upon the pathway by which the gas is exposed to humans or introduced into the environment. The primary concerns associated with the migration of LFG through the soil are as follows:

- Accumulation of LFG in a subsurface structure (i.e., basement, buried manhole, etc.) may expose those required to enter the structure to an oxygen deficient environment
- Accumulation of LFG introduces the risk of an explosion if a source of ignition is present
- The presence of LFG in the soil may have detrimental effects on vegetation due to displacement of oxygen from the root zone

Potential LFG migration receptors for the Site include the following:

- Scale house located in the southwest corner of the property
- Private residence located approximately 100 m southwest of the Site
- Feedlot operation buildings located adjacent to the southwest corner of the Site

As stated in the Landfill Criteria for Municipal Solid Waste, the concentration of combustible gas may not exceed the lower explosive limit (LEL) of 5 percent (volumetric basis) in soils at the property boundary or 25 percent LEL (1.25 percent methane in air on a volumetric basis) in on-Site or off-Site building structures. No methane was present at soil gas probe MW98-3 during the September 2008 monitoring event. It is noted that worst case conditions (i.e., winter) were not monitored during the sampling period.

The potential for LFG to migrate to on-Site structures requires a direct conduit for LFG to migrate and accumulate in the building envelope. The on-Site scale house is a raised temporary facility and does not present a conduit for migration into an enclosed space; therefore, the potential for accumulation of LFG in this structure is deemed low. The adjacent residence has a basement and the other buildings on the adjacent property are constructed with earth or concrete slab floors on the ground surface and thus would pose a higher risk for potential accumulation of LFG. During the development of Stage 3 passive gas vents should be installed in the pathway between the landfill footprint and the residence southwest of the site. LFG probes should be installed at the southwest corner of the property to monitor for LFG migration.

Due to the physical setting of the Site with the refuse discharge area presently at a higher elevation than the adjacent property to the south and west and no methane at

MW98-3, there is no evidence that LFG is migrating to the southern or western property limits. Further, it is recognized that LFG generation at the Site will be low due to low precipitation levels. Due to the elevated position of the refuse discharge area and the porous nature of the sandy daily cover soil being used, it is likely that any LFG being generated is venting into the atmosphere generally within the landfill footprint. It is noted, however, that additional monitoring locations along the southern and western property boundaries are recommended to confirm lack of LFG migration as the refuse discharge area expands in a southern and westerly direction as the Site is developed.

10.3 LANDFILL GAS MANAGEMENT

10.3.1 LANDFILL GAS COLLECTION

The Landfill Gas Management Regulation (LGMR) states that landfills with over 100,000 tonnes in place or receiving over 10,000 per year must undertake a LFG assessment. The Oliver Landfill received approximately 6,380 tonnes of MSW in 2007 and reached an estimated 160,000 tonnes of waste in place.

10.3.2 CURRENT REGULATORY TRIGGER LEVELS

Soil gas trigger levels are based on an exceedance of a specified concentration of combustible gas in surficial soils. Section 6.4 of the Landfill Criteria prescribes the following trigger levels:

- Concentration of combustible gas at the property boundary must not exceed the LEL (5 percent methane in air on a volumetric basis)
- Concentration of combustible gas in on-Site or off-Site building structures must not exceed 25 percent LEL (1.25 percent methane in air on a volumetric basis)

10.3.3 REGULATORY TRIGGER LEVELS

Under the LGMR municipal solid waste landfills with in excess of 100,000 tonnes in place and/or discharging over 10,000 tonnes of waste to the environment annually must carry out a LFG Assessment.

Based on the projected MSW generation rates in the landfill service area the annual waste mass landfilled will not exceed 10,000 tonnes per year over the design life of the Site; however, the Site reached 100,000 tonnes of waste in place sometime after 1995, therefore the preparation of a LFG assessment report conforming with MOE guidance is required. The LFG modeling in this report has been completed as per the LFG Generation Assessment Procedure Guidance, but a LFG assessment report conforming to the MOE template is required to be submitted by January 1, 2011.

Under the proposed LGMR, the installation of a landfill gas collection system is required for landfills producing over 1,000 tonnes of methane per year. Based on the results in Tables 10.1 and 10.2, the peak methane production rate will be between 371 and 505 tonnes per year at closure. Therefore although a LFG Assessment is required under the LGMR it is anticipated that the results of the LFG Assessment will demonstrate that the Site is producing less than 1,000 tonnes of methane per year and that the installation of a landfill gas collection system is not a regulatory requirement.

10.4 LANDFILL GAS MONITORING

The purpose of the LFG migration monitoring program is to monitor for the presence of combustible gas in the soil surrounding the Site and to initiate appropriate actions as may be warranted to control impacts of sub-surface migration.

In the event that on-Site structures are required to be constructed with on-grade floor slabs or evidence of sub-surface LFG migration is discovered (i.e., vegetative stress), a LFG Management Plan should be developed. Such a plan would most likely incorporate building atmosphere monitoring and/or additional LFG migration monitoring probes.

LFG migration monitoring in surficial soils would be carried out through the installation of additional LFG probes. Probes should be used to test for LFG migration to a depth of 3 m below ground surface. The probes should be screened from approximately 1.5 m below ground surface. Each probe would consist of a 19 mm diameter PVC pipe surrounded by gravel pack and sealed with a concrete/bentonite seal at the ground surface.

10.5 LANDFILL GAS CONTINGENCY MEASURES

Due to the potential impacts that LFG poses to the environment, a program is required to respond to incidents that may occur. LFG odours and sub-surface migration are impacts which may require activation of contingency measures. These measures are required to address the potential impacts of migration. Initiation of these measures must be based upon incidents of the trigger level criteria being exceeded. Regulatory trigger levels are described above and the following outlines appropriate response measures. Contingency measures to address combustible gas in the soil outside the limit of refuse include:

- Installation of additional gas probe nests
- Additional monitoring including barhole probe monitoring
- Installation of passive vents to reduce the positive pressure gradient
- Other effective measures that may also be available

10.5.1 LFG PASSIVE CONTROL SYSTEMS

For the purpose of mitigating localized LFG migration and odour issues, a passive LFG control system can be an effective strategy which can be integrated into the LFG management plan. The primary objective of a passive LFG control system is to mitigate LFG migration and odour issues. For the purpose of achieving this objective, it is satisfactory to passively vent the LFG and thereby reduce surficial pressure gradients and fugitive emissions in regions of the landfill in close proximity to active landfill operations (e.g., on-Site building structures, public access areas, etc.).

A passive LFG abatement system should meet the following basic design criteria:

- Long term cost-effective approach, from both a construction and operation and maintenance (O&M) perspective for achieving the primary objectives while permitting future expansion of the abatement system
- Maximum design flexibility in order to permit future alterations of the fill plan or post-closure activities

There are generally two LFG passive control systems available: passive venting and barrier systems. These systems are further discussed herein.

10.5.1.1 PASSIVE VENTING

Passive venting systems provide a method by which surficial pressure gradients can be reduced, while permitting migrating LFG to escape without active mechanical systems. Passive venting involves the installation of horizontal trenches (or vertical wells equipped with rise pipes) filled with coarse granular fill. Passive venting trenches are generally located along the perimeter of a landfill at the limit of refuse or around on-Site building structures. The trench may be tied to a vertical riser/dispersion pipe which permits the venting of gas at a controlled location and elevation.

Passive venting systems rely on the existence of positive pressure gradients (relative to atmospheric conditions) to facilitate the exhausting of soil gas to the atmosphere. The effectiveness of passive vent systems may be enhanced by equipping the ventilation risers with wind turbines.

A passive LFG venting system is recommended for the area between the limit of refuse and the residence southwest of the property to be implemented in Stage 3.

10.5.1.2 BARRIER SYSTEMS

Barrier systems can be an effective method to mitigate LFG migration. A physical or pressure barrier may be constructed in permeable soils, above the groundwater table, adjacent to the edge of a landfill to prevent lateral movement away from the limit of refuse. Barrier systems include slurry walls, concrete grout, sheet pile walls, synthetic membranes, and air pressure curtains.

10.5.2 BUILDING MONITORING PROGRAM

In the event that LFG is found to be present in the surficial soils adjacent to a building structure, a building monitoring program should be implemented to monitor for the potential presence of combustible gas within the building envelope. Installed system components should include, but are not limited to the following:

- A two stage alarm with audible and visible alarms distinguishable from any other alarm
- Battery backup for monitoring system operations without building power
- Status lights, sensor warning indication and reset switch located on an exterior control panel

Sensors should be located in each room of a building structure. It is suggested that the sensors be located in the ceiling of each room. It is suggested that each sensor location be selected based on the following parameters:

- Potential entry points of the gas
- High or low points where gas might collect

- Airflow dead zones in offices or other areas
- Ventilation patterns within the room including the location of heaters, vents, return air vents, and seasonal airflow patterns
- Locations of doors and windows
- Sensitivity of sensor to dust and moisture
- Installation in accordance with manufacturer's requirements
- Access to the sensor for calibration and maintenance

11.0 SITE FACILITIES

The following sections provide a description of the existing facilities and proposed relocation of existing facilities to facilitate the long-term development of the Site.

11.1 SCALE HOUSE

A weigh scale and scale house are located inside the entrance to the Site. The weigh scale is used to measure the weight of all waste haulage vehicles upon entering and leaving the Site. All re-use products are also processed through the scale house.

11.2 FENCING

Locked gates at the landfill entrance off Black Sage Road control Site access. These gates are locked outside normal operating hours to prohibit vehicle entrance and uncontrolled disposal when the Site is closed.

A Game fence (post and wire) currently exists around the Site perimeter, as shown on Drawing C-01. The existing fencing will require upgrading and expansion to accommodate for the proposed landfill development. The proposed location for an electric fence is presented on C-07. The electric fence will have one controlled gate for main Site access. The electric fence details are presented on Drawing C-09.

11.3 WASTE DIVERSION ACTIVITIES

Recycling facilities are located at Regional landfills and transfer stations throughout the Region for waste diversion purposes. The following materials are diverted through the RDOS recycling program: corrugated cardboard, mixed paper, newspaper, milk jugs, steel/ aluminium cans, and glass.

Agricultural plastic, asphalt roofing, agricultural tree stumps, concrete, masonry, tires, metal, white goods, batteries, soil, wood, propane tanks, gypsum, e-waste, and all plastics 1 – 7 except Styrofoam are also diverted from the landfill. Collection and storage areas are located on-Site. There is a collection system for used oil and product care depot for paint and other household waste at Site. All other diverted materials are temporarily stored on-Site before being transported to an end user.

Liquid waste, such as paint, motor oil, flammable liquids and household pesticides are directed to the Product Care depot and the BC Used Oil Management Association depot located on Site.

11.4 ACCESS ROAD

Access to the Site is from Black Sage Road and Sibco Landfill Road, approximately seven kilometres southeast of Oliver. The Site entrance is located in the south western portion of the Site.

11.5 EQUIPMENT

Adequate equipment will be maintained at the Site to ensure that operational requirements will be met. The equipment currently utilized at the Site, which will continue to be used during long-term operation of the Site is summarized below.

Equipment	*Operations*
345 Rex Trashmaster Compactor	• spreading and compacting waste and cover soils
951-C Caterpillar Track Loader	• spreading waste and cover soils • road construction and maintenance • excavation of cover soils • ditch cleaning and general Site maintenance
1845 Case Skid Steer Loader	• spreading waste and cover soils • road construction and maintenance • excavation of cover soils • ditch cleaning and general Site maintenance

Additional equipment will be used at the Site, on an as-required basis, during landfill construction phases.

12.0 SITE OPERATIONS

The Site is currently permitted and accepts domestic and commercial refuse. The Site also accepts recyclable materials; including batteries, propane tanks, used tires, scrap metal, white goods, e-waste, gypsum, asphalt shingles, soil and wood waste.

12.1 SITE ACCESS AND INFORMATION

Access to the Site is from Sibco Landfill Road, which approaches the Site from the south-west. A gate on the Sibco Landfill Road access road controls entrance and/or exit from the Site. The gate is locked outside normal operating hours to prohibit vehicle entrance and uncontrolled disposal when the Site is closed.

Signage is provided at the Site entrance as follows:

- Site name
- Site owner and operator
- Contact phone number and address for owner and operator
- Phone number in case of emergency (such as fire)
- Hours of operation
- Materials/waste accepted for landfill and recycling
- Materials/waste banned

12.1.1 HOURS OF OPERATION

The Site is open and operating from 10:00 am to 3:45 pm, Monday to Saturday during the months of March to November. The Site is open and operating from 12:00 p.m. to 3:45 p.m., Monday through Saturday from December to February. The Site is closed on Sunday, Boxing Day and statutory holidays.

12.2 SITE SUPERVISION

A Site Operator, under contract to the RDOS, will operate the Site during normal operation hours. As part of the operations, the staff of the Site Operator will complete the following tasks:

- Place and compact waste

- Prevent waste scavenging or burning
- Monitor quantities of waste, weighed and recorded, entering the Site
- Visual inspection of waste loads for the following prohibited from landfilling Site wastes (liquid or hazardous waste):
    - i) Explosive or highly combustible materials
    - ii) Liquid waste
    - iii) Raw sewage and septic tank sludge or effluent
    - iv) Pathological waste
    - v) Non-veterinary certified dead domestic animals
    - vi) Radioactive waste
    - vii) Waste oil
    - viii) Materials that are on fire or above a temperature of 65.5°C
    - ix) Car bodies and farm implements
    - x) Rubber tires
    - xi) Hazardous wastes as defined by BC MOE
- Report operation problems
- Application of daily cover
- Placement of final cover, topsoil and seeding as and when required
- Maintain secure Site entrances
- Maintain Site equipment
- Complete operation diaries and records
- Control surface water runoff by grading and berming the Site in order to keep surface water away from the waste and to contain surface water that has come in contact with waste

The Site operator maintains a daily record of materials received at the Site. Tipping fees are charged for all wastes entering the Site on a weight basis.

12.3 WASTE AND COVER SOIL PLACEMENT

Waste will be placed by utilizing the area method of landfilling, in which the waste will be placed and compacted over the prepared base or on previously filled areas, as applicable, in layers and covered with tarps or soil at the end of each work day. The width of the active disposal area will be limited to approximately 15 to 20 m at any one time.

Members of the public will be able to unload waste at the proposed waste drop-off area located near the Site entrance. Wastes will be transported from drop-off area by the Site Operator to the active disposal area or in the case of white goods, tires, etc. in vehicles/containers to an off-site processing facility. All outgoing loads will be weighed to determine the waste transported off-site and will be recorded as the type of waste or recyclable material and destination.

The Site Operator will transport waste to the working face and the landfill compactor will be used to spread and compact the waste. The waste will be compacted in lifts not exceeding 0.6 m thick. The waste will receive approximately five passes with the landfill compactor. Waste placement will continue in lifts to produce a cell of waste with a minimum height of 3 m, and a minimum surface grade of 2 percent to promote surface water runoff from the covered surface.

12.3.1 DAILY COVER SOIL

Daily cover helps to minimize litter migrating from active areas and assists the control of odour, vectors and vermin. Tarp covers are used at the Site in conjunction with soil material for the entire year, as an approved alternative daily cover system, weather permitting.

On a weekly basis, an additional 0.15 m layer of soil is applied to the working face. Whenever possible, this weekly cover will be scraped off the landfilled waste and/or scarified prior to placement of subsequent lifts of waste to promote hydraulic connection to the underlying waste.

The top and sides of a completed waste cell may also be covered with soil once the cell is at full height and the cell is progressing horizontally.

12.3.2 INTERMEDIATE COVER

Certain areas of the landfill may be completed with intermediate cover to allow additional settlement and consolidation of the waste prior to final waste placement to final contours. Intermediate cover will be placed over areas that remain inactive for periods exceeding 30 days. Intermediate cover will consist of a 0.3 m layer of non-cohesive soil placed over the waste, graded to promote surface water runoff.

Intermediate cover removal, prior to resumption of landfilling, will be performed to promote hydraulic connections between waste lifts and reduce airspace consumption.

12.3.3 FINAL COVER

During Stages 1 through 4, progressive final cover placement will be carried out on the side slope areas which have reached final elevations. Final cover will be constructed as detailed in Section 5.3.

The progressive placement of final cover reduces leachate generation by promoting surface runoff thereby reducing infiltration into the landfill.

12.3.4 WINTER AND WET WEATHER OPERATION

Winter operations require advanced planning for Site preparation, snow removal, and the stockpiling and storage of cover material.

Many operational problems occur as a direct result of failure to prepare an adequate disposal area in advance of winter. An area sufficient to hold more than the expected volume of waste should be prepared in advance of the onset of winter. In addition, stockpiles of cover material and areas for stockpiling snow should be provided and placed prior to the onset of winter.

On-Site equipment required to be used for continued landfill operations during rainfall events, will be provided with closed cabs.

Site roadways will be maintained in a passable condition during wet weather conditions. Secondary haul roads to the active landfill area within the waste footprint will be located so as to ensure continuous access to the active face during wet weather conditions. Should washouts of the Site roadways occur due to rainfall events, the roadways will be reconstructed using on-Site granular soils in a timely fashion.

12.3.5 RECEIPT, HANDLING, AND DISPOSAL OF ASBESTOS

Asbestos may be accepted at the Site for disposal. Disposal of asbestos containing waste will be carried out in compliance with the requirements of the Hazardous Waste Regulation under the Environmental Management Act (B.C. Reg. 63/88, O.C. 268/88).

12.3.6 CLEAN OR INERT FILL ACCEPTANCE

Specific contaminated soils may be accepted at the Site, provided these soils are Non-Hazardous. All contaminated soil relocation requests will be directed to the Solid Facilities Coordinator or the Solid Waste Facilities Assistant of the RDOS. The RDOS will accept the disposal of soils that are proven to be Non-Hazardous Waste and can be used as cover material or for construction (e.g. road base). Upon request to the RDOS, an applicant shall be issued a Soil Relocation Agreement (Appendix D). Only soils represented in the application shall be relocated. Prior to acceptance of any clean/inert fill, the landfill Operator will screen the supplier to determine and record the source, type, estimated quantity, and historical use associated with the material. In addition, the landfill Operator will conduct a visual and olfactory inspection of the material to determine if contaminants are potentially present. Should the inspection indicate that contamination is present, the supplier will be requested to complete chemical analysis of the material on a representative sample(s) prior to acceptance. The sample(s) will be analyzed at an accredited laboratory for select parameters, as determined from review of the source and historical use associated with the material.

12.4 STORM WATER CONTROL

Storm water control will be conducted through the construction of temporary berms around the base of excavations and the upper limit of the active area, to control and divert storm water runoff. Non-impacted storm water runoff will be directed away from the active disposal areas in order to minimize the volume of storm water infiltrating into the waste, and resulting leachate production. Any storm water coming into contact with the waste shall be contained and infiltrated within the waste footprint.

12.5 LITTER CONTROL

Preventative litter control measures are steps taken to minimize the blowing of litter from the active area of a landfill. The following measures will be used at the Site to control and minimize wind blown litter:

- All vehicular traffic transporting waste to and around the Site will be tarped, as required, to prevent litter from blowing out of the vehicle
- Daily cover will be used to cover all of the exposed waste to confine light weight material

- The working face location will be selected based on the direction and intensity of the wind to provide maximum shelter for the active area. The extent of the working face area will be kept to a minimum on windy days
- Should blowing litter become problematic, temporary, moveable, litter control fencing will be utilized at the active face of the Site, as required. Portable fencing at least 3 m high will be placed on a daily basis in close proximity downwind of the working face.
- The landfill contractor will collect litter at the Site and along the access road on an as-required basis.

12.6 NOISE CONTROL

Noise impacts from the Site may result from the operation of the landfill equipment. The operation of this equipment will comply with the noise emission standards as outlined in the Society of Automotive Engineers (S.A.E.) J88 – Latest Edition "Sound Measurement – Earth moving Machinery".

12.7 ODOUR CONTROL

In general, landfills have the potential to emit two types of odours: waste odour and landfill gas odour. Waste odour is generated by recently disposed waste and is controllable by the application of daily cover soil. LFG odour is generated during the anaerobic decomposition of organic waste material.

Should landfill gas odours become a problem at the Site, then an investigation into the problem will be conducted. The investigation will address such items as the location of odour problems around the Site, and potential Site-specific methods to control odours.

12.8 DUST CONTROL

Dust generation is common at most landfill sites due to the handling of soils, dry waste such as demolition waste, plaster and concrete and the movement of vehicles along on-Site gravel and dirt access roads.

Dust mitigation measures will be employed on an as-needed basis and may include the following:

- Reduce allowable vehicular speeds
- Use of water to control dust
- Pave roads
- Seeding programs
- Proper placement of stockpiles to minimize wind blown dispersion

Soil stockpiles that will not be used for more than one year will be seeded.

12.9 VECTOR AND VERMIN CONTROL

The terms vector and vermin refer to objectionable insect, rodents, birds and bears that sometimes establish habitat at a landfill. Common landfill vector and vermin are flies, rats, and gulls. The impact of these species is examined from a health perspective and from a social or psychological perspective.

Vectors and vermin are controlled by the application of cover material at a specified frequency or by other control measures as required and approved by the RDOS. Should vector and vermin become problematic, the following control measures can be taken:

- An electric bear fence should be used at the Site to discourage bears from entering the Site
- Should an outbreak of flies occur at the Site, an insect exterminator will be contracted to control the population on an as required basis
- Should rodents become established at the Site, extermination will be conducted by a licensed exterminator on an as required basis
- Should the presence of gulls become problematic at the Site, measures would be undertaken to control and discourage them. The more frequent application of cover soil will assist in mitigating the presence of gulls.

13.0 MONITORING, INSPECTION AND REPORTING

13.1 ENVIRONMENTAL MONITORING PROGRAM

An Environmental Monitoring Program (EMP) should be designed to assess and identify the potential impact of contaminants of concern (COCs) associated with landfilling activities on adjacent properties and water supplies in order to maintain regulatory compliance and mitigate potential environmental risk. As stipulated in Section 4 of the Landfill Criteria for Municipal Solid Waste, landfills must operate in a manner such that ground or surface water quality at or beyond the landfill property boundary does not degrade below that allowable by the BC MOE Approved and Working Criteria for Water Quality. In addition, landfills must not operate in a manner such that gas emissions create public odour nuisance or exceed federal, provincial or local air quality criteria.

The following sections outline the proposed Site EMP with respect to groundwater, leachate, surface water and soil gas monitoring. The requirements of the EMP are outlined in the following documentation issued by the BC MOE:

- Draft Operational Certificate No. PR-15280
- Landfill Criteria for Municipal Solid Waste
- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills

On the basis of findings during routine inspections and any other information related to the effect of discharge on the receiving environment, reductions or additional sampling and monitoring may be required.

13.1.1 GROUNDWATER MONITORING

The objective of the groundwater monitoring program is to detect the extent and magnitude of potential contamination to groundwater associated with landfilling activities, ensure regulatory compliance, and mitigate potential environmental risk. Groundwater monitoring wells are intended to permit water level measurements and to collect groundwater samples.

The current monitoring network is comprised of four (4) existing groundwater monitoring locations. Advancement of three (3) boreholes is proposed as shown on Figure 13.1. A summary of the proposed groundwater monitoring program and purpose of each monitoring location is provided in Table 13.1. The proposed groundwater monitoring locations address both the existing and proposed Site development conditions, such that the groundwater monitoring program can be conducted during the operational and post-closure periods. Challenges associated with the groundwater monitoring program at the Site include the following:

- At least three (3) groundwater monitoring wells are in a triangular array to define horizontal hydraulic gradient and direction of groundwater flow in the sand unit, however, dry conditions at MW08-1 limit interpretation. An additional well may be required in the future to facilitate groundwater flow interpretation but will be dependant on the results of the additional boreholes proposed.
- An upgradient well has not been established at the Site due to upgradient conditions (i.e., steep slope, potentially no water in overburden, etc.). Local water quality representative of background conditions will need to be established and reference for water quality assessment purposes.

Monitoring well construction and design should comply with the specifications as detailed in applicable regulatory guidelines. Well development and hydraulic response testing should also be conducted at the time of installation, if feasible. All wells should be equipped with tamper proof protective casings and caps.

The groundwater monitoring program should include hydraulic measurements, field parameters and analytical water quality monitoring. Groundwater samples shall be collected and analyzed for parameters listed in Table 13.2 on a quarterly basis to establish baseline conditions. Proposed parameters can be used to assess leachate impacts and are sufficient to provide a measure of quality assurance/quality control (QA/QC) (i.e., ion balance). An expanded list may be warranted if leachate impacts are noted to further define potential environmental impacts (i.e., heavy metals, volatile organic compounds, etc.).

Results of the groundwater monitoring program can be used to verify that adequate attenuation is occurring on Site and that water quality at the property boundary is in compliance with applicable regulatory criteria. In addition, the groundwater monitoring program is used to determine the need for and success of any remedial and contingency measures implemented.

13.1.2 SURFACE WATER MONITORING

Surface water at the Site is limited to runoff from stormwater events and will be managed as per the storm water management plan. The storm water management plan has been designed to infiltrate storm water runoff within Site boundaries, consequently a surface water monitoring program is not proposed.

13.1.3 LEACHATE MONITORING

The Site is located in an area with deep, freely draining soils with adequate on-Site natural attenuation. Evaluation of the leachate generation potential for the Site combined with the natural attenuation capacity identified that no leachate collection system is required for the Site. The feasibility of collecting on-Site samples for leachate characterization purposes will be determined based on proposed borehole advancement within the existing refuse limits and quarterly hydraulic monitoring at MW08-1 located directly downgradient of the existing refuse limits.

13.1.4 GAS MONITORING

Other than the on-Site raised building structures, and the nearby residence no other receptor to LFG migration exists in the vicinity of the Site. As previously discussed, on-Site building structures, such as the attendant shed, are raised temporary facilities and do not present a direct conduit for migration into an enclosed space unless snow accumulation prevents air circulation beneath the structures. Should snow accumulate to this point, the Site operator must take immediate measures to remove the snow from around the structures to prevent potential LFG migration into the buildings.

It is proposed that existing gas probe MW98-3 be decommissioned based on a review of construction details to improve sample collection efficiency and data quality. A total of three (3) gas probes are proposed along the southern property line as shown on Figure 13.1 to assess landfill gas migration. Gas probes should be equipped with a sampling port to facilitate monitoring of pressure, gas quality (methane, carbon dioxide, nitrogen) and water levels. Quarterly monitoring is proposed during the first two (2) years to establish baseline conditions. The frequency of future events can be determined based on a review of the quarterly data.

The potential for accumulation of landfill gas in confined spaces should be evaluated during the design of any future on-Site structures as well as any dwelling or structure in adjoining off-Site locations. A LFG Management Plan should be developed to incorporate LFG migration monitoring probes and building atmosphere monitoring if on-Site structures with foundations are constructed or in the event of future development in the area.

13.2 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) is an integral part of EMP design. QA/QC is necessary to provide confidence in data obtained. Laboratories generally have their own QA/QC programs. QA/QC measures can also be implemented in the field. Field duplicates and field blanks are commonly used to verify the reliability and accuracy of field handling/sampling and laboratory analysis. Appropriate sample handling, preservation, storage, and shipping methods need to be used. In addition, sample shipping must be coordinated such that sample analysis is conducted before specified holding times are exceeded. Field equipment calibration and maintenance should also be addressed.

13.3 INSPECTION AND RECORD KEEPING

Regular Site inspections will be conducted to verify that nuisance factors associated with housekeeping procedures such as dust, litter, and odour, are under control, thereby preventing routine operation nuisances from developing into more serious environmental problems. These inspections will be conducted on a weekly basis by the landfill operator. The landfill staff will maintain a checklist of housekeeping items that need to be implemented on a regular basis. Records of observations made during the Site inspections and all regular housekeeping activities carried out will also be maintained.

Operation complaints received by landfill personnel are directed, in writing, to the RDOS Regional Office to the attention of the Public Works Manager. The landfill personnel will undertake corrective action(s) as soon as possible after identification of need.

13.4 WASTE/SOIL VOLUME MONITORING

It is recommended that a survey of the active landfill area be completed every two years until closure of the Site. The survey data will be used to calculate the volume of landfill consumed, volume of cover soils used, and an estimate of the waste density obtained. This data will be used to update the soil balance along with the predictions of the Site capacity and Site life remaining.

13.5 ANNUAL OPERATIONS AND MONITORING REPORT

An Annual Operations and Monitoring (O&M) Report is to be prepared on an annual basis for submission to the Regional Manager, Environmental Protection on or before March 31 of the following year. The annual O&M report is to include the following information:

- Total estimated tonnage of waste placed into the landfill during the reporting period, as well as the calculated per capita waste generation rate
- Calculations of volume of waste, daily and final cover soil deposited or placed at the Site during the reporting period, and calculation of total volume of Site capacity used during the reporting period
- Statement of design volume and calculation of remaining Site life and capacity
- Operational plan for next 12 months
- Operational and maintenance expenditures
- Groundwater and surface water quality data and interpretation
- Assessment of the operation and performance of all engineered facilities, the need to amend the design and operation of the Site, areas of landfilling operations during the reporting period, areas of excavations during the reporting period, the progress of final and intermediate cover application, facilities installed during the report period, and Site preparations and facilities planned for installation during the next reporting period
- Provide a summary of public complaints received by the landfill operator and the responses made
- Discuss any operational problems encountered at the Site and corrective actions taken
- Discuss proposed design, operations or monitoring program changes from approved reports and plans

In addition, the following information should be included in the annual O&M report:

- Existing Site conditions
- Storm water management ditching
- Site fencing and signs
- Access road, access control gate and internal Site roads
- On-Site buildings

14.0 SPECIFIED RISK MATERIAL

There is a potential opportunity to dispose of SRM generated from within the RDOS at the Site. SRM is defined as those parts of a bovine carcass that are most likely to contain the bovine spongiform encephalopathy (BSE) (commonly known as Mad-Cow Disease) infective agent if the animal were infected with BSE. SRM must be removed from all cattle slaughtered for human consumption and are now banned from all animal feeds, pet foods, and fertilizers. Landfill sites are currently considered a permanent method of disposal for SRM but require specific authorization. Section 7.1 of the Landfill Criteria list dead animals and slaughter waste as prohibited waste unless approved by the manager (Regional Manager, Environmental Protection). A permit from the CFIA must also be obtained prior to landfilling SRM.

14.1 SRM DISPOSAL CAPACITY

CFIA has limited approved Sites to receive a maximum of 4,000 tonnes/year of slaughter waste/deadstock of which a maximum of 2,000 tonnes/year can originate from over-thirty-month-old cattle. Proposed technical requirements for the province of BC outlined in the PPSWR are based on the proportion of slaughter waste disposal volumes to total MSW and the annual rainfall at the Site. Current standards permit natural control landfills with low precipitation (0 to 400 mm/yr) to accept up to 2 percent of slaughter waste as a percentage of the volume of incoming MSW stream. The aforementioned waste disposal rate is considered to have a low leachate strength impact potential based on the climatic setting of the Site. A waste disposal rate of 2 to 5 percent is recommended for natural control landfills with enhanced technical requirements and has a moderate leachate strength impact potential but was not considered at this time until additional work is conducted to ensure that the disposal of dead animal/slaughter waste has minimal to no impact on the environment.

14.2 SRM TECHNICAL REQUIREMENTS

The following general and specific natural control landfill requirements were recommended in the PPSWR.

Site Characteristics:

- Proven record of acceptable surface water, groundwater and air quality that is in compliance with applicable legislation and no formal complaints lodged with regard to these characteristics
- No current leachate breakout issues
- Existing landfills must be in compliance with the requirements of the Landfill Criteria for a natural control landfill and have a current Operational Certificate.

There are currently no identified issues associated with the aforementioned Site characteristics. The Site has a proven record of acceptable surface water and air quality. Based on the Site setting and leachate generation potential, the risk is associated with groundwater contamination is assumed to be low, although on-Site groundwater quality data is not available to confirm this.

Buffer Distances:

- Minimum 50 m between landfill toe and property boundary
- Minimum 300 m between landfill and other facilities
- Minimum 100 m between landfill and nearest surface water
- Minimum 100 m between landfill and unstable area, ravine, steep bank or cliff
- Lot located within the 200 year floodplain
- Meets any other buffer distances required in the Landfill Criteria
- Minimum 4 m between the seasonal high water table and the bottommost waste cell

The Site meets all buffer distance requirements with the exception of the 300 m buffer between the Site and other facilities. A residence is located approximately 100 m southwest of the Site perimeter while a feedlot operation located adjacent to the southwest corner of the Site perimeter. An exemption to this buffer distance is acceptable given the physical setting, the attenuation capacity, and lack of leachate generation potential of the Site. In addition, monitoring systems exist along the western property boundary between the landfill and adjacent facilities, thus can be monitored to identify environmental concerns. Existing fencing adequately separates the Site from adjacent properties. Landfill development (i.e., waste footprint) within the eastern half of the Site has been maximized to provide the greatest buffer from the adjacent facilities.

No groundwater has been found directly downgradient of the limit of refuse at 23 m below ground surface, suggesting a sufficient buffer distance with respect to the vadose zone exists based on available information.

Environmental Systems Guidelines:

- Surface water diversion systems to divert clean run-on and run-off away from the landfill
- Bear fencing to prevent access to landfill from large predators
- Security fencing to prevent unauthorized access to the landfill
- Minimum 0.15 m topsoil layer on top of barrier layer required, as per the Landfill Criteria
- Closure system to be implemented in a phased approach once area has reached final contours as per the Landfill Criteria
- Minimum 2 m thick layer of low permeability soil with hydraulic conductivity of $1x\ 10^{-6}$ cm/s (silt or clay) below each waste cell
- Landfill gas venting or recovery system must be installed at the Site upon closure of each phase. The quantity of slaughter and poultry waste disposed at these types of landfills is likely to generate significant amounts of landfill gas. The Landfill Criteria calculations for landfill gas generation will most likely be an underestimate for these sites as the organic content of the waste disposed will be increased. A qualified professional should assess whether a passive or active gas system is required based on the quantities of waste disposed. If an active system is used it will reduce odour issues and also reduce greenhouse gas emissions from the Site.

The Site meets all environmental system guidelines with the exception of the minimum 2 m thick layer of low permeability soil with a hydraulic conductivity less than $1x10^{-6}$ cm/s (silt or clay) below each waste cell, as recommended by the PPSWR technical requirements. At the Site, each waste cell will be underlain by fine grained sand with a conservative hydraulic conductivity estimate of $1x10^{-3}$ cm/s, which does not meet existing standards. As detailed in the Hydrogeological Assessment, a low permeability layer below the expanded waste footprint is not deemed necessary for the Site given the low leachate generation potential, the vadose zone thickness of at least

23 m, and the fine grained overburden materials. A low permeability liner for SRM disposal in the proposed expanded waste footprint is not necessary since the geologic/hydrogeologic conditions result in less percolation than a two metre low permeability liner based on modeling results (CRA correspondence to Mr. Mark Raymond, Re: Response to Specified Risk Material Disposal Comments dated July 13, 2009). SRM disposal in the existing refuse limits will, however, require a two (2) metre low permeability layer since a significant vadose zone underlying the existing refuse limits does not appear to be present.

14.3 SRM FILLING PROCEDURE

Due to the nature of the soils readily available, the climatic conditions in the area, and final cover modeling results for the Oliver landfill, slaughter waste will be covered with a 1.0 m thick layer of silty sand instead of the 0.5 m thick layer of low permeability silt or clay cover material as detailed above.

14.4 SRM REPORTING AND ENVIRONMENTAL MONITORING GUIDELINES

Reporting and environmental monitoring guidelines are identified for the disposal of SRM material in the PPSWR and should be considered in developing an SRM disposal program.

15.0 SITE CLOSURE

The following sections outline Site-specific closure activities and post-development care requirements for the Site.

15.1 END USE

The Site will continue to be used as a waste management facility after the closure of the landfill although not as a waste disposal Site. Waste management activities at the Site may include a transfer station, organics management facility, septage management facility or other waste management facilities.

15.2 FINAL COVER

The final cover will be constructed as per the specifications outlined in Section 5.3. After the construction of the final cover, the cover will be inspected to ensure that construction has been completed according to the specifications outlined in this report. Once the seeded vegetation is established, the natural re-vegetation process will be allowed to occur. Section 15.7 identifies the final cover inspection and maintenance procedures.

15.3 SITE FACILITIES

The entrance and access roads to the areas requiring final cover will be kept in adequate condition under all weather conditions to allow equipment ready access to the landfill area.

During post development operations the Site will remain closed for waste disposal. A sign will be posted at the entrance stating the closed status of the Site for landfilling and where waste not accepted at the public transfer station can be disposed.

15.4 MAINTENANCE AND MONITORING

The environmental monitoring programs (Section 13.0) for the Site will be maintained during and after Site closure and will be evaluated and adjusted as needed.

15.5 CLOSURE SCHEDULE AND NOTIFICATION

The Site life will be determined, based upon the final contours presented on Drawing C-03 and the rate of filling of the Site. The Site life will be updated in the annual operations and monitoring report based on the final contours and the average fill rate for each year. Based upon forecasted fill rates the landfill will reach capacity in approximately 40 years.

Six months prior to landfill closure notification of the changes in the materials accepted at the site from the public and commercial haulers will be posted to the TNRD website as well as on signage at the Site entrance. Alternative disposal locations for materials no longer accepted at the Site will be provided with driving directions. In addition, scalehouse, transfer station and landfill attendants will inform the public and commercial haulers of the pending landfill closure in day to day interactions.

15.6 STORM WATER CONTROL

Storm water control at the Site will be managed by an engineered perimeter infiltration ditch as detailed in Section 8.3. During final cover construction, surface runoff will be controlled to minimize sediment transport into the perimeter ditches. To accomplish this, silt fencing will be used along the construction face of the landfill, where required, to control sediment transport.

15.7 POST DEVELOPMENT MAINTENANCE AND MONITORING

The post-development maintenance of the Site will consist of the monitoring programs previously mentioned in Section 13, as well as ongoing maintenance and inspection of the final cover.

Until the vegetative cover has established, quarterly visual inspections of the cover will be performed. Once satisfactory vegetative cover has established, visual inspections shall be undertaken semi-annually. Visual inspections determine if erosion channels have developed in the cover and if waste has been exposed. If erosion occurs and exposed waste is noted, affected areas will be repaired.

The long-term maintenance of the surface water management works will consist primarily of annual inspections for erosion damage and sediment build build-up in the perimeter ditch network. Erosion repairs and sediment removal will be completed as required.

The monitoring program will be continued during the post-development period and will be maintained until monitoring results indicate that parameter concentrations have adequately decreased to amend or discontinue the program as determined in consultation with the BC MOE.

16.0 DETAILED COST ANALYSIS

A detailed cost analysis for the Site has been prepared as part of the O&C Plan. The cost analysis presents all costs related to implementation of this O&C Plan for each development Stage as well as for the post-closure operation, maintenance, and monitoring period. The detailed cost analysis is presented in Appendix E.

All of Which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

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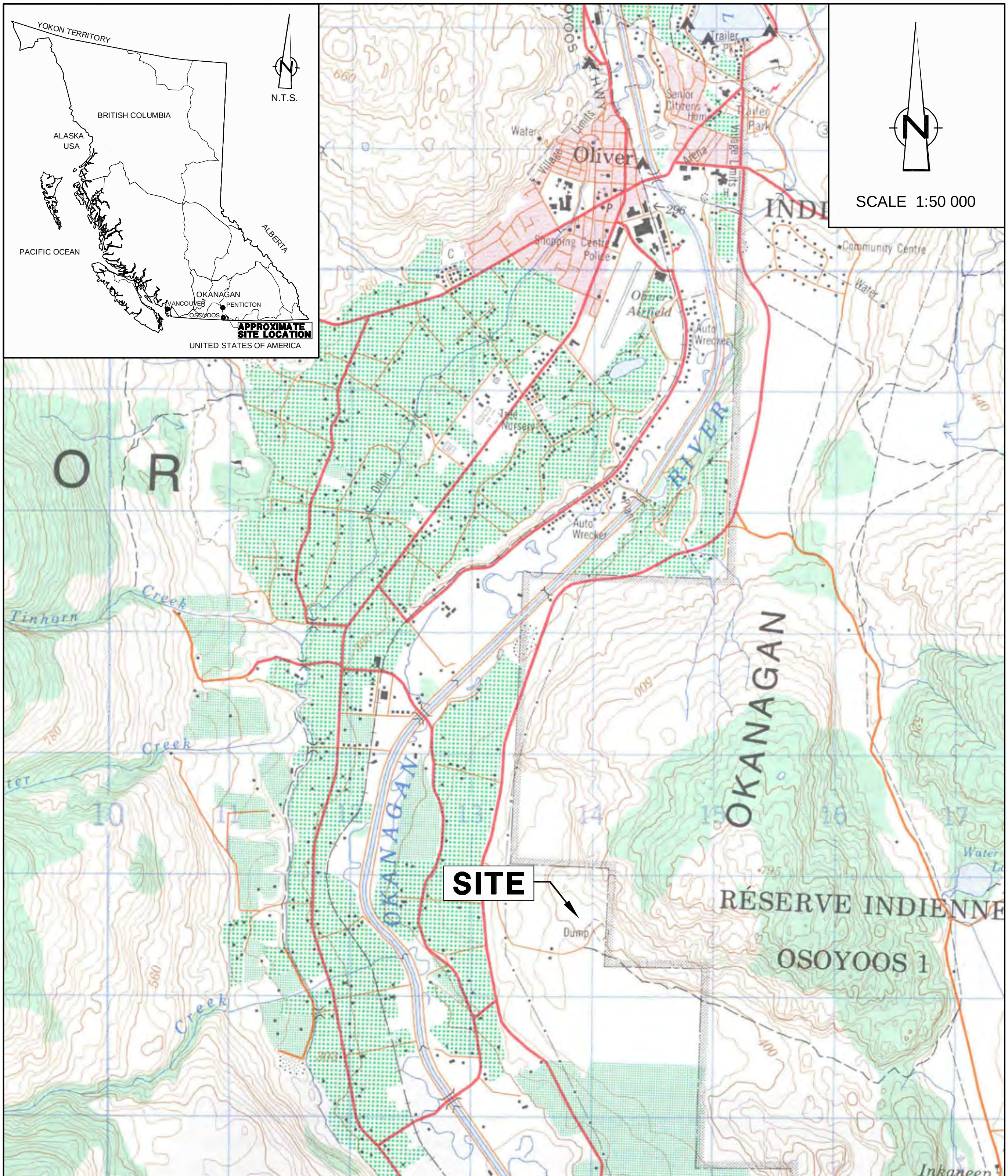
FIGURES

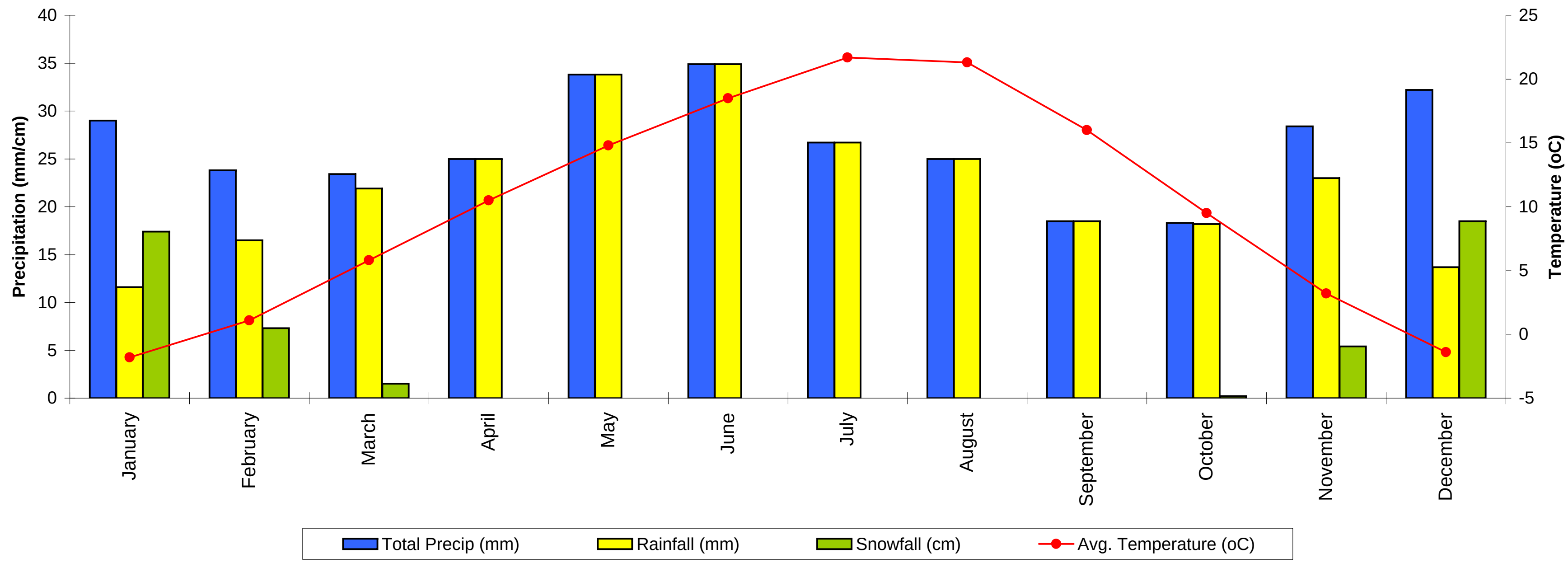


SOURCE: ENERGY, MINES AND RESOURCES CANADA
KEREMEOS 82 E/4 EDITION 4

figure 1.1

SITE LOCATION MAP
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL
Regional District of Okanagan-Similkameen

49846-10(004)GN-VA001 NOV 13/2008



Month	Daily Average Temperature (Celcius) (1)	Daily Maximum Temperature (Celcius) (1)	Daily Minimum Temperature (Celcius) (1)	Rainfall (mm) (2)	Snowfall (cm) (2)(3)	Precipation (mm) (2)	Humidity (%) (3)
January	-1.8	1	-4.7	11.6	17.4	29	72.2
February	1.1	5	-2.8	16.5	7.3	23.8	69.7
March	5.8	11.5	0.1	21.9	1.5	23.4	61.9
April	10.5	17.2	3.7	25	0	25	56.3
May	14.8	21.6	7.9	33.8	0	33.8	55.2
June	18.5	25.4	11.5	34.9	0	34.9	52.4
July	21.7	29.3	14	26.7	0	26.7	49.8
August	21.3	28.9	13.7	25	0	25	52.4
September	16	23.4	8.6	18.5	0	18.5	58.8
October	9.5	15.5	3.4	18.2	0.2	18.3	62.6
November	3.2	6.7	-0.3	23	5.4	28.4	70.0
December	-1.4	1.3	-4.1	13.7	18.5	32.2	72.0
Annual				**269**	**50**	**319**	

Notes:
(1) Source: Environment Canada: Climate Normals - Oliver STP (Station No. - 1125766), 1971 - 2000
(2) 1 cm of snowfall corresponds to 1 mm of precipitation
(3) Source: Environment Canada: Climate Normals - Penticton A (Station No. - 1126150), 1971 - 2000

CRA

figure 2.1
CLIMATE DATA
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL
Regional District of Okanagan-Similkameen

SOURCE: BC WATER RESOURCE ATLAS

figure 4.1

BUFFER ZONES
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL, OLIVER, BC
Regional District of Okanagan-Similkameen

CRA

49846-10(004)GN-VA004 JUN 23/2010

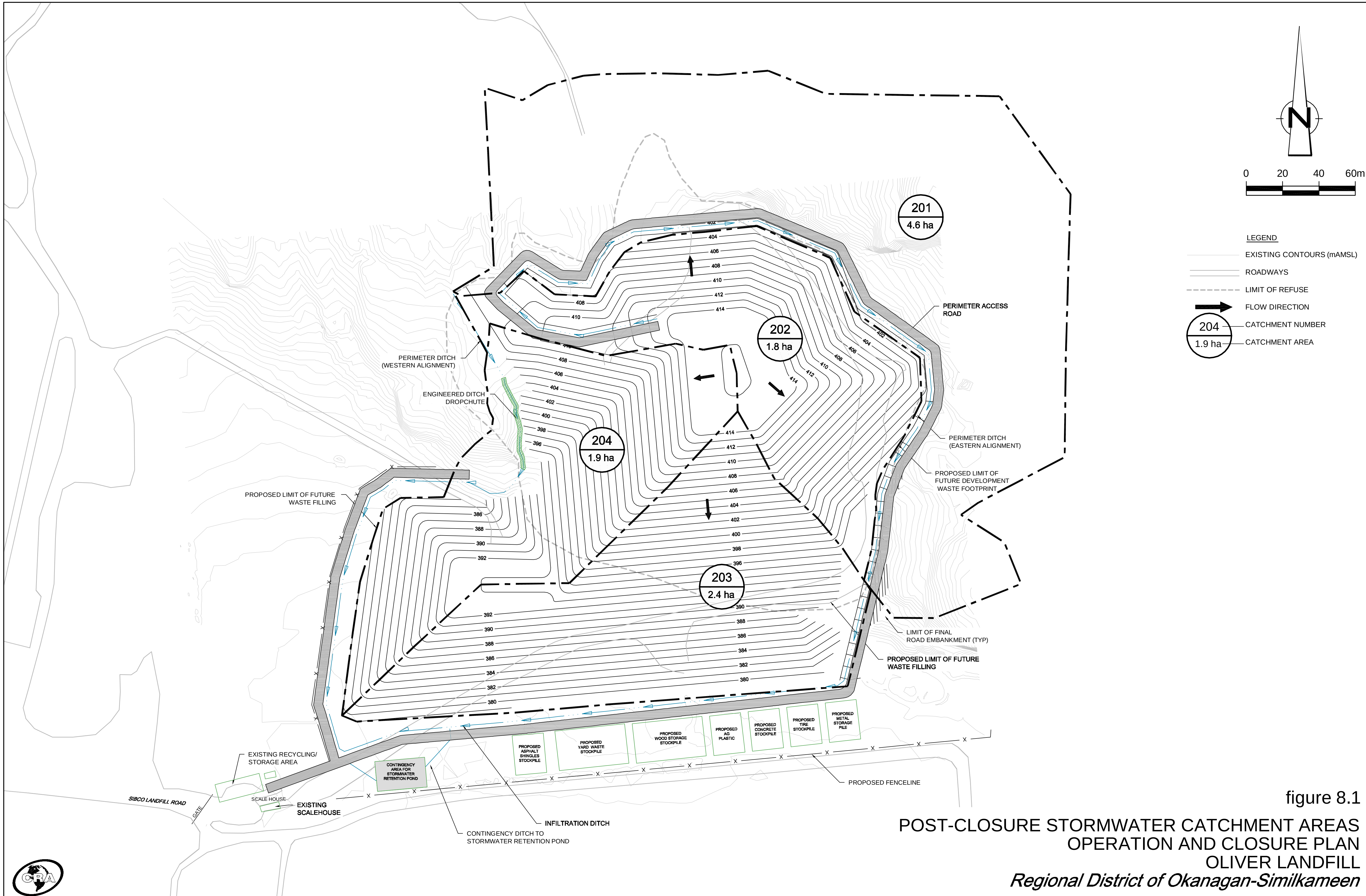
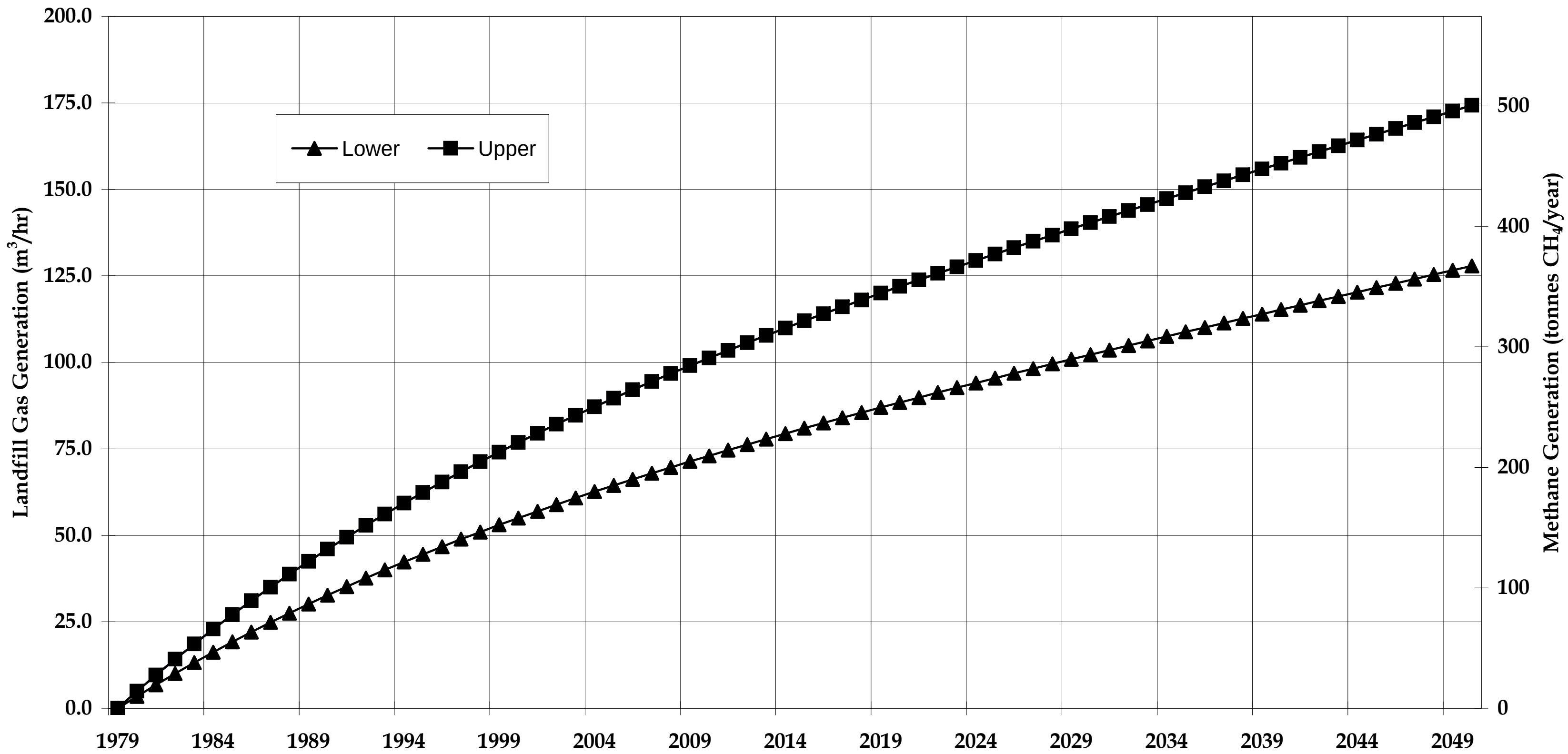


figure 8.1

POST-CLOSURE STORMWATER CATCHMENT AREAS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL
Regional District of Okanagan-Similkameen

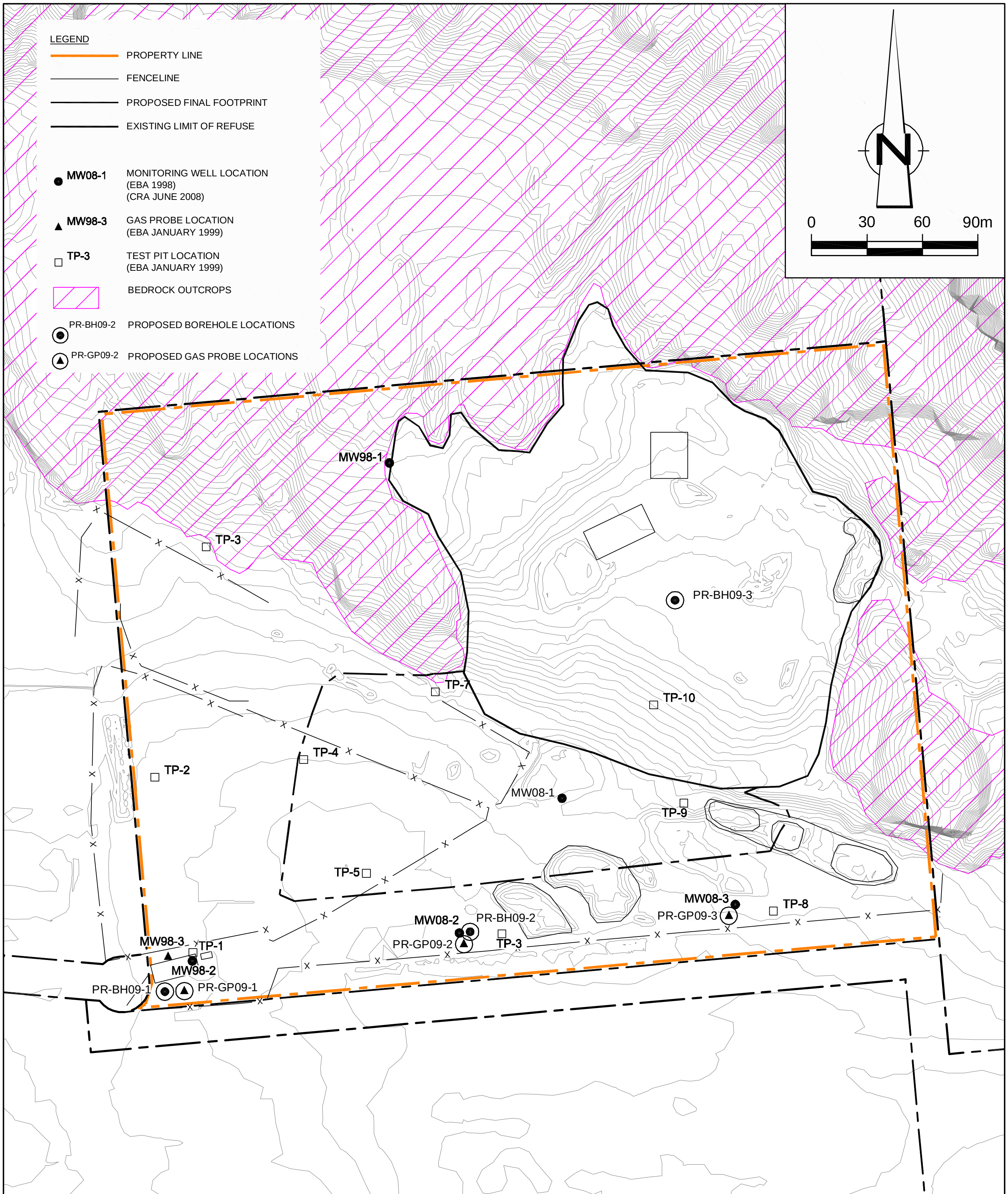
49846-10(004)GN-VA002 JUL 14/2009



			Upper Waste Composition	Lower Waste Composition
k values ($year^{-1}$)	0.01, 0.02, 0.05	Relatively Inert (%)	8.7%	33.5%
L_o (weighted) (m^3 CH4/tonne)	127	Moderately Decomposable (%)	51.0%	40.0%
Precipitation (mm/year)	319	Decomposable (%)	40.3%	26.5%
Volumetric LFG Composition (percent methane)	50%			
MOE Threshold	1,000 tonnes CH_4/yr			

figure 10.1

LANDFILL GAS PRODUCTION ESTIMATE
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL
Regional District of Okanagan Similkameen



SOURCE: 2007 ORTHO PHOTO AND CONTOUR INFORMATION

figure 13.1

PROPOSED ENVIRONMENTAL MONITORING PROGRAM
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL
Regional District of Okanagan-Similkameen

49846-10(004)GN-VA003 JUL 23/2009

TABLES

TABLE 2.1

DEVELOPMENT MODEL CLIMATE DATA
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Month	Daily Average Temperature (Celsius) (1)	Standard Deviation (1)	Daily Maximum Temperature (Celsius) (1)	Daily Minimum Temperature (Celsius) (1)	Average Rainfall (mm) (1)	Average Snowfall (cm) (1)	Average Total Precipitation (mm) (1)	Average Precipitation Days (No) (1)	Average Evapotranspiration (mm) (2)	Average Wind Speed (km/h) (2)	Average Relative Humidity (%) (2)
January	-2.6	2.9	0.4	-5.6	10.5	15.4	26	8.9	-	14.1	72.15
February	0.7	2.6	4.6	-3.3	17.2	7.6	24.8	8.1	-	12.9	69.65
March	5.5	1.6	11.4	-0.4	20.8	1.4	22.2	7.7	-	11.3	61.9
April	10.1	1.4	17.3	3	24.5	0	24.5	8.3	3.2	10.1	56.25
May	14.5	1.4	21.8	7.2	37.2	0	37.2	9.3	4.2	9.4	55.15
June	18.2	1.3	25.5	10.9	37.2	0	37.2	8.6	5.2	8.9	52.35
July	21.1	1.6	29.2	13	30.4	0	30.4	6.9	5.3	9.2	49.8
August	20.5	1.4	28.5	12.5	27.2	0	27.2	6.7	4.5	8.6	52.4
September	15.3	1.7	23.1	7.4	19.3	0	19.3	5.9	3.1	8.6	58.75
October	8.8	1.1	15.2	2.4	17.1	0.2	17.3	6.5	1.7	10.9	62.6
November	2.7	2.3	6.2	-0.9	23.5	4.6	28	9.3	-	14.7	69.95
December	-1.7	2.7	1.1	-4.5	15.8	17.7	33.5	9.9	-	15.7	71.95
Annual	9.4	1.7	15.4	3.5	280.7	46.9	327.5	96.2	-	11.2	61.05

Source Notes:
(1) Environment Canada, Climate Normals 1971 - 2000, Oliver Climate Station, # 1125760
(2) Environment Canada, Climate Normals 1971 - 2000, Penticton A Climate Station, #1126150

TABLE 3.1

PROJECTED WASTE DISPOSAL RATES
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BRITISH COLUMBIA

Year	Projected Population (1)	Projected MSW (tonnes/year) (2)	Projected Cumulative MSW Landfilled (m^3) (3)	Cumulative Airspace Used (m^3) (4)
2006	8,269	6,042	-	-
2007	8,327	6,084	-	-
2008	8,385	6,127	-	-
2009	8,444	6,170	-	-
2010	8,503	6,213	10,355	11,834
2011	8,562	6,256	20,782	23,751
2012	8,622	6,300	31,283	35,752
2013	8,683	6,344	41,857	47,836
2014	8,744	6,389	52,505	60,005
2015	8,805	6,433	63,227	72,260
2016	8,866	6,479	74,025	84,600
2017	8,928	6,524	84,898	97,026
2018	8,991	6,570	95,847	109,539
2019	9,054	6,616	106,873	122,140
2020	9,117	6,662	117,976	134,830
2021	9,181	6,708	129,157	147,608
2022	9,245	6,755	140,416	160,475
2023	9,310	6,803	151,753	173,433
2024	9,375	6,850	163,171	186,481
2025	9,441	6,898	174,668	199,620
2026	9,507	6,947	186,245	212,852
2027	9,574	6,995	197,904	226,176
2028	9,641	7,044	209,644	239,594
2029	9,708	7,093	221,467	253,105
2030	9,776	7,143	233,372	266,711
2031	9,844	7,193	245,361	280,412
2032	9,913	7,243	257,433	294,209
2033	9,983	7,294	269,590	308,103
2034	10,053	7,345	281,832	322,094
2035	10,123	7,397	294,160	336,183
2036	10,194	7,448	306,574	350,370
2037	10,265	7,501	319,075	364,657
2038	10,337	7,553	331,663	379,044
2039	10,409	7,606	344,340	393,531
2040	10,482	7,659	357,105	408,120
2041	10,556	7,713	369,960	422,811
2042	10,630	7,767	382,904	437,605
2043	10,704	7,821	395,940	452,503
2044	10,779	7,876	409,066	467,504
2045	10,854	7,931	422,285	482,611
2046	10,930	7,987	435,596	497,823
2047	11,007	8,042	449,000	513,142
2048	11,084	8,099	462,498	528,569
2049	11,161	8,155	476,090	544,103
2050	11,240	8,213	489,778	559,746

NOTES:

(1) Population is projected at 0.7 percent growth based on 2006 Stats Canada data for the Town of Oliver and Electoral Area C

(2) The 2006 MSW Landfilled volume is an actual measured value of 6000 tonnes.

(3) MSW data is projected based on 0.6 tonnes of refuse per year per head of population

(4) Assumes waste to cover ratio of 1:6

TABLE 5.1

EPIC (1) INPUT PARAMETERS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

EPIC INPUT PARAMETERS

Closed Landfill Cover

(a) Capillary-Barrier Evapotranspiration Final Cover (1.0 m soil blend underlain by 0.5 m sand)
(b) Ministry Standard Low Permeability Final Cover System (1.0 m compacted clay cover)

Site Parameters

Latitude	49° 07' 36.14"
Longitude	119° 32' 59.63"
Elevation	392 m
Drainage Area	9.6 ha
Maximum Drainage length	135 m
Field length	0.4 km - 25% slope
Field Width	0.4 km - 25% slope
Conservation Practice	None
Tillage Practice	No Tillage

Operating Parameters

Runoff CN analysis method	Stochastic
Peak Rate Estimate	Modified Rational Method EQ
ET calculation method	Hargraves
Irrigation	Dryland
CN	non-variable curve number
Runoff Estimation Methodology	CN estimate of Q
Field moisture and Wilting Point Methodology	input static
Rainfall distribution factor	1.3 (default)

Planting (hydro seeding schedule)

Land use Type	Annual Rye Grass with 'good' hydrologic condition
Vegetation Cover	Annual Rye Grass
Seeding Rate	90kg/ha

Soil Parameters

	Topsoil layer	*Low permeability soil layer*	*Sand evapotrapsiration layer*	*Waste*
Bulk Density (t/m^3)	1.3	1.05	1.55	1.00
Wilting Point (m/m)	0.09	0.17	0.04	0.08
Field Capacity (m/m)	0.19	0.29	0.08	0.29
Sand Content (%)	45	15	91	45
Silt Content (%)	35	15	7	30
pH	7.2	7.2	7.2	7.2
Organic matter (%)	0.6	0.5	0.6	0.5
Cation Exchange Capacity (cmol/kg)	7	32.5	4	4
Saturated Conductivity (mm/hr)	360	0.36	360	360

Weather Station Parameters

I.D.	Oliver Climate Station
Latitude	49° 10' 12"
Longitude	119° 33' 35"
Elevation	316
Ave Max Air Temperature	As per report Table 2.4
Ave Min Air Temperature	As per report Table 2.4
Precipitation Average	As per report Table 2.4
Rain Days Average	As per report Table 2.4
Relative Humidity	As per report Table 2.4
Average Wind Velocity	As per report Table 2.4

NOTES:
(1) EPIC - Environmental Policy Integrated Climate Model

TABLE 5.2

FINAL COVER MODEL ANALYSIS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER BC

Description	DAILY 0.15 m of sand	INTERMEDIATE 0.3 m of sand		MINISTRY STANDARD 0.15 m of top soil 1.0 m of compacted clay cover		EVAPOTRANSPIRATION 1.0 m of soil blend 0.5 m of sand	
Slope Detail	**Slope 1:20**	**Slope 1:4**	**Slope 1:20**	**Slope 1:4**	**Slope 1:20**	**Slope 1:4**	**Slope 1:20**
HELP Model Analysis							
Runoff (mm)	40	22	22	3	3	3	3
Evapotranspiration (mm)	232	269	269	319	319	271	271
Perculation (mm)	52	32	32	1	1	49	49
Total (mm)	323	323	323	323	323	323	323
EPIC Model Analysis							
Runoff (mm)					2.2		2.2
Evapotranspiration (mm)					323		322
Perculation below the root zone (mm)					0		0
Lateral Subsurface flow (mm)					8		7.9
Total (mm)					332		332

TABLE 6.1

SOIL REQUIREMENTS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Stage	Excavated Soil Volume (m^3) (1)	Daily Cover Soil Volume (2) (m^3)	Final Cover Soil Volume (m^3)	Soil Required (3) (m^3)
Stage 1	19,400	19,400	-	0
Stage 2	26,500	12,100	14,400	0
Stage 3	89,340	33,200	11,500	-44,640
Stage 4	0	13,300	18,800	32,100
Closure			22,800	22,800
Total	**135,200**	**78,000**	**67,500**	**10,300**

Notes:
(1) Volume of soil recovered from base excavation. Assume reusable soil recovery of approximately 100 percent by volume.
(2) Daily cover volume calculation based upon a 6:1 refuse to cover ratio.
(3) Borrow soil will be sourced from existing Soil Borrow Area.

TABLE 6.2

AIRSPACE CONSUMPTION SUMMARY
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Stage	Total Airspace (m^3)	Refuse Volume (1) (m^3)	Cover Volume (2) (m^3)	Stage to be complete (year) (3)	Closed Area (m^2)	Final Cover Soil (m^3)	Final Cover Topsoil m3	Total Cover Soil Volume (m^3)
Stage 1	135,649	116,300	19,400	2021	-	-		19,400
Stage 2	84,919	72,800	12,100	2027	14,400	14,400	2,160	26,500
Stage 3	232,114	199,000	33,200	2044	11,500	11,500	1,725	44,700
Stage 4	93,256	79,900	13,300	2049	18,800	18,800	2,820	32,100
Closure	-	-	-	-	22,800	22,800	3,420	22,800
Total	**545,938**	**468,000**	**78,000**	**40**	**67,500**	**67,500**	**10,100**	**145,500**

Notes:
(1) Net available area for refuse disposal.
(2) Daily cover volume calculation based upon a 6:1 ratio.
(3) Estimated start year is 2010

TABLE 8.1

HEC-HMS BASIN MODEL INPUT PARAMETERS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

BASIN MODELS

Basin Loss Method	SCS Curve Number
Basin Transform Method	Kinematic Wave
Baseflow Method	None
Reach Transform Method	Kinematic Wave

BASIN MODEL - EXISTING CONDITIONS

Catchment	Area	Area	Curve Number	Plane 1			Plane 2			Channel				
				Length	*Slope*	*Roughness*	*Length*	*Slope*	*Roughness*	*Length*	*Slope*	*Shape*	*Mannings Number*	*Channel Side Slope*
	(ha)	*(km^2)*		*(m)*	*(m/m)*	*(constant)*	*(m)*	*(m/m)*	*(constant)*	*(m)*	*(m/m)*			
101	7.8	0.078	40	200	0.05	0.4	120	0.30	0.4	200	0.12	*Triangle*	*0.035*	*3H:1V*
102	0.6	0.006	50	100	0.12	0.4	-	-	-	60	0.05	*Triangle*	*0.035*	*3H:1V*
103	1.2	0.012	50	150	0.20	0.4	-	-	-	110	0.05	*Triangle*	*0.035*	*3H:1V*
Total	9.6	0.096												

BASIN MODEL - POST CLOSURE CONDITIONS

Catchment	Area	Area	Curve Number	Plane			Plane			Channel				
				Length	*Slope*	*Roughness*	*Length*	*Slope*	*Roughness*	*Length*	*Slope*	*Shape*	*Mannings Number*	*Channel Side Slope*
	(ha)	*(km^2)*		*(m)*	*(m/m)*	*(constant)*	*(m)*	*(m/m)*	*(constant)*	*(m)*	*(m/m)*			
201	0.46	0.0046	40	123	0.30	0.4	-	-	-	150	0.03	*Triangle*	*0.035*	*3H:1V*
202	1.81	0.0181	65	46	0.24	0.4	-	-	-	150	0.03	*Triangle*	*0.035*	*3H:1V*
203	2.36	0.0236	65	129	0.24	0.4	-	-	-	220	0.005	*Triangle*	*0.035*	*3H:1V*
204	1.87	0.0187	65	150	0.18	0.4	-	-	-	115	0.03	*Triangle*	*0.035*	*3H:1V*
Total	6.5	0.0650												

TABLE 8.2

HEC-HMS METEORLOGIC AND CONTROL INPUT PARAMETERS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

METEORLOGIC MODELS

Precipitation Method	Frequency Storm
Evapouration Method	None
Snowmelt Method	None

					Duration - Precipitation					
	Probability (%)	**Intensity Duration** *(hr)*	**Storm Duration** *(hr)*	**Intensity Position** *(%)*	**1 hour** *(mm)*	**2 hour** *(mm)*	**3 hour** *(mm)*	**6 hour** *(mm)*	**12 hour** *(mm)*	**24 hour** *(mm)*
25 year 24 hour	4	1	24	50	25.0	31.0	34.5	38.4	45.0	54.0
				5						
100 year 24 hour	1	1	24	50	33.0	38.0	45.0	48.0	56.4	66.0

CONTROL SPECIFICATIONS

Start Date	01 Jan 2008
Start Time	12:00
End Date	03 Jan 2008
End Time	12:00
Time Interval	10 Minutes

TABLE 8.3

HEC-HMS MODEL RESULTS - RUNOFF PEAK FLOWS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Catchment Area	*Modeled Peak Flow* [(1)] 25 year 24 hour (m^3/s)	100 yr 24 hour (m^3/s)
EXISTING CONDITIONS		
101	0.003	0.004
102 [(2)]	0.000	0.000
103 [(2)]	0.000	0.000
offsite	0.003	0.004
CLOSED CONDITIONS		
201	0.003	0.004
202	0.007	0.026
203	0.006	0.018
204	0.004	0.013
J1	0.01	0.03
Offsite	0.017	0.05
R1	0.014	0.04

Notes:

(1) Flow modelled using US Army Corps of Engineers HEC-HMS (Hydrologic Modeling System), Version 3.3.

(2) Runoff flows were negligible.

(3) Refer to Figures 1.1 and 1.2 for catchment definitions.

TABLE 8.4

HEC-HMS MODEL RESULTS - RUNOFF VOLUMES
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Catchment Area	*Modeled Runoff Volume* [1] *25 year 24 hour (m^3)*	*100 year 24 hour (m^3)*
EXISTING CONDITIONS		
101	44	54
102	3	9
103	7	18
offsite	54	81
CLOSED CONDITIONS		
301	49	60
302	78	154
303	102	200
304	81	158
J1	128	214
J2	310	571
R1	229	414

Notes:
(1) Flow modeled using US Army Corps of Engineers HEC-HMS (Hydrologic Modeling System), Version 3.3
(2) Refer to Figures 1.1 and 1.2 for catchment definitions.

TABLE 9.1

TYPICAL LEACHATE CONCENTRATION TRENDS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Parameter	Unit	1 Year	5 Years	15 Years
Biological Oxygen Demand	mg/L	20,000	2,000	50
Ammonia	mg/L	1,500	350	60
Total Dissolved Solids	mg/L	20,000	5,000	2,000
Chloride	mg/L	2,000	1,500	500
Sulphate	mg/L	1,000	400	50
Phosphate	mg/L	150	50	-
Calcium	mg/L	2,500	900	300
Sodium	mg/L	2,000	700	100
Iron	mg/L	700	600	100
Aluminum	mg/L	150	50	-

SOURCE: Reinhart, Debra, 1995. The Impact of Leachate Recirculation on Municipal Solid Waste Landfill Operating Characteristics. Waste Management & Research (1996).

TABLE 9.2

SWANA 1991 LEACHATE CHARACTERISTICS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Constituents	**Range (mg / L)**
*pH	5.3 - 8.5
*Chemical Oxygen Demand (COD)	3,000 - 45,000
*chloride	100 - 3,000
*nitrite	5-40
*ammonia nitrogen	10 - 800
*specific conductance	--
*temperature	--
*water elevation	--
*sulphate	100 - 1,500
*cyanide	< 0.10
*VOCs	--
Biochemical Oxygen Demand (BOD)	2,000 - 30,000
Total Organic Carbon (TOC)	1,500 - 20,000
total suspended solids	200 - 1,000
organic nutrients	10 - 600
total phosphorus	1-70
ortho phosphorus	1-50
alkalinity as CaCO3	1,000 - 10,000
total hardness as CaCO3	300 - 10,000
calcium	200 - 3,000
magnesium	50 - 1,500
potassium	200 - 2,000
sodium	200 - 2,000
total iron	50 - 600

SOURCE: British Columbia Ministry of Environment, Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills, January 1996
* denotes those commonly used as indicator parameters (SWANA, 1991).

TABLE 10.1

LFG GENERATION EVALUATION LOWER ESTIMATE
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

	Relatively Inert	Moderately Decomposable	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH4/tonne
Waste Composition	8.7%	51.0%	40.3%	
lag time before start of gas production, lag =		1 years		
Historical Data Used (years)	26			
1st Year of Historical Data Used	1979			
50 Year Planning Horizon	2051			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density)	0.6557 kg/m^3		(25C,1ATM)	
carbon dioxide (density)	1.7988 kg/m^3		(25C,1ATM)	

Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Waste Tonnage Relatively Inert (tonnes)	Waste Tonnage Moderately Decomposable (tonnes)	Waste Tonnage Decomposable (tonnes)	Methane Generation Rate, k Relatively Inert ($year^{-1}$)	Methane Generation Rate, k Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)	Landfill Gas Production (m^3/hr)
1979	1	5,005	5,005	434	2,554	2,017	0.01	0.02	0.05	0.0	0.0
1980	2	5,040	10,045	437	2,572	2,031	0.01	0.02	0.05	14.1	4.9
1981	3	5,075	15,120	440	2,590	2,045	0.01	0.02	0.05	27.6	9.6
1982	4	5,111	20,230	443	2,608	2,060	0.01	0.02	0.05	40.8	14.2
1983	5	5,146	25,377	446	2,626	2,074	0.01	0.02	0.05	53.5	18.6
1984	6	5,182	30,559	449	2,645	2,089	0.01	0.02	0.05	65.8	22.9
1985	7	5,219	35,778	452	2,663	2,103	0.01	0.02	0.05	77.7	27.1
1986	8	5,255	41,033	456	2,682	2,118	0.01	0.02	0.05	89.3	31.1
1987	9	5,292	46,325	459	2,701	2,133	0.01	0.02	0.05	100.5	35.0
1988	10	5,329	51,654	462	2,719	2,148	0.01	0.02	0.05	111.3	38.8
1989	11	5,366	57,020	465	2,738	2,163	0.01	0.02	0.05	121.9	42.4
1990	12	5,404	62,424	469	2,758	2,178	0.01	0.02	0.05	132.1	46.0
1991	13	5,442	67,866	472	2,777	2,193	0.01	0.02	0.05	142.0	49.5
1992	14	5,480	73,346	475	2,796	2,208	0.01	0.02	0.05	151.7	52.8
1993	15	5,518	78,864	478	2,816	2,224	0.01	0.02	0.05	161.1	56.1
1994	16	5,557	84,421	482	2,836	2,239	0.01	0.02	0.05	170.3	59.3
1995	17	5,596	90,017	485	2,855	2,255	0.01	0.02	0.05	179.2	62.4
1996	18	5,635	95,652	489	2,875	2,271	0.01	0.02	0.05	187.9	65.4
1997	19	5,674	101,326	492	2,896	2,287	0.01	0.02	0.05	196.3	68.4
1998	20	5,714	107,040	495	2,916	2,303	0.01	0.02	0.05	204.6	71.2
1999	21	5,754	112,794	499	2,936	2,319	0.01	0.02	0.05	212.7	74.0
2000	22	5,794	118,588	502	2,957	2,335	0.01	0.02	0.05	220.5	76.8
2001	23	5,835	124,423	506	2,978	2,351	0.01	0.02	0.05	228.2	79.5
2002	24	5,876	130,299	509	2,998	2,368	0.01	0.02	0.05	235.8	82.1
2003	25	5,917	136,216	513	3,019	2,385	0.01	0.02	0.05	243.1	84.7
2004	26	5,958	142,174	517	3,041	2,401	0.01	0.02	0.05	250.3	87.2
2005	27	6,000	148,174	520	3,062	2,418	0.01	0.02	0.05	257.4	89.6
2006	28	6,042	154,216	524	3,083	2,435	0.01	0.02	0.05	264.3	92.0
2007	29	6,084	160,301	528	3,105	2,452	0.01	0.02	0.05	271.1	94.4
2008	30	6,127	166,427	531	3,127	2,469	0.01	0.02	0.05	277.8	96.7
2009	31	6,170	172,597	535	3,148	2,486	0.01	0.02	0.05	284.4	99.0
2010	32	6,213	178,810	539	3,170	2,504	0.01	0.02	0.05	290.8	101.3
2011	33	6,256	185,067	542	3,193	2,521	0.01	0.02	0.05	297.1	103.5
2012	34	6,300	191,367	546	3,215	2,539	0.01	0.02	0.05	303.4	105.6
2013	35	6,344	197,711	550	3,238	2,557	0.01	0.02	0.05	309.5	107.8
2014	36	6,389	204,100	554	3,260	2,575	0.01	0.02	0.05	315.5	109.9
2015	37	6,433	210,533	558	3,283	2,593	0.01	0.02	0.05	321.5	111.9
2016	38	6,479	217,012	562	3,306	2,611	0.01	0.02	0.05	327.4	114.0
2017	39	6,524	223,536	566	3,329	2,629	0.01	0.02	0.05	333.2	116.0
2018	40	6,570	230,105	570	3,352	2,648	0.01	0.02	0.05	338.9	118.0
2019	41	6,616	236,721	574	3,376	2,666	0.01	0.02	0.05	344.5	120.0
2020	42	6,662	243,383	578	3,400	2,685	0.01	0.02	0.05	350.1	121.9
2021	43	6,708	250,091	582	3,423	2,704	0.01	0.02	0.05	355.6	123.8
2022	44	6,755	256,847	586	3,447	2,722	0.01	0.02	0.05	361.1	125.7
2023	45	6,803	263,649	590	3,471	2,741	0.01	0.02	0.05	366.5	127.6
2024	46	6,850	270,500	594	3,496	2,761	0.01	0.02	0.05	371.8	129.5
2025	47	6,898	277,398	598	3,520	2,780	0.01	0.02	0.05	377.1	131.3
2026	48	6,947	284,344	602	3,545	2,799	0.01	0.02	0.05	382.4	133.1
2027	49	6,995	291,340	606	3,570	2,819	0.01	0.02	0.05	387.6	135.0
2028	50	7,044	298,384	611	3,595	2,839	0.01	0.02	0.05	392.8	136.8
2029	51	7,093	305,477	615	3,620	2,859	0.01	0.02	0.05	397.9	138.5
2030	52	7,143	312,620	619	3,645	2,879	0.01	0.02	0.05	403.0	140.3
2031	53	7,193	319,814	624	3,671	2,899	0.01	0.02	0.05	408.1	142.1
2032	54	7,243	327,057	628	3,696	2,919	0.01	0.02	0.05	413.1	143.8
2033	55	7,294	334,351	632	3,722	2,940	0.01	0.02	0.05	418.1	145.6
2034	56	7,345	341,696	637	3,748	2,960	0.01	0.02	0.05	423.1	147.3
2035	57	7,397	349,093	641	3,775	2,981	0.01	0.02	0.05	428.0	149.0
2036	58	7,448	356,541	646	3,801	3,002	0.01	0.02	0.05	432.9	150.7
2037	59	7,501	364,042	650	3,828	3,023	0.01	0.02	0.05	437.8	152.5
2038	60	7,553	371,595	655	3,854	3,044	0.01	0.02	0.05	442.7	154.2
2039	61	7,606	379,201	659	3,881	3,065	0.01	0.02	0.05	447.6	155.8
2040	62	7,659	386,860	664	3,908	3,087	0.01	0.02	0.05	452.4	157.5
2041	63	7,713	394,573	669	3,936	3,108	0.01	0.02	0.05	457.3	159.2
2042	64	7,767	402,340	673	3,963	3,130	0.01	0.02	0.05	462.1	160.9
2043	65	7,821	410,161	678	3,991	3,152	0.01	0.02	0.05	466.9	162.6
2044	66	7,876	418,037	683	4,019	3,174	0.01	0.02	0.05	471.7	164.3
2045	67	7,931	425,968	688	4,047	3,196	0.01	0.02	0.05	476.5	165.9
2046	68	7,987	433,955	692	4,076	3,219	0.01	0.02	0.05	481.3	167.6
2047	69	8,042	441,997	697	4,104	3,241	0.01	0.02	0.05	486.1	169.3
2048	70	8,099	450,096	702	4,133	3,264	0.01	0.02	0.05	490.9	170.9
2049	71	8,155	458,251	707	4,162	3,287	0.01	0.02	0.05	495.6	172.6
2050	72	8,213	466,464	712	4,191	3,310	0.01	0.02	0.05	500.4	174.2
2051		0	466,464	0	0	0	0.01	0.02	0.05	505.2	175.9
2052		0	466,464	0	0	0	0.01	0.02	0.05	486.7	169.5
2053		0	466,464	0	0	0	0.01	0.02	0.05	469.1	163.3
2054		0	466,464	0	0	0	0.01	0.02	0.05	452.1	157.4
2055		0	466,464	0	0	0	0.01	0.02	0.05	435.9	151.8
2056		0	466,464	0	0	0	0.01	0.02	0.05	420.3	146.4
2057		0	466,464	0	0	0	0.01	0.02	0.05	405.4	141.2
2058		0	466,464	0	0	0	0.01	0.02	0.05	391.1	136.2

TABLE 10.2

LFG GENERATION EVALUATION UPPER ESTIMATE
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

	Relatively Inert	Moderately Decomposable	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH4/tonne
Waste Composition	33.5%	40.0%	26.5%	
lag time before start of gas production, lag =	1 years			
Historical Data Used (years)	26			
1st Year of Historical Data Used	1979			
50 Year Planning Horizon	2051			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density)	0.6557 kg/m^3		(25C,1ATM)	
carbon dioxide (density)	1.7988 kg/m^3		(25C,1ATM)	

Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Waste Tonnage: Relatively Inert (tonnes)	Waste Tonnage: Moderately Decomposable (tonnes)	Waste Tonnage: Decomposable (tonnes)	Methane Generation Rate, k: Relatively Inert ($year^{-1}$)	Methane Generation Rate, k: Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k: Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)	Landfill Gas Production (m^3/hr)
1979	1	5,005	5,005	1,676	2,004	1,325	0.01	0.02	0.05	0.0	0.0
1980	2	5,040	10,045	1,688	2,018	1,334	0.01	0.02	0.05	9.9	3.5
1981	3	5,075	15,120	1,699	2,033	1,343	0.01	0.02	0.05	19.5	6.8
1982	4	5,111	20,230	1,711	2,047	1,353	0.01	0.02	0.05	28.8	10.0
1983	5	5,146	25,377	1,723	2,061	1,362	0.01	0.02	0.05	37.8	13.2
1984	6	5,182	30,559	1,735	2,076	1,372	0.01	0.02	0.05	46.6	16.2
1985	7	5,219	35,778	1,747	2,090	1,381	0.01	0.02	0.05	55.1	19.2
1986	8	5,255	41,033	1,760	2,105	1,391	0.01	0.02	0.05	63.3	22.0
1987	9	5,292	46,325	1,772	2,119	1,401	0.01	0.02	0.05	71.3	24.8
1988	10	5,329	51,654	1,784	2,134	1,410	0.01	0.02	0.05	79.0	27.5
1989	11	5,366	57,020	1,797	2,149	1,420	0.01	0.02	0.05	86.6	30.1
1990	12	5,404	62,424	1,809	2,164	1,430	0.01	0.02	0.05	93.9	32.7
1991	13	5,442	67,866	1,822	2,179	1,440	0.01	0.02	0.05	101.1	35.2
1992	14	5,480	73,346	1,835	2,195	1,450	0.01	0.02	0.05	108.0	37.6
1993	15	5,518	78,864	1,848	2,210	1,460	0.01	0.02	0.05	114.8	40.0
1994	16	5,557	84,421	1,861	2,225	1,471	0.01	0.02	0.05	121.4	42.3
1995	17	5,596	90,017	1,874	2,241	1,481	0.01	0.02	0.05	127.9	44.5
1996	18	5,635	95,652	1,887	2,257	1,491	0.01	0.02	0.05	134.2	46.7
1997	19	5,674	101,326	1,900	2,273	1,502	0.01	0.02	0.05	140.3	48.9
1998	20	5,714	107,040	1,913	2,288	1,512	0.01	0.02	0.05	146.3	51.0
1999	21	5,754	112,794	1,927	2,304	1,523	0.01	0.02	0.05	152.2	53.0
2000	22	5,794	118,588	1,940	2,321	1,534	0.01	0.02	0.05	158.0	55.0
2001	23	5,835	124,423	1,954	2,337	1,544	0.01	0.02	0.05	163.6	57.0
2002	24	5,876	130,299	1,967	2,353	1,555	0.01	0.02	0.05	169.1	58.9
2003	25	5,917	136,216	1,981	2,370	1,566	0.01	0.02	0.05	174.5	60.8
2004	26	5,958	142,174	1,995	2,386	1,577	0.01	0.02	0.05	179.8	62.6
2005	27	6,000	148,174	2,009	2,403	1,588	0.01	0.02	0.05	185.0	64.4
2006	28	6,042	154,216	2,023	2,420	1,599	0.01	0.02	0.05	190.1	66.2
2007	29	6,084	160,301	2,037	2,437	1,610	0.01	0.02	0.05	195.1	67.9
2008	30	6,127	166,427	2,052	2,454	1,622	0.01	0.02	0.05	200.0	69.6
2009	31	6,170	172,597	2,066	2,471	1,633	0.01	0.02	0.05	204.9	71.3
2010	32	6,213	178,810	2,080	2,488	1,644	0.01	0.02	0.05	209.6	73.0
2011	33	6,256	185,067	2,095	2,506	1,656	0.01	0.02	0.05	214.3	74.6
2012	34	6,300	191,367	2,110	2,523	1,667	0.01	0.02	0.05	219.0	76.2
2013	35	6,344	197,711	2,124	2,541	1,679	0.01	0.02	0.05	223.5	77.8
2014	36	6,389	204,100	2,139	2,559	1,691	0.01	0.02	0.05	228.0	79.4
2015	37	6,433	210,533	2,154	2,577	1,703	0.01	0.02	0.05	232.4	80.9
2016	38	6,479	217,012	2,169	2,595	1,715	0.01	0.02	0.05	236.8	82.5
2017	39	6,524	223,536	2,184	2,613	1,727	0.01	0.02	0.05	241.1	84.0
2018	40	6,570	230,105	2,200	2,631	1,739	0.01	0.02	0.05	245.4	85.4
2019	41	6,616	236,721	2,215	2,649	1,751	0.01	0.02	0.05	249.6	86.9
2020	42	6,662	243,383	2,231	2,668	1,763	0.01	0.02	0.05	253.8	88.4
2021	43	6,708	250,091	2,246	2,687	1,775	0.01	0.02	0.05	257.9	89.8
2022	44	6,755	256,847	2,262	2,705	1,788	0.01	0.02	0.05	262.0	91.2
2023	45	6,803	263,649	2,278	2,724	1,800	0.01	0.02	0.05	266.1	92.6
2024	46	6,850	270,500	2,294	2,743	1,813	0.01	0.02	0.05	270.1	94.0
2025	47	6,898	277,398	2,310	2,763	1,826	0.01	0.02	0.05	274.1	95.4
2026	48	6,947	284,344	2,326	2,782	1,838	0.01	0.02	0.05	278.0	96.8
2027	49	6,995	291,340	2,342	2,802	1,851	0.01	0.02	0.05	282.0	98.2
2028	50	7,044	298,384	2,359	2,821	1,864	0.01	0.02	0.05	285.8	99.5
2029	51	7,093	305,477	2,375	2,841	1,877	0.01	0.02	0.05	289.7	100.9
2030	52	7,143	312,620	2,392	2,861	1,891	0.01	0.02	0.05	293.6	102.2
2031	53	7,193	319,814	2,409	2,881	1,904	0.01	0.02	0.05	297.4	103.5
2032	54	7,243	327,057	2,425	2,901	1,917	0.01	0.02	0.05	301.2	104.9
2033	55	7,294	334,351	2,442	2,921	1,930	0.01	0.02	0.05	304.9	106.2
2034	56	7,345	341,696	2,460	2,942	1,944	0.01	0.02	0.05	308.7	107.5
2035	57	7,397	349,093	2,477	2,962	1,958	0.01	0.02	0.05	312.4	108.8
2036	58	7,448	356,541	2,494	2,983	1,971	0.01	0.02	0.05	316.2	110.1
2037	59	7,501	364,042	2,512	3,004	1,985	0.01	0.02	0.05	319.9	111.4
2038	60	7,553	371,595	2,529	3,025	1,999	0.01	0.02	0.05	323.6	112.7
2039	61	7,606	379,201	2,547	3,046	2,013	0.01	0.02	0.05	327.2	113.9
2040	62	7,659	386,860	2,565	3,067	2,027	0.01	0.02	0.05	330.9	115.2
2041	63	7,713	394,573	2,583	3,089	2,041	0.01	0.02	0.05	334.6	116.5
2042	64	7,767	402,340	2,601	3,111	2,056	0.01	0.02	0.05	338.2	117.8
2043	65	7,821	410,161	2,619	3,132	2,070	0.01	0.02	0.05	341.9	119.0
2044	66	7,876	418,037	2,637	3,154	2,084	0.01	0.02	0.05	345.5	120.3
2045	67	7,931	425,968	2,656	3,176	2,099	0.01	0.02	0.05	349.1	121.6
2046	68	7,987	433,955	2,674	3,199	2,114	0.01	0.02	0.05	352.8	122.8
2047	69	8,042	441,997	2,693	3,221	2,129	0.01	0.02	0.05	356.4	124.1
2048	70	8,099	450,096	2,712	3,243	2,143	0.01	0.02	0.05	360.0	125.3
2049	71	8,155	458,251	2,731	3,266	2,158	0.01	0.02	0.05	363.6	126.6
2050	72	8,213	466,464	2,750	3,289	2,174	0.01	0.02	0.05	367.2	127.9
2051	72	0	466,464	0	0	0	0.01	0.02	0.05	370.8	129.1
2052	72	0	466,464	0	0	0	0.01	0.02	0.05	358.1	124.7
2053	72	0	466,464	0	0	0	0.01	0.02	0.05	345.8	120.4
2054	72	0	466,464	0	0	0	0.01	0.02	0.05	334.1	116.3
2055	72	0	466,464	0	0	0	0.01	0.02	0.05	322.8	112.4
2056	72	0	466,464	0	0	0	0.01	0.02	0.05	312.0	108.6
2057	72	0	466,464	0	0	0	0.01	0.02	0.05	301.6	105.0
2058	72	0	466,464	0	0	0	0.01	0.02	0.05	291.6	101.5

TABLE 13.1

PROPOSED MONITORING WELL LOCATIONS
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

WELL ID	LOCATION DESCRIPTION	PURPOSE OF MONITORING	FREQUENCY (Proposed Schedule A) (1)	FREQUENCY (Proposed Schedule B) (2)
MW08-1	- located in the at the base of the slope south of the active fill area - instrumented in the sand unit	- monitor groundwater in the sand unit downgradientof the landfill - monitor water level elevation	Q	A
MW08-2	- located southwest and downgradient of the landfill in close proximity to the southern property boundary - instrumented in the sand unit	- monitor groundwater in the sand unit downgradientof the landfill - monitor water level elevation	Q	A
MW08-3	- located south and downgradient of the landfill in close proximity to the southern property boundary - instrumented in the sand unit	- monitor groundwater in the sand unit downgradientof the landfill - monitor water level elevation	Q	A
PR-MW4	- to be located south and downgradient of the landfill near MW08-2 - instrumented in the silt unit (deep)	- monitor groundwater in the sand unit downgradientof the landfill - monitor water level elevation	Q	A
PR-MW5	- to be located south and downgradient of the landfill near MW08-3 - instrumented in the silt unit (deep)	- monitor groundwater in the sand unit downgradientof the landfill - monitor water level elevation	Q	A
PR-BH6	- to be located in the existing waste mass - potentially instrumented in the silt unit at the base of the landfill	- assess the thickness and chracterize the overburden underlieing the existing landfill - assess potential leachate level elevation	Q	A

NOTES:
(1) - Schedule A analytical details provided in Table 13.2.
(2) - Schedule B analytical details provided in Table 13.3.
COCs - Contaminants of Concern
Q - Quarterly
A - Annualy

TABLE 13.2

PROPOSED ENVIRONMENTAL MONITORING PROGRAM SCHEDULE A
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLVIER, BC

Characteristics	Groundwater	Groundwater (if SRM accepted)
Field Observations		
Depth to Groundwater	√	
Flow		
Field Parameters		
Conductivity (mS/cm)	√	
pH	√	
Temperature (^{o}C)	√	
Dissolved Oxygen (DO)		
Redox Potential (Eh)	√	
Turbidity (NTU)	√	
General Chemistry		
pH	√	
Conductivity (mS/cm)	√	
Hardness (as $CaCO_3$)	√	
Biological Oxygen Demand (BOD)		√
Chemical Oxygen Demand (COD)	√	√
Alkalinity (Total & Speciated)	√	
Ammonia Nitrogen	√	√
Nitrate	√	√
Nitrite	√	√
Total Organic Carbon (TOC)	√	√
Total Kjeldahl Nitrogen (TKN)	√	√
Chloride	√	√
Sulphates	√	
Total Phosphorus	√	
Total Dissolved Solids		√
Fecal Coliforms		√
Metals		
Dissolved Metals	√	
Total Metals		
Aluminum	√	
Antimony	√	
Arsenic	√	
Barium	√	
Beryllium	√	
Cadmium	√	
Calcium	√	
Chromium	√	
Cobalt	√	
Copper	√	
Iron	√	
Lead	√	
Magnesium	√	
Manganese	√	
Mercury	√	
Molybdenum	√	
Nickel	√	
Phosphorus	√	
Potassium	√	
Selenium	√	
Silicon	√	
Silver	√	
Sodium	√	
Thallium	√	
Vanadium	√	
Zinc	√	

TABLE 13.3

PROPOSED ENVIRONMENTAL MONITORING PROGRAM SCHEDULE B
OPERATION AND CLOSURE PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Characteristics	Groundwater
VPH (VHW6 to 10 - BTEX)	√
CSR VH C6-C10	√
Chlorobenzenes	√
1,2-dichlorobenzene	√
1,3-dichlorobenzene	√
1,4-dichlorobenzene	√
Chlorobenzene	√
Monocyclic Aromatics	√
Benzene	√
Ethylbenzene	√
m & p-Xylene	√
o-Xylene	√
Styrene	√
Toluene	√
Xylenes (Total)	√

APPENDICES

APPENDIX A

OPERATIONAL CERTIFICATE No. 15280

[sign]CurrentDate

Tracking Number: 95
Authorization Number: 15280

REGISTERED MAIL

REGIONAL DISTRICT OKANAGAN SIMILKAMEEN
101 MARTIN STREET
PENTICTON, BC
V2A 5J9

Dear Operational Certificate Holder:

Enclosed is Operational Certificate 15280 issued under the provisions of the *Environmental Management Act*. Your attention is respectfully directed to the terms and conditions outlined in the operational certificate. An annual fee will be determined according to the Permit Fees Regulation.

This operational certificate does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with the operational certificate holder. It is also the responsibility of the operational certificate holder to ensure that all activities conducted under this authorization are carried out with regard to the rights of third parties, and comply with other applicable legislation that may be in force.

This decision may be appealed to the Environmental Appeal Board in accordance with Part 8 of the *Environmental Management Act*. An appeal must be delivered within 30 days from the date that notice of this decision is given. For further information, please contact the Environmental Appeal Board at (250) 387-3464.

Administration of this operational certificate will be carried out by staff from the Okanagan Region. Plans, data and reports pertinent to the operational certificate are to be submitted to the Regional Manager, Environmental Protection, at Ministry of Environment, Regional Operations, Okanagan Region, 102 Industrial Pl., Penticton, BC V2A 7C8.

Yours truly,

[sign]image:SigningAuthoritySignatureId

[sign]SignatureBlockFirstLine
for Director, *Environmental Management Act*
Okanagan Region

Enclosure

cc: Environment Canada

BRITISH COLUMBIA
The Best Place on Earth

MINISTRY OF ENVIRONMENT

OPERATIONAL CERTIFICATE

15280

Under the Provisions of the Environmental Management Act and in accordance with the Regional District of Okanagan Similkameen's Solid Waste Management Plan

REGIONAL DISTRICT OKANAGAN SIMILKAMEEN

101 MARTIN STREET
PENTICTON, BC
V2A 5J9

is authorized to manage and discharge Municipal Solid Waste and manage recyclable material from the Regional District of Okanagan Similkameen and environs at the Oliver landfill located near Oliver, British Columbia, subject to the conditions listed below. Contravention of any of these conditions is a violation of the Environmental Management Act and may result in prosecution. This authorization supersedes any previously issued authorization for this landfill.

1. AUTHORIZED DISCHARGES

1.1 Authorized source

This section applies to the discharge of refuse from a Sanitary Landfill. The site reference number for this discharge is E212370.

1.1.1 The maximum rate of discharge is 12000 tonnes per year.

1.1.2 The type of refuse which may be discharged is municipal solid waste and other wastes as authorized by the Director.

1.1.3 The authorized works are sanitary landfill and related appurtenances and related appurtenances approximately located as shown on Site Plan A.

1.1.4 The location of the facilities used to manage and discharge the Municipal Solid Waste and from which the discharge originates is located at Lot

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for Director, *Environmental Management Act*
Okanagan Region

954, District Lot 2450s, Similkameen Division of Yale District, Plan 14590, except Plan 31702, as shown on Site Plan A

1.1.5 The authorized facilities are signs, weigh scales, recyclable material and waste drop-off and storage facilities and related appurtenances approximately located as shown on Site Plan **A**.

2. DEFINITIONS

a) "Director" means the Director or a person delegated to act on behalf of the Director, as defined in the Environmental Management Act;

b) "Manager" means Regional Manager, Environmental Protection;

c) "Qualified Professional (QP)" means an applied scientist or technologist specializing in a particular applied science including, but not necessarily limited to: agrology, biology, chemistry, engineering, geology, or hydrogeology; and 1) who is registered in British Columbia with their appropriate professional organization, acting under that association's Code of Ethics and subject to disciplinary action by that association; and 2) who, through suitable education, experience, accreditation and knowledge, may be reasonably relied on to provide advice within their area of expertise.

3. GENERAL REQUIREMENTS

3.1 Maintenance of Works and Emergency Procedures

The Operational Certificate Holder shall inspect the authorized works regularly and maintain them in good working order. In the event of an emergency or condition beyond the control of the Operational Certificate Holder which prevents effective operation of the authorized works or leads to unauthorized discharge, the Operational Certificate Holder shall comply with all applicable statutory requirements, immediately notify the Regional Manager, Environmental Protection, and take appropriate remedial action for the prevention or mitigation of pollution. The Director may reduce or suspend operations to protect the environment until the authorized works have been restored and/or corrective steps have been taken to prevent unauthorized discharges.

3.2 Process Modifications

The Regional Manager, Environmental Protection, shall be notified prior to implementing changes to any process that may adversely affect the quality and/or quantity of the discharge.

3.2.1 Scavenging of waste is to be prevented. The salvaging of wastes should be encouraged by providing areas and facilities for separation of recyclable or reusable materials.

3.3 **Plans - New Works**

a) Site development, operating, leachate management, closure and post-closure plans must be submitted to the Regional Manager, Environmental Protection, as required.

b) The plans referenced in subsection a) must address, but not be limited to, each of the subsections in the Landfill Criteria for Municipal Solid Waste including performance, siting, design, operational and closure and post-closure criteria.

Plans and specifications of the works shall be certified by a QP, and submitted to the Regional Manager, Environmental Protection. A QP must certify that the works have been constructed in accordance with the plans before discharge commences.

c) The facilities must be developed, operated and decommissioned in accordance with the plans referenced in subsection a).

3.4 **Landfill Gas**

a) When 100,000 tonnes of waste have been discharged at the landfill, an assessment of the potential for landfill gas generation must be submitted to the Regional Manager, Environmental Protection.

b) The landfill gas assessment must address, but is not limited to, subsections 4.2 and 6.4 of the Landfill Criteria for Municipal Solid Waste and section 6 of the Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills.

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for Director, *Environmental Management Act*
Okanagan Region

c) The potential for landfill gas generation is to be re-assessed at least once every 5 years after the initial assessment.

3.5 **Additional Facilities or Works**

The Director may require investigations, surveys, and the construction of additional facilities or works including, but not limited to, additional leachate, bear-proof and landfill gas facilities. The Director may also amend the requirements of any of the information required by this operational certificate including plans, programs, assessments and reports.

3.6 **Operational and Closure Plan**

3.6.1 An Operational and Closure Plan, prepared by a QP shall be submitted for authorization by the Regional Manager, on or before June 30, 2010.

3.6.2 The Operational and Closure Plan shall include the following:

- Anticipated total waste volumes and tonnage, and life of the landfill (ie: 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 and implementation schedule for monitoring groundwater, surface water and landfill gas, erosion and settlement for a minimum post closure period of 25 years;

3.6.3 Terms of reference for the Operational and Closure Plan are subject to approval by the Director.

3.6.4 The Director may request revisions to the Operational and Closure Plan. Terms of reference for the revisions to the Operational and Closure Plan are subject to approval by the Director.

3.6.5 Operation of this landfill is to be in accordance with the approved Operational and Closure Plan.

3.6.6 If there should be an inconsistency between this Operational Certificate and the authorized Operational and Closure Plan, the Operational Certificate shall take precedence.

3.7 **<u>Protection of Groundwater and Surface Water Quality</u>**

3.7.1 The closed Landfill must be managed such that both groundwater and surface water quality at or beyond the landfill property boundary meets the British Columbia Water Quality Guidelines (Criteria) and A Compendium of Working Water Quality guidelines for British Columbia: 1998 Edition.

3.7.2 If results of groundwater or surface monitoring indicate any exceedance of the above-noted water quality criteria, the Director may require additional leachate management measures including improvement/modification of the works. Terms of reference for any leachate management study and/or design work will be subject to the approval of the Director.

3.8 **<u>Property Boundary</u>**

The buffer zone between any municipal solid waste discharged and the property boundary is to be at least 50 metres of which the 15 metres closest to the property boundary must be reserved for natural or landscaped screening (berms or vegetative screens). Depending on adjacent land use and environmental factors, buffer zones of less than 50 metres but not less than 15 metres may be authorized by the Director.

3.9 **<u>Setbacks</u>**

The distance between the discharged municipal solid waste and the nearest residence, water supply intake, hotel, restaurant, food processing facility, school, church or public park is to be a minimum of 300 metres. The distance between the discharged municipal solid waste and the nearest surface water is to be a minimum of 100 metres. Greater or lesser separation distances may be authorized by the Director where justified. For those landfills designed to collect and recover methane gas generated, the issue of potential on-site or off-site users of the energy should be addressed in siting the landfill, consistent with the preceding regarding public places.

3.10 **Natural Control Landfill**

3.10.1 The bottommost solid waste cell is to be at least 1.2 metres above the seasonal high water table. Greater or lesser separation depths may be authorized based on soil permeability and the leachate renovation capability of the soil.

3.10.2 There is to be at least a 2 metres thick layer of low permeability soil with a hydraulic conductivity of 1 x 10-6 cm/s or less (i.e. silt or clay), below each of the bottommost waste cells. Lesser thicknesses or no layer of low permeability soil may be authorized based on the potential for leachate generation and the unsaturated depth, permeability and leachate renovation capability of the existing soil.

3.11 **Water**

The disposal of municipal solid waste into water is unacceptable. Surface water diversion to restrict storm water runoff from contacting the wastes is required.

3.12 **Final Cover**

Final cover for landfill sites is to consist of a minimum of 1 metre of low permeability (<1 x 10 5 cm/s) compacted soil plus a minimum of 0.15 metre of topsoil with authorized vegetation established. The depth of the topsoil layer should be related to the type of vegetation proposed (ie rooting depth). Soils of higher permeability may be authorized based on leachate generation potential at the landfill site. Final cover is to be constructed with slopes between 4% and 33% with appropriate run-on/run-off drainage controls and erosion controls. An assessment of the need for gas collection and recovery systems shall be made so that, in the event such systems are required, cover can be appropriately designed

and constructed. Final cover is to be installed within 90 days of landfill closure or on any areas of the landfill which will not receive any more refuse within the next 12 months. Completed portions of the landfill are to progressively receive final cover during the active life of the landfill.
Additional layers of natural materials including earth and aggregate and/or synthetic materials may be necessary for inclusion in the final cover design due to site specific conditions and the presence of management systems for leachate and landfill gas

3.13 **Access Road**

An appropriately constructed and maintained access road to, and a road system within the landfill site capable of supporting all vehicles hauling waste, are required during the operating life of the landfill.

3.14 **Fencing and Access**

Fencing is required to be installed around the perimeter of the landfill. The type and extent of fencing will depend on the existing natural vegetation, topographic features and the type of material being accepted, is to be authorized by the Director. All access points are to have locking gates.

3.15 **Design by Qualified Persons**

Any further expansion or development is to be designed by a QP. All plans, specifications, and reports are to be signed and sealed by a QP.

3.16 **Designated Areas**

Maintain areas for the separation, handling and storage of recyclable or reusable materials where applicable.
When a separated recyclable material is a Hazardous Waste, it is to be stored and managed in accordance with the Hazardous Waste Regulation.

3.17 **Signs**

A sign is to be posted at each entrance of the landfill with the following current information:
Site name; Owner and operator; Contact information for owner and operator,and phone number in case of emergency (such as fire); Hours of operation (if applicable); Materials/wastes accepted for landfill and recycling; Materials/wastes banned; and Tipping fees (if applicable).

Additional signs which clearly indicate the directions to the active tipping face, public disposal area, recycling and waste separation areas, etc. should also be displayed.

3.18 **Supervision**

Fulltime, trained operators are required toe present at this landfill during operating hours. The gates are to be locked to prevent unauthorized access during non-operating hours. Properly designed and maintained public waste disposal and/or recyclable material bins situated outside the main gate may be provided for after hours use. The operator is required to be familiar with the Operational Certificate, inspection records, the authorized Operational and Closure Plan and all annual reports.

3.19 **Scavenging**

Scavenging of waste is to be prevented. The salvaging of wastes should be encouraged by providing areas and facilities for separation of recyclable or reusable materials.

3.20 **Dust Control**

Dust created within the landfill property is to be controlled, using methods and materials acceptable to the Director, such that it does not cause a public nuisance.

3.21 **Waste Compaction and Covering**

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for Director, *Environmental Management Act*
Okanagan Region

3.21.1 Wastes are to be spread in thin layers (0.6 m or less) on the working face and compacted. The working face area should be minimized as much as possible. A compacted layer of cover material of at least 0.15 metre of soil or functionally equivalent depth of other cover material, as authorized by the Director, is to be placed on all exposed solid waste at the end of each day of operation. If the landfill should operate continuously 24 hours per day, 0.15 m of cover material is to be applied at a frequency authorized by the Director. Under specific circumstances, such as during bear season, the Director may specify more stringent cover requirements. During periods of extreme weather conditions, such as those that cause the ground to freeze, an exemption to the normal cover requirements may be authorized at a frequency authorized by the Director.

3.21.2 An intermediate cover consisting of a compacted layer of at least 0.30 metre of soil or functionally equivalent depth of other cover material is to be placed where no additional solid waste has been deposited or will be deposited within a period of 30 days.

3.22 **Litter control**

Litter is to be controlled by compacting the waste, minimizing the working face area, applying cover, providing litter control fences and instituting a regular litter pickup and general good housekeeping program or any other measures required by the Director.

3.23 **Vectors**

Vectors are to be controlled by the application of cover material at a specified frequency or by other control measures as required and authorized by the Regional Manager.

3.24 **Wildlife**

The landfill is to be operated so as to minimize the attraction of wildlife such as bears and birds by applying cover at required frequencies and instituting a good housekeeping program. Further control measures, such as bear control fences, and bird control devices, may be specified by the Director.

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for Director, *Environmental Management Act*
Okanagan Region

3.25 **Fire Protection**

Adequate fire-fighting equipment is to be available to extinguish surface or underground fires. Recyclables and reusable materials are to be stored in such a manner as to not constitute a fire hazard.

3.26 **Ozone Depleting Substances**

Release of ozone depleting substances from the storage, handling and disposal of used refrigerator equipment, freezers, motor vehicle air conditioners and other air conditioning equipment, fire extinguishers or other equipment containing ozone depleting substances is strictly forbidden as per the requirements of the Ozone Depleting Substances Regulation.

4. MONITORING AND REPORTING REQUIREMENTS

4.1 **Municipal Solid Waste Measurement**

The Operational Certificate Holder shall provide a complete record of the quantity of waste received in the Annual Report data in a form suitable for inspection by the Director and submit the data, suitably tabulated, to the Regional Manager, for the previous year.

4.1.1 Provide and maintain a weigh scale and record the weight of refuse discharged to the landfill over a 24-hour period or provide a volume measurement system and record the volume and a weight conversion of refuse discharged to the landfill over a 24-hour period

4.1.2 Record the weight or volume of recyclable and reusable materials not being discharged and that are being separated, stored or processed at the landfill over a 24-hour period.

4.2 **Vegetation Monitoring**

Inspect vegetation during the growing season in the vicinity of the landfill at least once per year to determine if any environmental impacts are occurring, and take appropriate remedial action if necessary.

4.3 **Monitoring Program**

4.3.1 A monitoring program must be developed to identify any impacts to the environment and public health from the landfill.

4.3.2 The monitoring program must address, but not be limited to, subsections 4.1, 4.2 and 7.15 of the Landfill Criteria for Municipal Solid Waste and the Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills.

4.3.3 Monitoring must be conducted in accordance with the monitoring program.

4.4 **Annual Operating and Monitoring Report**

An annual operating and monitoring report for the preceding 12 month period from January 1 to December 31 must be submitted to the Regional Manager, Environmental Protection, by June 1 of each year.

The report must include:
-An executive summary;
-Records of the amounts of materials brought to the site, the amount of material landfilled at the site, and the amount of materialdiverted for recycling;
-Remaining site life and capacity;
-Review of the preceding year of operation, plans for the next year and any new information or proposed changes relating to the facilities and plans;
-Comparison of the monitoring data with the performance criteria in section 4 of the Landfill Criteria for Municipal Solid Waste and the Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills, interpretation of the monitoring data, identification and interpretation of irregularities and trends, recommendations, and any proposed changes to the monitoring program.

4.5 **Future Monitoring**

The Director may specify in writing a monitoring program if the Director feels it is necessary for the protection of the environment. This may include sampling of environmental media and the preparation and submission of related reports.

4.6 **Changes to Sampling and Monitoring Program**

On the basis of findings during routine inspections and , the review of the annual report, and any other information related to the effect of the discharge on the receiving environment, the Director may require modifications to the sampling and monitoring of the discharge and receiving environment.

4.7 **Format of Submission**

Monitoring and/or reporting information shall be submitted in an electronic and/or printed format which is suitable for review by the public and/or other government agencies and is satisfactory to the Regional Manager

4.8 **Declaration of Landfill**

Landfills sited on titled land must register a covenant that the property was used for the purpose of waste disposal as a charge against the title to the property as provided for under Section 215.1 of the Land Title Act. Landfills located on crown land are to have a notation on file registered that the property was used for the purpose of waste disposal.

4.9 **Buildings and Structures**

The construction of buildings and other structures on landfills containing putrescible wastes is not recommended for a minimum period of 25 years after closure due to concerns about combustible gas and excessive settlement. Such activity will only be considered and /or authorized after an investigation and report by a QP. The report is to be submitted for authorization to the Regional Waste Manager prior to initiating construction activities.

4.10 **Operation of Gas Recovery and Management System**

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for Director, *Environmental Management Act*
Okanagan Region

Where landfill gas recovery and management is required, operation of the system should be considered an integral part of overall landfill management. The system should be planned for from the early design stage of the landfill and arrangements made for its operation for a minimum 25 year life after closure.

4.11 **<u>Operation of Other Control Systems</u>**

Operation of other environmental control systems for leachate and run-off as well as monitoring of leachate, groundwater and surface water must be continued during the entire post closure period unless the early suspension of such operations or monitoring is authorized by the Director.

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for Director, *Environmental Management Act*
Okanagan Region

Province of British Columbia

MINISTRY OF ENVIRONMENT, LANDS AND PARKS

BC Environment

Environmental Protection
#201-3547 Skaha Lake Rd.
Penticton, British Columbia
V2A 7K2
Telephone: (604) 490-8200
Fax: (604) 492-1314

Von

Oliver Landfill

REGISTERED MAIL

File: PR 04911

Date: July 22, 1993

Regional District of Okanagan Similkameen
101 Martin St
Penticton BC V2A 5J9

Dear Sir or Madam:

Enclosed is a copy of amended Permit PR 04911 issued under the provisions of the Waste Management Act. Your attention is respectfully directed to the terms and conditions outlined in this reformatted permit.

This permit does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority shall rest with the Permittee.

The Permittee shall ensure that any discharge under this permit meets the requirements of other regulatory agencies including, but not restricted to, Environment Canada and the Department of Fisheries and Oceans (Canada).

An annual permit fee will be determined according to the Waste Management Fees Regulation.

The administration of this permit will be carried out by staff from our Regional Office located in Penticton, (telephone 490-8200). Plans, data and reports pertinent to the permit are to be submitted to the Environmental Protection office, Suite 201, 3547 Skaha Lake Road, Penticton, British Columbia, V2A 7K2.

Yours truly,

T.R. Forty, P.Eng.
Assistant Regional Waste Manager
Okanagan Sub-Region

Enclosure

PROVINCE OF
BRITISH COLUMBIA

Environmental Protection
#201 - 3547 Skaha Lake Road
Penticton
British Columbia, V2A 7K2
Telephone: (604) 490-8200

MINISTRY OF ENVIRONMENT,
LANDS AND PARKS

PERMIT

Under the Provisions of the Waste Management Act

Regional District of Okanagan-Similkameen

101 Martin Street

Penticton, British Columbia

V2A 5J9

is authorized to discharge refuse to the ground at a Modified Landfill located at Oliver, British Columbia subject to the conditions listed below. Contravention of any of these conditions is a violation of the Waste Management Act and may result in prosecution.

An annual Permit fee will be charged in accordance with the Waste Management Permit Fees Regulation.

1. SPECIFIC AUTHORIZED DISCHARGES AND RELATED REQUIREMENTS

The discharge to which this Permit is applicable is municipal solid waste disposed of to a Modified Landfill operation including sludge disposal and controlled burning of woodwaste.

Modified Landfill as defined by section 3.2 of the "Landfill Criteria for Municipal Solid Waste", published by the Municipal Waste Reduction Branch, Environmental Protection Division, Ministry of Environment, Lands, and Parks, British Columbia, 1993.

1.1 Location of Discharge

The landfill, sludge disposal, and burning operations shall be restricted to Lot 954, District Lot 2450s, Similkameen Division, Yale District, Plan 14590, Except Plan 31702, located approximately as shown on the attached Appendix A.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

1.2 Origin of Discharge

The location from which the refuse originates from is generally described as the Oliver-Osoyoos area.

1.3 Discharge Quantity

The maximum quantity of refuse which may be discharged into the landfill is 1100 tonnes in any calender month.

1.4 Authorized Discharges

Discharge of refuse into the landfill shall be restricted to residential and commercial generators.

1.5 Prohibited Discharges

The co-disposal of the following wastes with the rest of the municipal solid waste is prohibited unless specifically approved by the Regional Waste Manager:

- Special Wastes other than those specifically authorized in the Special Waste Regulations;
- Automobiles, white goods, other large metallic objects and tires;
- Biomedical waste as defined in the document "Guidelines for the Management of Biomedical Wastes in Canada' (CCME, February 1992); and
- Slaughter house, fish hatchery and farming wastes or cannery wastes and byproducts.

Burial of these wastes in dedicated locations (i.e. avoiding co-disposal) at a landfill site may be approved only if there is no other viable alternative such as treatment/disposal, recycling, reprocessing or composting. Viability is to be determined by the Regional Waste Manager. For those cases in which the dedicated disposal of otherwise prohibited wastes is approved, the specific on-site location of the disposal shall be recorded to allow ready access to the waste should corrective or further action pertaining to the management of these wastes be required by the Ministry at some time in the future.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2. OPERATIONAL REQUIREMENTS

2.1 Landfill Operational Requirements

2.1.1 Landfilling Method

The landfill shall be operated using the area method. The refuse shall be compacted using heavy equipment and shall be placed in lifts with a maximum depth of 3 metres. Refuse shall be placed at least 1 metre above the highest groundwater level. The inactive banks of the landfill shall be maintained at a maximum overall slope of 1 vertical to 4 horizontal (25%). The dumping area shall be fenced or bermed to control the size of the open face to be covered. The landing shall be cleared of scattered refuse when cover material is applied.

2.1.2 Water

The disposal of municipal solid waste into water is unacceptable. Surface water diversion to restrict storm water run off from contacting the wastes is required. The distance between the discharged refuse and the nearest surface water is to be a minimum of 100 m.

2.1.3 Signs

A sign is to be posted at each entrance gate with the following current information:

- site name
- owner and operator
- contact phone number and address for owner and operator
- phone number in case of emergency (such as fire)
- hours of operation
- materials/waste accepted for landfill and recycling
- materials/waste banned

Additional signs are required to clearly indicate the directions to the main tipping face, public disposal area, and the recycling/waste separation areas as applicable.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.1.4 Scavenging and Salvaging

Uncontrolled scavenging of waste is to be prevented.

2.1.5 Dust Control

Dust created within the landfill property is to be controlled, using methods and materials acceptable to the Regional Waste Manager, such that it does not cause a public nuisance.

2.1.6 Waste Deposition and Compaction

Wastes are to be spread in thin layers (0.6m or less) on the full length of the working face and compacted.

2.1.7 Regular Cover Material

Suitable soil cover material is to be applied to a compacted depth of at least 0.15m on all exposed solid waste at a minimum frequency of once per day.

2.1.8 Intermediate Cover

Suitable intermediate soil cover material is to be applied to a compacted depth of 0.30m on areas of the landfill where no additional solid waste has been or will be deposited within a period of 30 days.

2.1.9 Final Cover

Final cover for landfill sites is to consist of a minimum of 1m of low permeability ($<1 \times 10^{-5}$ cm/s) compacted soil plus a minimum of 0.15m of topsoil with approved vegetation established. Soils of higher permeability may be approved based on leachate generation potential at the landfill site. Final cover is to be installed within 90 days of landfill closure or on any areas of the landfill which will not receive any more refuse within the next year. Completed portions of the landfill are to progressively receive final cover during the active life of the landfill.

2.1.10 Cover During Extreme Weather Conditions

During periods of extreme weather conditions, such as those that cause the ground to freeze, an exemption to the cover requirement may be approved by the Regional Waste Manager upon written request.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.1.11 Litter Control

Litter is to be controlled by compacting the waste, minimizing the work face area, applying cover at the required frequencies, providing litter control fences and instituting a regular litter pick up and general good housekeeping program or as specified by the Regional Waste Manager. Areas such as outside the front gate or along roads adjacent to the dump are to be kept free of litter.

2.1.12 Vector and Wildlife Control

Vectors (carriers capable of transmitting a pathogen from one organism to another including, but not limited to, flies and other insects, rodents, and birds) are to be controlled by the application of cover material at the required frequency or as specified by the Regional Waste Manager. This landfill is to be operated so as to minimize the attraction of wildlife such as bears and birds by applying cover at required frequencies and instituting a good housekeeping program or as required by the Regional Waste Manager.

2.1.13 Site Access

Appropriately constructed and maintained access roads capable of supporting all vehicles hauling waste are required during the operating life of the landfill.

2.1.14 Restricted Access

Fencing is required around the perimeter of the landfill. The type and extent of fencing will depend on the existing natural vegetation and topographic features and is to be approved by the Manager. All access points are to have locking gates. The gates are to be locked to prevent unauthorized access during non-operating hours.

2.1.15 Site Restoration

Site restoration shall be carried out to the satisfaction of the Regional Waste Manager.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.2 Operational Requirements for Sludge Disposal

2.2.1 Location

Sewage waste disposal shall be restricted to the area shown on attached Appendix A. The location and design of the designated sewage waste disposal area shall be approved by the Regional Waste Manager. This area shall be fenced to restrict access to the exfiltration lagoons. Signs worded "SEWAGE WASTE DISPOSAL" in a minimum of 10 centimetre high letters shall be erected and maintained such that the lagoons are identifiable from any approach.

2.2.2 Freeboard and Berms

A minimum freeboard of 60 centimetres shall be maintained at all times. The lagoon berms shall be maintained in good working order and the Regional Waste Manager shall be notified immediately of any failure or overflow.

2.2.3 Nature of Wastes

The nature of wastes which may be discharged to the designated lagoon is that of typical septic tank pumpage, and sewage treatment plant sludge. Industrial sludges (including, but not limited to, oil separation sludges and the like) shall not be discharged to the designated lagoons.

2.2.4 Sludge Removal

If the sludge is to be removed from the lagoon for final disposal on the adjacent landfill, the lagoon must be rested for a sufficient amount of time to allow the wastes to dewater. Once the solidified sludge is deposited on the landfill, it must be covered immediately with a minimum of 30 centimetres of compacted cover material.

2.2.5 Lagoon Closure

If the lagoon is to be closed, the sludge must be allowed to dewater to a moisture content that will support final cover. The lagoon must then be covered with a minimum of 1 metre of compacted soil and sloped to promote runoff.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.3 Operational Requirements for Open Burning

2.3.1 Quantity and Frequency

The maximum quantity of wood waste to be burned is 340 tonnes at each burn at a frequency not to exceed 3 times per year during the period from November to April inclusive.

2.3.2 Authorized Burn Materials

Acceptable material to be burned is wood waste including dried stumps, brush, and untreated wood. Stumps shall be stockpiled prior to burning to allow the stumps to dry out. The source of burn materials shall be restricted to residential and commercial generators.

2.3.3 Prohibited Burn Materials

Prohibited burn materials include, but are not limited to putrescible wastes, animal carcasses, mattresses, rubber, plastic, tar, insulation, or any nuisance causing combustibles.

2.3.4 Location

The operation is to be restricted to an area on the site which is satisfactory to the Regional Waste Manager. The burning area is to be located in an area on site that has not been previously landfilled.

2.3.5 Setbacks

The burning area is to be a minimum of 15m away from the refuse fill area and firebreaks are to be provided. Scrap tires stockpiled on site shall be located a minimum of 30m away from the burn area.

2.3.6 Separate Piles

Brush and wood is to be stacked in a series of separate piles to facilitate fire control and to enhance a hot burn.

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.3.7 Continuous Burn

Each burn shall comprise one continuous period necessary to reduce the stockpiled waste to ashes. Materials shall be charged in a manner to promote best combustion and restrict the uplift of lighter constituents. Conditions shall promote rapid combustion and dispersion of combustion products. The duration of the burn shall not exceed 3 days, or as otherwise directed by the Ministry of Forests, Penticton District Office, at which time all burning and smoking areas are to be completely extinguished.

2.3.8 Residue of Combustion

The residue of combustion shall be incorporated into the landfill within 3 days of the residue cooling to ambient temperature.

2.3.9 Attendant at Burn

Burning shall take place only when an attendant is on duty.

2.3.10 Burning Permit

Authorization to burn in the form of a burning permit is to be obtained from the B.C. Ministry of Forests and/or any appropriate municipal authority. A copy of this burning permit is to be submitted to the Regional Waste Manager.

2.3.11 Atmospheric Conditions

Atmospheric conditions are to be suitable so that there is no threat to public health and safety and no nuisance or hazard is caused by smoke or odour.

2.3.12 Notification of Agencies

Notification of the burn shall be provided 7 days prior to the burn to the following agencies:

- B.C. Ministry of Forests
- Appropriate Municipality authority if applicable
- Regional Waste Manager

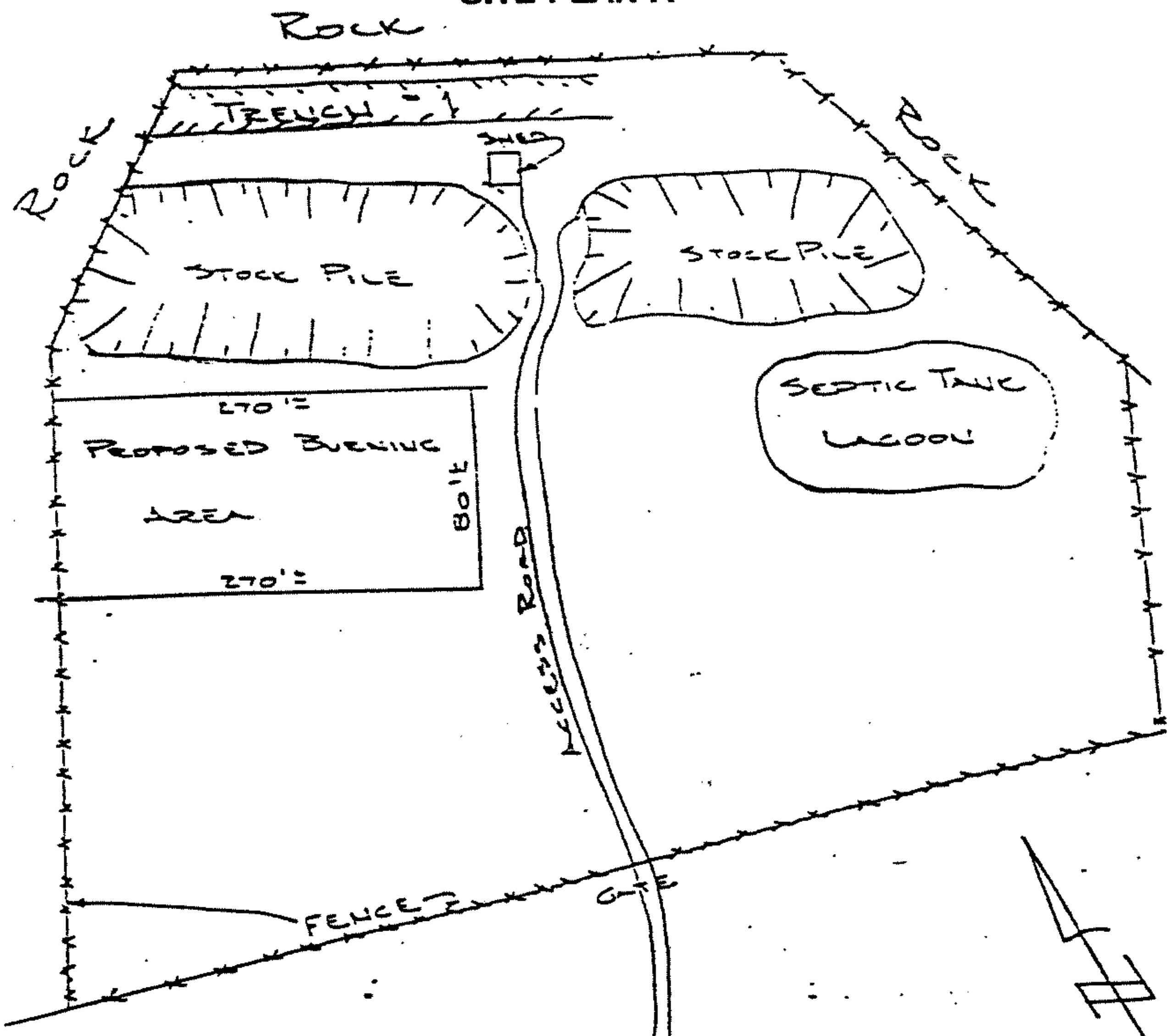
T.R. Forty, P.Eng.
Assistant Regional Waste Manager

2.3.13 Fire Control

Adequate fire fighting equipment as specified in the burning permit is to be provided. As a minimum measure of fire control, adequate heavy equipment and stockpiled suitable soil material is required to be on site to smother or contain accidental fires. Suitable devices such as pressurized water supply, or chemical type fire extinguishers shall be available for extinguishing fires as required to prevent the spreading of fires to surrounding areas. Firebreaks shall be maintained and cleared of combustible materials at least twice per year.

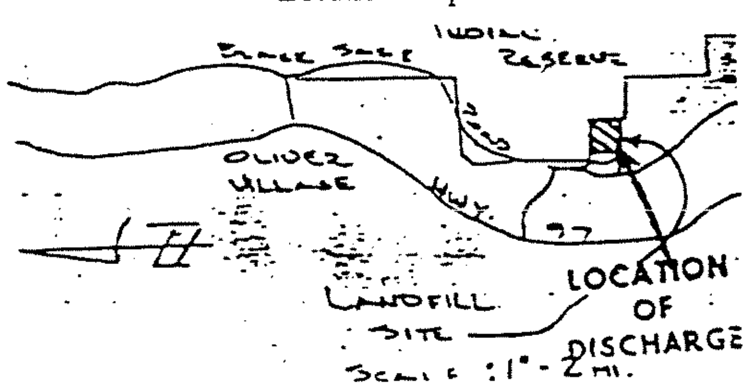
T.R. Forty, P.Eng.
Assistant Regional Waste Manager

SITE PLAN A



Lot 954, District Lot 2450s
Similkameen Division of Yale District
Plan 14590, Except Plan B1702

Location Map



Permit No.: PR 04911

Date: July 22, 1993

T.R. Forty, P.Eng.
Assistant Regional Waste Manager

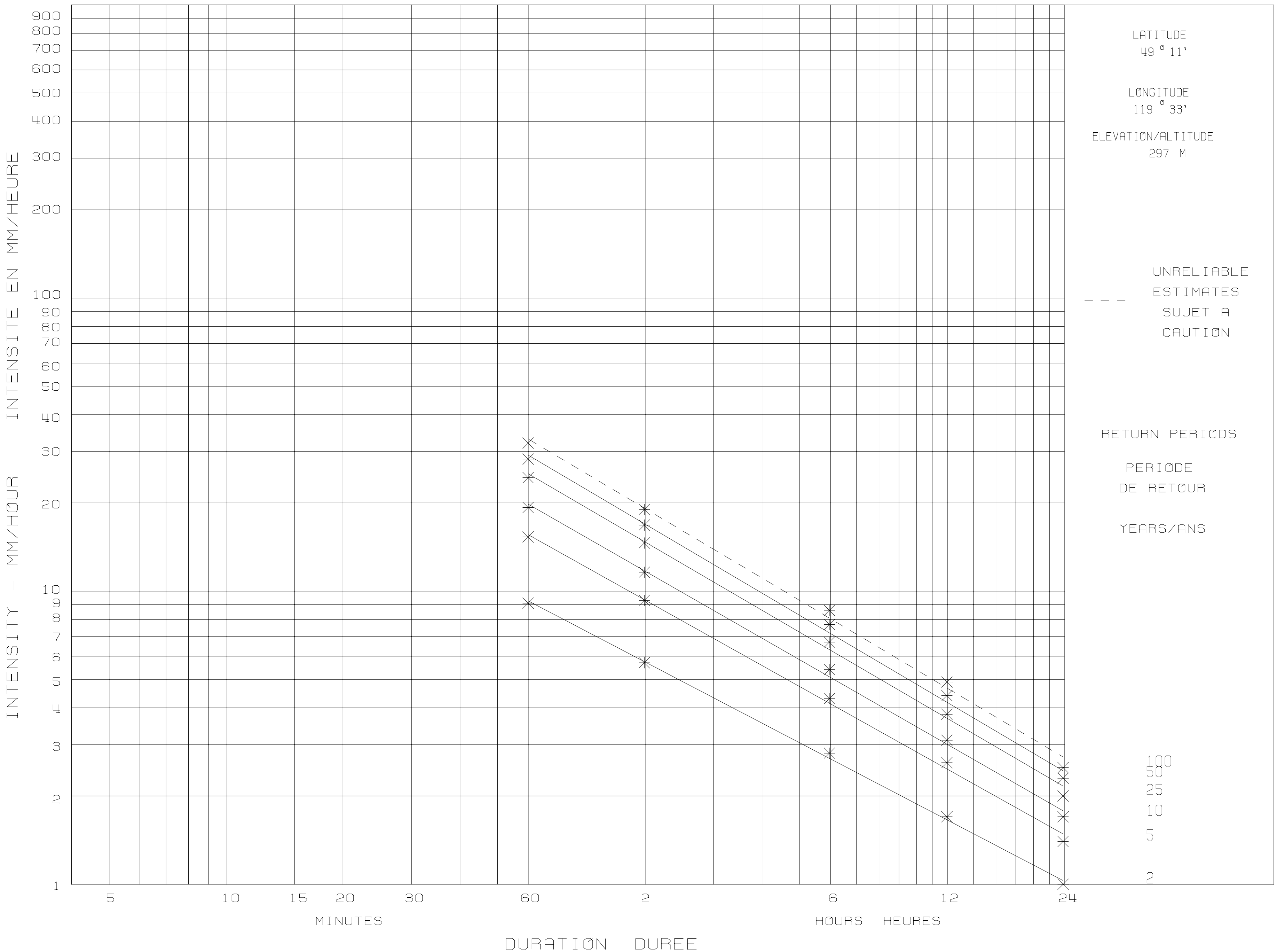
APPENDIX B

OLIVER INTENSITY DURATION FREQUENCY CURVE

SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR-
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A OLIVER STP BC

GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD 1973 - 1997 24 YEARS/AN



PREPARED BY - PREPARE PAR LE
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA

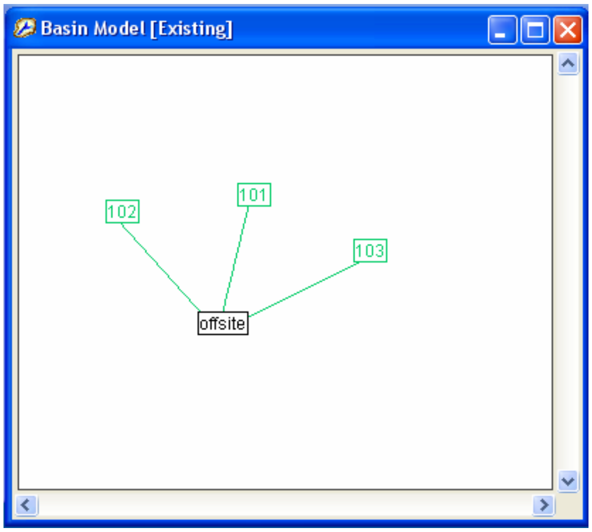
APPENDIX C

STORMWATER MANAGEMENT SYSTEM MODEL RESULTS

PROJECT NO.:	049846	DESIGNED BY:	RSS
PROJECT NAME:	Oliver Landfill O&C	CHECKED BY:	
DATE:	9 July 2009	PAGE 1 OF 1	

APPENDIX C : HEC-HMS Modeling Results

EXISTING BASIN MODEL



Global Summary Results for Run "Existing 25 YR"

Project: 49846 Oliver Landfill   Simulation Run: Existing 25 YR

Start of Run: 01Jan2008, 12:00   Basin Model: Existing
End of Run: 03Jan2008, 12:00   Meteorologic Model: 25 yr 24-hr storm
Compute Time: 13Feb2009, 10:42:27   Control Specifications: Oliver Landfill

Volume Units: MM 1000 M3

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
101	0.078	0.003	02Jan2008, 01:10	0.044
102	0.006	0.000	02Jan2008, 01:30	0.003
103	0.012	0.000	02Jan2008, 01:50	0.007
offsite	0.096	0.003	02Jan2008, 01:10	0.054

25 year 24 hour Storm Event

Global Summary Results for Run "Existing 100 Yr"

Project: 49846 Oliver Landfill   Simulation Run: Existing 100 Yr

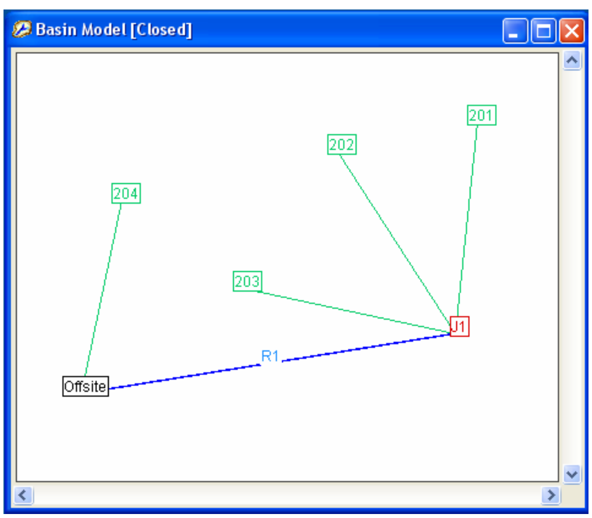
Start of Run: 01Jan2008, 12:00   Basin Model: Existing
End of Run: 03Jan2008, 12:00   Meteorologic Model: 100 yr 24-hr storm
Compute Time: 13Feb2009, 10:42:21   Control Specifications: Oliver Landfill

Volume Units: MM 1000 M3

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
101	0.078	0.004	02Jan2008, 00:50	0.054
102	0.006	0.000	02Jan2008, 02:10	0.009
103	0.012	0.000	02Jan2008, 02:30	0.018
offsite	0.096	0.004	02Jan2008, 01:10	0.081

100 year 24 hour Storm Event

CLOSED BASIN MODEL



Global Summary Results for Run "Closed 25 Yr"

Project: 49846 Oliver Landfill   Simulation Run: Closed 25 Yr

Start of Run: 01Jan2008, 12:00   Basin Model: Closed
End of Run: 03Jan2008, 12:00   Meteorologic Model: 25 yr 24-hr storm
Compute Time: 09Jul2009, 18:10:49   Control Specifications: Oliver Landfill

Volume Units: MM 1000 M3

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
201	0.0460	0.003	02Jan2008, 01:10	0.049
202	0.0181	0.007	02Jan2008, 00:50	0.078
203	0.0236	0.006	02Jan2008, 01:40	0.102
204	0.0187	0.004	02Jan2008, 01:50	0.081
J1	0.0641	0.010	02Jan2008, 00:50	0.128
Offsite	0.1064	0.017	02Jan2008, 01:30	0.310
R1	0.0877	0.014	02Jan2008, 01:10	0.229

25 year 24 hour Storm Event

Global Summary Results for Run "Closed 100 Yr"

Project: 49846 Oliver Landfill   Simulation Run: Closed 100 Yr

Start of Run: 01Jan2008, 12:00   Basin Model: Closed
End of Run: 03Jan2008, 12:00   Meteorologic Model: 100 yr 24-hr storm
Compute Time: 09Jul2009, 18:10:44   Control Specifications: Oliver Landfill

Volume Units: MM 1000 M3

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
201	0.0460	0.004	02Jan2008, 00:50	0.060
202	0.0181	0.026	02Jan2008, 00:30	0.154
203	0.0236	0.018	02Jan2008, 01:00	0.200
204	0.0187	0.013	02Jan2008, 01:10	0.158
J1	0.0641	0.030	02Jan2008, 00:30	0.214
Offsite	0.1064	0.050	02Jan2008, 00:50	0.571
R1	0.0877	0.040	02Jan2008, 00:40	0.414

100 year 24 hour Storm Event

APPENDIX D

LANDFILL DEVELOPMENT STAGE COST ANALYSIS

TABLE D-1

LANDFILL DEVELOPMENT COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
FENCING					
	Fencing	m	589	$ 44.00	$25,916
EARTHWORKS					
	Base excavation, sorting, stockpiling and final placement	m^3	89,340	$ 10.00	$893,400
	Soil Excavation: Cover Material	m^3	45,900	$ 4.00	$183,600
	Rock Cut	m^3	650	$ 200.00	$130,000
SURFACE WATER CONTROL					
	Clearing	m^2	2,502	$ 2.50	$6,255
	Perimeter Ditches	m	1,251	$ 100.00	$125,100
	Culverts	m	63	$ 200.00	$12,600
FINAL COVER					
	Seed and mulch	m^2	63,594	$ 2.00	$127,188
	Place and compact silty soil (from on-Site source)	m^3	66,774	$ 7.00	$467,416
	Place and grade topsoil	m^2	9,539	$ 12.00	$114,469
ACCESS ROADS					
	Perimeter access road	m	1,143	$ 50.00	$57,150
MISCELLANEOUS					
	Installation of new monitoring wells	each	3	$ 6,000.00	$18,000
				SUBTOTAL	$2,161,094
ADMINISTRATIVE AND EXECUTION REQUIREMENTS (15% of Subtotal)	Bonds, Insurance, Mobilization and Startup, Temporary Facilities and Controls, Demobilization and Closeout.				$324,164
CONTINGENCY ALLOWANCE (10% of subtotal)					$216,109
ENGINEERING ALLOWANCE (15% of subtotal)					$324,164
				TOTAL (Excluding GST)	$3,025,600

TABLE D-2

LANDFILL DEVELOPMENT COST SUMMARY BY STAGE
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

STAGE	TOTAL COST (1)	ESTIMATED COMPLETION YEAR
STAGE 1	$838,400	2021
STAGE 2	$289,300	2027
STAGE 3	$1,435,500	2044
STAGE 4	$431,300	2050
	$2,994,500	

Notes:

(1) Including administrative and execution requirements, contingency allowance, and engineering allowance.

TABLE D-3

STAGE 1 DEVELOPMENT COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
FENCING					
	Fencing	m	589	$ 44.00	$25,916
EARTHWORKS					
	Soil Excavation: Cover Material	m^3	19,400	$ 4.00	$77,600
	Rock Cut	m^3	650	$ 200.00	$130,000
SURFACE WATER CONTROL					
	Clearing	m^2	2,502	$ 2.50	$6,255
	Perimeter Ditches	m	1,251	$ 100.00	$125,100
	Culverts	m	63	$ 200.00	$12,600
FINAL COVER					
	Seed and mulch	m^2	13,539	$ 2.00	$27,078
	Place and compact silty soil (from on-Site source)	m^3	13,539	$ 7.00	$94,773
	Place and grade topsoil	m^3	2,031	$ 12.00	$24,370
ACCESS ROADS					
	Perimeter access road	m	1,143	$ 50.00	$57,150
MISCELLANEOUS					
	Installation of new monitoring wells	each	3	$ 6,000.00	$18,000
				SUBTOTAL	$598,842
ADMINISTRATIVE AND EXECUTION REQUIREMENTS (15% of Subtotal)					$89,826
	Bonds, Insurance, Mobilization and Startup, Temporary Facilities and Controls, Demobilization and Closeout.				
CONTINGENCY ALLOWANCE (10% of subtotal)					$59,884
ENGINEERING ALLOWANCE (15% of subtotal)					$89,826
				TOTAL (Excluding GST)	$838,400

TABLE D-4

STAGE 2 DEVELOPMENT COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
FENCING					
	Fencing	m	0	$ 44.00	$0
EARTHWORKS					
	Soil Excavation: Cover Material	m^3	26,500	$ 4.00	$106,000
SURFACE WATER CONTROL					
	Clearing	m^2	0	$ 2.50	$0
	Perimeter Ditches	m	0	$ 100.00	$0
	Culverts	m	0	$ 200.00	$0
FINAL COVER					
	Seed and mulch	m^2	9,314	$ 2.00	$18,628
	Place and compact silty soil (from on-Site source)	m^3	9,314	$ 7.00	$65,198
	Place and grade topsoil	m^3	1,397	$ 12.00	$16,765
ACCESS ROADS					
	Perimeter access road	m	0	$ 50.00	$0
MISCELLANEOUS					
	Installation of new monitoring wells	each	0	$ 6,000.00	$0
				SUBTOTAL	$206,591
ADMINISTRATIVE AND EXECUTION REQUIREMENTS (15% of Subtotal)	Bonds, Insurance, Mobilization and Startup, Temporary Facilities and Controls, Demobilization and Closeout.				$30,989
CONTINGENCY ALLOWANCE (10% of subtotal)					$20,659
ENGINEERING ALLOWANCE (15% of subtotal)					$30,989
				TOTAL (Excluding GST)	$289,300

TABLE D-5

STAGE 3 DEVELOPMENT COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

ITEM	DESCRIPTION	UNIT	QUANTITY		UNIT PRICE	TOTAL PRICE
FENCING						
	Fencing	m	0	$	44.00	$0
EARTHWORKS						
	Base excavation, sorting, stockpiling and final placement	m^3	89,340	$	10.00	$893,400
	Soil Excavation: Cover Material	m^3	0	$	4.00	$0
SURFACE WATER CONTROL						
	Clearing	m^2	0	$	2.50	$0
	Perimeter Ditches	m	0	$	100.00	$0
	Culverts	m	0	$	200.00	$0
FINAL COVER						
	Seed and mulch	m^2	12,216	$	2.00	$24,432
	Place and compact silty soil (from on-Site source)	m^3	12,216	$	7.00	$85,512
	Place and grade topsoil	m^3	1,832	$	12.00	$21,989
ACCESS ROADS						
	Perimeter access road	m	0	$	50.00	$0
MISCELLANEOUS						
	Installation of new monitoring wells	each	0	$	6,000.00	$0
					SUBTOTAL	$1,025,333
ADMINISTRATIVE AND EXECUTION REQUIREMENTS (15% of Subtotal)	Bonds, Insurance, Mobilization and Startup, Temporary Facilities and Controls, Demobilization and Closeout.					$153,800
CONTINGENCY ALLOWANCE (10% of subtotal)						$102,533
ENGINEERING ALLOWANCE (15% of subtotal)						$153,800
					TOTAL (Excluding GST)	$1,435,500

TABLE D-6

STAGE 4 DEVELOPMENT COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
FENCING					
	Fencing	m	0	$ 44.00	$0
EARTHWORKS					
	Soil Excavation: Cover Material	m^3	0	$ 4.00	$0
SURFACE WATER CONTROL					
	Clearing	m^2	0	$ 2.50	$0
	Perimeter Ditches	m	0	$ 100.00	$0
	Culverts	m	0	$ 200.00	$0
FINAL COVER					
	Seed and mulch	m^2	28,525	$ 2.00	$57,050
	Place and compact silty soil (from on-Site source)	m^3	28,525	$ 7.00	$199,675
	Place and grade topsoil	m^3	4,279	$ 12.00	$51,345
ACCESS ROADS					
	Perimeter access road	m	0	$ 50.00	$0
MISCELLANEOUS					
	Installation of new monitoring wells	each	0	$ 6,000.00	$0
				SUBTOTAL	$308,070
ADMINISTRATIVE AND EXECUTION REQUIREMENTS (15% of Subtotal)	Bonds, Insurance, Mobilization and Startup, Temporary Facilities and Controls, Demobilization and Closeout.				$46,211
CONTINGENCY ALLOWANCE (10% of subtotal)					$30,807
ENGINEERING ALLOWANCE (15% of subtotal)					$46,211
				TOTAL (Excluding GST)	$431,300

TABLE D-7

ENVIRONMENTAL MONITORING AND MAINTENANCE COST SUMMARY
DESIGN AND OPERATIONS PLAN
OLIVER LANDFILL SITE
OLIVER, BC

Item	*Description*	*Unit*	*Unit Cost* ($)	*# Units* (frequency per year)	*Cost*
1)	Monitoring Well Maintenance				
	a) Groundwater Monitoring Wells (7 wells) (1)	per well	$5,000.00	0.8	$4,000.00
2)	Annual Site Inspections	visit	$3,000.00	1	$3,000.00
3)	Annual Monitoring Program	L.S.	$24,000.00	1	$24,000.00
4)	Annual Monitoring Reporting	L.S.	$7,000.00	1	$7,000.00
5)	General Site Maintenance				
	a) Landscaping	event	$3,000.00	0.5	$1,500.00
6)	Surface Water Management Maintenance				
	a) Grading of ditches / erosion control / repair	event	$5,000.00	0.3	$1,500.00
	Total				**$41,000.00**

Notes:

'(1) Frequency of 0.1 per year for 8 monitoring wells, or 0.8 frequency.