2018 Design, Operations, and Closure Plan

Glenmore Landfill
Kelowna, British Columbia

City of Kelowna

GHD | 10271 Shellbridge Way Suite 165 Richmond British Columbia V6X 2W8 Canada | 084612 | Report No 04 | November 30 2018

Table of Contents

Figure Index

Table Index

Table Index (following text)

Drawing Index

Appendix Index

Symbols and Abbreviations

%	Percent
ACM	Asbestos containing material
ALC	BC Agricultural Land Commission
ALR	Agricultural Land Reserve
AMSL	Above Mean Sea Level
ASP	Aerated Static Pile
BC	British Columbia
BTU	British thermal unit
BOD	Biological Oxygen Demand
C&D waste	Construction and Demolition Waste
cfm	Cubic Feet Per Minute
City	City of Kelowna
CLS	Contaminating Lifespan
cm/s	Centimetre per second
COD	Chemical Oxygen Demand
CSDP	Comprehensive Site Development Plan (CH2M HILL, 2008)
CSR	Contaminated Sites Regulation
District	Regional District of Central Okanagan
DOCP	Design, Operations, and Closure Plan

DW	Drinking Water
ECS	Engineered Compost Systems
EMA	Environmental Management Act
EMP	Environmental Monitoring Program
ENV	British Columbia Ministry of Environment and Climate Change (Formerly BC Ministry of Environment)
FOS	Factor of Safety
FWAL	Fresh Water Aquatic Life
GEID	Glenmore Ellison Irrigation District
GCL	Geosynthetic Clay Liner
GHD	GHD Limited
Ha	Hectare
HDPE	High Density Polyethylene
HEC-HMS	Hydrologic Engineering Centre-Hydrologic Modelling System
HELP	Hydrologic Evaluation of Landfill Performance
HWR	Hazardous Waste Regulation
IDF	Intensity-Duration-Frequency
km	Kilometre
Landfill	Waste footprint of the Glenmore Landfill
Landfill Criteria	Second Edition Landfill Criteria for Municipal Solid Waste, dated June 2016
LFG	Landfill Gas
LMP	Leachate Management Plan
LTF	Leachate Treatment Facility
m	Metre
m^2	Square metre
m^3	Cubic metre
mm	Millimetre
mm^2	Square millimetre
mm/yr	Millimetre per year
MOE	British Columbia Ministry of Environment (Former name for BC Ministry of Environment and Climate Change Strategy)
MSW	Municipal Solid Waste
NBCC	National Building Code of Canada
NRC	Natural Resources Canada
O&M	Operations and Maintenance
OC	Operational Certificate (12218)
PGA	Peak ground acceleration

PID	Parcel Identification
QA/QC	Quality Assurance and Quality Control
RCRA	Resource Conservation and Recovery Act
RFID	Radio-frequency identification
RDCO	Regional District of Central Okanagan
ROW	Right of way
Site	Glenmore Landfill and surrounding property included in the OC
SSO	Separated source organics
SWP	Surface Water Management Plan
SWMP	Solid Waste Management Plan
t/m^3	Tonnes per cubic metre
TDG	Transportation of Dangerous Goods
UBCO	University of British Columbia Okanagan
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
WQG	Water Quality Guidelines
WSA	Waste Sustainability Act

1. Introduction

The following report presents the 2018 Design, Operations, and Closure Plan (DOCP) for the Glenmore Landfill. The DOCP is an update to the approved 2008 Comprehensive Site Development Plan (CSDP) and provides the Landfill development plan for the next 10 years. The DOCP has been prepared to meet the requirements of the Operation Certificate No.12218 (OC) and the Landfill Criteria for Municipal Solid Waste (Landfill Criteria) (BC Ministry of Environment, 2016).

The Glenmore Landfill is owned by the City of Kelowna and is authorized to landfill 170,000 tonnes of waste per year from within the Regional District of Central Okanagan (RDCO) and the Big White area. The Landfill is a multi-purpose waste management facility, providing waste management services for non-hazardous solid waste from municipal, commercial, institutional and light industrial sources. The Glenmore Landfill is identified in the draft 2017 Solid Waste Management Plan (SWMP) and approved 2006 SWMP as a landfill and waste management facility in the Regional District of Central Okanagan (RDCO).

For the purpose of this report, the term *Landfill* refers to the Glenmore Landfill waste footprint, including future fill areas, and the term *Site* refers to the Landfill and adjacent City owned property that support Landfill operations as outlined in the OC. The OC was last amended in 2015.

2. Purpose and Scope

The purpose of this document is to provide the design, operations and closure plan for the Landfill; and to fulfill the requirements specified in the OC (Appendix A) and the Landfill Criteria, both issued by the BC Ministry of Environment and Climate Change (ENV).

The scope of the DOCP is to:

- Describe of the facility and the physical setting of the Site.
- Present the 10-year conceptual design of the Landfill including the base liner system, leachate collection system, and final cover.
- Present the Surface Water Management Plan and Leachate Management Plan for the Site.
- Identify major capital works required to implement the Landfill Development Plan.
- Demonstrate that the Landfill Criteria design objectives and minimal requirements for the Landfill and environmental control systems are met.
- Present the operational procedures for waste acceptance and landfilling.
- Present the environmental monitoring and Landfill monitoring plans.
- Present the closure and post-closure requirements for the Landfill.

3. Regulatory Setting

The Landfill is approved as a regional landfill and waste management facility through ministerial approval of the RDCO's 2006 Solid Waste Management Plan (SWMP) (Earth Tech (Canada) Inc, 2006) under the Environmental Management Act. The RDCO and member municipalities are authorized to manage solid waste in the region in accordance with the approved SWMP. The long-term vision of the SWMP is to increase diversion of waste from Landfill through the introduction of municipal waste diversion programs, maintaining a user pay system, and lobbying the Provincial Government to increase the number of product stewardship programs. An updated SWMP (Morrison Hershfield, 2017) prepared in 2016 and submitted to ENV in 2017, identifies the Site as the operational landfill within the region. The 2016 SWMP includes additional waste diversion initiatives and targets a regional waste diversion rate of 50% by 2022 and an average residual disposal rate of 600 kg per capita by 2022.

The Landfill is designed, constructed, operated, and monitored in accordance with the OC, regulations under EMA, and ENV guidance documents. In addition, there are federal, provincial and municipal acts, regulations and by-laws that are application to the design and operations of the Site.

Table 3.1 summarizes the regulatory framework within which the Landfill is authorized and operates.

Table 3.1 Regulatory Framework

Regulation/Guideline/Approval	Summary	Regulating Body
Environmental Management Act (EMA)	Governs any matter relating to the management, protection and enhancement of the environment. The approval of solid waste management plans by the minister of the environment is authorized under EMA. EMA approves the lieutenant Governor in Council to make and enforce regulations. If a solid waste management plan is approved by the minister, EMA authorizes the director to issue an operational certificate to the municipality or owner of a site or facility covered by a waste management plan.	ENV
Operational Certificate No. 12218 (OC)	The OC authorizes the discharge of waste with the conditions listed in the OC. The OC cannot conflict with the approved solid waste management plan and the conditions in the OC take precedence over regulations and guidance.	ENV

Regulation/Guideline/Approval	Summary	Regulating Body
Regulations under EMA	Applicable regulations include: • Contaminated Sites Regulation (CSR) • Hazardous Waste Regulation (HWR) • Landfill Gas Management Regulation (LFGR) • Organic Matter Recycling Regulation (OMMR)	ENV
Second Edition Landfill Criteria for Municipal Solid Waste, June 2016 (Landfill Criteria)	Guidance document outlining recommended practices for Landfill design, construction, operation and monitoring.	ENV
Approved Water Quality Guidelines and Working Water Quality Guidelines (WQGs)	Approved WQGs are policy statements and applied province wide, providing the basis for water quality assessments and informing decision-making in the natural resource sector. Working Guidelines provides environmental benchmarks for safe levels of substances for the protection of a given water use and have not yet been approved by the Province.	ENV
Landfill Gas Generation Assessment Procedure Guidance (2009)	Guidance document on a procedure for the assessment of landfill gas (LFG) generation at municipal solid waste landfills in BC.	ENV
Landfill Gas Management Facilities Design Guidelines (2010)	Guidance document for the design and operation of LFG collection and destruction system in BC.	ENV
Zoning Bylaw 8000	The Zoning Bylaw 8000 governs land use and the form, siting, height, density of all development within the City boundaries to provide for the orderly development of the community and to avoid conflicts between incompatible uses. The Bylaw divides the City into residential, commercial, agricultural, institutional, industrial and other zones. Each of these zones has its own specific regulations.	City of Kelowna

Regulation/Guideline/Approval	Summary	Regulating Body
Agricultural Land Commission Act	Sets the legislative framework for the establishment and administration of the agricultural land preservation program, and identifies farm activities and non-farm uses that are permitted on land designated as part of the Agricultural Land Reserve (ALR). Portions of the Site are in the ALR and have an approval from the Agricultural Land Commission.	BC Agricultural Land Commission (ALC)
Sanitary Sewer/Storm Drain Regulation Bylaw No. 6618-90	Authorizes the discharge of non-domestic wastewater (e.g. leachate) to sanitary sewer.	City of Kelowna
Water Sustainability Act (WSA)	Law for managing the diversion and use of water resources. The WSA provides important new tools and updates BC's strategy for protecting, managing and using water efficiently throughout the province. Municipalities are generally exempt from the WSA under Section 32 – local government drainage works if water is not used for a water use purpose. Water use for irrigation, however, is not exempt under this section.	ENV
Conditional Water Licence 123789	Licence to divert water from the northeast pond to Bredin Pond. (The City is applying to include authorization to use the water for irrigation but a final licence had not been received at the time of this report.)	ENV
Solid Waste Management Bylaw No. 10106	This bylaw sets out the regulations for the City's residential garbage collection system and landfill. It includes the types of waste permitted, disposal requirements for specific types of waste and materials that are prohibited from the landfill. The bylaw also sets out the landfill disposal fees, garbage pick-up rates and special annual levy for landfill disposal costs.	City of Kelowna
National Pollutant Release Inventory (NPRI)	Reporting of pollutant releases to air, land, and water. City reports pollutants from leachate sent to WWTP and air emissions from dust and landfill gas fugitive emissions and combustion.	Federal Ministry of Environment and Climate Change

4. Site Background

4.1 Site Location and Setting

The Landfill and administration building are located at 2720 John Hindle Drive in Kelowna, BC approximately 1.5 kilometres (km) east of Okanagan Lake and 9 km northeast of downtown Kelowna. The Scale House civic address is 2710 John Hindle Drive. The Landfill is situated in a narrow-flat bottomed valley known as Glenmore Valley surrounded by two ridges, Bredin Hill on the northeast and Tutt Mountain on the southeast. The adjacent land use is a mix of roads, rural development, agricultural and natural forested land. The Site consists of the following main areas, as shown on Figure 4.1:

- Phase 1 – active disposal area located in the northern portion of the Landfill.
- Phase 2 – active disposal area located in the central portion of the Landfill.
- Phase 3 – historical and future disposal area located south of Phase 2. Phase 3 currently consists of a slough.
- Compost Facility – located in the south of Phase 3 and currently used for composting operations.
- Northeast Area – area located in the northeast corner of the Landfill that includes the Northeast Pond.
- Scale House/Public Drop-Off Area – Landfill entrance and public drop-off area located at the south end of the Site.

4.2 Legal Description

The ENV site reference number for the waste discharge is E104956. The Site occupies the following land parcels:

- All of Parcel Identification (PID) 024-353-281
- Part of PID 024-353-302
- All of PID 024-353-329
- All of PID 024-353-752
- All of PID 011-843-322
- All of PID 011-843-331
- All of PID 011-843-357
- All of PID 011-843-365
- All of PID 011-843-373
- All of PID 011-845-163
- All of PID 011-843-381
- Part of PID 029-954-444

- All of PID 024-954-398
- All of PID 011-843-071
- All of PID 011-843-187
- All of PID 011-843-195
- All of PID 011-843-209
- All of PID 011-843-217

4.3 Landfill Development and History

The City opened the Glenmore Landfill in 1966 and began operations by infilling the slough area (located in Phase 3) previously known as Alki Lake. The Landfill is located on land that was originally leased from two local land owners, and later purchased by the City. The southern portion of the Landfill previously known as the Tutt Lease (Phase 3) comprises approximately 28 hectares (ha) and is currently a slough. Landfill cells were developed at the bottom of the slough by excavating approximately 4.5 metre (m) deep trenches and constructing soil berms around the cell. The cells were installed in an irregular pattern throughout the slough area. The northern end of the slough received two lifts of waste and the southern end received one lift (CH2M HILL Canada Limited, 2008). Landfilling in the Phase 3 area ceased in the early 1980s. Since, the waste trenches have become covered by standing water with a grid pattern of roads constructed from site soils and construction and demolition waste protruding above the waterline in certain locations. The grid pattern of roads is a result of temporary access roads that were constructed to enable environmental drilling investigations in the slough. The slough has become nesting habitat for birds, including the American avocet. The City has been filling the Phase 3 area seasonally with coarse construction and demolition debris (e.g. wood, concrete, rubble) as per the approved CSDP (CH2M HILL, 2008).

The northern portion of the Landfill, previously known as the Bredin Lease, comprises approximately 53 ha and includes the Phase 1 and 2 Areas of the active Landfill area. Waste has been actively discharged to the Bredin Lease Area since 1966 (CH2M HILL Canada Limited, 2008). In 2001, a Landfill cell with an engineered liner and leachate collection system was constructed at the northern end of the Site (known as the Northern Expansion).

The City purchased additional properties around the active Landfill area, which are often referred to as the Acquisition Lands. The Acquisition Lands originally consisted of parcels to the north and east of the Bredin Lease. More recently, land to the south of the Phase 3 Area was purchased to support landfill activities, as well as the construction of John Hindle Drive.

4.4 Zoning and Adjacent Land Use

The majority of the Site is zoned as A-1 (Agricultural) and forms part of the Agricultural Land Reserve (ALR). The entrance facilities are located on a lot zoned for P-4 (Utilities). The operation of the Landfill on properties zoned as A-1 is a legal non-conforming land use for the property. Appropriate solid waste zoning of the lands around the Landfill is being established by the City Planning Department to enable the future development of the Site.

Land use immediately to the north and south of the Landfill is agricultural and rural-residential. McKinley Reservoir is located approximately 1 km to the northwest of the Site and is operated by the Glenmore Ellison Irrigation District (GEID). North Glenmore Dog Park is located northwest of the Landfill. Tutt Farm is located west of the Site, at north-east intersection of Glenmore Road and John Hindle Drive. The land across Glenmore Road west of the Site is primarily mountainous. The Quail Ridge subdivision is located to the east of the Site, and is separated from the Landfill footprint by the City-owned Acquisition Lands. Quail Ridge Linear Park is also located east of the Landfill and the Quail Ridge Flume Trail follows the path of historic flume that diverted water from north of the Site to the Brandt Creek area. John Hindle Drive connects the Glenmore Landfill and the University of British Columbia Okanagan (UBCO) campus.

Figure 4.2 provides a map of the zoning and land use within 1 km of the Site.

4.5 Landfill Criteria Buffer Zones

The Landfill Criteria stipulates buffer zones around MSW landfills with recommended set-back distances to various features when siting a landfill, as summarized below:

- No landfilling is to take place within 50 m of the property boundary, of which the 30 m closest to the property boundary is to be reserved for natural or landscaped vegetative screening. Depending on adjacent land use and environmental factors, buffer zones of less than 50 m but not less than 15 m may be authorized by the Director.
- Minimum 500 m buffer zone between the limit of refuse and an existing or planned sensitive land use. Sensitive land uses include, but are not limited to: schools, residences, hotels, restaurants, cemeteries, food processing facilities, churches and municipal parks.
- Minimum 100 m buffer zone between the limit of refuse and a heritage or archaeological site.
- Minimum 8 kilometer (km) buffer zone between the limit of refuse and an airport.
- Minimum 300 m buffer zone between the limit of refuse and a water supply well or water supply intake.
- Minimum 500 m buffer zone between the limit of refuse and a municipal or other high capacity water supply well.
- Minimum 100 m buffer zone between the limit of refuse and surface water.
- Minimum 100 m buffer zone between the limit of refuse and the sea level maximum high tide or seasonal high watermark of an inland lake shoreline.

Figure 4.3 illustrates the 50 m, 100 m, 300 m and 500 m buffer zones from the final Landfill footprint. As shown in Figure 4.3, the Landfill property boundary is greater than 50 m from the Landfill footprint. The Landfill footprint is greater than 300 m but less than 500 m from one residence north of the Landfill and 2 residences northwest of the Landfill. The 1993 Landfill Criteria provided a recommended buffer distance to residences of 300 m, which was subsequently amended to 500 m in the 2016 Landfill Criteria. The Landfill footprint in the northwest corner was established prior to 2016. The residence and property north of the Landfill footprint is owned by the City.

4.6 Nuisance Assessment Impact Areas

A Landfill nuisance study was completed to assess the potential extent of current and future nuisance impacts from landfill operations (Conestoga-Rovers & Associates, 2014) (GHD, 2017). Figure 4.4 illustrates the modelled boundaries of nuisance impacts including:

- Extent of odour impact of 5 odour units, greater than 0.5 percent of the time on an annual basis
- Extent of odour impacts of 1 odour unit, greater than 0.5 percent of the time on an annual basis
- Extent of dust impacts of over 120 ug/m^3 greater than 3 percent of the time
- Extent of noise impacts up to 50 dB during daytime steady state levels

The City will be undertaking additional nuisance impact modelling and the extent of modelled nuisance impacts should be updated with the next DOCP update.

5. Site Physical Characteristics

5.1 Topography

The topography of the Okanagan area is a result of past periods of glaciation, which carved out the north-south trending Okanagan Valley. The Site is situated within a shallow bowl that is bounded by the walls of Glenmore Valley. Glenmore Valley trends north-south, generally parallel with the Okanagan Lake. The valley floor gradually slopes towards the south with some bedrock knolls such as Diamond Mountain immediately south of the Site property boundary. Two small mountains, Bredin Hill and Tutt Mountain, are located to the northeast and southeast of the Site, respectively.

The valley floor is at an elevation of approximately 440 m above mean sea level (AMSL) and the sides of the valley reach heights of approximately 560 m AMSL. The area to the north of the Site slopes up to the north and reaches heights of approximately 520 m AMSL. The area immediate to the south of the Site slopes to the south to an approximate elevation of 435 m AMSL.

A map presenting the topography in the vicinity of the Site is provided on Figure 5.1.

5.2 Drainage and Watercourses

5.2.1 Regional Surface Water Bodies

Okanagan Lake is located approximately 1.5 km to the west of the Site. Okanagan Lake drains into the Okanagan River, which subsequently drains to Lake Skaha, Vaseux Lake, then Osoyoos Lake, and ultimately to the Columbia River. The Site is located upstream of Mill Creek and Brandt's Creek, however there are no direct surface drainage pathways between the Site and these surface water bodies. Brandt's Creek and Mill Creek both flow from northeast to southwest and ultimately discharge to Okanagan Lake.

Little Robert Lake and Robert Lake are located approximately 250 m south and 650 m southeast, respectively, of the southern Site boundary. Bubna Slough, a natural alkaline lake, is located approximately 1.5 km north of the Site. McKinley Reservoir is located approximately 1 km to the northwest of the Site.

5.2.2 Site Drainage

Before to the inception of the Landfill at the Site, an alkaline lake known as Alki Lake occupied the area. The lake was recharged by direct precipitation and overland flows from i) McKinley Reservoir and Bubna Slough via an old channel entering the northwest corner of the Site, ii) an area northeast of the present-day Northeast Pond, iii) by a small pond to the west of Alki Lake (Golder, 2012), and iv) groundwater discharge may also have been included at Alki Lake. A surface water outlet is inferred to have been historically present at the southwest corner of Alki Lake, with flows directed into Little Robert Lake and then Robert Lake (Golder, 2012).

When landfilling commenced at the Site, waste was deposited into Alki Lake to infill it (Gartner Lee Limited, 1990). Presently, the remaining portion of Alki Lake is referred to as Phase 3 or the Slough. The former Alki Lake/Slough does not have any overland outlet drainages and are drained by the Landfill leachate collection system. Groundwater migration from the Slough to the south may also be occurring.

At present-day, all surface water flow into the Site is contained and/or managed within the Site, with no surface water flow off the Site property. Site surface water run-off is managed in three constructed ponds, Northeast Pond, Bredin Pond, and Tutt Pond. Surface water from the Northeast Pond flows to Bredin Pond, which flows into Tutt Pond. An overflow pipe links Tutt Pond to the Slough. Water in the ponds is used for irrigation purposes on adjacent agricultural lands.

The ponds are further described in Section 6.9.

5.3 Geology

5.3.1 Regional Geology

Bedrock geology to the east of Okanagan Lake is primarily composed of Proterozoic to Mesozoic aged gneisses and schists intruded by Mesozoic aged Nelson Plutonic Suite composed of mozonites, granites, and granodiorites. A series of lava flows and sedimentary inclusions including the Yellow Lake Member, Marron Formation, and White Lake Formation were deposited during the Eocene Epoch (Okulitch, 2013). These Eocene aged formations have been structurally fractured and faulted (Gartner Lee Limited, 1990).

Overburden geology in the Okanagan area is dictated by the previous glaciation and post-glaciation activities in the region. In general, glacial till overlays the bedrock, which is overlaid by glaciofluvial sands and gravels. During the post-glaciation period, glaciolacustrine silts and clays were deposited over the glaciofluvial sands and gravels (Gartner Lee Limited, 1990).

5.3.2 Local Geology

Bedrock outcrops at the ridges along the western and eastern sides of the Site. Overburden material is primarily found in the valley floor and pinches out towards the sides of the valley. Bredin Hill and Tutt Mountain are ridges located to the northeast and to the southeast of the Landfill, respectively.

Based on previous investigations and data interpretations completed by Gartner Lee Limited (1990, 1992), Golder Associates (2005, 2009, 2014), EBA and SLR (2011, 2012), two bedrock units are encountered at the Site. From borehole log lithology, a volcanic bedrock is generally encountered in the northern, central, and eastern areas of the Site. A description of the volcanic bedrock is not provided in the Site borehole logs. In the southern and western areas of the Site, a sedimentary bedrock composed of siltstones, mudstones and sandstones is encountered. It is interpreted that the sedimentary bedrock deposits are part of the White Lake Formation (Golder Associates Ltd., 2014).

Two normal faults are located in the vicinity of the Site as well as within the existing boundaries of the Landfill, however it is interpreted that these faults are inactive as the Holocene aged overburden materials do not appear to be disturbed by fault movements (Golder Associates Ltd., 2014).

Overburden geology at the Site is similar to the regional overburden geology description provided in Section 5.3.1. Glacial till overlies the bedrock at the Site and is estimated to range between 0 and 25 m in thickness (Gartner Lee Limited, 1990). The glaciofluvial sands and gravels overlie the till and are estimated to be 0 to 9 m thick. Glaciolacustrine silt and clay deposits are on top of the glaciofluvial sands and gravels and are approximately 15 m thick in the centre of the Site.

5.4 Hydrogeology

5.4.1 Regional Hydrogeology

The BC aquifer classification system indicates Aquifer 469 and Aquifer 470 are present in the areas at and around the Site. Aquifer 469 is an overburden aquifer composed of sands and gravels with moderate productivity, low vulnerability, and low demand. Aquifer 470 is a bedrock aquifer composed of volcanic rocks likely belonging to the Penticton Group or Harper Ranch Group (BC Ministry of Environment, 2012).

5.4.2 Local Hydrogeology

Horizontal groundwater flow primarily occurs in the sand and gravel overburden deposits and the underlying bedrock.

Groundwater in both the sand and gravel and bedrock aquifers flows horizontally towards the centre of the Site from the walls of the valley located to the east and west of the Site. Groundwater within the overburden also flows from north to south along the floor of the valley.

The estimated range of horizontal hydraulic conductivities of each of these units is listed in the table below:

Table 5.1 Hydraulic Conductivities

Unit	Hydraulic Conductivity
Clay	10-6 to 10-9 cm/s
Sand and gravel	10-2 to 10-6 cm/s
Till	10-5 to 10-9 cm/s
Bedrock	10-2 to 10-6 cm/s
Source: (Gartner Lee Limited, 1992)	

In general, vertical groundwater flow is in the upwards direction within the lower elevations of the Site. Minimal vertical groundwater migration is observed near the sidewalls of Glenmore Valley, (Gartner Lee Limited, 1992). At some nested monitoring locations, a downwards vertical gradient has been observed, including the GL6/GL18, GL8/GL16, GL15, GL27, and GL28 well series (Golder Associates Ltd., 2012). These groundwater monitoring locations are located in the vicinity of the Slough.

Groundwater flow throughout the Site is also noted to be upwards provided the leachate level within the Landfill is maintained at an elevation at or below 437 m AMSL. (Golder Associates Ltd., 2016)

5.5 Groundwater Use

From iMapBC (accessed May 7, 2018) there are three water wells located within a one km radius of the Site. The water uses for each of the three water wells are indicated as either unknown, other, or not listed. Well tags 19830, 20594, and 71857 were installed in 1966, 1967, and 1979, respectively. These three wells are all located hydraulically upgradient from the Site.

The well licenses and a map indicating the well locations are included in Appendix B.

In March 2014, SLR completed a door-to-door survey to locate any water wells within a 500 m radius of the Site. SLR did not identify any existing water wells during the door-to-door survey (SLR Consulting Canada Ltd., 2015).

5.6 Surface Water Use

From iMapBC (accessed May 7, 2018), four surface water points of diversion are located within a one km radius of the Site. Three of the four points of diversion (licenses C029197, C034631, and C061861) are located on McKinley Reservoir. Points of diversion licenses C029197, C034631, and C061861 are all for the storage of water diverted from Kelowna Creek in the McKinley Reservoir.

Surface water point of diversion C123789 is for the damming and storage of water from Northeast Pond associated with managing surface water on the Landfill Site.

The point of diversion licenses and a map indicating their locations are included in Appendix B.

5.7 Climate

The climate of the Central Okanagan is marked by hot, dry summers, and cool winters. Climatic data for the Site is based on Environment Canada's Climate Normals measured between 1981 and 2010 at the Kelowna climate station (Climate ID 1123970). Climate ID 1123970 is located at the Kelowna Airport approximately 2.5 km to the east of the Site at an elevation of approximately 430 m AMSL. The average annual temperature is 8.1 degrees Celsius. The average annual precipitation is 386.9 millimetres (mm). On average 89 centimetres (cm) of snowfall is recorded per year. The average total monthly precipitation and average daily temperature records are presented in Table 5.1, following the text.

6. Existing Site Infrastructure and Operations

6.1 Entrance Facilities and Scale House

The Site entrance and scale house are located in the southeast corner of the Site off John Hindle Drive. In 2014, the new landfill entrance works were commissioned, and use of the former public drop-off area adjacent to Phase 1 was discontinued.

The City installed two unattended scale terminals on the outer inbound and outbound scales in 2013. These two scales were automated with Radio-frequency identification (RFID) access cards and control gates that allow high volume commercial haulers to access the Landfill. The unattended system was rolled out in 2015 using a staged approach, and the program was expanded in 2018. These automated scales may be converted to manual operations at any time to help manage high traffic volumes.

6.2 Public Drop-Off Areas

The public drop-off area comprises of a grade-separated drop-off wall with 17 roll-off bin bays, and an at-grade recycling sorting area. Each bay is labelled with the accepted material to be deposited in the corresponding bin.

6.3 Tipping Fees and Hours of Operations

Tipping fees and hours of operations for the Glenmore Landfill are published on the City's website. At the time of writing, the Landfill is open seven days a week from 7:30 a.m. to 4:45 p.m. Tipping fees were last changed on January 18, 2018 in accordance with the Solid Waste Management Bylaw No. 10106.

6.4 Fencing

The Site perimeter is partially fenced. Vehicular access is blocked by chain link gates on the southern boundary of the Site north of John Hindle Drive. Agricultural fencing surrounds the portion of the Site property leased for the cattle farm on the southeast and southwest corners of the Site. The western Site perimeter is fenced with a chain link fence and gates at the former entrance. An agricultural fence just north of the Landfill separates the field located to the north. Additional fencing was installed east of Bredin Hill in 2018. There are no fences east of Tutt Mountain; however, the mountain itself is a physical barrier to Landfill access.

6.5 Material Stockpile Areas

Various material stockpiles are staged on the Landfill including:

- Concrete
- Asphalt
- Asphalt shingles
- Drywall

- Tires and rims
- Yard waste
- Clean wood
- Painted wood

The stockpiles above are currently managed in the eastern portion of Phase 1 and 2. The City has developed a plan to relocate the stockpiles to the current compost area south of Phase 3 from 2019 to 2023.

Drywall is managed in two different ways at the Site. Drywall scraps from new construction (new drywall) is stockpiled and then transferred off Site for recycling, whereas drywall from renovations or demolitions (used drywall) is managed in a landfill monocell or buried at the active face.

6.6 Composting

Two soil conditioner/ soil amendment products, OgoGrow and GlenGrow are publically available for purchase at the Site.

Organic wastes including yard waste, prunings and some clean construction wood waste are composted on-Site and sold as soil conditioner called GlenGrow. The production of GlenGrow compost is located at the 10-hectare site constructed to the south of the Phase 3 area of the Landfill. Stockpiling and grinding of yard waste feedstock is still accomplished in the receiving area east of Phase 2. Plans are in the works for relocating the organics and recyclable receiving area adjacent the composting facility to the south of the Phase 3 slough.

OgoGrow is a biosolids based compost produced at the Regional Compost Facility, off-Site. Inputs into the production of OgoGrow include hogfuel and ash from the local forestry industry. The City exchanges clean dimension lumber diverted from the landfill with Tolko Industries for hog fuel to be utilized in the production of OgoGrow.

6.7 Landfilling

Active filling currently takes place in above-grade landfill cells located in Phases 1 and 2. The Landfill is being developed over the previous waste surfaces by placing and compacting refuse in cells of approximately 12,000 cubic meters. Wastes are spread in thin layers (0.6 m or less) and compacted. Compaction is achieved using a Tana E525 landfill compactor, or with a CAT 836H Compactor as back-up. An alternative daily cover, consisting of fiber mulch is applied on the working face. Intermediate soil cover (0.3 m thick) is applied over completed lifts.

6.8 Leachate Management

The existing Landfill footprint, with the exception of the northern expansion cell, utilizes a natural control liner system that consists of more than 2 metres of in-situ native clay with a hydraulic conductivity of between 10^{-6} and 10^{-9} cm/s (CH2M HILL Canada Limited, 2008). The cell located at the far north end of Phase 1 (referred to as the Northern Expansion) is equipped with an engineered geomembrane liner. As discussed in Section 5.4.2, groundwater flow at the Site is noted to be upwards, provided the leachate level is maintained at an elevation at or below 437 m above mean sea level (AMSL).

Leachate collection within the existing landfilled areas of Phase 1 and Phase 2 consists of gravity drains that convey leachate via a leachate forcemain located along the west side of the Landfill for eventual discharge to the municipal sanitary sewer system.

Three lift stations facilitate the movement of leachate across the Site: Lift Station #1 (LS#1), located in the northwest portion of the Site, Lift Station #2 (LS#2), located in the southwest corner of Phase 2, and combined sewer and leachate Lift Station #3 (LS#3), located at the leachate pre-treatment system in the northwest portion of the Site. LS#3 (or McKinley Lift Station) was constructed in 2016 as part of property development in the residential areas northwest of the Landfill and construction of an upgraded sewer line in the Glenmore Road corridor next to the Site.

LS#2 pumps leachate collected from Phase 2 into a gravity system that feeds into LS#1 and LS#3. Collected leachate is pre-treated with Bioxide at LS#3 to address potential elevated hydrogen sulfide levels. The combined sewage and leachate is also aerated and treated for odours by a Biorem Multi-Stage Biofilter. The effluent is discharged into the municipal sanitary sewer system at Glenmore Road North and is ultimately treated at the City’s wastewater treatment plant. The leachate management system also includes an emergency back-up leachate discharge forcemain to the Quail Ridge subdivision, however; as of November 2016, leachate is no longer regularly discharged to the sewer force main to the Quail Ridge system.

The leachate collection system includes the following components:

- A 0.3 m thick leachate collection system and perforated collection piping within the lined Northern Expansion area.
- A perforated leachate collection pipe oriented east-west across the central portion of Phase 1 and Phase 2 that drains to the west.
- A perforated leachate collection pipe oriented east-west installed on the Phase 2 and Phase 3 boundary that drains to the western leachate lift station (LS#2).
- Non-perforated leachate forcemain to convey collected leachate to appropriate lift stations and/or leachate manholes.

The existing leachate piping and pump stations are shown on Drawing C-02.

6.9 Leachate Recirculation

A leachate recirculation pilot program was undertaken by the City in 2007, in an effort to increase the landfill gas generation rate and thereby increasing the flow of recovered gas used to operate a small-scale power generation system. The power generation system has since been decommissioned and landfill gas is either destroyed or recovered for beneficial reuse as described in Section 6.12.

Leachate recirculation consists of pumping collected leachate back into covered waste cells through landfill gas collection trenches. With increased in-situ moisture content, leachate recirculation increases the rate of anaerobic decomposition of waste, and therefore leads to an increase in the rate of landfill gas generation. The pilot program has shown promise that leachate recirculation is a viable management strategy for the Landfill. Consequently, since 2010 horizontal landfill gas collectors twinned with perforated pipe designed for leachate recirculation have been installed in the Landfill.

The leachate recirculation system utilizes the submersible pumps in the existing leachate lift stations; LS#1 located in Phase 1 and LS#2 in Phase 2. The leachate recirculation header located in the western portion in Phase 1 begins at the connection to LS#1. The current Phase 1 leachate distribution header extends north to landfill gas trench F1 (LGT F1) and south past LGT F5. The recirculation header is installed below grade and parallel to the existing LFG 400 mm diameter header along the western slope of Phase 1. The manifold is connected to the existing twinned (both gas and leachate piping) LGTs (Type I), as well as to untwined LGTs (Type II), which only have gas piping. The manifold incorporates stub-outs or blind flanges for future connection immediately north of LGT F1 and south of LGT F5 (CH2M HILL Canada Limited, 2017). The existing LFG and leachate recirculation trenches are shown on Drawing C-02.

The impacts of leachate recirculation on landfill gas quality are continuously being evaluated as part of Site operations.

6.10 Surface Water and Groundwater Management Strategy

The existing surface water and groundwater management strategy described in this section summarizes the 2016 report entitled: *Surface Water and Groundwater Management Strategy: Glenmore Landfill* prepared by Golder, and has been updated as required.

Surface water run-off from the covered areas of the Landfill and from surrounding areas within the Site catchment basin is collected in a network of ditches that drain to on-Site surface water basins. There are presently four surface water bodies on the Site including three constructed ponds known as Bredin Pond, Tutt Pond and Northeast Pond, and a shallow slough located within Phase 3. The ponds receive water inflow from direct precipitation, shallow groundwater discharge as lateral interflow from the unsaturated zone beneath the Landfill, and overland flow (Golder Associates Ltd., 2016). The existing surface water management framework was developed to manage surface water run-off from the Site and run-on from off-Site areas, as well as to provide irrigation for agricultural fields in the vicinity.

Bredin Pond

Bredin Pond was constructed in 1994 and has a compacted clay liner base and sides. The pond, located at the northwest corner of the Site, is approximately 1.4 ha in size and has an approximate depth of 2.5 m. The storage capacity of Bredin Pond is 35,000 m^3 (CH2M HILL Canada Limited, 2006). Bredin Pond has pipe inlets that collect runoff from the watershed to the north and northwest, and from localized runoff at the Landfill around the pond. Bredin Pond also receives piped seepage from the toe drain on the earthen dam (see Northeast Pond). The City can manage the water level in Bredin Pond by pumping water from Bredin Pond to the Northeast Pond. Water collected in Bredin Pond is used to irrigate the agricultural field north of the Landfill.

The City targets maintaining the water level in Bredin Pond to no more than 0.7 m lower than the leachate elevation in the Landfill (UMA Oct 1994). A difference of greater than 0.7 m may cause backpressure and uplift of the Bredin Pond liner.

Tutt Pond

Tutt Pond, located in the southwestern portion of the site, was constructed in 1986. The pond is 4 m deep with a surface area of 1 ha and a storage capacity of 40,000 m^3, all approximate (CH2M HILL Canada Limited, 2006). The pond was not constructed with a clay liner, however, it may be situated partially within the native clay unit that is present near-surface across the Landfill (Golder Associates Ltd., 2016). Water from Tutt Pond has been historically pumped out for irrigating farmlands located southwest of the Landfill.

According to Golder (2016) pumping of Tutt Pond below an elevation of approximately 437.5 to 437.7 m ASL may induce a reversal in groundwater flows from the Slough to Tutt Pond.

Northeast Pond

The storage pond located behind the clay core earthen dam in the northeast corner of the Landfill is referred to as Northeast Pond. The pond was constructed to manage surface water and possible irrigation use. The earthen dam was designed to prevent surface water and shallow groundwater from entering the landfill footprint from the northeast. Surface water from Northeast Pond can be diverted to Bredin Pond through the primary outlet pipe when a certain water elevation is reached within the Pond.

Slough

The Slough, which is described in Section 5.2.2, has the capacity of store and evaporate a water. The area receives surface water from Tutt Pond, the compost area, Phase 1 and 2 of the Landfill and the entrance facility, as well as groundwater discharge.

6.10.1 Irrigation

Water from Tutt Pond is used for irrigating farmlands located south of the Landfill, however, surface water is contained on the Site property. Water levels are managed to reduce the risk of leachate from being drawn into the pond. Water from Bredin Pond is used to irrigate the field north of the Landfill and water from the Northeast Pond can also be used for irrigation.

6.11 Potable Water

Potable water is supplied to the Site by the Glenmore Ellison Improvement District (GEID). The potable water supply from the GEID is connected to several fire hydrants are located around the perimeter of the Landfill.

6.12 Landfill Gas Management

The Landfill has an active landfill gas (LFG) collection system that, as of 2018, consists of gas collection wellfields with 64 vertical wells in the lower C waste lifts of Phase 2, 54 LFG trenches in Phases 1 and 2, and a blower and flare station. Thirty-three LFG trenches are co-located (or twinned) with a leachate recirculation pipe (CH2M HILL Canada Limited, 2017). The LFG collected is routed to a skid-mounted prefabricated 600 normal cubic metres per hour (350 standard cubic feet per minute (scfm)) blower/open flare apparatus.

In 2012, Fortis BC Energy Inc. (Fortis) signed a Landfill Gas Purchasing Agreement to purchase LFG from the City upon the City meeting minimum flow and quality requirements. Fortis operates a Biogas Plant conversion facility, located at the north-west corner of the Site that upgrades the LFG to pipeline natural gas quality. The Biogas Plant was constructed in 2014 and commissioning was completed in 2017.

Successful trials of the Fortis Biogas Plant were performed in 2017. Additional optimization and integration with the existing Landfill Flare System continued throughout 2017 and almost 52 percent of the total landfill gas recovered was beneficially reused.

Landfill gas was monitored monthly in all buildings within 300 m of buried waste, monthly in perimeter vapour probes and at a minimum monthly at gas wellheads in compliance with the requirements of the Landfill Gas Management Regulation. Gas quality and quantity at the flare and upstream of the Fortis Biogas Plant is monitored on a continual basis.

7. Site Development Plan

The long-term development plan is to extend the footprint of Phase 1 over the former drop-off area and east to Bredin Pond, extend Phase 2 east to Tutt Mountain, and develop Phase 3 south of Phase 2. Generally, the fill progression will be from north to south. The long-term filling and development strategy was prepared by CH2M HILL in 2014 as an update to the former fill plan presented in the CSDP.

7.1 Filling Plan

Future development will be completed within the Phase 1, Phase 2, and Phase 3 footprints, beginning first with Phase 1 and Phase 2. The approximate limits of staged development areas for the remainder of the Landfill development are provided on Drawing C-08. Phases 1, 2 and 3 of the Landfill have been divided into filling Areas 1 through 8. The long-term development plan is to extend the footprint of Phase 1 over the former drop-off area located southeast of Bredin Pond and east to Bredin Hill, extend Phase 2 to Tutt Mountain, and develop Phase 3. In general, filling will progress from north to south.

The proposed fill plan for the next ten years has been developed in six stages. Filling in 2018 and 2019 will occur on the Phase 1 and Phase 2 plateau with some filling occurring on Area 1 in the latter half of 2019. In 2019, the Area 2 liner extension (including perimeter road and irrigation line relocation) will be constructed in preparation for filling in 2020. From 2020 to 2024, filling of alternates between Area 1 and Area 2. In 2024, the liner system is constructed on Area 3 to allow for filling beginning in 2027. Filling will occur in Area 3 from 2027 to 2034. Table 7.2 summarizes the estimated tonnages and airspace consumption rates for each year of filling between 2018 and 2034.

Details of sequencing are presented for the fill area planned of development between 2018 and 2034, only. The fill plan beyond 2034, is discussed conceptually and will be presented in more detail in future updates to the DOCP. The fill plan presented in this DOCP is presented to show the planned sequencing of the fill operations and conceptual capacity of each area over the next 10 years. The fill plan will change as operations develop and may deviate from the areas and sequencing shown in this report.

7.1.1 2017 & 2018 Existing Fill Areas

During development of the DOCP in 2017 and 2018 filling was taking place on the landfill plateau in Phase 1 and Phase 2.

7.1.2 2018 – 2019 Fill Areas

In 2018 and 2019, filling will continue in Phase 2 (elevation 461 to 464 m AMSL) and a new lift will be started in the north portion of Phase 1 (elevation 464 to 470 m AMSL). Collectively, this portion of Phases 1 and 2 is referred to as Area 1a on Drawing C-08. In 2019, a new lift will be started in Phase 2 (elevation 464 to 470 m AMSL) and the first lift in Area 1 (elevation 440 to 446 m AMSL) will be started. After this stage, the Phase 1 and Phase 2 intermediate cover can be applied to the Phase 1 and 2 plateau as this area will not be filled again until 2024.

7.1.3 2020 – 2021 Fill Areas

In 2020, the second lift will be placed in Area 1 (elevation 446 to 452 m AMSL). In the latter half of 2020 and in 2021 the first lift will be placed in Area 2 (approximate elevation 448 to 454 m AMSL).

7.1.4 2022 – 2023 Fill Areas

Similarly in 2021 to 2023, Area 1 (elevation 452 to 458 m AMSL) and Area 2 (elevation 454 to 460 m AMSL) will be filled.

7.1.5 2023 – 2024 Fill Areas

In the first half of 2023, Area 2 (elevation 460 to 466 m AMSL) will be filled. In the latter half of 2023 and first half of 2024 filling will continue in Area 1 (elevation 458 to 464 m AMSL).

7.1.6 2024 – 2027 Fill Areas

In the first quarter of 2024, a lift will be placed on Area 2 (elevation 466 to 470 m AMSL). After this lift, Area 2 will be at the same elevation as the Phase 1 fill areas from 2019. Area 1 and Phase 1 are filled with one lift (464 to 470 m AMSL) for approximately 2 years from 2024 to 2027. To provide flexibility and capacity should fill rates increase; this fill plan includes constructing the Area 3 liner system (northeast liner) in 2024 although the capacity may not be needed until 2027.

7.1.7 2027 – 2034 Fill Areas

Starting in 2027, Area 3 will be filled. As the footprint of Area 3 is larger than one year of filling, successive lifts can be placed overtop one another each year.

7.1.8 Future Fill Areas

A detailed fill plan for filling beyond 2034 will be developed with future updates to the DOCP. In general, filling will continue in Phase 2 with the development of Areas 4 and 5, and subsequently continue into Phase 3.

7.1.9 Filling of Phase 3 with Select Construction and Demolition Waste

The City has been filling the Phase 3 area seasonally with coarse construction and demolition debris (e.g. wood, concrete, rubble) as per the approved CSDP (CH2M HILL, 2008). The City will continue with the seasonal filling of Phase 3 coarse construction and demolition debris while the impact of additional waste on the groundwater south of Phase 3 is assessed as per the recommendations in Section 11.1.

7.2 LFG and Leachate Recirculation Trenches

LFG collection trenches, twinned LFG and leachate recirculation trenches will be installed in phases as the Landfill is developed, in accordance with the LFG Management Facilities Design Plan. LFG Management is described in detail in Section 15.

7.3 Capital Projects

The following table summarizes the planned Site development projects over the next 20 years that support implementing the filling plan described in Section 7.2. Table 5.1 of Appendix C presents the long-term capital plan for the Landfill from 2019 through to post-closure.

Table 7.1 Future Site Development Projects

Design	Construction	Area	Development
Fall 2018	2019	Area 1	Decommissioning of the former entrance and public drop-off area off Glenmore Road, which is designated as a fill area. Includes decommissioning or relocation of several buildings and other structures as well as electrical/ utilities abandonment. Construction of perimeter road and berm. Construction of a geomembrane liner system for Area 1 that gravity drains to the leachate collection system [24,000m^2].
2019	2020	Area 2	Relocation of the perimeter access road and irrigation piping. Extension of the LFG header and geomembrane liner system for Area 2 [23,000 m^2]. The City will need to convert the McKinley Road right of way (ROW) to a utility ROW prior to Area 2 liner expansion.
2022/2023	2023/2024	Area 3	Extension of the geomembrane liner system for Area 3. Construction of leachate pump station and forcemain [60,000 m^2]. Electrical power will need to be extended to the east side.
2031	2032	Area 4	Decommissioning of the surface water dam located at Northeast Pond. Extension of the geomembrane liner system for Area 4 [20,000 m^3].
2019-2025	2025-2030	North Pond	Construction of the North surface water diversion pond and associated piping and ditching to support surface water management plan. Construction of diversion piping around the Landfill.

During filling of Area 1 the landfill gas trenches will need to be disconnected on the western side slope and either extended to the new western side slope or accessed from the eastern side slope.

8. Waste Acceptance and Life Span Analysis

8.1 Limit of Waste

The Landfill footprint is shown on Drawing C-01, and includes Areas 1 through 8. The footprints of Areas 1 through 8 are outlined on Drawing C-08. Drawing C-01 also shows the current limit of waste and the proposed final limit of waste.

8.2 Waste Catchment

The waste catchment for the Site includes the RDCO and Big White area. As stated in the SWMP, the Landfill receives garbage from the curbside collection programs in the region, private haulers, self-haul customers (both residential and small business) and the transfer stations of Traders Cove and North Westside, Westside and garbage from Big White Resort in the Kootenay Boundary Regional District. In 2018, the Site serviced a population of approximately 200,000.

8.3 Waste Acceptance and Waste Diversion

The Site accepts MSW waste from private and commercial waste haulers within the RDCO, as well as providing services for self-haul residential and commercial customers. The Site accepts residential waste; industrial, commercial, and institutional waste; and construction and demolition waste.

As specified in the OC, the following controlled waste streams are authorized for discharge:

- Contaminated soil, as defined by the HWR is subject to the following conditions:
  - Deposited in layers less than 0.3 m thick
  - Deposited a minimum of 1.2 m above the seasonal high groundwater table and 2.0 m below the final grade of the Landfill
- Waste asbestos in compliance with the requirements of Section 40 of the Hazardous Waste Regulation.

As specified in the OC, the following waste streams are not to be discharged:

- Hazardous wastes, other than those specifically approved for disposal to authorized landfills, as defined in the Hazardous Waste Regulation under the *Environmental Management Act*.
- Anatomical, pathological, and untreated biomedical wastes as defined in the Guidelines for the Management of Biomedical Wastes in Canada, with exception of the limited biomedical wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw.
- Bulk liquids and semi-solid wastes, which contain free liquids, as determined by US EPA Method 9095A Paint Filter Liquids Test.
- Dead animals and slaughter house, fish hatchery and farming wastes or cannery wastes and by-products with the exception of slaughter waste from small (less than 200 bird) independent backyard chicken farms. Limited biomedical and carcass wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw will also be accepted.

The following items are banned from the Landfill and are managed separately either on or off-Site:

- Household Hazardous Wastes (paints, solvents, oil, pesticides, cleaners etc.)
- Asphalt & Concrete – (accepted at the Glenmore Landfill but must be separated)
- Asphalt Shingles - (accepted at the Glenmore Landfill but must be separated)
- All Recyclables including paper, newspaper, cardboard, boxboard, plastic containers, plastic film and tin cans
- Refundable beverage containers
- Electronics and Computers (stereos, TV's, monitors etc.)
- Small Appliances (anything with a battery or plugs into the wall) and Power Tools (such as saws and drills)
- Outdoor Power Equipment (such as lawn mowers and trimmers)
- Batteries
- Tires (accepted at the Glenmore Landfill but must be separated)
- Residential light bulbs and light fixtures
- Yard Waste (accepted at the Glenmore Landfill but must be separated)
- Large Appliances (accepted at the Glenmore Landfill but must be separated)
- Drywall/Gypsum - Special bins are located at landfill sites for Drywall/Gypsum
- Hog fuel, log yard debris and chipped wood waste – reuse for temporary roads, dust control or a component of alternative daily cover

8.4 Estimated Site Life

Based on CH2M HILL's 2014 long-term fill plan, the remaining Landfill capacity was 39,788,450 m^3. An airspace consumption rate of 0.72 tonnes of MSW per cubic metre of airspace (t/m^3) was used to estimate an annual airspace consumption rate of 208,333 m^3 per year (150,000 tonnes per year). The projected site life is based on an average of 150,000 tonnes per year for the next 10 years. After 10 years, the fill rate is projected to increase by 1.8 percent per year which is equivalent to population growth rate in the City from 1996 to 2016. The estimated Site life is approximately 90 years. Table 8.1 presents the airspace capacity summary. Future fill rates will be impacted by the rate of economic growth in the region, the Landfill diversion rate, and debris from natural disasters.

The amount of waste discharged each year has varied significantly in the last ten years and the fill plan should be reviewed annually to confirm the remaining capacity and development timelines. The maximum authorized rate of waste discharge in the OC is 170,000 tonnes annually.

9. Landfill Design

The Landfill Criteria siting and design standards apply to new landfills, lateral expansions of existing landfills, and new landfill phases where filling will not occur on top of previously placed MSW. The design of the Landfill is based on the requirements outlined in the Landfill Criteria and site-specific conditions. The design described in this section focuses on the 10-year period of this DOCP. Further design of Landfill expansion will be presented in future updates to this document.

9.1 Landfill Siting

The siting criteria (Section 2.1.2) outlined in the Landfill Criteria are applicable to new landfills and lateral expansions of existing landfills. A lateral expansion is defined in the Landfill Criteria as an increase in the landfill footprint. The Landfill footprint in the approved CSDP included the Phase 4 footprint, which is no longer included in the long-term development plan. The Landfill footprint identified in this DOCP is significantly smaller than the Landfill footprint in the approved CSDP, and is therefore not a lateral expansion. The final Landfill footprint is shown on Drawing C 01.

The northern limit of the Landfill footprint in this DOCP is approximately 20 m further north than in the CSDP. The adjusted Landfill footprint is approximately 480 m from the City owned residence north of the Landfill.

9.2 Base Liner

The Landfill Criteria specify the requirements for base liner design, which are applicable to lateral expansions and new landfill phases where filling will not occur on top of previously placed MSW. The design criteria is as follows:

- Landfill base shall be a minimum 1.5 m above groundwater.
- Minimum base slope of 2 percent for primary drainage paths (leachate collection piping) and 0.5 percent for secondary drainage paths.
- Maximum drainage path in the drainage blanket to a leachate collection pipe shall be 50 m.
- Minimum specifications for the primary HDPE geomembrane liner are:
  - Primary liner: 1.5 mm thick HDPE geomembrane liner with 100 year service life.
  - Secondary liner: Geosynthetic Clay Liner (GCL) or 0.75 m thick compacted clay liner with a minimum hydraulic conductivity of 1 x 10-7 cm/sec.
  - 300 mm thick stone drainage blanket with perforated collector pipes with protective geotextile layers.
  - Stone drainage blanket shall be constructed of 50 mm diameter clear stone with minimal fines.

Future Landfill areas will be constructed with a base liner and leachate collection system comprised of the following from bottom to top:

- Geosynthetic clay liner (GCL)
- 60-mil High Density Polyethylene (HDPE) liner

- Non-woven geotextile
- 0.3 m of drainage blanket with leachate collection piping
- Woven geotextile

Perforated leachate collection laterals will be installed within the drainage layer and converge on perforated leachate collection pipes. Leachate will be collected and pumped to the existing on-Site pre-treatment system prior to discharge to the sewer. The base liner design is shown on Detail 7, Drawing C-22.

9.3 Leachate Collection and Base Contours

The existing leachate collection system will be expanded to include leachate collection from all future fill areas of the Landfill. An overview of the final conditions leachate collection system is provided on Drawing C-15. This DOCP provides the conceptual design of leachate collection systems for Areas 1, 2 and 3. The base contours and leachate collection systems for Areas 1, 2 and 3 are shown on Drawings C-16, C-17 and C-18, respectively.

Area 1

Landfilling in Area 1 will take place over existing waste in an area formerly occupied by the public drop-off area. The Area 1 leachate collection system has been designed to connect with the existing leachate collection piping in the area, as shown on Drawing C-16. Components of the leachate collection system in Area 1 include:

- Leachate sump located approximately in the middle of Area 1. The sump will drain by gravity to the perimeter leachate collection header.
- Perforated leachate lateral pipes spaced at 15 m intervals sloping towards the leachate header at 2 percent. The pipe will discharge into a new manhole that will convey leachate to existing MH2.

The groundwater table in the vicinity of Area 1 is located at an approximate elevation of 439 m (Golder, 2016), which is below the base of the liner system.

Area 2

Landfilling in Area 2 will include the extension of the geomembrane liner to the north of the existing northern limit of waste. The leachate collection system in Area 2 will include an engineered liner system, which will be fused to the existing liner in place, and perforated leachate collection piping. The leachate collection system will include:

- Perforated leachate header pipe located at the southern end of the cell sloping at 2 percent to the west. The pipe will discharge into a new manhole.
- Leachate forcemain extension to connect the new Area 2 leachate manhole to the existing leachate collection system.
- Perforated leachate lateral pipes spaced at 15 m intervals sloping towards the leachate header at 2 percent. Every third lateral will adjoin to the header with a Y-connection to facilitate clean-out along the length of the header pipe.

The base contours in Area 2 will be at minimum 1.5 m above the groundwater table. The Area 2 leachate collection system and base contours are shown on Drawing C-17.

Area 3

Area 3 is located at the northeast corner of the Landfill and includes landfilling against the western side slope of Bredin Hill. The base of Area 3 was designed to tie-into the western extent of the existing north liner and the Area 2 liner. Due to variations in the local topography the slope of the base will vary. The leachate collection system includes:

- Leachate sump located at the south-eastern extent of the cell equipped with two electrical submergible leachate pumps.
- Perforated leachate header pipe along the midline of the cell sloping towards the leachate sump.
- Perforated leachate lateral pipes sloping towards the header pipe at 2 percent.
- Leachate pipe clean-outs located along the northern and eastern edges of the cell.
- Clean-outs for leachate header and lateral pipes.
- Leachate forcemain extension around the perimeter of Areas 2 and 3 to connect the cell to the existing leachate collection system.

Due to topographic constraints, the Area 3 leachate sump will be located below the groundwater table. Drawing C-18 shows the base contours and leachate collection system for Area 3.

10. Geotechnical and Seismic Assessment

This section presents a summary of the geotechnical analysis, localized seismic information for the Site, and veneer stability analysis of the proposed final conditions of the Landfill for static and seismic conditions.

10.1 Geotechnical Overview

Based on review of borehole logs and the geotechnical site description presented in the CH2M HILL Geotechnical Investigation and Analysis Report (2015) as previously discussed in Section 5, the general stratigraphy of the subsurface conditions can be grouped into five geologic units.

Fill

Fill materials are present in various areas of the Site. The material generally consists of landfilling material consisting of waste materials and wood chips with thicknesses ranging from 0 to 10.2 m. Reworked clay fill was also observed in some areas, such as underlying the landfill waste in boreholes GL-35, BH11-19, and BH11-24, or from the ground surface in borehole BH15-05. Where encountered, the reworked clay fill was observed to have a thickness up to 5.9 m.

Clay

Clay was encountered in the majority of observed boreholes throughout the Site in various thicknesses. Based on Atterberg Limits results from the CH2M HILL 2015 investigation, the clay is described as fat clay (CH); however, it was also often visually described as lean clay in various other drilling investigations. The clay layer was generally thickest in the centre of the site with thicknesses up to 19.0 m. The relative density of this strata ranged from soft to stiff, with stiffer soils generally encountered at the north and south edges of the Landfill.

Granular Soils

Various layers of granular soils, ranging from silty sand to sandy silt to sand and gravel, were observed underlying the clay layers and occasionally sandwiched between clay layers. This layer was described as loose to very dense, and more typically described as compact to dense.

Glacial Till

Boreholes encountering bedrock typically encountered a glacial till layer underlying the granular soil layer. The glacial till layer was predominantly classified as silty sand with gravel and trace clay, however it was described as silty clay with some gravel at the north end of the Landfill in monitoring wells GL-0, GL-1, and GL-23. The glacial till was generally described as hard or dense to very dense with observed thicknesses up to 18.5 m.

Bedrock

Bedrock depth varied throughout the Site and was generally described as sedimentary or volcanic rock. The volcanic rock was generally encountered in the northern, central, and eastern areas of the Site. The sedimentary rock was composed of siltstones, mudstone, and sandstones and was generally observed in the southern and western portions of the Site.

10.2 Previous Geotechnical Investigations

This section presents a summary of geotechnical investigations recently completed for the Site. Various drilling investigation reports exist for the Site, however these reports present only factual geotechnical information that was summarized in Section 10.1 above.

10.2.1 Geotechnical Investigation and Analysis Report (CH2M HILL, 2015)

CH2M HILL completed a field investigation consisting of 7 boreholes and 3 test pits. Laboratory testing associated with the investigation consisted of consolidation testing, consolidated-undrained triaxial testing, and index testing. At the time of the report, the geometry of the proposed Landfill was slightly different with proposed slopes of 3.26:1; the geometry has changed and the slopes are now proposed at a steeper 3:1.

With the results of the investigation, CH2M HILL completed a slope stability analysis using Slide 6.0 consisting of four (4) cross-sections. Each cross-section was analyzed for short term static, long term static, and long term seismic conditions. The factors of safety for the Landfill were found to be 1.20 to 1.66 for short term (static) conditions, 1.40 to 1.52 for long term (static conditions), and 0.67 to 0.90 for long term (seismic conditions). Based on these results, CH2M HILL proposed that the Landfill is safe for static conditions; however, permanent deformations are anticipated under seismic loading.

CH2M HILL also completed settlement modelling using Settle3D to analyze the amount of settlement of the clay and existing waste and within the new waste material. Based on the proposed fill plan at the time of the report, settlements were anticipated to be up to 8 m within the original placed materials when the Landfill reached its design height (at year 15), with minimal settlements between year 15 and year 100; 4.5 m of this thickness will be attributed to compression of the fresh waste. The total settlement when considering the proposed waste thickness was up to 13.7 m.

10.2.2 Well Water Survey and Bedrock Geology Review in the Vicinity of the Glenmore Landfill (Golder Associates Ltd., SLR, 2015)

A hydrogeological assessment and a geological review were conducted by Golder Associates Ltd. and SLR, respectively.

The report from SLR references mapping by Church (1981) as well as communication with Dr. Murray Roed and Dr. John Greenough. The references conclude that a NNW trending fault west of the Landfill and a NNE trending fault southwest of the Landfill likely intersect below the footprint of the Landfill; however this faulting has been deemed to be inactive. The report also considers the likelihood of an earthquake in the Okanagan region to be low.

The report from Golder discusses the bedrock and hydrogeological conditions of the Site. Based on the report, encountered bedrock was generally sedimentary rock on the west and south of the side while volcanic bedrock was more regularly encountered in the north and the central sections of the Site. The hydrogeological conditions are discussed in Section 5.5.

10.2.3 Ultimate Long Term Filling Plan and Development Considerations for Glenmore Landfill (CH2M HILL, 2014)

As part of their technical memo for discussing the filling plan for Landfill, CH2M HILL discuss their geotechnical review of the Landfill area. In this review, CH2M HILL compares clay thicknesses and properties throughout the Site. Limited data exists with minimum blow count information, however the thicknesses and properties of the clay vary substantially throughout the Site. Thicknesses presented vary from 0 m to 17 m. The memo also discussed that depth to bedrock varies throughout the Site, with shallow thicknesses on the east side of the Site and much deeper on the north end of the Landfill.

This technical memo recommended 12 borings around the proposed Landfill footprint to fill information gaps, define the properties of the clay layer, and complete slope stability assessments.

10.2.4 Technical Review (CH2M HILL, 2014)

CH2M HILL completed a technical review on a number of reports related to the hydrogeologic setting of the Site. Although this report is primarily related to hydrogeology, it does provide some information on regional bedrock faulting. A normal fault was identified on the west side of the Landfill and a separate normal fault was identified on the southwest of the Landfill. This faulting is relatively consistent with faulting described in the bedrock geology review completed SLR (2015).

10.2.5 Summary

Over 300 boreholes, test pits, and monitoring wells have been completed spread throughout the Site at varying depths. CH2M HILL recently completed a thorough analysis of the slope stability and settlement of the Site, however, their slope stability investigation has been completed based on a previous layout and slope design of the Landfill. A geotechnical investigation including borehole and updated slope stability assessment will be completed as part of this DOCP.

10.3 Seismic Evaluation

The National Building Code of Canada (NBCC) specifies that buildings and their components should be designed for seismic events with 2 percent probability of exceedance in 50 years (i.e., return period of 2475 years). The NBCC seismic hazard calculations are provided in Appendix E. The Code does not specifically comment on the appropriate seismic event for landfills or earth structures. The US Environmental Protection Agency (US EPA) Resource Conservation and Recovery Act (RCRA) Subtitle D (Richardson et. al., 1995) states that hazardous waste landfill facilities and its engineered components should be designed for maximum horizontal acceleration resulting from a seismic event with a 10 percent probability of exceedance in 250 years (i.e., return period of 2373 years).

Considering the nature of the Landfill and the low consequences of its failure during an extreme seismic event, NBCC 2010 and RCRA Subtitle D provide very conservative design criteria, especially for short-term conditions. Therefore, in the absence of a specific design code for this application for the seismic condition present at this Site the following were used:

- Short-term - a seismic event with 5 percent probability of exceedance in 50 years (return period of 1000 years) is used (this value is conservative to account for the unknown properties of the newly placed waste material and potential seismic amplifications due to its unconsolidated nature).
- Long-term (post closure) - seismic event with 2 percent probability of exceedance in 50 years (return period of 2475 years).

10.3.1 Liquefaction Potential

The liquefaction potential of the Site has not been evaluated. Soils most susceptible to liquefaction are loose sands and soft silts below the water table. Liquefaction is not likely to be an issue in the majority of native soils encountered at the Site as they consist primarily of lean to fat clays. However the geologic units consisting of silty sand to sand may be susceptible to liquefaction. Gradation results and SPT blow counts would need to be analyzed to confirm likelihood of liquefaction and currently limited information is available, with the exception of the CH2M HILL (2015) geotechnical report. A geotechnical investigation including borehole and updated slope stability assessment will be completed within the next 10 years, as part of this DOCP, to collect data in support of the slope stability and liquefaction analysis.

10.4 Veneer Cover Stability

The proposed cover system of 3H:1V is not anticipated to be partly or full saturated; therefore veneer cover stability analyses were carried out assuming a nominal water head of 0 mm above the GCL. This analysis should be re-evaluated during the final cap design with properties from actual materials that will be used in the final design.

The interface shear strength is a function of the shear strength of the two materials forming an interface in a cover system comprised of multiple components. The sliding stability analyses are carried out to evaluate the potential of sliding along a geosynthetic layer interface as this type of sliding may tear the geosynthetic material. Shear testing should be performed to evaluate the sliding potential of the actual materials used in design. The interface shear strength is further governed by the weaker material at the interface. The shear strength parameters used are shown on the analyses provided on Table 10.1.

The analyses were carried out using the infinite slope method proposed in Richardson *et al.* (1995), and the results are provided in Table 10.1. A review of the results shows the targeted factors of safety for static conditions were achieved (factor of safety of 1.62) for the proposed cover system placed on 3H:1V, with a marginally low factor of safety of 1.09 for the pseudo-static conditions. Hence, the proposed cover system is expected to be stable under the conditions noted above.

Yield accelerations, exceedance of which will trigger cover movements, were calculated as fractions of gravitational forces during the pseudo-static analyses. The values of calculated yield accelerations are provided for each cover system interface on Table 10.1. According to Griffin and Hynes (1984), slopes and embankments with yield acceleration equal to 50 percent of peak ground acceleration (PGA) will experience permanent seismic deformation of less than 1 m in any earthquake even where seismic acceleration is amplified by a factor of three. A review of the results show that the yield strength of the cover system marginally exceed 50 percent of the PGA meaning that permanent deformation is unlikely to exceed 1 m in any earthquake event where seismic acceleration is amplified by a factor of three.

11. Groundwater Impact Assessment

11.1 Groundwater Impact Assessment Plan

As described in Section 5, the Site is located in a valley where groundwater flows within the bottom of the valley horizontally towards the centre of the valley and maintains a vertical upward gradient. As a result, the base of the valley within the Site is the groundwater discharge zone, with the exception of the southern Slough area.

The impact assessment is focused on the potential for impacts to groundwater to occur within the southern portion of the Site.

As stated in Section 7, the City plans to place a base mat layer of C&D waste in the Slough to prepare Phase 3 of the Site for landfilling. Some waste has previously been placed in the Slough; however, the potential effects of additional of C&D waste on groundwater chemistry at the southern Site boundary cannot be estimated at this time. In order to assess the potential impact of filling the Slough with C&D waste, further field investigations and groundwater modelling is required. The following general methodology will be used to complete the groundwater impact assessment, as part of this DOCP:

- Install a minimum of three additional monitoring well nests each consisting of three individual wells located in the vicinity of the southern Site boundary as illustrated in Drawing C-05. Each of the wells will target the clay, sand, and till hydrostratigraphic units and will be used to further establish the existing conditions in this area of the Site.

- Pumping tests or single well response tests will be completed to estimate the hydraulic conductivity of each of these units at the southern Site boundary.
- Determine the flux of groundwater flowing through the Slough.
- Model the potential geochemical impacts to groundwater quality at the southern Site boundary within the Slough as a result of future placing of C&D waste as a base layer and the diversion of surface water away from the Slough. The modelling will include a sensitivity analysis and the forecasted increase of leachate strength.

12. Site Operations

The Site operations follow good management practices based on industry standards and will be carried out in accordance with the standards set out by the OC and the Landfill Criteria. The following section describes the planned Site operations for the 10-year period of this DOCP.

12.1 Entrance Facilities

The weigh scale and public drop-off area are planned to continue operating as described in Section 6.1. The weigh scales shall be maintained in proper working order and meet the requirements of the federal Weights and Measures Act.

12.2 Opening Hours

The Landfill opening hours are seven days a week from 7:30 a.m. - 4:45 p.m.

12.3 Landfilling

Waste will be discharged to the Landfill according to the general procedures described below:

12.3.1 Waste Placement and Compaction

Waste placement and compaction will continue in a similar manner to current operations described in Section 6.7. Active filling will take place in the areas designed and the sequence described in Section 7.1. Waste will be spread in thin layers (0.6 m or less) and compacted with a landfill compactor Tana E525 or similar. An alternative daily cover, consisting of fiber mulch is applied on the working face. Once a lift is complete, 0.3 m of intermediate soil cover is applied over the area. As per the recommendations in the Geotechnical Investigation and Analysis Report (CH2M HILL, 2015), no more than 6 m of waste will be placed over a single area in one year.

12.3.2 Waste Containing Asbestos

Asbestos containing materials (ACM), as defined by the HWR, is to be transported in compliance with the Transportation of Dangerous Goods (TDG) Act and Regulations. The disposal of ACM will be completed in accordance with Part 6, Section 40 of the HWR. ACM is received Monday, Wednesday and Friday by appointment only.

12.3.3 Contaminated Soil

The OC authorizes the discharge of hydrocarbon contaminated soil, but currently does not authorize the discharge of soil contaminated with other contaminants (e.g. metals, high/low pH). The City is applying for an OC amendment to allow for landfilling of contaminated soil, as defined in the HWR. Contaminated soil is to be landfilled in lifts no higher than 0.3 m, at least 1.2 m above the seasonal high groundwater table and 2 m below the final grade of the Landfill.

12.4 Cover Placement

Placement of daily, intermediate and final cover on the Landfill is required to control vectors and reduce infiltration and LFG emissions. Cover material will be placed according to the best practices described below.

12.4.1 Daily Cover

Daily cover is placed on the active face at the end of each operating day. Daily cover consists of either 150 mm of soil or approved alternative cover (such as fibre mulch). Soil used for daily cover may be removed from the active face immediately prior to landfilling in the same area. Soil used for daily cover has minimal fines to prevent perched leachate layers within the waste and to prevent dust migration from the Landfill. Surface water contacting the daily cover is contained and treated as leachate and is conveyed to the leachate management system.

12.4.2 Intermediate Cover

Intermediate cover is placed on areas of the Landfill that are not scheduled to receive the placement of additional waste for 30 days or more. Intermediate cover consists of 300 mm of soil or approved alternative cover. The thickness may include daily cover if daily cover is present in the area. Soil used for intermediate cover may be removed from the active face immediately prior to landfilling in the same area. The surface water runoff from the intermediate cover can be treated as clean surface water.

12.4.3 Final Cover

Final cover will be placed within 365 days on any part of the Landfill footprint within that has reached final contours and is large enough to warrant final cover application. The engineered final cover design is described in Section 9.6.

12.5 Inclement Weather

During inclement weather, the active area may be located at a lower elevation area to minimize traffic on the steep hill leading to the top of the Landfill. Daily cover may be delayed during inclement weather to facilitate operations.

12.6 Leachate Breakouts

Leachate breakouts on the side slope will be managed by excavating an infiltration pit at and immediately upslope of the leachate breakout, filling with drain rock, and covering with low permeability soil. The objective of the infiltration pit is to remove the horizontal confining layer and facilitate the vertical infiltration of leachate.

If leachate breakouts are occurring on the side slopes in areas of leachate recirculation, the rate of leachate addition should be reduced.

12.7 Nuisance Controls

The following controls will be implemented to minimize the potential of nuisance impacts to receptors. The receptors within 1 km of the Landfill are shown on Figure 4.1.

12.7.1 Litter Control

Litter will be controlled by compaction of waste and minimizing the working face. In addition, temporary/mobile fencing can be placed around the Site as required.

12.7.2 Dust Control

Dust is generated at landfills from material management and from roads. Dust mitigation measures are employed at the Site on an as-needed basis and may include the following:

- Use of fibre mulch daily cover and granular soils with minimal fines
- Reduced vehicular speeds
- Topping of roads with wood chips
- Use of water to control dust
- Proper placement of stockpiles

12.7.3 Vector Control

Municipal solid waste is an attractant to birds and other wildlife. Proper application of daily and intermediate cover minimizes vector attraction. Other methods to deter nuisance birds include the use of, auditory repellents such as recorded bird-distress calls, bear bangers, screechers etc. and the use of a falconer. A pest control contractor is used to manage rodents and other pests.

12.7.4 Mud Control

Granular material and wood chips are used to reduce the generation of mud on Site roads. A wheel wash system is in place to minimize mud tracking off Site.

12.7.5 Odour Control

The following measures will be used at the Site to minimize generation nuisance odours:

- Operation and progressive expansion of the landfill gas collection system
- Application of daily and intermediate cover
- Odour control systems on leachate management infrastructure

- When odorous waste is anticipated strategies will be implemented, such as immediate burial or immediate cover

12.7.6 Sight Lines

Visual aesthetics and sight lines around the Landfill have been addressed by the planting of trees and shrubs in the new berm along John Hindle Drive and on the hillside to the east of the residential drop-off transfer station. Additional planting projects are scheduled for 2018 along John Hindle Drive. Further landscaping along the western side of the Landfill along Glenmore Road will be evaluated in future years. Vegetation is managed through regular mowing of weeds, as required.

12.7.7 Noise

Noise is common occurrence at landfill facilities and a part of a safe operation. The relocation of the material management areas to the south portion of the Site will aid in reducing noise impacts to receptors. The City will consider noise generation in the future purchase of landfill equipment.

12.8 Landfill Fire Management

The Landfill will be operated in a manner that reduces the risk of landfill fires by implementing the following measures:

- Appropriate placement, thickness, and compaction of inert daily and intermediate cover and compaction as outlined in Section 6.5 to minimize oxygen intrusion.
- Fire breaks will be maintained surrounding the Landfill footprint with a minimum width of 15 m. The fire breaks will be free of trees, brush, tall grass, and other combustible materials.
- The Landfill has year-round access to a water supply and fire hydrants are located around the perimeter.
- Fire safety measures in-place, in accordance with the Site fire safety and emergency response plan (Appendix F).

12.9 Scavenging

Scavenging is defined in the Landfill Criteria as the informal and unauthorized recovery and removal of waste. Scavenging of waste from the active face and within the Site is prohibited due to health and safety concerns.

12.10 Diversion and Recycling Operations

As described in Section 8.3, a variety of waste streams are being diverted from the Landfill. Recycling programs include management of:

- Household Hazardous Wastes (paints, solvents, oil, pesticides, cleaners etc.)
- All Recyclables including paper, newspaper, cardboard, boxboard, plastic containers, plastic film and tin cans
- Refundable beverage containers

- Electronics and Computers (stereos, TV's, monitors etc.)
- Small Appliances (anything with a battery or plugs into the wall) and Power Tools (such as saws and drills)
- Outdoor Power Equipment (such as lawn mowers and trimmers)
- Batteries
- Residential light bulbs and light fixtures

The following materials are stockpiled at the Landfill for reuse or recycling:

- Hog fuel, log yard debris and chipped wood waste – reuse for temporary roads, dust control or a component of alternative daily cover
- Asphalt & Concrete
- Asphalt Shingles
- Drywall/Gypsum
- Large Appliances
- Yard Waste
- Tires
- Soil - resulting from large and small residential, commercial developments. The soil received is generally a mix of clay and topsoil and is suitable for use for daily and intermediate cover.

12.11 Composting Operations

Composting operations on-Site are conducted in compliance with the requirements of the Organics Matter Recycling Regulation and are authorized under the Landfill OC.

Composting operations may be upgraded from the current turned windrow system to Aerated Static Pile (ASP) system and will take place in the area designated on Figure 4.1. OPUS (2016) reviewed several options and concluded that upgrading to the ASP system provides long-term cost savings compared to other options, and improves public safety, reduces downtime, increases space for operations and finished compost, improves level of service to the public, reduces contamination of compost products and reduces overall carbon footprint. This option is anticipated to reduce the footprint of composting operations by 87 percent, making room for both organics and inorganics stockpiles in the existing composting area, with minimal space incursion into the Slough.

12.12 Landfill Gas Management Facilities

Landfill gas management facilities will continue to be installed, operated and maintained according to the LFG Plan (see Appendix G).

12.13 Access Roads and Ditching

As the Landfill is developed, the existing Ring Road will be relocated to allow for the expanded Landfill footprint and to accommodate ditching along the top of the Landfill slope. The proposed access road is shown on Drawing C-06.

12.14 Site Security and Signage

Access to the Site will continue to be via the existing site entrance off John Hindle Drive. The Site entrance gate is locked outside of normal operating hours to prohibit entrance and uncontrolled disposal when the site is closed. Additional security measures include an entrance facility security camera and external security contractor.

12.15 Record Keeping

All relevant records will be maintained by the Site owner for the entire operating life of the Landfill and for the duration of the contaminating lifespan, as estimated in Section 16. Relevant records will be available on-Site for a minimum of 7 years, and all records will be submitted to the Director within 14 days of a request from ENV. Records will include the following:

- The Operational Certificate
- All plans and reports prepared in support of the development for the Site
- Inspection records conducted by regulatory agencies
- A complaint log system providing source of complaint, nature of complaint, time received and actions taken
- Waste tonnages and volumes disposed of in the Landfill for each category of waste received
- Waste sources, characterization and approvals

12.16 Reporting Requirements

The Annual Report should contain two essential components:

- The Annual Environmental Monitoring Report
- The Annual Operations Report

Both of these reports shall assess the performance of and report on the operational status of the Landfill for a specified year period. The requirements of both the reports are outlined in the Landfill Criteria. In addition, the airspace utilization factor should be estimated and reported in the annual report using the most recent available data.

13. Surface Water Management Plan (SWP)

A conceptual surface water management plan was developed for the Site final condition and presented in the memorandum provided in Appendix H. An overview of the SWP presented in the memorandum is provided in the subsections below.

13.1 SWP Objectives

The objective of the SWP is to provide the design and operational procedures to route storm water runoff from the Landfill in a manner that is practical, effective and ensures that downstream receptors are not adversely impacted.

13.2 SWP Design Criteria

The designs developed in the SWP have been prepared to meet regulatory guidelines contained in the Landfill Criteria (BC Ministry of Environment, 2016) and to ensure that the runoff/discharge associated with Site land use and operations will not adversely impact receiving waters downstream. For this Site, there is currently no discharge to a downstream receiving waterbody, therefore the SWP provides the estimated runoff volumes that will discharge from the Site under the final development condition for the various design storms. The surface water management infrastructure has been designed with reference to the Landfill Criteria and in accordance with the BC Supplement to TAC (Transportation Association of Canada) Geometric Design Guide 2007 Edition (BC Ministry of Transportation , 2007). The stormwater management system was designed using the 24-hour, 5-year, 10-year and 100-year synthetic design storm with a Type II distribution.

13.3 SWP Overview

13.3.1 Current Conditions

The Site is located within a larger catchment area with currently no natural outlet for surface water runoff.

Outside of the Landfill footprint, surface water runoff, shallow groundwater and seeps/springs from the contributing drainage area north of the Site are collected and conveyed through a series of ditches and culverts to the surface water management (SWM) pond system The existing SWM ponds (Bredin Pond, Tutt Pond and the Northeast Pond) are described in Section 6.10. The collected surface water is discharged through evaporation, irrigation of surrounding farm fields, or pumping to the City sanitary sewer.

Within the Landfill footprint, surface water runoff is managed as leachate through infiltration into the waste mass or collection in the Slough.

13.3.2 Final Conditions

The conceptual long-term surface water management strategy for the Site is as follows:

- Surface water from off-site areas north of the Landfill will be collected by an interceptor swale, stored within a proposed North SWM Pond, and diverted around the Site within a buried pipe, ultimately discharging to Brandt Creek. A downstream assessment of impacts from post-development runoff in excess of the pre-development runoff from the Landfill will be completed as part of the detailed design of the drainage system.

- Within the Landfill footprint, runoff will be collected in a series of perimeter swales and directed to the existing Bredin Pond and ultimately to the proposed South Pond. The existing Tutt Pond will be decommissioned and replaced with a lined channel or buried pipe. Runoff collected in the South Pond will be diverted to other surface water management systems such as the City stormwater sewer/ditch system along Glenmore Road.
- The Northeast Pond is currently impounded by a dam, and will be ultimately decommissioned. Due to the configuration of the Landfill perimeter swale and surrounding topography, the remaining pond will be repurposed as a dry-pond that will receive runoff from a portion of the eastern Landfill and an off-Site area located to the east/ northeast of the pond. Runoff collected will discharge to the proposed South Pond via a gravity sewer.

A schematic of the surface water of the closure condition surface water management plan is provided in Drawing C-19. Details describing the surface water modeling are provided in Appendix H.

The final conditions surface water management infrastructure will be constructed in a staged process as the Landfill is developed. The perimeter ditch network will be constructed as each perimeter cell is developed. As the side slopes of the Landfill reach final contours and are closed, surface water runoff will be routed to the perimeter ditch network.

13.4 Interim Pumping of Surface Water

Until the final conditions surface water routing is implemented, surface water will continue to the managed as per the CSDP.

Surface water from outside of the Landfill and from Landfill areas with intermediate cover will be pumped between Bredin Pond and the Northeast Pond based on the required storage capacity. The Northeast Pond can also be drained back to Bredin Pond. Water from Tutt Pond and Bredin Pond will be used to irrigate surrounding farm fields and may be used for dust control on roads. During high flow events (e.g. spring freshet) Tutt Pond may overflow to the Slough though a culvert. The water in the Slough is collected through the Landfill leachate collection system and is reduced through evaporation.

In the event of high volumes of surface water in excess of what can be managed in the Slough, water from Tutt Pond can be pumped to Little Robert Lake. Additional piping and ditches may be installed by the City to convey surface water to an alternate final location (i.e., Brandt's Creek or Glenmore Road ditches) to reduce potential quantity and quality impacts to Little Robert Lake. The off-Site pumping of surface water will only be used as necessary to provide the City with flexibility in managing surface water.

Water impacted by leachate will continue to be routed to the City sanitary sewer system.

14. Leachate Management

A leachate management plan (LMP) has been prepared to provide short-term and long-term solutions for leachate collection, storage, treatment, and disposal at the Site. The LMP is presented in a standalone memo provided in Appendix I. The LMP is summarized in the subsections below.

14.1 Leachate Management Objectives

A LMP has been prepared to provide short-term and long-term solutions for leachate collection, storage, treatment, and disposal at the Site.

The objectives of the leachate management plan are to provide methods for Landfill leachate collection, treatment, and disposal; estimate leachate generation rates; forecast leachate quality; and identify the discharge requirements that are protective of groundwater, surface water, and the receiving environment.

14.2 Leachate Management Overview

14.2.1 Leachate Management Strategy Implementation

In general, the leachate management works will be constructed as the Landfill is developed and will include leachate collection, storage, and conveyance systems. Existing conditions are described in Section 6.8.

Future development will be completed within the Phase 1, Phase 2, and Phase 3 footprints, beginning first with Phase 1 and Phase 2. As indicated in Section 9.2, future landfilling areas will be constructed with a base liner and leachate collection system. Perforated leachate collection laterals will be installed within the drain rock layer and converge on perforated leachate collection pipes. Leachate will be collected and pumped to the existing on-Site pre-treatment system prior to discharge to the sanitary sewer or recirculated.

Final cover will be applied in segments once waste reaches target elevations. Final cover will be applied on the Phase 1 and Phase 2 side slopes when filling in Phase 2 commences. Final cover will be applied to the Phase 3 side slopes when the elevation in Phase 3 matches the Phase 2 plateau. Final cover over the central portion of the Landfill will be applied when the final contours are reached in this area.

14.3 Leachate Quantity

14.3.1 HELP Modelling Leachate Generation Estimate

Leachate generation rates change over time as the Landfill is developed and various types of cover are applied. An understanding of forecasted leachate generation rates throughout landfill development assists in determining appropriate leachate management methods and contingency plans. As the Site currently discharges pre-treated leachate to the City sanitary sewer, an understanding of the forecasted quantity of pre-treated leachate being discharged to the sewer is also necessary to ensure sufficient sewer capacity is available for residential developments in the area. Efforts to reduce leachate generation therefore also increase the sanitary sewer capacity for residential development.

Leachate generation rate estimates were developed to support the development of the design and operation procedures for landfill leachate collection and treatment systems.Leachate generation modeling was completed using the Hydraulic Evaluation of Landfill Performance (HELP) model. The HELP model uses local, historical precipitation data and design characteristics from the landfill cover systems to estimate precipitation infiltration rates through the landfill cover surface into the waste mound. Since the Landfill is designed to collect leachate using the various leachate collection systems, all infiltrated precipitation is considered as leachate for the purposes of leachate generation estimates.

The HELP model provides infiltration rates per unit area based on the type of cover that is applied and the liner details. To calculate leachate generation forecasts, infiltration rates have been developed for daily cover, intermediate cover, and final cover conditions in Landfill areas with an engineered liner and natural control liner areas. As detailed in Appendix **I**, GHD completed a comparison of the leachate generation rates using either clay or a GCL for final cover as well as using either the in-situ natural clay or a GCL as the base liner for the future landfilling areas.

Table 14.1 below summarizes the HELP modelling results for the monthly average infiltration rates for each cover system and an engineered base liner system, as all future Landfill areas will be developed with an engineered base.

Table 14.1 HELP Model Leachate Generation Rates

	Generation Rate 1 Daily Cover - Engineered Base Liner (mm)	Generation Rate 2 Intermediate Cover - Engineered Base Liner (mm)	Generation Rate 3 Final Cover (mm)
January	5.1	19.7	1.0
February	10.0	19.1	0.7
March	20.1	16.2	0.7
April	38.2	21.7	1.3
May	15.5	9.9	1.3
June	7.8	7.4	1.1
July	10.5	11.7	1.2
August	14.9	14.2	1.3
September	15.9	15.0	1.2
October	11.5	11.1	1.1
November	11.6	10.0	1.1
December	14.3	19.9	1.2
Total	**175.5**	**175.8**	**13.0**

As stated in Section 5.4.2, hydrogeologic conditions beneath the Landfill footprint result in an upward hydraulic gradient. The HELP model generally accounts for percolation through the base liner system, thereby slightly reducing the leachate collection rates. Since there is an upward gradient, this percolation rate has been included in the leachate generation rates shown in Table 14.1.

14.3.2 Current Leachate Flow Rates

GHD compared the flow rates from the Leachate Lift Station 3 to the current leachate generation rates obtained from the HELP modelling. There is a discrepancy between the forecast based on current leachate generation rates, and the forecast based on the HELP model. The discrepancy is likely due to the influence of groundwater inflow up through the Landfill base and from the collection of surface water in the leachate collection system. As described in the Surface Water and Groundwater Management Strategy prepared by Golder Associates in 2016, the amount of leachate generation has increased in the past few years along with the amount of groundwater observed in the Slough (Golder Associates, 2016).

Table 14.2 below presents the average daily leachate flow rates from Leachate Lift Station 3 for each month and compares to the forecasted current leachate generation rates from the HELP model. The rates show that some of the estimated leachate generation rates are close to the actual observed rates. However, the remaining months show the actual leachate collection rate to be significantly higher than the forecasted generation rate. As previously stated, the difference is likely due to the influence of groundwater and surface water on the leachate generation rate.

Table 14.2 Groundwater Influence on Leachate Generation

Month	Average Leachate Lift Station 3 Flow Rate (m^3/day)	Forecasted Leachate Generation Rate – Current Footprint (m^3/day)	Estimated Groundwater and Surface Water Influence on Leachate Generation (m^3/day)
January	176	167	9
February	176	202	-
March	158	180	-
April	217	261	-
May	368	63	305
June	272	83	189
July	221	124	97
August	165	153	12
September	173	152	21
October	161	95	66
November	206	127	79
December	184	180	4
Average Monthly Flow	**206**	**149**	**57**

14.4 Leachate Quality

14.4.1 Current Leachate Quality

Table 14.3 below lists the leachate parameters used to forecast leachate quality, and provides the minimum and maximum values as well as the average observed from samples collected in 2016 from the three leachate monitoring locations at the Site. Assessment of these results provides an indication of the variation in leachate strength across the Site.

Table 14.3 2016 Leachate Analytical Results

Parameter	Min	Max	Average MH1	Average MH3	Average Lift Station 2	Average Overall
pH (pH units)	7.45	8.32	7.89	7.81	8.05	7.91
Alkalinity (total as CaCo3)	934	24,600	2,348	3,181	10,715	5,415
Chemical oxygen demand	46	1,110	225	432	867	508
Dissolved organic carbon	13.8	268	63.5	113	195	124
Total Dissolved Solids	1,580	30,700	3,638	4,808	15,115	7,853
Ammonia (as N)	11.4	192	41.3	81.8	138	87.0
Chloride	168	890	323	453	567	448
Nitrate (as N)	0.17	5.71	2.12	5.71	<0.5	3.31
Nitrite (as N)	0.028	0.215	0.078	0.165	0.03	0.099
Orthophosphate, Total	0.222	22	0.399	1.48	9.85	3.91
Phosphorous, Dissolved	<0.3	10.4	2.07	3.50	6.23	4.16
Sulphate	252	2,920	646	702	1,352	900
Sulphide as S	0.023	275	8.09	43.9	148	66.5
Sulfide (as H_2S), Dissolved	0.024	292	8.59	46.6	157	70.6
Iron	0.07	0.276	0.168	0.106	0.07	0.130
Manganese	0.09	0.86	0.550	0.358	0.392	0.433
Notes: All in mg/L < - Result less than indicated detection limit						

Based on the analytical results from leachate samples collected from the existing Landfill, GHD concludes the following:

- Leachate strength varies across the Site.
- Moderate concentrations of alkalinity, Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), phosphorus, and sulphide are present throughout the Landfill, however the concentration of alkalinity, COD, TDS, phosphorus, and sulphide in leachate collected at the southwest corner of Phase 2 are significantly higher than those present throughout the rest of the Landfill, which is generally correlated to younger waste.
- Most parameters show a moderate leachate strength when compared to typical landfill leachate in BC; however, the alkalinity and TDS concentrations in leachate collected at the southwest corner of Phase 2 are representative of a strong leachate.
- Iron and manganese concentrations are generally low compared to typical landfill leachate in BC.

14.4.2 Leachate Quality Forecast

As stated in Section 14.4.1, there is a variation in leachate strength observed between the older waste and the younger waste fill areas. The variations leachate strength are likely to continue as new waste is landfilled at the Site. The composition of leachate will likely shift slightly towards older leachate, more consistent with what is currently observed at MH1 and MH3. Furthermore, leachate generation is currently diluted by the accumulated groundwater and surface water within the Slough. As the waste footprint grows, the proportion of groundwater and surface water within the leachate will decrease, resulting in a more concentrated leachate.

It is also noted that the leachate recirculation program described in Section 6.9 is intended to increase in-situ moisture content and promote anaerobic digestion of the waste. This may result in an increase to organic concentrations in leachate such as ammonia and biochemical oxygen demand (BOD). Leachate recirculation coupled with the forecasted increased proportion of leachate generated from older waste, and the reduced dilution by groundwater and surface water will likely result in leachate concentrations increasing over time. A forecast of leachate quality over the next 10 years is shown on Table 14.4 below based on historical leachate quality results.

Table 14.4 Forecasted Leachate Quality

Parameter	Concentration Range (mg/L) (mixed leachate quality
pH	7.5 – 8.5
Alkalinity	5,000 – 10,000
BOD	200 – 500
COD	500 – 1,200
Ammonia	50 – 250
Chloride	250 – 1,000
Phosphorus	1 – 10
Sulphide	50 – 300
TDS	3,000 – 30,000
Iron	0.1 – 0.5
Manganese	0.1 – 1

14.5 Leachate Treatment and Disposal

Existing leachate collection infrastructure is described in Section 6.8. Collected leachate is conveyed to the leachate pre-treatment system through the following lift stations:

- Leachate Lift Station #1 located west of Phase 1
- Leachate Lift Station #2 located in the southwest corner of Phase 2
- Leachate Lift Station #3 located at the leachate pre-treatment system

These lift stations convey leachate to the leachate pre-treatment system and ultimately to the City sanitary sewer. The leachate pre-treatment system reduces odour in the leachate prior to discharge to the sewer through the reduction of hydrogen sulphide concentrations using an aerator and biofilter. Based on the leachate quality review, the sulphide concentrations in combined leachate samples collected from the sanitary sewer discharge are significantly lower than those in the raw leachate (99.8% reduction), indicating the system is functioning well.

Discharge to the sanitary sewer following pre-treatment is expected to continue to be a feasible long-term leachate management solution, provided the pre-treatment system is capable of managing long-term leachate flow rates. As such, an alternative analysis for leachate management options is not thoroughly investigated in this DOCP. Discussion regarding alternative leachate treatment and disposal methods are provided in Appendix I.

15. Landfill Gas (LFG) Management Plan

15.1 LFG Production Background

LFG is primarily generated as a result of biological decomposition of organic waste material. The processes involved in biological decomposition of solid waste are highly variable. In the early stages of decomposition (typically less than 2 years after initial placement), microbial activity is oxygen consuming (aerobic). This results in relatively high in-situ temperatures, production of gases composed primarily of carbon dioxide (CO_2) with other trace compounds, and production of acidic leachate.

As the oxygen in the solid waste mass is consumed, activity of anaerobic microbes increases and eventually results in production of LFG that is predominantly methane (CH_4) and CO_2, and in some cases hydrogen sulphide gas (H_2S). In this phase of the decomposition, the in-situ temperatures are typically in the range of 30 to 40°C and the leachate has a more basic pH. This methanogenic phase of decomposition will reach an equilibrium level, which will continue for some length of time. The equilibrium condition and the duration of methanogenic decomposition are the primary determinants of the LFG production over time. Within a few years, this anaerobic stage typically becomes and remains dominant until all organic matter in the Landfill has been fully decomposed.

These processes are dependent upon the following primary parameters:

- Age of solid waste
- Quantity of solid waste
- Solid waste composition
- Moisture content
- Density and filling practices
- Climate (i.e., precipitation and temperatures)
- Landfill chemistry

This list is not considered comprehensive but serves to illustrate the complexity of the processes involved in the production of LFG. The solid waste age, quantity, and composition, along with site moisture content are considered the primary influences on the rate and duration of LFG production.

The composition and quantity of the solid waste placed in a landfill will determine the amount of material available for decomposition. Materials with a higher organic content are more readily decomposable than those wastes with a low or no organic content. For example, food and agricultural wastes contribute more readily to LFG production than construction rubble. In general, waste that is derived from residential sources contains a higher decomposable fraction than those derived from other sources.

Collected LFG may contain varying amounts of nitrogen (N_2) and oxygen (O_2) due to intrusion of outside ambient air into the landfill. The typical composition of the gas may be in the following range depending on the operation of the LFG collection system:

- Methane – 35 to 60 percent by volume
- Carbon dioxide – 35 to 60 percent by volume
- Oxygen – 0 to 5 percent by volume
- Nitrogen – 0 to 15 percent by volume

For modelling and design purposes, the composition of LFG produced and collected is assumed to be 50 percent CH_4 and 50 percent CO_2, each by volume.

The optimal range of moisture content in refuse for methane production is reported to be 40 to 70% by weight (Reinhart & Townsend, 1998). Actual LFG production is sensitive to moisture; however, the degree of moisture distribution and saturation within the landfill are difficult to determine. Furthermore, there are various technical difficulties in ensuring adequate leachate distribution and collection within a landfill.

Due to the complexity of the processes involved in LFG production, the methods available to predict variations in production over the life of a site provide only estimates to permit the design of control systems. Flexibility to address changes in the LFG production should always be a primary design consideration in any LFG management program.

The use of predictive models provides the best method of defining a particular site's LFG generation potential. The following subsections present the results of estimated LFG production at the Site with mathematical models.

15.2 Regulatory Criteria

The ENV Landfill Gas Management Regulation (LFG Regulation) requires the following:

- *Regulated landfills*, defined as landfills receiving over 10,000 tonnes of waste per year, or landfills that have over 100,000 tonnes of waste in place, must complete a LFG generations assessment every five years.
- The assessment of the forecasted LFG generation rate in the year of the assessment and for the next 5 years be prepared by a qualified professional and submitted to the ENV.
- If the landfill is currently generating over 1,000 tonnes of methane per year, according to the LFG generation assessment, then a LFG design plan must be submitted to the ENV within one year.

- Once the LFG design plan is accepted, an active landfill gas collection system is required to be installed within four years of the LFG design plan acceptance.

The production of hydrogen sulphide gas is related to health and safety concerns, as well as nuisance impacts, and is regulated under WorkSafeBC, as discussed in Section 15.5.

15.3 LFG Generation Assessment

Based on the total tonnes of waste in place and annual fill rate, Glenmore Landfill is considered a *regulated landfill* site as per Section 4(5) of the LFG Regulation and landfill gas (LFG) generation assessment reports are required to be submitted to ENV every 5 years and as required in Section 4(5) of the LFG Regulation.

The most recent LFG generation assessment was prepared in 2016. This assessment is included in Appendix J. The LFG generation assessment estimated that the methane generation at the Site in 2018 is approximately 1,912 tonnes of CH_4/year. The next update to the LFG Generation Assessment is required in 2021.

15.4 LFG Management Facilities Design Plan

Based on the results of the initial LFG Generation Assessment (CH2M Hill, 2010), the Landfill was estimated to generate 1,000 tonnes or more of methane gas in the year preceding the assessment, thereby triggering the regulatory requirement for a Landfill Gas Management Facilities Design Plan (LFG Plan) under Section 7(1) of the LFG Regulation.

The LFG Plan was prepared by CH2M HILL (2012) to meet the requirements of Section 7(2) of the LFG Regulation. The LFG Plan is provided in Appendix G, and summarized in the subsections below. No updates to the LFG Plan are presented in this DOCP, however a conceptual LFG management schematic of the header extension is provided in Drawing C-20.

15.4.1 LFG Management Design Criteria

The LFG facilities align with design standards performance objectives and performance standards summarized in Table 1.1 of the Landfill Gas Management Facilities Design Guidelines prepared for ENV by Conestoga Rovers & Associates (CRA, now GHD) in 2010. As a regulated site, the LFG collection system has been designed and installed in a phased approach to maximize the collection of generated LFG. The LFG extraction control plan was designed for Phase 1 and Phase 2 filling areas and has been implemented to aid reduction of greenhouse gas (GHG) emissions through current and future beneficial uses (i.e., upgrading of methane by Fortis BC) and thermal destruction through flaring. A Phase 3 LFG control system concept has been developed however; the LFG Plan will be amended in the future to include detailed Phase 3 control system design.

15.4.2 LFG Management Overview

Based on LFG modeling completed as part of the preparation of the CSDP in 2001 (CH2M HILL Canada Limited, 2001), the need for a LFG control system was identified.

Phase 1 and Phase 2

Detailed design of the LFG collection system in the Phase 1 area was completed in 2003 and construction of initial horizontal gas collectors and the header system was ongoing with active landfilling operations from 2004 to 2007. The Phase 2 LFG recovery system was designed to tie into the existing Phase 1 system via an extended 400 mm diameter perimeter ring manifold. Detailed design was completed in mid-2005.

The Phase 1 and Phase 2 LFG horizontal collectors consist of 150 mm diameter SDR 11 perforated pipes. Vertical extraction wells were installed in Phase 2 to collect LFG from areas where waste has been in place prior to the installation of any horizontal collectors. Vertical wells are spaced 60 m apart and are connected directly to the associated horizontal collectors. Phase 2 vertical wells consist of 100 mm and 50 mm diameter HDPE SDR 17 perforated pipes embedded in boreholes with gravel.

The combined LFG control system for Phases 1 and 2 was designed based on a LFG flow rate capacity of 11.9 million cubic meters per year (m^3/yr). Interim gas control is provided by a 600 m^3/hr blower flare station commissioned in November 2005.

A vault houses a gate valve at the end of each run of the horizontal gas collector to balance the collection field, and sample ports for gas quality and velocity monitoring. The LFG laterals connect the vaulted well and the LFG collection field to the ring header. The wellheads are currently above grade and will not be completed in below grade vaults until final cover has been placed.

Subheader H4 was installed east-west across the plateau of the landfill just north of Area 1 to allow for connection of the horizontal-in that will be impacted by filling in Area 1. The wellheads of the horizontal wells east of Area 1 are currently on the west side. During filling of Area 1, wellheads can be added to the east side of the horizontals and connected to a future subheader. The east side subheader will connect to the LFG header on the west side of the Landfill through subheader H4.

Phase 3

The conceptual design for the Phase 3 LFG collection system also includes the placement of 150 mm diameter HDPE SRD 11 perforated pipes in collection trenches in the waste. The horizontal collectors would be spaced approximately 60 m apart and follow an east-west orientation similar to Phases 1 and 2. The first series of horizontal collectors would be laid in a trench in the waste following placement of the first lift of waste (approximately 6 m of waste). The next series would be installed after the next waste lift offset from the first by 30 m.

A ring header system will also be installed in Phase 3, and eventually all three phases of the collection system will be tied to each other via the main collection header pipe.

Condensate Management

LFG is saturated with water vapour and condensate may form in the LFG management system. Condensate management is required to remove and collect condensate forming in the LFG piping network and direct it to the leachate collection system for disposal as leachate.

LFG Extraction Plant and Utilization / Combustion System

The LFG extraction plant extracts, transports, and combusts the collected LFG and houses the mechanical and electrical components required to extract and destroy LFG (i.e., the LFG blower and flare). The blower and flare station consist of a series of skid-mounted units with modular expansion capacity.

The current LFG Management operation is described in Section 6.12, and includes flaring of LFG and beneficial re-use via the Fortis Biogas conversion facility located on-Site.

Fortis BC owns and operates a methane upgrading plant that upgrades recovered LFG from the Landfill to meet pipeline quality gas specifications. The gas is then conveyed to Fortis BC's natural gas distribution network. Alternatively, LFG is thermally destroyed through the flaring system.

15.5 LFG and Safety

As indicated in Section 15.1, LFG is produced primarily due to biological decomposition, generating CO_2 and CH_4. Predominantly due to pressure gradients, LFG migrates through either the landfill cover or adjacent soil and enters the atmosphere, contributing greenhouse gas (GHG) emissions, creating health and toxicity issues, and creating nuisance odours. These impacts are largely dependent upon the pathway by which humans and the environment are exposed.

Sub-surface migration of LFG is influenced by pressure differentials within the waste mass, LFG migration from areas of high pressure to areas of low pressure, diffusion of LFG through from areas of high concentrations to low concentrations, and the permeability of the waste, liner, and cover systems.

Sub-surface migration of LFG poses two primary concerns related to the accumulation of gases within or below structures near the Landfill. First, 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. Second, accumulation of LFG introduces the risk of an explosion if a source of ignition is present. The risk of explosion occurs when the concentration of methane in air exceeds its Lower Explosive Limit (LEL). Because 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.

Visual observation of the sub-surface migration of LFG is possible through identification of areas impacted by vegetative stress. Vegetative stress 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.

H_2S, if present, presents immediate danger to the health and safety of workers. WorkSafeBC regulations and guidelines must be followed. At a minimum, the following procedures are recommended, if the potential for H_2S becomes an issue:

- No persons shall traverse or operate equipment within the limit of waste or near the leachate management infrastructure without wearing a 4-gas meter.

- All leachate collection system cleanout and sump riser pipes blind flanges should be completely sealed, bolted, locked, and identified with appropriate signage.
- Appropriate measures should be taken to prevent persons untrained in H_2S safety and without the appropriate personal protective equipment from entering the site. Appropriate signage should be installed around the limit of waste.
- Appropriate chain link fencing and signage should be installed around leachate sumps, leachate manhole, and toe drains.
- All workers and contractors working in designated Site "Hot Zones" (fenced areas) should be required to have completed the H_2S Alive course.
- All workers and contractors working on-Site should be required to have reviewed and acknowledged the Site health and safety plan which discusses the H_2S safety plan and restricts smoking anywhere onsite.

15.6 LFG Control and Monitoring

The highest likelihood of LFG migration to outside the limit of waste occurs during the winter months when snow and ice can form an impermeable blanket across the ground surface. It is therefore recommended that the potential off-Site LFG migration be monitored at the periphery of the Site, and into the existing buildings currently occupied by the operational personnel. The soil gas concentrations at the Landfill boundary must not exceed the lower explosive limit of methane (five percent by volume). The soil gas concentrations in on-Site buildings must not exceed 20 percent of the lower explosive limit of methane (one percent by volume) at any time. Current LFG monitoring activities conducted at the Site are described in Section 18.4.

16. Contaminating Lifespan Assessment

The contaminating lifespan (CLS) is the period of time after final closure of the Landfill that is required for leachate parameters from the Landfill to sufficiently decay such that the quality of the leachate meets the applicable water quality performance criteria, as discussed further in Section 18. At the end of the CLS the leachate generated at the Site no longer poses an environmental risk to the receiving environment. The CLS is used to determine the length of the post-closure environmental monitoring program, as discussed in Section 18. This section presents the CLS Assessment for the Site.

Based on the current Landfill design and projected filling rate, approximately 90 years of Site life remain. The CLS Assessment should be updated based on available data and with new research on degradation rates during each subsequent DOCP or if future detailed design activities require an updated CLS Assessment.

16.1 First Order Decay Model

The CLS of the Site was estimated using a first order decay function. Completing the first order decay function is not possible for all leachate indicator parameters as decay constants have not been developed for all of the common leachate indicator parameters such as iron and manganese

(Lu *et al*., 1981). Due to this limitation, the parameters selected to estimate the CLS include chloride and ammonia. Chloride and ammonia have also been identified as key leachate indicators for the Site, based on groundwater chemistry interpretation (Golder, 2018). Chloride was selected as it only decays through dissolution. Ammonia was selected to perform a check of the chloride decay rate; however, it should be noted that ammonia may be subject to biological influence.

Leachate indicator parameter degradation was simulated utilizing the 1DTRANSEN model. The leachate source concentration in the one-dimensional transport model is governed by the time function.

$$C_0 = \begin{cases} (t/t_1)C_B + C_A & 0 < t < t_1 \\ C_B & t_1 \leq t < t_2 \\ C_B e^{-\lambda t} & t \geq t_2 \end{cases}$$

Where:

C_0 = Parameter concentration at time of sufficient degradation

C_A = Parameter concentration prior to landfilling

C_B = Parameter concentration at Site closure

t = Simulation time

t_1 = Time landfilling commences

t_2 = Time of Site closure

λ = Decay constant

For the purpose of this assessment, GHD focused on the post-closure period (i.e., $t \geq t_2$). When the simulation time is greater than t_2, the source concentration is assumed to decay exponentially at a rate of λ, the first order decay constant. The concentration at Site closure, C_B, was estimated for each constituent of concern, based on leachate data obtains from the Site's leachate monitoring program as well as forecasted leachate quality as indicated in Section 14.4.2.

16.1.1 Estimated Leachate Concentrations

Concentrations of the leachate parameters used in this CLS Assessment were estimated using 2014 - 2017 leachate quality data from leachate samples collected from three manholes located on the Site's leachate collection system. GHD understands the leachate collected in the Site's leachate collection system is diluted with groundwater and surface water as the estimated leachate generation rate for the Site described in Section 14.3.2, is markedly lower than the measured leachate volumes collected by the Site's leachate collection system. GHD has also calculated the CLS of the Site using estimated leachate concentration values indicated in Section 14.4.2. The CLS estimate using the existing leachate concentration data provides a conservative estimate and the

CLS estimate using the estimated leachate concentrations included in Appendix K provides a "maximum" estimate.

16.1.2 Results

The First Order Decay Method estimates the CLS for each constituents of concern identified for the Site. The CLS is measured by years for each constituent to decay to meet the applicable CSR water quality standards or to return to background groundwater conditions. Table 16.1 below provides a summary of the results of the CLS Assessment; the supporting calculations are provided in Appendix K.

Table 16.1 Contaminating Lifespan Estimate Results

Parameter	Years to Meet Applicable Water Quality Criteria (mean estimate)	Years to Meet Applicable Water Quality Criteria (maximum estimate)
Chloride	25	36
Ammonia	69	79

16.2 Rowe Model

The Rowe Model was used to provide a second estimate of the CLS of the Landfill to compare to the First Order Decay CLS estimate. The methodology and results of the Rowe Model are further described in the subsections below.

16.2.1 Model Based on Rowe (1995)

Rowe (1995) examined the issue of leachate strength decrease for conservative contaminant species (e.g., chloride) where the decrease in strength is essentially due to dilution (i.e., no biological breakdown or precipitation) as water infiltrated through the waste with time. Limited information regarding the proportion of other common landfill derived contaminates in landfills is available as it has not been investigated, therefore only chloride can be used in Rowe model calculations at this time. Assuming that the decrease in chloride is due to dilution, the variation in concentration at any time t is given by:

$$C_{(t)} = C_o e^{[-\left(\frac{q_o}{H_r}+\lambda\right)t]}$$

Where:

$$H_r = \frac{p * M_o}{A_0 * C_0}$$

Where:

$C_{(t)}$ = target concentration [i.e., BC CSR] (kg/m^3)

C_o = peak or average chloride concentration (mg/L)

q_o = average rate of infiltration (m/yr)

H_r = reference height of leachate (kg)

M_o = mass of waste in landfill (kg)

p = proportion of the total mass of waste that is contributed by chloride

A_o = area of landfill footprint (m^2)

λ = first order decay constant

t = time required (yr)

Note that this model was used for three scenarios, as follows:

- Scenario 1: Maximum chloride concentration (from modelling), average proportion of chloride in waste
- Scenario 2: Average chloride concentration (from Site leachate data), maximum proportion of chloride in waste
- Scenario 3: Maximum chloride concentration (from modelling), maximum proportion of chloride in waste

Scenario 3 represents the maximum estimate conditions.

16.2.2 Site Parameters

Concentrations of Chloride

As described in Section 16.1.1.

Dry Density of Waste

A dry waste density of 720 kg of waste per m^3 of airspace was used as this figure was also used to estimate airspace consumption rates in this DOCP.

Volume of Waste

The total volume of airspace in Stage 3 is approximately 9,000,000 m^3 (8,700,000 m^3 of waste) within an area of approximately 346,000 m^2.

Chloride Percentage in Waste

The mass of contaminant can be characterized in terms of the mass of waste and proportion of that mass which is the chemical of interest. Rowe (1995) reports that the data on the mass of contaminants in waste are relatively sparse and published data of chloride representative of municipal waste are in the range of 0.07 percent and 0.21 percent of the in-situ mass of refuse. For the Rowe model calculations a chloride waste percentage of 0.14 was used for the average estimates and 0.21 percent was used for the maximum estimates.

Target Concentration

The target concentration is defined by the CSR standards required to achieve compliance in the groundwater. The Irrigation standard is 100 mg/L and the Drinking Water Standard is 250 mg/L. For the purpose of the CLS Assessment, a resulting concentration above these thresholds would be defined as an "unacceptable impact" at the Site boundary.

16.2.3 Rowe Model Results

The CLS for chloride was evaluated using the Rowe Model to confirm the result of the First Order Decay Method for estimated CLS. The estimated CLS, in years, for each scenario modelled is presented in the table below. The supporting calculations are provided in Appendix K.

Scenario	Years to Meet CSR IW Criteria
Maximum chloride concentration, average proportion of chloride in waste	35
Average chloride concentration, maximum proportion of chloride in waste	25
Maximum chloride concentration, maximum proportion of chloride in waste	35

Rowe Model calculations were also completed to determine the required time to reach compliance with the CSR DW water quality standards (Appendix K). The CLS estimates using the Rowe Model ranged from 10 to 21 years to reach CSR DW levels. As stated in Section 7.4 of the Landfill Criteria, estimated contaminating lifespans less than 30 years are not permitted, therefore the CLS estimates of 10 and 21 years will not be used in future planning for the Site.

16.3 Summary of Contaminating Lifespan Assessments

The First Order Decay Method determined that the mean concentration time period and "maximum estimate" time period estimates for chloride to decay to meet CSR and BC WQG Irrigation standards/guidelines is 25 years and 36 years, respectively. As stated in Section 7.4 of the Landfill Criteria, estimated contaminating lifespans less than 30 years are not permitted, therefore the mean concentration estimate for chloride of 25 years should not be used in future planning for the Site.

Using the First Order Decay Method, GHD determined that the mean concentration time period and ”maximum estimate” time period estimates for ammonia to decay to meet the BC WQG for Freshwater Aquatic Life is 69 years and 79 years, respectively.

The Rowe Model was used to provide a second estimate of the CLS of the Landfill to compare to the First Order Decay CLS estimate for chloride. The Rowe Model estimates a CLS of 25 years using the mean chloride concentration and 35 years using the maximum predicted concentration. As stated in Section 7.4 of the Landfill Criteria, estimated contaminating lifespans less than 30 years are not permitted, therefore the mean concentration estimate for chloride of 25 years will not be used in future planning for the Site.

Based on the above, the maximum estimated CLS of 79 years should be used in estimates of the sites contaminating lifespan. GHD notes that the forecasted closure date is 90 years in the future, and that the CLS estimate should be updated with each DOCP update with updated leachate data and new and/or amended first order decay constants as additional Landfill leachate research is completed.

17. Closure Plan and Post Closure Period

17.1 Progressive Closure Strategy

As per Section 8.4, the estimated Site life is approximately 90 years. Areas of the Landfill that reach final waste contours as shown in Drawing C-05 will be closed once sufficient area to warrant construction of final cover is available. The final cover design is discussed in Section 9.3.

The Site life should be updated in the annual operations and monitoring report based on the final waste contours and average annual fill rates.

17.2 End Use

There is presently no end use plan formulated for the Site. A detailed End Use Plan will be developed for the Site within one to two years prior to closure. The end use plan will comply with the requirements of the CSR and a new declaration under Part 8 of the CSR may be submitted to the MOE Director. The End Use Plan will be submitted to the Regional Waste Manager for review and approval prior to implementation.

17.3 Post Closure Requirements

17.3.1 Post Closure Period

The post-closure period is defined by the Landfill Criteria as the period of time from installation of final cover over the entire Landfill to the end of the contaminating lifespan. As indicated in Section 16, the upper bound estimate for the CLS for the Site was estimated to be 79 years.

17.3.2 Post Closure Environmental Monitoring

Based on the environmental conditions of the Site at the time of closure, a post-closure EMP will be developed and conducted at the Site. It will include the following:

- Hydraulic monitoring of groundwater levels
- Field monitoring, sampling, and/or chemical analysis of surface water, groundwater, leachate, and LFG
- General site inspections for settlement, erosion, and vegetative stress

The post-closure monitoring program will continue for the duration of the post-closure period. As the Site conditions relative to the quantity and quality of surface water and groundwater stabilize and become predictable under post-closure conditions, amendments to the environmental monitoring program may be warranted. Any proposed amendments to the long-term environmental monitoring program will be submitted to the Director for review and approval prior to implementation.

17.3.3 Final Cover

The final cover will be inspected at least annually and vegetation will be managed (cut, removed or restored as required) at least twice annually or more often as required to prevent damage via the growth of deep rooting plants. Inspection should include identification of any exposed areas of the GCL cap, to ensure that no significant damage has occurred due to plant growth, sloughing of the cover, leachate breakouts, burrowing animals, or significant settlement. Damage observed will be noted and repaired as soon as practical.

17.3.4 Site Access Roads and Fencing

Site access roads will be maintained post-closure to ensure safe access by monitoring and maintenance staff and to facilitate any required maintenance. Site access roads will be inspected annually and repaired as required to ensure safe access to the Site.

Site fencing will be maintained and/or replaced to prevent unauthorized entry to the Site and potential damage to Site infrastructure. Upon closure, a suitable fence should be installed to prevent public entry. Fenced areas will include, at a minimum, the Landfill, the LFG flare compound and associated above ground infrastructure, and the SWM Ponds.

17.3.5 Vectors, Vermin, and Animal Control

After closure, the Site will continue to be monitored for the presence of vectors, vermin, and wildlife and should problems become evident, the appropriate steps will be taken to address the issue.

17.3.6 Surface Water Control

The strategy outlined in the surface water management plan in Section 13.0 will be maintained at the Site during the post-closure period to manage and control surface water flows. The mid-slope swales, ditches, and SWM Ponds will be designed to for the post-closure period. Channels with steep slopes will require erosion protection, as discussed in Section 13.0. Ditches, the SWM Ponds, and inlet and outlet structures will require reassessment upon Site closure to ensure that they are functioning satisfactorily. Vegetation will be maintained on the Landfill surface to control erosion and promote evapotranspiration, and in the channels to ensure channels maintain their design capacity. Surface water management infrastructure will be inspected annually and damage will be noted and repaired as required. The surface water management works including ditches, swales, culverts, pipes, and the SWM Ponds monitored and maintained as required.

17.3.7 Leachate Collection System

The leachate management plan described in Section 14.0 will be operated and maintained at the Site during the post-closure period. It is assumed the leachate collection system will operate throughout the entire post-closure period. Each lift station and the leachate pre-treatment station should be inspected on a monthly basis to ensure the leachate collection system is operating properly. Any damages or operational issues noted at the leachate collection system should be repaired as soon as possible.

17.3.8 LFG Collection System

The LFG management system including collection infrastructure and flare compound will operate after closure. The operational life of the LFG management infrastructure will be determined based on reduction in methane generation rates, however, it is assumed to be not less than the post-closure period unless operational data indicates that methane concentrations are reduced to a level which warrants the cessation of the flare operation. Typically, a LFG collection rate less than 100 cubic metres per hour does not warrant flare operation. Post-closure period operation of LFG infrastructure will include operation, maintenance and repair (as needed).

18. Environmental Monitoring Plan (EMP)

The purpose of the environmental monitoring plan (EMP) is to monitor the quality of leachate, groundwater and surface water, and to monitor for the presence of LFG at, and in the vicinity of the Site. The EMP will detect actual and/or potential landfill-derived impacts to the receiving environment, if occurring. The scope of the EMP for the Site has been developed with consideration of the requirements outlined in the following documents:

- Landfill (ENV, 2016)
- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills (ENV, 1996)
- The Site's OC12218
- 2017 Annual Water Quality Monitoring Report (Golder, 2018) (2017 Annual Report)
- BC LFG Management Facilities Design Guidelines (ENV, 2010)

The EMP is Site specific and is based on Site geology, hydrogeology, leachate indicator parameters and previous monitoring results. The following section presents a summary and recommendations for the EMP. Further details on current and historical environmental data including regulatory compliance and trends are presented in the 2017 Annual Report.

18.1 Leachate Monitoring

As indicated in Section 9.1 of the Landfill Criteria, the purpose of a Landfill's leachate monitoring program is to determine the site-specific leachate indicator parameters to ensure they are included in the groundwater and surface water monitoring program. This section summarizes the current leachate monitoring program and indicates future monitoring locations as the leachate collection system at the Site expands.

18.1.1 Current Leachate Monitoring Program

The leachate monitoring program consists of sample collection for field and laboratory analysis at three manholes located along the Site's leachate collection system. The locations of each manhole are indicated on Figure 18.1. Leachate samples are collected from each manhole on a quarterly basis for general chemistry parameters, nutrients, dissolved metals, and petroleum hydrocarbon constituents. A detailed list of parameters included in the leachate monitoring program is provided in

Appendix L. The leachate manholes included in the current leachate monitoring program are as follows:

- MH3 (N Pumphouse Manhole) – West side of Phase 1
- MH1 (P1 Leachate Manhole) – Southwest corner of Phase 1
- Wet Well (S Leachate Wet Well) – Southwest corner of Phase 2

18.1.2 Leachate Monitoring Program Amendments

As the Landfill footprint and related leachate collection infrastructure expands into Area 1, Area 2, and Area 3, the addition of new sampling locations in the Site's expanded leachate collection system is required to ensure Site leachate is adequately characterized to include the appropriate monitoring parameters in the Site's EMP. The inclusion of accessible and suitable sampling locations should be incorporated in the detailed design of the expanded leachate collection system.

18.2 Groundwater

This section details the current groundwater monitoring program conducted at the Site and proposed additions to the groundwater monitoring program to address the future development of the Site.

18.2.1 Groundwater Quality Performance Criteria

Groundwater quality at the Site is compared to the BC CSR generic numerical water quality standards (including amendments up to B.C. Reg. 253/2016, November 1, 2017) as follows:

- Schedule 3.2 Column 3 Aquatic Life, Freshwater (AW)
- Schedule 3.2 Column 4 Irrigation (IW)

The CSR AW standard is applied to the Site as per Protocol 21 for Contaminated Sites – Water Use Determination (ENV, 2017). The CSR IW standard is applied to groundwater quality for the Site as surface water from Tutt Pond and Bredin Pond are used for irrigation purposes off-Site.

Groundwater quality at the Site is also compared to the following BC Approved Water Quality Guidelines (ENV, 2018) and BC Working Water Quality Guidelines (MOE, 2017) (BC WQGs):

- Irrigation
- Freshwater Aquatic Life (GL23-1, GL28-1/2/3, 09BH03-S/D, and 09BH06-S/D only)

As requested by ENV, groundwater quality at the GL28-1/2/3 well series is also compared to the following:

- Guidelines for Canadian Drinking Water Quality (Health Canada, 2017)

18.2.2 Current Groundwater Monitoring Program

At this time, there are 82 groundwater monitoring wells included in the Site's EMP. Hydraulic monitoring is conducted at each of the 82 monitoring wells on a semi-annual basis each spring (following the freshet season) and fall. During the spring monitoring event, 23 monitoring wells are sampled for field and laboratory analysis. Groundwater samples are collected for analysis of general chemistry parameters, nutrients, and dissolved metals. The wells sampled during the spring monitoring event are listed in Table 18.1 below and are grouped based on their location relative to the Landfill and screened hydrostratigraphic unit.

Table 18.1 Current EMP - Spring

	Waste	Clay	Sand/Gravel	Till	Bedrock
North of Phase 1 (background)			GL0-3	GL0-2	GL0-1
Northeast of Phase 1 (background)			GL23-1		
Phase 1			GL3-5		
Phase 2	GL6-1 (2011)	GL2-1	GL5-2, GL18-2		
Phase 3			GL35-3	GL9-3	GL9-1
South of Phase 3				GL12-1	GL29-1
Southwest of Phase 3		GL27-3			GL16-1, GL17-1, GL27-1
Downgradient of the Site (compliance)		GL28-3	GL28-2	GL28-1	

Monitoring wells 09BH06D and 09BH03 located downgradient of the Site, are also sampled during the spring monitoring event. . The borehole logs for these locations were not available at the time of preparing this report, therefore the screened hydrostratigraphic unit(s) is/are not known.

During the fall monitoring event, nine monitoring wells are sampled for field and laboratory analysis. The wells sampled during the fall monitoring event are listed in Table 18.2 below and are grouped based on their location relative to the Landfill and screened hydrostratigraphic unit.

Table 18.2 Current EMP - Fall

	Waste	Clay	Sand/gravel	Till	Bedrock
South of Phase 3				GL12-1	GL29-1
Southwest of Phase 3				GL15-2	GL17-1, GL27-1, GL15-1
Downgradient of the Site (compliance)		GL28-3	GL28-2	GL28-1	

A detailed list of parameters included in the groundwater monitoring program is provided in Appendix L.

18.2.3 Groundwater Monitoring Program Amendments

As development of the Landfill progress, the following existing monitoring wells should be included in the Site's groundwater monitoring program for sample collection during the spring and fall monitoring events:

	Waste	Clay	Sand/gravel	Till	Bedrock
Area 1		GL2-2	GL2-1	GL20-1	
Area 3		GL4-2	GL4-1		

In addition to the monitoring locations above, nested monitoring wells GL0-1/2/3 will need to be decommissioned and replaced when landfilling at Area 2 progresses. The proposed location for the replacement wells for GL0-1/2/3 is indicated on Figure 18.1.

18.3 Surface Water

This section details the current surface water monitoring program conducted at the Site and proposed additions to the surface water monitoring program to address the future development of the Site.

18.3.1 Surface Water Quality Performance Criteria

Surface water quality at the Site is compared to the BC CSR generic numerical water quality standards (including amendments up to B.C. Reg. 253/2016, November 1, 2017) as follows:

- Schedule 3.2 Column 4 Irrigation

The CSR IW standard is applied to surface water quality for the Site as surface water from Tutt Pond and Bredin Pond are used for irrigation purposes off-Site.

Surface water quality at the Site is also compared to the following BC Approved Water Quality Guidelines (ENV, 2018) and BC Working Water Quality Guidelines (MOE, 2017) (BC WQGs):

- Irrigation
- Freshwater Aquatic Life (Northeast Pond only)

18.3.2 Current Surface Water Monitoring Program

Surface water monitoring is conducted at the Site on a semi-annual (spring and fall) basis. The current surface water monitoring program at the Site consists of sampling the four existing surface water ponds on-Site as follows:

- Northeast Pond – northeast corner of the Site
- Tutt Pond – west side of the Site
- Bredin Pond – northwest corner of the Site
- Slough – central area of the Site

The location of each of these surface water sampling locations is indicated on Figure 18.1. A detailed list of analytes included in the surface water monitoring program is provided in Appendix L.

18.3.3 Surface Water Monitoring Program Amendments

As increased surface water management infrastructure is developed at the Site as further detailed in Section 13, additional surface water monitoring locations should be added to the EMP including, but not limited to the following locations:

- North surface water pond, located north of LFG flare compound
- South surface water pond, located at southwest corner of the limit of waste
- Background ephemeral surface water locations north of the Site

Surface water quality should be compared to the Criteria in Section 18.3.1 and background surface water quality.

18.4 LFG Monitoring

This section details the current LFG monitoring program conducted at the Site and proposed additions to the LFG monitoring program to address the existing conditions and planned development of the Site.

LFG monitoring is required to ensure the health and safety of the Site staff, users of the Site and the public. The LFG monitoring program should be developed and conducted in accordance with Section 8.0 of the BC LFG Management Facilities Design Guidelines (ENV, 2010) and Sections 4.2 and 9.3 of the Landfill Criteria.

18.4.1 Current LFG Monitoring Program

LFG monitoring is conducted on a monthly basis at the following locations:

- Five (5) subsurface perimeter probes located near Bredin Pond adjacent to the western property boundary of the Site
- 64 Gas wellheads
- Buildings within 300 m of buried waste

The locations of the LFG perimeter probes are presented on Figure 18.1.

18.4.2 LFG Monitoring Program Amendments

At this time, the current perimeter gas probe network does not surround the current limit of waste and likely requires expansion. As per Section 8.1 of the LFG Management Facilities Design Guidelines (MOE, 2010), LFG Migration Assessment should be completed by a Qualified Professional to identify potential pathways of LFG migration to off-Site receptors prior to installing additional perimeter LFG probes.

As per Section 9.0 of the LFG Management Facilities Design Guidelines (MOE, 2010), all buildings on-Site must have continuous air monitoring for combustible gas. At this time, the City is working to assess the risk of LFG exposure for the buildings at and near the Site to develop an updated LFG monitoring plan for these buildings.

18.5 Annual Operations and Monitoring Report

An annual operations and monitoring report (Annual Report) will be prepared for the Site summarizing the site operations or post-closure activities completed at the Site for the preceding calendar year. The Annual Report will include the reporting items indicated in Section 4.2 of the OC as well as Section 10.6 of the Landfill Criteria.

19. Fire Safety and Emergency Contingency Plan

A Fire Safety and Emergency Contingency Plan is required for the Site in accordance with the BC Occupational Health and Safety Regulation 296/97 Part 4, S.4.13 - 4.18 (Emergency Preparedness and Response) and Part 5, s.5.97 - 5.102 (Emergency Procedures), as well as Section 2.8 of the BC Fire Code. The Fire Safety and Emergency Contingency Plan is required to be submitted to the appropriate fire authority(ies), the responding fire department(s), the Director, and the City.

A copy of the draft Fire Safety and Emergency Contingency Plan is included as Appendix F to this DOCP. This plan should be reviewed and updated at least once annually.

20. Contingency Measures

As defined by the Landfill Criteria, contingency measures are practical and implementable measures in the event of a failure or non-compliance with the Site's Performance Criteria. Performance Criteria are defined by the Landfill Criteria as groundwater and surface water quality, landfill gas management, and nuisance (Section 4.0 of the Landfill Criteria).

The following list presents potential conditions and associated potential contingency measures that could be implemented at the Site.

- If leachate derived impacts are identified in groundwater migrating from the Site:
  - Increase extent and frequency of groundwater monitoring to investigate/ confirm the nature and extent of the impacts
  - Inspect the leachate collection system and complete any repairs required as soon as possible.
  - Undertake measures to further reduce leachate generation, such as advanced placement of progressive intermediate or final cover.
  - Consider acquiring access to the affected land(s) to increase the attenuation capacity and Landfill buffer zones within the Site (if possible).
  - Consider installation of a groundwater extraction system to reduce the flux of impacted groundwater migrating from the Site.

- If leachate derived impacts are identified in off-site natural surface water bodies:
    - Review surface water management on the Landfill to prevent the release of leachate impacted surface water to the surface water management system.
    - Increase surface water controls within the active Landfill area.
    - Accelerate the schedule of the intermediate/final cover placement and construction of the post-closure surface water management works.
- If LFG impacts are detected at levels higher than 20 percent of the lower explosive limit in on-Site buildings, or higher than 50 percent of the lower explosive limit at the Site boundary:
    - Review the performance of the existing landfill gas collection system and identify measures to improve performance.
    - Install LFG migration vents and/or barriers to mitigate landfill gas migration in soil gas to the property boundary or on-Site buildings.
- If the City receives a complaint of nuisance impacts from neighboring properties:
    - Review the source of the activity or action that generated the reported nuisance and develop changes to operations that could be implemented to mitigate the nuisance.

The applicability of each contingency measure listed above to the potential Site-specific condition would be assessed at the time that the potential condition is identified through the implementation of the EMP. The condition and the action plan to address the condition would be submitted to the MOE in the Annual Operations Report as per Landfill Criteria Section 10.6.

21. Financial Security Plan

Appendix C presents the Financial Security Plan for the Landfill.

The Financial Security Plan has been developed based on Section 8 of the Landfill Criteria and includes the forecasted cost of closure and post-closure maintenance and environmental monitoring for the contaminating lifespan of the Landfill. The estimate of the amount of financial security required is based on two scenarios; emergency closure (i.e., closure before reaching final capacity) and closure when planned capacity is reached. As the Landfill has approximately 90 years of capacity remaining and the future costs are discounted, the cost of financial security under the emergency closure section is higher, as the costs are estimated based on closing the Landfill in 2019/2020 (emergency closure).

22. Closure

All of Which is Respectfully Submitted,

GHD

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
D. J. LIDDY
33360

Deacon Liddy, P.Eng., MBA

RHasior

Roxanne Hasior, B.A.Sc. EIT

Michaela Dyck

Michaela Dyck, B.Sc. GIT

23. References

BC Ministry of Environment. (2012). *Aquifer Classification Worksheet Aquifer Number 470.*

BC Ministry of Environment. (2016). *Landfill Criteria for Municipal Solid Waste, Second Edition.*

BC Ministry of Transportation. (2007). *Supplement to TAC (Transportation Association of Canada) Geometric Design Guide 2007 Edition. .*

CH2M HILL Canada Limited. (2001). *Comprehensive Site Development Plan Glenmore Landfill .* Prepared for the City of Kelowna.

CH2M HILL Canada Limited. (2006). *Surface Water Management Plan.* Prepared for the City of Kelowna.

CH2M HILL Canada Limited. (2008). *Comprehensive Site Developement Plan.* Prepared for the City of Kelowna.

CH2M HILL Canada Limited. (2015). *City of Kelowna Glenmore Landfill - Preliminary Design and Phasing for the Leachate Recirculation and LFG Collection Systems.* Prepared for: City of Kelowna.

CH2M HILL Canada Limited. (2017). *Leachate Recirculation Operational Procedure Manual.* Prepared for the City of Kelowna.

Church, B. (1981). *Geology of Kelowna, tertiary outllier (east half), Preliminary Map No. 45.* Ministry of Energy, Mines and Petroleum Resources Canada.

Conestoga-Rovers & Associates. (2014). *Assessment of Potential Nuisance Levels of Niose, Odour, Dust, Light & Litter.* Prepared for Glenmore Landfill.

DataBC. (2018). *iMapBC.*

Gartner Lee Limited. (1990). *Phase 1 Environmental Assessment City of Kelowna Glenmore Landfill.*

Gartner Lee Limited. (1992). *Glenmore Landfill Hydrogeological Investigation.*

GHD. (2017). *Memo - Professional Opinion - Diamond Mountain Development Nuisance Boundary .* Prepared for Glenmore Landfill.

Golder Associates. (2016, July). Surface Water and Groundwater Management Strategy.

Golder Associates Ltd. (2009). *Hydrogeological Assessment – North Pond Aquifer, Glenmore Landfill, Kelowna, BC.* Prepared for the City of Kelowna.

Golder Associates Ltd. (2012). *Detailed Hydrogeological Assessment, Glenmore Landfill, Kelowna, BC.* Prepared for the City of Kelowna.

Golder Associates Ltd. (2014). *Hydrogeological Assessment of Bedrock Faults in Terms of their Potential to Support Off-Site Groundwater and Leachate Migration.* Prepared for the City of Kelowna.

Golder Associates Ltd. (2016). *2015 Annual Water Quality Monitoring Report, Glenmore Landfill, Kelowna, BC.* Prepared for the City of Kelowna.

Golder Associates Ltd. (2016). *Surface Water and Groundwaste Management Strategy.* Prepared for the City of Kelowna.

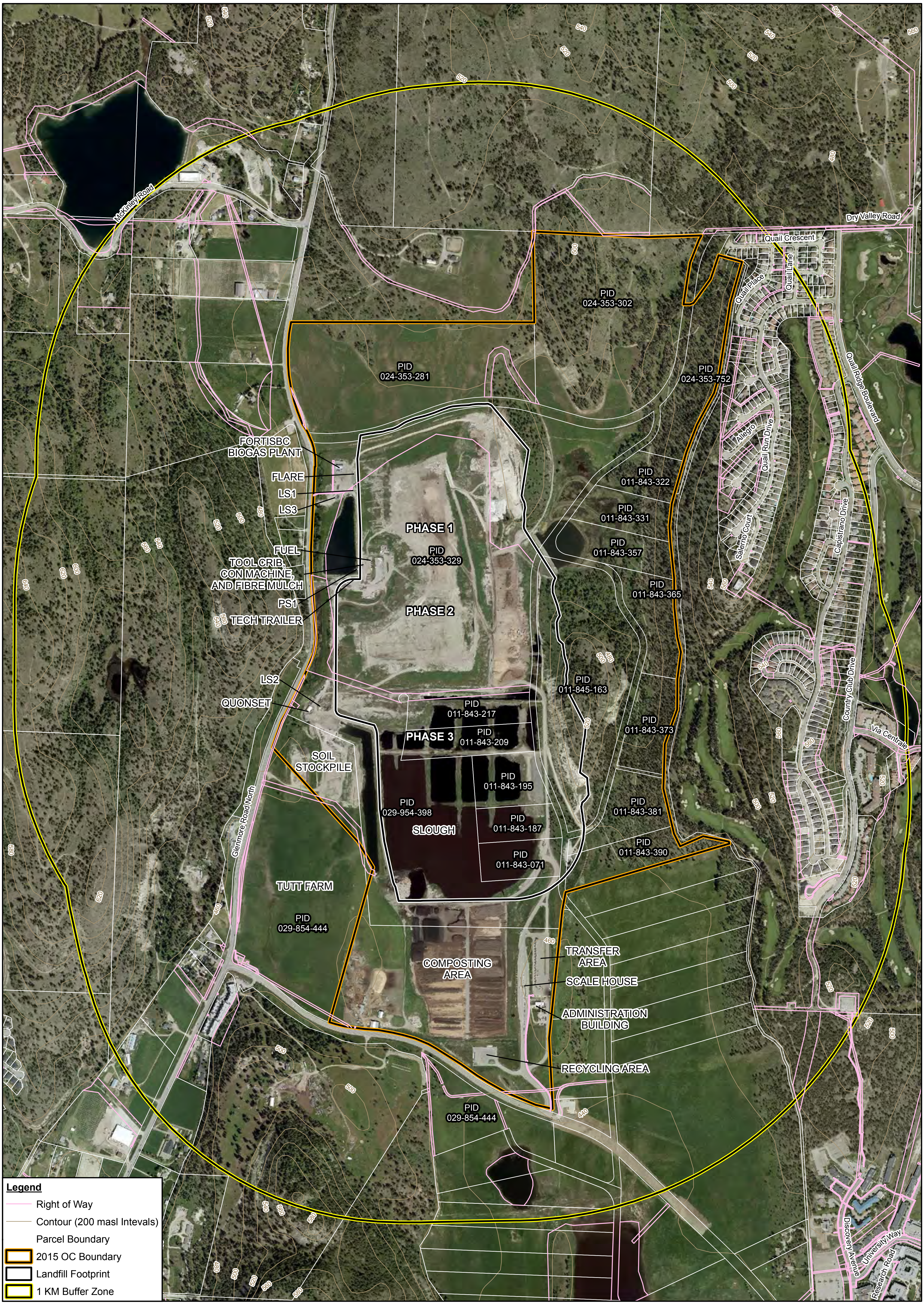
Golder Associates Ltd. (2017). *2016 Glenmore Landfill Annual Report.* Prepared for the City of Kelowna.

Morrison Hershfield. (2017). *Solid Waste Management Plan Regional District of Central Okanagan - Final Draft.*

Okulitch, A. (2013). *Geology Okanagan Watershed.*

OPUS International Consultants Ltd. . (2016). *Glenmore Landfill Composting Options Study.* Prepared for: City of Kelowna.

SLR Consulting Canada Ltd. (2015). *Water Well Survey and Bedrock Geology Review in the Vicinity of the Glenmore Landfill.* Prepared for the City of Kelowna.



Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17).
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 110 220 330
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

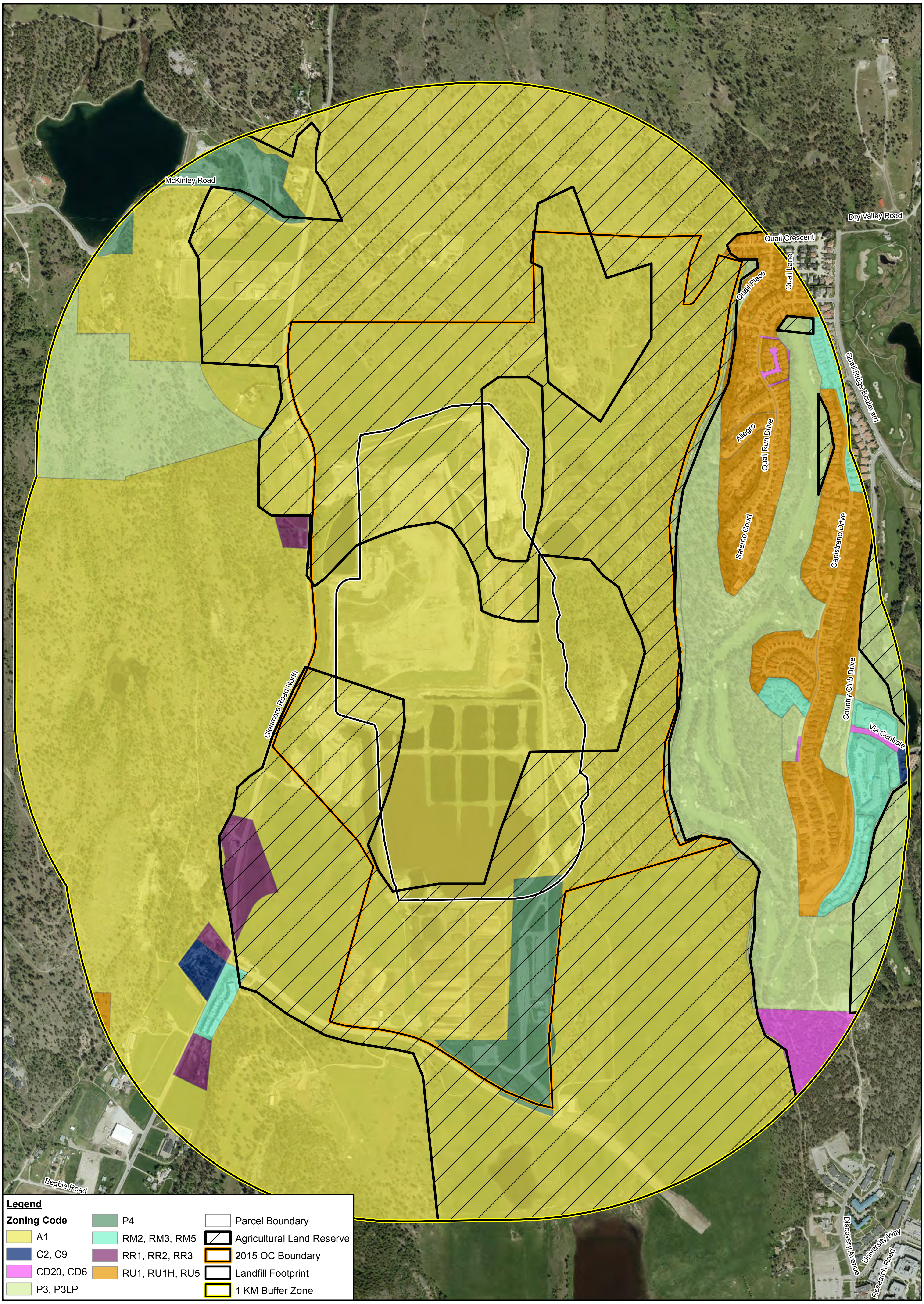
2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Jul 11, 2018

SITE PLAN

FIGURE 4.1

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT006.mxd



Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17). Data as of City of Kelowna open data download, Accessed 2018
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 110 220 330
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

N

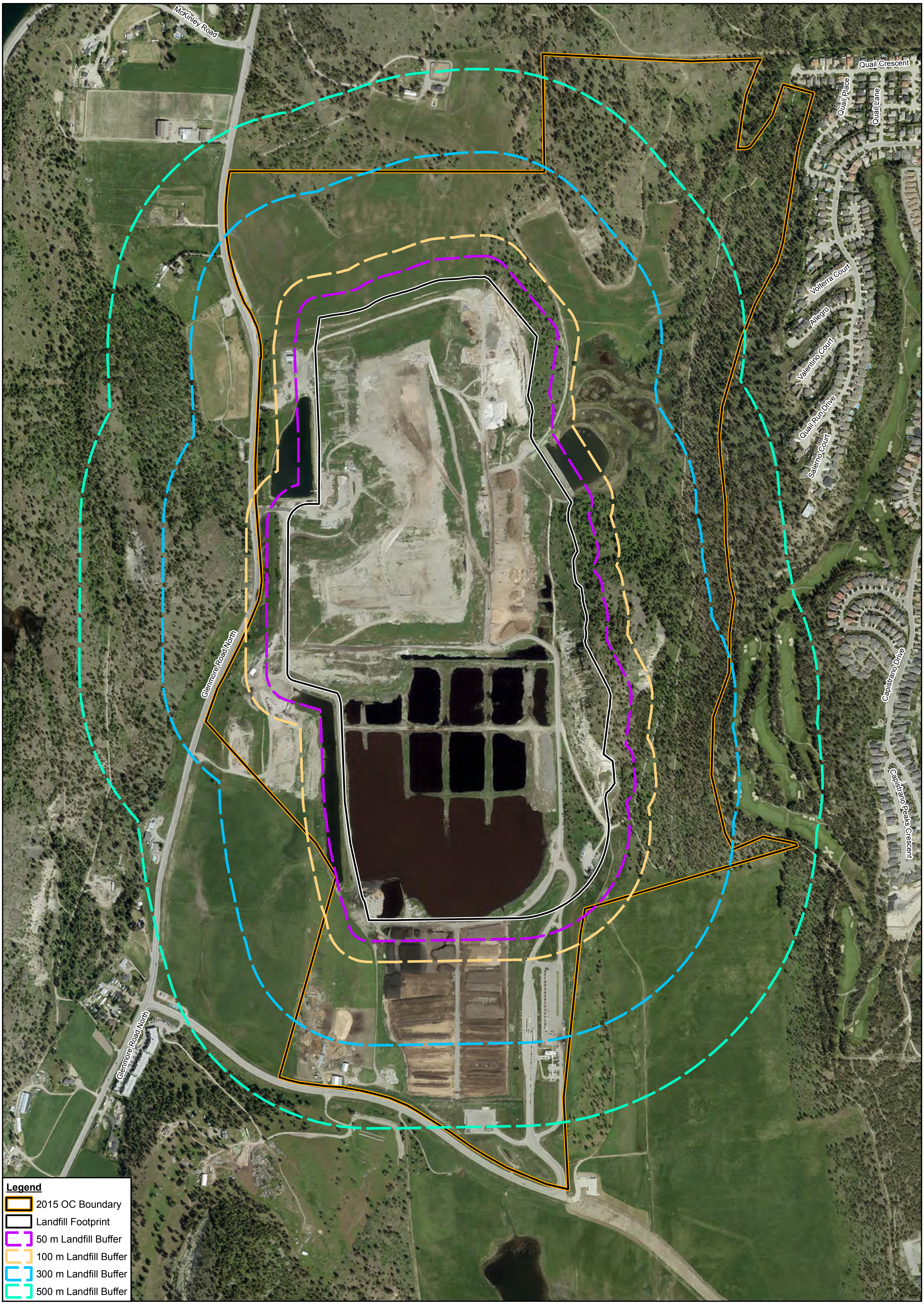
2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Jul 6, 2018

ZONING AND LAND USE

FIGURE 4.2

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT007.mxd



Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17).
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 85 170 255
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

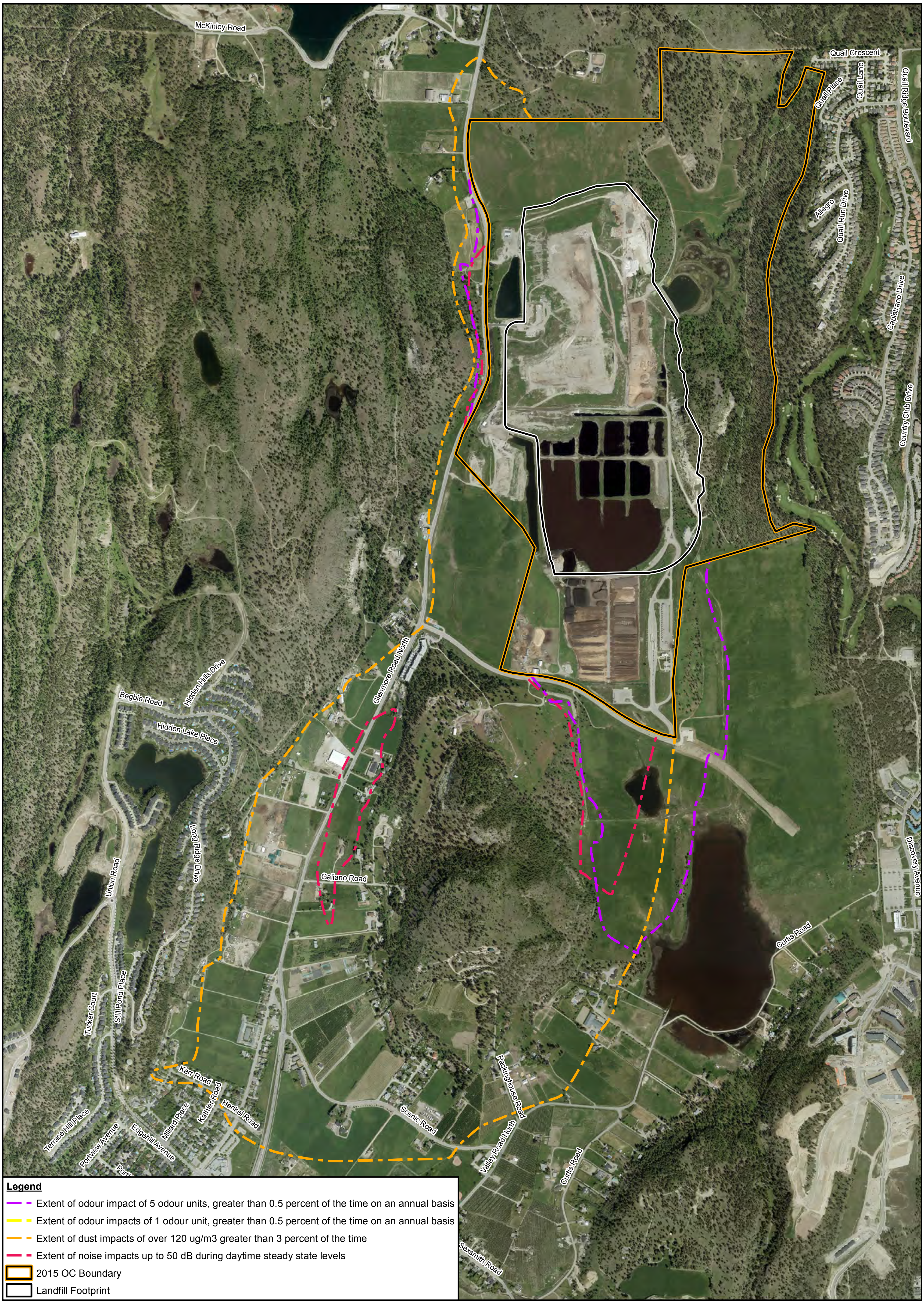
DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

BUFFER ZONES

084612-22
Sep 7, 2018

FIGURE4.3

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT011.mxd



Legend
- Extent of odour impact of 5 odour units, greater than 0.5 percent of the time on an annual basis
- Extent of odour impacts of 1 odour unit, greater than 0.5 percent of the time on an annual basis
- Extent of dust impacts of over 120 ug/m3 greater than 3 percent of the time
- Extent of noise impacts up to 50 dB during daytime steady state levels
- 2015 OC Boundary
- Landfill Footprint

Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17).
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 140 280 420
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

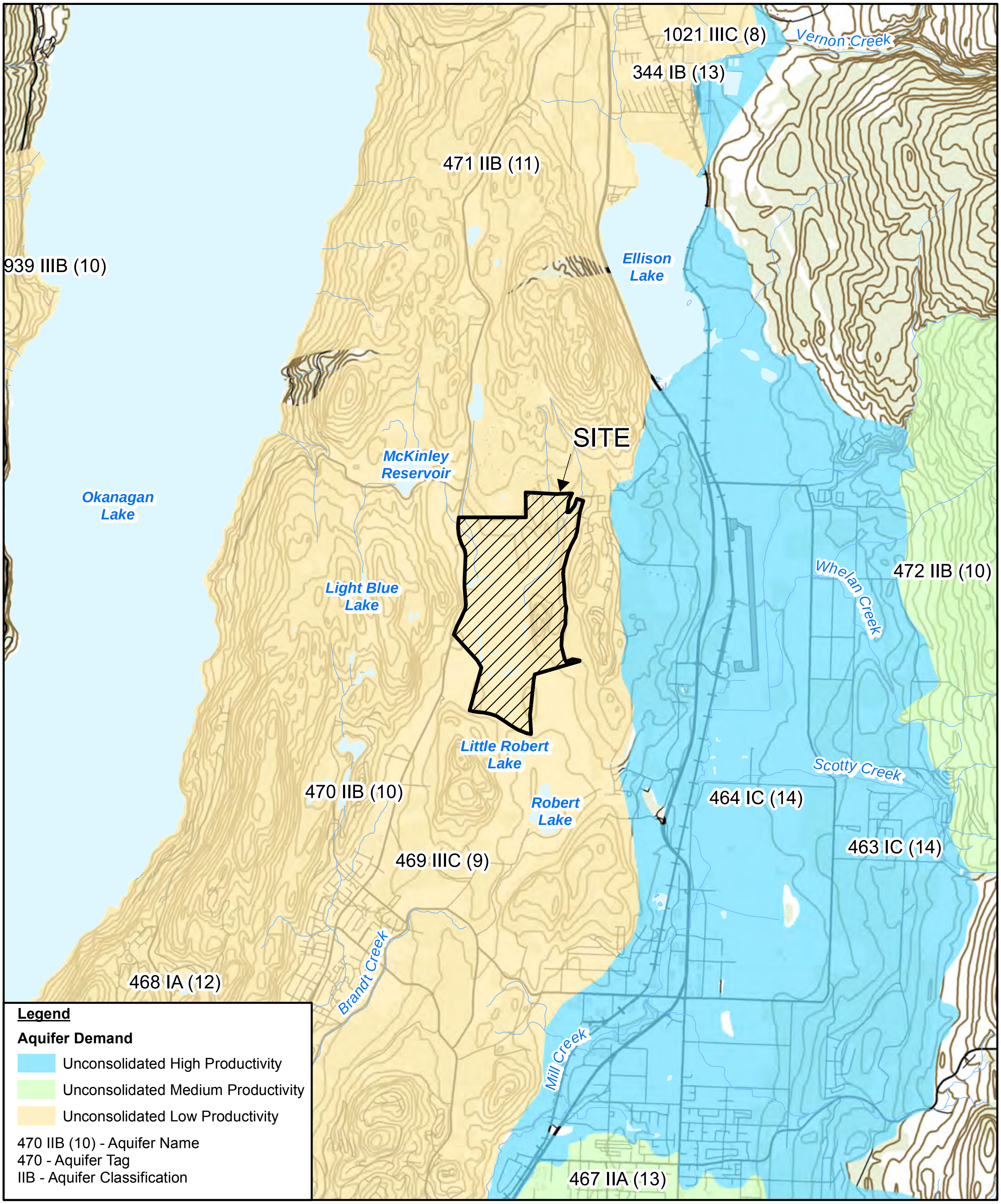
DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Oct 18, 2018

EXTENT OF MODELLED NUISANCE IMPACTS

FIGURE4.4

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT012.mxd



Source: CanVec Edition 1.1 © Department of Natural Resources Canada. All rights reserved. National Road Network 2.0 GeoBase. DataBC 2018

0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Jul 5, 2018

DRAINAGE MAP

FIGURE 5.1

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT009.mxd

Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17). Floodplain data from Kelowna open Data Source
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 350 700 1,050
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

N

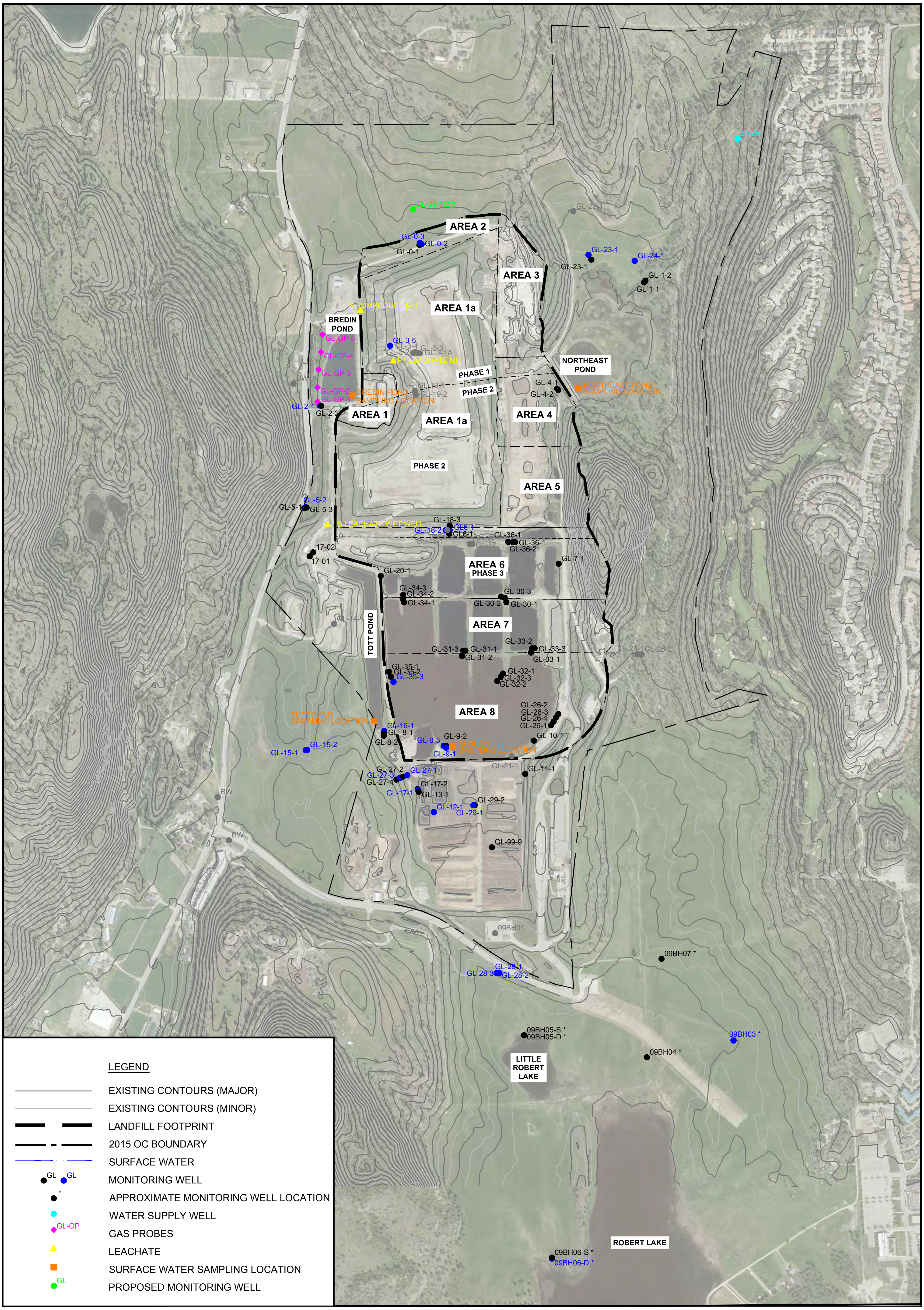
2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Jul 6, 2018

SITE PLAN - FLOODPLAIN

FIGURE 9.1

GIS File: Q:\GIS\PROJECTS\84000s\84612\Layouts\004\084612-22(004)GIS-OT010.mxd



CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

MONITORING LOCATIONS

084612-22

Jul 12, 2018

FIGURE 18.1

CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA001.dwg

GLENMORE LANDFILL
CITY OF KELOWNA
KELOWNA, BRITISH COLUMBIA

DESIGN, OPERATIONS & CLOSURE PLAN

SEPTEMBER 2018

PROJECT NUMBER: 84612-22

AREA MAP

LOCATION MAP

DRAWING LIST

DWG. No.	DRAWING TITLE
G-01	COVER PAGE
C-01	SITE PLAN
C-02	EXISTING CONDITIONS - BASE LINER AND LEACHATE COLLECTION AND RECIRCULATION SYSTEMS
C-03	EXISTING CONDITIONS - LANDFILL GAS COLLECTION SYSTEM
C-04	EXISTING CONDITIONS - SURFACE WATER WORKS
C-05	EXISTING CONDITIONS - BOREHOLE AND MONITORING WELLS
C-06	FINAL CONDITIONS
C-07	FINAL CONDITIONS - CROSS-SECTIONS
C-08	FILL PLAN
C-09	2018 - 2019 FILL AREAS - AREAS 1 & 1A
C-10	2020 - 2021 FILL AREAS - AREAS 1 & 2
C-11	2021 - 2023 FILL AREAS - AREAS 1 & 2
C-12	2023 - 2024 FILL AREAS - AREAS 1 & 2
C-13	2024 - 2027 FILL AREAS - AREAS 1 & 2
C-14	2027 - 2034 FILL AREAS - AREA 3
C-15	BASE LINER AND LEACHATE COLLECTION SYSTEM
C-16	AREA 1 LEACHATE COLLECTION SYSTEM
C-17	AREA 2 BASE LINER AND LEACHATE COLLECTION SYSTEM
C-18	AREA 3 BASE LINER AND LEACHATE COLLECTION SYSTEM
C-19	SURFACE WATER MANAGEMENT PLAN
C-20	LANDFILL GAS HEADER EXTENSION
C-21	DETAILS - FINAL COVER, PERIMETER TIE-IN
C-22	DETAILS - BASE LINER & LEACHATE COLLECTION SYSTEM
C-23	DETAILS - LEACHATE COLLECTION SUMP AND SUMP RAISER - AREA 3

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Reuse of Documents

Client

CITY OF KELOWNA
GLENMORE LANDFILL

Project

DESIGN, OPERATIONS
AND CLOSURE PLAN

No.	Issue	Drawn	Approved	Date
1	FINAL	TW	DL	10/11/2018
0	ISSUED FOR REVIEW	TW	DL	09/19/2018

Drawn	T. WAGSTAFF	Designer	R. HASIOR
Drafting Check	T. WAGSTAFF	Design Check	D. LIDDY
Project Manager	D. LIDDY	Date	11/1/2018
This document shall not be used for construction unless signed and sealed for construction.		Scale	N/A
Original Size	ANSI D	Bar is 20mm on original size drawing 0 20mm	

Project No. 84612-22

Title

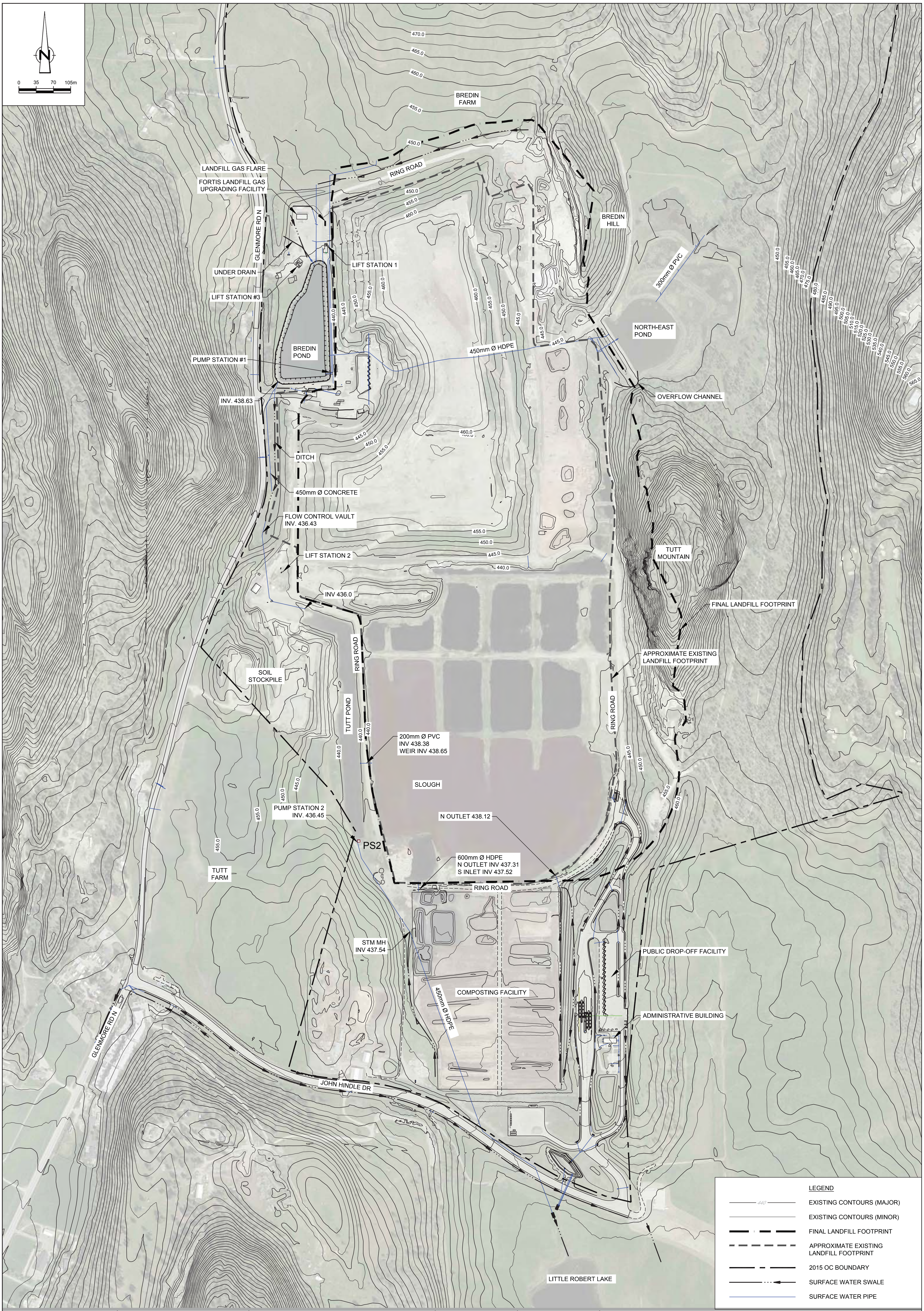
COVER PAGE

Sheet No.

G-01

Sheet 1 of 24

Plot Date: 1 November 2018 - 9:58 AM Plotted By: Tyler Wagstaff CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)GN\84612-22(004)GN-WA001.dwg



Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

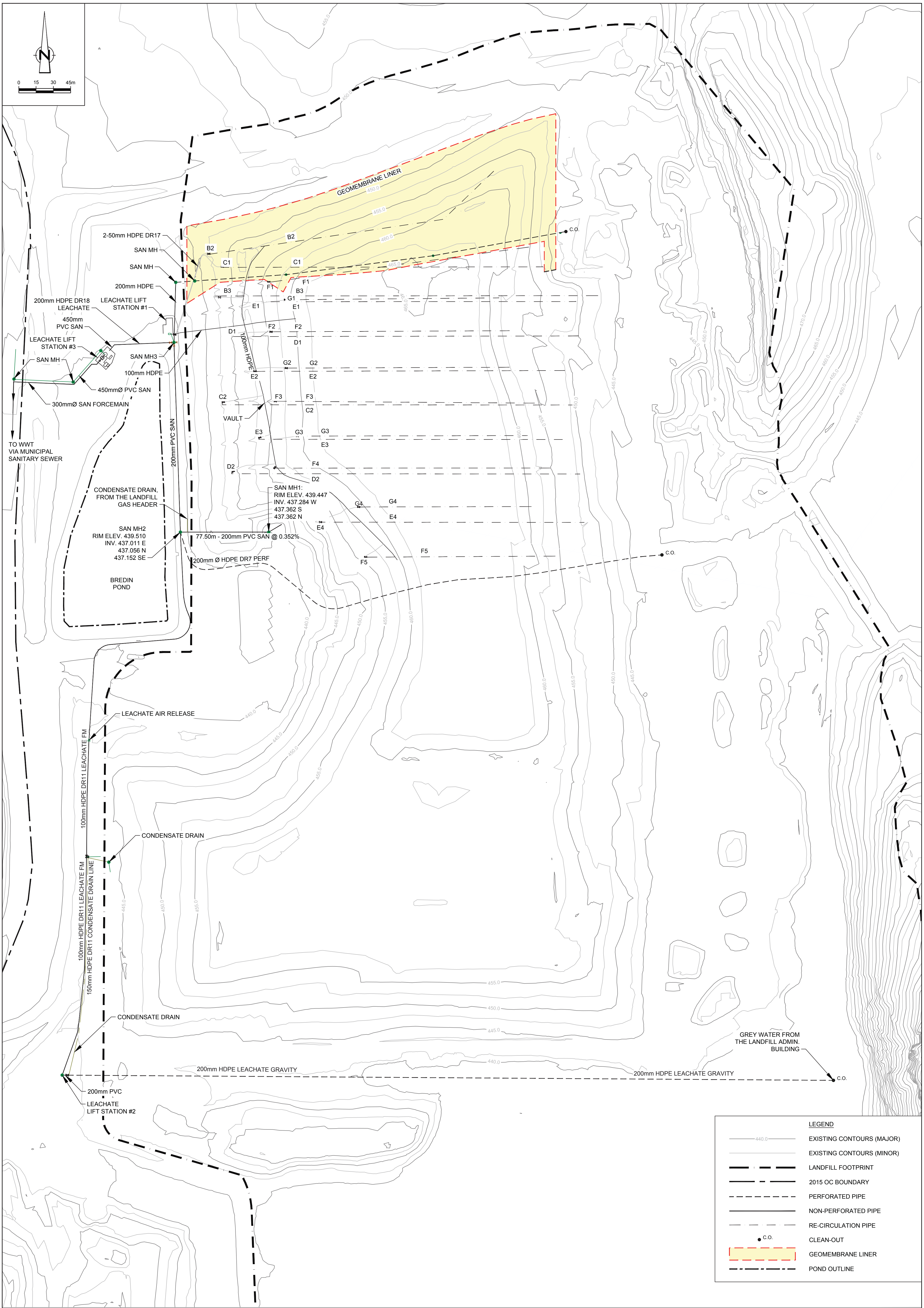
Drawn	S.BRIGGS	Designer	S.BRIGGS
Drafting Check	T.GERMSHEID	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-25
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title SITE PLAN

Project No. 084612-22

Original Size ANSI D
Sheet No. C-01
Sheet 2 of 24

Plot Date: 25 October 2018 - 4:44 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA001.dwg



LEGEND

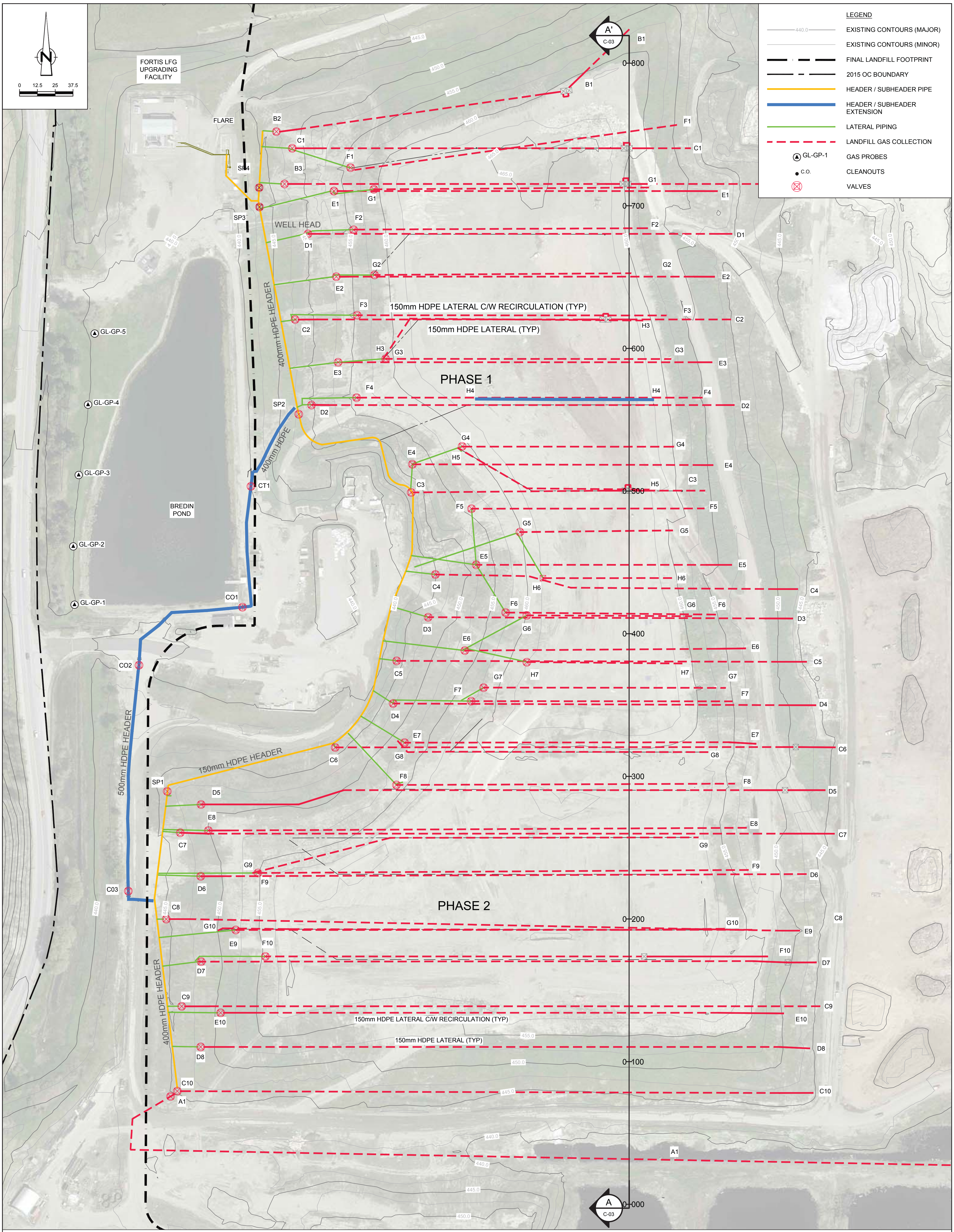
440.0	EXISTING CONTOURS (MAJOR)
	EXISTING CONTOURS (MINOR)
	LANDFILL FOOTPRINT
	2015 OC BOUNDARY
	PERFORATED PIPE
	NON-PERFORATED PIPE
	RE-CIRCULATION PIPE
● C.O.	CLEAN-OUT
	GEOMEMBRANE LINER
	POND OUTLINE

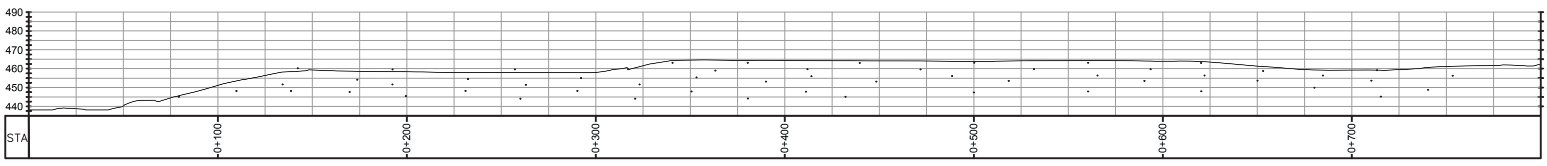
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 F 604 214 0525 W www.ghd.com

Drawn	S.BRIGGS	Designer	S.BRIGGS
Drafting Check	T.GERMSHEID	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-25
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title EXISTING CONDITIONS - BASE LINER AND LEACHATE COLLECTION AND RECIRCULATION SYSTEMS
Project No. 084612-22
Original Size ANSI D
Sheet No. C-02
Sheet 3 of 24





SECTION A-A'

HOR. SCALE 1:1000

C-03

Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	S.BRIGGS
Drafting Check	T.GERMSHEID	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-31
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

Title
EXISTING CONDITIONS
LANDFILL GAS COLLECTION SYSTEM

Project No. 084612-22

Original Size ANSI D

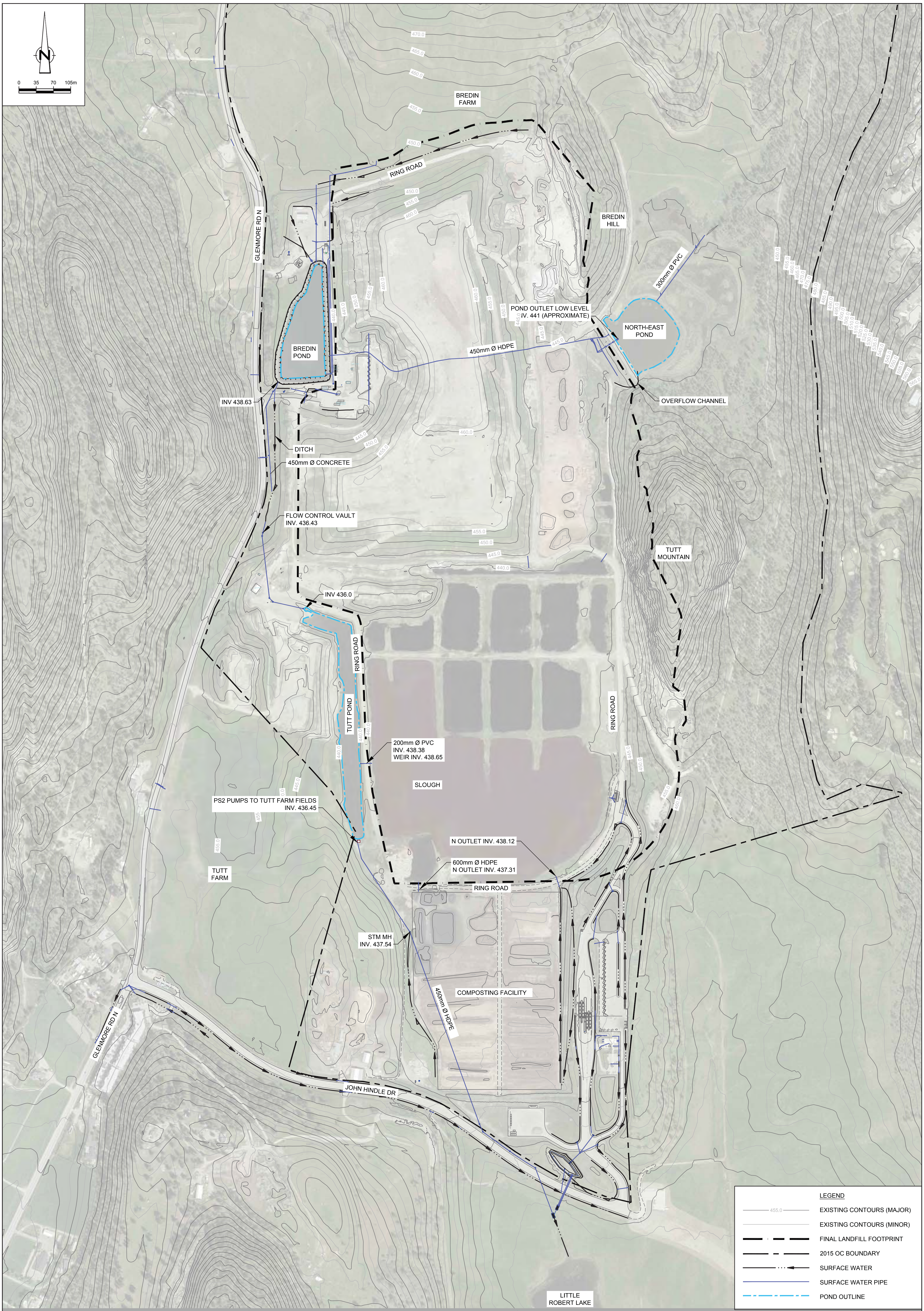
Sheet No. C-03

Sheet 4 of 24

Plot Date: 31 October 2018 - 4:02 PM

Plotted By: Tyler Wagstaff

CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA003.dwg



Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	S.BRIGGS
Drafting Check	T.GERMSHEID	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-25
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title EXISTING CONDITIONS
SURFACE WATER WORKS
Project No. 084612-22
Original Size ANSI D
Sheet No. C-04
Sheet 5 of 24

Plot Date: 30 October 2018 - 9:32 AM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA004.dwg

LEGEND

450.0	EXISTING CONTOURS (MAJOR)
	EXISTING CONTOURS (MINOR)
	FINAL LANDFILL FOOTPRINT
	2015 OC BOUNDARY
TP T	TEST PIT
AH BH	BOREHOLE
GL 17-01,02	GROUNDWATER
GL-GP	GAS PROBE
AH58	DECOMMISSIONED
● PR-MW	PROPOSED NESTED GROUNDWATER MONITORING WELL LOCATION

Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	S.BRIGGS
Drafting Check	T.GERMSHEID	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-31
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

Title
EXISTING CONDITIONS
BOREHOLES AND MONITORING WELLS

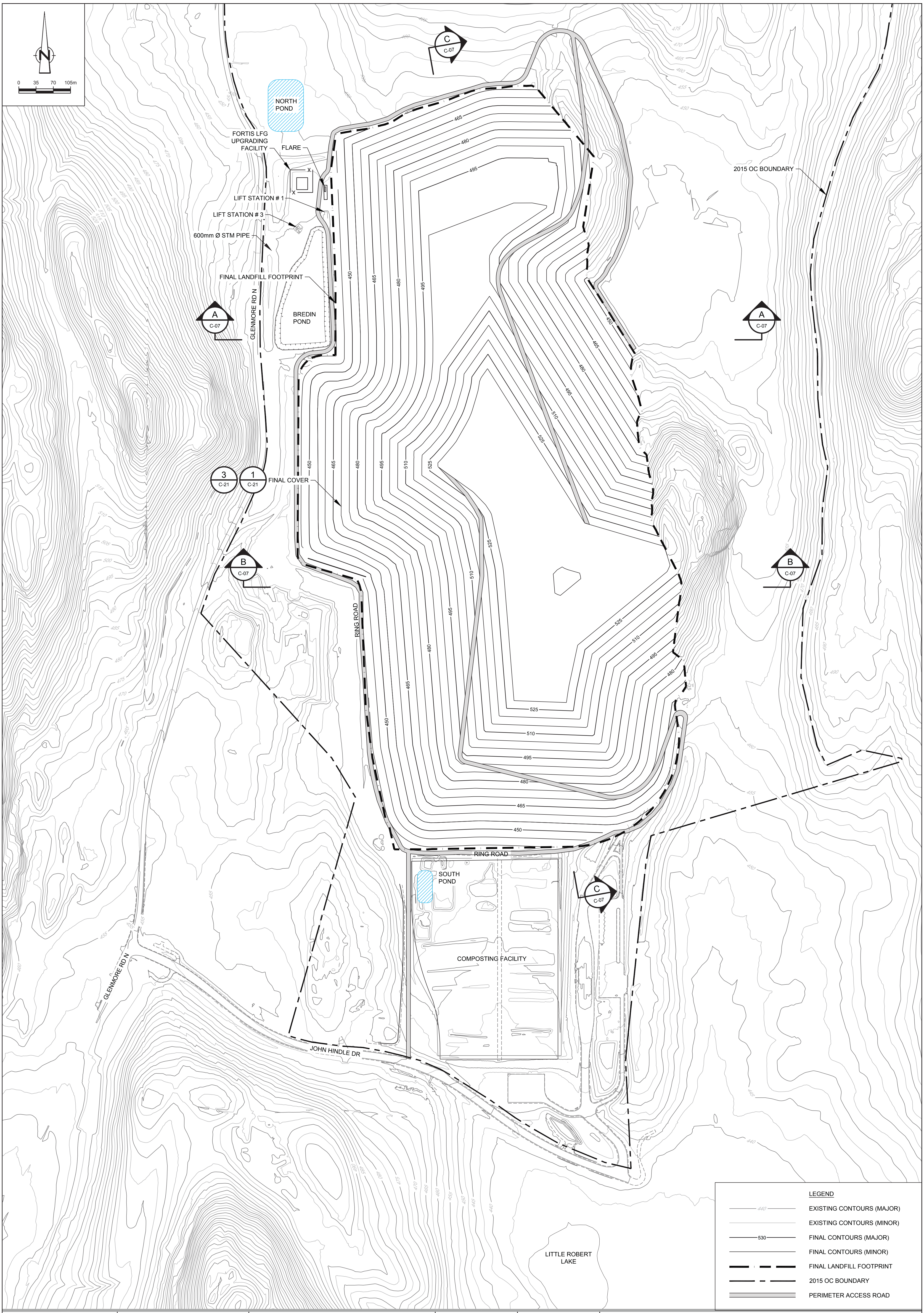
Project No. 084612-22

Original Size ANSI D

Sheet No. C-05

Sheet 6 of 24

Plot Date: 31 October 2018 - 4:08 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA005.dwg



Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

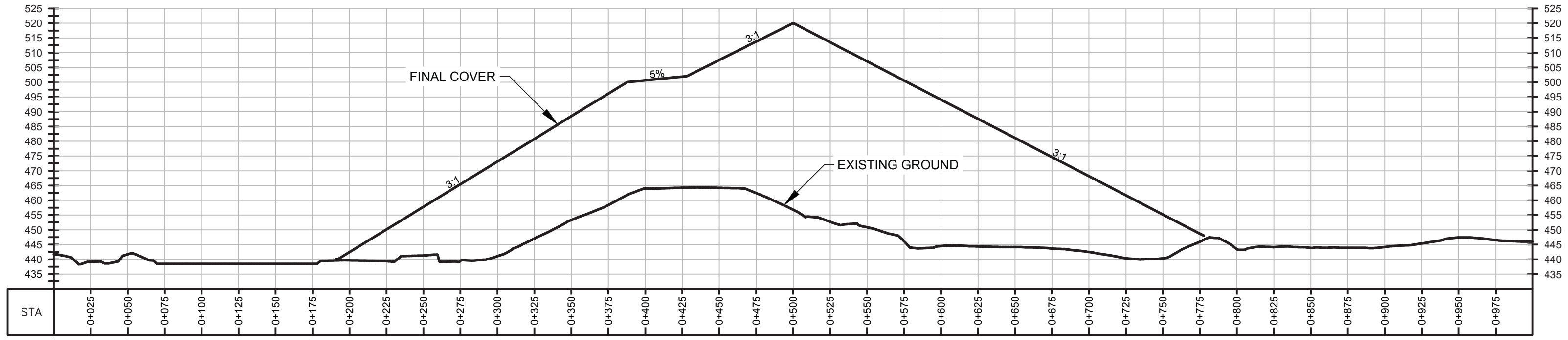
Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-29
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL DESIGN, OPERATIONS AND CLOSURE PLAN

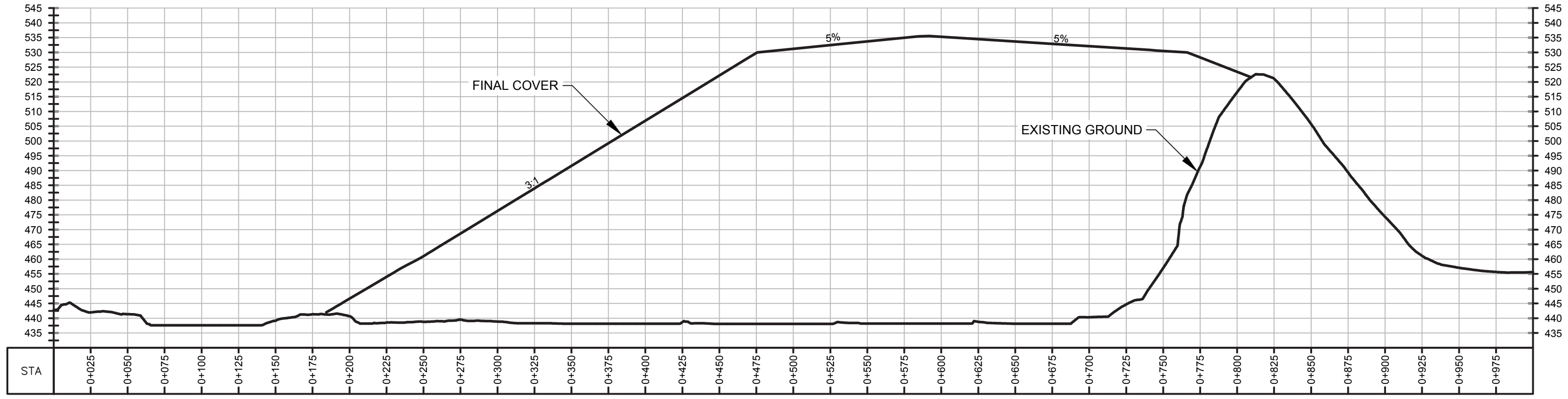
Title
FINAL CONTOURS

Project No. 084612-22
Original Size ANSI D
Sheet No. C-06
Sheet 7 of 24

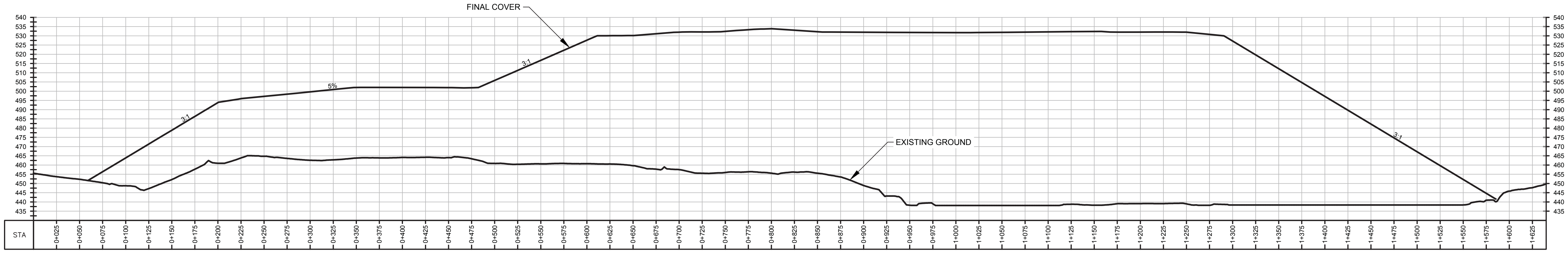
Plot Date: 31 October 2018 - 1:52 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA006.dwg



SECTION A-A'
HOR. 1:2500
VER. 1:1250
C-06



SECTION B-B'
HOR. 1:2500
VER. 1:1250
C-06



SECTION C-C'
HOR. 1:2500
VER. 1:1250
C-06

GHD
10271 Shellbridge Way, Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **W** www.ghd.com

Reuse of Documents

Client

CITY OF KELOWNA -
GLENMORE LANDFILL

Project

DESIGN, OPERATIONS
AND CLOSURE PLAN

No.	Issue	Drawn	Approved	Date
1	FINAL	TW	DL	10/11/2018
0	ISSUED FOR REVIEW	TW	DL	09/19/2018

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D. LIDDY
Project Manager	D. LIDDY	Date	Oct 12, 2018
This document shall not be used for construction unless signed and sealed for construction.		Scale	H=1:2500 V=1:1250
Original Size	ANSI D	Bar is 20mm on original size drawing 0 20mm	

Project No. 084612-22

Title

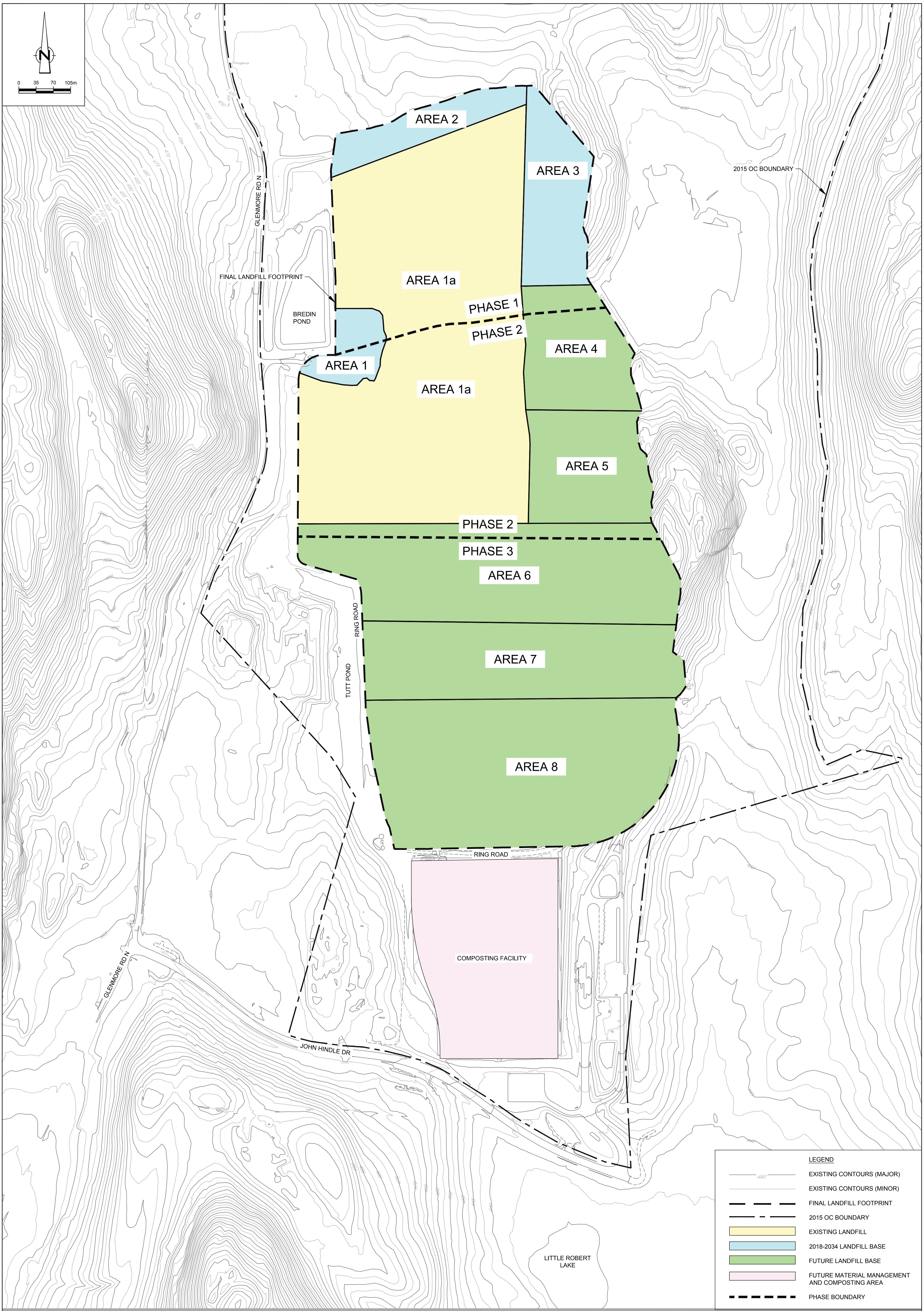
FINAL CONDITIONS
CROSS SECTIONS

Sheet No.

C-07

Sheet 8 of 24

Plot Date: 31 October 2018 - 12:37 PM   Plotted By: Tyler Wagstaff   CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA007.dwg



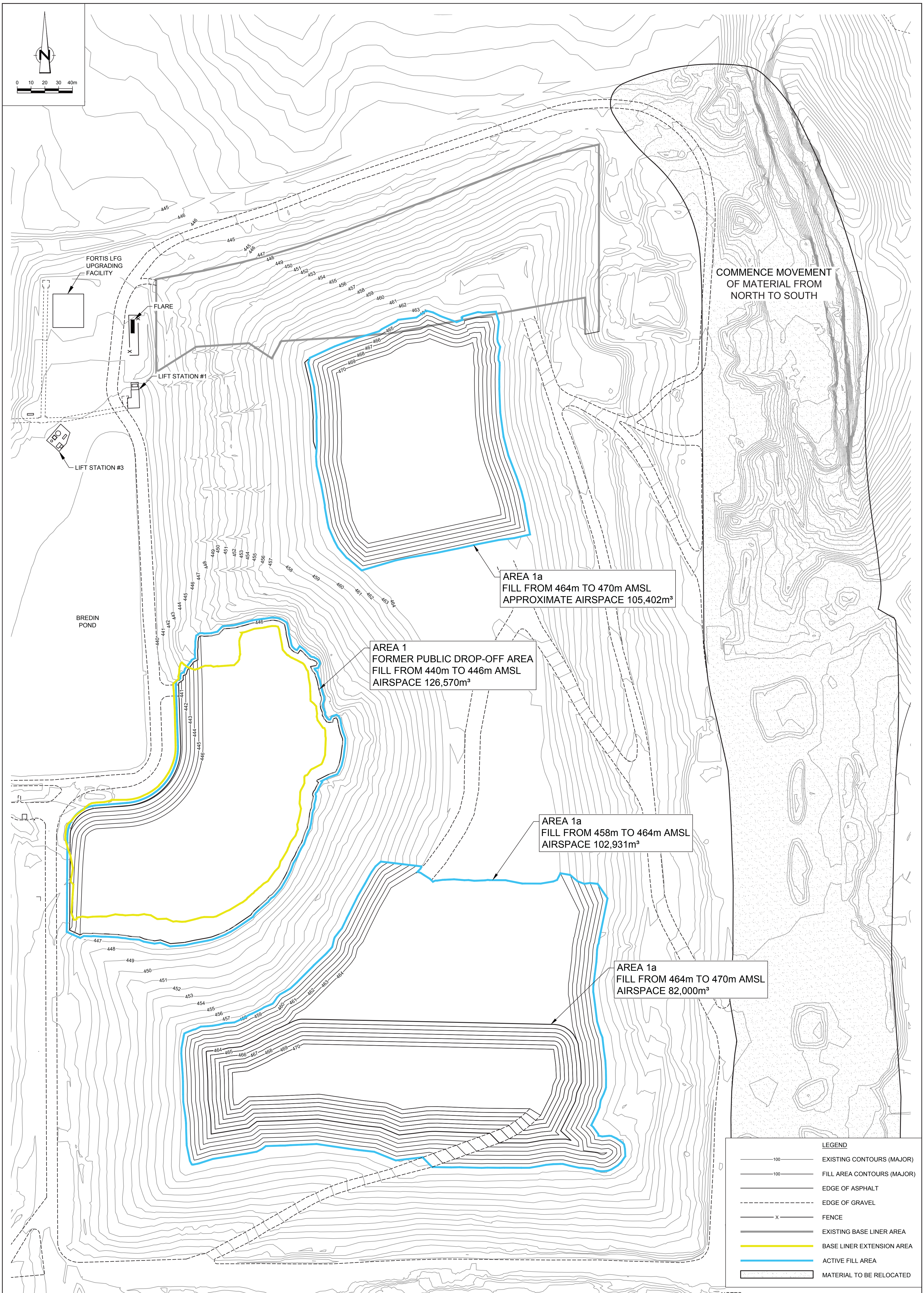
Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn S.BRIGGS
Designer R.HASIOR
Drafting Check R.HASIOR
Design Check D.LIDDY
Project Manager D.LIDDY
Date 2018-10-11
This document shall not be used for construction unless signed and sealed for construction.
Scale 1:3500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title LANDFILL BASE AREAS

Project No. 084612-22
Original Size ANSI D
Sheet No. C-08
Sheet 9 of 24



NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

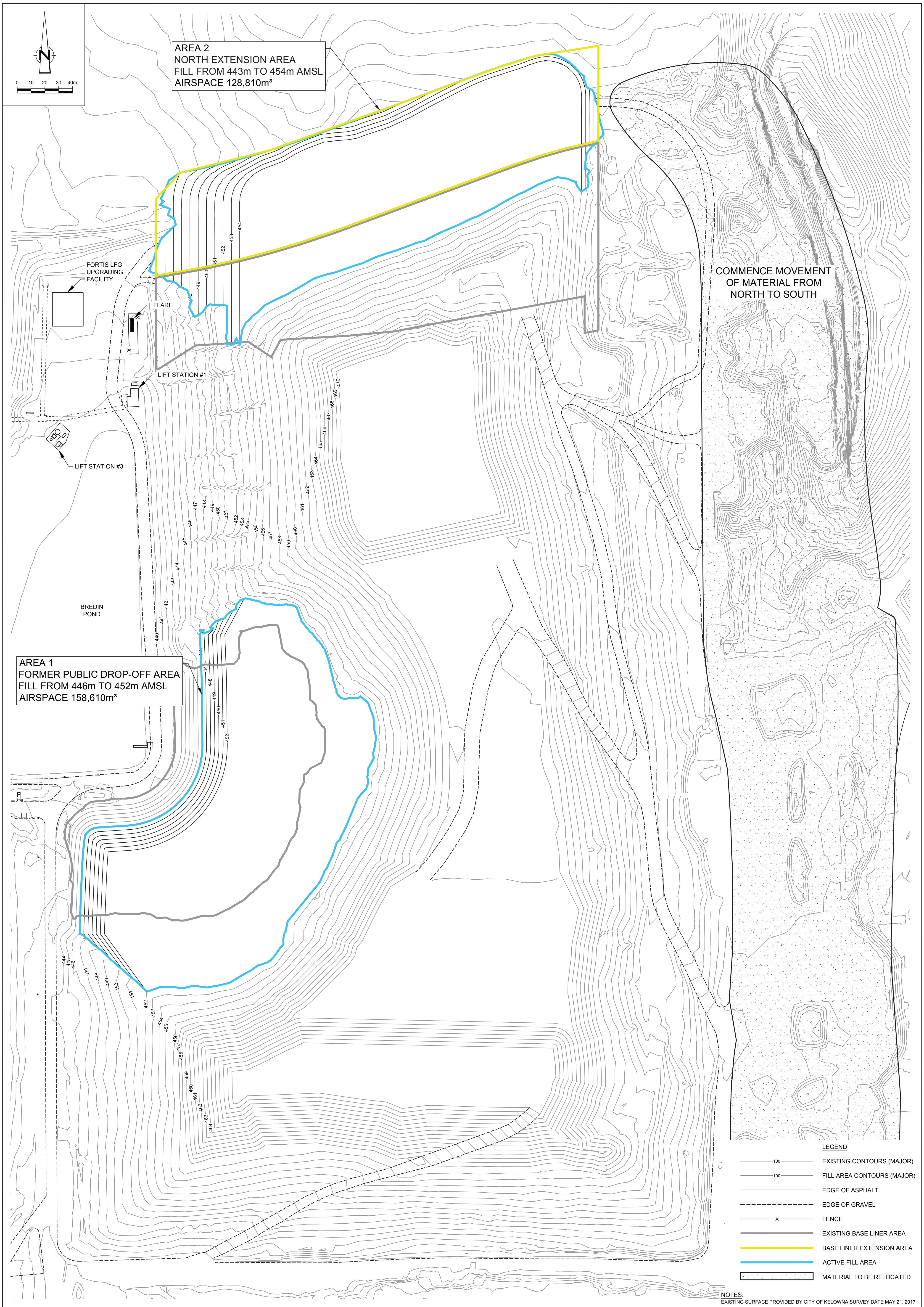
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.
© 2018 GHD

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-26
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2018 - 2019 FILL AREAS: AREA 1 & 1A
Project No. 084612-22
Original Size ANSI D
Sheet No. C-09
Sheet 10 of 24

Plot Date: 31 October 2018 - 1:59 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA009.dwg



NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original
size drawing
0 20mm

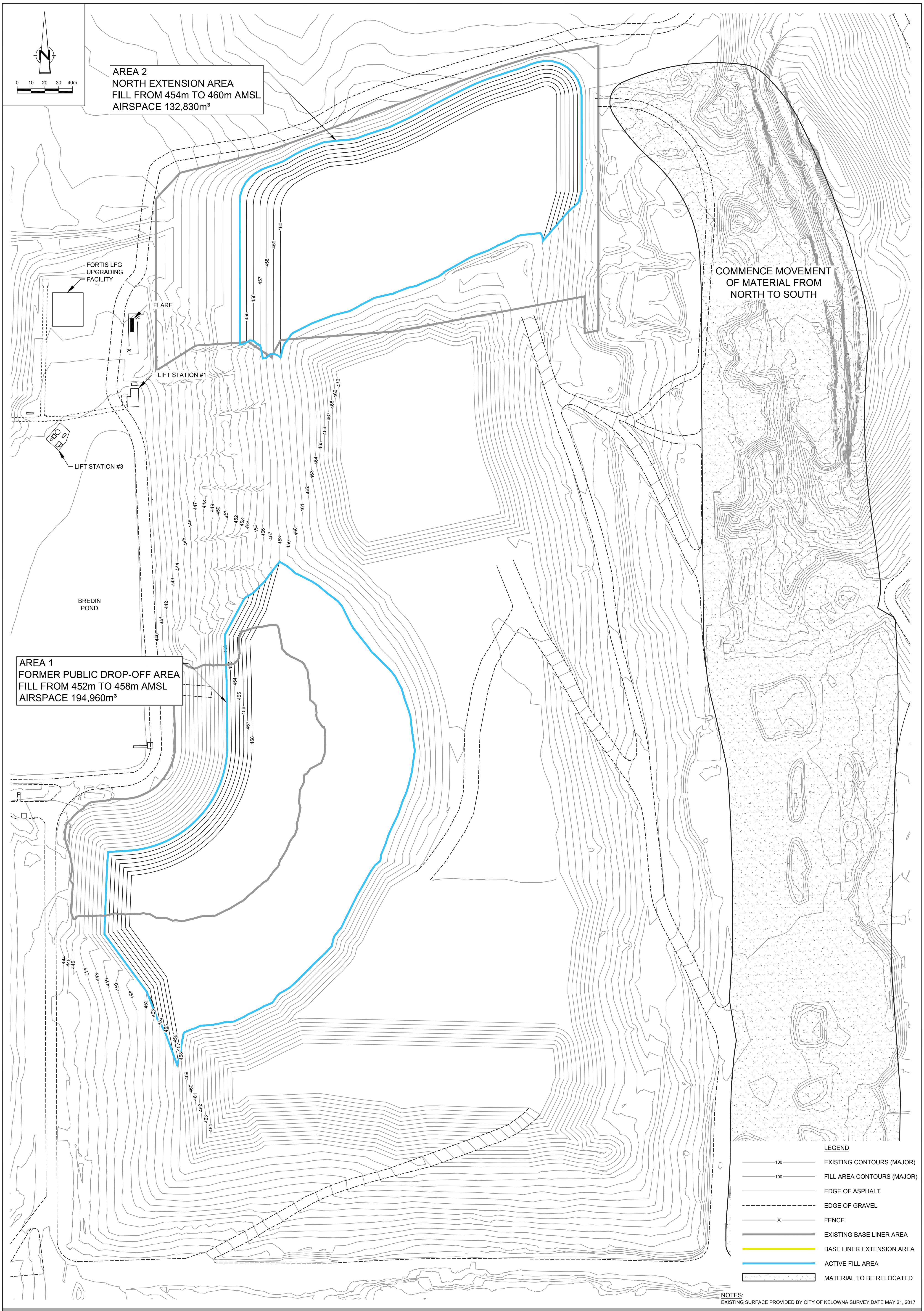
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-18
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2020 - 2021 FILL AREAS: AREA 1 & 2
Project No. 084612-22
Original Size ANSI D
Sheet No. C-10
Sheet 11 of 24

Plot Date: 31 October 2018 - 1:58 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA010.dwg



NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

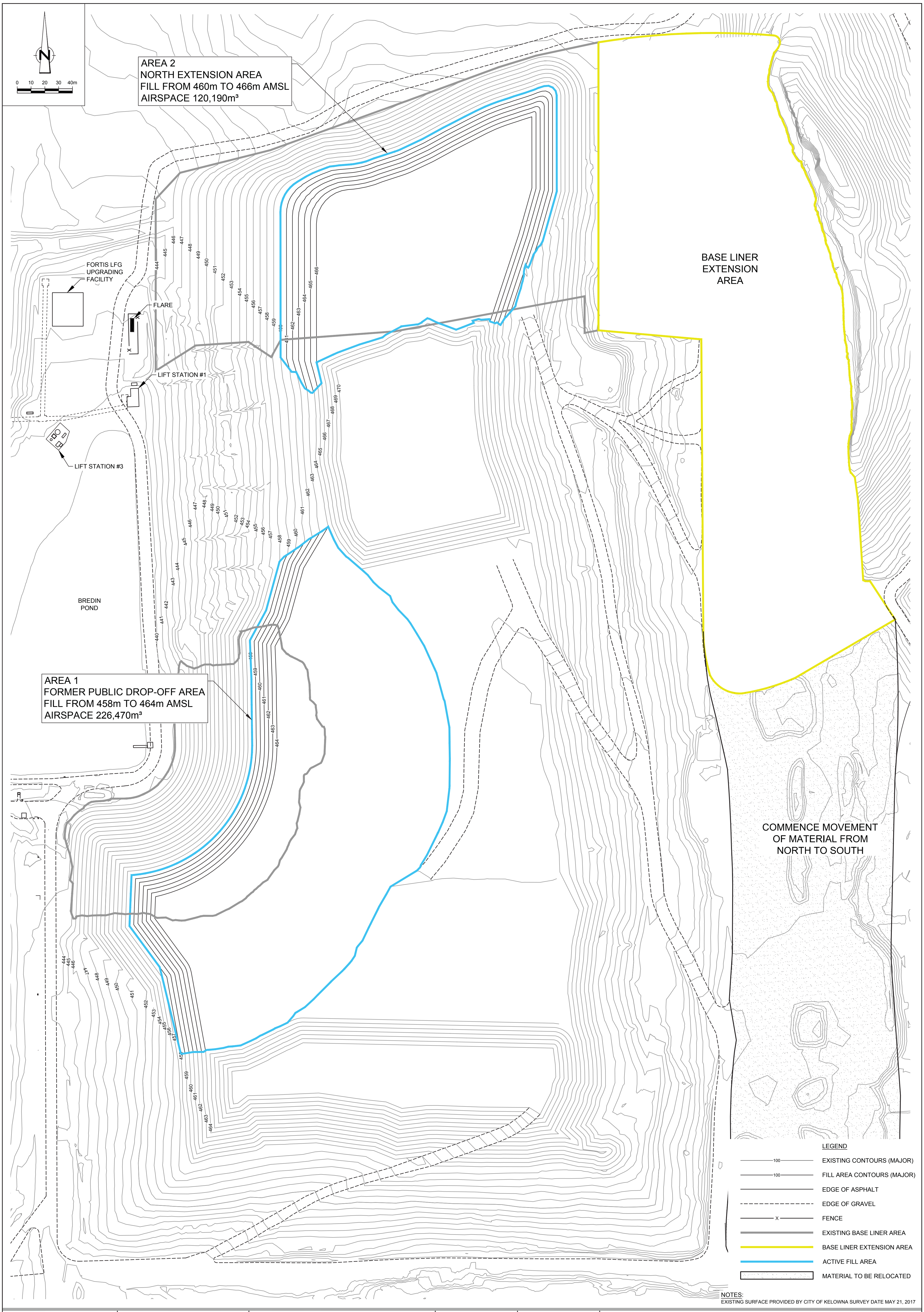
GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 F 604 214 0525 W www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-29
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2021 - 2023 FILL AREAS: AREA 1 & 2

Project No. 084612-22
Original Size ANSI D
Sheet No. C-11
Sheet 12 of 24

Plot Date: 31 October 2018 - 2:15 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA011.dwg



NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

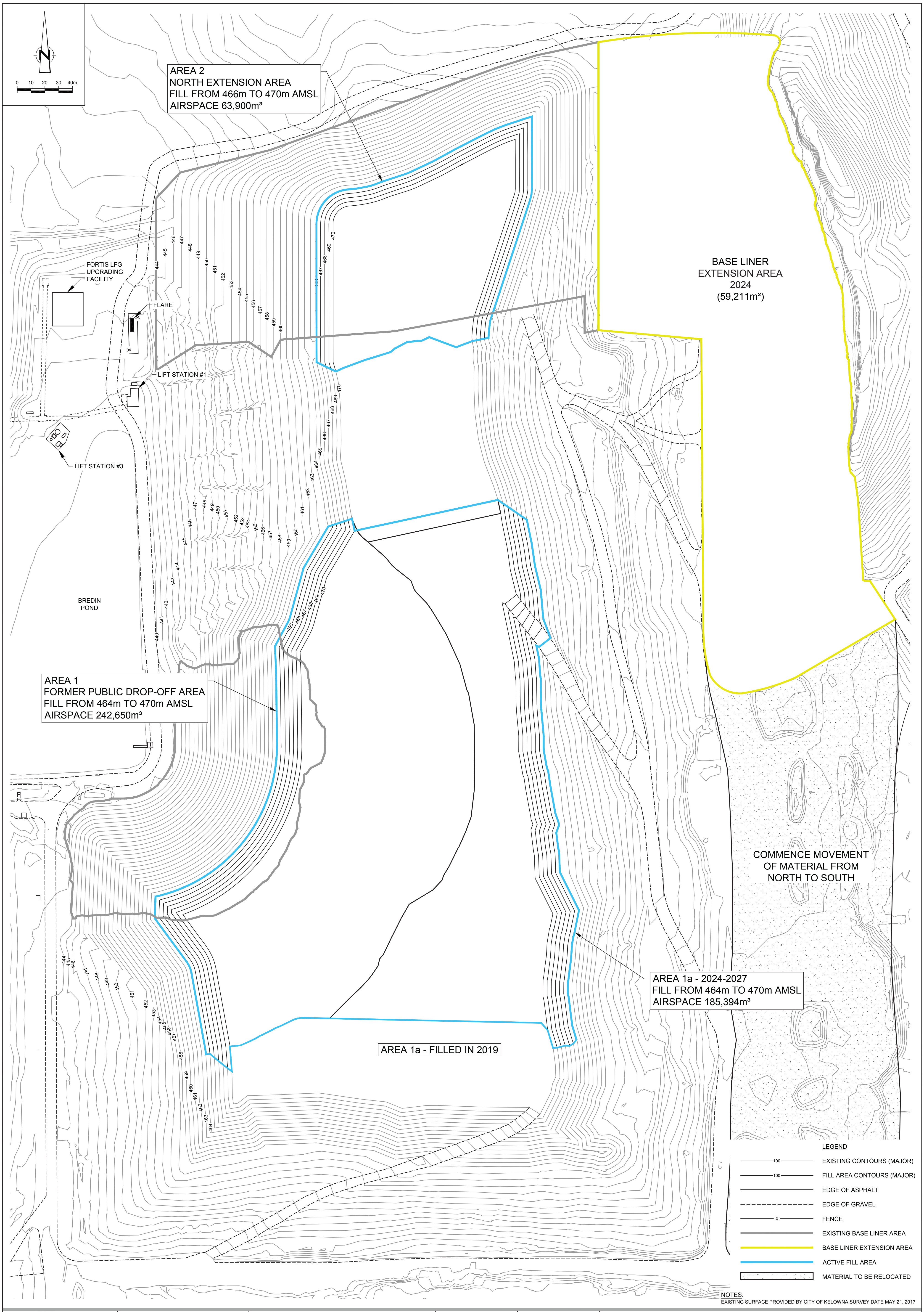
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn S.BRIGGS
Designer R.HASIOR
Drafting Check R.HASIOR
Design Check D.LIDDY
Project Manager D.LIDDY
Date 2018-10-29
This document shall not be used for construction unless signed and sealed for construction.
Scale 1:1250

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2023 - 2024 FILL AREAS
Project No. 084612-22
Original Size ANSI D
Sheet No. C-12
Sheet 13 of 24

Plot Date: 31 October 2018 - 2:22 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA012.dwg



NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

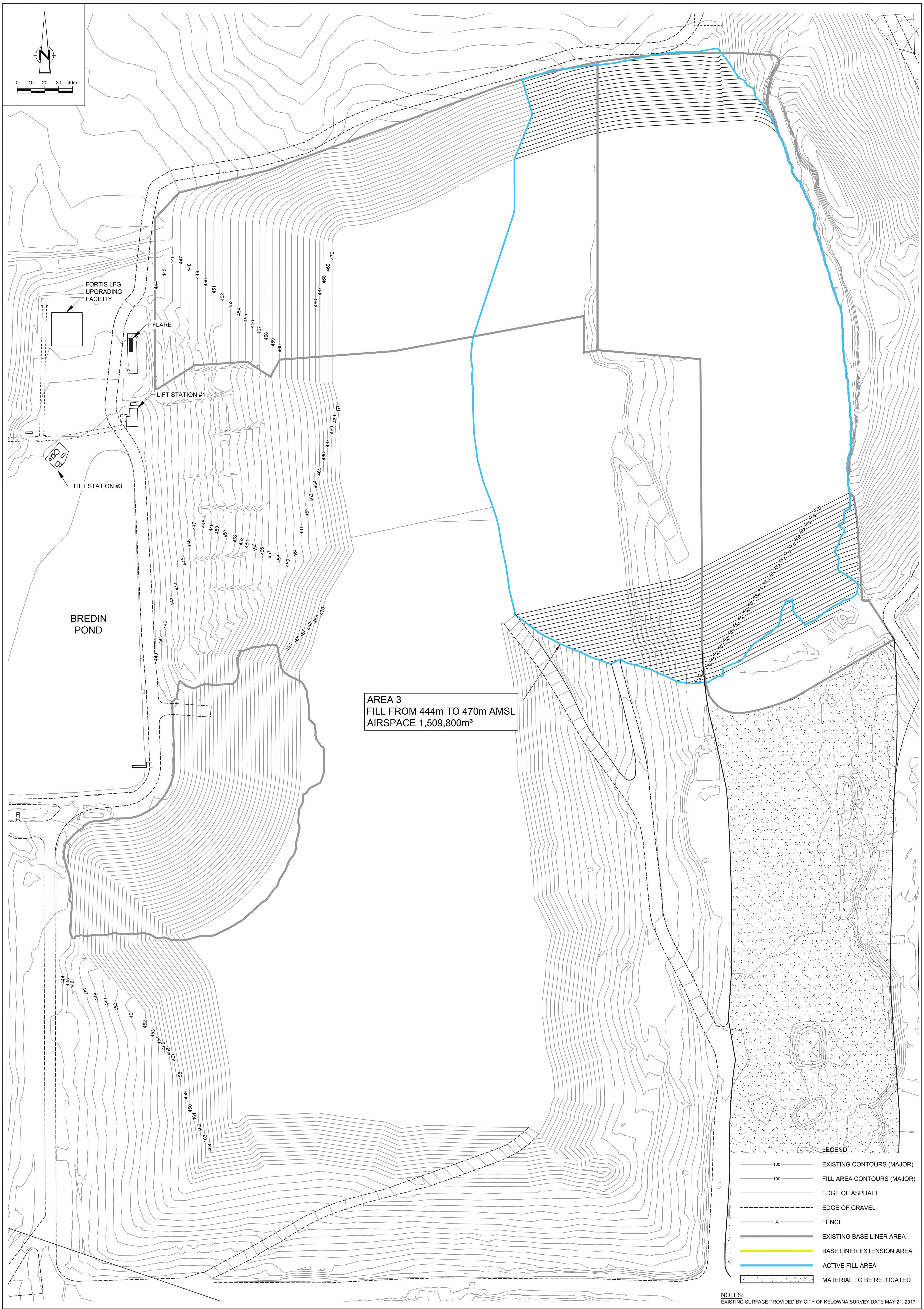
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-30
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2024 - 2027 FILL AREAS: AREA 1, 2, & AREA 1a
AREA 3 BASE LINER EXPANSION
Project No. 084612-22
Original Size ANSI D
Sheet No. C-13
Sheet 14 of 24

Plot Date: 31 October 2018 - 2:32 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA013.dwg



AREA 3
FILL FROM 444m TO 470m AMSL
AIRSPACE 1,509,800m³

LEGEND

—100—	EXISTING CONTOURS (MAJOR)
—100—	FILL AREA CONTOURS (MAJOR)
——	EDGE OF ASPHALT
- - -	EDGE OF GRAVEL
—X—	FENCE
——	EXISTING BASE LINER AREA
——	BASE LINER EXTENSION AREA
——	ACTIVE FILL AREA
▨	MATERIAL TO BE RELOCATED

NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R. HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-30
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

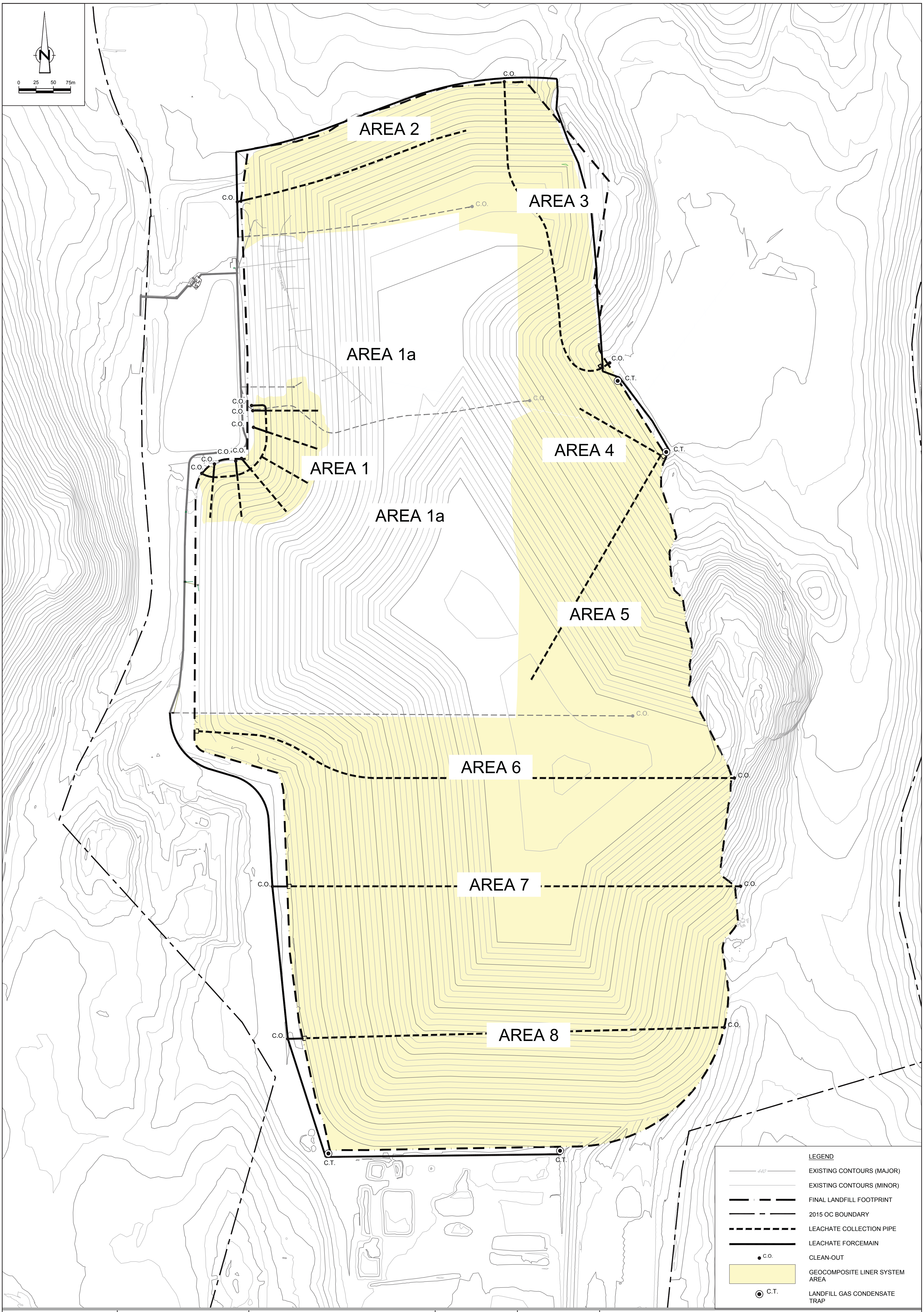
Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

Title
2027 - 2034 FILL AREAS: AREA 3

Project No. 084612-22

Original Size ANSI D
Sheet No. C-14
Sheet 15 of 24

Plot Date: 31 October 2018 - 2:38 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-CA014.dwg



Reuse of Documents

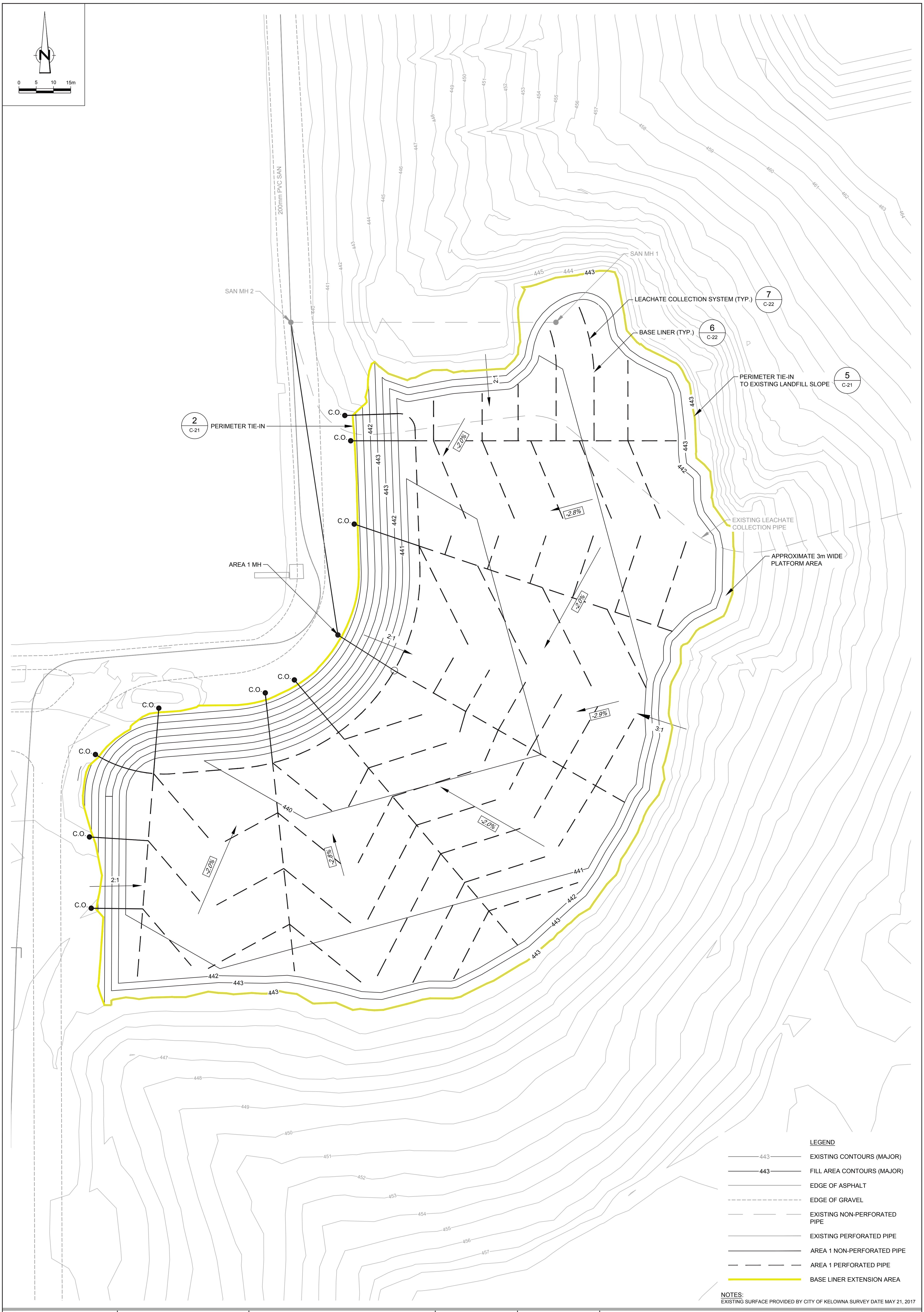
GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	T.WAGSTAFF	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-09-19
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:2500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title LEACHATE COLLECTION SYSTEM

Project No. 084612-22
Original Size ANSI D
Sheet No. C-15
Sheet 16 of 24

Plot Date: 31 October 2018 - 2:59 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA018.dwg



LEGEND

443	EXISTING CONTOURS (MAJOR)
443	FILL AREA CONTOURS (MAJOR)
	EDGE OF ASPHALT
	EDGE OF GRAVEL
	EXISTING NON-PERFORATED PIPE
	EXISTING PERFORATED PIPE
	AREA 1 NON-PERFORATED PIPE
	AREA 1 PERFORATED PIPE
🟨	BASE LINER EXTENSION AREA

NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original size drawing
0 20mm

Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-12
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title AREA 1 LEACHATE COLLECTION SYSTEM

Project No. 084612-22
Original Size ANSI D
Sheet No. C-16
Sheet 17 of 24

Plot Date: 31 October 2018 - 3:17 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA019.dwg

LEGEND

—443—	EXISTING CONTOURS (MAJOR)
—443—	FILL AREA CONTOURS (MAJOR)
———	EDGE OF ASPHALT
- - - -	EDGE OF GRAVEL
— — —	EXISTING NON-PERFORATED PIPE
———	EXISTING PERFORATED PIPE
———	AREA 2 NON-PERFORATED PIPE
— — —	AREA 2 PERFORATED PIPE
▬	EXISTING BASE LINER AREA
▬	BASE LINER EXTENSION AREA

NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

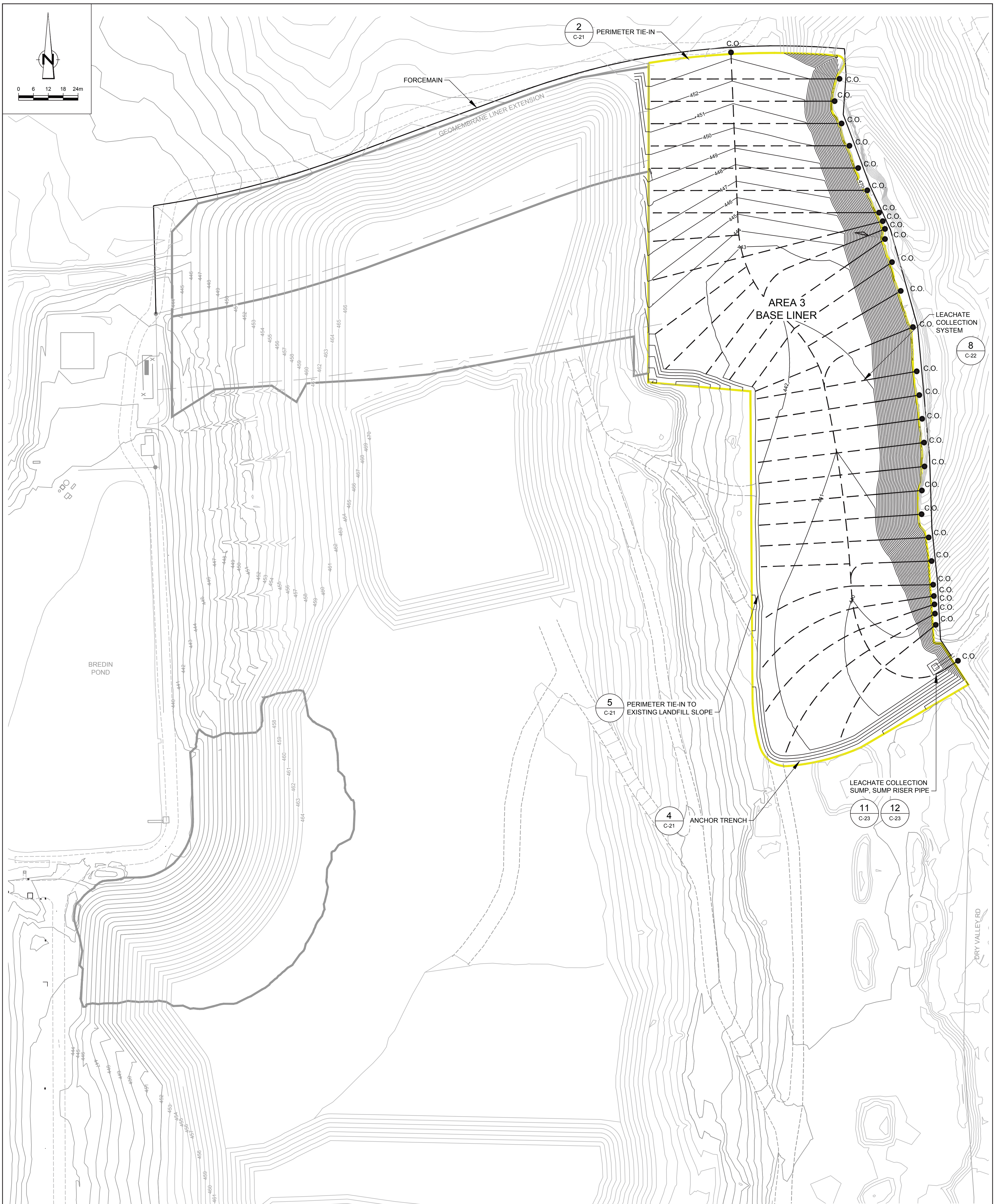
Reuse of Documents
This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-30
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:750

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title AREA 2 BASE LINER
AND LEACHATE COLLECTION SYSTEM
Project No. 084612-22
Original Size ANSI D
Sheet No. C-17
Sheet 18 of 24

Plot Date: 30 October 2018 - 3:26 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA020.dwg



LEGEND

——443——	EXISTING CONTOURS (MAJOR)
——443——	FILL AREA CONTOURS (MAJOR)
————	EDGE OF ASPHALT
- - - - -	EDGE OF GRAVEL
—— ——	EXISTING NON-PERFORATED PIPE
————	EXISTING PERFORATED PIPE
━━━━	AREA 3 NON-PERFORATED PIPE
━ ━ ━	AREA 3 PERFORATED PIPE
▬	EXISTING BASE LINER AREA
🟨	BASE LINER EXTENSION AREA

NOTES:
EXISTING SURFACE PROVIDED BY CITY OF KELOWNA SURVEY DATE MAY 21, 2017

Bar is 20mm on original
size drawing
0 20mm

Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

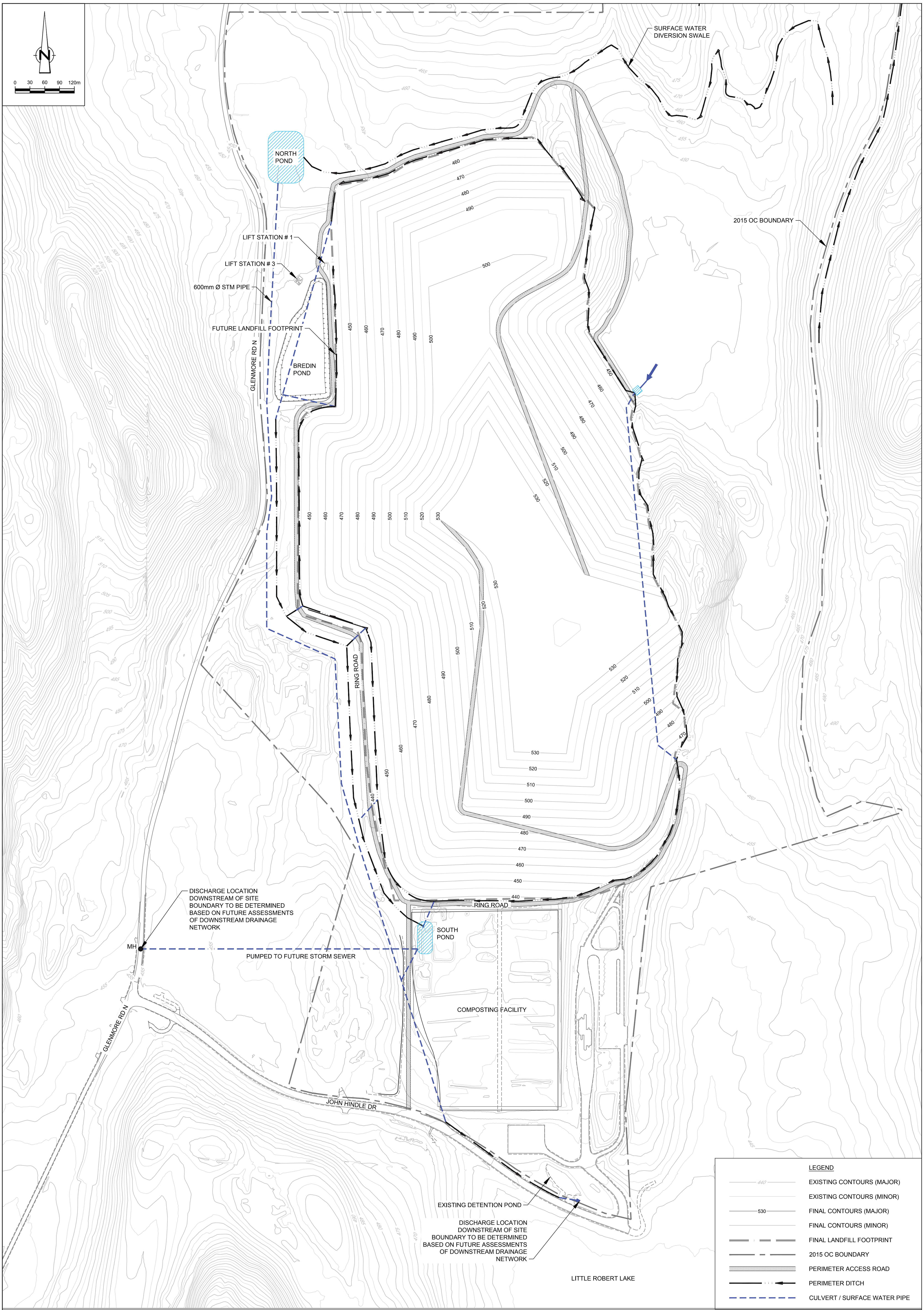
Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-30
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:1250

Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

Title
AREA 3 BASE LINER
AND LEACHATE COLLECTION SYSTEM

Project No. 084612-22

Original Size ANSI D
Sheet No. C-18
Sheet 19 of 24



GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	T. WAGSTAFF	Designer	R. HASIOR
Drafting Check	R.HASIOR	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-10-17
This document shall not be used for construction unless signed and sealed for construction.		Scale	######

Client
CITY OF KELOWNA - GLENMORE LANDFILL

Project
DESIGN, OPERATIONS AND CLOSURE PLAN

Title
SURFACE WATER MANAGEMENT PLAN

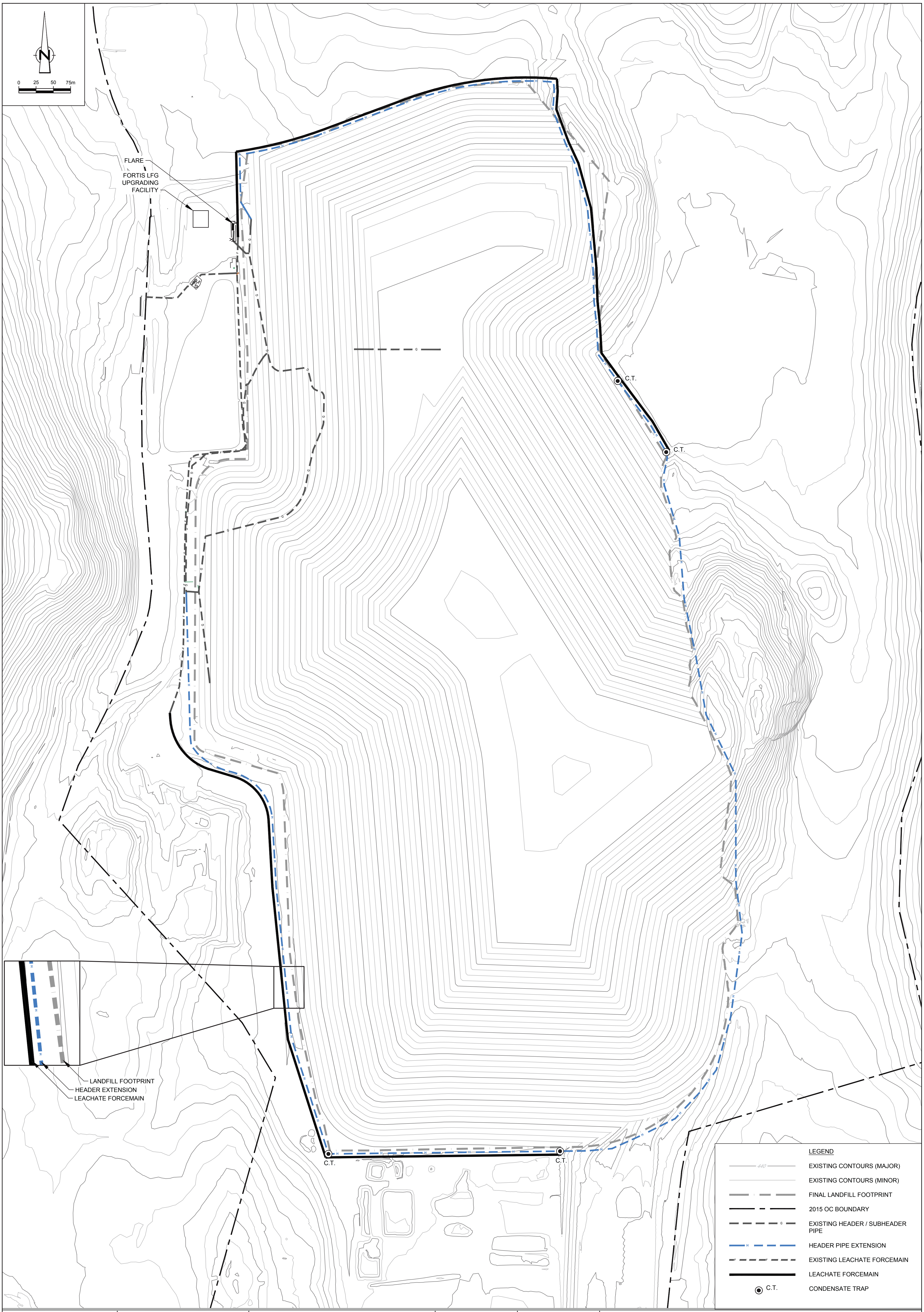
Project No. 084612-22

Original Size ANSI D

Sheet No. C-19

Sheet 20 of 24

Plot Date: 1 November 2018 - 4:06 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA024.dwg



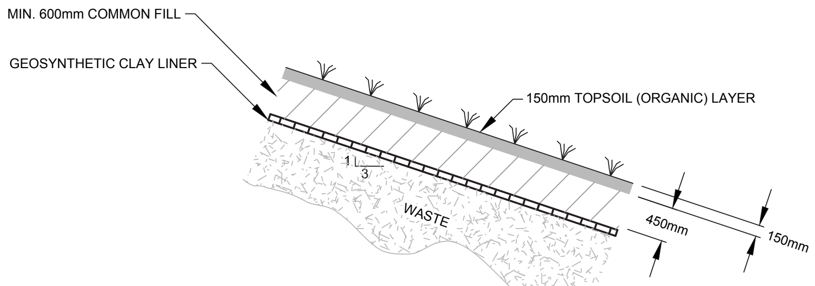
Reuse of Documents

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

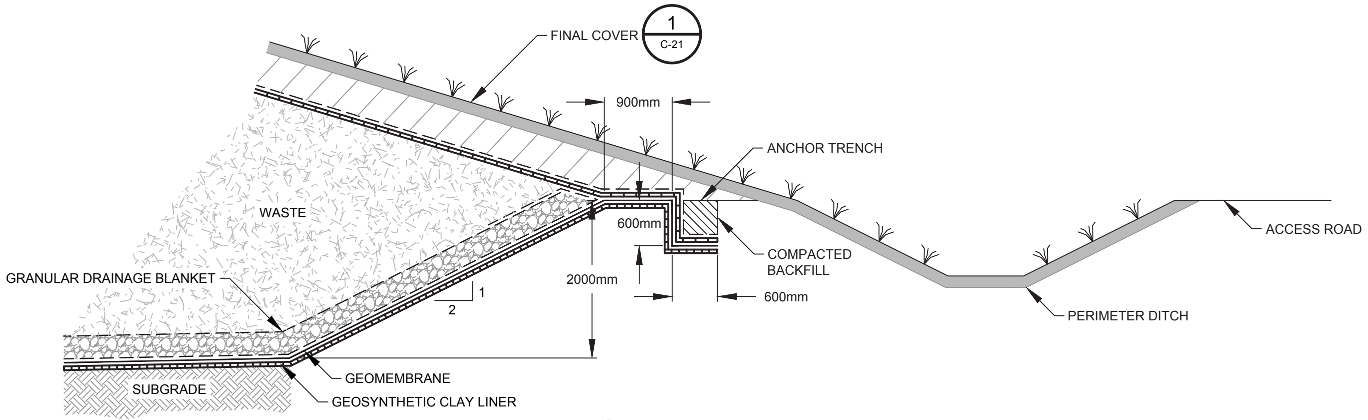
Drawn T.WAGSTAFF
Designer R.HASIOR
Drafting Check R.HASIOR
Design Check D.LIDDY
Project Manager D.LIDDY
Date 2018-10-31
This document shall not be used for construction unless signed and sealed for construction.
Scale 1:2500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title LANDFILL GAS HEADER EXTENSION

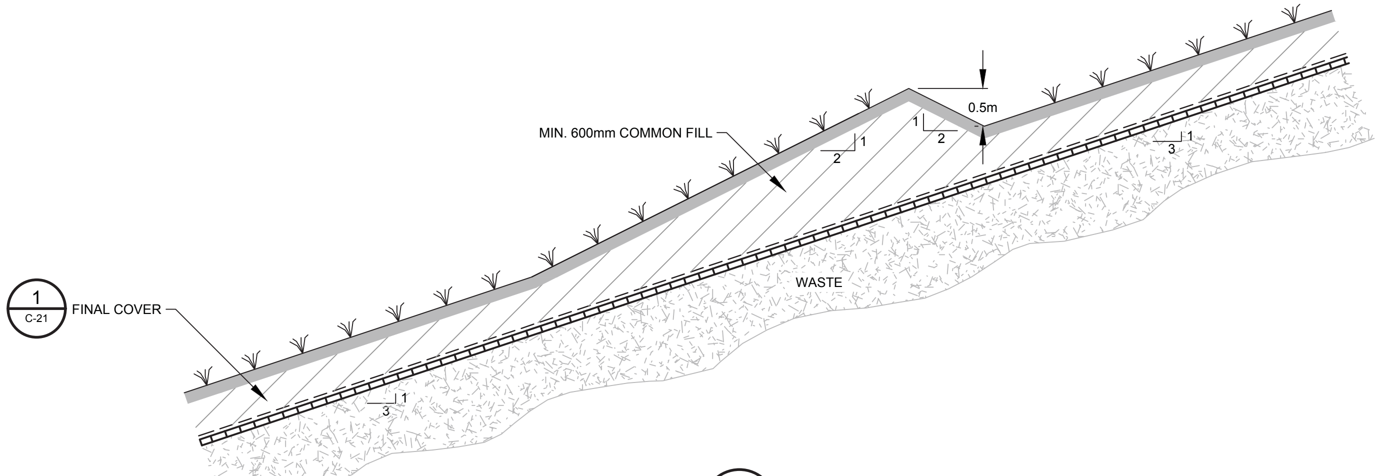
Project No. 084612-22
Original Size ANSI D
Sheet No. C-20
Sheet 21 of 24



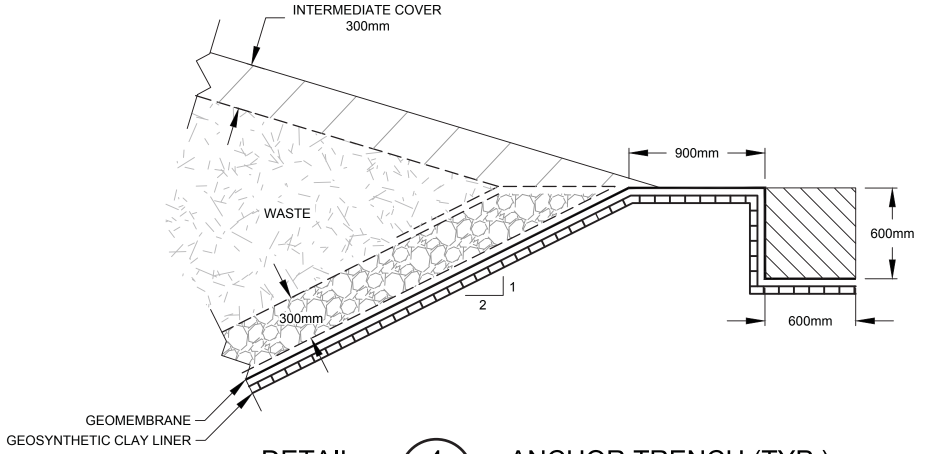
DETAIL 1 FINAL COVER
SCALE 1:50 C-21



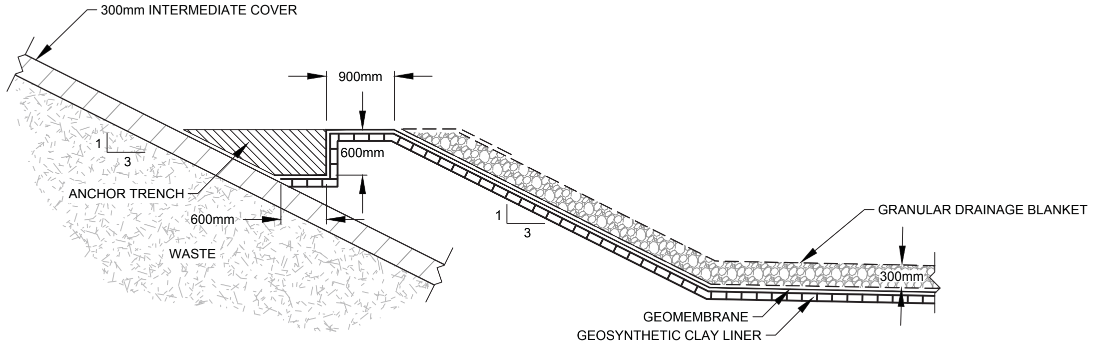
DETAIL 2 PERIMETER TIE-IN (TYP.) AREA 2
SCALE 1:50 C-16



DETAIL 3 MID-SLOPE SWALE (TYP.)
SCALE 1:50 C-06



DETAIL 4 ANCHOR TRENCH (TYP.) AREA 3
SCALE 1:25 C-18



DETAIL 5 PERIMETER TIE-IN TO EXISTING LANDFILL SLOPE
SCALE 1:50 C-16

GHD
10271 Shellbridge Way, Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **W** www.ghd.com

Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization. © 2018 GHD

Client

CITY OF KELOWNA -
GLENMORE LANDFILL

Project

DESIGN, OPERATIONS
AND CLOSURE PLAN

1	FINAL	TW	DL	10/11/2018
0	ISSUED FOR REVIEW	TW	DL	09/19/2018
No.	Issue	Drawn	Approved	Date

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D. LIDDY
Project Manager	D. LIDDY	Date	Oct 17, 2018
This document shall not be used for construction unless signed and sealed for construction.		Scale	AS SHOWN
Original Size	ANSI D	Bar is 20mm on original size drawing 0 20mm	

Project No. 084612-22

Title

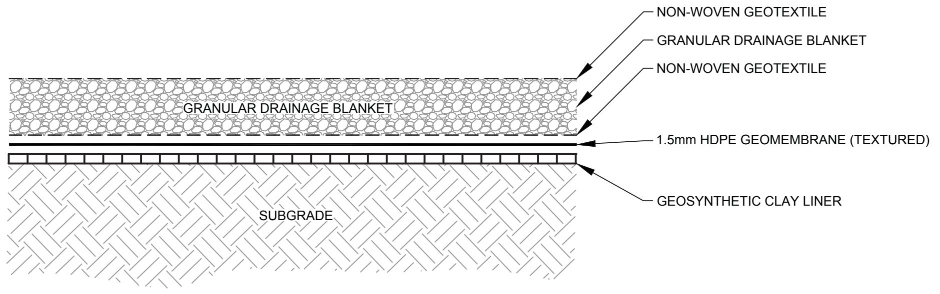
FINAL COVER AND PERIMETER
TIE-IN DETAILS

Sheet No.

C-21

Sheet 22 of 24

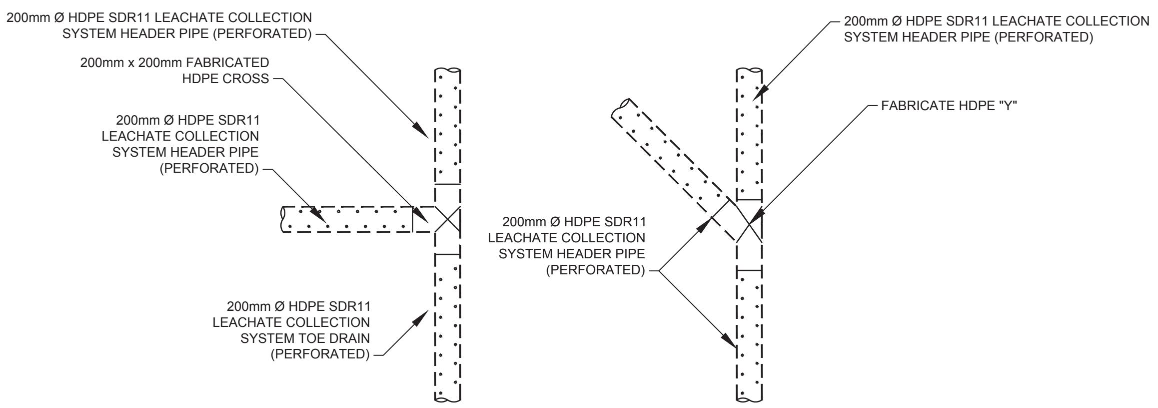
Plot Date: 31 October 2018 - 12:43 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA026.dwg



DETAIL 6 BASE LINER (TYP.) AREA 2 & 3

SCALE 1:20

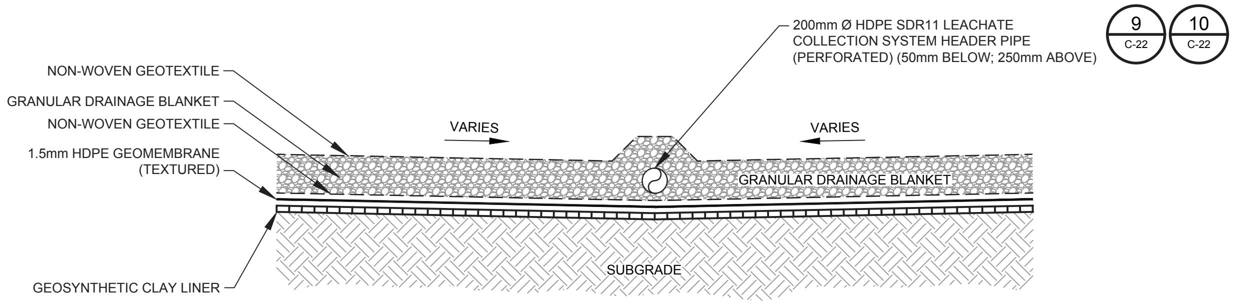
C-16



DETAIL 9 LEACHATE COLLECTION SYSTEM PIPE CONNECTIONS

SCALE 1:30

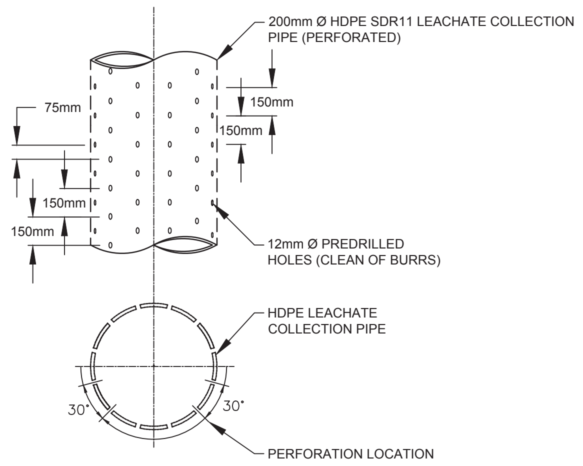
C-22



DETAIL 7 LEACHATE COLLECTION SYSTEM (TYP.)

SCALE 1:30

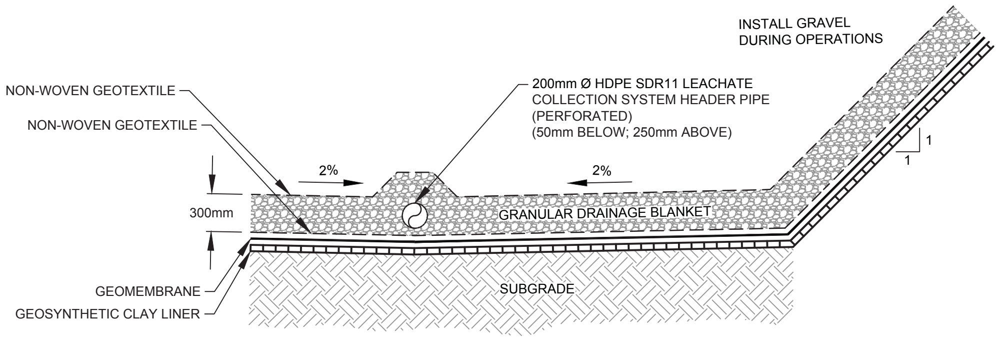
C-16



DETAIL 10 LEACHATE COLLECTION SYSTEM PIPE PERFORATIONS

SCALE N.T.S.

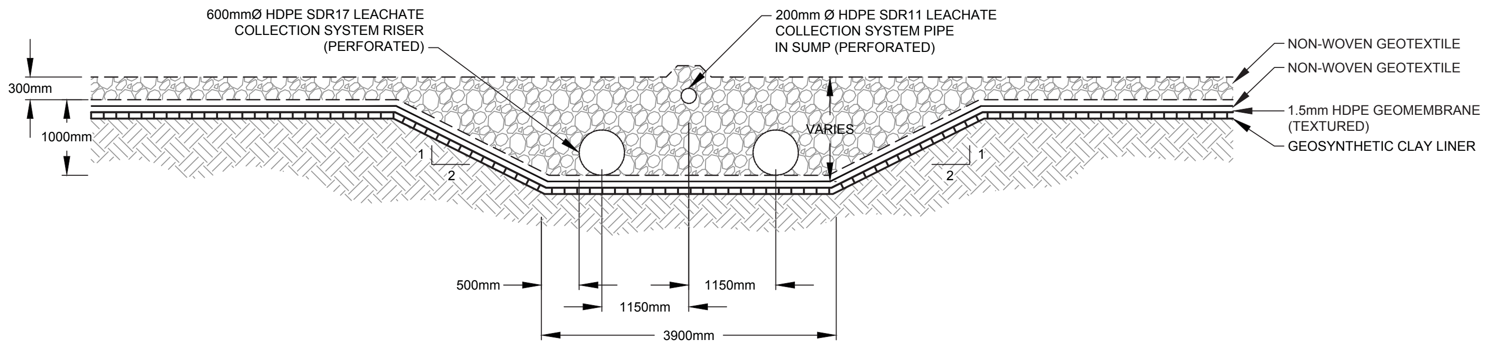
C-22



DETAIL 8 LEACHATE COLLECTION SYSTEM AREA 3

SCALE 1:30

C-18



DETAIL 11 LEACHATE COLLECTION SYSTEM SUMP AREA 3

SCALE 1:50

C-18

GHD
10271 Shellbridge Way, Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **W** www.ghd.com

Client
CITY OF KELOWNA - GLENMORE LANDFILL

Project
DESIGN, OPERATIONS AND CLOSURE PLAN

No.	Issue	Drawn	Approved	Date
1	FINAL	TW	DL	10/11/2018
0	ISSUED FOR REVIEW	TW	DL	09/19/2018

Drawn S.BRIGGS
Designer R.HASIOR
Drafting Check R.HASIOR
Design Check D. LIDDY
Project Manager D. LIDDY
Date Oct 17, 2018

This document shall not be used for construction unless signed and sealed for construction.

Scale AS SHOWN

Original Size ANSI D

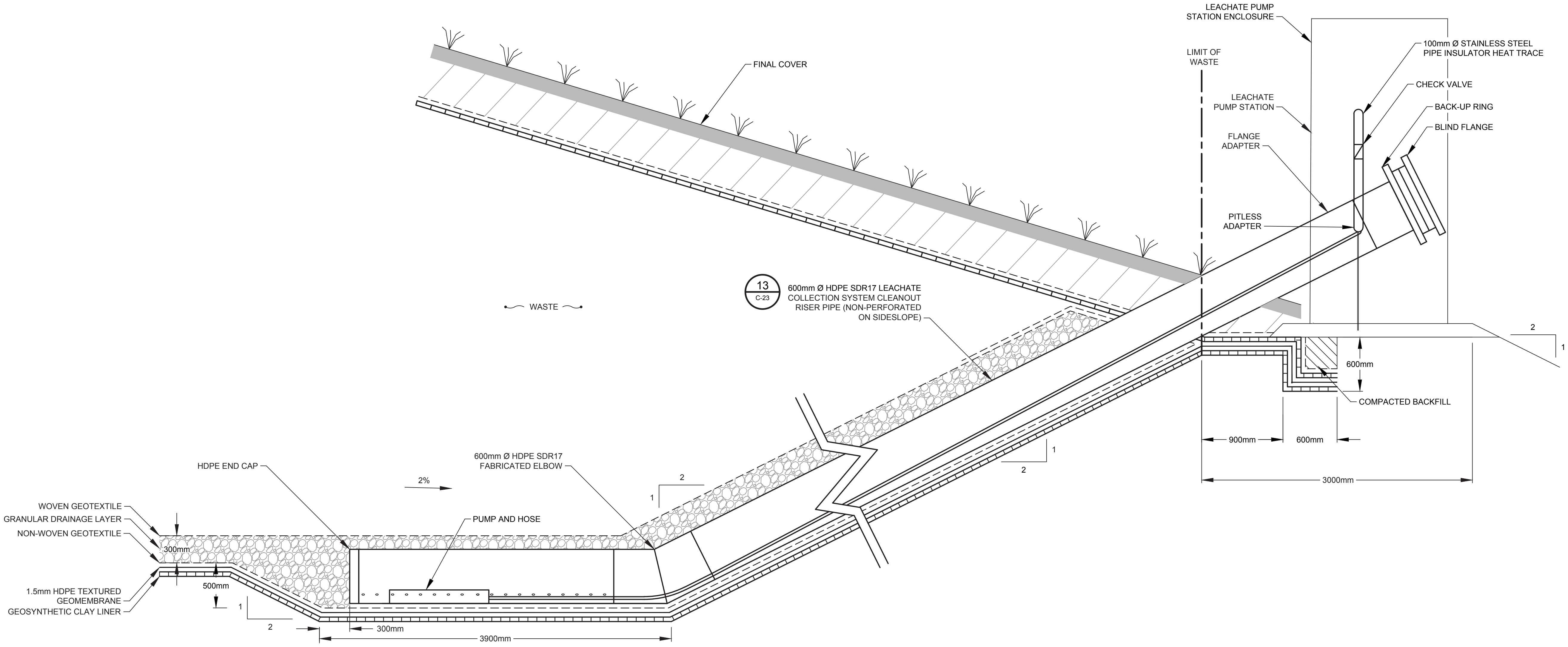
Bar is 20mm on original size drawing
0 20mm

Project No. 084612-22

Title
BASE LINER AND LEACHATE COLLECTION SYSTEM DETAILS

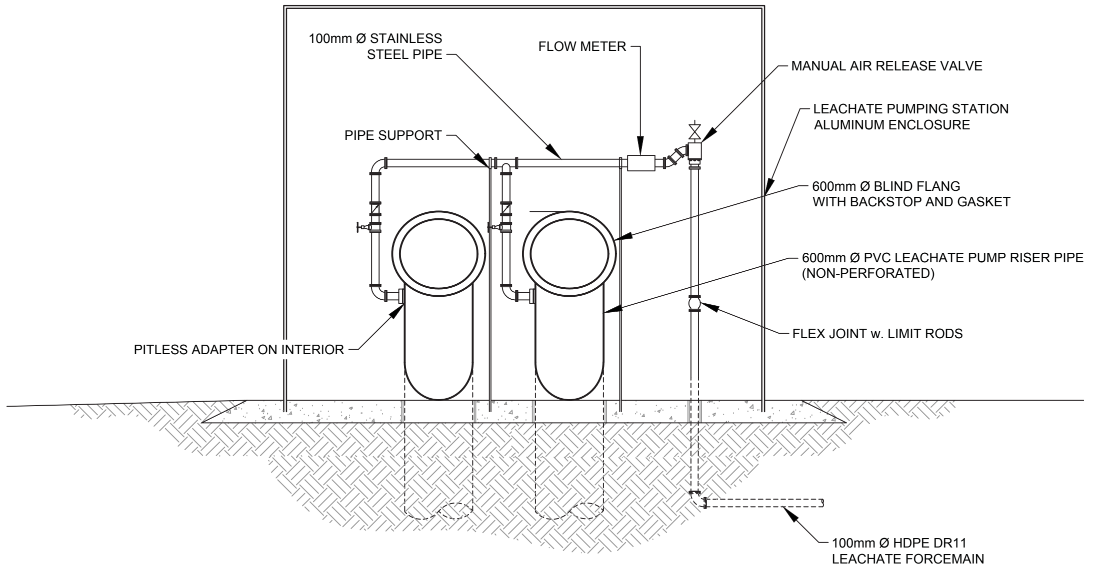
Sheet No.
C-22

Sheet 23 of 24



DETAIL 12 C-18 LEACHATE COLLECTION SUMP, SUMP RISER PIPE AREA 3

SCALE 1:25



DETAIL 13 C-23 RISER PIPE SECTION A

N.T.S.

GHD
10271 Shellbridge Way, Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **W** www.ghd.com

Client
CITY OF KELOWNA - GLENMORE LANDFILL

Project
DESIGN, OPERATIONS AND CLOSURE PLAN

No.	Issue	Drawn	Approved	Date
1	FINAL	TW	DL	10/11/2018
0	ISSUED FOR REVIEW	TW	DL	09/19/2018

Drawn	S.BRIGGS	Designer	R.HASIOR
Drafting Check	R.HASIOR	Design Check	D. LIDDY
Project Manager	D. LIDDY	Date	Nov 1, 2018
This document shall not be used for construction unless signed and sealed for construction.		Scale	AS SHOWN
Original Size	ANSI D	Bar is 20mm on original size drawing 0 20mm	

Project No. 084612-22

Title
LEACHATE COLLECTION SUMP & SUMP RISER AREA 3 - DETAILS

Sheet No.
C-23

Sheet 24 of 24

Plot Date: 1 November 2018 - 4:20 PM
Plotted By: Tyler Wagstaff
CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA026.dwg

Table 5.1

Climate Data
2018 Design, Operations, and Closure Plan
Glenmore Landfill
Kelowna, BC

Month	**Daily Average Temperature** *Celsius*	**Daily Maximum Temperature** *Celsius*	**Daily Minimum Temperature** *Celsius*	**Rainfall** *mm*	**Snowfall** *cm*	**Precipitation** *mm*	**Average Relative Humidity - 0600 LST** *%*	**Average Relative Humidity - 1500 LST** *%*
January	-2.5	0.8	-5.8	8.9	26.9	31	86.5	76.4
February	-0.9	3.6	-5.3	10	10.8	19	86	65.2
March	4.1	10.1	-2	16.9	4.8	21.6	84.3	48.8
April	8.4	15.5	1.3	28.3	0.8	29.1	80.3	39.8
May	12.8	20.2	5.4	39.2	0	40.2	77.2	40
June	16.6	24.2	9.1	45.9	0	45.9	73.5	39.3
July	19.5	27.9	11.1	37.2	0	37.2	73.4	35.6
August	19.1	27.6	10.6	32.1	0	32.1	79.2	36.2
September	13.9	21.7	5.9	31.7	0	32.4	86.2	42.2
October	7.3	13.4	1.3	29.1	0.1	29.2	87.9	55.6
November	1.6	5.6	-2.4	24.4	13.6	36.7	87.9	70.6
December	-2.6	0.7	-5.9	7.6	32	32.6	85.1	75.7
Annual	**8.1**	**14.3**	**1.9**	**311.3**	**89.0**	**386.9**	**82.3**	**52.1**

Temperature and Precipitation Date Source: Source: Environment Canada: Climate Normals - Kelowna A (Climate ID 1123970), 1981-2010 Station Data. Approximately 2.5 km from Glenmore Landfill. Elevation 429.5 m

Table 7.2

Fill Sequence
2018 Design, Operations, and Closure Plan
Glenmore Landfill
Kelowna, BC

				Landfilling Area		Phase 1 & 2		Area 1					Area 2				Area 3
				Filling Elevation		458 to 464	464 to 470	440 to 446	446 to 452	452 to 458	458 to 464	464 to 470	443 to 454	454 to 460	460 to 466	466 to 470	440 to 470
				Airspace Capacity		102,931	372,560	126,570	158,610	194,960	226,470	242,650	128,810	132,830	120,190	63,900	1,509,800
Year		Annual Mass Landfilled (tonnes)	Annual Airspace Consumption (m^3)	Drawing Number													
1	2018	150,000	208,333	C-09		0	267,158	126,570	158,610	194,960	226,470	242,650					
2	2019	150,000	208,333			0	185,394	0	158,610	194,960	226,470	242,650	128,810	132,830	120,190	63,900	
3	2020	150,000	208,333		C-10	0	185,394	0	0	194,960	226,470	242,650	79,087	132,830	120,190	63,900	
4	2021	150,000	208,333	C-11		0	185,394			65,713	226,470	242,650	0	132,830	120,190	63,900	
5	2022	150,000	208,333			0	185,394			9,790	226,470	242,650		0	120,190	63,900	
6	2023	150,000	208,333		C-12	0	185,394			0	148,117	242,650			0	63,900	
7	2024	150,000	208,333	C-13		0	185,394				3,683	242,650				0	1,509,800
8	2025	150,000	208,333			0	185,394				0	38,000					1,509,800
9	2026	150,000	208,333			0	15,061					0					1,509,800
10	2027	150,000	208,333		C-14	0	0										1,316,528
11	2028	150,000	208,333														1,108,194
12	2029	150,000	208,333														899,861
13	2030	150,000	208,333														691,528
14	2031	150,000	208,333														483,194
15	2032	150,000	208,333														274,861
16	2033	150,000	208,333														66,528
17	2034	150,000	208,333														0

Table 8.1

Airspace Capacity Summary
2018 Design, Operations, and Closure Plan
Glenmore Landfill
Kelowna, BC

Year		Airspace Available	Waste Deposited		Airspace Remaining
		(m3)	(tonnes)	(m3)	(m3)
1	2018	39,788,450	150,000	208,333	39,580,117
2	2019		150,000	208,333	39,371,783
3	2020		150,000	208,333	39,163,450
4	2021		150,000	208,333	38,955,117
5	2022		150,000	208,333	38,746,783
6	2023		150,000	208,333	38,538,450
7	2024		150,000	208,333	38,330,117
8	2025		150,000	208,333	38,121,783
9	2026		150,000	208,333	37,913,450
10	2027		150,000	208,333	37,705,117
11	2028		152,700	212,083	37,493,033
12	2029		155,449	215,901	37,277,133
13	2030		158,247	219,787	37,057,345
14	2031		161,095	223,743	36,833,602
15	2032		163,995	227,771	36,605,832
16	2033		166,947	231,870	36,373,961
17	2034		169,952	236,044	36,137,917
18	2035		173,011	240,293	35,897,624
19	2036		176,125	244,618	35,653,006
20	2037		179,295	249,021	35,403,985
21	2038		182,523	253,504	35,150,481
22	2039		185,808	258,067	34,892,414
23	2040		189,153	262,712	34,629,702
24	2041		192,557	267,441	34,362,261
25	2042		196,023	272,255	34,090,007
26	2043		199,552	277,155	33,812,851
27	2044		203,144	282,144	33,530,707
28	2045		206,800	287,223	33,243,484
29	2046		210,523	292,393	32,951,092
30	2047		214,312	297,656	32,653,436
31	2048		218,170	303,014	32,350,422
32	2049		222,097	308,468	32,041,955
33	2050		226,095	314,020	31,727,934
34	2051		230,164	319,673	31,408,262
35	2052		234,307	325,427	31,082,835
36	2053		238,525	331,284	30,751,551
37	2054		242,818	337,248	30,414,303
38	2055		247,189	343,318	30,070,985
39	2056		251,638	349,498	29,721,487
40	2057		256,168	355,789	29,365,699
41	2058		260,779	362,193	29,003,506
42	2059		265,473	368,712	28,634,794
43	2060		270,251	375,349	28,259,444
44	2061		275,116	382,105	27,877,339
45	2062		280,068	388,983	27,488,356

Table 8.1

Airspace Capacity Summary
2018 Design, Operations, and Closure Plan
Glenmore Landfill
Kelowna, BC

Year		Airspace Available	Waste Deposited		Airspace Remaining
		(m3)	(tonnes)	(m3)	(m3)
46	2063		285,109	395,985	27,092,371
47	2064		290,241	403,113	26,689,258
48	2065		295,466	410,369	26,278,889
49	2066		300,784	417,755	25,861,134
50	2067		306,198	425,275	25,435,859
51	2068		311,710	432,930	25,002,929
52	2069		317,320	440,723	24,562,206
53	2070		323,032	448,656	24,113,550
54	2071		328,847	456,732	23,656,819
55	2072		334,766	464,953	23,191,866
56	2073		340,792	473,322	22,718,544
57	2074		346,926	481,842	22,236,702
58	2075		353,171	490,515	21,746,188
59	2076		359,528	499,344	21,246,844
60	2077		365,999	508,332	20,738,511
61	2078		372,587	517,482	20,221,029
62	2079		379,294	526,797	19,694,232
63	2080		386,121	536,279	19,157,953
64	2081		393,071	545,932	18,612,021
65	2082		400,147	555,759	18,056,262
66	2083		407,349	565,763	17,490,499
67	2084		414,681	575,946	16,914,552
68	2085		422,146	586,313	16,328,239
69	2086		429,744	596,867	15,731,372
70	2087		437,480	607,611	15,123,761
71	2088		445,354	618,548	14,505,213
72	2089		453,371	629,682	13,875,532
73	2090		461,531	641,016	13,234,516
74	2091		469,839	652,554	12,581,962
75	2092		478,296	664,300	11,917,662
76	2093		486,905	676,258	11,241,404
77	2094		495,670	688,430	10,552,974
78	2095		504,592	700,822	9,852,152
79	2096		513,674	713,437	9,138,715
80	2097		522,921	726,279	8,412,437
81	2098		532,333	739,352	7,673,085
82	2099		541,915	752,660	6,920,425
83	2100		551,670	766,208	6,154,217
84	2101		561,600	780,000	5,374,218
85	2102		571,708	794,040	4,580,178
86	2103		581,999	808,332	3,771,846
87	2104		592,475	822,882	2,948,964
88	2105		603,140	837,694	2,111,270
89	2106		613,996	852,773	1,258,497
90	2107		625,048	868,122	390,375

Table 10.1

Infinite Slope Analysis
2018 Design, Operations, and Closure Plan
Glenmore Landfill
Kelowna, BC

Critical Interface	Cover Density g (kN/m^3)	Layer Thickness (m)	Depth to Failure plane z (m)	Depth to Water d_w (m)	Interface Shear Strength		Landfill Slope b		Factor of Safety		K_y
					Cohesion c (kPa)	Angle of friction (f)	H:V	Degrees	Static	Pseudo-static	
Top soil + vegetative soil + sand protective cover Vs Non-woven Geotextile	18	0.60	0.60	0.45	0	32	3 :1	18.4	1.62	1.09	0.17
Top soil + vegetative soil + sand protective cover + Non-woven Geotextile Vs Geosynthetic Clay Liner	18	0.60	0.60	0.45	0	32	3 :1	18.4	1.62	1.09	0.17
Top soil + vegetative soil + sand protective cover + Non-woven Geotextile + Geosynthetic Clay Liner vs landfill waste	18	0.60	0.60	0.45	2	30	3 :1	18.4	2.11	1.44	0.31

Factor of Safety (FS) = $\dfrac{c/(g.z.\cos^2 b) + \tan f\,[1-g_w(z-d_w)/(g.z)] - k_s \tan b \tan f}{k_s + \tan b}$

yield acceleration k_y = $\dfrac{c/(g.z.\cos^2 b)+\tan f\,[1-g_w(z-d_w)/(g.z)] - \tan b}{1+ \tan f \tan b}$

g_w (density of water kN/m^3) = 9.81

Seismic coefficient k_s = 0.137 g

For Static Factor of Safety k_s = 0

Notes:

1) Depth to critical surface/water measured vertically from the ground surface

2) Yield acceleration k_y = 50 percent of the amplified maximum horizontal acceleration of 0.137g.

3) The calculated factors of safety are based on assumed interface friction values from CRA database values and must be confirmed by site-specific testing.

Appendices

Appendix A
Operational Certificate 12218

June 29, 2015

Tracking Number: 60825
Authorization Number: 12218

REGISTERED MAIL

City of Kelowna
City Hall
1435 Water Street
Kelowna BC V1Y 1J4

Dear Operational Certificate Holder:

Enclosed is Amended Operational Certificate 12218 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 Southern Interior Region - Okanagan. Plans, data and reports pertinent to the operational certificate are to be submitted to the Director, Environmental Protection, at Ministry of Environment, Regional Operations, Southern Interior Region - Okanagan, 102 Industrial Pl., Penticton, BC V2A 7C8.

Ministry of Environment
Environmental Protection Division
102 Industrial Pl.
Penticton, BC V2A 7C8
Southern Interior Region - Okanagan
Telephone: (250) 490-8200
Facsimile: (250) 490-2231

Yours truly,

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

Enclosure

cc: Environment Canada
Regional District of Central Okanagan

BRITISH COLUMBIA

MINISTRY OF ENVIRONMENT

OPERATIONAL CERTIFICATE

12218

Under the Provisions of the Environmental Management Act

CITY OF KELOWNA

City Hall
1435 Water Street
Kelowna BC V1Y 1J4

is authorized to manage waste and recyclable material from the Regional District of Central Okanagan and environs including the Big White area, at the Glenmore Landfill located 9 kilometres north-east of the Kelowna city centre, 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 Operational Certificate is issued pursuant to the provisions of Section 28 of the *Environmental Management Act*. This Operational Certificate supersedes all previous versions of Operational Certificate 12218 issued under the authority of the *Waste Management Act and the Environmental Management Act.*

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

1. AUTHORIZED DISCHARGES

1.1 This section applies to the discharge of refuse from municipal, commercial and light industrial sources to a sanitary landfill known as the Glenmore Landfill. The site reference number for this discharge is E104956.

1.1.1 The maximum authorized rate of waste discharge is 170,000 tonnes annually. The maximum quantity of waste discharged must not exceed the design capacity of the landfill as specified in an approved Design and Operations Plan. The final footprint and profile of the discharged waste must be within that specified in the Design and Operations Plan and approximately as shown on the attached locations map.

Date issued:	December 8, 2000
Date amended: (most recent)	June 29, 2015

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

1.1.2 The characteristics of the waste discharged to the landfill are those of municipal solid waste as defined in the *Environmental Management Act* and other waste as may be authorized by the Director.

1.1.3 The following types of wastes must not be discharged:

(1) Hazardous wastes, other than those specifically approved for disposal to authorized landfills, as defined in the Hazardous Waste Regulation under the *Environmental Management Act*.

(2) Anatomical, pathological, and untreated biomedical wastes as defined in the *Guidelines for the Management of Biomedical Wastes in Canada* (Canadian Council of Ministers of the Environment, February 1992). With exception of the limited biomedical wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw.

(3) Bulk liquids and semi-solid wastes, which contain free liquids, as determined by US EPA Method 9095A Paint Filter Liquids Test, Test Methods for Evaluating Solid Wastes-Physical/Chemical Methods (EPA Publication No. Sw-846).

(4) Hog fuel, log yard debris and chipped wood waste. The reuse of these materials for temporary roads, dust control or a component of alternative daily cover is permitted.

(5) Recyclable materials, including automobiles, white goods, other large metallic objects and tires, as directed by the Director.

(6) Dead animals and slaughter house, fish hatchery and farming wastes or cannery wastes and by-products with the exception of slaughter waste from small (less than 200 bird) independent backyard chicken farms. Limited biomedical and carcass wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw will also be accepted.

Burial of these wastes in dedicated locations (i.e. avoiding co-disposal) at the landfill site may be authorized by the Director only if there is no other viable alternative such as treatment/disposal, recycling, reprocessing or composting.

The viability of alternatives is to be determined by the Director based on submission of cost data by the holder of the Operational Certificate. For those cases in which the dedicated disposal of otherwise prohibited wastes is authorized, the specific on-site location of the disposal must 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.

1.1.4 Notwithstanding the requirements of section 1.1.3(1) the disposal of waste asbestos in compliance with the requirements of Section 40 of the Hazardous Waste Regulation under the *Environmental Management Act* is hereby authorized.

1.1.5 Notwithstanding the requirements of section 1.1.3(1), the deposit of hydrocarbon contaminated soils below the Hazardous Waste Regulation criteria is authorized at this landfill subject to the following conditions:

(1) Soil contaminated with hydrocarbons must be deposited in layers less than 0.3 meters; and

(2)Soil contaminated with hydrocarbons must be deposited a minimum of 1.2 meters above the seasonal high groundwater level and a minimum of 2.0 meters below the final grade of the landfill to prevent the impact on groundwater and any future vegetation on the site.

1.1.6 Composting of yard waste must be in accordance with the Organic Matter Recycling Regulation under the *Environmental Management Act*.

1.1.7 The discharged waste must originate from within the Regional District of Central Okanagan and Big White area, subject to the following:

(a) Waste discharged to this landfill must satisfy the requirements of the Central Okanagan Regional District Solid Waste Management Plan.

(b)Waste discharged to this landfill must not contravene the Regional Solid Waste Management Plan of the Regional District from which the waste originated.

1.1.8 The works authorized are a sanitary landfill and related appurtenances as specified in the approved Design and Operations Plan The landfill and any new works must be operated to meet or surpass the requirements for a sanitary landfill as described in the *BC Landfill Criteria for Municipal Solid Waste* unless otherwise approved by the Director.

1.1.9 Municipal solid waste that has value for the purposes of reuse or reprocessing must be considered recyclable material. Recyclable materials may be diverted from disposal and temporarily stored at the landfill facility prior to removal from the site. The nature of the recyclable material authorized for storage at the landfill facility must be to the satisfaction of the Director.

2. OPERATING REQUIREMENTS

2.1 Design, Operations and Closure Plans

2.1.1 The City must submit a Design, Operations and Closure Plan prepared by a suitably qualified professional for approval by the Director by June 30, 2016, and a Financial Security Plan by June 30, 2017. The Design, Operations and Closure Plan must address, but not be limited to, each of the subsections in the Landfill Criteria for Municipal Solid Waste unless otherwise approved by the Director, including performance, siting, design, operational, closure and post-closure criteria. The facilities must be developed, operated and closed in accordance with the Design, Operations and Closure Plan. Should there be any inconsistency between this Operation Certificate and the Design, Operations and Closure Plan, this Operational Certificate must take precedence.

2.1.2 The Design, Operations and Closure plans must be reviewed every 5 years throughout the operating life of the landfill and updated to encompass the next 10 years of landfill operation and/or post-closure activities. The updated landfill design, operating and closure plans must be prepared by a professional engineer or geoscientist licensed to practice in the province of British Columbia and knowledgeable in such matters. The updated plans must be submitted to the Director for approval and must include any information relevant to the design, operations, closure and post-closure care of the landfill.

2.1.3 The landfill facility must be constructed and maintained in accordance with the approved Design, Operations and Closure plans and subject to the conditions set therein. A knowledgeable professional engineer must carry out field reviews of the landfill construction and installation of works. As-constructed drawings of the landfill and all works, including elevations relative to a common datum, must be submitted (or retained on site) to the Director. The as-constructed drawings must be sealed by a professional engineer or geoscientist who is licensed to practice in the province of British Columbia and knowledgeable in the appropriate field of study.

2.1.4 Written authorization from the Director must be obtained prior to implementing any changes to the approved plans. Based on any information obtained in connection with this facility, the Director may require revision of, or addition to, the design, operations and closure plans.

2.1.5 The following design, operations and closure plans are approved:

(1) Comprehensive Site Development Plan for Glenmore landfill, dated August 2001, prepared by CH2MHill.
(2) Comprehensive Site Development Plan for Glenmore landfill, dated June 2008, prepared by CH2MHill.
(3) Landfill Gas Management Facilities Design Plan (Final) Glenmore Landfill site, dated January 2012, prepared by CH2MHill

2.1.6 In accordance with Section 40 of the *Environmental Management Act* and Part 2 of the Contaminated Sites Regulation, the Operational Certificate holder must submit a site profile to the Director at least ten days prior to decommissioning the facilities authorized in Section 1.

2.2 **Qualified Professionals**

All information, including plans, drawings, assessments, investigations, surveys, programs and reports, must be certified by a qualified professional. As-built plans and drawings of the facilities and works must be certified by a qualified professional

2.2.1 "qualified professional" means a person who:

(a) is registered in British Columbia with his or her appropriate professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association; and

(b) through suitable education, experience, accreditation and knowledge may be reasonably relied on to provide advice within his or her area of expertise as it relates to this Operational Certificate

2.3 Maintenance of Works and Emergency Procedures

The authorized works must be inspected regularly and maintained in good working order. In the event of an emergency or condition beyond the control of the City of Kelowna including, but not limited to, unauthorized fires arising from spontaneous combustion or other causes, or detection of surfacing leachate on the property, the City of Kelowna must take appropriate remedial action and notify the Regional Ministry Office. The Director may reduce or suspend operations to protect the environment until the authorized works has been restored, and/or corrective steps taken to prevent unauthorized discharges.

2.4 Additional Information, Facilities or Works

The Director may, in writing, require investigations, surveys, the submission of additional information, and the construction of additional facilities or works. The Director may also, in writing, amend the information, including plans, drawings, assessments, investigations, surveys, programs and reports, required by this Operational Certificate. Any amendments to the information are without effect unless the Director has approved of such amendments in writing.

2.5 Landfill Site Development

2.5.1 In accordance with the approved Design, Operations and Closure Plan, surface water diversions and groundwater drainage works must be installed to prevent surface water run-off and groundwater seepage from entering the waste discharge area. The effect of sediment transport from areas upgradient and within the landfill site must be considered when designing, installing and maintaining the surface water diversion system. Diversion and drainage structures must be maintained by the Operational Certificate Holders on a regular basis to the satisfaction of the Director.

2.5.2 A berm of suitable material must be constructed to limit visibility of the active waste discharge area where practical for travellers using the Glenmore Road and John Hindle Drive.

2.5.3 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.

2.6 Waste Compaction and Coverage

2.6.1 The City must ensure that waste deposition and compaction meets or exceeds the requirements specified in the latest version of the Landfill Criteria for Municipal Solid Waste for daily, intermediate and final cover unless otherwise approved by the Director. Control must be exercised to ensure keeping freshly deposited refuse in a well defined and small/manageable working face.

Discharged wastes must be compacted and cover material applied as outlined in section 2.6. Wastes must be compacted and covered on a continuous basis. However, if operations are reduced to less than 24 hours per day, then provisions such as security, fencing, and/or other measures approved by the Director must be deployed to prevent wildlife access. All wastes must be covered within 24 hours of discharge to the landfill.

2.6.2 The area of the active landfill working face must be minimized as much as possible. Wastes must be spread in thin layers of 60 centimetres, or less, on the working face and compacted. A compacted layer of at least 15 centimetres of suitable soils, or a functionally equivalent depth of other cover material acceptable to the Director, must be placed on all exposed compacted waste.

2.6.3 An intermediate cover of at least 30 centimetres of compacted soils, or a functionally equivalent depth of other cover material acceptable to the Director, must be applied on any areas of the active landfill site to which waste will not be discharged for a period of 30 days or more.

2.6.4 Final cover must be installed within 180 days of completion of the landfill to the final elevations as specified in the approved plans. Completed portions of the landfill must progressively receive final cover during the active life of the landfill. Final cover must consist of at least 1 metre of low permeability compacted mineral soil, overlain by at least 15 centimetres of topsoil capable of supporting indigenous vegetation. With the written approval of the Director, the topsoil used for this final covering may be mixed with conditioning agents such as sludge (biosolids), compost and the like to add organics and improve the moisture holding capacity and nutrient value of the soil. Final cover must be constructed and maintained with adequate drainage and erosion controls and seeded with suitable grasses.

2.6.5 The Director may vary the frequency of covering when freezing conditions adversely affect normal operation.

2.7 Landfill Management

2.7.1 The landfill must be supervised to the satisfaction of the Director. Landfill supervisors must be trained in landfill operations pertaining to the conditions of this Operational Certificate and the approved design, operating and closure plans. Personnel must be trained to industry standards and at least one employee of the City must be trained and certified as a Manager of Landfill Operations or a British Columbia Qualified Landfill Operator by the Solid Waste Association of North America or equivalent.

2.7.2 Access to the site must be controlled and supervised. All access points must have locking gates and must be locked during periods when supervision is not available.

2.7.3 Public scavenging and salvaging of waste at the landfill site is prohibited. Designated safe areas for reuse as identified by the City of Kelowna will be permitted.

2.7.4 Designated areas must be maintained for the storage of recyclable materials. These designated area(s) must be separate from the active landfill area and must be maintained free of litter. Storage of recyclable materials at the landfill site must be limited to a reasonable length of time subject to the approval of the Director.

2.7.5 Litter and wind strewn waste must be controlled by limiting the area of the working face, installing a wind blown litter collection fence in a location which is in the anticipated prevailing downwind direction of the landfill working face, instituting a regular litter pickup, general good site maintenance practises or any other measures required by the Director.

2.7.6 The landfill must be operated in a manner acceptable to the Director to reduce the potential of public nuisance.

2.7.7 The landfill must be operated so as not to create a significant threat to public health or safety, with respect to landfill gas, odours, unauthorized access, roads, traffic, airport activity, noise, dust, litter, vectors, or wildlife attraction using methods and materials acceptable to the Director.

2.7.8 Open burning of waste is prohibited. It is recognized that open burning may be required at the landfill when volumes of wood waste stored at the landfill become large, or shipping wastes to offsite solutions become unfeasible. The City will apply to the Director for a burning permit as needed.

2.7.9 The landfill must be operated so as to minimize the attraction of nuisance wildlife and disease vectors such as birds and rodents by applying adequate cover to the waste and by maintaining the site free of litter. Additional control measures may be specified by the Director if wildlife and/or vector attraction to the site becomes a public safety hazard.

2.7.10 The landfill works must be inspected on a regular basis by the landfill supervisor. In the event of an emergency or any condition, which prevents continuing operation of the approved method of landfill operation and control, or results in non-compliance with the terms and conditions of this Operational Certificate, the Director must be notified immediately and appropriate remedial action taken.

2.7.11 The Director may require future upgrading of the landfill control works to protect the environment during the operating life of the landfill and for a minimum post-closure period of 25 years.

2.8 Ground and Surface Water Quality Impairment

The quality of ground and surface water at the property boundary must not exceed the appropriate (e.g.freshwater aquatic life, drinking water, etc.) water quality criteria in the British Columbia Approved Water Quality Guidelines and A Compendium of Working Water Quality Guidelines for British Columbia, as amended from time to time, or their replacements approved by the Director in writing. Where natural background water quality exceeds the appropriate water quality criteria, the quality of ground and surface water at the property boundary must not exceed natural background water quality. Water quality criteria from other jurisdictions can only be used for contaminants which have not been dealt with in the British Columbia Guidelines. After considering existing and potential future uses of ground and surface water, a qualified professional may recommend the appropriate water quality criteria. The appropriate water quality criteria are subject to the approval of the Director in writing.

If excursions result to the specified water quality criteria, the Director may require that leachate management control measures or works be undertaken. Terms of reference for any leachate management study and/or design work is subject to the authorization of the Director.

2.9 Landfill Gas Management

The Landfill must not cause combustible gas concentrations to exceed the lower explosive limit in soils at the property boundary or 20% of the lower explosive limit at or in on-site or off-site structures.

The City must ensure that the facility is in compliance with the requirements of the Landfill Gas Management Regulation under the *Environmental Management Act*.

3. MONITORING

3.1 Environmental Protection Monitoring

The City must implement and maintain ground, surface water, leachate collection sump fluids and landfill gas monitoring programs prepared by a qualified professional in accordance with the monitoring programs approved in the Design, Operations and Closure plans approved by the Director. The monitoring programs must identify potential environmental impacts of the authorized facility and must address but not be limited to the Landfill Criteria for Municipal Solid Waste and Guidelines for Environmental Monitoring. It must take into consideration results from previous monitoring programs and any other investigations conducted at the site to ensure that early detection of potential impacts is possible.

The monitoring programs must be reviewed in the annual report required under section 4.2. Based on the information submitted in the annual report, or any other information obtained in connection with this site, the Director may vary the frequency, location and analyses of ground and surface water, leachate collection sump fluid and landfill gas sampling.

3.2 Management of Leachate Collection System Fluid

Leachate collection sump fluid levels must be monitored and fluid removed from the leachate collection system as specified in the approved design, operating and closure plans. A sample of fluid from each of the leachate collection sumps must be collected on a quarterly basis and laboratory analyses obtained for the leachate indicator parameters identified in the monitoring program. The Director may vary the location and frequency of sampling and analyses of leachate collection system fluid should conditions warrant. Fluid recovered from the leachate collection system may be used within the landfill footprint for irrigation, dust suppression and/or re-circulated within the buried waste as well as directed to the Kelowna Wastewater Treatment facility unless otherwise directed by the Director. Other methods of treatment and/or disposal of the leachate collection sump fluids must have the prior approval of the Director.

3.3 Groundwater Contamination by Leachate

Should it be determined that leachate is being generated and carried in the groundwater or surface water and, in the opinion of the Director, requires interception and treatment, appropriate remedial measures as approved by the Director must be implemented.

4. REPORTING

4.1 Interim Reporting and Record Keeping

The leachate collection sump fluid level readings, groundwater elevation and combustible gas monitoring data, and the sump fluid, groundwater and gas sampling analyses results must be available for inspection at the Glenmore Landfill office. Data from monitoring and sample analysis must be submitted to the Director with the annual report in accordance with section 7.2. Between annual reporting events, the Director must be promptly informed of any significant changes from long term trends observed in the parameters that are monitored.

4.2 Annual Report

An annual report must be electronically submitted by March 31 of each year for the previous calendar year of landfill operation or post-closure activities. The report should contain the Annual Environmental Monitoring Report and the Annual Operation Report.

The Annual Environmental Monitoring Report must include:

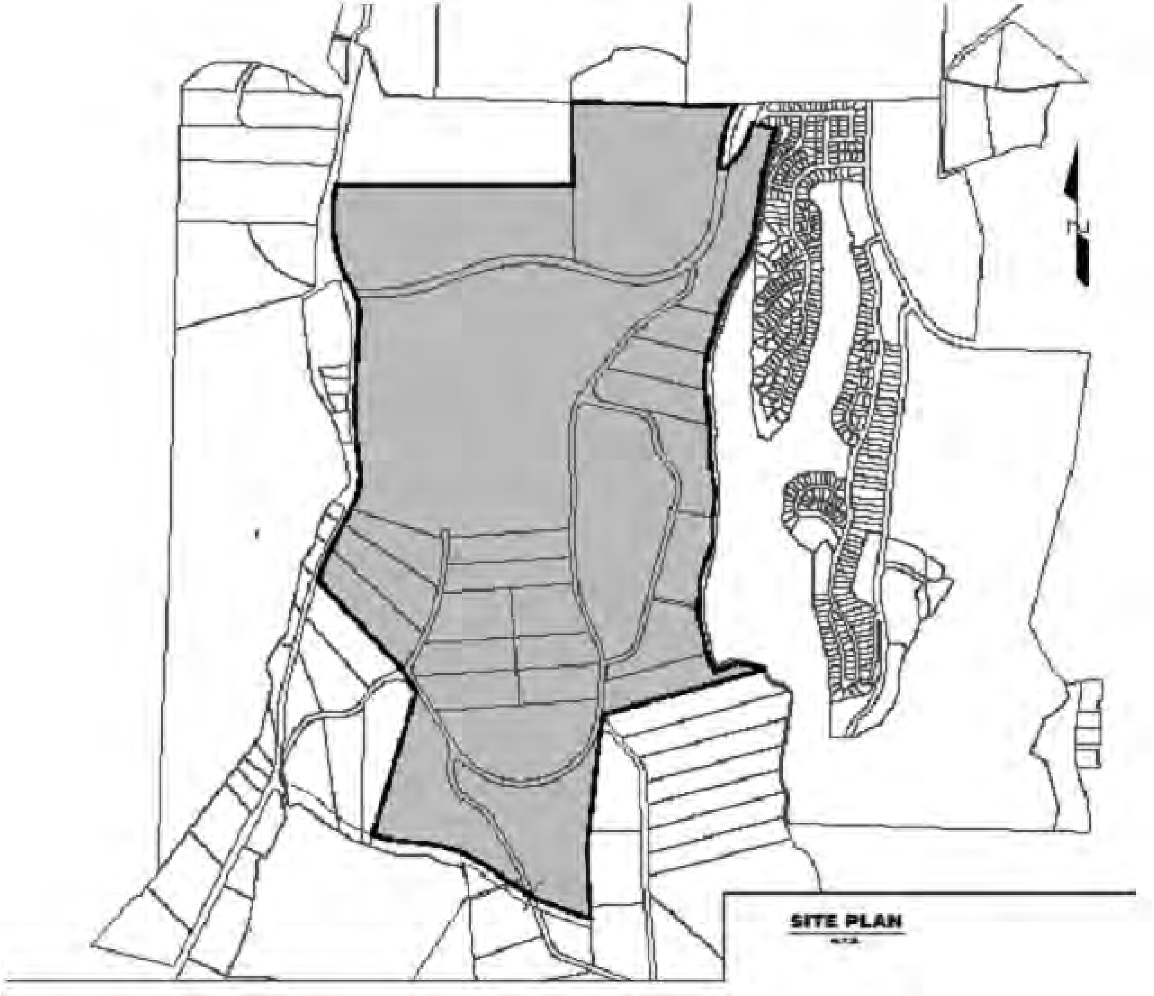
- Results of the environmental monitoring program.
- Data tabulation, comparison to performance criteria, interpretation, trend analysis, graphs, etc.
- Identification of any current or predicted future non-compliance with performance criteria.
- Conclusions, recommendation and proposed changes to the environmental monitoring program.

The Annual Operation Report should include at a minimum:

- Total volume, tonnage, and types of waste discharged into the landfill for the year.
- Types and tonnages of waste that were not directly disposed of into the landfill such as recycled, composted, etc.
- Leachate quantities collected, treated and discharged.
- Landfill gas quantities collected, flared and utilized. If applicable, an annual report should be done in the format required by the Landfill Gas Management Regulation and submitted either separately or as a part of the Annual Report.
- Operational plan for the next 12 months.
- Remaining site life and capacity.
- Closure works completed.
- Any changes from approved reports, plans and specifications.
- Any complaints received and the action taken as a result of a complaint.
- Financial Security Plan update.
- Identification of any non-compliance with the Solid Waste Management Plan, operational certificate and a proposed action plan and schedule to measure the performance of the proposed measures in achieving compliance.
- If possible: compaction, waste to cover ratio and airspace utilization factor.

Copies of the annual report must be provided to the public library in Kelowna and posted on the Operational Certificate holder's web sites.

SITE PLAN

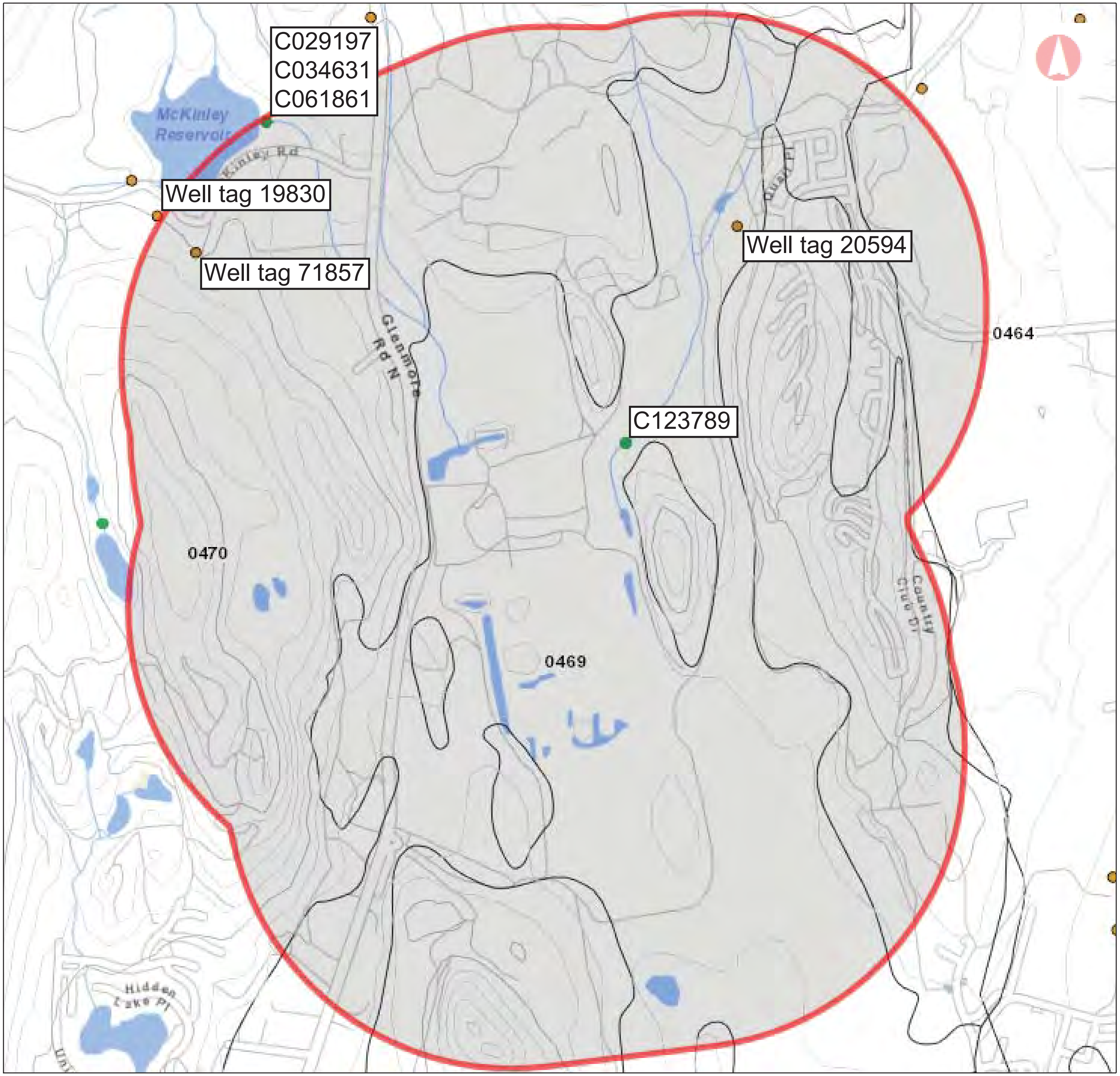


LOCATION MAP

Date issued: December 8, 2000
Date amended: June 29, 2015
(most recent)

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

Appendix B
Surrounding Water Use



BRITISH COLUMBIA

iMap BC Glenmore

Legend

Water Wells - Licensed/Unli

WELL_LICENCE_GENERAL_S

- ● Licensed
- ● Unlicensed

● Water Wells - Private Dome

● Water Wells - Lithology

● Water Wells - All

● Water Wells - Artesian

Points of Diversion

STATUS

- ● Active Application
- ● Active Application and Licence
- ● Inactive
- ● Active Licence

0 0.41 0.81 km

1: 20,000

Copyright/Disclaimer

Datum: NAD83

Projection: NAD_1983_BC_Environment_Albers

Key Map of British Columbia

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 19830

Owner: C STEPHENS

Address:

Area: KELOWNA

WELL LOCATION:
OSOYOOS (ODYD) Land District
District Lot: Plan: Lot:
Township: 23 Section: 21 Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 83): 082E093423 Well: 1

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Licence General Status: UNLICENSED
Well Use: Other
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 6.0 inches
Casing drive shoe:
Well Depth: 25 feet
Elevation: 0 feet (ASL)

Construction Date: 1966-02-01 00:00:00

Driller: Art Moore & Son
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 0 (Driller's Estimate)
Development Method:
Pump Test Info Flag:
Artesian Flow:
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag:
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: 25 feet

Lithology Info Flag:

File Info Flag:

Sieve Info Flag:

Screen Info Flag:

Site Info Details:

Other Info Flag:

Other Info Details:

Flag:

Material:

Method:

Depth (ft):

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From 0	to 1 Ft.	topsoil
From 1	to 4 Ft.	gravel sand and clay
From 4	to 6.6 Ft.	cemented gravel
From 6.6	to 14 Ft.	clay with some sand
From 14	to 18 Ft.	clay and gravel (w.b.)
From 18	to 23 Ft.	clay and rocks
From 23	to 24 Ft.	light brown clay
From 24	to 25 Ft.	yellow clay
From 25	to 0 Ft.	bedrock

- Return to Main
- Return to Search Options
- Return to Search Criteria

082E.093.4.2.3.

82 E.093
4.2.3

E/14-S½

1

UNITS TOWNSHIP	6 5 4 C E MERIDIAN	2 1 TENS	7 4 2 1 UNITS RANGE	2 1 TENS	7 4 2 1 UNITS SECTION	NE SE SW NW QUARTER	4 2 1 TENS	7 4 2 1 UNITS LAND DISTRICT

MUNICIPALITY: UNITS 4 7 — TENS 1 2 4 7

GROUND — WATER DIVISION, WATER INVESTIGATIONS BRANCH, DEPT. OF LANDS, FORESTS, and WATER RESOURCES, VICTORIA, B.C.

UP No MAPPING

LOCATION Sec 21 TP 23 Osoyoos Dist.
(COMPLETE LEGAL DESCRIPTION)

OWNER'S NAME MR. & MRS. C STEPHENS ADDRESS "WILD LIFE SANCTUARY" McKINLEY RD., GLENMORE DIST. KELOWNA

DRILLER'S NAME MOORE & SON ADDRESS BOX 13 WINFIELD DATE OF COMPLETION FEB /66

DEPTH 25' ELEVATION OF COLLAR (163) CASING DIAM. 6" LENGTH ______ TYPE ______

METHOD OF DIGGING DRILLED SCREEN ☐ SIZE ______ LENGTH ______ TYPE ______

LOCATION OF SCREEN ______ DEVELOPED ☐ DESCRIBE ______

PERFORATED CASING ☑ LENGTH 3' 6" LOCATION OF PERFORATIONS ______

WTN 19830

GRAVEL PACK ☐ LENGTH ______ DIAM. ______ SIZE GRAVEL, ETC. ______

PUMP ☐ TYPE ______ POWER ______

CAPACITY ______ OTHER DATA ______

COSTS WELL ______ PUMP ______ PUMP HOUSE, ETC. ______

MAINTENANCE ______

DISTANCE TO WATER FROM TOP OF CASING ______ ☐ ESTIMATED ☐ MEASURED ELEVATION ______ FLUCTUATION ______

HIGH WATER ______ MONTH ______ LOW WATER ______ MONTH ______ OBSERVATION DATA ☐ FILE No. ______

WATER USE NO SUITABLE FORMATION FOR A WELL. WATER SEEPED IN AT APPROX. ½ I.GPM. THROUGH AN OPEN HOLE.

North of OS 1
82E/14 495

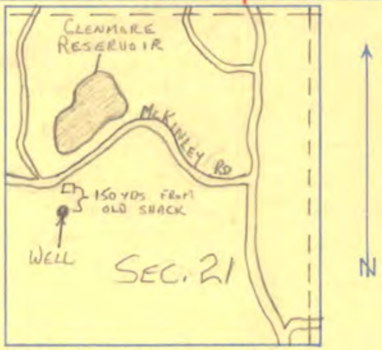
MAX. RATE WITHDRAWAL ☐ ESTIMATED ☐ MEASURED ______

TEMPERATURE ______ PUMPS SAND ☐ ______

CLOGS SCREEN ☐ TYPE DEPOSIT ______ AQUIFER DATA ______

LICENSE No. ______ DATE LICENSE ______ AMOUNT ______

DATE APPLICATION ______ USE ______



LOCATION SKETCH—INDICATE NORTH

APPROX. 700' SOUTH OF THE GLENMORE RESERVOIR
100 YDS SOUTH OF THE FLINTOFF RANCH GATE
NORTH OF SHEET 1.

SYSTEMS EQUIPMENT LIMITED, VICTORIA—CANADA 0 2231-65 SYSTEMSORT

1008

WATER QUALITY: ANALYSIS, SOFT, HARD, HIGH IRON, HIGH SULPHUR, SALTY, ALKALINE, SALINE, POLLUTED, INADEQUATE QUALITY

DRY HOLE, INADEQUATE QUANTITY, PUMPING TEST

CAPACITY GPD.: 0 — 10^3, 10^3 — 10^4, 10^4 — 10^5, 10^5 — 10^6, 10^6

METHOD: DUG, DRIVEN, DRILLED, JETTED, BORED

DEPTH: 0 — 25, 25 — 50, 50 — 100, 100 — 200, 200 — 400, >400

OBSERVATION, ABANDONED, DEVELOPED, SCREEN, PERF. CASING, GRAVEL ENV., PUMP

TYPE WELL: FLOWING, NON-FLOW ARTESIAN, WATER TABLE, PART CONFINED

ROCK, SPRING

SUPPLY AQUIFER		OTHER AQUIFER PRESENT		OTHER AQUIFER PRESENT		CHARACTER OF SUPPLY AQUIFER	WATER USE	RELIABILITY OF DATA
UNITS	TENS	UNITS	TENS	UNITS	TENS			
1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	SAND GRAVEL TILL	DOMESTIC GARDEN STOCK COOLING IRRIGATION INDUSTRIAL WATERWORKS	GOOD FAIR POOR

LOG

FROM	TO	DESCRIPTION	NAME
0	1	TOP SOIL	
1	4	GRAVEL SAND + CLAY	
4	6' 6"	CEMENTED GRAVEL	
6' 6"	14'	CLAY WITH SOME SAND	
14	18	CLAY & GRAVEL (W.B)	
18	23	CLAY & ROCKS	
23	24	LIGHT BROWN CLAY	
24	25	YELLOW CLAY	
25	–	BEDROCK	

SAMPLE No. ________ DATE ________

LAB. ________

COLIFORM ORGANISMS ________

TOTAL BACTERIA ________

COLOUR ________ ODOUR ________

TASTE ________

ANALYSIS

	PPM
Total Hardness	
Carbonate Hard	
Magnesium Hard	
Fe	
SO_2	
Ca	
Mg	
Na	
K	
HCO_3	
CO_3	
Cl	
SO_4	
NO_3	
B	
E	
Total Dis-solids	
Total Alkalinity	
Suspended Solids	
Ph	

PUMPING TEST SUMMARY

TEST BY ________

DATE ________ FILE No. ________

SPECIFIC CAPACITY ________ PERMIABILITY ________

STORAGE COEFF ________ TRANSMISSIBILITY ________

REMARKS ________

OTHER DATA

SIZE ANALYSIS, ETC. ________

CARD BY D. J. DATE April 66

SOURCES INFORMATION Moore + Son

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 20594

Owner: WILFRED WERGER

Address: GLENMORE RD

Area: KELOWNA

WELL LOCATION:
OSOYOOS (ODYD) Land District
District Lot: Plan: 16293 Lot: 2
Township: 23 Section: 16 Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 83): 082E093424 Well: 1

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Licence General Status: UNLICENSED
Well Use: Unknown Well Use
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 6.5 inches
Casing drive shoe:
Well Depth: 105 feet
Elevation: 0 feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: feet
Lithology Info Flag:

Construction Date: 1967-04-01 00:00:00

Driller: Okanagan Rotary Well Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 5 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Development Method:
Pump Test Info Flag:
Artesian Flow:
Artesian Pressure (ft):
Static Level: 35 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag:
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag:
Material:
Method:
Depth (ft):

File Info Flag:

Sieve Info Flag:

Screen Info Flag:

Site Info Details:

Other Info Flag:

Other Info Details:

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size

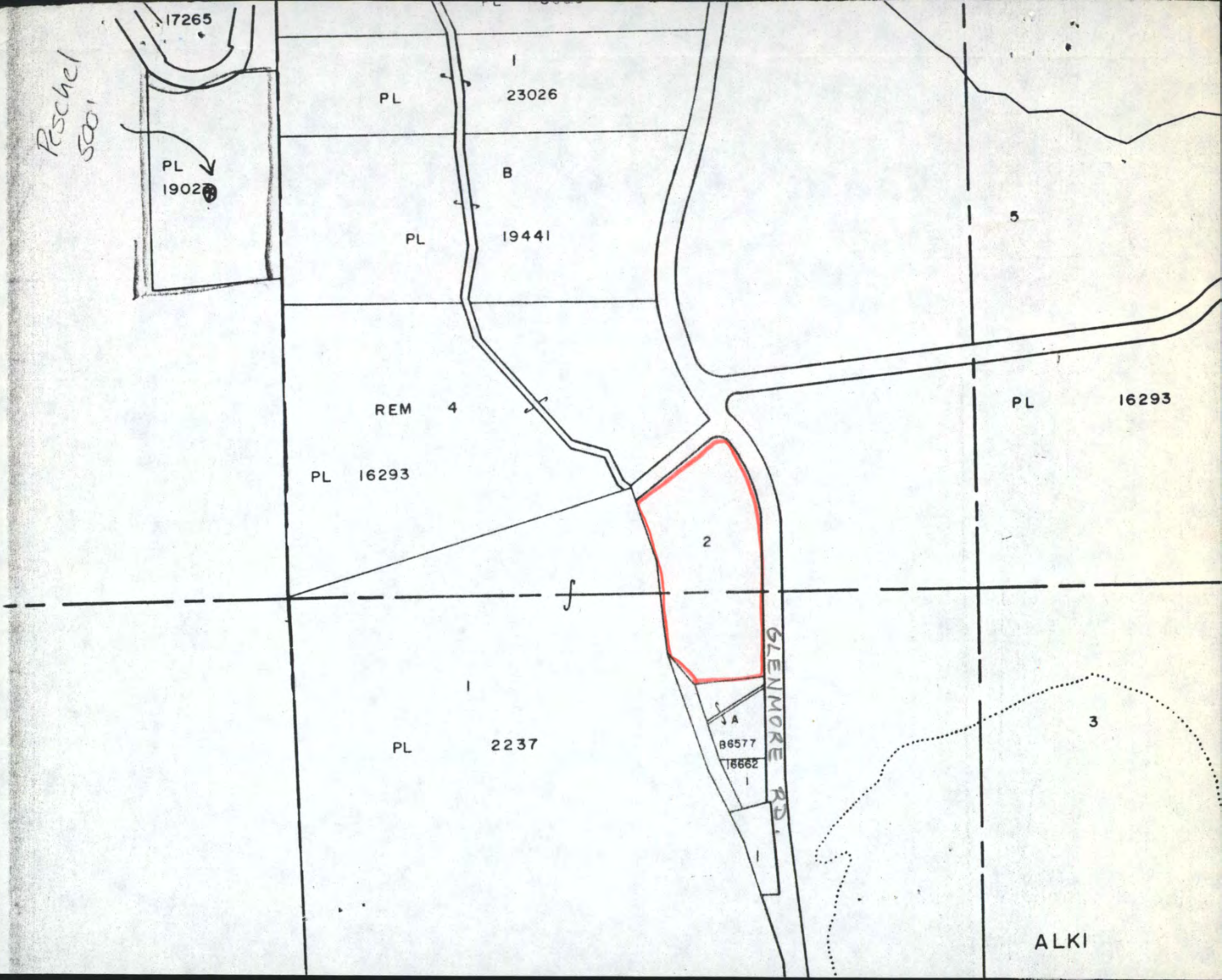
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From 0 to 10 Ft. brown clay, sand and rocks
From 10 to 42 Ft. hard clay -yellowish- then light brown
From 42 to 64 Ft. hard grey clay
From 64 to 86 Ft. slate, white and black rock w.b.
From 86 to 105 Ft. hard clay and white lime

- Return to Main
- Return to Search Options
- Return to Search Criteria


17265
I
PL
23026
Pischel
500'
PL
19027
B
PL
19441
REM 4
PL 16293
2
GLENMORE RD.
A
B6577
16662
I
I
I
PL
2237
5
PL
16293
3
ALKI

82E·093·4·2·4

1

7	4	2	1	7	4	2	1	6	5	4	C	E	2	1	7	4	2	1	2	1	7	4	2	1	NE	SE	SW	NW	4	2	1	7	4	2	1
								RIDIAN					TENS		UNITS				TENS		UNITS				QUARTER				TENS			UNITS			
													RANGE						SECTION										LAND DISTRICT						

UNITS 1 2 4 7 — TENS 1 2 4 7 — MUNICIPALITY

GROUND — WATER DIVISION, WATER INVESTIGATIONS BRANCH, DEPT. OF LANDS, FORESTS, and WATER RESOURCES, VICTORIA, B.C.

Osoyoos Dist

No Mapping

LOCATION Lot 2 Plan 16293 GLENMORE RD. KELOWNA SEC. 16+21 TP 23
(COMPLETE LEGAL DESCRIPTION)

OWNER'S NAME Wilfred Werger ADDRESS R.R.1 Glenmore (Kelowna city) WTN20594

DRILLER'S NAME Okanagan Rotary Water Wells ADDRESS ______ DATE OF COMPLETION Apr 1/67

DEPTH 105' ELEVATION OF COLLAR 105 CASING DIAM. 6¼" LENGTH ______ TYPE ______

METHOD OF DIGGING drilled SCREEN ☐ SIZE ______ LENGTH ______ TYPE ______

LOCATION OF SCREEN ______ DEVELOPED ☐ DESCRIBE ______

PERFORATED CASING ☐ LENGTH ______ LOCATION OF PERFORATIONS ______

GRAVEL PACK ☐ LENGTH ______ DIAM. ______ SIZE GRAVEL, ETC. ______

PUMP ☐ TYPE ______ POWER ______

CAPACITY ______ OTHER DATA ______

COSTS WELL ______ PUMP ______ PUMP HOUSE, ETC. ______

MAINTENANCE ______

DISTANCE TO WATER FROM TOP OF CASING 35' ☐ ESTIMATED ☑ MEASURED ELEVATION ______ FLUCTUATION ______

HIGH WATER ______ MONTH ______ LOW WATER ______ MONTH ______ OBSERVATION DATA ☐ FILE No. ______

WATER USE ______

MAX. RATE WITHDRAWAL ☐ ESTIMATED ☐ MEASURED ______

west of os2

TEMPERATURE ______ PUMPS SAND ☐ ______

CLOGS SCREEN ☐ TYPE DEPOSIT ______ AQUIFER DATA ______

LICENSE No. ______ DATE LICENSE ______ AMOUNT ______

DATE APPLICATION ______ USE ______

LOCATION SKETCH—INDICATE NORTH

WATER QUALITY: ANALYSIS, SOFT, HARD, HIGH IRON, HIGH SULPHUR, SALTY, ALKALINE, SALINE, POLLUTED, INADEQUATE QUALITY

DRY HOLE
INADEQUATE QUANTITY
PUMPING TEST

CAPACITY GPD.: 0 — 10^3, 10^3 — 10^4, 10^4 — 10^5, 10^5 — 10^6, 10^6

METHOD: DUG, DRIVEN, DRILLED, JETTED, BORED

DEPTH: 0 — 25, 25 — 50, 50 — 100, 100 — 200, 200 — 400, >400

OBSERVATION, ABANDONED, DEVELOPED, SCREEN, PERF. CASING, GRAVEL ENV., PUMP

TYPE WELL: FLOWING, NON-FLOW ARTESIAN, WATER TABLE, PART CONFINED

ROCK
SPRING

VISIrecord®

12708

992

SUPPLY AQUIFER		OTHER AQUIFER PRESENT		OTHER AQUIFER PRESENT		CHARACTER OF SUPPLY AQUIFER	WATER USE	RELIABILITY OF DATA
UNITS	TENS	UNITS	TENS	UNITS	TENS			
1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	1 2 4 7	SAND, GRAVEL, TILL	DOMESTIC, GARDEN, STOCK, COOLING, IRRIGATION, INDUSTRIAL, WATERWORKS	GOOD, FAIR, POOR

LOG

FROM	TO	DESCRIPTION	NAME
0	10	brown clay, sand & rocks	
10	42	hard clay - yellowish - then light brown.	
42	64	hard grey clay	
64	86	slate, white & black rock W.B.	
86	105	hard clay & white lime	

SAMPLE No. ______ DATE ______

LAB. ______

COLIFORM ORGANISMS ______

TOTAL BACTERIA ______

COLOUR ______ ODOUR ______

TASTE ______

PUMPING TEST SUMMARY

TEST BY ______

DATE ______ FILE No. ______

SPECIFIC CAPACITY ______ PERMIABILITY ______

STORAGE COEFF ______ TRANSMISSIBILITY ______

REMARKS bailed 5 g.p.m.

thick black water - never cleared

ANALYSIS

	PPM
Total Hardness	
Carbonate Hard	
Magnesium Hard	
Fe	
SO_2	
Ca	
Mg	
Na	
K	
HCO_3	
CO_3	
Cl	
SO_4	
NO_3	
B	
E	
Total Dis-solids	
Total Alkalinity	
Suspended Solids	
Ph	

OTHER DATA

SIZE ANALYSIS, ETC. ______

CARD BY AA. DATE Dec 68

SOURCES INFORMATION Okanagan Rotary Water Wells

VISIrecord®
12717

BRITISH
COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 71857

Owner: PESCHEL OTTO

Address: MCKINLEY RESERVOIR

Area: WINFIELD

WELL LOCATION:
OSOYOOS (ODYD) Land District
District Lot: Plan: 19023 Lot: A
Township: 23 Section: 21 Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 83): 082E093423 Well: 3

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Licence General Status: UNLICENSED
Well Use:
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: inches
Casing drive shoe:
Well Depth: 500 feet
Elevation: feet (ASL)

Construction Date: 1979-06-19 00:00:00

Driller: Okanagan Water Well Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: (Driller's Estimate) UNKNOWN YIELD
Development Method:
Pump Test Info Flag: N
Artesian Flow: UNKNOWN YIELD
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM): N

Water Utility: N
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: feet

Lithology Info Flag: N

File Info Flag: N

Sieve Info Flag: N

Screen Info Flag: N

Site Info Details:

Other Info Flag:

Other Info Details:

Flag: N

Material:

Method:

Depth (ft):

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
NOT CASED. VERY LITTLE H20.

LITHOLOGY INFORMATION:

From 0 to 500 Ft. ROCK HOLE 0 nothing entered 0 nothing entered 0 nothing entered

- Return to Main
- Return to Search Options
- Return to Search Criteria

kanagan Water Well Drilling Ltd.

3706 - 24th AVENUE · VERNON, B.C. V1T 1L9 · PHONE 542-7827

Date June 19 1979

Phone

AE Otto Peschel

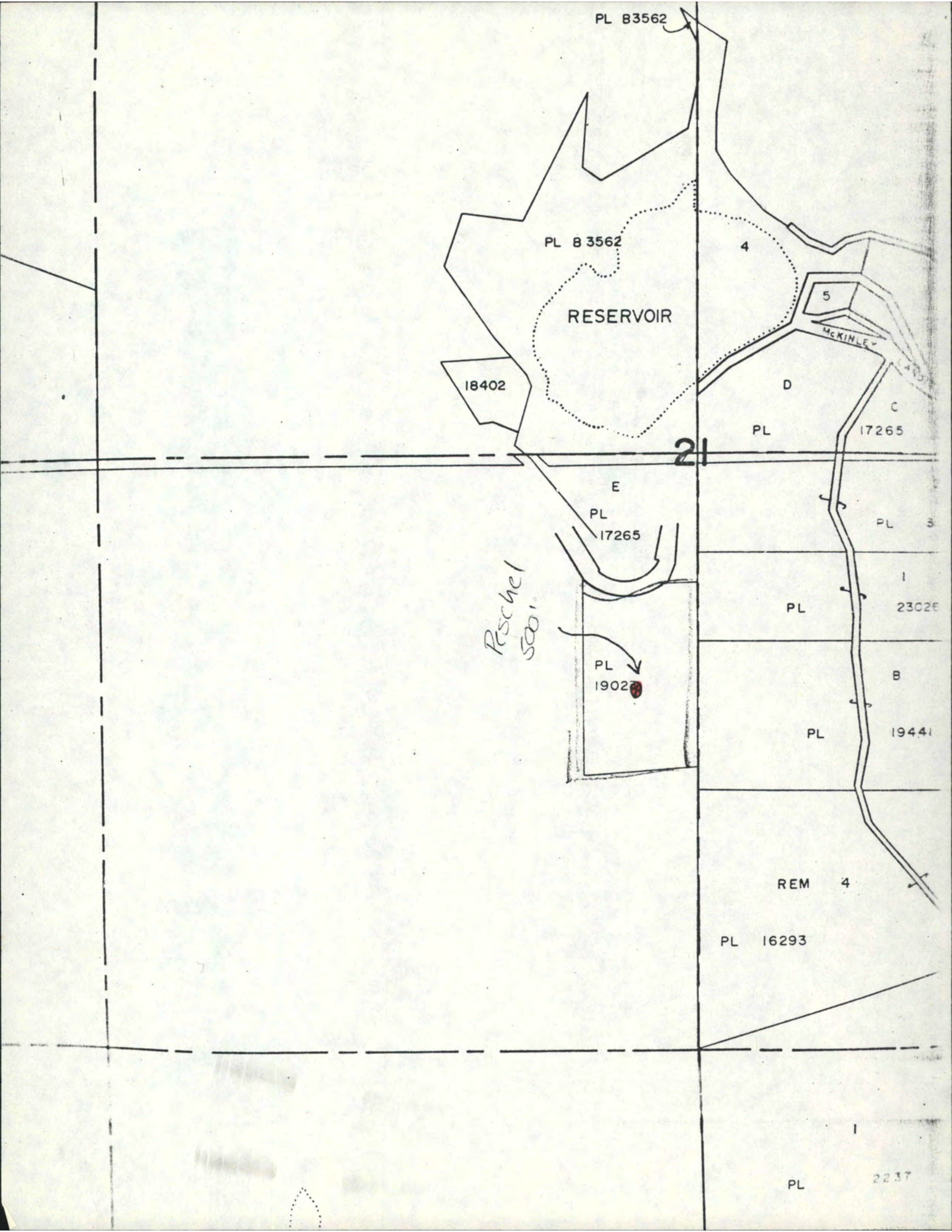
RESS P.O.B. 1114 Kelowna

Lot 11 B Sec 21 Twp 23
Plan 10233 [illegible] 41 ODYD

DESCRIPTION	PRICE PER	AMOUNT
0 rock hole (charge for	$13.50	$3325.00
500') half to be		
paid for by Otto		
Peschel.		
[illegible] O. Peschel		
Drilled at the		
Winfield water reservoir		
EIVE IN GOOD ORDER		
	TAX	
	TOTAL	$3375.00

ER NO. | CASH | CHEQUE

TERMS: DEPOSIT OR 25% ON COMPLET


PL B3562
PL B 3562
4
RESERVOIR
5
McKINLEY
CA
18402
D
C
PL
17265
21
E
PL
17265
PL
3
1
PL
23026
Pschel
500'
PL
19027
B
PL
19441
REM
4
PL
16293
1
PL
2237

82E 093423 WTN 71857 #3

WATER WELL RECORD

DEPT. OF ENVIRONMENT, WATER RESOURCES SERVICE, WATER INVESTIGATIONS BRANCH VICTORIA, BRITISH COLUMBIA

Z ___ WELL NO. ___

E

N

Z X Y NO.

NAT. TOPO. SHEET NO. ___

LEGAL DESCRIPTION: LOT A SEC. 21 TP. 23 R. ___ D.L. ___ LAND DISTRICT 050Y005 PLAN 19023

DESCRIPTIVE LOCATION MCKINLEY RESERVOIR LICENCE NO. ___ DATE ___

OWNER'S NAME OTTO PESCHEL ADDRESS P.O. BOX 1114 KELOWNA

DRILLER'S NAME OKANAGAN WATER WELL ADDRESS ___ DATE COMPLETED JUNE 79

79/06/19

DEPTH 500' ELEVATION OF ___ ☐ ESTIMATED ☐ SURVEYED CASING DIAM. ___ LENGTH ___

METHOD OF CONSTRUCTION DRILLED CASING DIAM ___ LENGTH ___

SCREEN LOCATION ___ SCREEN ☐ SIZE ___ LENGTH ___ TYPE ___

SANITARY SEAL YES ☐ NO ☐ SCREEN ☐ SIZE ___ LENGTH ___ TYPE ___

PERFORATED CASING ☐ LENGTH ___ PERFORATIONS FROM ___ TO ___

GRAVEL PACK ☐ LENGTH ___ DIAM. ___ SIZE GRAVEL, ETC. ___

DISTANCE TO WATER ___ ☐ ESTIMATED WATER LEVEL

FROM ___ ☐ MEASURED ELEVATION ___ ARTESIAN PRESSURE ___

DATE OF WATER LEVEL MEASUREMENT ___ WATER USE ___

PRODUCTION TEST SUMMARY

DATE ___

TEST BY ___

BAIL TEST ☐ PUMP TEST ☐ DURATION OF TEST ___

RATE ___ DRAWDOWN ___

WATER LEVEL AT COMPLETION OF TEST ___

AVAILABLE DRAWDOWN ___ SPECIFIC CAPACITY ___

PERMEABILITY ___ STORAGE COEFF. ___

TRANSMISSIVITY ___

RECOMMENDED PUMPING RATE ___

RECOMMENDED PUMP SETTING ___

CHEMISTRY

TEST BY ___ DATE ___

TOTAL DISSOLVED SOLIDS ___ mg/l TEMPERATURE ___ °C pH ___ SILICA (SiO_2) ___ mg/l

CONDUCTANCE ___ μmhos/cm AT 25°C TOTAL IRON (Fe) ___ mg/l TOTAL HARDNESS ($CaCO_3$) ___ mg/l

TOTAL ALKALINITY ($CaCO_3$) ___ mg/l PHEN. ALKALINITY ($CaCO_3$) ___ mg/l MANGANESE (Mn) ___ mg/l

COLOUR ___ ODOUR ___ TURBIDITY ___

ANIONS	mg/l	epm
CARBONATE (CO_3)		
BICARBONATE (HCO_3)		
SULPHATE (SO_4)		
CHLORIDE (Cl)		
$NO_2 + NO_3$ (NITROGEN)		
* TKN. (NITROGEN)		
PHOSPHORUS (P)		

CATIONS	mg/l	epm
CALCIUM (Ca)		
MAGNESIUM (Mg)		
SODIUM (Na)		
POTASSIUM (K)		
IRON (DISSOLVED)		

* TKN = TOTAL KJELDAHL NITROGEN CHEMISTRY SITE NO. ___

NO_2 = NITRITE NO_3 = NITRATE

007171

CHEMISTRY FIELD TESTS

TEST BY ___ DATE ___ EQUIPMENT USED ___

LITHOLOGY

FROM	TO	DESCRIPTION
0	500'	ROCK HOLE.
		Tried 4 wells on this property very little water in any of them. well not cased.

CONTENTS OF FOLDER

☐ DRILL LOG
☐ SIEVE ANALYSIS
☐ PUMP TEST DATA
☐ GEOPHYSICAL LOGS
☐ CHEMICAL ANALYSIS
☐ REPORT

OTHER ___

SOURCES OF INFORMATION DRILLER

NORTH

WEST

EAST

SOUTH

CARD BY P.J.W. DATE Jan. 21, 1980

ADDITIONAL DATA ADDED BY

REMARKS

Province of British Columbia
Water Act

ORDER

Section 39 of the
Water Act of British Columbia
RSBC 1996, Chap. 483

File Numbers: 0254102, 0281437 & 0370025

IN THE MATTER OF Conditional Water Licence No. 029197, Conditional Water Licence No. 034631 and Conditional Water Licence No. 061861 held by the Glenmore-Ellison Improvement District (herein referred to as GEID), which authorizes the storage behind the McKinley Reservoir Dam from Kelowna Creek.

WHEREAS the GEID plans the following construction for the McKinley Dam Headworks Upgrade Project which can be categorized as:

1. Construction of a new intake structure including concrete work, inlet pipe fittings, and trashrack,
2. Excavation through existing dam at high elevation for pipe installation,
3. Construction of an intake valve chamber,
4. Installation of a 900 mm diameter Ductile Iron intake pipe along the upstream face of the dam, through the dam, and along the downstream dam face, including required earthwork, trenching and backfilling, and
5. Construction of a valve chamber at downstream toe of dam.

WHEREAS the GEID requests authorization to proceed with the McKinley Dam Headworks Upgrade Project; and

WHEREAS the GEID has submitted the following design documents of the proposed work:

1. McKinley Reservoir Dam Improvements, Predesign Report, dated May 2003, by Ker Wood Leidal Associates Ltd. (herein referred to as KWL),
2. McKinley Reservoir Dam Improvements, Technical Memorandum (Predesign Report Update), dated September 22, 2003, by KWL,
3. Preliminary Design Plans, Drawing Set No. 2028-008, revision 0, dated September 2003, by KWL, and
4. Contract No. 2028-008A documents, technical specifications and supervision plan., dated September 2003, by KWL..

WHEREAS a Senior Dam Safety Officer from the Dam Safety Section has reviewed and approved the plans for the upgrade.

NOW THEREFORE pursuant to Section 39 of the *Water Act* of British Columbia, RSBC 1996, Chap. 483, and pursuant to the Dam Safety Regulation, BC Reg. 44/2000, OIC 131/2000, I, Glen Davidson, P.Eng., Deputy Comptroller of Water Rights, hereby order that Glenmore-Ellison Irrigation District has authorization to proceed with the McKinley Dam Headworks Upgrade subject to the following conditions:

1. Signed Final Design Plans, KWL Drawing Set No. 2028-008, are to be submitted to the Dam Safety Officer for authorization to proceed,
2. Existing McKinley Dam and Balancing Reservoir Operation, Maintenance and Surveillance Manual and Emergency Preparedness Plan is to be upgraded following completion of the McKinley Dam Headworks Upgrade Project,
3. Changes, of a minor nature, may be made to the design provided that they are signed off by the Project Engineer, and
4. Drawings of record are to be produced on completion of the project and kept with the records of the dam and an electronic (pdf) copy of the drawing of record sent to the Dam Safety Officer for our files.

THIS ORDER does not relieve you of obtaining all other permits and approvals from all other agencies.

THIS ORDER is dated at Victoria, British Columbia this 7th day of October, 2003.

Glen Davidson, P.Eng
Deputy Comptroller of Water Rights

WATER RESOURCES SERVICE
WATER RIGHTS BRANCH

DEPARTMENT OF LANDS, FORESTS,
AND WATER RESOURCES

THE PROVINCE OF BRITISH COLUMBIA—WATER ACT

CONDITIONAL WATER LICENCE

Glenmore Irrigation District of 1481 Water Street, Kelowna, B.C.

is/are hereby authorized to store water as follows:—

(*a*) The source(s) of the water-supply is/are Kelowna Creek and the reservoir is the Glenmore Balancing Reservoir.

(*b*) The point(s) of storage is/are located as shown on the attached plan.

(*c*) The date from which this licence shall have precedence is 11th December, 1963.

(*d*) The purpose for which the water is to be used is as set out in Conditional Water Licence No. 15908.

(*e*) The maximum quantity of water which may be stored is 772 acre feet per annum, and such additional quantity as the Engineer may from time to time determine should be allowed for losses.

(*f*) The period of the year during which the water may be stored is 1st October to 15th June.

(*g*) ~~The land upon which the water is to be used and to which~~ this licence is appurtenant ~~is~~ to the Irrigation Undertaking of the Glenmore Irrigation District.

(*h*) The works authorized to be constructed are earth fill dam, and they shall be located approximately as shown on the attached plan.

(*i*) The construction of the said works has been commenced, and shall be completed and the water beneficially used on or before the 31st day of December, 1966.

ENTERED ON
Map 8401
By R.M. E.B.

Gordon J.A. Kidd,
Comptroller of Water Rights.

FILE No. 0254102 Date issued: 1 September 1964

CONDITIONAL LICENCE No. 29197

OVERSIZE
8.3

DRAWING

TO BE

INSERTED!

Province of British Columbia
Water Act

ORDER

Section 39 of the
Water Act of British Columbia
RSBC 1996, Chap. 483

File Numbers: 0254102, 0281437 & 0370025

IN THE MATTER OF Conditional Water Licence No. 029197, Conditional Water Licence No. 034631 and Conditional Water Licence No. 061861 held by the Glenmore-Ellison Improvement District (herein referred to as GEID), which authorizes the storage behind the McKinley Reservoir Dam from Kelowna Creek.

WHEREAS the GEID plans the following construction for the McKinley Dam Headworks Upgrade Project which can be categorized as:

1. Construction of a new intake structure including concrete work, inlet pipe fittings, and trashrack,
2. Excavation through existing dam at high elevation for pipe installation,
3. Construction of an intake valve chamber,
4. Installation of a 900 mm diameter Ductile Iron intake pipe along the upstream face of the dam, through the dam, and along the downstream dam face, including required earthwork, trenching and backfilling, and
5. Construction of a valve chamber at downstream toe of dam.

WHEREAS the GEID requests authorization to proceed with the McKinley Dam Headworks Upgrade Project; and

WHEREAS the GEID has submitted the following design documents of the proposed work:

1. McKinley Reservoir Dam Improvements, Predesign Report, dated May 2003, by Ker Wood Leidal Associates Ltd. (herein referred to as KWL),
2. McKinley Reservoir Dam Improvements, Technical Memorandum (Predesign Report Update), dated September 22, 2003, by KWL,
3. Preliminary Design Plans, Drawing Set No. 2028-008, revision 0, dated September 2003, by KWL, and
4. Contract No. 2028-008A documents, technical specifications and supervision plan., dated September 2003, by KWL..

WHEREAS a Senior Dam Safety Officer from the Dam Safety Section has reviewed and approved the plans for the upgrade.

NOW THEREFORE pursuant to Section 39 of the *Water Act* of British Columbia, RSBC 1996, Chap. 483, and pursuant to the Dam Safety Regulation, BC Reg. 44/2000, OIC 131/2000, I, Glen Davidson, P.Eng., Deputy Comptroller of Water Rights, hereby order that Glenmore-Ellison Irrigation District has authorization to proceed with the McKinley Dam Headworks Upgrade subject to the following conditions:

1. Signed Final Design Plans, KWL Drawing Set No. 2028-008, are to be submitted to the Dam Safety Officer for authorization to proceed,
2. Existing McKinley Dam and Balancing Reservoir Operation, Maintenance and Surveillance Manual and Emergency Preparedness Plan is to be upgraded following completion of the McKinley Dam Headworks Upgrade Project,
3. Changes, of a minor nature, may be made to the design provided that they are signed off by the Project Engineer, and
4. Drawings of record are to be produced on completion of the project and kept with the records of the dam and an electronic (pdf) copy of the drawing of record sent to the Dam Safety Officer for our files.

THIS ORDER does not relieve you of obtaining all other permits and approvals from all other agencies.

THIS ORDER is dated at Victoria, British Columbia this 7th day of October, 2003.

Glen Davidson, P.Eng
Deputy Comptroller of Water Rights

WATER RESOURCES SERVICE
WATER RIGHTS BRANCH

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

THE PROVINCE OF BRITISH COLUMBIA—WATER ACT

CONDITIONAL WATER LICENCE

Glenmore Irrigation District of 1481 Water Street,
Kelowna, B. C.

is/are hereby authorized to store water as follows:—

(*a*) The source(s) of the water-supply is/are Kelowna Creek and storage in Glenmore balancing reservoir.

(*b*) The point(s) of storage is/are located as shown on the attached plan.

(*c*) The date from which this licence shall have precedence is 17th July, 1968.

(*d*) The purpose for which the water is to be used is as set out in Conditional Water Licence No. 15908.

(*e*) The maximum quantity of water which may be stored is 35 acre feet per annum, and such additional quantity as the Engineer may from time to time determine should be allowed for losses.

(*f*) The period of the year during which the water may be stored is 1st October to 15th June.

(*g*) The land upon which the water is to be used and to which this licence is appurtenant is as set out in Conditional Water Licence No. 15908.

(*h*) The works authorized to be constructed are ditch, flume and dam, and they shall be located approximately as shown on the attached plan.

(*i*) The construction of the said works has been completed and the water shall be beneficially used on or before the 31st day of December, 1971.

ENTERED ON
Map No. 8426 B
8427 A
By G.P.E.S.A.

H. D. DeBeck,
Comptroller of Water Rights.

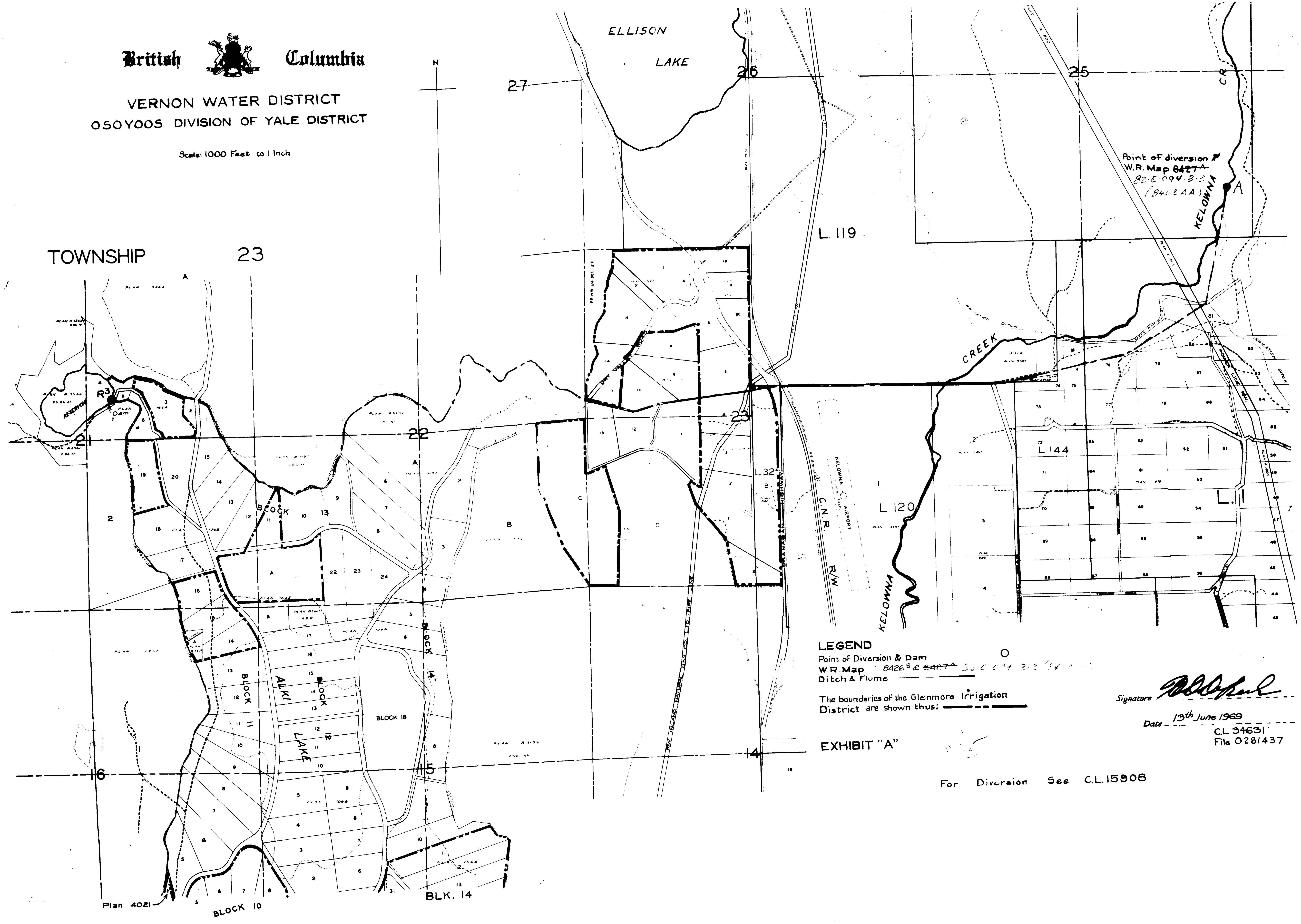
File No. 0281437 Date issued: 13 June 1969 Conditional Licence No. 34631

o

British Columbia

VERNON WATER DISTRICT
OSOYOOS DIVISION OF YALE DISTRICT

Scale: 1000 Feet to 1 Inch



LEGEND

Point of Diversion & Dam ○

W.R. Map 8426B & ~~8427A~~ 82.E.094.3.3 (84.3AA)

Ditch & Flume

The boundaries of the Glenmore Irrigation District are shown thus:

EXHIBIT "A"

Signature

Date 13th June 1969

C.L. 34631
File 0281437

For Diversion See C.L. 15908

Province of British Columbia
Water Act

ORDER

Section 39 of the
Water Act of British Columbia
RSBC 1996, Chap. 483

File Numbers: 0254102, 0281437 & 0370025

IN THE MATTER OF Conditional Water Licence No. 029197, Conditional Water Licence No. 034631 and Conditional Water Licence No. 061861 held by the Glenmore-Ellison Improvement District (herein referred to as GEID), which authorizes the storage behind the McKinley Reservoir Dam from Kelowna Creek.

WHEREAS the GEID plans the following construction for the McKinley Dam Headworks Upgrade Project which can be categorized as:

1. Construction of a new intake structure including concrete work, inlet pipe fittings, and trashrack,
2. Excavation through existing dam at high elevation for pipe installation,
3. Construction of an intake valve chamber,
4. Installation of a 900 mm diameter Ductile Iron intake pipe along the upstream face of the dam, through the dam, and along the downstream dam face, including required earthwork, trenching and backfilling, and
5. Construction of a valve chamber at downstream toe of dam.

WHEREAS the GEID requests authorization to proceed with the McKinley Dam Headworks Upgrade Project; and

WHEREAS the GEID has submitted the following design documents of the proposed work:

1. McKinley Reservoir Dam Improvements, Predesign Report, dated May 2003, by Ker Wood Leidal Associates Ltd. (herein referred to as KWL),
2. McKinley Reservoir Dam Improvements, Technical Memorandum (Predesign Report Update), dated September 22, 2003, by KWL,
3. Preliminary Design Plans, Drawing Set No. 2028-008, revision 0, dated September 2003, by KWL, and
4. Contract No. 2028-008A documents, technical specifications and supervision plan., dated September 2003, by KWL..

WHEREAS a Senior Dam Safety Officer from the Dam Safety Section has reviewed and approved the plans for the upgrade.

NOW THEREFORE pursuant to Section 39 of the *Water Act* of British Columbia, RSBC 1996, Chap. 483, and pursuant to the Dam Safety Regulation, BC Reg. 44/2000, OIC 131/2000, I, Glen Davidson, P.Eng., Deputy Comptroller of Water Rights, hereby order that Glenmore-Ellison Irrigation District has authorization to proceed with the McKinley Dam Headworks Upgrade subject to the following conditions:

1. Signed Final Design Plans, KWL Drawing Set No. 2028-008, are to be submitted to the Dam Safety Officer for authorization to proceed,
2. Existing McKinley Dam and Balancing Reservoir Operation, Maintenance and Surveillance Manual and Emergency Preparedness Plan is to be upgraded following completion of the McKinley Dam Headworks Upgrade Project,
3. Changes, of a minor nature, may be made to the design provided that they are signed off by the Project Engineer, and
4. Drawings of record are to be produced on completion of the project and kept with the records of the dam and an electronic (pdf) copy of the drawing of record sent to the Dam Safety Officer for our files.

THIS ORDER does not relieve you of obtaining all other permits and approvals from all other agencies.

THIS ORDER is dated at Victoria, British Columbia this 7th day of October, 2003.

Glen Davidson, P.Eng
Deputy Comptroller of Water Rights

WATER MANAGEMENT
BRANCH

MINISTRY OF
ENVIRONMENT
& Parks

THE PROVINCE OF BRITISH COLUMBIA—WATER ACT

CONDITIONAL WATER LICENCE

Glenmore Irrigation District of R. R. #1, Glenmore Road, Kelowna, B. C. V1Y 7P9

is hereby authorized to divert and store water as follows:

(a) The stream on which the rights are granted is Kelowna Creek and the reservoir is McKinley Reservoir.

(b) The point of storage is located as shown on the attached plan.

(c) The date from which this licence shall have precedence is 5th March, 1982.

(d) The purpose for which this licence is issued is as set out in Conditional Water Licence 61860.

(e) The maximum quantity of water which may be diverted into storage is 182 acre feet per annum.

(f) The period of the year during which the water may be stored is 1st October to 30th June.

(g) The land upon which the water is to be used and to which this licence is appurtenant is as set out in Conditional Water Licence.

(h) The works authorized to be constructed are dam and reservoir, which shall be located approximately as shown on the attached plan.

(i) The construction of the said works shall be completed and the water beneficially used prior to the 31st day of December, 1990. Thereafter, the licensee shall continue to make a regular beneficial use of water in the manner authorized herein.

(j) Construction of the dam authorized under clause (h) hereof shall not be commenced until plans of same have been submitted to and approved by the Comptroller of Water Rights.

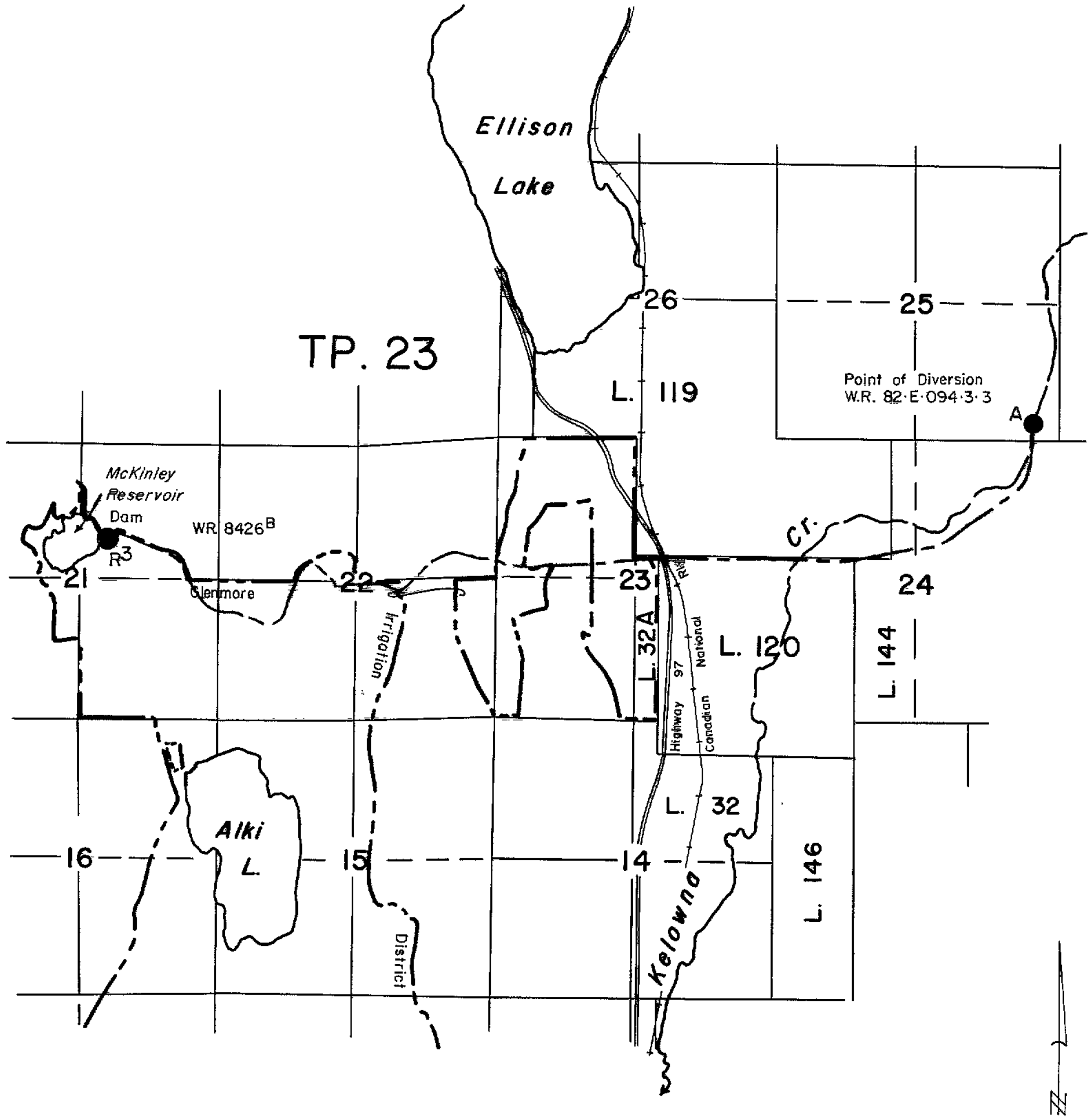
(k) The reservoir area shall be cleared and the debris disposed of in such a manner and extent as directed by the Comptroller of Water Rights.

J. E. Farrell
Deputy Comptroller of Water Rights

File No. 0370025 Date issued: 30th January, 1987 CONDITIONAL LICENCE 61861

W-183

Province of British Columbia



WATER DISTRICT : VERNON
PRECINCT : KELOWNA
LAND DISTRICT : OSOYOOS DIVISION OF YALE

Signature ....
Date ....January 30, 1987....

LEGEND

Scale : 40 Chains to 1 Inch
Point of Diversion, Dam : ●
Map Number : WR 82·E·094·3·3, WR. 8426B
Pipe : ——— — ———

C.L. 61861
File 0370025

For Diversion See C.L. 61860

BRITISH
COLUMBIA
The Best Place on Earth

WATER ACT

CONDITIONAL WATER LICENCE

The City of Kelowna, 1435 Water Street, Kelowna BC V1Y 1J4, are hereby authorized to divert and use water as follows:

(a) The source on which the rights are granted is Avocet Creek, and the reservoir is on the creek.

(b) The point of diversion is located as shown on the attached plan.

(c) The date from which this licence shall have precedence is 10th March, 2008.

(d) The purpose for which this licence is issued is land improvement.

(e) The maximum quantity of water which may be diverted is 100 acre feet per annum.

(f) The period of the year during which the water may be used is the whole year.

(g) The land improvement under taking of the licensee upon which the water is to be used and to which this licence is appurtenant is Lots 4, 5 and 6, Block 14, Sections 15 and 22, Plan 1068; Block 18, Section 15, Plan 1068; and Lot 5, Sections 15, 16, 21 and 22, Plan KAP63448; all of Township 23, Osoyoos Division Yale District.

(h) The authorized works are dam, reservoir and pipe which shall be located approximately as shown on the attached plan.

(i) The construction of the said works shall be completed and the water shall be beneficially used prior to the 31st day of December 2013. Thereafter, the licensee shall continue to make regular beneficial use of the water in the manner authorized herein.

(j) This licence is issued pursuant to the provisions of the *Water Act* to ensure compliance with that statute, which makes it an offence to divert or use water from a stream in British Columbia without proper authorization. It is the responsibility of the licensee 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.

(k) The dam authorized under clause (h) is subject to the Dam Safety Regulation and shall be designed, constructed and maintained to the satisfaction of a Dam Safety Officer under the Water Act.

Conrad Pryce

Conrad J. Pryce, P. Eng.
Assistant Regional Water Manager
Water Stewardship Division
Ministry of Environment

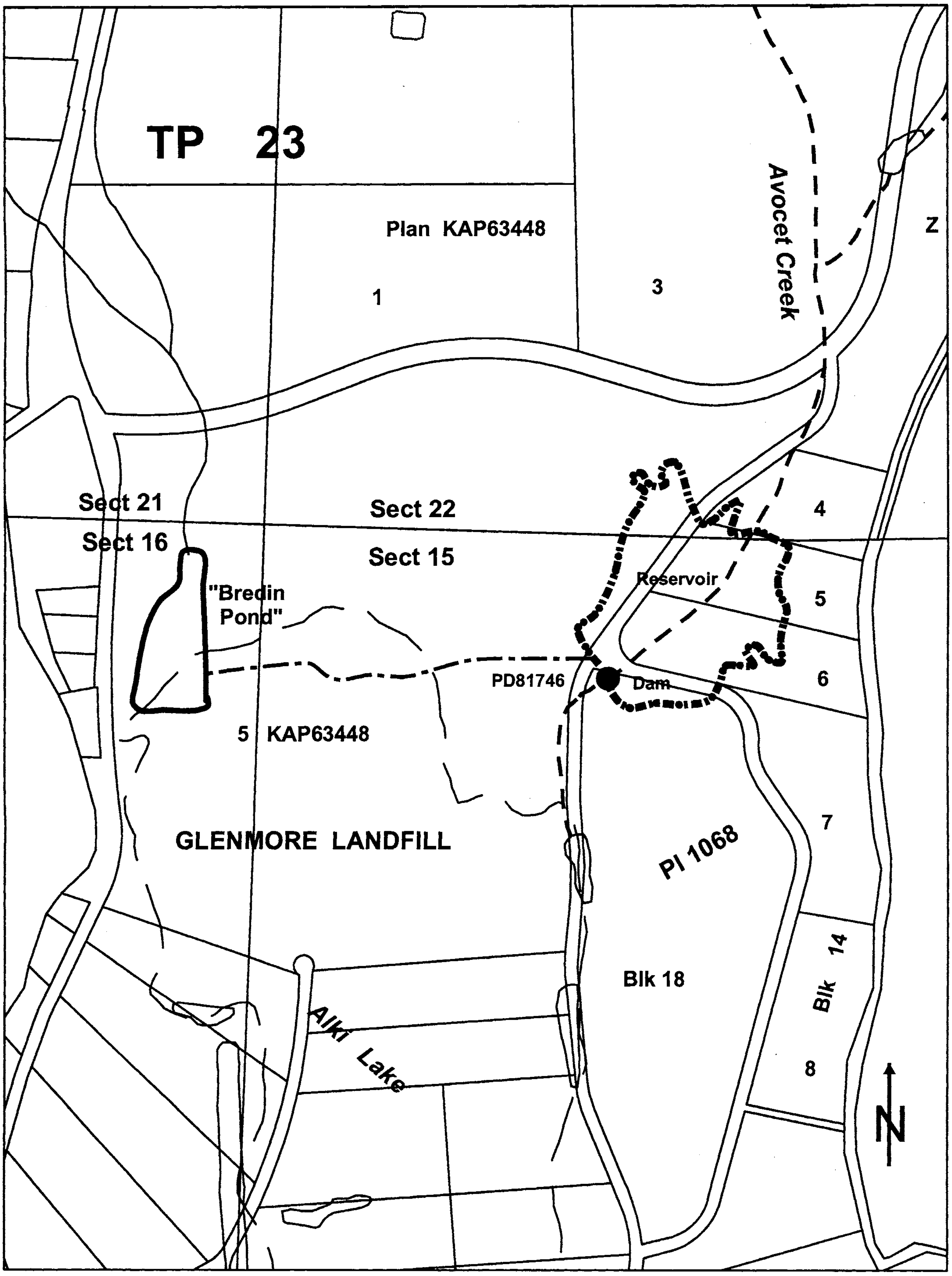
Date Issued: February 4, 2010

File: 8002781

CONDITIONAL LICENCE: 123789

2

BRITISH
COLUMBIA
The Best Place on Earth



WATER DISTRICT: Vernon
PRECINCT: Kelowna
LAND DISTRICT: Osoyoos Division Yale District

Signature: Conrad Pryce

Date: February 4, 2010

LEGEND:

Scale:	1:7,500
Point of Diversion: PD81746	●
Map Number:	8426B (82.E.093.4.2)
Pipe:	▬ - ▬ - ▬

Licence: C123789

File: 8002781

This licence is appurtenant to the Land Improvement undertaking of the licensee:

Appendix C
Financial Security Plan

Memorandum

November 1, 2018

To: Scott Hoekstra, Kevin Wahl   Ref. No.: 084612-22

DL

From: Deacon Liddy/cs/05   Tel: 604-214-0510

Subject: **Financial Security Plan**
Glenmore Landfill
Kelowna, British Columbia

1. Introduction

GHD was retained by the City of Kelowna (City) to prepare a Financial Security Plan (FS Plan) for the Glenmore Landfill (Landfill or Site) located in Kelowna, British Columbia (BC) as part of preparing a Design, Operations and Closure Plan (DOCP) for the Site. The FS Plan was prepared by GHD based on a projected schedule of Landfill development and estimated costs of Landfill closure, post-closure activities and contingency measures. The Landfill development plan is described in the 2018 Design, Operations and Closure Plan (DOCP).

The 2018 DOCP was prepared to meet the requirements of *"British Columbia Landfill Criteria for Municipal Solid Waste, Second Edition"* (BCMOE, June 2016), herein referred to as the *"Landfill Criteria"*. Financial security is required for all private landfills in accordance with *Section 8.0 - Financial Security* of the Landfill Criteria. The amount of the financial security provided in each year must be adequate to fund the closure of the landfill in that year and fund post-closure operations, monitoring, and maintenance for the estimated contaminated lifespan.

For the purpose of preparing the FS Plan, the operating lifespan of the Landfill was assumed to be from 2019 to 2107 with closure in 2108. The amount of financial security required in each year between 2019 and 2107 is calculated herein. The FS Plan is required to be updated at the commencement of a new landfill phase, which would include updating the operating lifespan of the Landfill. The period of review should not exceed 5 years.

2. Activities Considered for the Financial Security Calculation

Table 2.1 provides a summary of the inputs to the financial security calculation. The amount of financial security was calculated as the sum of the following costs, as prescribed by Section 8.2 of the Landfill Criteria:

- Cost of sudden and unexpected closure or planned closure, whichever is greater.

- Cost of post-closure operation, maintenance, monitoring and reporting for the contaminating lifespan of the landfill.
- Cost of implementing contingency measures.

The tasks and activities considered are outlined in the section below.

2.1 Landfill Closure

The activities considered in the Landfill closure costs are:

- Compaction and grading of the landfill surface
- Final cover placement
- Hydroseeding the landfill surface

The final cover system design is described in Section 9.6 of the DOCP, and consists of the following elements from top to bottom:

- Vegetated topsoil/growth media (minimum 150 millimetre (mm))
- Protective cover material comprising 600 mm thick common fill material
- Geocomposite drainage layer comprised of double-sided non-woven geotextile over geo-net
- Textured LLDPE geomembrane liner 1.5 mm (60 mil), double sided textured (microspike)

2.2 Post-Closure Operation and Maintenance

The post-closure operation and maintenance (O&M) costs consider the annual cost of Site monitoring, operation, and maintenance after the closure of the landfill, either planned or sudden and unexpected. The activities associated with post-closure O&M are:

- Operation of the leachate pump station
- Operation of the landfill gas collection system
- Annual water management equipment maintenance or replacement, as required
- Operation and maintenance of surface water control works, roads, fence, and site access gate
- Management and maintenance of the landfill final cover system including maintenance related to the vegetative cover
- Post-Closure Environmental Effects Monitoring and Reporting
    - For the first ten years post-closure, the Environmental Monitoring Plan (EMP) will include quarterly monitoring. After ten years the EMP monitoring frequency will be reduced to a semi-annual basis.

Post-closure O&M activities and estimated associated costs are outlined in Table 2.2.

2.3 Contingency Measures

The contingency measures costs consider both the one-time and the annual costs of implementing contingency measures to mitigate potential groundwater quality, and/or surface water discharge quality impacts. An allowance of $1,500,000 has been included to implement contingency measures under the planned closure scenario and $500,000 under the emergency closure scenario. The planned closure allowance is higher than the emergency closure as planned closure is over 90 years in the future.

2.4 Additional Contingency

Additional contingency costs are calculated in accordance with *Section 8.3 – Calculating Financial Security* in the Landfill Criteria. The additional contingency costs are 20 percent of the sum of the closure costs, post-closure costs and the contingency measures cost.

3. Site Operating Parameters

The closure and post-closure costs were established by taking into the consideration the Landfill development plan presented in the DOCP, an assumed schedule for development, and the contaminating lifespan of the Landfill with respect to groundwater, surface water and landfill gas.

3.1 Landfill Development

Future development will be completed within the Phase 1, Phase 2, and Phase 3 footprints, beginning first with Phase 1 and Phase 2. Phases 1, 2 and 3 of the landfill have been divided into filling Areas 1 through 8. The long-term development plan is to extend the footprint of Phase 1 over the former drop-off area located southeast of Bredin Pond and east to Bredin Hill; extend Phase 2 to Tutt Mountain, and develop Phase 3. In general, filling will progress from north to south.

3.2 Contaminating Lifespan

The contaminating lifespan of a Landfill is the time required for the leachate concentrations to decrease by a combination of biological decomposition of the organics, physiochemical processes which reduce the solubility of inorganics, dissolution, adsorption, or complexation and dilution by infiltration, to regulatory-defined surface water quality objectives (i.e., Contaminated Sites Regulation Water Quality Standards). Post-closure O&M funding has been estimated for the duration of the contaminating lifespan of the Site, following closure of the Site, to ensure that adequate funds are available to mitigate any potential environmental impacts.

As discussed in Section 16 – *Contaminating Lifespan Assessment* of the DOCP, it is anticipated that leachate generated from the Site will reduce to concentrations below regulatory levels in less than 80 years from time of closure.

4. Discount and Inflation Rates

The discount and inflation rates used for the cost projection were selected in accordance with Section 8.4 of the Landfill Criteria. Calculations for financial security were completed in September 2018 and all discount and inflation rates are current to that date. All values are presented in 2018 Canadian dollars.

4.1 Discount Rate

The current Government of Canada long-term benchmark bond yield is 2.25% (Table 2.1), as published on the Bank of Canada website: http://www.bankofcanada.ca/rates/interest-rates/canadian-bonds.

4.2 Inflation Rate

The inflation rate was selected based on the Vancouver Metropolitan Area Non-Residential Building Construction Index from 2008 to 2017. The 10-year construction inflation rate for the period between 2008 and 2017 is 0.96 percent, as presented in Table 2.1.

5. Cost Estimates

5.1 Capital Costs

Capital costs have been estimated based on a conceptual quantity estimate from the DOCP Drawings and GHD's experience with recent landfill construction projects in BC. The conceptual assumptions used to develop the costs are presented below:

- Landfill Base and Leachate Collection System
  - Base Grading and Preparation – $20/m^2
  - Geosynthetic Clay Liner (GCL) – $12/m^2
  - Geomembrane – $12/m^2
  - Non-woven geosynthetic cushion layer – $3/m^2
  - Drain rock – 0.3 m depth – $26/m^2
  - Leachate collection piping – $7/m^2
  - Woven Geosynthetic drain rock protection layer - $3/m^2
  - 20% Contingency – $17/m^2
  - Total – $100/m^2
- Final Cover System
  - Grading and surface preparation – $10/m^2
  - Geosynthetic clay liner – $12/m^2
  - Soil barrier Layer – 0.6 m depth, assumed from on-Site stockpiles – $13/m^2

  - Topsoil – 0.15 m depth – assume manufactured from on-Site compost, wood chips and sand – \$4.5/m^2
  - 20% Contingency – \$8/m^2
  - Total – \$48/m^2 (\$38/m^2 used in financial security calculations as a 20% contingency is added to all costs in the summary calculation)
- Leachate Pump Station for Area 3, including power supply – \$1,500,000
- Leachate Pump Station for Area 4 – \$750,000
- Leachate forcemain – \$215/m
- Perimeter landfill gas header – \$250/m
- Conceptual cost of north pond – \$500,000
- Surface water piping – \$500/m
- Cost of relocation of material management areas – sourced from Glenmore Landfill Composting Options Study and Phasing Plan – Revision 1, Opus September 2017

5.2 Closure Costs

The Landfill is forecasted to operate for over 90 years and be closed in 2107. The cost to install final cover is estimated at \$100 per m^2. Final cover installation will be consistent with the DOCP and the Landfill Criteria, as described in Section 2.1.

Sudden and unexpected closure of Landfill involves closing an area of approximately 913,064 m^2, all of the landfill footprint (Phases 1 to 3).

Planned closure involves progressive closure of a total area of 913,064 m^2 in three stages, starting in approximately 2053 and ending with final closure in 2108.

Final cover costs were calculated by multiplying the unit cost of final cover by the area receiving cover in a given year and applying the appropriate discount and inflation adjustments described in Section 4.

Table 5.1 and 5.2 provide the details of the landfill closure costs over the planned life of the landfill, and provides the present value (CAD 2019) of both planned and sudden and unexpected closure costs for each year.

5.3 Post-Closure O&M Costs

Table 5.3 present the calculations for the financial assurance required for post-closure O&M of the Landfill over the contaminating life span (80 years) for each given year of closure. Post-closure O&M costs are presented in present values (CAD 2018), calculated using the discount rate and inflation rate discussed in Section 4. Nominal costs of post-closure O&M are detailed in Table 2.2.

6. Financial Security Plan Summary

Table 6.1 presents a summary of the financial security calculations and total financial security required in for planned and emergency closure.

The required financial security decreases with each year as the Landfill is developed. The financial security estimate for the emergency closure scenario is $81,080,000 and for the planned closure is $30,660,000.

Table 2.1

Calculation Inputs
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Calculation Date	Jan-18		Jan-18	
Closure Scenario	**Sudden / Unexpected Closure**		**2107 Closure**	
Capital Costs and Calculations	**Table 5.1**		**Table 5.1**	
Closure Costs and Calculations	**Table 5.2**		**Table 5.2**	
Post-Closure Period	**80 Years**		**80 Years**	
Post-Closure Operation and Maintenance Period*	2019	2098	2107	2186
Post-Closure Operation and Maintenance Costs	**Table 2.2**		**Table 2.2**	
Post-Closure Operation and Maintenance Calculations	**Table 5.3**		**Table 5.3**	
Inflation Rate	**0.96%**		**0.96%**	
Vancouver Non-Residential Cosntruction Price Index	0.96%		0.96%	
Q1 2008 Index (2002 Index = 100)	154.4		154.4	
Q4 2017 Index	125.9		125.9	
Discount Rate	**2.25%**		**2.25%**	
Government of Canada Benchmark Long term Bond Yield (effective Sept 4, 2018)	2.25%		2.25%	
Additional Contingency	**20%**		**20%**	
Summary Table	**Table 6.1**		**Table 6.1**	

* 80 years following year of closure

Table 2.2

Post-Closure Operations and Maintenance Costs
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Annual Post Closure Operations and Maintenance Costs	First 10 Years	After 10 Years
Leachate Pump Stations	$ 250,000	$ 100,000
LFG Collection System	$ 100,000	$ 75,000
Surface Water Control Works, Roads, Fences & Gates	$ 50,000	$ 15,000
Management and maintenance of final cover (fertilizing, irrigation, re-seeding)	$ 50,000	$ 15,000
Quarterly EMP (first 10 years)	$ 150,000	
Annual EMP (after 10 years)	-	$ 75,000
Total (per year)	**$ 600,000**	**$ 280,000**

Table 5.1

Capital Costs and Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Year	Fill Area	Scheduled Lined Cell Construction Area (m2)	Unit Cost of Lined Cell Construction (per m2)	Cost of Lined Cell Construction	Length of LFG Perimeter Header	Unit Cost of LFG Perimeter Header	Cost of LFG Perimeter Header	Length of Leachate Perimeter Piping	Unit Cost of Leachate Perimeter	Cost of Perimeter LFG Piping	Cost of Pump Station Construction	Cost of North Pond and Surface Water Piping	Cost of Relocation of Material Management Areas	Closure Stage	Scheduled Final Cover Construction Area (m2)	Unit Cost of Final Cover Construction (per m2)	Cost of Final Cover Construction	Sub-Total Capital Costs	Engineering Design (7.5% in year before constuction)	Engineering Construction (7.5% in year of construction)	Total
2019	1	24,000	$ 100	$ 2,400,000									$ 2,500,000					$ 4,900,000	$ 495,000	$ 367,500	$ 5,762,500
2020	2	23,000	$ 100	$ 2,300,000									$ 4,300,000					$ 6,600,000	$ 135,000	$ 495,000	$ 7,230,000
2021													$ 1,800,000					$ 1,800,000	$ 965,472	$ 135,000	$ 2,900,472
2022	3	46,000	$ 100	$ 4,600,000	1,000	$ 250	$ 250,000	1,037	$ 215	$ 222,955	$ 1,500,000		$ 6,300,000					$ 12,872,955	$ 450,000	$ 965,472	$ 14,288,427
2023													$ 6,000,000					$ 6,000,000	$ -	$ 450,000	$ 6,450,000
2024																		$ -	$ 105,000	$ -	$ 105,000
2025												$ 1,400,000						$ 1,400,000	$ 255,000	$ 105,000	$ 1,760,000
2026													$ 3,400,000					$ 3,400,000	$ -	$ 255,000	$ 3,655,000
2027																		$ -	$ -	$ -	$ -
2028																		$ -	$ -	$ -	$ -
2029																		$ -	$ 142,500	$ -	$ 142,500
2030													$ 1,900,000					$ 1,900,000	$ -	$ 142,500	$ 2,042,500
2031																		$ -	$ 446,502	$ -	$ 446,502
2032	4	51,000	$ 100	$ 5,100,000	281	$ 250	$ 70,250	154	$ 215	$ 33,110	$ 750,000							$ 5,953,360	$ -	$ 446,502	$ 6,399,862
2033																		$ -	$ -	$ -	$ -
2034																		$ -	$ -	$ -	$ -
2035																		$ -	$ -	$ -	$ -
2036																		$ -	$ -	$ -	$ -
2037																		$ -	$ -	$ -	$ -
2038																		$ -	$ -	$ -	$ -
2039																		$ -	$ -	$ -	$ -
2040																		$ -	$ -	$ -	$ -
2041																		$ -	$ 409,238	$ -	$ 409,238
2042	5	54,000	$ 100	$ 5,400,000	226	$ 250	$ 56,500											$ 5,456,500	$ -	$ 409,238	$ 5,865,738
2043																		$ -	$ -	$ -	$ -
2044																		$ -	$ -	$ -	$ -
2045																		$ -	$ -	$ -	$ -
2046																		$ -	$ -	$ -	$ -
2047																		$ -	$ -	$ -	$ -
2048																		$ -	$ -	$ -	$ -
2049																		$ -	$ -	$ -	$ -
2050																		$ -	$ -	$ -	$ -
2051																		$ -	$ 1,058,226	$ -	$ 1,058,226
2052	6	139,000	$ 100	$ 13,900,000	628	$ 250	$ 157,000	245	$ 215	$ 52,675								$ 14,109,675	$ 1,273,277	$ 1,058,226	$ 16,441,177
2053														1	353,688	$ 48	$ 16,977,024	$ 16,977,024	$ -	$ 1,273,277	$ 18,250,301
2054																		$ -	$ -	$ -	$ -
2055																		$ -	$ -	$ -	$ -
2056																		$ -	$ -	$ -	$ -
2057																		$ -	$ -	$ -	$ -
2058																		$ -	$ -	$ -	$ -
2059																		$ -	$ -	$ -	$ -
2060																		$ -	$ -	$ -	$ -
2061																		$ -	$ 758,275	$ -	$ 758,275
2062	7	100,000	$ 100	$ 10,000,000	302	$ 250	$ 75,500	162	$ 215	$ 34,830								$ 10,110,330	$ -	$ 758,275	$ 10,868,605
2063																		$ -	$ -	$ -	$ -
2064																		$ -	$ -	$ -	$ -
2065																		$ -	$ -	$ -	$ -
2066																		$ -	$ -	$ -	$ -
2067																		$ -	$ -	$ -	$ -
2068																		$ -	$ -	$ -	$ -
2069																		$ -	$ -	$ -	$ -
2070																		$ -	$ -	$ -	$ -
2071																		$ -	$ 1,385,473	$ -	$ 1,385,473
2072	8	173,000	$ 100	$ 17,300,000	1,120	$ 250	$ 280,000	665	$ 215	$ 142,975	$ 750,000							$ 18,472,975	$ -	$ 1,385,473	$ 19,858,448
2073																		$ -	$ -	$ -	$ -
2074																		$ -	$ -	$ -	$ -
2075																		$ -	$ -	$ -	$ -
2076																		$ -	$ -	$ -	$ -
2077																		$ -	$ -	$ -	$ -
2078																		$ -	$ -	$ -	$ -
2079																		$ -	$ -	$ -	$ -
2080																		$ -	$ -	$ -	$ -
2081																		$ -	$ -	$ -	$ -
2082																		$ -	$ -	$ -	$ -
2083																		$ -	$ -	$ -	$ -
2084																		$ -	$ -	$ -	$ -
2085																		$ -	$ -	$ -	$ -
2086																		$ -	$ -	$ -	$ -
2087																		$ -	$ -	$ -	$ -
2088																		$ -	$ -	$ -	$ -
2089																		$ -	$ -	$ -	$ -
2090																		$ -	$ -	$ -	$ -
2091																		$ -	$ -	$ -	$ -
2092																		$ -	$ -	$ -	$ -
2093																		$ -	$ -	$ -	$ -
2094																		$ -	$ -	$ -	$ -

Table 5.1

Capital Costs and Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Year	Fill Area	Scheduled Lined Cell Construction Area (m2)	Unit Cost of Lined Cell Construction (per m2)	Cost of Lined Cell Construction	Length of LFG Perimeter Header	Unit Cost of LFG Perimeter Header	Cost of LFG Perimeter Header	Length of Leachate Perimeter Piping	Unit Cost of Leachate Perimeter	Cost of Perimeter LFG Piping	Cost of Pump Station Construction	Cost of North Pond and Surface Water Piping	Cost of Relocation of Material Management Areas	Closure Stage	Scheduled Final Cover Construction Area (m2)	Unit Cost of Final Cover Construction (per m2)	Cost of Final Cover Construction	Sub-Total Capital Costs	Engineering Design (7.5% in year before constuction)	Engineering Construction (7.5% in year of construction)	Total
2095																		$ -	$ -	$ -	$ -
2096																		$ -	$ -	$ -	$ -
2097																		$ -	$ -	$ -	$ -
2098																		$ -	$ 768,154	$ -	$ 768,154
2099														2	213,376	$ 48	$ 10,242,048	$ 10,242,048	$ -	$ 768,154	$ 11,010,202
2100																		$ -	$ -	$ -	$ -
2101																		$ -	$ -	$ -	$ -
2102																		$ -	$ -	$ -	$ -
2103																		$ -	$ -	$ -	$ -
2104																		$ -	$ -	$ -	$ -
2105																		$ -	$ -	$ -	$ -
2106																		$ -	$ -	$ -	$ -
2107																		$ -	$ 1,245,600	$ -	$ 1,245,600
2108	Closure													3	346,000	$ 48	$ 16,608,000	$ 16,608,000	$ -	$ 1,245,600	$ 17,853,600
																				Total	$ 156,955,797

Table 5.2

Closure Cost Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Year	Closure Stage	Scheduled Final Cover Construction Area (m2)	Unit Cost of Final Cover Construction (per m2)	Cost of Final Cover Construction	Sub-Total Capital Costs	Engineering Design (7.5% in year before constuction)	Engineering Construction (7.5% in year of construction)	Total	Future Value	Present Value
2019					$ -	$ -	$ -	$ -	$ -	$ -
2020					$ -	$ -	$ -	$ -	$ -	$ -
2021					$ -	$ -	$ -	$ -	$ -	$ -
2022					$ -	$ -	$ -	$ -	$ -	$ -
2023					$ -	$ -	$ -	$ -	$ -	$ -
2024					$ -	$ -	$ -	$ -	$ -	$ -
2025					$ -	$ -	$ -	$ -	$ -	$ -
2026					$ -	$ -	$ -	$ -	$ -	$ -
2027					$ -	$ -	$ -	$ -	$ -	$ -
2028					$ -	$ -	$ -	$ -	$ -	$ -
2029					$ -	$ -	$ -	$ -	$ -	$ -
2030					$ -	$ -	$ -	$ -	$ -	$ -
2031					$ -	$ -	$ -	$ -	$ -	$ -
2032					$ -	$ -	$ -	$ -	$ -	$ -
2033					$ -	$ -	$ -	$ -	$ -	$ -
2034					$ -	$ -	$ -	$ -	$ -	$ -
2035					$ -	$ -	$ -	$ -	$ -	$ -
2036					$ -	$ -	$ -	$ -	$ -	$ -
2037					$ -	$ -	$ -	$ -	$ -	$ -
2038					$ -	$ -	$ -	$ -	$ -	$ -
2039					$ -	$ -	$ -	$ -	$ -	$ -
2040					$ -	$ -	$ -	$ -	$ -	$ -
2041					$ -	$ -	$ -	$ -	$ -	$ -
2042					$ -	$ -	$ -	$ -	$ -	$ -
2043					$ -	$ -	$ -	$ -	$ -	$ -
2044					$ -	$ -	$ -	$ -	$ -	$ -
2045					$ -	$ -	$ -	$ -	$ -	$ -
2046					$ -	$ -	$ -	$ -	$ -	$ -
2047					$ -	$ -	$ -	$ -	$ -	$ -
2048					$ -	$ -	$ -	$ -	$ -	$ -
2049					$ -	$ -	$ -	$ -	$ -	$ -
2050					$ -	$ -	$ -	$ -	$ -	$ -
2051					$ -	$ -	$ -	$ -	$ -	$ -
2052					$ -	$ -	$ -	$ -	$ -	$ -
2053					$ -	$ -	$ -	$ -	$ -	$ -
2054					$ -	$ -	$ -	$ -	$ -	$ -
2055					$ -	$ -	$ -	$ -	$ -	$ -
2056					$ -	$ -	$ -	$ -	$ -	$ -
2057					$ -	$ -	$ -	$ -	$ -	$ -
2058					$ -	$ -	$ -	$ -	$ -	$ -
2059					$ -	$ -	$ -	$ -	$ -	$ -
2060					$ -	$ -	$ -	$ -	$ -	$ -
2061					$ -	$ 1,053,106	$ -	$ 1,053,106	$ 1,569,971	$ 616,641
2062	1	353,688	$ 40	$ 14,041,414	$ 14,041,414	$ -	$ 1,053,106	$ 15,094,520	$ 22,717,889	$ 8,726,606
2063					$ -	$ -	$ -	$ -	$ -	$ -
2064					$ -	$ -	$ -	$ -	$ -	$ -

Table 5.2

Closure Cost Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Year	Closure Stage	Scheduled Final Cover Construction Area (m2)	Unit Cost of Final Cover Construction (per m2)	Cost of Final Cover Construction	Sub-Total Capital Costs	Engineering Design (7.5% in year before constuction)	Engineering Construction (7.5% in year of construction)	Total	Future Value	Present Value
2065					$ -	$ -	$ -	$ -	$ -	$ -
2066					$ -	$ -	$ -	$ -	$ -	$ -
2067					$ -	$ -	$ -	$ -	$ -	$ -
2068					$ -	$ -	$ -	$ -	$ -	$ -
2069					$ -	$ -	$ -	$ -	$ -	$ -
2070					$ -	$ -	$ -	$ -	$ -	$ -
2071					$ -	$ -	$ -	$ -	$ -	$ -
2072					$ -	$ -	$ -	$ -	$ -	$ -
2073					$ -	$ -	$ -	$ -	$ -	$ -
2074					$ -	$ -	$ -	$ -	$ -	$ -
2075					$ -	$ -	$ -	$ -	$ -	$ -
2076					$ -	$ -	$ -	$ -	$ -	$ -
2077					$ -	$ -	$ -	$ -	$ -	$ -
2078					$ -	$ -	$ -	$ -	$ -	$ -
2079					$ -	$ -	$ -	$ -	$ -	$ -
2080					$ -	$ -	$ -	$ -	$ -	$ -
2081					$ -	$ -	$ -	$ -	$ -	$ -
2082					$ -	$ -	$ -	$ -	$ -	$ -
2083					$ -	$ -	$ -	$ -	$ -	$ -
2084					$ -	$ -	$ -	$ -	$ -	$ -
2085					$ -	$ -	$ -	$ -	$ -	$ -
2086					$ -	$ 635,327	$ -	$ 635,327	$ 1,201,276	$ 270,521
2087	2	213,376	$ 40	$ 8,471,027	$ 8,471,027	$ -	$ 635,327	$ 9,106,354	$ 17,382,778	$ 3,828,368
2088					$ -	$ -	$ -	$ -	$ -	$ -
2089					$ -	$ -	$ -	$ -	$ -	$ -
2090					$ -	$ -	$ -	$ -	$ -	$ -
2091					$ -	$ -	$ -	$ -	$ -	$ -
2092					$ -	$ -	$ -	$ -	$ -	$ -
2093					$ -	$ -	$ -	$ -	$ -	$ -
2094					$ -	$ -	$ -	$ -	$ -	$ -
2095					$ -	$ -	$ -	$ -	$ -	$ -
2096					$ -	$ -	$ -	$ -	$ -	$ -
2097					$ -	$ -	$ -	$ -	$ -	$ -
2098					$ -	$ -	$ -	$ -	$ -	$ -
2099					$ -	$ -	$ -	$ -	$ -	$ -
2100					$ -	$ -	$ -	$ -	$ -	$ -
2101					$ -	$ -	$ -	$ -	$ -	$ -
2102					$ -	$ -	$ -	$ -	$ -	$ -
2103					$ -	$ -	$ -	$ -	$ -	$ -
2104					$ -	$ -	$ -	$ -	$ -	$ -
2105					$ -	$ -	$ -	$ -	$ -	$ -
2106					$ -	$ -	$ -	$ -	$ -	$ -
2107					$ -	$ 1,030,215	$ -	$ 1,030,215	$ 2,378,391	$ 335,669
2108	3	346,000	$ 40	$ 13,736,200	$ 13,736,200	$ -	$ 1,030,215	$ 14,766,415	$ 34,415,932	$ 4,750,336
							Total	**$ 41,685,937**	**$ 79,666,239**	**$ 18,528,141**

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2019 Closure (Emergency Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2019	0			
2020	1	$ 600,000	$ 605,732	$ 592,403
2021	2	$ 600,000	$ 611,518	$ 584,901
2022	3	$ 600,000	$ 617,360	$ 577,495
2023	4	$ 600,000	$ 623,257	$ 570,183
2024	5	$ 600,000	$ 629,211	$ 562,963
2025	6	$ 600,000	$ 635,222	$ 555,835
2026	7	$ 600,000	$ 641,290	$ 548,796
2027	8	$ 600,000	$ 647,416	$ 541,847
2028	9	$ 600,000	$ 653,601	$ 534,986
2029	10	$ 280,000	$ 307,927	$ 246,499
2030	11	$ 280,000	$ 310,869	$ 243,378
2031	12	$ 280,000	$ 313,839	$ 240,296
2032	13	$ 280,000	$ 316,837	$ 237,253
2033	14	$ 280,000	$ 319,863	$ 234,249
2034	15	$ 280,000	$ 322,919	$ 231,283
2035	16	$ 280,000	$ 326,004	$ 228,355
2036	17	$ 280,000	$ 329,118	$ 225,463
2037	18	$ 280,000	$ 332,262	$ 222,608
2038	19	$ 280,000	$ 335,436	$ 219,789
2039	20	$ 280,000	$ 338,640	$ 217,006
2040	21	$ 280,000	$ 341,875	$ 214,259
2041	22	$ 280,000	$ 345,141	$ 211,546
2042	23	$ 280,000	$ 348,438	$ 208,867
2043	24	$ 280,000	$ 351,767	$ 206,222
2044	25	$ 280,000	$ 355,127	$ 203,611
2045	26	$ 280,000	$ 358,520	$ 201,033
2046	27	$ 280,000	$ 361,945	$ 198,487
2047	28	$ 280,000	$ 365,402	$ 195,974
2048	29	$ 280,000	$ 368,893	$ 193,492
2049	30	$ 280,000	$ 372,417	$ 191,042
2050	31	$ 280,000	$ 375,974	$ 188,623
2051	32	$ 280,000	$ 379,566	$ 186,235
2052	33	$ 280,000	$ 383,192	$ 183,877
2053	34	$ 280,000	$ 386,852	$ 181,548
2054	35	$ 280,000	$ 390,548	$ 179,250
2055	36	$ 280,000	$ 394,279	$ 176,980
2056	37	$ 280,000	$ 398,045	$ 174,739
2057	38	$ 280,000	$ 401,848	$ 172,526
2058	39	$ 280,000	$ 405,686	$ 170,342
2059	40	$ 280,000	$ 409,562	$ 168,185
2060	41	$ 280,000	$ 413,474	$ 166,055
2061	42	$ 280,000	$ 417,424	$ 163,953
2062	43	$ 280,000	$ 421,412	$ 161,877
2063	44	$ 280,000	$ 425,437	$ 159,827
2064	45	$ 280,000	$ 429,502	$ 157,803
2065	46	$ 280,000	$ 433,605	$ 155,805

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2019 Closure (Emergency Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2066	47	$ 280,000	$ 437,747	$ 153,832
2067	48	$ 280,000	$ 441,928	$ 151,884
2068	49	$ 280,000	$ 446,150	$ 149,961
2069	50	$ 280,000	$ 450,412	$ 148,062
2070	51	$ 280,000	$ 454,715	$ 146,187
2071	52	$ 280,000	$ 459,059	$ 144,336
2072	53	$ 280,000	$ 463,444	$ 142,509
2073	54	$ 280,000	$ 467,871	$ 140,704
2074	55	$ 280,000	$ 472,340	$ 138,923
2075	56	$ 280,000	$ 476,853	$ 137,163
2076	57	$ 280,000	$ 481,408	$ 135,427
2077	58	$ 280,000	$ 486,007	$ 133,712
2078	59	$ 280,000	$ 490,649	$ 132,019
2079	60	$ 280,000	$ 495,337	$ 130,347
2080	61	$ 280,000	$ 500,068	$ 128,697
2081	62	$ 280,000	$ 504,845	$ 127,067
2082	63	$ 280,000	$ 509,668	$ 125,458
2083	64	$ 280,000	$ 514,537	$ 123,869
2084	65	$ 280,000	$ 519,452	$ 122,301
2085	66	$ 280,000	$ 524,414	$ 120,752
2086	67	$ 280,000	$ 529,424	$ 119,223
2087	68	$ 280,000	$ 534,482	$ 117,714
2088	69	$ 280,000	$ 539,587	$ 116,223
2089	70	$ 280,000	$ 544,742	$ 114,752
2090	71	$ 280,000	$ 549,946	$ 113,299
2091	72	$ 280,000	$ 555,199	$ 111,864
2092	73	$ 280,000	$ 560,503	$ 110,447
2093	74	$ 280,000	$ 565,857	$ 109,049
2094	75	$ 280,000	$ 571,263	$ 107,668
2095	76	$ 280,000	$ 576,720	$ 106,305
2096	77	$ 280,000	$ 582,229	$ 104,959
2097	78	$ 280,000	$ 587,791	$ 103,630
2098	79	$ 280,000	$ 593,406	$ 102,318
2099	80	$ 280,000	$ 599,075	$ 101,022
				$ 16,659,430

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2107 Closure (Planned Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2019	0			
2020	0			
2021	0			
2022	0			
2023	0			
2024	0			
2025	0			
2026	0			
2027	0			
2028	0			
2029	0			
2030	0			
2031	0			
2032	0			
2033	0			
2034	0			
2035	0			
2036	0			
2037	0			
2038	0			
2039	0			
2040	0			
2041	0			
2042	0			
2043	0			
2044	0			
2045	0			
2046	0			
2047	0			
2048	0			
2049	0			
2050	0			
2051	0			
2052	0			
2053	0			
2054	0			
2055	0			
2056	0			
2057	0			
2058	0			
2059	0			
2060	0			
2061	0			
2062	0			
2063	0			
2064	0			
2065	0			

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2107 Closure (Planned Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2066	0			
2067	0			
2068	0			
2069	0			
2070	0			
2071	0			
2072	0			
2073	0			
2074	0			
2075	0			
2076	0			
2077	0			
2078	0			
2079	0			
2080	0			
2081	0			
2082	0			
2083	0			
2084	0			
2085	0			
2086	0			
2087	0			
2088	0			
2089	0			
2090	0			
2091	0			
2092	0			
2093	0			
2094	0			
2095	0			
2096	0			
2097	0			
2098	0			
2099	0			
2100	0			
2101	0			
2102	0			
2103	0			
2104	0			
2105	0			
2106	0			
2107	0			
2108	1	$ 600,000	$ 1,398,414	$ 193,019
2109	2	$ 600,000	$ 1,411,773	$ 190,575
2110	3	$ 600,000	$ 1,425,259	$ 188,162
2111	4	$ 600,000	$ 1,438,874	$ 185,779
2112	5	$ 600,000	$ 1,452,620	$ 183,427
2113	6	$ 600,000	$ 1,466,496	$ 181,104
2114	7	$ 600,000	$ 1,480,505	$ 178,811
2115	8	$ 600,000	$ 1,494,648	$ 176,547

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2107 Closure (Planned Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2116	9	$ 600,000	$ 1,508,926	$ 174,312
2117	10	$ 600,000	$ 1,523,341	$ 172,104
2118	11	$ 280,000	$ 717,683	$ 79,298
2119	12	$ 280,000	$ 724,539	$ 78,294
2120	13	$ 280,000	$ 731,461	$ 77,303
2121	14	$ 280,000	$ 738,448	$ 76,324
2122	15	$ 280,000	$ 745,502	$ 75,358
2123	16	$ 280,000	$ 752,624	$ 74,403
2124	17	$ 280,000	$ 759,814	$ 73,461
2125	18	$ 280,000	$ 767,072	$ 72,531
2126	19	$ 280,000	$ 774,400	$ 71,613
2127	20	$ 280,000	$ 781,797	$ 70,706
2128	21	$ 280,000	$ 789,266	$ 69,811
2129	22	$ 280,000	$ 796,805	$ 68,927
2130	23	$ 280,000	$ 804,417	$ 68,054
2131	24	$ 280,000	$ 812,102	$ 67,192
2132	25	$ 280,000	$ 819,860	$ 66,341
2133	26	$ 280,000	$ 827,691	$ 65,501
2134	27	$ 280,000	$ 835,598	$ 64,672
2135	28	$ 280,000	$ 843,581	$ 63,853
2136	29	$ 280,000	$ 851,639	$ 63,045
2137	30	$ 280,000	$ 859,775	$ 62,246
2138	31	$ 280,000	$ 867,988	$ 61,458
2139	32	$ 280,000	$ 876,280	$ 60,680
2140	33	$ 280,000	$ 884,651	$ 59,912
2141	34	$ 280,000	$ 893,101	$ 59,153
2142	35	$ 280,000	$ 901,633	$ 58,404
2143	36	$ 280,000	$ 910,246	$ 57,664
2144	37	$ 280,000	$ 918,942	$ 56,934
2145	38	$ 280,000	$ 927,720	$ 56,213
2146	39	$ 280,000	$ 936,582	$ 55,502
2147	40	$ 280,000	$ 945,529	$ 54,799
2148	41	$ 280,000	$ 954,562	$ 54,105
2149	42	$ 280,000	$ 963,681	$ 53,420
2150	43	$ 280,000	$ 972,886	$ 52,743
2151	44	$ 280,000	$ 982,180	$ 52,075
2152	45	$ 280,000	$ 991,563	$ 51,416
2153	46	$ 280,000	$ 1,001,035	$ 50,765
2154	47	$ 280,000	$ 1,010,598	$ 50,122
2155	48	$ 280,000	$ 1,020,252	$ 49,488
2156	49	$ 280,000	$ 1,029,998	$ 48,861
2157	50	$ 280,000	$ 1,039,837	$ 48,242
2158	51	$ 280,000	$ 1,049,771	$ 47,631
2159	52	$ 280,000	$ 1,059,799	$ 47,028
2160	53	$ 280,000	$ 1,069,923	$ 46,433
2161	54	$ 280,000	$ 1,080,144	$ 45,845
2162	55	$ 280,000	$ 1,090,462	$ 45,264
2163	56	$ 280,000	$ 1,100,879	$ 44,691
2164	57	$ 280,000	$ 1,111,396	$ 44,125
2165	58	$ 280,000	$ 1,122,013	$ 43,567

Table 5.3

Post-Closure Operations and Maintenance Calculations
Financial Security Plan
Glenmore Landfill
Kelowna, BC

2107 Closure (Planned Closure) - 80 year O&M Costs

Year	Post-Closure Year	Post-Closure Costs	Post-Closure Costs (FV)	Post-Closure Costs (PV)
2166	59	$ 280,000	$ 1,132,731	$ 43,015
2167	60	$ 280,000	$ 1,143,552	$ 42,470
2168	61	$ 280,000	$ 1,154,476	$ 41,932
2169	62	$ 280,000	$ 1,165,504	$ 41,402
2170	63	$ 280,000	$ 1,176,638	$ 40,877
2171	64	$ 280,000	$ 1,187,878	$ 40,360
2172	65	$ 280,000	$ 1,199,226	$ 39,849
2173	66	$ 280,000	$ 1,210,682	$ 39,344
2174	67	$ 280,000	$ 1,222,247	$ 38,846
2175	68	$ 280,000	$ 1,233,923	$ 38,354
2176	69	$ 280,000	$ 1,245,711	$ 37,868
2177	70	$ 280,000	$ 1,257,611	$ 37,389
2178	71	$ 280,000	$ 1,269,624	$ 36,915
2179	72	$ 280,000	$ 1,281,753	$ 36,448
2180	73	$ 280,000	$ 1,293,997	$ 35,986
2181	74	$ 280,000	$ 1,306,358	$ 35,531
2182	75	$ 280,000	$ 1,318,838	$ 35,081
2183	76	$ 280,000	$ 1,331,436	$ 34,637
2184	77	$ 280,000	$ 1,344,155	$ 34,198
2185	78	$ 280,000	$ 1,356,996	$ 33,765
2186	79	$ 280,000	$ 1,369,959	$ 33,338
2187	80	$ 280,000	$ 1,383,046	$ 32,915
				$ 5,519,837

Table 6.1

Financial Security Calculation Summary
Financial Security Plan
Glenmore Landfill
Kelowna, BC

Scenario		Planned Closure		Emergency Closure
Closure Capital Cost (PV) (1)	$	18,528,141	$	50,401,133
Max Capital Closure Cost (2)	**$**	**18,528,141**	**$**	**50,401,133**
Post Closure O&M Cost (PV)	**$**	**5,519,837**	**$**	**16,659,430**
Allowance to Implement Contingency Measures	**$**	**1,500,000**	**$**	**500,000**
Subtotal	$	25,547,978	$	67,560,563
Additional Financial Contingency (20%)	**$**	**5,109,596**	**$**	**13,512,113**
Financial Security Required	**$**	**30,660,000**	**$**	**81,080,000**

Notes:
(1) Cost of closure is based on remaining landfill area to be closed in each year based on an assumed schedule and cost of aeration lagoon retrofit at time of closure.
Details provided in Table 5.1.
(2) Maximum of capital costs of emergency and planned closure costs in each year.
(3) Post closure O&M costs are detailed in Table 2.2, and calculations are presented in Table 5.2.
(4) Contingency Measures costs are detailed in Tables 2.3 and 5.3.
(5) 2018 Canadian dollars, based on discount and inflation rates presented in Table 2.1.

Appendix D
LFG Collection System and Leachate Recirculation Design – CH2M HILL

City of Kelowna Glenmore Landfill – Preliminary Design and Phasing Plan for the Leachate Recirculation and LFG Collection Systems

PREPARED FOR:	City of Kelowna
PREPARED BY:	Raymond Li, P.Eng./CH2M HILL Elizabeth Butterfield/CH2M HILL Travis Pyle/CH2M HILL
REVIEWED BY:	Chuck Smith, P.Eng./CH2M HILL Suzanne Byrne, PGD/CH2M HILL
APPROVED BY:	Chuck Smith, P.Eng./CH2M HILL
DATE:	March 26, 2015
PROJECT NUMBER:	653224

1. Introduction

This technical memorandum (TM) presents the updated preliminary design for the leachate and landfill gas (LFG) systems at the City of Kelowna's (CoK's) Glenmore Landfill (Site). The design aligns with the ultimate fill plan [26,246,000 cubic metres, in accordance with Figure 2 of *Ultimate Long term Filling Plan and Development Considerations for the Glenmore Landfill* (CH2M HILL, 2014] and makes use of existing LFG and leachate recirculation infrastructure. The design also takes into account the previous preliminary design for the leachate recirculation system, the LFG collection system design for Phases 1 and 2, and as-built information for sections of the collection systems completed by CoK.

This TM also summarizes the proposed phasing plan for installation of gas header, lateral gas piping, and horizontal gas collectors; and leachate recirculate piping, and the leachate forcemain through the full build-out of the Site (Phases 1 – 3).

The following drawings are included as an attachment to this TM:

- Drawing C-1: Overall Site Plan
- Drawing C-1A: Enlarged Site Plan (Area A)
- Drawing C-1B: Enlarged Site Plan (Area B)
- Drawing C-2: Enlarged Site Plan 2015 LFG & Leachate Design
- Drawing C-3: LFG Header Plan and Profile STA 10+00 to STA 16+00
- Drawing C-4: LFG Header Plan and Profile STA 16+00 to END
- Drawing C-5: Ultimate Fill Plan Cross-Section
- Drawing C-6: Details

2. Background

The Glenmore Landfill Site is a municipal solid waste (MSW) landfill as defined by British Columbia Ministry of Environment (BCMoE), and is owned and operated by CoK servicing residents within the Regional District of Central Okanagan (RDCO). The landfill accepts MSW waste from private and commercial waste haulers within the RDCO as well as providing services for self-haul residential and commercial customers. The landfill accepts residential waste; industrial, commercial, and institutional waste (ICI); and construction & demolition (C&D) waste. The landfill also offers alternatives to disposal such as recycling and organic waste composting programs.

The Site has an active LFG collection system (owned and operated by CoK) consisting of a gas collection wellfield with 64 vertical wells (in the lower “C” waste lifts of Phase 2), 36 landfill gas trenches (LGTs) in Phase 1 and 2 combined, and a blower/flare station. Of the 36 LGTs, 20 are co-located (or “twinned”) with a leachate recirculation (reinjection) pipe. The LFG collection system (collection piping and well system) has a design capacity of 1,360 standard cubic metre per hour (scmh) (800 standard cubic feet per minute [scfm]) based on final design (Phase 1 and 2, CH2M HILL 2005). The LFG collected is routed to a skid-mounted prefabricated 600 Nm3/h (350 scfm) blower/open flare package for thermal destruction. The 2005 blower/flare system design was based on a high-efficiency enclosed flare package; however, based on low gas recovery and landfill phasing, a smaller temporary blower/flare system was installed. The LFG collection system was installed and commissioned in early 2005 with the gas recovery utilized for the initial operation of a 30 kilowatt microturbine system. The blower/flare skid was added in November 2005, with full-scale LFG recovery operations commencing in December 2005. The microturbine system was expanded to 90 kilowatt capacity in 2007 (and eventually decommissioned in 2014). CoK operates and maintains the LFG collection system.

In 2013, CoK entered into an agreement with FortisBC to upgrade the LFG to high British thermal unit, pipeline-quality gas to be fed into the natural gas distribution system. The facility was constructed in 2014 with the intent of upgrading about 425 scmh (250 scfm) of LFG and is currently in the commissioning stage. It is anticipated to be in full-scale operations by early 2015.

3. Design Criteria and Assumptions

The following assumptions were used to estimate future waste disposal quantities[1]:

- Population increase of 1.31 percent per year (based on the average incremental increase from 2010 to 2013)
- Landfilled MSW tonnages per capita per year of 0.583 for CoK’s service area (based on the average incremental increase from 2010 to 2013)
- Effective in-place waste density of 0.7 tonne per cubic metre

The following information was used in developing the phasing plan:

- CoK’s pipe installation schedule spreadsheet (Wahl, 2004, personal communication)
- Total airspace volume of the Site (Phases 1 -3) at full build-out of 26,246,000 cubic metres, in accordance with Figure 2 of *Ultimate Long term Filling Plan and Development Considerations for the Glenmore Landfill* (CH2M HILL, 2014)
- Minimum burial depth of pipes outside of the landfill for frost protection of 0.91 metre (36 inches). Reference – Livestock Watering Factsheet, BC Ministry of Agriculture and Lands (Order No. 590.307-1, January 2006). Factsheet estimates a frost depth of 0.69 metre (27 inches) for Kelowna and notes 0.91 metre (36 inches) for Okanagan Valley in which Kelowna is located. 0.91 m was used for design purposes.
- Minimum LFG capture rate of 75 percent as per the BCMoE Guidance for performance objective.
- Sizing of LFG pipeline assumes 90 percent LFG capture rate as a conservative measure.

---

[1] The reported 2014 waste tonnage was 123,128. CoK considers this an anomaly and requested that CH2M HILL use the population growth factor of 1.31 percent and a rate of 0.583 tonnes per cubic metre from 2013 to 2014 and beyond for waste projection estimates.

3.1 Estimated Waste Disposal Quantities

The above criteria and assumptions were used to project the annual waste tonnages that would be accepted at the Site. Table 1 shows the forecasted waste tonnages from 2014 through 2092. These data along with actual tonnages from 1980 to 2013, were used for gas generation calculations.

TABLE 1
Projected Annual Waste Quantities

Year	Population	Projected Waste Disposed(tonnes)	Cumulative Waste Disposed (tonnes)	Cumulative Waste Disposal Volume (cubic metre)
1980 - 2013	---	---	3,232,863	4,618,376
2014[(a)]	190,866	111,339	3,344,202	4,777,431
2015	193,364	112,796	3,456,997	4,938,568
2016	195,896	114,272	3,571,270	5,101,814
2017	198,460	115,768	3,687,038	5,267,197
2018	201,057	117,284	3,804,322	5,434,745
2019	203,689	118,819	3,923,140	5,604,486
2020	206,355	120,374	4,043,514	5,776,449
2021	209,057	121,950	4,165,464	5,950,663
2022	211,793	123,546	4,289,010	6,127,157
2023	214,565	125,163	4,414,173	6,305,961
2024	217,374	126,801	4,540,974	6,487,106
2025	220,219	128,461	4,669,436	6,670,622
2026	223,102	130,143	4,799,578	6,856,540
2027	226,022	131,846	4,931,424	7,044,892
2028	228,981	133,572	5,064,996	7,235,709
2029	231,978	135,320	5,200,317	7,429,024
2030	235,014	137,092	5,337,409	7,624,870
2031	238,091	138,886	5,476,295	7,823,278
2032	241,207	140,704	5,616,999	8,024,284
2033	244,364	142,546	5,759,545	8,227,921
2034	247,563	144,412	5,903,957	8,434,224
2035	250,804	146,302	6,050,259	8,643,227
2036	254,087	148,217	6,198,476	8,854,966
2037	257,412	150,157	6,348,633	9,069,476
2038	260,782	152,123	6,500,756	9,286,794
2039	264,195	154,114	6,654,870	9,506,957
2040	267,654	156,131	6,811,001	9,730,002
2041	271,157	158,175	6,969,176	9,955,966
2042	274,706	160,245	7,129,422	10,184,888
2043	278,302	162,343	7,291,765	10,416,806
2044	281,945	164,468	7,456,232	10,651,761
2045	285,636	166,621	7,622,853	10,889,790
2046	289,374	168,802	7,791,655	11,130,936
2047	293,162	171,011	7,962,666	11,375,238
2048	297,000	173,250	8,135,916	11,622,737

TABLE 1

Projected Annual Waste Quantities

Year	Population	Projected Waste Disposed(tonnes)	Cumulative Waste Disposed (tonnes)	Cumulative Waste Disposal Volume (cubic metre)
2049	300,887	175,518	8,311,434	11,873,477
2050	304,826	177,815	8,489,249	12,127,498
2051	308,816	180,143	8,669,391	12,384,845
2052	312,858	182,501	8,851,892	12,645,560
2053	316,953	184,889	9,036,781	12,909,687
2054	321,102	187,310	9,224,091	13,177,272
2055	325,305	189,761	9,413,852	13,448,360
2056	329,563	192,245	9,606,097	13,722,996
2057	333,877	194,762	9,800,859	14,001,227
2058	338,247	197,311	9,998,170	14,283,100
2059	342,675	199,894	10,198,064	14,568,662
2060	347,160	202,510	10,400,574	14,857,963
2061	351,705	205,161	10,605,735	15,151,050
2062	356,308	207,846	10,813,581	15,447,973
2063	360,972	210,567	11,024,148	15,748,784
2064	365,697	213,323	11,237,472	16,053,531
2065	370,484	216,116	11,453,588	16,362,268
2066	375,334	218,945	11,672,532	16,675,046
2067	380,246	221,810	11,894,343	16,991,918
2068	385,224	224,714	12,119,056	17,312,938
2069	390,266	227,655	12,346,712	17,638,160
2070	395,375	230,635	12,577,347	17,967,638
2071	400,550	233,654	12,811,001	18,301,430
2072	405,793	236,713	13,047,714	18,639,591
2073	411,105	239,811	13,287,525	18,982,178
2074	416,486	242,950	13,530,475	19,329,249
2075	421,937	246,130	13,776,605	19,680,864
2076	427,460	249,352	14,025,957	20,037,081
2077	433,056	252,616	14,278,573	20,397,961
2078	438,724	255,922	14,534,495	20,763,564
2079	444,467	259,272	14,793,767	21,133,953
2080	450,285	262,666	15,056,434	21,509,191
2081	456,179	266,104	15,322,538	21,889,340
2082	462,150	269,588	15,592,126	22,274,465
2083	468,199	273,116	15,865,242	22,664,631
2084	474,328	276,691	16,141,933	23,059,905
2085	480,537	280,313	16,422,246	23,460,352
2086	486,827	283,982	16,706,229	23,866,041
2087	493,199	287,700	16,993,928	24,277,040
2088	499,655	291,465	17,285,394	24,693,419
2089	506,195	295,281	17,580,674	25,115,249

TABLE 1
Projected Annual Waste Quantities

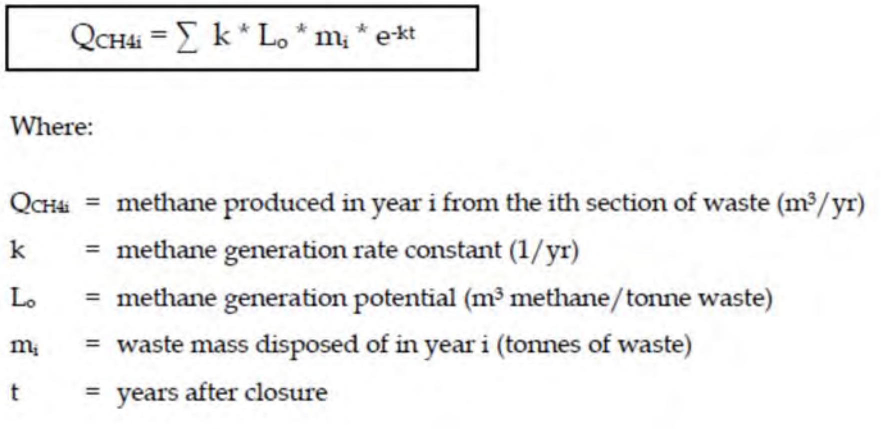
Year	Population	Projected Waste Disposed(tonnes)	Cumulative Waste Disposed (tonnes)	Cumulative Waste Disposal Volume (cubic metre)
2090	512,821	299,146	17,879,820	25,542,600
2091	519,534	303,061	18,182,881	25,975,545
2092	526,334	189,319	18,372,200	26,246,000

(a) The reported 2014 waste tonnage was 123,128. CoK considers this an anomaly and requested that CH2M HILL use the population growth factor of 1.31 percent and a rate of 0.583 tonnes per cubic metre from 2013 to 2014 and beyond for waste projection estimates.

3.2 Landfill Gas Generation Projections

3.2.1 BCMoE LFG Modelling

Methane production at the Site was estimated using the LFG Generation Estimation Tool (Tool) as specified in the BC MOE LFG Guideline. The model is based on a first-order equation for quantifying emissions from the decomposition of wastes in MSW landfills.



$$\boxed{Q_{CH4i} = \sum k * L_o * m_i * e^{-kt}}$$

Where:

Q_{CH4i} = methane produced in year i from the ith section of waste (m^3/yr)
k = methane generation rate constant (1/yr)
L_o = methane generation potential (m^3 methane/tonne waste)
m_i = waste mass disposed of in year i (tonnes of waste)
t = years after closure

The following assumptions are used in the Tool:

- Lag time before start of gas production: 1 year
- Methane by volume: 50 percent
- Carbon dioxide by volume: 50 percent
- Methane density [@ standard temperature and pressure (STP)]: 0.6557 kg/m^3
- Carbon dioxide density (@ STP): 1.7988 kg/m^3

3.2.1.1 Model Inputs

Methane Generation Rate (k):

Input parameters used for the constant, k, are based on Table 5.2 in the BCMOE Landfill Gas Generation Assessment Procedure Guidelines. With an average annual precipitation of 386.9 millimetres[2] (>250 mm to <500 mm), the model uses a k-value for the Site as follows:

- 0.01/yr for relatively inert waste
- 0.02/yr for moderately decomposable waste

---

[2] Reference: Climate Normals Station Data (1981 – 2010) for Kelowna Airport, BC from Government of Canada

- 0.05/yr for decomposable wastes

Methane Generation Potential (L_o):

The input parameters used for the L_o value are based on Table 5.1 in the BCMoE LFG Guideline. For this Site, the model uses a L_o-value of 20 m^3 methane (CH_4)/ metric tonne of waste for relatively inert waste, 120 m^3 CH_4/metric tonne of waste for moderately decomposable waste, and 160 m^3 CH_4/metric tonne of waste for decomposable waste.

Waste Addition Factor:

According to Section 5.4 in the BCMoE LFG Guideline*,* the selected k-value should be corrected based on the landfill's operation and maintenance practices, including stormwater management, cover properties, and the extent of leachate recirculation or stormwater injection. Based on Table 5.3 of the BC MOE LFG Guideline*,* the water addition factor appropriate for the Site conditions is 1.0.

Waste Tonnage by Category:

Characterization according to waste types is required to conduct the simulation using the BCMoE LFG Guideline proposed calculation tool. Waste must be characterized into three categories: relatively inert, moderately decomposable, and decomposable. Based on the Landfill Gas Generation Assessment (CH2M HILL, 2010), the Glenmore waste composition is as follows:

- Decomposable waste: 37 percent
- Moderately decomposable: 35 percent
- Relatively inert waste: 28 percent

3.2.1.2 LFG Generation Results

Table 2 shows the annual methane production using the BCMoE calculation tool. The model output is provided in Attachment 1.

TABLE 2
Annual methane Production Using the BC MOE Calculation Tool

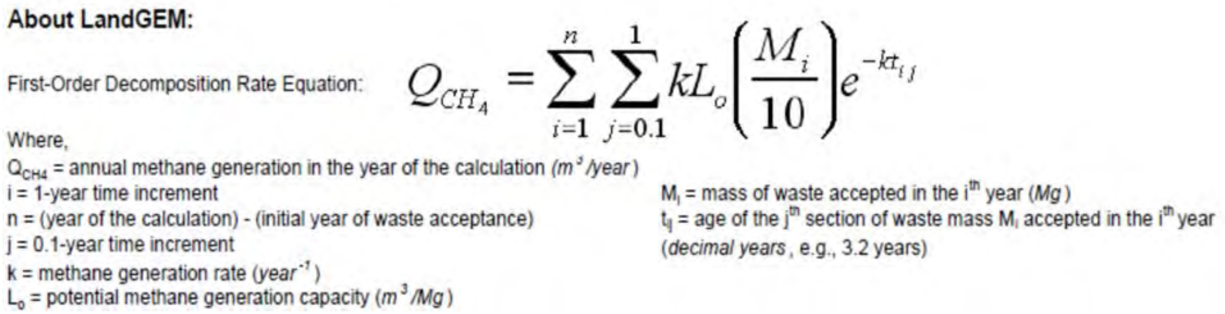
Year	Annual Methane Production (tonnes/yr)	Methane Production (scmh)	LFG Production (scmh)
1980	0	0	0
1981	232	40	81
1982	455	79	158
1983	653	114	227
1984	843	147	293
1985	1,024	178	357
1986	1,199	209	417
1987	1,366	238	475
1988	1,526	266	531
1989	1,680	292	585
1990	1,828	318	636
1991	1,970	343	686
1992	2,106	366	733
1993	2,252	392	784
1994	2,383	415	829
1995	2,495	434	868
1996	2,593	451	902
1997	2,688	468	935

TABLE 2
Annual methane Production Using the BC MOE Calculation Tool

Year	Annual Methane Production (tonnes/yr)	Methane Production (scmh)	LFG Production (scmh)
1998	2,817	490	980
1999	2,910	506	1,013
2000	3,004	523	1,046
2001	3,105	540	1,081
2002	3,218	560	1,120
2003	3,343	582	1,163
2004	3,448	600	1,200
2005	3,574	622	1,244
2006	3,700	644	1,288
2007	3,841	668	1,337
2008	3,942	686	1,372
2009	4,034	702	1,404
2010	4,158	724	1,447
2011	4,290	746	1,493
2012	4,383	763	1,525
2013	4,477	779	1,558
2014	4,570	795	1,590

3.2.2 EPA LandGEM Modelling

As the BCMoE LFG Tool only predicts through the assessment year (2014), the United States Environmental Protection Agency (USEPA) Landfill Gas Emissions Model, Version 3.02 (LandGEM) was used to estimate LFG production beyond 2014 at the Site. LandGEM is a mathematical model that estimates LFG generation potential using a first-order kinetic decay equation. The model approximates LFG generation per unit mass of waste over time.



About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10}\right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

The fundamental elements of the LandGEM model are the annual waste placed in the landfill, LFG generation rate constant, k, and the unit potential methane generation capacity, L_o. The annual waste mass placed in the landfill is the total mass of refuse placed in the landfill that has LFG generation potential (i.e. MSW tonnes each year). The unit LFG generation rate decay value (k) is the volume of LFG generated per unit mass of refuse per unit of time (i.e., m^3 LFG/kg waste/yr). It is predominantly influenced by the local climate, conditions within the landfill, and initial moisture content of the waste. The LFG generation capacity (L_0) is the total volume of LFG produced per unit mass of refuse (i.e., m^3 LFG/kg waste). It is predominantly influence by the composition of the refuse.

3.2.2.1 Model Inputs

The same values for k and L_o were used for LandGEM to match the BCMoE Tool. The Site LFG generation rate was estimated by modeling LFG generation based on the time period waste will be deposited in the Site. Since waste composition effects LFG generation potential, specifically the LFG generation capacity, waste placed in the Site was modeled using applicable values established for the waste placement period.

3.2.2.2 Results

The LandGEM model output reports are provided in Attachment 1. The model was run twice for each of the three waste types in order to capture the entire waste fill duration (that is, the model only allows up to 80 years for each model run). The results were then added and superimposed on one another to arrive at the total, composite gas generation estimate.

Figure 1 presents the estimated LFG generation rate between 1980 and 2100. While LFG is expected to be generated for a longer time period, the precision of the estimated LFG generation rates decreases as the model time scale increases. Assuming a maximum recovery rate of 90 percent for purposes of design, the peak LFG generation is approximately 4,650 scmh, or about 2,738 scfm. It should be noted that estimated generation rates presented are annual average values and are for a LFG mixture containing 50 percent methane and 50 percent carbon dioxide, by volume.

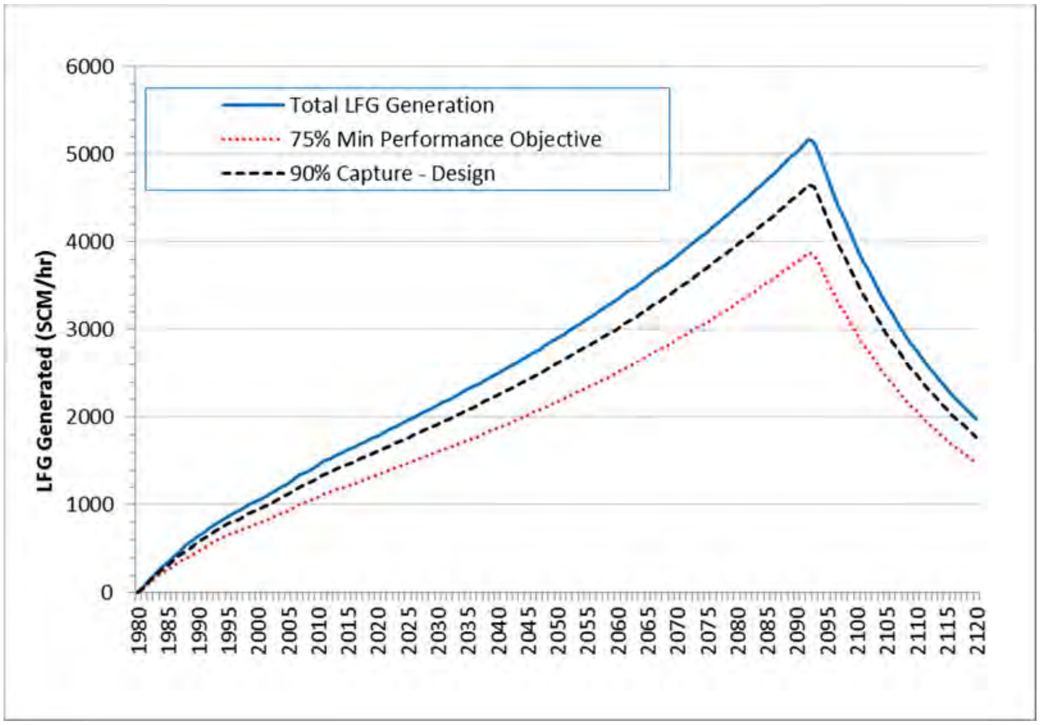


FIGURE 1. LANDFILL GAS GENERATION ESTIMATE (EPA LANDGEM)

4. Phasing Plan

In order to estimate the timeframe for installation of LGTs and leachate recirculation lines, including the progressive extension of the LFG and leachate recirculation ring header, subheader and tie-line systems, a waste fill phasing plan is needed for the Site. In lieu of having this plan, it has been assumed for this exercise that Phases 1 and 2 will reach capacity before CoK will begin filling Phase 3. This phasing plan focuses on near- and long-term installation of gas and leachate systems associated with Phases 1 and 2.

4.1 Landfill Gas Trenches (LGTs)

4.1.1 Near-Term

Based on the CoK pipe installation schedule, twinned LGTs D6, E8, G1 through G7, and G10 will be installed in 2015. Twinned LGTs F8 and F9 will be installed in 2016, and G8 and G9 will be installed in 2017. These LGTs are shown in Drawing C-5 (attached). Table 3 presents the LGTs currently scheduled for construction according to the CoK pipe installation schedule.

TABLE 3
Near-Term Future LGT Installation Schedule (2015-2017)

LGT	Year	Approximate Trench Length (m)
D6	2015	435
E8	2015	365
F8	2016	228
F9	2016	352
G1	2015	162
G2	2015	179
G3	2015	195
G4	2015	153
G5	2015	119
G6	2015	127
G7	2015	159
G8	2017	211
G9	2017	306
G10	2015	308

4.1.2 Long-Term

Installation of LGTs after 2017 will be conducted on an as-needed basis, aligning with the proposed locations as shown on Drawing C-5. LGTs will be placed approximately 60 metres apart. The vertical placement shown on Drawing C-5 assumes all future waste lifts will be approximately 3 metres in depth. This design approach for installation of LGTs follows the 2005 Phase 2 LFG Collection System detailed design. The following is assumed to be the general timeline for installation of future LGTs using the past LGT construction as guidance.

- 2018: H1 through H7 will be constructed, with the area at approximately H8 being used as a haul road.
- 2019: H9 and H10 will be constructed, with the area at approximately H8 being used as a haul road.
- 2020: I1 and I2 will be constructed, with the area at approximately H8 being used as a haul road.
- 2021: I3 through I6 and H8 will be constructed, with the area at approximately I7 being used as a haul road.
- 2022: I8 and I9 will be constructed, with the area at approximately I7 being used as a haul road.
- 2023: J1 and J2 will be constructed, with the area at approximately I7 being used as a haul road.
- 2024**:** J3 through J5, I7, J7, and J8 will be constructed, with the area at approximately J6 being used as a haul road.

Note that the lift naming and estimated elevations may change based on the final fill plan design accepted by CoK.

4.2 LFG Header and Leachate Recirculation System

4.2.1 LFG Header Pipe Sizing

Pipe sizes were determined using the Mueller formula, which is typically used for estimating low-pressure gas flow in smooth-walled pipes (for example, polyvinyl chloride [PVC] and high-density polyethylene [HDPE]). The equation was developed by the American Gas Association and is referenced in the Plexco *Pipe Engineering Manual for System Design*, 1992 ed., p. 22. The equation gives the pressure drop that will occur in a given pipe at a given gas flow rate, as follows (English Units):

$$\Delta P = \left\lfloor \frac{Q}{49.52 \times d^{2.725}} \right\rfloor^{(1.739)} \times FS \times L$$

Where ΔP= pressure drop in pipe (Point 2 – Point 1), inches water column (in. wc)

Q = flow rate in pipe, standard cubic feet per minute (scfm)

FS = factor of safety (1.5)

d = pipe diameter, inches

L = pipe length, feet

The maximum pressure change (ΔP) is used to establish the minimum pipe diameter. This constant can be changed, but our experience indicates that maintaining approximately 0.005 in. water column (wc) per foot of pipe optimizes the tradeoff in costs between blower capacity and pipe size (typically, for pipe sizes of 24 inches [610 mm] and smaller in diameter). Furthermore, the pipe velocity needs to be less than 25 feet per second (fps) or approximately 7.6 m/sec in order to drain condensate in a counter-current flow regime without air movement obstruction. These are typical values for blower systems that operate in the regime of 40 to 50 in. wc (1,020 mm to 1,525 mm wc) of vacuum pressure like that at the Site. The results of these calculations were converted to metric values for pipe sizing (Attachment 2).

Two scenarios were evaluated for this pipe sizing calculation based on peak gas generation. Scenario 1 assumes that 100 percent of the collected landfill gas from the east side of future Phase 3 goes south and into the west side header and then into the blower (2,311 scfm) with a small balance of gas from Phase 1 also added (141 scfm) and the rest coming from the north header and around to the blower (286 scfm), for a total of 2,738 scfm. In this scenario, the south and west side header segment controls the sizing of the header pipe with a minimum inside diameter of approximately 18 inches, which equates to a 20-inch (500-mm) SDR 17 HDPE pipe (inside diameter of 17.6 inches).

Scenario 2 assumes that 50 percent of the LFG on the east side of future Phase 3 goes south and into the west header and then into blower (1,769 scfm) with a small balance of gas from Phase 1 also added (141 scfm) and the rest coming from the north and around to the blower (828 scfm), for a total of 2,738 scfm. In this scenario, the south and west header segments could be reduced to 12-inch (300 mm) SDR 17 HDPE (inside diameter of 11.2 inches); however, to aid in system operational flexibility, the south and west side headers will be sized based on Scenario 1 – 20-inch (500 mm) diameter SDR 17 HDPE pipe.

4.2.2 Leachate Recirculation Manifold Sizing

The manifold pipe for the leachate recirculation system will generally vary from 100 mm (4 inches) to 150 mm (6 inches) depending on the pipe segment characteristics (proximity to the pump station and the vertical elevation rise). These pipe segments will be designed during detailed design of expansion areas and new pump stations when the time comes.

4.2.1 Near-Term

The existing LFG header along the waste slope on the west side of Phases 1 and 2 will be converted to a subheader line. The subheader will be connected to a new LFG ring header constructed outside of the waste fill limits per the “Table Top” Ultimate Long-Term Filling Plan (CH2M HILL, 2014). Segments of the ring header will be constructed as the filling progresses. The segment to be constructed in the near term is shown in plan and profile on Drawings C-3 and C-4. The LFG header will be placed directly adjacent to the existing leachate forcemain that currently runs along the west side of the landfill. Two new condensate traps will be constructed at the low points of the LFG header. A new leachate recirculation manifold will be constructed adjacent to the LFG subheader to distribute leachate collected from Phase 1 and 2 back into the landfill. The leachate manifold will be connected to recirculation lines already in place in the twinned LGTs. The ends of the LFG ring header and the leachate recirculation manifold will be flanged for future extension.

Items to be constructed in the near-term (2015 through 2017) will depend on CoK’s available budget. The proposed items include:

- Construction of the leachate recirculation manifold beginning at the connection to the existing leachate lift station extending from the north to west end of LGT F1 and south past the west end of LGT F5. The recirculation manifold will be installed below grade and parallel to the existing LFG 400-mm-diameter header along the west slope of Phase 1. Connections to be completed to the existing twinned LGTs as construction of the manifold progresses. The manifold will incorporate stub-outs for future connection immediately north of LGT F1.
- Construction of the LFG header from the connection to the blower/flare station west of Phase 1 to a point south of the low point on the east side of Bredin Pond. The construction of the LFG header in this segment will include two inspection risers, two stub-outs (flanges) for future connection, one condensate trap, and one connection to the existing subheader within the Phase 1 waste.
- Construction of the leachate recirculation manifold on the west side of Phase 2. This will include a new manhole and isolation valve along the leachate forcemain east of Bredin pond to enable recirculation (as shown on Drawing C-3). The leachate recirculation manifold will connect to the existing leachate forcemain north of LGT C8 along the west side of Phase 2. The leachate recirculation manifold will begin north of LGT E5 and have stub-outs for future connection south of LGT E10.
- Construction of the LFG header from the flange south of the proposed low point on the east side of Bredin Pond to a flange for the future extension of the ring header south of LGT A1. The construction of the LFG header will include five inspection risers, three stub-outs for future connection (one on the southern end of the completed LFG header and two intermediate), two condensate traps, and one connection to the subheader within the Phase 2 waste.

4.2.2 Long-Term

The LFG header and leachate recirculation pipes will be constructed completely around the landfill to form a ring outside of the limits of the final fill plan. Portions of the ring will be constructed as the landfill filling progresses, with stub-outs for future connections to LFG cross subheaders (running east to west) that will need to be constructed within the landfill filling area to reach all portions of the landfill gas collection wellfield.

5. Cost Estimate

The purpose of this estimate is to provide CoK with an engineer’s opinion of construction costs for the project.

5.1 Estimate Classification

This cost estimate is considered a Class 4 estimate as defined by the American Association of Cost Engineering (AACE), with a typical accuracy of +50 percent to –30 percent.

This estimate has been prepared for general guidance in project evaluation and implementation from the information available at the time of the estimate. The final cost of the project will depend upon the actual labor and material costs, competitive market conditions, and construction scope, final project costs, implementation schedule and other variable factors. As a result, the final project costs will vary from the estimate presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding. This estimate is based on material, equipment, and labor pricing as of March 2015.

5.2 Markups/Taxes

The following typical contractor markups were applied to the cost estimate:

- Contingency – 25 percent

5.3 Cost Resources

The following is a list of the various cost resources used in the development of the cost estimate:

- R.S. Means
- CH2M HILL historical data
- Estimator judgment
- Bid prices from similar work in recent years

5.4 Estimate Methodology

This cost estimate is considered a unit price type estimate based on recent hard money bid quotations for similar work in the area. The estimate may include cost allowances and costs per unit (for example, square feet) for certain components of the estimate.

5.5 Key Assumptions

The estimate is based on the project being competitively tendered. If the project is self-performed, the result could decrease the estimated project cost by 10 to 20 percent. This estimate should be evaluated for market changes after 90 days of the issue date.

Excluded costs include:

- Non-construction or soft costs for design, services during construction, land, permitting, legal, and owner administration costs
- Material adjustment allowances above and beyond what is included at the time of the cost estimate
- Escalation
- Taxes – no GST or PST taxes are included in the estimate.
- Escalation is not included for future construction. Estimate is in March 2015 dollars.

5.7 Cost Summary

The estimated cost to install the new LFG header and leachate recirculation manifolds as part of this project is shown in Table 4. The 2015 Project costs have been broken out into two segments. The first segment is north of the blower and back south towards Bredin Pond (STA 15+60 to STA 18+10). The second segment is continues to work south from STA 15+60 to STA 10+00. Refer to Drawings C-3 and C-4.

TABLE 4

Engineer's Construction Cost Estimate for Project (2015 dollars)

Item No.	Description	Estimate Quantity	Unit	Unit Price	Extended Unit Price
1. Installation of leachate recirculation manifold within Phase 1					
1	Manifold (100 mm SDR 17 HDPE)	330	M	$120	$39,600
2	Connections to existing LGTs	9	EA	$1,500	$13,500
Item 1 Subtotal					**$53,100**
2. Installation of LFG header adjacent to Phase 1 (STA 15+60 – STA 18+10)					

1	Header (500 mm SDR 17 HDPE)	250	M	$400	$100,000
2	Inspection Risers	2	EA	$2,000	$4,000
3	Connection to blower/flare	1	EA	$2,000	$2,000
4	Condensate trap (gravity drain system with sump)	1	EA	$12,500	$12,500
5	Connection to existing subheader	1	EA	$2,500	$2,500
6	Blind Flanges for Future Connections	2	EA	$2,500	$5,000
Item 2 Subtotal					**$126,000**
3. Installation of leachate recirculation manifold within Phase 2					
1	Manifold (100 mm SDR 17 HDPE)	440	M	$120	$52,800
2	Connections to existing LGTs	11	EA	$1,500	$16,500
3	Manhole/Valve on Leachate Forcemain	1	LS	$10,000	$10,000
Item 3 Subtotal					**$79,300**
4. Installation of LFG header adjacent to Phase 2 (STA 10+00 – STA 15+60)					
1	Header (500 mm SDR 17 HDPE)	560	M	$400	$224,000
2	Inspection Risers	5	EA	$2,000	$10,000
3	Condensate trap (gravity drain system with sump)	2	EA	$12,500	$25,000
4	Connection to existing subheader	1	EA	$2,500	$2,500
6	Blind Flanges for Future Connections	3	EA	$2,500	$7,500
Item 4 Subtotal					**$269,000**
Construction Subtotal					**$527,400**
Contingency		25%			$131,850
Project Construction Total (rounded)					**$659,250**
Lower Range		**-30%**			**$461,427**
Upper Range		**50%**			**$988,875**

The estimated cost for the installation of the LGTs that are scheduled in the near-term are shown in Table 5.

TABLE 5
Engineer's Construction Cost Estimate for LGTs (2015-2017) (2015 dollars)[a]

Item No.	Description	Estimate Quantity	Unit	Unit Price	Extended Unit Price
Installation of LGTs (Near-Term):					
2015					
1	D6	435	M	$120	$52,200
2	E8	365	M	$120	$43,800
3	G1	162	M	$120	$19,440
4	G2	179	M	$120	$21,480
5	G3	195	M	$120	$23,400
6	G4	153	M	$120	$18,360
7	G5	119	M	$120	$14,280
8	G6	127	M	$120	$15,240
9	G7	159	M	$120	$19,080
10	G10	308	M	$120	$36,960
11	Wellheads	10	EA	$7,500	$75,000
Subtotal 2015 LGTs					**$339,240**

TABLE 5

Engineer's Construction Cost Estimate for LGTs (2015-2017) (2015 dollars)[a]

Item No.	Description	Estimate Quantity	Unit	Unit Price	Extended Unit Price
2016					
12	F8	228	M	$120	$27,360
13	F9	352	M	$120	$42,240
14	Wellheads	2	EA	$7,500	$15,000
Subtotal 2016 LGTs					**$84,600**
2017					
15	G8	211	M	$120	$25,320
16	G9	306	M	$120	$36,720
17	Wellheads	2	EA	$7,500	$15,000
Subtotal 2017 LGTs					**$77,040**

(a) Assumes CoK self-performed.

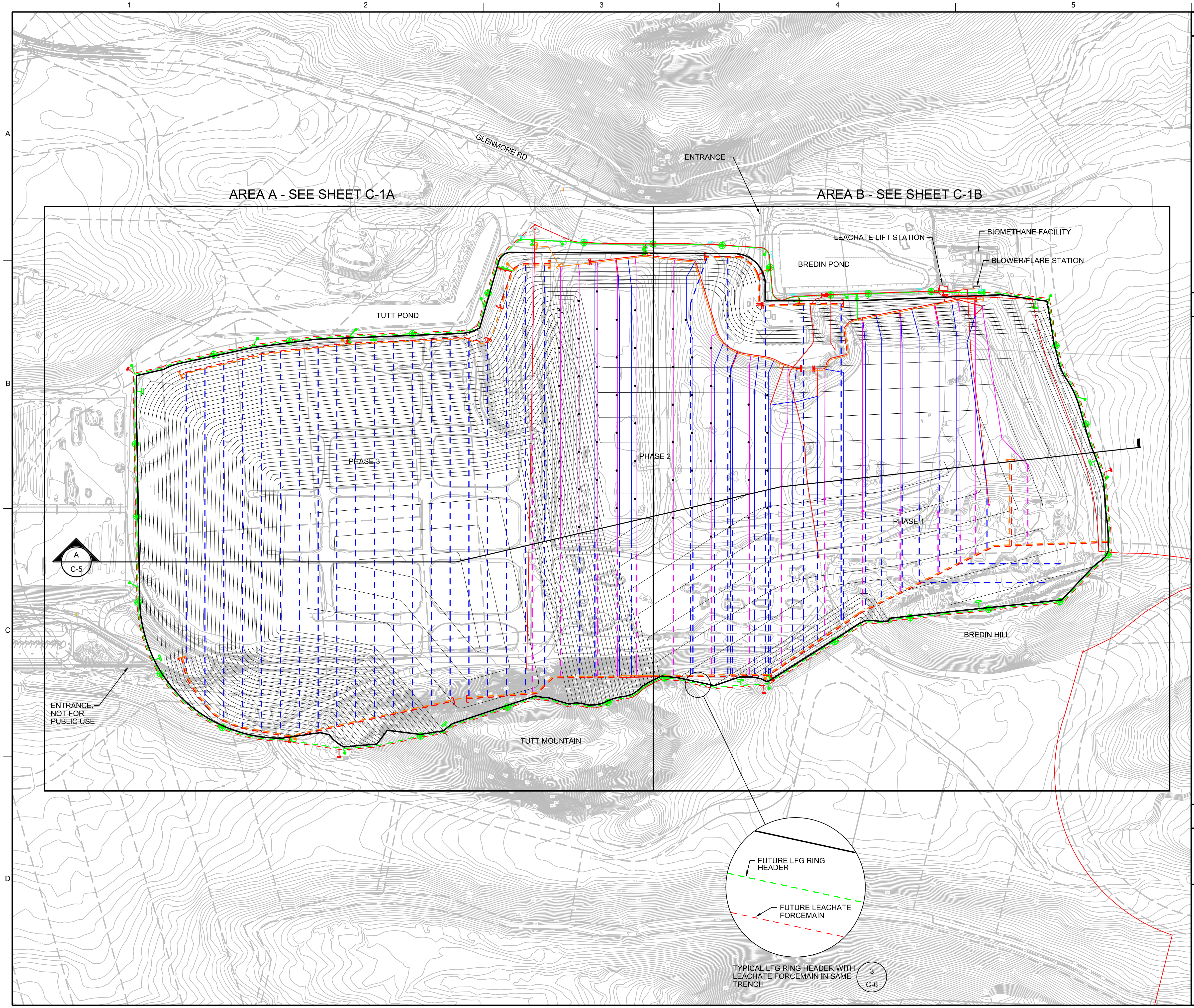
The estimated unit cost for installation of future infrastructure is presented Table 6.

TABLE 6

Engineer's Construction Cost Estimate for Future Infrastructure – Unit Prices (2015 dollars)

Item No.	Description	Unit	Unit Price
1	Manifold (100 mm SDR 17 HDPE)	M	$120
2	Header (500 mm SDR 17 HDPE)	M	$400
3	Shared Manifold and Header Trench	M	$260
4	Leachate Pump Station	EA	$35,000
5	Header Valves/Stations	EA	$10,000
6	Header Inspection Risers	EA	$2,000
7	Twinned LGT/Leachate Recirc Lines	M	$120
8	Condensate Traps (gravity drain system with sump)	EA	$12,500

Drawings



TYPICAL LFG RING HEADER WITH LEACHATE FORCEMAIN IN SAME TRENCH

SHEET NOTES

1. FUTURE LFG RING HEADER AND LEACHATE FORCEMAIN LINES TO BE PLACED IN THE SAME TRENCH. CONDENSATE TRAPS TO BE INSTALLED AT LFG HEADER LOW POINTS.
2. EXISTING TOPOGRAPHY SOURCE: 2012 AERIAL MAPPING PROVIDED BY CITY OF KELOWNA.
3. FUTURE LGTs SHOWN FOR FIRST TWO ROWS ONLY. ALL SUBSEQUENT ROWS WILL STAGGER THE PREVIOUS ROWS PER SECTION A/C-5.

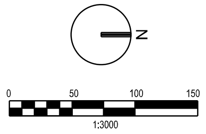
LEGEND

GAS HEADER ALIGNMENT
LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
LGT
LEACHATE COLLECTION
GAS SUBHEADER
FUTURE GAS HEADER
FUTURE LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
FUTURE LGT
FUTURE LEACHATE COLLECTION
FUTURE GAS SUBHEADER
CONDENSATE TRAP
450 CONTOUR FROM 2012 AERIAL TOPO
450 CONTOUR FROM TABLE TOP FILL PLAN 2014
PROPERTY/LEGAL LINE
GAS WELL
ULTIMATE FILL PLAN WASTE LIMITS
LFG HEADER CLEANOUT/ INSPECTION RISER
BLIND FLANGE FOR FUTURE CONNECTION
CAP
VALVE
LEACHATE PUMP STATION/BOOSTER

* SYMBOLS ON ALL SHEETS MAY APPEAR EXAGGERATED FOR READABILITY

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN	DR	CHK	APVD
E BUTTERFIELD	B BUTTERFIELD	T PYLE	R LI

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

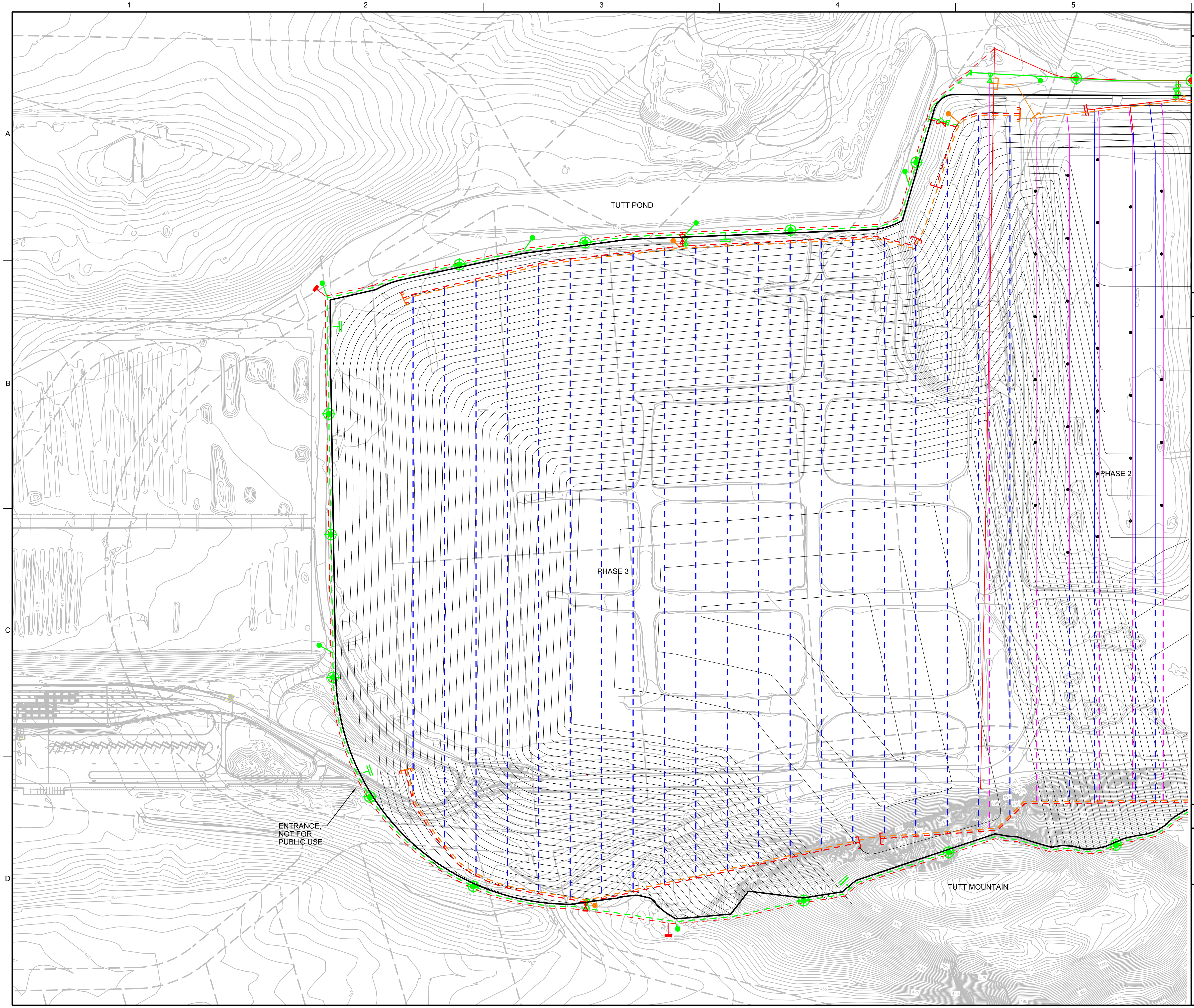
CH2MHILL®

CIVIL

OVERALL SITE PLAN

DATE	DEC 2014
PROJ	653224
DWG	C-1
SHEET	1 of 8

FILENAME: 005-C-2001_653224.dgn
PLOT DATE: 2015\03\23
PLOT TIME: 9:34:20 AM



SHEET NOTES

1. FUTURE LFG RING HEADER AND LEACHATE FORCEMAIN LINES TO BE PLACED IN THE SAME TRENCH. CONDENSATE TRAPS TO BE INSTALLED AT LFG HEADER LOW POINTS.
2. EXISTING TOPOGRAPHY SOURCE: 2012 AERIAL MAPPING PROVIDED BY CITY OF KELOWNA.
3. FUTURE LGTs SHOWN FOR FIRST TWO ROWS ONLY. ALL SUBSEQUENT ROWS WILL STAGGER THE PREVIOUS ROWS PER SECTION A/C-5.

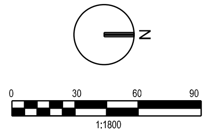
LEGEND

🟩	GAS HEADER ALIGNMENT
🟦	LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
🟪	LGT
🟥	LEACHATE COLLECTION
🟧	GAS SUBHEADER
- - -	FUTURE GAS HEADER
- - -	FUTURE LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
- - -	FUTURE LGT
- - -	FUTURE LEACHATE COLLECTION
- - -	FUTURE GAS SUBHEADER
—●	CONDENSATE TRAP
450	CONTOUR FROM 2012 AERIAL TOPO
450	CONTOUR FROM TABLE TOP FILL PLAN 2014
— —	PROPERTY/LEGAL LINE
•	GAS WELL
—	ULTIMATE FILL PLAN WASTE LIMITS
⊕	LFG HEADER CLEANOUT/ INSPECTION RISER
—‖	BLIND FLANGE FOR FUTURE CONNECTION
—]	CAP
⋈	VALVE
—▮	LEACHATE PUMP STATION/BOOSTER

* SYMBOLS ON ALL SHEETS MAY APPEAR EXAGGERATED FOR READABILITY

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



NO.	DATE	REVISION	BY	APVD
0	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD R LI

CITY OF KELOWNA

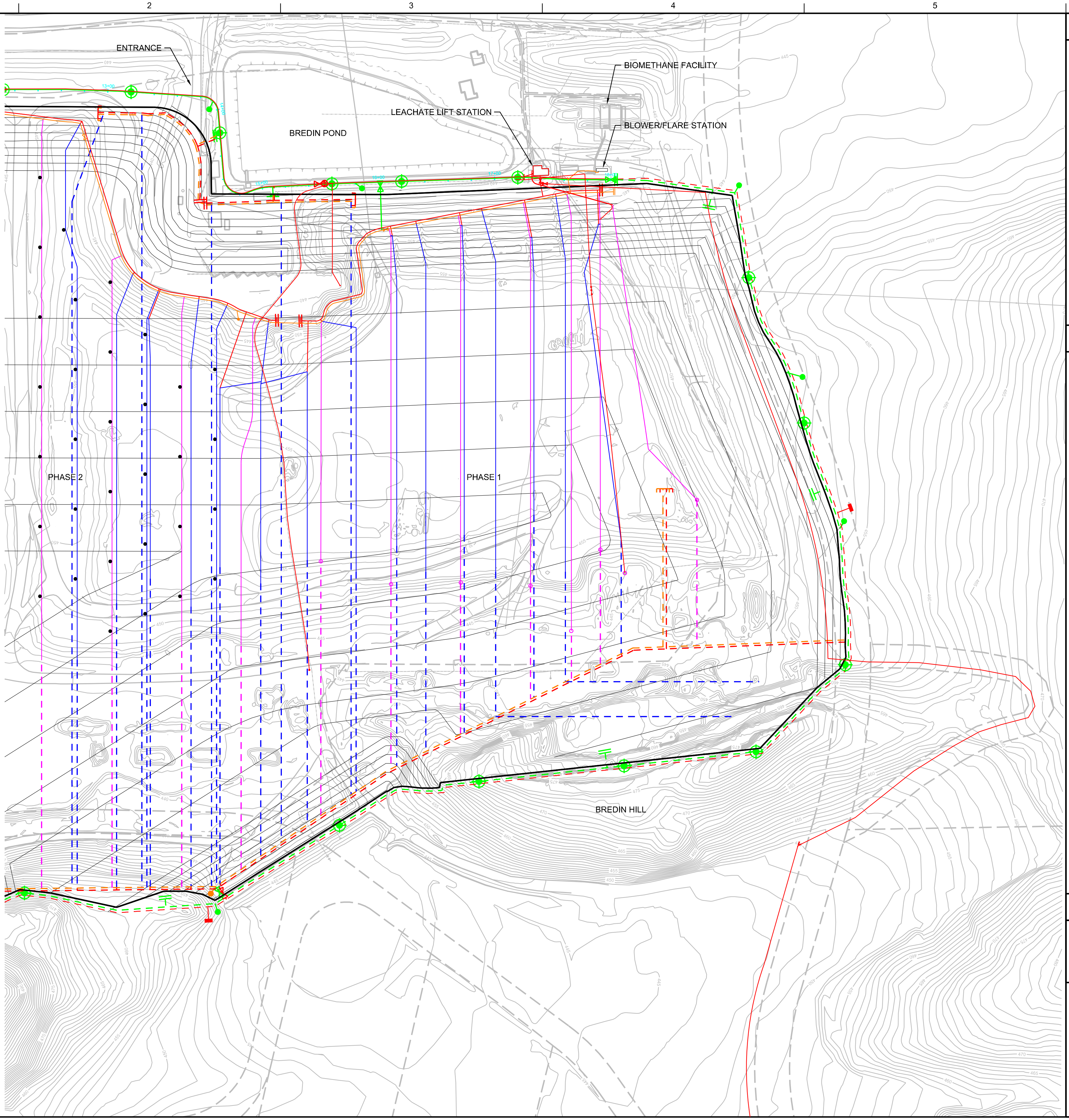
Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

CH2MHILL®

CIVIL
ENLARGED SITE PLAN
AREA A

DATE	DEC 2014
PROJ	653224
DWG	C-1A
SHEET	2 of 8

FILENAME: 005-C-2001A_653224.dgn
PLOT DATE: 2015\03\20
PLOT TIME: 3:59:14 PM



SHEET NOTES

1. FUTURE LFG RING HEADER AND LEACHATE FORCEMAIN LINES TO BE PLACED IN THE SAME TRENCH. CONDENSATE TRAPS TO BE INSTALLED AT LFG HEADER LOW POINTS.
2. EXISTING TOPOGRAPHY SOURCE: 2012 AERIAL MAPPING PROVIDED BY CITY OF KELOWNA.
3. FUTURE LGTs SHOWN FOR FIRST TWO ROWS ONLY. ALL SUBSEQUENT ROWS WILL STAGGER THE PREVIOUS ROWS PER SECTION A/C-5.

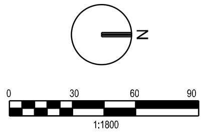
LEGEND

- GAS HEADER ALIGNMENT
- LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
- LGT
- LEACHATE COLLECTION
- GAS SUBHEADER
- FUTURE GAS HEADER
- FUTURE LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
- FUTURE LGT
- FUTURE LEACHATE COLLECTION
- FUTURE GAS SUBHEADER
- CONDENSATE TRAP
- 450 CONTOUR FROM 2012 AERIAL TOPO
- 450 CONTOUR FROM TABLE TOP FILL PLAN 2014
- PROPERTY/LEGAL LINE
- ● GAS WELL
- ULTIMATE FILL PLAN WASTE LIMITS
- LFG HEADER CLEANOUT/ INSPECTION RISER
- BLIND FLANGE FOR FUTURE CONNECTION
- CAP
- VALVE
- LEACHATE PUMP STATION/BOOSTER

* SYMBOLS ON ALL SHEETS MAY APPEAR EXAGGERATED FOR READABILITY

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



NO.	DATE	REVISION	BY	APVD
0	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD R LI

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

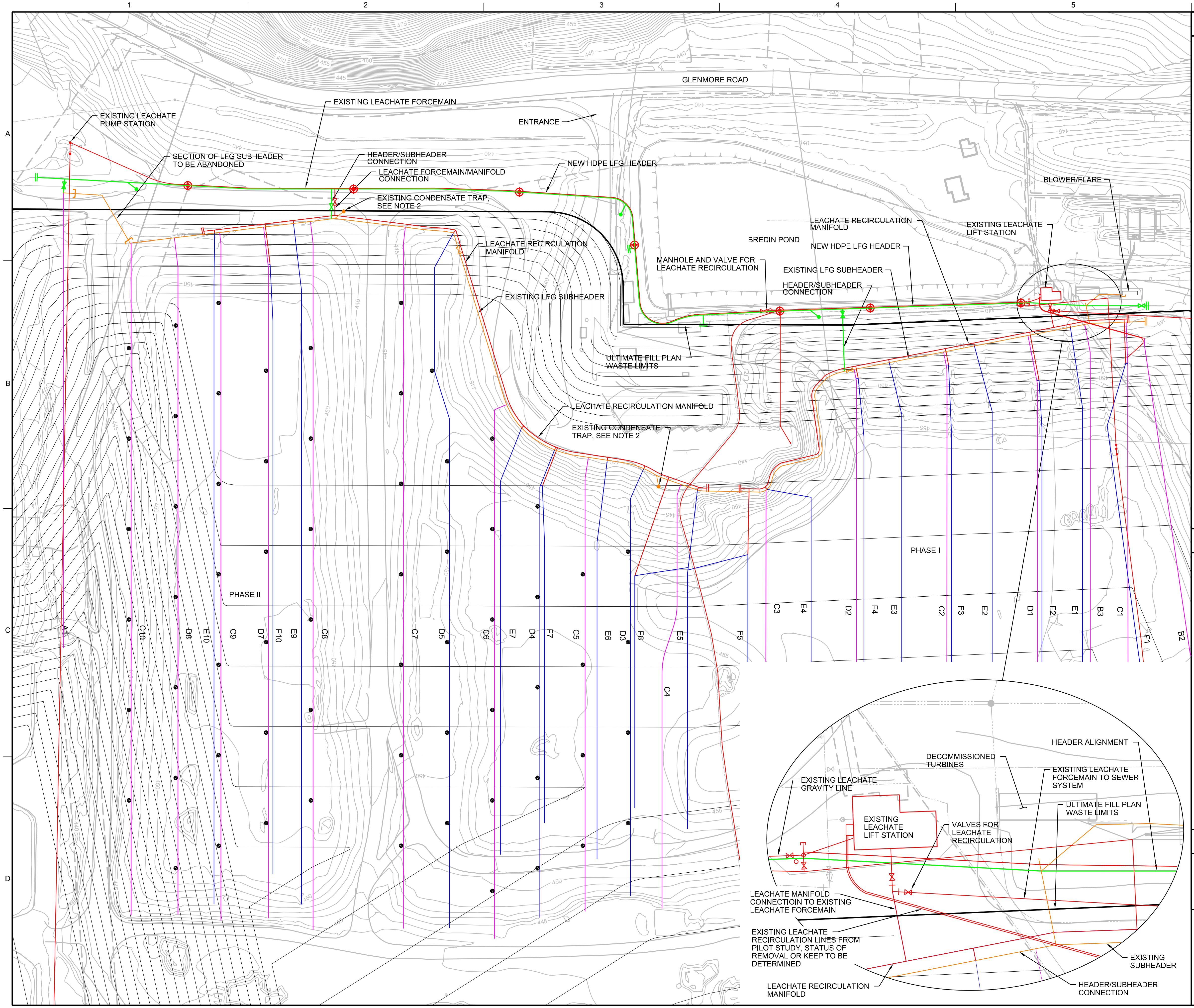
CH2MHILL®

CIVIL
ENLARGED SITE PLAN
AREA B

DATE	DEC 2014
PROJ	653224
DWG	C-1B
SHEET	3 of 8

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

FILENAME: 005-C-2001B_653224.dgn PLOT DATE: 2015\03\23 PLOT TIME: 9:36:34 AM



SHEET NOTES

1. LFG HEADER TO BE PLACED DIRECTLY ADJACENT TO EXISTING LEACHATE FORCEMAIN.
2. EXISTING CONDENSATE TRAPS ALONG LFG SUBHEADER CURRENTLY DRAIN INTO ROCK PITS.

LEGEND

GAS HEADER ALIGNMENT
LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
LGT
LEACHATE COLLECTION
GAS SUBHEADER
CONTOUR FROM 2012 AERIAL TOPO
CONTOUR FROM TABLE TOP FILL PLAN 2014
PROPERTY/LEGAL LINE
● GAS WELL
ULTIMATE FILL PLAN WASTE LIMITS
LFG HEADER CLEANOUT/ INSPECTION RISER
BLIND FLANGE FOR FUTURE CONNECTION
CAP
VALVE

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS

N

0 10 20 30 40 50
1:1250

1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL
NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
E BUTTERFIELD	B BUTTERFIELD	T PYLE	R LI

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

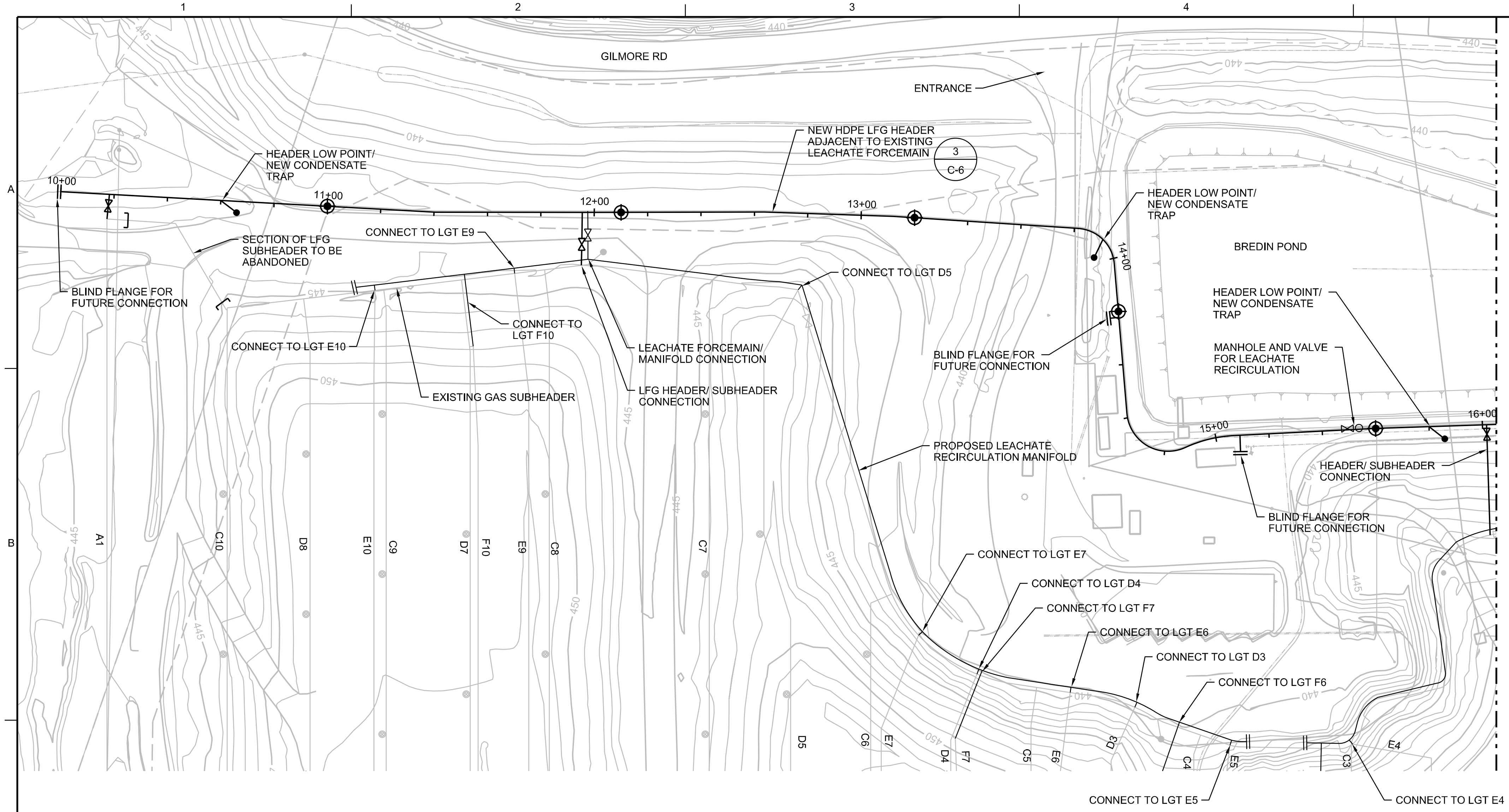
CH2MHILL®

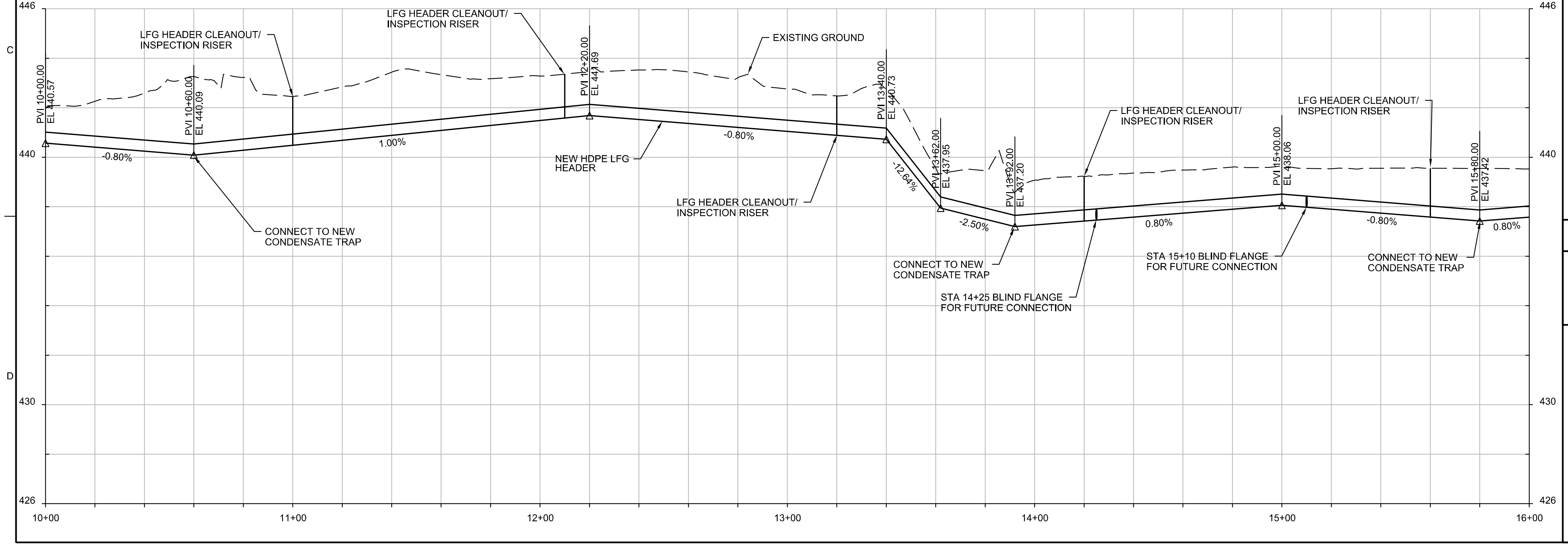
CIVIL

ENLARGED SITE PLAN
2015 LFG & LEACHATE DESIGN

DATE	DEC 2014
PROJ	653224
DWG	C-2
SHEET	4 of 8

FILENAME: 005-C-2002_653224.dgn
PLOT DATE: 2015\03\20
PLOT TIME: 3:55:02 PM





SHEET NOTES

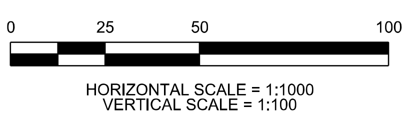
1. ALL ELEVATIONS SHOWN ARE TO INVERT OF PIPE.

LEGEND

450	CONTOUR FROM 2012 AERIAL TOPO
- - -	PROPERTY/LEGAL LINE
●	EXISTING GAS WELL
⊕	LFG HEADER CLEANOUT/ INSPECTION RISER
—‖	BLIND FLANGE FOR FUTURE CONNECTION
—]	CAP
⋈	VALVE
○	MANHOLE
—●	CONDENSATE TRAP

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



HORIZONTAL SCALE = 1:1000
VERTICAL SCALE = 1:100

NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD R LI

CITY OF KELOWNA

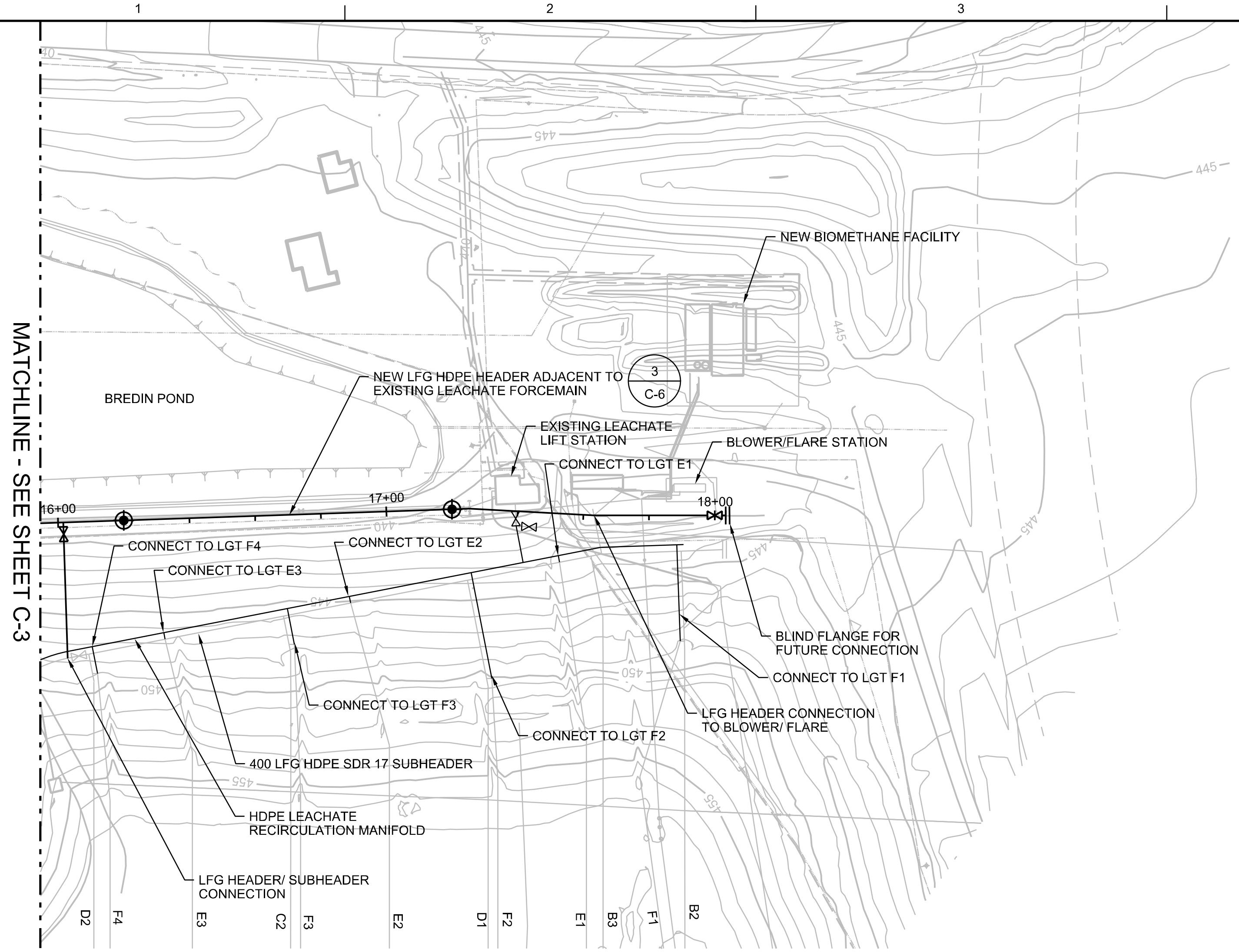
Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

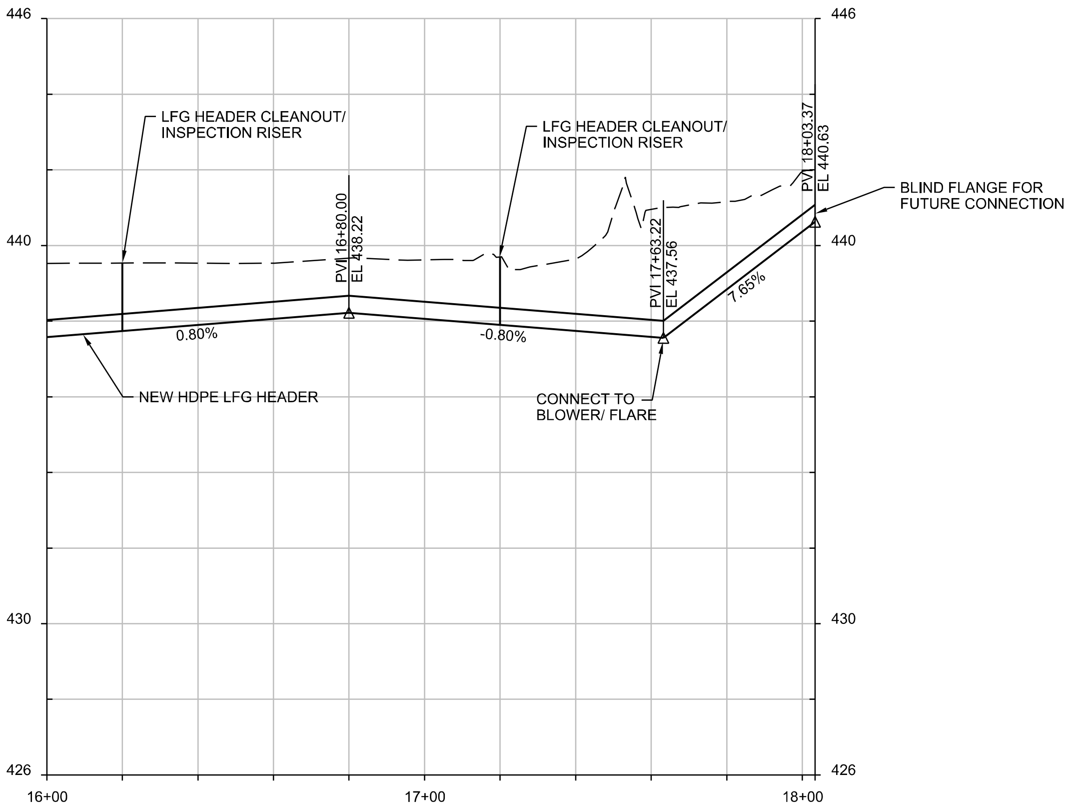
CH2MHILL®

CIVIL
LFG HEADER PLAN AND PROFILE
STA 10+00 TO STA 16+00

DATE	DEC 2014
PROJ	653224
DWG	C-3
SHEET	5 of 8

FILENAME: 005-C-2003_653224.dgn PLOT DATE: 2015\03\24 PLOT TIME: 1:49:08 PM





SHEET NOTES

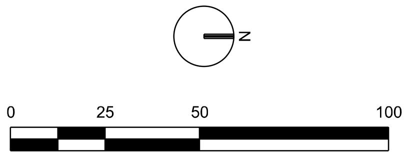
1. ALL ELEVATIONS SHOWN ARE TO INVERT OF PIPE.

LEGEND

——450——	CONTOUR FROM 2012 AERIAL TOPO
— — —	PROPERTY/LEGAL LINE
◈	LFG HEADER CLEANOUT/ INSPECTION RISER
——‖	BLIND FLANGE FOR FUTURE CONNECTION
⋈	VALVE

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



HORIZONTAL SCALE = 1:1000
VERTICAL SCALE = 1:100

NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD R LI

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

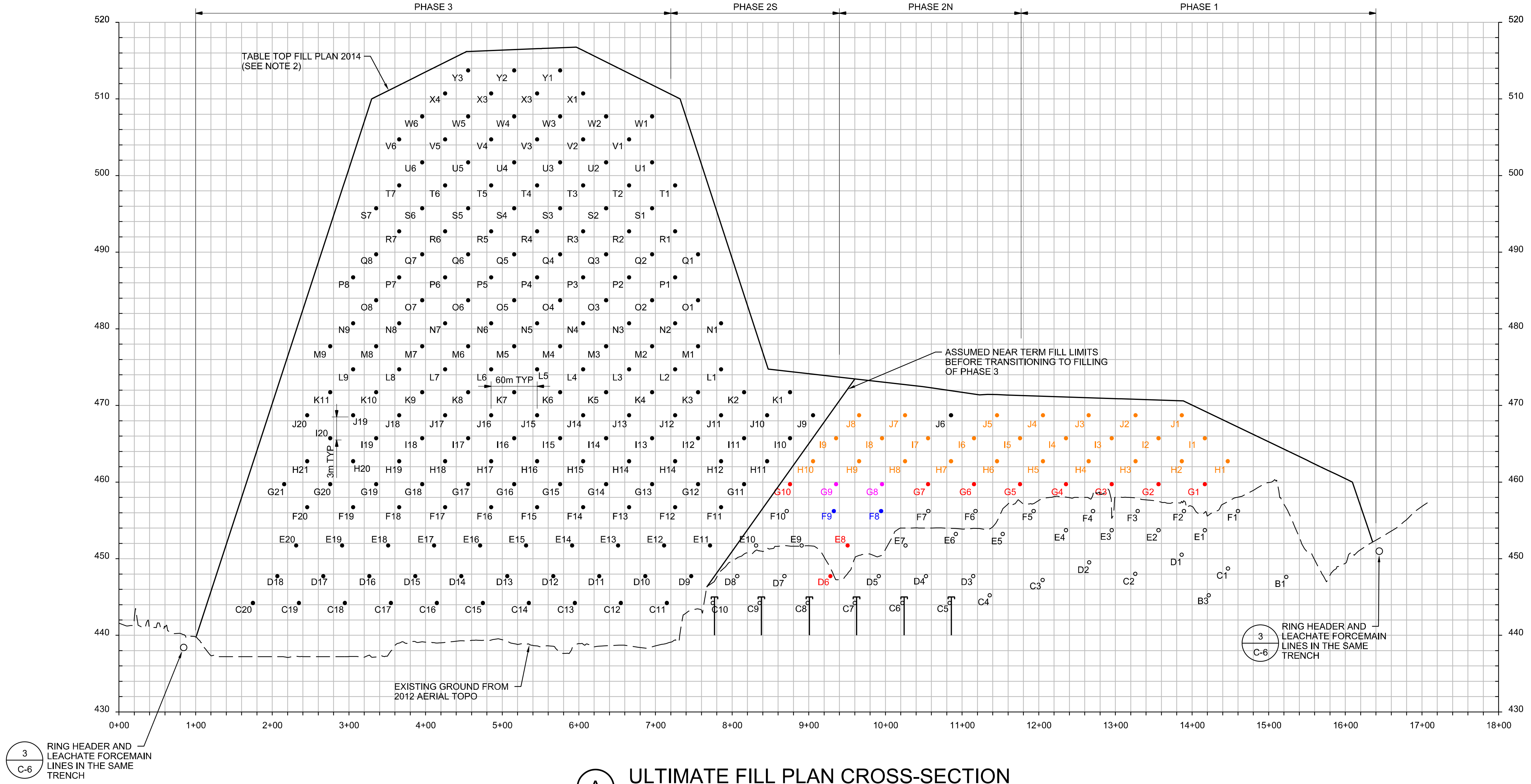
CH2MHILL®

CIVIL

LFG HEADER PLAN AND PROFILE
STA 16+00 TO END

DATE	DEC 2014
PROJ	653224
DWG	C-4
SHEET	6 of 8

FILENAME: 005-C-2004_653224.dgn
PLOT DATE: 2015\03\24
PLOT TIME: 1:51:11 PM



A ULTIMATE FILL PLAN CROSS-SECTION

H: 1:3000
V: 1:300

LEGEND

○ F7	EXISTING LGT
● G3	FUTURE LGT TO BE INSTALLED IN 2015
● F8	FUTURE LGT TO BE INSTALLED IN 2016
● G8	FUTURE LGT TO BE INSTALLED IN 2017
● J5	FUTURE LGT TO BE INSTALLED FROM 2018 TO 2024
● F13	FUTURE LGT TO BE INSTALLED AFTER 2024
⊤	EXISTING BURIED GAS WELLS

SHEET NOTES:

1. ALL FUTURE LGTs SHALL BE TWINNED WITH A LEACHATE RECIRCULATION PIPE. SEE SHEET C-2 FOR EXISTING LGTs CURRENTLY INSTALLED WITH TWINNED LEACHATE RECIRCULATION PIPES.
2. ULTIMATE FILL PLAN ELEVATION BASED ON FIGURE 2 OF ULTIMATE LONG TERM FILLING PLAN AND DEVELOPMENT CONSIDERATIONS FOR GLENMORE LANDFILL (CH2M HILL 2014).

CH2MHILL®

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

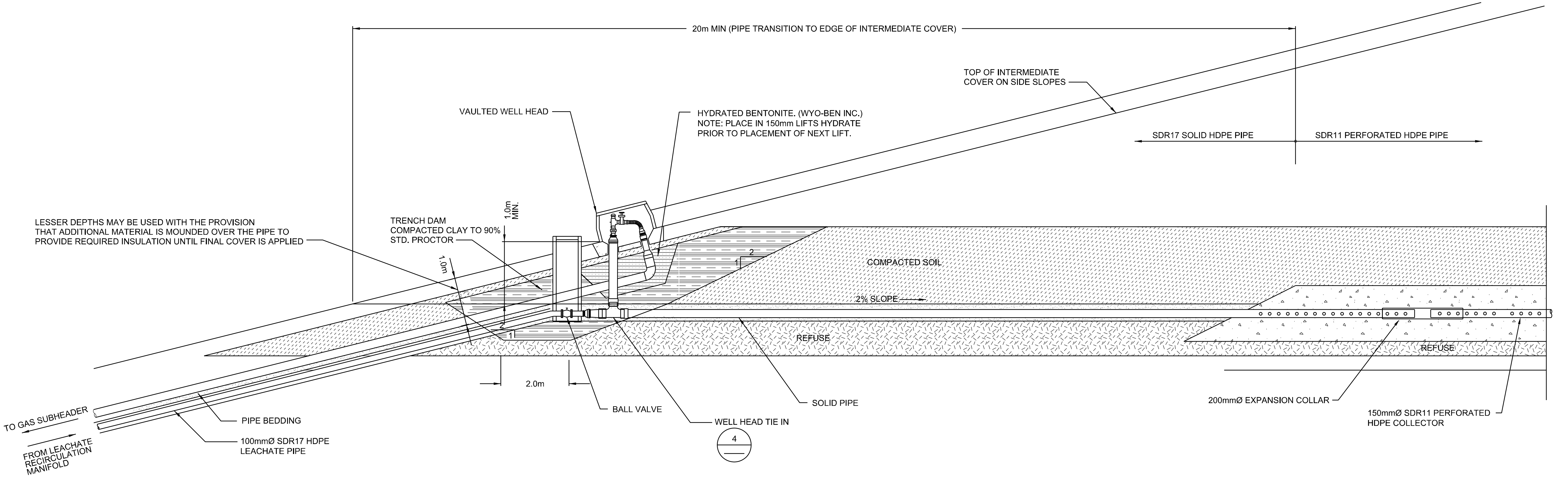
CIVIL
ULTIMATE FILL PLAN CROSS-SECTION

NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN	DR	CHK	APVD
E BUTTERFIELD	B BUTTERFIELD	T PYLE	R LI

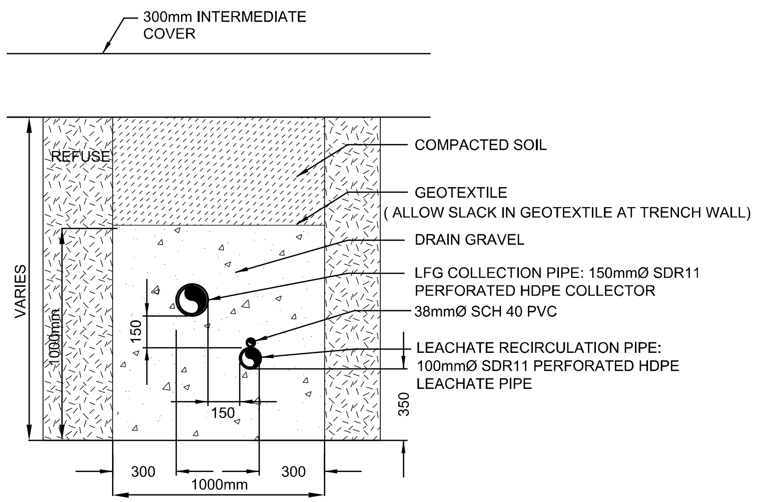
DATE	DEC 2014
PROJ	653224
DWG	C-5
SHEET	7 of 8

FILENAME: 005-C-3001_653224.dgn PLOT DATE: 2015\03\20 PLOT TIME: 2:10:45 PM



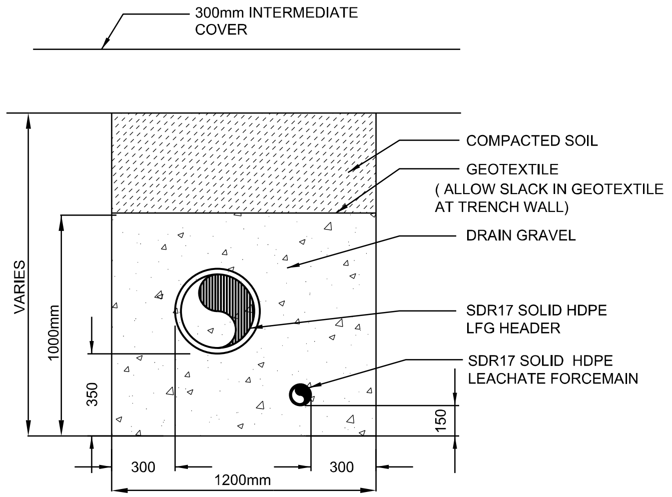
1 LGT/SUBHEADER/LEACHATE RECIRCULATION CONNECTION

NTS



2 TWINNED LGT AND LEACHATE RECIRCULATION LINES IN REFUSE

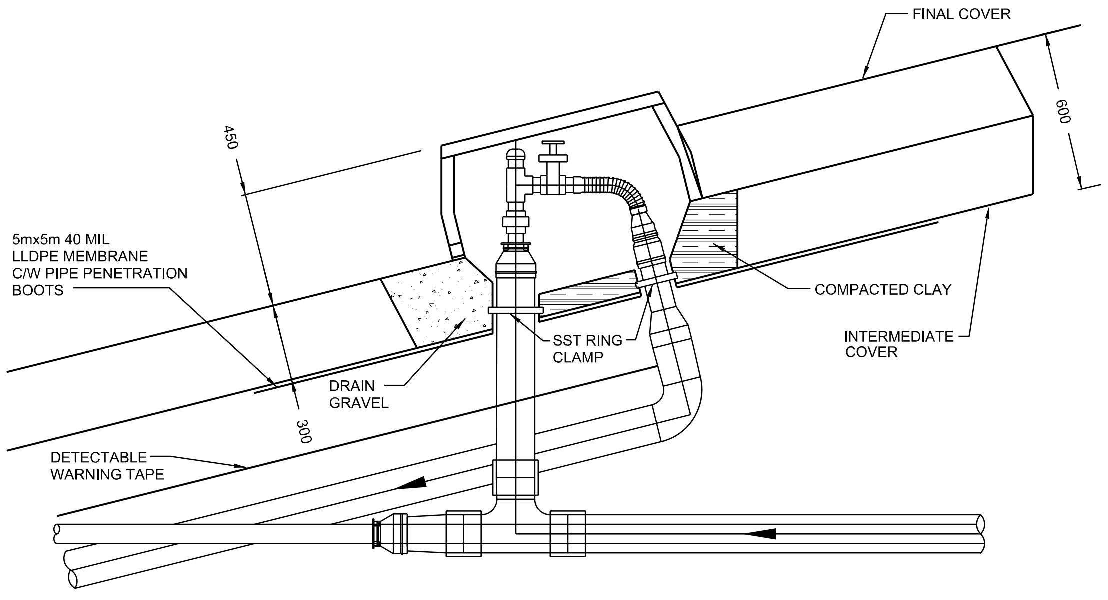
NTS



3 RING HEADER AND LEACHATE FORCEMAIN LINES TRENCH SECTION

NTS

C-1
C-3
C-4



4 WELLHEAD TIE-IN

NTS

NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

DSGN	DR	CHK	APVD
E BUTTERFIELD	B BUTTERFIELD	T PYLE	R LI

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

CH2MHILL®

CIVIL
DETAILS

DATE	DEC 2014
PROJ	653224
DWG	C-6
SHEET	8 of 8

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

Attachment 1
Landfill Gas Modelling Output Reports

Year of Assessment	2010		LFG Management Regulation Referen
Annual Tonnage in Preceding Year	114,590	(tonnes/year)	4-2-a
Total waste in Place in the Preceding Ye	2,789,588	(tonnes/year)	4-2-c
Methane generation in the Preceding Ye	4,034	(tonnes CH4/year)	4-2-d

Next Five Years	Waste Tonnage (tonnes)	Methane Generation (tonnes CH4/year)	
2010	119,861	4,158	4-2-b & 4-2-e
2011	106,387	4,290	4-2-b & 4-2-e
2012	108,110	4,383	4-2-b & 4-2-e
2013	108,917	4,477	4-2-b & 4-2-e
2014	111,339	4,570	4-2-b & 4-2-e

	Relatively Inert	Moderately Decomposabl	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH4/tonne
lag time before start of gas production, lag =	1	years		
Historical Data Used (years)	30			
1st Year of Historical Data Used	1980			
4 Years after Reporting Year	2014			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density) - 1atm, 25C	0.6557	kg/m^3	(25C,SP)	
carbon dioxide (density)	1.7988	kg/m^3	(25C,SP)	

Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Waste Tonnage			Methane Generation Rate, k			Annual Methane Production (tonnes/yr)
				Relatively Inert (tonnes)	Moderately Decomposable (tonnes)	Decomposable (tonnes)	Relatively Inert (year^{-1})	Moderately Decomposable (year^{-1})	Decomposable (year^{-1})	
1980	1	93,679	93,679	26,230	32,788	34,661	0.01	0.02	0.05	0.00
1981	2	93,679	187,358	26,230	32,788	34,661	0.01	0.02	0.05	232.35
1982	3	87,434	274,792	24,482	30,602	32,351	0.01	0.02	0.05	454.99
1983	4	87,434	362,226	24,482	30,602	32,351	0.01	0.02	0.05	652.86
1984	5	87,434	449,660	24,482	30,602	32,351	0.01	0.02	0.05	842.52
1985	6	87,434	537,094	24,482	30,602	32,351	0.01	0.02	0.05	1024.36
1986	7	87,434	624,528	24,482	30,602	32,351	0.01	0.02	0.05	1198.72
1987	8	87,434	711,962	24,482	30,602	32,351	0.01	0.02	0.05	1365.94
1988	9	87,434	799,396	24,482	30,602	32,351	0.01	0.02	0.05	1526.34
1989	10	87,434	886,830	24,482	30,602	32,351	0.01	0.02	0.05	1680.24
1990	11	87,434	974,264	24,482	30,602	32,351	0.01	0.02	0.05	1827.91
1991	12	87,434	1,061,698	24,482	30,602	32,351	0.01	0.02	0.05	1969.66
1992	13	93,852	1,155,550	26,279	32,848	34,725	0.01	0.02	0.05	2105.72
1993	14	89,753	1,245,303	25,131	31,414	33,209	0.01	0.02	0.05	2252.29
1994	15	84,272	1,329,575	23,596	29,495	31,181	0.01	0.02	0.05	2382.85
1995	16	80,458	1,410,033	22,528	28,160	29,769	0.01	0.02	0.05	2494.66
1996	17	80,794	1,490,827	22,622	28,278	29,894	0.01	0.02	0.05	2592.64
1997	18	95,904	1,586,731	26,853	33,566	35,484	0.01	0.02	0.05	2687.69
1998	19	83,756	1,670,487	23,452	29,315	30,990	0.01	0.02	0.05	2816.57
1999	20	85,258	1,755,745	23,872	29,840	31,545	0.01	0.02	0.05	2910.27
2000	21	89,547	1,845,292	25,073	31,341	33,132	0.01	0.02	0.05	3004.13
2001	22	95,815	1,941,107	26,828	33,535	35,452	0.01	0.02	0.05	3105.05
2002	23	102,522	2,043,629	28,706	35,883	37,933	0.01	0.02	0.05	3217.67
2003	24	96,772	2,140,401	27,096	33,870	35,806	0.01	0.02	0.05	3342.58
2004	25	106,483	2,246,884	29,815	37,269	39,399	0.01	0.02	0.05	3448.38
2005	26	108,597	2,355,481	30,407	38,009	40,181	0.01	0.02	0.05	3574.23
2006	27	116,218	2,471,699	32,541	40,676	43,001	0.01	0.02	0.05	3700.45
2007	28	102,688	2,574,387	28,753	35,941	37,995	0.01	0.02	0.05	3840.71
2008	29	100,611	2,674,998	28,171	35,214	37,226	0.01	0.02	0.05	3941.95
2009	30	114,590	2,789,588	32,085	40,107	42,398	0.01	0.02	0.05	4034.23
2010	31	119,861	2,909,449	33,561	41,951	44,349	0.01	0.02	0.05	4157.76
2011	32	106,387	3,015,836	29,788	37,235	39,363	0.01	0.02	0.05	4289.63
2012	33	108,110	3,123,946	30,271	37,839	40,001	0.01	0.02	0.05	4383.01
2013	34	108,917	3,232,863	30,497	38,121	40,299	0.01	0.02	0.05	4477.21
2014	35	111,339	3,344,202	31,175	38,968	41,195	0.01	0.02	0.05	4569.93

LandGEM - Version 3.02

US EPA Office of Research and Development

CLEAN
AIR
TECHNOLOGY
CENTER

EPA

LandGEM
Landfill Gas Emissions Model
Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1980**	
Landfill Closure Year (with 80-year limit)	**2059**	
Actual Closure Year (without limit)	***2059***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**160**	m^3*/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1980	34,661	38,127	0	0
1981	34,661	38,127	34,661	38,127
1982	32,351	35,586	69,322	76,255
1983	32,351	35,586	101,673	111,840
1984	32,351	35,586	134,024	147,426
1985	32,351	35,586	166,374	183,012
1986	32,351	35,586	198,725	218,597
1987	32,351	35,586	231,075	254,183
1988	32,351	35,586	263,426	289,769
1989	32,351	35,586	295,777	325,354
1990	32,351	35,586	328,127	360,940
1991	32,351	35,586	360,478	396,525
1992	34,725	38,198	392,828	432,111
1993	33,209	36,529	427,554	470,309
1994	31,181	34,299	460,762	506,838
1995	29,769	32,746	491,943	541,137
1996	29,894	32,883	521,712	573,883
1997	35,484	39,033	551,606	606,767
1998	30,990	34,089	587,090	645,800
1999	31,545	34,700	618,080	679,888
2000	33,132	36,446	649,626	714,588
2001	35,452	38,997	682,758	751,034
2002	37,933	41,726	718,210	790,031
2003	35,806	39,386	756,143	831,757
2004	39,399	43,339	791,948	871,143
2005	40,181	44,199	831,347	914,482
2006	43,001	47,301	871,528	958,681
2007	37,995	41,794	914,529	1,005,981
2008	37,226	40,949	952,523	1,047,776
2009	42,398	46,638	989,749	1,088,724
2010	44,349	48,783	1,032,148	1,135,362
2011	39,363	43,300	1,076,496	1,184,146
2012	40,001	44,001	1,115,859	1,227,445
2013	40,299	44,329	1,155,860	1,271,446
2014	41,195	45,315	1,196,159	1,315,775
2015	41,734	45,908	1,237,355	1,361,090
2016	42,281	46,509	1,279,089	1,406,998
2017	42,834	47,118	1,321,370	1,453,507
2018	43,395	47,734	1,364,204	1,500,624
2019	43,963	48,359	1,407,599	1,548,359

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2020	44,538	48,992	1,451,562	1,596,718
2021	45,121	49,634	1,496,100	1,645,710
2022	45,712	50,283	1,541,222	1,695,344
2023	46,310	50,941	1,586,934	1,745,627
2024	46,917	51,608	1,633,244	1,796,568
2025	47,531	52,284	1,680,160	1,848,177
2026	48,153	52,968	1,727,691	1,900,460
2027	48,783	53,661	1,775,844	1,953,428
2028	49,422	54,364	1,824,627	2,007,090
2029	50,069	55,075	1,874,049	2,061,454
2030	50,724	55,796	1,924,117	2,116,529
2031	51,388	56,527	1,974,841	2,172,325
2032	52,061	57,267	2,026,229	2,228,852
2033	52,742	58,016	2,078,290	2,286,119
2034	53,432	58,776	2,131,032	2,344,135
2035	54,132	59,545	2,184,464	2,402,910
2036	54,840	60,324	2,238,596	2,462,455
2037	55,558	61,114	2,293,436	2,522,780
2038	56,285	61,914	2,348,994	2,583,894
2039	57,022	62,724	2,405,280	2,645,808
2040	57,769	63,545	2,462,302	2,708,532
2041	58,525	64,377	2,520,070	2,772,078
2042	59,291	65,220	2,578,595	2,836,455
2043	60,067	66,074	2,637,886	2,901,675
2044	60,853	66,938	2,697,953	2,967,748
2045	61,650	67,815	2,758,806	3,034,687
2046	62,457	68,702	2,820,456	3,102,501
2047	63,274	69,602	2,882,912	3,171,204
2048	64,102	70,513	2,946,187	3,240,805
2049	64,941	71,436	3,010,289	3,311,318
2050	65,792	72,371	3,075,230	3,382,754
2051	66,653	73,318	3,141,022	3,455,124
2052	67,525	74,278	3,207,675	3,528,442
2053	68,409	75,250	3,275,200	3,602,720
2054	69,305	76,235	3,343,609	3,677,970
2055	70,212	77,233	3,412,914	3,754,205
2056	71,131	78,244	3,483,125	3,831,438
2057	72,062	79,268	3,554,256	3,909,682
2058	73,005	80,306	3,626,318	3,988,950
2059	73,961	81,357	3,699,323	4,069,255

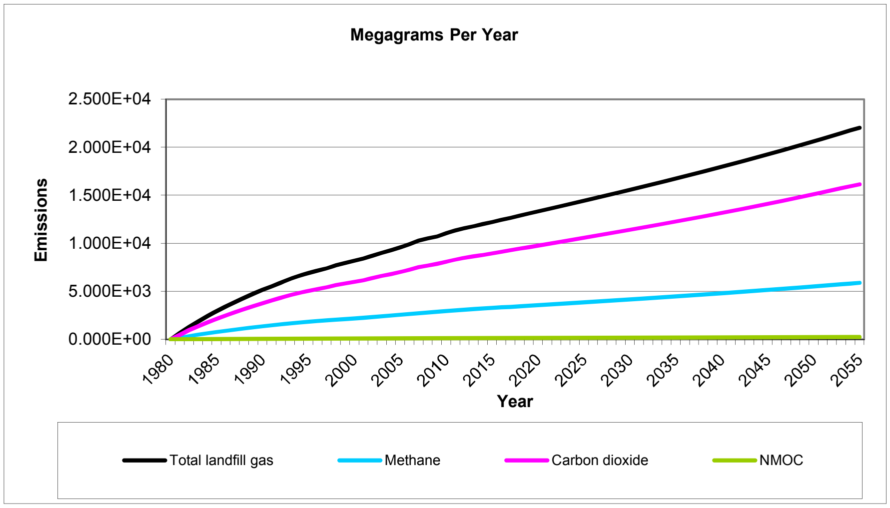
Pollutant Parameters

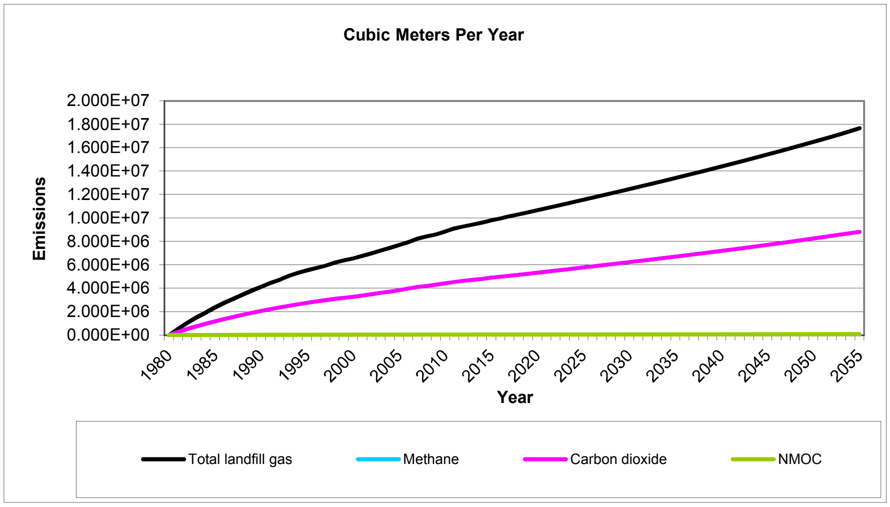
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

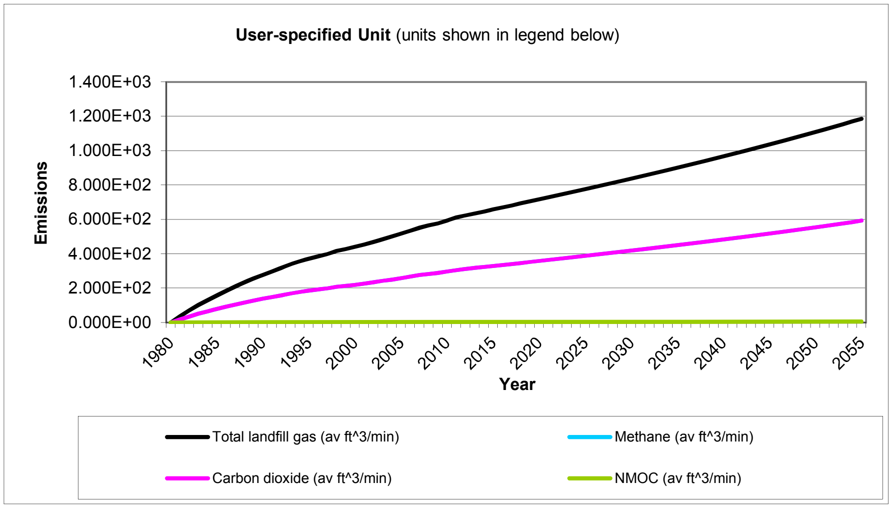
Pollutant Parameters (Continued)

		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
Emissions
2.500E+04
2.000E+04
1.500E+04
1.000E+04
5.000E+03
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
2.000E+07
1.800E+07
1.600E+07
1.400E+07
1.200E+07
1.000E+07
8.000E+06
6.000E+06
4.000E+06
2.000E+06
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
1.400E+03
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1980	0	0	0	0	0	0
1981	6.772E+02	5.423E+05	3.644E+01	1.809E+02	2.711E+05	1.822E+01
1982	1.321E+03	1.058E+06	7.110E+01	3.530E+02	5.291E+05	3.555E+01
1983	1.889E+03	1.513E+06	1.016E+02	5.046E+02	7.563E+05	5.082E+01
1984	2.429E+03	1.945E+06	1.307E+02	6.488E+02	9.725E+05	6.534E+01
1985	2.943E+03	2.356E+06	1.583E+02	7.860E+02	1.178E+06	7.916E+01
1986	3.431E+03	2.748E+06	1.846E+02	9.165E+02	1.374E+06	9.230E+01
1987	3.896E+03	3.120E+06	2.096E+02	1.041E+03	1.560E+06	1.048E+02
1988	4.338E+03	3.474E+06	2.334E+02	1.159E+03	1.737E+06	1.167E+02
1989	4.759E+03	3.810E+06	2.560E+02	1.271E+03	1.905E+06	1.280E+02
1990	5.159E+03	4.131E+06	2.775E+02	1.378E+03	2.065E+06	1.388E+02
1991	5.539E+03	4.435E+06	2.980E+02	1.480E+03	2.218E+06	1.490E+02
1992	5.901E+03	4.725E+06	3.175E+02	1.576E+03	2.363E+06	1.587E+02
1993	6.292E+03	5.038E+06	3.385E+02	1.681E+03	2.519E+06	1.693E+02
1994	6.634E+03	5.312E+06	3.569E+02	1.772E+03	2.656E+06	1.785E+02
1995	6.919E+03	5.541E+06	3.723E+02	1.848E+03	2.770E+06	1.861E+02
1996	7.164E+03	5.736E+06	3.854E+02	1.913E+03	2.868E+06	1.927E+02
1997	7.398E+03	5.924E+06	3.980E+02	1.976E+03	2.962E+06	1.990E+02
1998	7.731E+03	6.190E+06	4.159E+02	2.065E+03	3.095E+06	2.080E+02
1999	7.959E+03	6.373E+06	4.282E+02	2.126E+03	3.187E+06	2.141E+02
2000	8.187E+03	6.556E+06	4.405E+02	2.187E+03	3.278E+06	2.203E+02
2001	8.435E+03	6.755E+06	4.539E+02	2.253E+03	3.377E+06	2.269E+02
2002	8.717E+03	6.980E+06	4.690E+02	2.328E+03	3.490E+06	2.345E+02
2003	9.033E+03	7.233E+06	4.860E+02	2.413E+03	3.617E+06	2.430E+02
2004	9.292E+03	7.440E+06	4.999E+02	2.482E+03	3.720E+06	2.500E+02
2005	9.608E+03	7.694E+06	5.170E+02	2.567E+03	3.847E+06	2.585E+02
2006	9.925E+03	7.947E+06	5.340E+02	2.651E+03	3.974E+06	2.670E+02
2007	1.028E+04	8.233E+06	5.531E+02	2.746E+03	4.116E+06	2.766E+02
2008	1.052E+04	8.426E+06	5.661E+02	2.811E+03	4.213E+06	2.831E+02
2009	1.074E+04	8.597E+06	5.776E+02	2.868E+03	4.299E+06	2.888E+02
2010	1.104E+04	8.841E+06	5.940E+02	2.949E+03	4.421E+06	2.970E+02
2011	1.137E+04	9.104E+06	6.117E+02	3.037E+03	4.552E+06	3.058E+02
2012	1.158E+04	9.276E+06	6.232E+02	3.094E+03	4.638E+06	3.116E+02
2013	1.180E+04	9.449E+06	6.349E+02	3.152E+03	4.725E+06	3.174E+02
2014	1.201E+04	9.619E+06	6.463E+02	3.209E+03	4.809E+06	3.231E+02
2015	1.223E+04	9.794E+06	6.581E+02	3.267E+03	4.897E+06	3.290E+02
2016	1.245E+04	9.969E+06	6.698E+02	3.326E+03	4.985E+06	3.349E+02
2017	1.267E+04	1.014E+07	6.816E+02	3.384E+03	5.072E+06	3.408E+02
2018	1.289E+04	1.032E+07	6.934E+02	3.443E+03	5.160E+06	3.467E+02
2019	1.311E+04	1.050E+07	7.052E+02	3.501E+03	5.248E+06	3.526E+02
2020	1.333E+04	1.067E+07	7.170E+02	3.560E+03	5.336E+06	3.585E+02
2021	1.355E+04	1.085E+07	7.289E+02	3.619E+03	5.424E+06	3.644E+02
2022	1.377E+04	1.102E+07	7.408E+02	3.678E+03	5.512E+06	3.704E+02
2023	1.399E+04	1.120E+07	7.527E+02	3.737E+03	5.601E+06	3.763E+02
2024	1.421E+04	1.138E+07	7.647E+02	3.796E+03	5.690E+06	3.823E+02
2025	1.444E+04	1.156E+07	7.767E+02	3.856E+03	5.780E+06	3.883E+02
2026	1.466E+04	1.174E+07	7.888E+02	3.916E+03	5.870E+06	3.944E+02
2027	1.489E+04	1.192E+07	8.009E+02	3.976E+03	5.960E+06	4.005E+02
2028	1.511E+04	1.210E+07	8.132E+02	4.037E+03	6.051E+06	4.066E+02
2029	1.534E+04	1.229E+07	8.254E+02	4.098E+03	6.143E+06	4.127E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2030	1.557E+04	1.247E+07	8.378E+02	4.159E+03	6.235E+06	4.189E+02
2031	1.580E+04	1.265E+07	8.503E+02	4.221E+03	6.327E+06	4.251E+02
2032	1.604E+04	1.284E+07	8.628E+02	4.284E+03	6.421E+06	4.314E+02
2033	1.627E+04	1.303E+07	8.755E+02	4.346E+03	6.515E+06	4.377E+02
2034	1.651E+04	1.322E+07	8.882E+02	4.410E+03	6.610E+06	4.441E+02
2035	1.675E+04	1.341E+07	9.011E+02	4.474E+03	6.705E+06	4.505E+02
2036	1.699E+04	1.360E+07	9.140E+02	4.538E+03	6.802E+06	4.570E+02
2037	1.723E+04	1.380E+07	9.271E+02	4.603E+03	6.899E+06	4.636E+02
2038	1.748E+04	1.399E+07	9.403E+02	4.668E+03	6.997E+06	4.701E+02
2039	1.772E+04	1.419E+07	9.536E+02	4.734E+03	7.096E+06	4.768E+02
2040	1.797E+04	1.439E+07	9.670E+02	4.801E+03	7.196E+06	4.835E+02
2041	1.823E+04	1.459E+07	9.806E+02	4.868E+03	7.297E+06	4.903E+02
2042	1.848E+04	1.480E+07	9.943E+02	4.936E+03	7.399E+06	4.972E+02
2043	1.874E+04	1.500E+07	1.008E+03	5.005E+03	7.502E+06	5.041E+02
2044	1.900E+04	1.521E+07	1.022E+03	5.074E+03	7.606E+06	5.111E+02
2045	1.926E+04	1.542E+07	1.036E+03	5.145E+03	7.711E+06	5.181E+02
2046	1.953E+04	1.563E+07	1.051E+03	5.215E+03	7.817E+06	5.253E+02
2047	1.979E+04	1.585E+07	1.065E+03	5.287E+03	7.925E+06	5.325E+02
2048	2.006E+04	1.607E+07	1.080E+03	5.359E+03	8.033E+06	5.398E+02
2049	2.034E+04	1.629E+07	1.094E+03	5.433E+03	8.143E+06	5.471E+02
2050	2.062E+04	1.651E+07	1.109E+03	5.507E+03	8.254E+06	5.546E+02
2051	2.090E+04	1.673E+07	1.124E+03	5.581E+03	8.366E+06	5.621E+02
2052	2.118E+04	1.696E+07	1.139E+03	5.657E+03	8.479E+06	5.697E+02
2053	2.146E+04	1.719E+07	1.155E+03	5.734E+03	8.594E+06	5.774E+02
2054	2.175E+04	1.742E+07	1.170E+03	5.811E+03	8.710E+06	5.852E+02
2055	2.205E+04	1.765E+07	1.186E+03	5.889E+03	8.827E+06	5.931E+02
2056	2.234E+04	1.789E+07	1.202E+03	5.968E+03	8.946E+06	6.011E+02
2057	2.264E+04	1.813E+07	1.218E+03	6.049E+03	9.066E+06	6.092E+02
2058	2.295E+04	1.838E+07	1.235E+03	6.130E+03	9.188E+06	6.173E+02
2059	2.326E+04	1.862E+07	1.251E+03	6.212E+03	9.311E+06	6.256E+02
2060	2.357E+04	1.887E+07	1.268E+03	6.295E+03	9.435E+06	6.340E+02
2061	2.242E+04	1.795E+07	1.206E+03	5.988E+03	8.975E+06	6.030E+02
2062	2.132E+04	1.707E+07	1.147E+03	5.696E+03	8.537E+06	5.736E+02
2063	2.028E+04	1.624E+07	1.091E+03	5.418E+03	8.121E+06	5.457E+02
2064	1.929E+04	1.545E+07	1.038E+03	5.154E+03	7.725E+06	5.190E+02
2065	1.835E+04	1.470E+07	9.875E+02	4.902E+03	7.348E+06	4.937E+02
2066	1.746E+04	1.398E+07	9.393E+02	4.663E+03	6.990E+06	4.696E+02
2067	1.661E+04	1.330E+07	8.935E+02	4.436E+03	6.649E+06	4.467E+02
2068	1.580E+04	1.265E+07	8.499E+02	4.220E+03	6.325E+06	4.250E+02
2069	1.503E+04	1.203E+07	8.085E+02	4.014E+03	6.016E+06	4.042E+02
2070	1.429E+04	1.145E+07	7.690E+02	3.818E+03	5.723E+06	3.845E+02
2071	1.360E+04	1.089E+07	7.315E+02	3.632E+03	5.444E+06	3.658E+02
2072	1.293E+04	1.036E+07	6.958E+02	3.455E+03	5.178E+06	3.479E+02
2073	1.230E+04	9.851E+06	6.619E+02	3.286E+03	4.926E+06	3.310E+02
2074	1.170E+04	9.371E+06	6.296E+02	3.126E+03	4.685E+06	3.148E+02
2075	1.113E+04	8.914E+06	5.989E+02	2.973E+03	4.457E+06	2.995E+02
2076	1.059E+04	8.479E+06	5.697E+02	2.828E+03	4.240E+06	2.849E+02
2077	1.007E+04	8.066E+06	5.419E+02	2.690E+03	4.033E+06	2.710E+02
2078	9.581E+03	7.672E+06	5.155E+02	2.559E+03	3.836E+06	2.577E+02
2079	9.114E+03	7.298E+06	4.904E+02	2.434E+03	3.649E+06	2.452E+02
2080	8.670E+03	6.942E+06	4.664E+02	2.316E+03	3.471E+06	2.332E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	8.247E+03	6.604E+06	4.437E+02	2.203E+03	3.302E+06	2.218E+02
2082	7.844E+03	6.282E+06	4.221E+02	2.095E+03	3.141E+06	2.110E+02
2083	7.462E+03	5.975E+06	4.015E+02	1.993E+03	2.988E+06	2.007E+02
2084	7.098E+03	5.684E+06	3.819E+02	1.896E+03	2.842E+06	1.909E+02
2085	6.752E+03	5.407E+06	3.633E+02	1.803E+03	2.703E+06	1.816E+02
2086	6.423E+03	5.143E+06	3.455E+02	1.716E+03	2.571E+06	1.728E+02
2087	6.109E+03	4.892E+06	3.287E+02	1.632E+03	2.446E+06	1.643E+02
2088	5.811E+03	4.653E+06	3.127E+02	1.552E+03	2.327E+06	1.563E+02
2089	5.528E+03	4.427E+06	2.974E+02	1.477E+03	2.213E+06	1.487E+02
2090	5.258E+03	4.211E+06	2.829E+02	1.405E+03	2.105E+06	1.415E+02
2091	5.002E+03	4.005E+06	2.691E+02	1.336E+03	2.003E+06	1.346E+02
2092	4.758E+03	3.810E+06	2.560E+02	1.271E+03	1.905E+06	1.280E+02
2093	4.526E+03	3.624E+06	2.435E+02	1.209E+03	1.812E+06	1.218E+02
2094	4.305E+03	3.447E+06	2.316E+02	1.150E+03	1.724E+06	1.158E+02
2095	4.095E+03	3.279E+06	2.203E+02	1.094E+03	1.640E+06	1.102E+02
2096	3.895E+03	3.119E+06	2.096E+02	1.041E+03	1.560E+06	1.048E+02
2097	3.705E+03	2.967E+06	1.994E+02	9.898E+02	1.484E+06	9.968E+01
2098	3.525E+03	2.822E+06	1.896E+02	9.415E+02	1.411E+06	9.482E+01
2099	3.353E+03	2.685E+06	1.804E+02	8.956E+02	1.342E+06	9.020E+01
2100	3.189E+03	2.554E+06	1.716E+02	8.519E+02	1.277E+06	8.580E+01
2101	3.034E+03	2.429E+06	1.632E+02	8.104E+02	1.215E+06	8.161E+01
2102	2.886E+03	2.311E+06	1.553E+02	7.708E+02	1.155E+06	7.763E+01
2103	2.745E+03	2.198E+06	1.477E+02	7.332E+02	1.099E+06	7.385E+01
2104	2.611E+03	2.091E+06	1.405E+02	6.975E+02	1.045E+06	7.024E+01
2105	2.484E+03	1.989E+06	1.336E+02	6.635E+02	9.945E+05	6.682E+01
2106	2.363E+03	1.892E+06	1.271E+02	6.311E+02	9.460E+05	6.356E+01
2107	2.247E+03	1.800E+06	1.209E+02	6.003E+02	8.998E+05	6.046E+01
2108	2.138E+03	1.712E+06	1.150E+02	5.710E+02	8.560E+05	5.751E+01
2109	2.034E+03	1.628E+06	1.094E+02	5.432E+02	8.142E+05	5.471E+01
2110	1.934E+03	1.549E+06	1.041E+02	5.167E+02	7.745E+05	5.204E+01
2111	1.840E+03	1.473E+06	9.900E+01	4.915E+02	7.367E+05	4.950E+01
2112	1.750E+03	1.402E+06	9.417E+01	4.675E+02	7.008E+05	4.709E+01
2113	1.665E+03	1.333E+06	8.958E+01	4.447E+02	6.666E+05	4.479E+01
2114	1.584E+03	1.268E+06	8.521E+01	4.230E+02	6.341E+05	4.261E+01
2115	1.507E+03	1.206E+06	8.106E+01	4.024E+02	6.032E+05	4.053E+01
2116	1.433E+03	1.148E+06	7.710E+01	3.828E+02	5.738E+05	3.855E+01
2117	1.363E+03	1.092E+06	7.334E+01	3.641E+02	5.458E+05	3.667E+01
2118	1.297E+03	1.038E+06	6.977E+01	3.464E+02	5.192E+05	3.488E+01
2119	1.233E+03	9.877E+05	6.636E+01	3.295E+02	4.938E+05	3.318E+01
2120	1.173E+03	9.395E+05	6.313E+01	3.134E+02	4.698E+05	3.156E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1980	0	0	0	0	0	0
1981	4.963E+02	2.711E+05	1.822E+01	7.775E+00	2.169E+03	1.457E-01
1982	9.685E+02	5.291E+05	3.555E+01	1.517E+01	4.233E+03	2.844E-01
1983	1.384E+03	7.563E+05	5.082E+01	2.169E+01	6.051E+03	4.065E-01
1984	1.780E+03	9.725E+05	6.534E+01	2.789E+01	7.780E+03	5.228E-01
1985	2.157E+03	1.178E+06	7.916E+01	3.378E+01	9.425E+03	6.333E-01
1986	2.515E+03	1.374E+06	9.230E+01	3.939E+01	1.099E+04	7.384E-01
1987	2.855E+03	1.560E+06	1.048E+02	4.473E+01	1.248E+04	8.385E-01
1988	3.179E+03	1.737E+06	1.167E+02	4.981E+01	1.389E+04	9.336E-01
1989	3.487E+03	1.905E+06	1.280E+02	5.463E+01	1.524E+04	1.024E+00
1990	3.781E+03	2.065E+06	1.388E+02	5.923E+01	1.652E+04	1.110E+00
1991	4.060E+03	2.218E+06	1.490E+02	6.359E+01	1.774E+04	1.192E+00
1992	4.325E+03	2.363E+06	1.587E+02	6.775E+01	1.890E+04	1.270E+00
1993	4.611E+03	2.519E+06	1.693E+02	7.224E+01	2.015E+04	1.354E+00
1994	4.862E+03	2.656E+06	1.785E+02	7.616E+01	2.125E+04	1.428E+00
1995	5.071E+03	2.770E+06	1.861E+02	7.944E+01	2.216E+04	1.489E+00
1996	5.250E+03	2.868E+06	1.927E+02	8.225E+01	2.295E+04	1.542E+00
1997	5.422E+03	2.962E+06	1.990E+02	8.494E+01	2.370E+04	1.592E+00
1998	5.666E+03	3.095E+06	2.080E+02	8.876E+01	2.476E+04	1.664E+00
1999	5.833E+03	3.187E+06	2.141E+02	9.138E+01	2.549E+04	1.713E+00
2000	6.000E+03	3.278E+06	2.203E+02	9.400E+01	2.622E+04	1.762E+00
2001	6.182E+03	3.377E+06	2.269E+02	9.685E+01	2.702E+04	1.815E+00
2002	6.388E+03	3.490E+06	2.345E+02	1.001E+02	2.792E+04	1.876E+00
2003	6.620E+03	3.617E+06	2.430E+02	1.037E+02	2.893E+04	1.944E+00
2004	6.810E+03	3.720E+06	2.500E+02	1.067E+02	2.976E+04	2.000E+00
2005	7.042E+03	3.847E+06	2.585E+02	1.103E+02	3.078E+04	2.068E+00
2006	7.274E+03	3.974E+06	2.670E+02	1.139E+02	3.179E+04	2.136E+00
2007	7.535E+03	4.116E+06	2.766E+02	1.180E+02	3.293E+04	2.213E+00
2008	7.711E+03	4.213E+06	2.831E+02	1.208E+02	3.370E+04	2.264E+00
2009	7.868E+03	4.299E+06	2.888E+02	1.233E+02	3.439E+04	2.311E+00
2010	8.092E+03	4.421E+06	2.970E+02	1.268E+02	3.536E+04	2.376E+00
2011	8.332E+03	4.552E+06	3.058E+02	1.305E+02	3.642E+04	2.447E+00
2012	8.490E+03	4.638E+06	3.116E+02	1.330E+02	3.710E+04	2.493E+00
2013	8.648E+03	4.725E+06	3.174E+02	1.355E+02	3.780E+04	2.540E+00
2014	8.804E+03	4.809E+06	3.231E+02	1.379E+02	3.848E+04	2.585E+00
2015	8.964E+03	4.897E+06	3.290E+02	1.404E+02	3.918E+04	2.632E+00
2016	9.125E+03	4.985E+06	3.349E+02	1.429E+02	3.988E+04	2.679E+00
2017	9.285E+03	5.072E+06	3.408E+02	1.455E+02	4.058E+04	2.727E+00
2018	9.446E+03	5.160E+06	3.467E+02	1.480E+02	4.128E+04	2.774E+00
2019	9.606E+03	5.248E+06	3.526E+02	1.505E+02	4.198E+04	2.821E+00
2020	9.767E+03	5.336E+06	3.585E+02	1.530E+02	4.269E+04	2.868E+00
2021	9.929E+03	5.424E+06	3.644E+02	1.555E+02	4.339E+04	2.916E+00
2022	1.009E+04	5.512E+06	3.704E+02	1.581E+02	4.410E+04	2.963E+00
2023	1.025E+04	5.601E+06	3.763E+02	1.606E+02	4.481E+04	3.011E+00
2024	1.042E+04	5.690E+06	3.823E+02	1.632E+02	4.552E+04	3.059E+00
2025	1.058E+04	5.780E+06	3.883E+02	1.657E+02	4.624E+04	3.107E+00
2026	1.074E+04	5.870E+06	3.944E+02	1.683E+02	4.696E+04	3.155E+00
2027	1.091E+04	5.960E+06	4.005E+02	1.709E+02	4.768E+04	3.204E+00
2028	1.108E+04	6.051E+06	4.066E+02	1.735E+02	4.841E+04	3.253E+00
2029	1.124E+04	6.143E+06	4.127E+02	1.761E+02	4.914E+04	3.302E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2030	1.141E+04	6.235E+06	4.189E+02	1.788E+02	4.988E+04	3.351E+00
2031	1.158E+04	6.327E+06	4.251E+02	1.814E+02	5.062E+04	3.401E+00
2032	1.175E+04	6.421E+06	4.314E+02	1.841E+02	5.137E+04	3.451E+00
2033	1.193E+04	6.515E+06	4.377E+02	1.868E+02	5.212E+04	3.502E+00
2034	1.210E+04	6.610E+06	4.441E+02	1.895E+02	5.288E+04	3.553E+00
2035	1.227E+04	6.705E+06	4.505E+02	1.923E+02	5.364E+04	3.604E+00
2036	1.245E+04	6.802E+06	4.570E+02	1.950E+02	5.442E+04	3.656E+00
2037	1.263E+04	6.899E+06	4.636E+02	1.978E+02	5.519E+04	3.708E+00
2038	1.281E+04	6.997E+06	4.701E+02	2.007E+02	5.598E+04	3.761E+00
2039	1.299E+04	7.096E+06	4.768E+02	2.035E+02	5.677E+04	3.814E+00
2040	1.317E+04	7.196E+06	4.835E+02	2.064E+02	5.757E+04	3.868E+00
2041	1.336E+04	7.297E+06	4.903E+02	2.093E+02	5.838E+04	3.922E+00
2042	1.354E+04	7.399E+06	4.972E+02	2.122E+02	5.919E+04	3.977E+00
2043	1.373E+04	7.502E+06	5.041E+02	2.151E+02	6.002E+04	4.033E+00
2044	1.392E+04	7.606E+06	5.111E+02	2.181E+02	6.085E+04	4.088E+00
2045	1.412E+04	7.711E+06	5.181E+02	2.211E+02	6.169E+04	4.145E+00
2046	1.431E+04	7.817E+06	5.253E+02	2.242E+02	6.254E+04	4.202E+00
2047	1.451E+04	7.925E+06	5.325E+02	2.272E+02	6.340E+04	4.260E+00
2048	1.470E+04	8.033E+06	5.398E+02	2.304E+02	6.427E+04	4.318E+00
2049	1.491E+04	8.143E+06	5.471E+02	2.335E+02	6.514E+04	4.377E+00
2050	1.511E+04	8.254E+06	5.546E+02	2.367E+02	6.603E+04	4.437E+00
2051	1.531E+04	8.366E+06	5.621E+02	2.399E+02	6.693E+04	4.497E+00
2052	1.552E+04	8.479E+06	5.697E+02	2.432E+02	6.783E+04	4.558E+00
2053	1.573E+04	8.594E+06	5.774E+02	2.464E+02	6.875E+04	4.619E+00
2054	1.594E+04	8.710E+06	5.852E+02	2.498E+02	6.968E+04	4.682E+00
2055	1.616E+04	8.827E+06	5.931E+02	2.531E+02	7.062E+04	4.745E+00
2056	1.638E+04	8.946E+06	6.011E+02	2.565E+02	7.157E+04	4.809E+00
2057	1.660E+04	9.066E+06	6.092E+02	2.600E+02	7.253E+04	4.873E+00
2058	1.682E+04	9.188E+06	6.173E+02	2.635E+02	7.350E+04	4.939E+00
2059	1.704E+04	9.311E+06	6.256E+02	2.670E+02	7.449E+04	5.005E+00
2060	1.727E+04	9.435E+06	6.340E+02	2.706E+02	7.548E+04	5.072E+00
2061	1.643E+04	8.975E+06	6.030E+02	2.574E+02	7.180E+04	4.824E+00
2062	1.563E+04	8.537E+06	5.736E+02	2.448E+02	6.830E+04	4.589E+00
2063	1.487E+04	8.121E+06	5.457E+02	2.329E+02	6.497E+04	4.365E+00
2064	1.414E+04	7.725E+06	5.190E+02	2.215E+02	6.180E+04	4.152E+00
2065	1.345E+04	7.348E+06	4.937E+02	2.107E+02	5.879E+04	3.950E+00
2066	1.279E+04	6.990E+06	4.696E+02	2.004E+02	5.592E+04	3.757E+00
2067	1.217E+04	6.649E+06	4.467E+02	1.907E+02	5.319E+04	3.574E+00
2068	1.158E+04	6.325E+06	4.250E+02	1.814E+02	5.060E+04	3.400E+00
2069	1.101E+04	6.016E+06	4.042E+02	1.725E+02	4.813E+04	3.234E+00
2070	1.048E+04	5.723E+06	3.845E+02	1.641E+02	4.578E+04	3.076E+00
2071	9.965E+03	5.444E+06	3.658E+02	1.561E+02	4.355E+04	2.926E+00
2072	9.479E+03	5.178E+06	3.479E+02	1.485E+02	4.143E+04	2.783E+00
2073	9.016E+03	4.926E+06	3.310E+02	1.412E+02	3.941E+04	2.648E+00
2074	8.577E+03	4.685E+06	3.148E+02	1.344E+02	3.748E+04	2.519E+00
2075	8.158E+03	4.457E+06	2.995E+02	1.278E+02	3.566E+04	2.396E+00
2076	7.761E+03	4.240E+06	2.849E+02	1.216E+02	3.392E+04	2.279E+00
2077	7.382E+03	4.033E+06	2.710E+02	1.156E+02	3.226E+04	2.168E+00
2078	7.022E+03	3.836E+06	2.577E+02	1.100E+02	3.069E+04	2.062E+00
2079	6.680E+03	3.649E+06	2.452E+02	1.046E+02	2.919E+04	1.961E+00
2080	6.354E+03	3.471E+06	2.332E+02	9.954E+01	2.777E+04	1.866E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	6.044E+03	3.302E+06	2.218E+02	9.468E+01	2.641E+04	1.775E+00
2082	5.749E+03	3.141E+06	2.110E+02	9.006E+01	2.513E+04	1.688E+00
2083	5.469E+03	2.988E+06	2.007E+02	8.567E+01	2.390E+04	1.606E+00
2084	5.202E+03	2.842E+06	1.909E+02	8.149E+01	2.273E+04	1.528E+00
2085	4.948E+03	2.703E+06	1.816E+02	7.752E+01	2.163E+04	1.453E+00
2086	4.707E+03	2.571E+06	1.728E+02	7.374E+01	2.057E+04	1.382E+00
2087	4.477E+03	2.446E+06	1.643E+02	7.014E+01	1.957E+04	1.315E+00
2088	4.259E+03	2.327E+06	1.563E+02	6.672E+01	1.861E+04	1.251E+00
2089	4.051E+03	2.213E+06	1.487E+02	6.347E+01	1.771E+04	1.190E+00
2090	3.854E+03	2.105E+06	1.415E+02	6.037E+01	1.684E+04	1.132E+00
2091	3.666E+03	2.003E+06	1.346E+02	5.743E+01	1.602E+04	1.076E+00
2092	3.487E+03	1.905E+06	1.280E+02	5.463E+01	1.524E+04	1.024E+00
2093	3.317E+03	1.812E+06	1.218E+02	5.196E+01	1.450E+04	9.740E-01
2094	3.155E+03	1.724E+06	1.158E+02	4.943E+01	1.379E+04	9.265E-01
2095	3.001E+03	1.640E+06	1.102E+02	4.702E+01	1.312E+04	8.813E-01
2096	2.855E+03	1.560E+06	1.048E+02	4.472E+01	1.248E+04	8.383E-01
2097	2.716E+03	1.484E+06	9.968E+01	4.254E+01	1.187E+04	7.975E-01
2098	2.583E+03	1.411E+06	9.482E+01	4.047E+01	1.129E+04	7.586E-01
2099	2.457E+03	1.342E+06	9.020E+01	3.849E+01	1.074E+04	7.216E-01
2100	2.337E+03	1.277E+06	8.580E+01	3.662E+01	1.022E+04	6.864E-01
2101	2.223E+03	1.215E+06	8.161E+01	3.483E+01	9.717E+03	6.529E-01
2102	2.115E+03	1.155E+06	7.763E+01	3.313E+01	9.243E+03	6.211E-01
2103	2.012E+03	1.099E+06	7.385E+01	3.152E+01	8.793E+03	5.908E-01
2104	1.914E+03	1.045E+06	7.024E+01	2.998E+01	8.364E+03	5.620E-01
2105	1.820E+03	9.945E+05	6.682E+01	2.852E+01	7.956E+03	5.346E-01
2106	1.732E+03	9.460E+05	6.356E+01	2.713E+01	7.568E+03	5.085E-01
2107	1.647E+03	8.998E+05	6.046E+01	2.580E+01	7.199E+03	4.837E-01
2108	1.567E+03	8.560E+05	5.751E+01	2.455E+01	6.848E+03	4.601E-01
2109	1.490E+03	8.142E+05	5.471E+01	2.335E+01	6.514E+03	4.377E-01
2110	1.418E+03	7.745E+05	5.204E+01	2.221E+01	6.196E+03	4.163E-01
2111	1.349E+03	7.367E+05	4.950E+01	2.113E+01	5.894E+03	3.960E-01
2112	1.283E+03	7.008E+05	4.709E+01	2.010E+01	5.606E+03	3.767E-01
2113	1.220E+03	6.666E+05	4.479E+01	1.912E+01	5.333E+03	3.583E-01
2114	1.161E+03	6.341E+05	4.261E+01	1.818E+01	5.073E+03	3.408E-01
2115	1.104E+03	6.032E+05	4.053E+01	1.730E+01	4.825E+03	3.242E-01
2116	1.050E+03	5.738E+05	3.855E+01	1.645E+01	4.590E+03	3.084E-01
2117	9.991E+02	5.458E+05	3.667E+01	1.565E+01	4.366E+03	2.934E-01
2118	9.503E+02	5.192E+05	3.488E+01	1.489E+01	4.153E+03	2.791E-01
2119	9.040E+02	4.938E+05	3.318E+01	1.416E+01	3.951E+03	2.655E-01
2120	8.599E+02	4.698E+05	3.156E+01	1.347E+01	3.758E+03	2.525E-01

LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o\left(\frac{M_i}{10}\right)e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2060**	
Landfill Closure Year (with 80-year limit)	**2092**	
Actual Closure Year (without limit)	***2092***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**160**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
2060	74,929	82,422	0	0
2061	75,910	83,501	74,929	82,422
2062	76,903	84,594	150,838	165,922
2063	77,910	85,701	227,742	250,516
2064	78,930	86,823	305,651	336,217
2065	79,963	87,959	384,581	423,039
2066	81,009	89,110	464,544	510,998
2067	82,070	90,277	545,553	600,109
2068	83,144	91,459	627,623	690,386
2069	84,232	92,656	710,767	781,844
2070	85,335	93,869	795,000	874,500
2071	86,452	95,097	880,335	968,368
2072	87,584	96,342	966,787	1,063,466
2073	88,730	97,603	1,054,370	1,159,808
2074	89,892	98,881	1,143,101	1,257,411
2075	91,068	100,175	1,232,992	1,356,291
2076	92,260	101,486	1,324,060	1,456,466
2077	93,468	102,815	1,416,320	1,557,953
2078	94,691	104,160	1,509,788	1,660,767
2079	95,931	105,524	1,604,480	1,764,928
2080	97,186	106,905	1,700,410	1,870,451
2081	98,459	108,304	1,797,597	1,977,357
2082	99,747	109,722	1,896,056	2,085,661
2083	101,053	111,158	1,995,803	2,195,383
2084	102,376	112,613	2,096,856	2,306,542
2085	103,716	114,087	2,199,232	2,419,155
2086	105,073	115,581	2,302,948	2,533,242
2087	106,449	117,094	2,408,021	2,648,823
2088	107,842	118,626	2,514,470	2,765,917
2089	109,254	120,179	2,622,312	2,884,543
2090	110,684	121,752	2,731,566	3,004,723
2091	112,133	123,346	2,842,250	3,126,475
2092	70,048	77,053	2,954,383	3,249,821
2093	0	0	3,024,431	3,326,874
2094	0	0	3,024,431	3,326,874
2095	0	0	3,024,431	3,326,874
2096	0	0	3,024,431	3,326,874
2097	0	0	3,024,431	3,326,874
2098	0	0	3,024,431	3,326,874
2099	0	0	3,024,431	3,326,874

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2100	0	0	3,024,431	3,326,874
2101	0	0	3,024,431	3,326,874
2102	0	0	3,024,431	3,326,874
2103	0	0	3,024,431	3,326,874
2104	0	0	3,024,431	3,326,874
2105	0	0	3,024,431	3,326,874
2106	0	0	3,024,431	3,326,874
2107	0	0	3,024,431	3,326,874
2108	0	0	3,024,431	3,326,874
2109	0	0	3,024,431	3,326,874
2110	0	0	3,024,431	3,326,874
2111	0	0	3,024,431	3,326,874
2112	0	0	3,024,431	3,326,874
2113	0	0	3,024,431	3,326,874
2114	0	0	3,024,431	3,326,874
2115	0	0	3,024,431	3,326,874
2116	0	0	3,024,431	3,326,874
2117	0	0	3,024,431	3,326,874
2118	0	0	3,024,431	3,326,874
2119	0	0	3,024,431	3,326,874
2120	0	0	3,024,431	3,326,874
2121	0	0	3,024,431	3,326,874
2122	0	0	3,024,431	3,326,874
2123	0	0	3,024,431	3,326,874
2124	0	0	3,024,431	3,326,874
2125	0	0	3,024,431	3,326,874
2126	0	0	3,024,431	3,326,874
2127	0	0	3,024,431	3,326,874
2128	0	0	3,024,431	3,326,874
2129	0	0	3,024,431	3,326,874
2130	0	0	3,024,431	3,326,874
2131	0	0	3,024,431	3,326,874
2132	0	0	3,024,431	3,326,874
2133	0	0	3,024,431	3,326,874
2134	0	0	3,024,431	3,326,874
2135	0	0	3,024,431	3,326,874
2136	0	0	3,024,431	3,326,874
2137	0	0	3,024,431	3,326,874
2138	0	0	3,024,431	3,326,874
2139	0	0	3,024,431	3,326,874

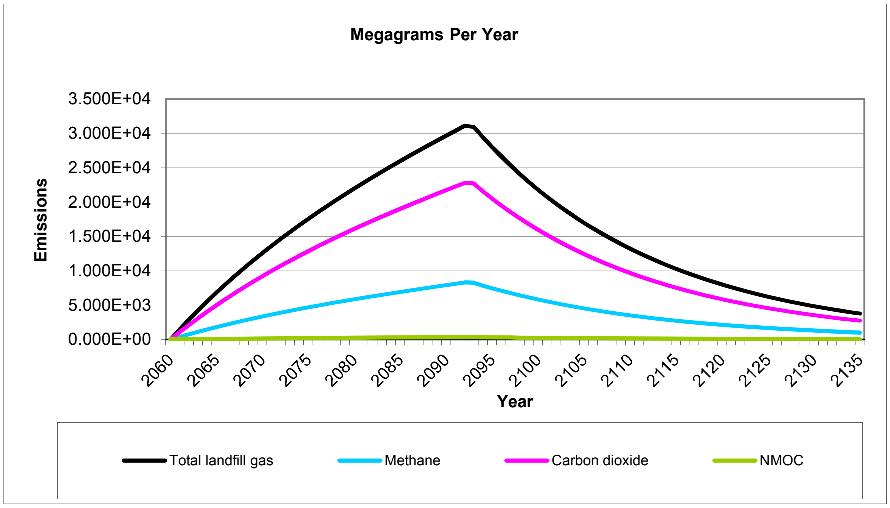
Pollutant Parameters

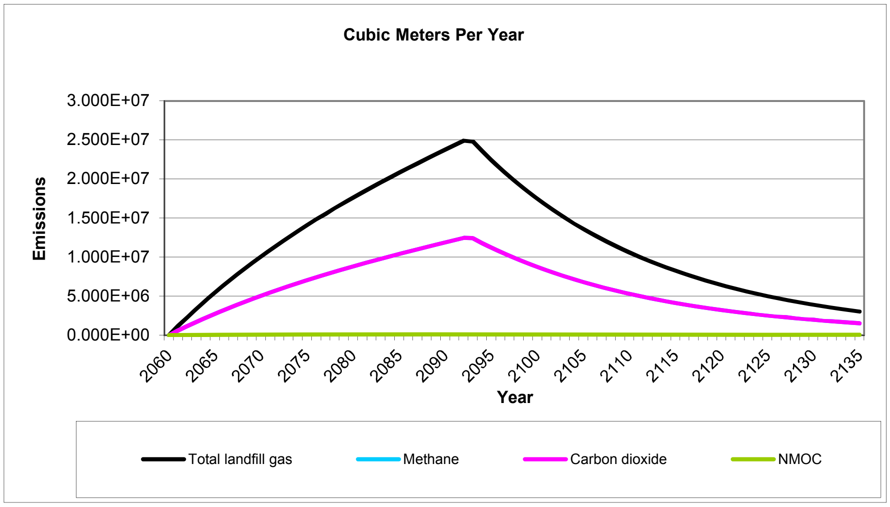
	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

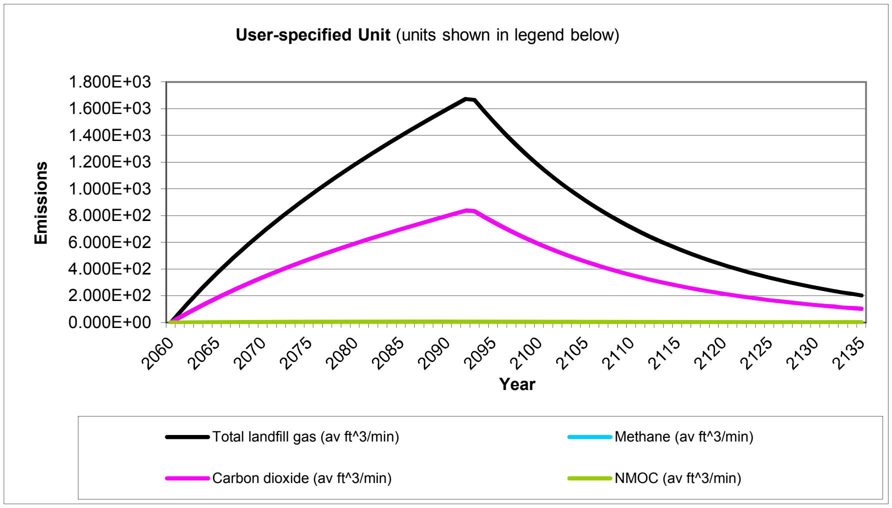
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
Emissions
3.500E+04
3.000E+04
2.500E+04
2.000E+04
1.500E+04
1.000E+04
5.000E+03
0.000E+00
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
3.000E+07
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+06
0.000E+00
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
1.800E+03
1.600E+03
1.400E+03
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	1.464E+03	1.172E+06	7.877E+01	3.911E+02	5.862E+05	3.938E+01
2062	2.876E+03	2.303E+06	1.547E+02	7.682E+02	1.151E+06	7.736E+01
2063	4.238E+03	3.394E+06	2.280E+02	1.132E+03	1.697E+06	1.140E+02
2064	5.554E+03	4.447E+06	2.988E+02	1.483E+03	2.224E+06	1.494E+02
2065	6.825E+03	5.465E+06	3.672E+02	1.823E+03	2.733E+06	1.836E+02
2066	8.054E+03	6.450E+06	4.334E+02	2.151E+03	3.225E+06	2.167E+02
2067	9.244E+03	7.403E+06	4.974E+02	2.469E+03	3.701E+06	2.487E+02
2068	1.040E+04	8.326E+06	5.594E+02	2.777E+03	4.163E+06	2.797E+02
2069	1.151E+04	9.220E+06	6.195E+02	3.076E+03	4.610E+06	3.098E+02
2070	1.260E+04	1.009E+07	6.778E+02	3.365E+03	5.044E+06	3.389E+02
2071	1.365E+04	1.093E+07	7.345E+02	3.647E+03	5.466E+06	3.672E+02
2072	1.468E+04	1.175E+07	7.896E+02	3.920E+03	5.876E+06	3.948E+02
2073	1.567E+04	1.255E+07	8.431E+02	4.186E+03	6.274E+06	4.216E+02
2074	1.664E+04	1.332E+07	8.953E+02	4.445E+03	6.662E+06	4.476E+02
2075	1.758E+04	1.408E+07	9.461E+02	4.697E+03	7.041E+06	4.731E+02
2076	1.851E+04	1.482E+07	9.957E+02	4.943E+03	7.410E+06	4.978E+02
2077	1.941E+04	1.554E+07	1.044E+03	5.184E+03	7.770E+06	5.221E+02
2078	2.029E+04	1.624E+07	1.091E+03	5.419E+03	8.122E+06	5.457E+02
2079	2.115E+04	1.693E+07	1.138E+03	5.649E+03	8.467E+06	5.689E+02
2080	2.199E+04	1.761E+07	1.183E+03	5.874E+03	8.804E+06	5.916E+02
2081	2.282E+04	1.827E+07	1.228E+03	6.095E+03	9.135E+06	6.138E+02
2082	2.363E+04	1.892E+07	1.271E+03	6.311E+03	9.460E+06	6.356E+02
2083	2.442E+04	1.956E+07	1.314E+03	6.524E+03	9.779E+06	6.570E+02
2084	2.521E+04	2.018E+07	1.356E+03	6.733E+03	1.009E+07	6.781E+02
2085	2.598E+04	2.080E+07	1.398E+03	6.939E+03	1.040E+07	6.988E+02
2086	2.674E+04	2.141E+07	1.439E+03	7.142E+03	1.071E+07	7.193E+02
2087	2.749E+04	2.201E+07	1.479E+03	7.342E+03	1.101E+07	7.394E+02
2088	2.823E+04	2.260E+07	1.519E+03	7.539E+03	1.130E+07	7.593E+02
2089	2.896E+04	2.319E+07	1.558E+03	7.735E+03	1.159E+07	7.790E+02
2090	2.968E+04	2.377E+07	1.597E+03	7.928E+03	1.188E+07	7.984E+02
2091	3.039E+04	2.434E+07	1.635E+03	8.119E+03	1.217E+07	8.176E+02
2092	3.110E+04	2.491E+07	1.673E+03	8.308E+03	1.245E+07	8.367E+02
2093	3.095E+04	2.479E+07	1.665E+03	8.268E+03	1.239E+07	8.327E+02
2094	2.944E+04	2.358E+07	1.584E+03	7.865E+03	1.179E+07	7.921E+02
2095	2.801E+04	2.243E+07	1.507E+03	7.481E+03	1.121E+07	7.535E+02
2096	2.664E+04	2.133E+07	1.433E+03	7.117E+03	1.067E+07	7.167E+02
2097	2.534E+04	2.029E+07	1.364E+03	6.769E+03	1.015E+07	6.818E+02
2098	2.411E+04	1.930E+07	1.297E+03	6.439E+03	9.652E+06	6.485E+02
2099	2.293E+04	1.836E+07	1.234E+03	6.125E+03	9.181E+06	6.169E+02
2100	2.181E+04	1.747E+07	1.174E+03	5.827E+03	8.734E+06	5.868E+02
2101	2.075E+04	1.662E+07	1.116E+03	5.542E+03	8.308E+06	5.582E+02
2102	1.974E+04	1.580E+07	1.062E+03	5.272E+03	7.902E+06	5.310E+02
2103	1.877E+04	1.503E+07	1.010E+03	5.015E+03	7.517E+06	5.051E+02
2104	1.786E+04	1.430E+07	9.609E+02	4.770E+03	7.150E+06	4.804E+02
2105	1.699E+04	1.360E+07	9.140E+02	4.538E+03	6.802E+06	4.570E+02
2106	1.616E+04	1.294E+07	8.694E+02	4.316E+03	6.470E+06	4.347E+02
2107	1.537E+04	1.231E+07	8.270E+02	4.106E+03	6.154E+06	4.135E+02
2108	1.462E+04	1.171E+07	7.867E+02	3.906E+03	5.854E+06	3.933E+02
2109	1.391E+04	1.114E+07	7.483E+02	3.715E+03	5.569E+06	3.742E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2110	1.323E+04	1.059E+07	7.118E+02	3.534E+03	5.297E+06	3.559E+02
2111	1.259E+04	1.008E+07	6.771E+02	3.362E+03	5.039E+06	3.386E+02
2112	1.197E+04	9.586E+06	6.441E+02	3.198E+03	4.793E+06	3.220E+02
2113	1.139E+04	9.119E+06	6.127E+02	3.042E+03	4.559E+06	3.063E+02
2114	1.083E+04	8.674E+06	5.828E+02	2.893E+03	4.337E+06	2.914E+02
2115	1.030E+04	8.251E+06	5.544E+02	2.752E+03	4.125E+06	2.772E+02
2116	9.801E+03	7.848E+06	5.273E+02	2.618E+03	3.924E+06	2.637E+02
2117	9.323E+03	7.466E+06	5.016E+02	2.490E+03	3.733E+06	2.508E+02
2118	8.869E+03	7.102E+06	4.772E+02	2.369E+03	3.551E+06	2.386E+02
2119	8.436E+03	6.755E+06	4.539E+02	2.253E+03	3.378E+06	2.269E+02
2120	8.025E+03	6.426E+06	4.317E+02	2.143E+03	3.213E+06	2.159E+02
2121	7.633E+03	6.112E+06	4.107E+02	2.039E+03	3.056E+06	2.053E+02
2122	7.261E+03	5.814E+06	3.907E+02	1.939E+03	2.907E+06	1.953E+02
2123	6.907E+03	5.531E+06	3.716E+02	1.845E+03	2.765E+06	1.858E+02
2124	6.570E+03	5.261E+06	3.535E+02	1.755E+03	2.630E+06	1.767E+02
2125	6.250E+03	5.004E+06	3.362E+02	1.669E+03	2.502E+06	1.681E+02
2126	5.945E+03	4.760E+06	3.198E+02	1.588E+03	2.380E+06	1.599E+02
2127	5.655E+03	4.528E+06	3.042E+02	1.510E+03	2.264E+06	1.521E+02
2128	5.379E+03	4.307E+06	2.894E+02	1.437E+03	2.154E+06	1.447E+02
2129	5.117E+03	4.097E+06	2.753E+02	1.367E+03	2.049E+06	1.376E+02
2130	4.867E+03	3.897E+06	2.619E+02	1.300E+03	1.949E+06	1.309E+02
2131	4.630E+03	3.707E+06	2.491E+02	1.237E+03	1.854E+06	1.245E+02
2132	4.404E+03	3.527E+06	2.369E+02	1.176E+03	1.763E+06	1.185E+02
2133	4.189E+03	3.355E+06	2.254E+02	1.119E+03	1.677E+06	1.127E+02
2134	3.985E+03	3.191E+06	2.144E+02	1.064E+03	1.595E+06	1.072E+02
2135	3.791E+03	3.035E+06	2.039E+02	1.013E+03	1.518E+06	1.020E+02
2136	3.606E+03	2.887E+06	1.940E+02	9.631E+02	1.444E+06	9.700E+01
2137	3.430E+03	2.746E+06	1.845E+02	9.162E+02	1.373E+06	9.227E+01
2138	3.263E+03	2.613E+06	1.755E+02	8.715E+02	1.306E+06	8.777E+01
2139	3.103E+03	2.485E+06	1.670E+02	8.290E+02	1.243E+06	8.349E+01
2140	2.952E+03	2.364E+06	1.588E+02	7.885E+02	1.182E+06	7.942E+01
2141	2.808E+03	2.249E+06	1.511E+02	7.501E+02	1.124E+06	7.554E+01
2142	2.671E+03	2.139E+06	1.437E+02	7.135E+02	1.069E+06	7.186E+01
2143	2.541E+03	2.035E+06	1.367E+02	6.787E+02	1.017E+06	6.835E+01
2144	2.417E+03	1.935E+06	1.300E+02	6.456E+02	9.677E+05	6.502E+01
2145	2.299E+03	1.841E+06	1.237E+02	6.141E+02	9.205E+05	6.185E+01
2146	2.187E+03	1.751E+06	1.177E+02	5.842E+02	8.756E+05	5.883E+01
2147	2.080E+03	1.666E+06	1.119E+02	5.557E+02	8.329E+05	5.596E+01
2148	1.979E+03	1.585E+06	1.065E+02	5.286E+02	7.923E+05	5.323E+01
2149	1.882E+03	1.507E+06	1.013E+02	5.028E+02	7.536E+05	5.064E+01
2150	1.791E+03	1.434E+06	9.634E+01	4.783E+02	7.169E+05	4.817E+01
2151	1.703E+03	1.364E+06	9.164E+01	4.549E+02	6.819E+05	4.582E+01
2152	1.620E+03	1.297E+06	8.717E+01	4.328E+02	6.487E+05	4.358E+01
2153	1.541E+03	1.234E+06	8.292E+01	4.117E+02	6.170E+05	4.146E+01
2154	1.466E+03	1.174E+06	7.887E+01	3.916E+02	5.869E+05	3.944E+01
2155	1.394E+03	1.117E+06	7.503E+01	3.725E+02	5.583E+05	3.751E+01
2156	1.326E+03	1.062E+06	7.137E+01	3.543E+02	5.311E+05	3.568E+01
2157	1.262E+03	1.010E+06	6.789E+01	3.370E+02	5.052E+05	3.394E+01
2158	1.200E+03	9.611E+05	6.458E+01	3.206E+02	4.805E+05	3.229E+01
2159	1.142E+03	9.142E+05	6.143E+01	3.050E+02	4.571E+05	3.071E+01
2160	1.086E+03	8.696E+05	5.843E+01	2.901E+02	4.348E+05	2.922E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3 /year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3 /year)*	*(av ft^3/min)*
2161	1.033E+03	8.272E+05	5.558E+01	2.759E+02	4.136E+05	2.779E+01
2162	9.827E+02	7.869E+05	5.287E+01	2.625E+02	3.934E+05	2.644E+01
2163	9.347E+02	7.485E+05	5.029E+01	2.497E+02	3.742E+05	2.515E+01
2164	8.892E+02	7.120E+05	4.784E+01	2.375E+02	3.560E+05	2.392E+01
2165	8.458E+02	6.773E+05	4.551E+01	2.259E+02	3.386E+05	2.275E+01
2166	8.045E+02	6.442E+05	4.329E+01	2.149E+02	3.221E+05	2.164E+01
2167	7.653E+02	6.128E+05	4.118E+01	2.044E+02	3.064E+05	2.059E+01
2168	7.280E+02	5.829E+05	3.917E+01	1.945E+02	2.915E+05	1.958E+01
2169	6.925E+02	5.545E+05	3.726E+01	1.850E+02	2.773E+05	1.863E+01
2170	6.587E+02	5.275E+05	3.544E+01	1.759E+02	2.637E+05	1.772E+01
2171	6.266E+02	5.017E+05	3.371E+01	1.674E+02	2.509E+05	1.686E+01
2172	5.960E+02	4.773E+05	3.207E+01	1.592E+02	2.386E+05	1.603E+01
2173	5.670E+02	4.540E+05	3.050E+01	1.514E+02	2.270E+05	1.525E+01
2174	5.393E+02	4.318E+05	2.902E+01	1.441E+02	2.159E+05	1.451E+01
2175	5.130E+02	4.108E+05	2.760E+01	1.370E+02	2.054E+05	1.380E+01
2176	4.880E+02	3.908E+05	2.625E+01	1.303E+02	1.954E+05	1.313E+01
2177	4.642E+02	3.717E+05	2.497E+01	1.240E+02	1.858E+05	1.249E+01
2178	4.415E+02	3.536E+05	2.376E+01	1.179E+02	1.768E+05	1.188E+01
2179	4.200E+02	3.363E+05	2.260E+01	1.122E+02	1.682E+05	1.130E+01
2180	3.995E+02	3.199E+05	2.150E+01	1.067E+02	1.600E+05	1.075E+01
2181	3.800E+02	3.043E+05	2.045E+01	1.015E+02	1.522E+05	1.022E+01
2182	3.615E+02	2.895E+05	1.945E+01	9.656E+01	1.447E+05	9.725E+00
2183	3.439E+02	2.754E+05	1.850E+01	9.185E+01	1.377E+05	9.251E+00
2184	3.271E+02	2.619E+05	1.760E+01	8.737E+01	1.310E+05	8.799E+00
2185	3.111E+02	2.492E+05	1.674E+01	8.311E+01	1.246E+05	8.370E+00
2186	2.960E+02	2.370E+05	1.592E+01	7.906E+01	1.185E+05	7.962E+00
2187	2.815E+02	2.254E+05	1.515E+01	7.520E+01	1.127E+05	7.574E+00
2188	2.678E+02	2.144E+05	1.441E+01	7.153E+01	1.072E+05	7.204E+00
2189	2.547E+02	2.040E+05	1.371E+01	6.805E+01	1.020E+05	6.853E+00
2190	2.423E+02	1.940E+05	1.304E+01	6.473E+01	9.702E+04	6.519E+00
2191	2.305E+02	1.846E+05	1.240E+01	6.157E+01	9.229E+04	6.201E+00
2192	2.193E+02	1.756E+05	1.180E+01	5.857E+01	8.779E+04	5.898E+00
2193	2.086E+02	1.670E+05	1.122E+01	5.571E+01	8.351E+04	5.611E+00
2194	1.984E+02	1.589E+05	1.067E+01	5.299E+01	7.943E+04	5.337E+00
2195	1.887E+02	1.511E+05	1.015E+01	5.041E+01	7.556E+04	5.077E+00
2196	1.795E+02	1.437E+05	9.658E+00	4.795E+01	7.187E+04	4.829E+00
2197	1.708E+02	1.367E+05	9.187E+00	4.561E+01	6.837E+04	4.594E+00
2198	1.624E+02	1.301E+05	8.739E+00	4.339E+01	6.503E+04	4.370E+00
2199	1.545E+02	1.237E+05	8.313E+00	4.127E+01	6.186E+04	4.157E+00
2200	1.470E+02	1.177E+05	7.908E+00	3.926E+01	5.885E+04	3.954E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	1.073E+03	5.862E+05	3.938E+01	1.681E+01	4.689E+03	3.151E-01
2062	2.108E+03	1.151E+06	7.736E+01	3.302E+01	9.211E+03	6.189E-01
2063	3.106E+03	1.697E+06	1.140E+02	4.866E+01	1.357E+04	9.121E-01
2064	4.070E+03	2.224E+06	1.494E+02	6.376E+01	1.779E+04	1.195E+00
2065	5.002E+03	2.733E+06	1.836E+02	7.836E+01	2.186E+04	1.469E+00
2066	5.903E+03	3.225E+06	2.167E+02	9.247E+01	2.580E+04	1.733E+00
2067	6.775E+03	3.701E+06	2.487E+02	1.061E+02	2.961E+04	1.990E+00
2068	7.620E+03	4.163E+06	2.797E+02	1.194E+02	3.330E+04	2.238E+00
2069	8.439E+03	4.610E+06	3.098E+02	1.322E+02	3.688E+04	2.478E+00
2070	9.234E+03	5.044E+06	3.389E+02	1.446E+02	4.035E+04	2.711E+00
2071	1.001E+04	5.466E+06	3.672E+02	1.567E+02	4.373E+04	2.938E+00
2072	1.076E+04	5.876E+06	3.948E+02	1.685E+02	4.700E+04	3.158E+00
2073	1.148E+04	6.274E+06	4.216E+02	1.799E+02	5.019E+04	3.372E+00
2074	1.220E+04	6.662E+06	4.476E+02	1.910E+02	5.330E+04	3.581E+00
2075	1.289E+04	7.041E+06	4.731E+02	2.019E+02	5.632E+04	3.784E+00
2076	1.356E+04	7.410E+06	4.978E+02	2.125E+02	5.928E+04	3.983E+00
2077	1.422E+04	7.770E+06	5.221E+02	2.228E+02	6.216E+04	4.176E+00
2078	1.487E+04	8.122E+06	5.457E+02	2.329E+02	6.498E+04	4.366E+00
2079	1.550E+04	8.467E+06	5.689E+02	2.428E+02	6.773E+04	4.551E+00
2080	1.612E+04	8.804E+06	5.916E+02	2.525E+02	7.043E+04	4.732E+00
2081	1.672E+04	9.135E+06	6.138E+02	2.620E+02	7.308E+04	4.910E+00
2082	1.732E+04	9.460E+06	6.356E+02	2.713E+02	7.568E+04	5.085E+00
2083	1.790E+04	9.779E+06	6.570E+02	2.804E+02	7.823E+04	5.256E+00
2084	1.847E+04	1.009E+07	6.781E+02	2.894E+02	8.074E+04	5.425E+00
2085	1.904E+04	1.040E+07	6.988E+02	2.983E+02	8.321E+04	5.591E+00
2086	1.960E+04	1.071E+07	7.193E+02	3.070E+02	8.564E+04	5.754E+00
2087	2.014E+04	1.101E+07	7.394E+02	3.156E+02	8.804E+04	5.915E+00
2088	2.069E+04	1.130E+07	7.593E+02	3.241E+02	9.041E+04	6.075E+00
2089	2.122E+04	1.159E+07	7.790E+02	3.325E+02	9.275E+04	6.232E+00
2090	2.175E+04	1.188E+07	7.984E+02	3.407E+02	9.506E+04	6.387E+00
2091	2.228E+04	1.217E+07	8.176E+02	3.490E+02	9.735E+04	6.541E+00
2092	2.279E+04	1.245E+07	8.367E+02	3.571E+02	9.962E+04	6.694E+00
2093	2.269E+04	1.239E+07	8.327E+02	3.554E+02	9.915E+04	6.662E+00
2094	2.158E+04	1.179E+07	7.921E+02	3.381E+02	9.431E+04	6.337E+00
2095	2.053E+04	1.121E+07	7.535E+02	3.216E+02	8.971E+04	6.028E+00
2096	1.953E+04	1.067E+07	7.167E+02	3.059E+02	8.534E+04	5.734E+00
2097	1.857E+04	1.015E+07	6.818E+02	2.910E+02	8.118E+04	5.454E+00
2098	1.767E+04	9.652E+06	6.485E+02	2.768E+02	7.722E+04	5.188E+00
2099	1.681E+04	9.181E+06	6.169E+02	2.633E+02	7.345E+04	4.935E+00
2100	1.599E+04	8.734E+06	5.868E+02	2.504E+02	6.987E+04	4.694E+00
2101	1.521E+04	8.308E+06	5.582E+02	2.382E+02	6.646E+04	4.465E+00
2102	1.447E+04	7.902E+06	5.310E+02	2.266E+02	6.322E+04	4.248E+00
2103	1.376E+04	7.517E+06	5.051E+02	2.156E+02	6.014E+04	4.041E+00
2104	1.309E+04	7.150E+06	4.804E+02	2.050E+02	5.720E+04	3.843E+00
2105	1.245E+04	6.802E+06	4.570E+02	1.950E+02	5.441E+04	3.656E+00
2106	1.184E+04	6.470E+06	4.347E+02	1.855E+02	5.176E+04	3.478E+00
2107	1.127E+04	6.154E+06	4.135E+02	1.765E+02	4.924E+04	3.308E+00
2108	1.072E+04	5.854E+06	3.933E+02	1.679E+02	4.683E+04	3.147E+00
2109	1.019E+04	5.569E+06	3.742E+02	1.597E+02	4.455E+04	2.993E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2110	9.696E+03	5.297E+06	3.559E+02	1.519E+02	4.238E+04	2.847E+00
2111	9.224E+03	5.039E+06	3.386E+02	1.445E+02	4.031E+04	2.708E+00
2112	8.774E+03	4.793E+06	3.220E+02	1.374E+02	3.834E+04	2.576E+00
2113	8.346E+03	4.559E+06	3.063E+02	1.307E+02	3.647E+04	2.451E+00
2114	7.939E+03	4.337E+06	2.914E+02	1.244E+02	3.470E+04	2.331E+00
2115	7.552E+03	4.125E+06	2.772E+02	1.183E+02	3.300E+04	2.217E+00
2116	7.183E+03	3.924E+06	2.637E+02	1.125E+02	3.139E+04	2.109E+00
2117	6.833E+03	3.733E+06	2.508E+02	1.070E+02	2.986E+04	2.006E+00
2118	6.500E+03	3.551E+06	2.386E+02	1.018E+02	2.841E+04	1.909E+00
2119	6.183E+03	3.378E+06	2.269E+02	9.686E+01	2.702E+04	1.816E+00
2120	5.881E+03	3.213E+06	2.159E+02	9.213E+01	2.570E+04	1.727E+00
2121	5.594E+03	3.056E+06	2.053E+02	8.764E+01	2.445E+04	1.643E+00
2122	5.322E+03	2.907E+06	1.953E+02	8.336E+01	2.326E+04	1.563E+00
2123	5.062E+03	2.765E+06	1.858E+02	7.930E+01	2.212E+04	1.486E+00
2124	4.815E+03	2.630E+06	1.767E+02	7.543E+01	2.104E+04	1.414E+00
2125	4.580E+03	2.502E+06	1.681E+02	7.175E+01	2.002E+04	1.345E+00
2126	4.357E+03	2.380E+06	1.599E+02	6.825E+01	1.904E+04	1.279E+00
2127	4.144E+03	2.264E+06	1.521E+02	6.492E+01	1.811E+04	1.217E+00
2128	3.942E+03	2.154E+06	1.447E+02	6.176E+01	1.723E+04	1.158E+00
2129	3.750E+03	2.049E+06	1.376E+02	5.875E+01	1.639E+04	1.101E+00
2130	3.567E+03	1.949E+06	1.309E+02	5.588E+01	1.559E+04	1.047E+00
2131	3.393E+03	1.854E+06	1.245E+02	5.316E+01	1.483E+04	9.964E-01
2132	3.228E+03	1.763E+06	1.185E+02	5.056E+01	1.411E+04	9.478E-01
2133	3.070E+03	1.677E+06	1.127E+02	4.810E+01	1.342E+04	9.016E-01
2134	2.921E+03	1.595E+06	1.072E+02	4.575E+01	1.276E+04	8.576E-01
2135	2.778E+03	1.518E+06	1.020E+02	4.352E+01	1.214E+04	8.158E-01
2136	2.643E+03	1.444E+06	9.700E+01	4.140E+01	1.155E+04	7.760E-01
2137	2.514E+03	1.373E+06	9.227E+01	3.938E+01	1.099E+04	7.381E-01
2138	2.391E+03	1.306E+06	8.777E+01	3.746E+01	1.045E+04	7.021E-01
2139	2.274E+03	1.243E+06	8.349E+01	3.563E+01	9.940E+03	6.679E-01
2140	2.164E+03	1.182E+06	7.942E+01	3.389E+01	9.456E+03	6.353E-01
2141	2.058E+03	1.124E+06	7.554E+01	3.224E+01	8.994E+03	6.043E-01
2142	1.958E+03	1.069E+06	7.186E+01	3.067E+01	8.556E+03	5.749E-01
2143	1.862E+03	1.017E+06	6.835E+01	2.917E+01	8.139E+03	5.468E-01
2144	1.771E+03	9.677E+05	6.502E+01	2.775E+01	7.742E+03	5.202E-01
2145	1.685E+03	9.205E+05	6.185E+01	2.640E+01	7.364E+03	4.948E-01
2146	1.603E+03	8.756E+05	5.883E+01	2.511E+01	7.005E+03	4.707E-01
2147	1.525E+03	8.329E+05	5.596E+01	2.388E+01	6.663E+03	4.477E-01
2148	1.450E+03	7.923E+05	5.323E+01	2.272E+01	6.338E+03	4.259E-01
2149	1.380E+03	7.536E+05	5.064E+01	2.161E+01	6.029E+03	4.051E-01
2150	1.312E+03	7.169E+05	4.817E+01	2.056E+01	5.735E+03	3.853E-01
2151	1.248E+03	6.819E+05	4.582E+01	1.955E+01	5.455E+03	3.665E-01
2152	1.187E+03	6.487E+05	4.358E+01	1.860E+01	5.189E+03	3.487E-01
2153	1.129E+03	6.170E+05	4.146E+01	1.769E+01	4.936E+03	3.317E-01
2154	1.074E+03	5.869E+05	3.944E+01	1.683E+01	4.696E+03	3.155E-01
2155	1.022E+03	5.583E+05	3.751E+01	1.601E+01	4.467E+03	3.001E-01
2156	9.722E+02	5.311E+05	3.568E+01	1.523E+01	4.249E+03	2.855E-01
2157	9.247E+02	5.052E+05	3.394E+01	1.449E+01	4.041E+03	2.715E-01
2158	8.796E+02	4.805E+05	3.229E+01	1.378E+01	3.844E+03	2.583E-01
2159	8.367E+02	4.571E+05	3.071E+01	1.311E+01	3.657E+03	2.457E-01
2160	7.959E+02	4.348E+05	2.922E+01	1.247E+01	3.479E+03	2.337E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2161	7.571E+02	4.136E+05	2.779E+01	1.186E+01	3.309E+03	2.223E-01
2162	7.202E+02	3.934E+05	2.644E+01	1.128E+01	3.148E+03	2.115E-01
2163	6.851E+02	3.742E+05	2.515E+01	1.073E+01	2.994E+03	2.012E-01
2164	6.517E+02	3.560E+05	2.392E+01	1.021E+01	2.848E+03	1.914E-01
2165	6.199E+02	3.386E+05	2.275E+01	9.711E+00	2.709E+03	1.820E-01
2166	5.896E+02	3.221E+05	2.164E+01	9.237E+00	2.577E+03	1.731E-01
2167	5.609E+02	3.064E+05	2.059E+01	8.787E+00	2.451E+03	1.647E-01
2168	5.335E+02	2.915E+05	1.958E+01	8.358E+00	2.332E+03	1.567E-01
2169	5.075E+02	2.773E+05	1.863E+01	7.950E+00	2.218E+03	1.490E-01
2170	4.828E+02	2.637E+05	1.772E+01	7.563E+00	2.110E+03	1.418E-01
2171	4.592E+02	2.509E+05	1.686E+01	7.194E+00	2.007E+03	1.348E-01
2172	4.368E+02	2.386E+05	1.603E+01	6.843E+00	1.909E+03	1.283E-01
2173	4.155E+02	2.270E+05	1.525E+01	6.509E+00	1.816E+03	1.220E-01
2174	3.952E+02	2.159E+05	1.451E+01	6.192E+00	1.727E+03	1.161E-01
2175	3.760E+02	2.054E+05	1.380E+01	5.890E+00	1.643E+03	1.104E-01
2176	3.576E+02	1.954E+05	1.313E+01	5.603E+00	1.563E+03	1.050E-01
2177	3.402E+02	1.858E+05	1.249E+01	5.329E+00	1.487E+03	9.990E-02
2178	3.236E+02	1.768E+05	1.188E+01	5.069E+00	1.414E+03	9.502E-02
2179	3.078E+02	1.682E+05	1.130E+01	4.822E+00	1.345E+03	9.039E-02
2180	2.928E+02	1.600E+05	1.075E+01	4.587E+00	1.280E+03	8.598E-02
2181	2.785E+02	1.522E+05	1.022E+01	4.363E+00	1.217E+03	8.179E-02
2182	2.649E+02	1.447E+05	9.725E+00	4.150E+00	1.158E+03	7.780E-02
2183	2.520E+02	1.377E+05	9.251E+00	3.948E+00	1.101E+03	7.401E-02
2184	2.397E+02	1.310E+05	8.799E+00	3.755E+00	1.048E+03	7.040E-02
2185	2.280E+02	1.246E+05	8.370E+00	3.572E+00	9.966E+02	6.696E-02
2186	2.169E+02	1.185E+05	7.962E+00	3.398E+00	9.480E+02	6.370E-02
2187	2.063E+02	1.127E+05	7.574E+00	3.232E+00	9.018E+02	6.059E-02
2188	1.963E+02	1.072E+05	7.204E+00	3.075E+00	8.578E+02	5.764E-02
2189	1.867E+02	1.020E+05	6.853E+00	2.925E+00	8.160E+02	5.482E-02
2190	1.776E+02	9.702E+04	6.519E+00	2.782E+00	7.762E+02	5.215E-02
2191	1.689E+02	9.229E+04	6.201E+00	2.646E+00	7.383E+02	4.961E-02
2192	1.607E+02	8.779E+04	5.898E+00	2.517E+00	7.023E+02	4.719E-02
2193	1.529E+02	8.351E+04	5.611E+00	2.395E+00	6.681E+02	4.489E-02
2194	1.454E+02	7.943E+04	5.337E+00	2.278E+00	6.355E+02	4.270E-02
2195	1.383E+02	7.556E+04	5.077E+00	2.167E+00	6.045E+02	4.061E-02
2196	1.316E+02	7.187E+04	4.829E+00	2.061E+00	5.750E+02	3.863E-02
2197	1.251E+02	6.837E+04	4.594E+00	1.961E+00	5.470E+02	3.675E-02
2198	1.190E+02	6.503E+04	4.370E+00	1.865E+00	5.203E+02	3.496E-02
2199	1.132E+02	6.186E+04	4.157E+00	1.774E+00	4.949E+02	3.325E-02
2200	1.077E+02	5.885E+04	3.954E+00	1.687E+00	4.708E+02	3.163E-02

LandGEM
Landfill Gas Emissions Model
Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)
M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1980**	
Landfill Closure Year (with 80-year limit)	**2059**	
Actual Closure Year (without limit)	***2059***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.010**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**20**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
1980	26,230	28,853	0	0
1981	26,230	28,853	26,230	28,853
1982	24,482	26,930	52,460	57,706
1983	24,482	26,930	76,942	84,636
1984	24,482	26,930	101,423	111,566
1985	24,482	26,930	125,905	138,495
1986	24,482	26,930	150,386	165,425
1987	24,482	26,930	174,868	192,355
1988	24,482	26,930	199,349	219,284
1989	24,482	26,930	223,831	246,214
1990	24,482	26,930	248,312	273,144
1991	24,482	26,930	272,794	300,073
1992	26,279	28,906	297,275	327,003
1993	25,131	27,644	323,554	355,909
1994	23,596	25,956	348,685	383,553
1995	22,528	24,781	372,281	409,509
1996	22,622	24,885	394,809	434,290
1997	26,853	29,538	417,432	459,175
1998	23,452	25,797	444,285	488,713
1999	23,872	26,259	467,736	514,510
2000	25,073	27,580	491,609	540,769
2001	26,828	29,511	516,682	568,350
2002	28,706	31,577	543,510	597,861
2003	27,096	29,806	572,216	629,438
2004	29,815	32,797	599,312	659,244
2005	30,407	33,448	629,128	692,040
2006	32,541	35,795	659,535	725,488
2007	28,753	31,628	692,076	761,283
2008	28,171	30,988	720,828	792,911
2009	32,085	35,294	748,999	823,899
2010	33,561	36,917	781,085	859,193
2011	29,788	32,767	814,646	896,110
2012	30,271	33,298	844,434	928,877
2013	30,497	33,546	874,705	962,175
2014	31,175	34,292	905,202	995,722
2015	31,583	34,741	936,376	1,030,014
2016	31,996	35,196	967,959	1,064,755
2017	32,415	35,657	999,956	1,099,951
2018	32,839	36,123	1,032,371	1,135,608
2019	33,269	36,596	1,065,210	1,171,731

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2020	33,705	37,075	1,098,479	1,208,327
2021	34,146	37,560	1,132,184	1,245,402
2022	34,593	38,052	1,166,330	1,282,963
2023	35,046	38,550	1,200,923	1,321,015
2024	35,504	39,055	1,235,968	1,359,565
2025	35,969	39,566	1,271,473	1,398,620
2026	36,440	40,084	1,307,442	1,438,186
2027	36,917	40,609	1,343,882	1,478,270
2028	37,400	41,140	1,380,799	1,518,879
2029	37,890	41,679	1,418,199	1,560,019
2030	38,386	42,224	1,456,089	1,601,698
2031	38,888	42,777	1,494,474	1,643,922
2032	39,397	43,337	1,533,363	1,686,699
2033	39,913	43,904	1,572,760	1,730,036
2034	40,435	44,479	1,612,673	1,773,940
2035	40,965	45,061	1,653,108	1,818,419
2036	41,501	45,651	1,694,072	1,863,480
2037	42,044	46,248	1,735,573	1,909,131
2038	42,594	46,854	1,777,617	1,955,379
2039	43,152	47,467	1,820,212	2,002,233
2040	43,717	48,088	1,863,364	2,049,700
2041	44,289	48,718	1,907,080	2,097,788
2042	44,869	49,356	1,951,369	2,146,506
2043	45,456	50,002	1,996,238	2,195,862
2044	46,051	50,656	2,041,694	2,245,863
2045	46,654	51,319	2,087,745	2,296,520
2046	47,264	51,991	2,134,399	2,347,839
2047	47,883	52,671	2,181,663	2,399,830
2048	48,510	53,361	2,229,547	2,452,501
2049	49,145	54,059	2,278,057	2,505,862
2050	49,788	54,767	2,327,201	2,559,922
2051	50,440	55,484	2,376,990	2,614,689
2052	51,100	56,210	2,427,430	2,670,172
2053	51,769	56,946	2,478,530	2,726,383
2054	52,447	57,691	2,530,299	2,783,329
2055	53,133	58,446	2,582,745	2,841,020
2056	53,829	59,212	2,635,879	2,899,466
2057	54,533	59,987	2,689,707	2,958,678
2058	55,247	60,772	2,744,240	3,018,665
2059	55,970	61,567	2,799,488	3,079,436

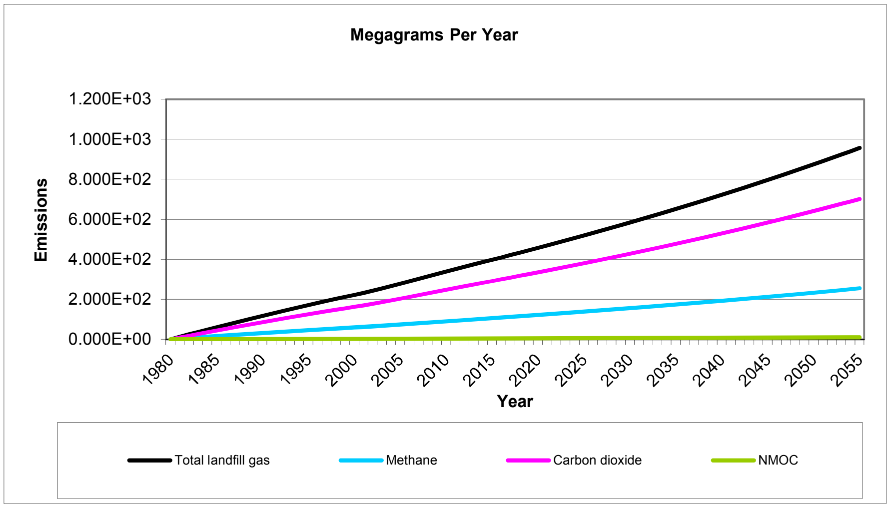
Pollutant Parameters

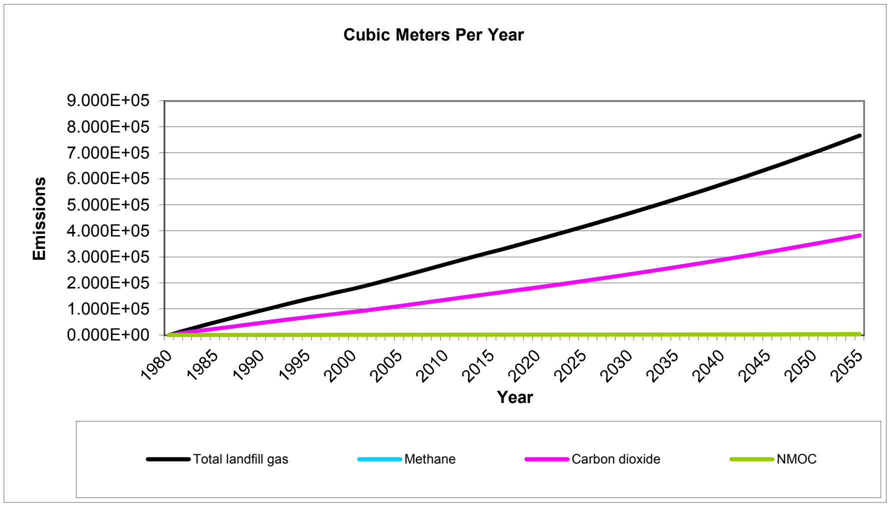
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

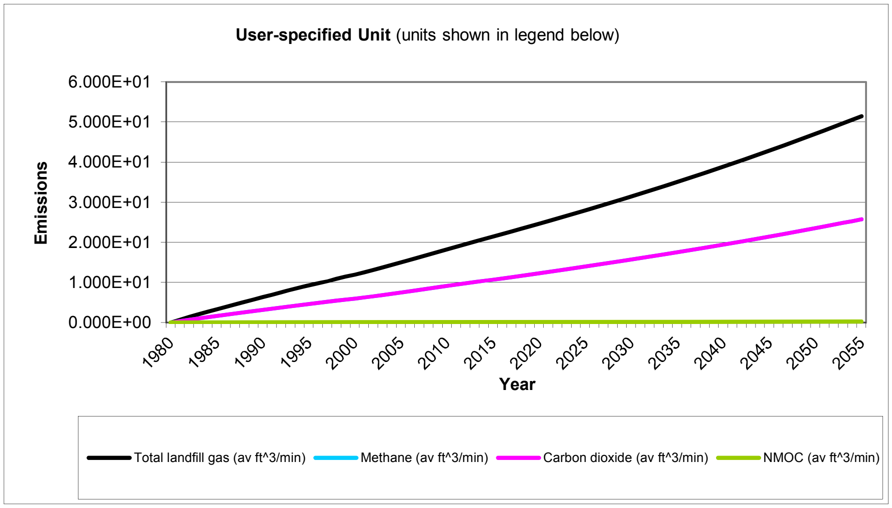
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
Emissions
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
9.000E+05
8.000E+05
7.000E+05
6.000E+05
5.000E+05
4.000E+05
3.000E+05
2.000E+05
1.000E+05
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
6.000E+01
5.000E+01
4.000E+01
3.000E+01
2.000E+01
1.000E+01
0.000E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	**Total landfill gas**			**Methane**		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
1980	0	0	0	0	0	0
1981	1.304E+01	1.044E+04	7.018E-01	3.484E+00	5.222E+03	3.509E-01
1982	2.596E+01	2.079E+04	1.397E+00	6.934E+00	1.039E+04	6.983E-01
1983	3.787E+01	3.033E+04	2.038E+00	1.012E+01	1.516E+04	1.019E+00
1984	4.967E+01	3.977E+04	2.672E+00	1.327E+01	1.989E+04	1.336E+00
1985	6.135E+01	4.913E+04	3.301E+00	1.639E+01	2.456E+04	1.650E+00
1986	7.292E+01	5.839E+04	3.923E+00	1.948E+01	2.919E+04	1.962E+00
1987	8.436E+01	6.756E+04	4.539E+00	2.253E+01	3.378E+04	2.270E+00
1988	9.570E+01	7.663E+04	5.149E+00	2.556E+01	3.832E+04	2.574E+00
1989	1.069E+02	8.562E+04	5.753E+00	2.856E+01	4.281E+04	2.876E+00
1990	1.180E+02	9.451E+04	6.350E+00	3.153E+01	4.726E+04	3.175E+00
1991	1.290E+02	1.033E+05	6.942E+00	3.447E+01	5.166E+04	3.471E+00
1992	1.399E+02	1.120E+05	7.528E+00	3.737E+01	5.602E+04	3.764E+00
1993	1.516E+02	1.214E+05	8.156E+00	4.049E+01	6.070E+04	4.078E+00
1994	1.626E+02	1.302E+05	8.748E+00	4.343E+01	6.510E+04	4.374E+00
1995	1.727E+02	1.383E+05	9.292E+00	4.613E+01	6.915E+04	4.646E+00
1996	1.822E+02	1.459E+05	9.802E+00	4.866E+01	7.294E+04	4.901E+00
1997	1.916E+02	1.534E+05	1.031E+01	5.119E+01	7.672E+04	5.155E+00
1998	2.031E+02	1.626E+05	1.093E+01	5.424E+01	8.131E+04	5.463E+00
1999	2.127E+02	1.703E+05	1.144E+01	5.682E+01	8.517E+04	5.722E+00
2000	2.225E+02	1.781E+05	1.197E+01	5.942E+01	8.907E+04	5.985E+00
2001	2.327E+02	1.864E+05	1.252E+01	6.216E+01	9.318E+04	6.261E+00
2002	2.437E+02	1.952E+05	1.311E+01	6.511E+01	9.759E+04	6.557E+00
2003	2.556E+02	2.047E+05	1.375E+01	6.827E+01	1.023E+05	6.876E+00
2004	2.665E+02	2.134E+05	1.434E+01	7.119E+01	1.067E+05	7.170E+00
2005	2.787E+02	2.232E+05	1.500E+01	7.445E+01	1.116E+05	7.498E+00
2006	2.911E+02	2.331E+05	1.566E+01	7.774E+01	1.165E+05	7.830E+00
2007	3.043E+02	2.437E+05	1.637E+01	8.129E+01	1.219E+05	8.187E+00
2008	3.156E+02	2.527E+05	1.698E+01	8.430E+01	1.264E+05	8.490E+00
2009	3.265E+02	2.614E+05	1.757E+01	8.721E+01	1.307E+05	8.783E+00
2010	3.392E+02	2.716E+05	1.825E+01	9.060E+01	1.358E+05	9.125E+00
2011	3.525E+02	2.823E+05	1.897E+01	9.416E+01	1.411E+05	9.483E+00
2012	3.638E+02	2.913E+05	1.957E+01	9.718E+01	1.457E+05	9.787E+00
2013	3.752E+02	3.005E+05	2.019E+01	1.002E+02	1.502E+05	1.009E+01
2014	3.867E+02	3.096E+05	2.080E+01	1.033E+02	1.548E+05	1.040E+01
2015	3.983E+02	3.190E+05	2.143E+01	1.064E+02	1.595E+05	1.072E+01
2016	4.101E+02	3.284E+05	2.206E+01	1.095E+02	1.642E+05	1.103E+01
2017	4.219E+02	3.378E+05	2.270E+01	1.127E+02	1.689E+05	1.135E+01
2018	4.338E+02	3.474E+05	2.334E+01	1.159E+02	1.737E+05	1.167E+01
2019	4.458E+02	3.570E+05	2.399E+01	1.191E+02	1.785E+05	1.199E+01
2020	4.579E+02	3.667E+05	2.464E+01	1.223E+02	1.834E+05	1.232E+01
2021	4.701E+02	3.765E+05	2.530E+01	1.256E+02	1.882E+05	1.265E+01
2022	4.825E+02	3.863E+05	2.596E+01	1.289E+02	1.932E+05	1.298E+01
2023	4.949E+02	3.963E+05	2.662E+01	1.322E+02	1.981E+05	1.331E+01
2024	5.074E+02	4.063E+05	2.730E+01	1.355E+02	2.031E+05	1.365E+01
2025	5.200E+02	4.164E+05	2.798E+01	1.389E+02	2.082E+05	1.399E+01
2026	5.327E+02	4.265E+05	2.866E+01	1.423E+02	2.133E+05	1.433E+01
2027	5.455E+02	4.368E+05	2.935E+01	1.457E+02	2.184E+05	1.467E+01
2028	5.584E+02	4.472E+05	3.004E+01	1.492E+02	2.236E+05	1.502E+01
2029	5.715E+02	4.576E+05	3.075E+01	1.526E+02	2.288E+05	1.537E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m ^{3} /year)*	*(av ft^3/min)*	*(Mg/year)*	*(m ^{3} /year)*	*(av ft^3/min)*
2030	5.846E+02	4.681E+05	3.145E+01	1.562E+02	2.341E+05	1.573E+01
2031	5.979E+02	4.788E+05	3.217E+01	1.597E+02	2.394E+05	1.608E+01
2032	6.113E+02	4.895E+05	3.289E+01	1.633E+02	2.447E+05	1.644E+01
2033	6.248E+02	5.003E+05	3.362E+01	1.669E+02	2.502E+05	1.681E+01
2034	6.384E+02	5.112E+05	3.435E+01	1.705E+02	2.556E+05	1.717E+01
2035	6.522E+02	5.222E+05	3.509E+01	1.742E+02	2.611E+05	1.754E+01
2036	6.661E+02	5.334E+05	3.584E+01	1.779E+02	2.667E+05	1.792E+01
2037	6.801E+02	5.446E+05	3.659E+01	1.817E+02	2.723E+05	1.829E+01
2038	6.942E+02	5.559E+05	3.735E+01	1.854E+02	2.779E+05	1.868E+01
2039	7.085E+02	5.673E+05	3.812E+01	1.892E+02	2.837E+05	1.906E+01
2040	7.229E+02	5.789E+05	3.889E+01	1.931E+02	2.894E+05	1.945E+01
2041	7.374E+02	5.905E+05	3.968E+01	1.970E+02	2.953E+05	1.984E+01
2042	7.521E+02	6.023E+05	4.047E+01	2.009E+02	3.011E+05	2.023E+01
2043	7.670E+02	6.141E+05	4.126E+01	2.049E+02	3.071E+05	2.063E+01
2044	7.819E+02	6.261E+05	4.207E+01	2.089E+02	3.131E+05	2.104E+01
2045	7.971E+02	6.382E+05	4.288E+01	2.129E+02	3.191E+05	2.144E+01
2046	8.123E+02	6.505E+05	4.371E+01	2.170E+02	3.252E+05	2.185E+01
2047	8.277E+02	6.628E+05	4.453E+01	2.211E+02	3.314E+05	2.227E+01
2048	8.433E+02	6.753E+05	4.537E+01	2.253E+02	3.376E+05	2.269E+01
2049	8.591E+02	6.879E+05	4.622E+01	2.295E+02	3.439E+05	2.311E+01
2050	8.749E+02	7.006E+05	4.707E+01	2.337E+02	3.503E+05	2.354E+01
2051	8.910E+02	7.135E+05	4.794E+01	2.380E+02	3.567E+05	2.397E+01
2052	9.072E+02	7.265E+05	4.881E+01	2.423E+02	3.632E+05	2.441E+01
2053	9.236E+02	7.396E+05	4.969E+01	2.467E+02	3.698E+05	2.485E+01
2054	9.402E+02	7.528E+05	5.058E+01	2.511E+02	3.764E+05	2.529E+01
2055	9.569E+02	7.662E+05	5.148E+01	2.556E+02	3.831E+05	2.574E+01
2056	9.738E+02	7.798E+05	5.239E+01	2.601E+02	3.899E+05	2.620E+01
2057	9.909E+02	7.934E+05	5.331E+01	2.647E+02	3.967E+05	2.666E+01
2058	1.008E+03	8.073E+05	5.424E+01	2.693E+02	4.036E+05	2.712E+01
2059	1.026E+03	8.212E+05	5.518E+01	2.739E+02	4.106E+05	2.759E+01
2060	1.043E+03	8.353E+05	5.613E+01	2.786E+02	4.177E+05	2.806E+01
2061	1.033E+03	8.270E+05	5.557E+01	2.759E+02	4.135E+05	2.778E+01
2062	1.023E+03	8.188E+05	5.502E+01	2.731E+02	4.094E+05	2.751E+01
2063	1.012E+03	8.107E+05	5.447E+01	2.704E+02	4.053E+05	2.723E+01
2064	1.002E+03	8.026E+05	5.393E+01	2.677E+02	4.013E+05	2.696E+01
2065	9.923E+02	7.946E+05	5.339E+01	2.651E+02	3.973E+05	2.669E+01
2066	9.824E+02	7.867E+05	5.286E+01	2.624E+02	3.933E+05	2.643E+01
2067	9.727E+02	7.789E+05	5.233E+01	2.598E+02	3.894E+05	2.617E+01
2068	9.630E+02	7.711E+05	5.181E+01	2.572E+02	3.856E+05	2.591E+01
2069	9.534E+02	7.634E+05	5.130E+01	2.547E+02	3.817E+05	2.565E+01
2070	9.439E+02	7.558E+05	5.079E+01	2.521E+02	3.779E+05	2.539E+01
2071	9.345E+02	7.483E+05	5.028E+01	2.496E+02	3.742E+05	2.514E+01
2072	9.252E+02	7.409E+05	4.978E+01	2.471E+02	3.704E+05	2.489E+01
2073	9.160E+02	7.335E+05	4.928E+01	2.447E+02	3.668E+05	2.464E+01
2074	9.069E+02	7.262E+05	4.879E+01	2.422E+02	3.631E+05	2.440E+01
2075	8.979E+02	7.190E+05	4.831E+01	2.398E+02	3.595E+05	2.415E+01
2076	8.890E+02	7.118E+05	4.783E+01	2.374E+02	3.559E+05	2.391E+01
2077	8.801E+02	7.047E+05	4.735E+01	2.351E+02	3.524E+05	2.368E+01
2078	8.714E+02	6.977E+05	4.688E+01	2.327E+02	3.489E+05	2.344E+01
2079	8.627E+02	6.908E+05	4.641E+01	2.304E+02	3.454E+05	2.321E+01
2080	8.541E+02	6.839E+05	4.595E+01	2.281E+02	3.420E+05	2.298E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	8.456E+02	6.771E+05	4.550E+01	2.259E+02	3.386E+05	2.275E+01
2082	8.372E+02	6.704E+05	4.504E+01	2.236E+02	3.352E+05	2.252E+01
2083	8.289E+02	6.637E+05	4.459E+01	2.214E+02	3.319E+05	2.230E+01
2084	8.206E+02	6.571E+05	4.415E+01	2.192E+02	3.286E+05	2.208E+01
2085	8.124E+02	6.506E+05	4.371E+01	2.170E+02	3.253E+05	2.186E+01
2086	8.044E+02	6.441E+05	4.328E+01	2.149E+02	3.220E+05	2.164E+01
2087	7.964E+02	6.377E+05	4.285E+01	2.127E+02	3.188E+05	2.142E+01
2088	7.884E+02	6.313E+05	4.242E+01	2.106E+02	3.157E+05	2.121E+01
2089	7.806E+02	6.251E+05	4.200E+01	2.085E+02	3.125E+05	2.100E+01
2090	7.728E+02	6.188E+05	4.158E+01	2.064E+02	3.094E+05	2.079E+01
2091	7.651E+02	6.127E+05	4.117E+01	2.044E+02	3.063E+05	2.058E+01
2092	7.575E+02	6.066E+05	4.076E+01	2.023E+02	3.033E+05	2.038E+01
2093	7.500E+02	6.005E+05	4.035E+01	2.003E+02	3.003E+05	2.018E+01
2094	7.425E+02	5.946E+05	3.995E+01	1.983E+02	2.973E+05	1.997E+01
2095	7.351E+02	5.887E+05	3.955E+01	1.964E+02	2.943E+05	1.978E+01
2096	7.278E+02	5.828E+05	3.916E+01	1.944E+02	2.914E+05	1.958E+01
2097	7.206E+02	5.770E+05	3.877E+01	1.925E+02	2.885E+05	1.938E+01
2098	7.134E+02	5.713E+05	3.838E+01	1.906E+02	2.856E+05	1.919E+01
2099	7.063E+02	5.656E+05	3.800E+01	1.887E+02	2.828E+05	1.900E+01
2100	6.993E+02	5.599E+05	3.762E+01	1.868E+02	2.800E+05	1.881E+01
2101	6.923E+02	5.544E+05	3.725E+01	1.849E+02	2.772E+05	1.862E+01
2102	6.854E+02	5.489E+05	3.688E+01	1.831E+02	2.744E+05	1.844E+01
2103	6.786E+02	5.434E+05	3.651E+01	1.813E+02	2.717E+05	1.826E+01
2104	6.719E+02	5.380E+05	3.615E+01	1.795E+02	2.690E+05	1.807E+01
2105	6.652E+02	5.326E+05	3.579E+01	1.777E+02	2.663E+05	1.789E+01
2106	6.586E+02	5.273E+05	3.543E+01	1.759E+02	2.637E+05	1.772E+01
2107	6.520E+02	5.221E+05	3.508E+01	1.742E+02	2.610E+05	1.754E+01
2108	6.455E+02	5.169E+05	3.473E+01	1.724E+02	2.584E+05	1.737E+01
2109	6.391E+02	5.118E+05	3.438E+01	1.707E+02	2.559E+05	1.719E+01
2110	6.327E+02	5.067E+05	3.404E+01	1.690E+02	2.533E+05	1.702E+01
2111	6.264E+02	5.016E+05	3.370E+01	1.673E+02	2.508E+05	1.685E+01
2112	6.202E+02	4.966E+05	3.337E+01	1.657E+02	2.483E+05	1.668E+01
2113	6.140E+02	4.917E+05	3.304E+01	1.640E+02	2.458E+05	1.652E+01
2114	6.079E+02	4.868E+05	3.271E+01	1.624E+02	2.434E+05	1.635E+01
2115	6.019E+02	4.820E+05	3.238E+01	1.608E+02	2.410E+05	1.619E+01
2116	5.959E+02	4.772E+05	3.206E+01	1.592E+02	2.386E+05	1.603E+01
2117	5.900E+02	4.724E+05	3.174E+01	1.576E+02	2.362E+05	1.587E+01
2118	5.841E+02	4.677E+05	3.143E+01	1.560E+02	2.339E+05	1.571E+01
2119	5.783E+02	4.631E+05	3.111E+01	1.545E+02	2.315E+05	1.556E+01
2120	5.725E+02	4.584E+05	3.080E+01	1.529E+02	2.292E+05	1.540E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
1980	0	0	0	0	0	0
1981	9.560E+00	5.222E+03	3.509E-01	1.498E-01	4.178E+01	2.807E-03
1982	1.902E+01	1.039E+04	6.983E-01	2.980E-01	8.314E+01	5.586E-03
1983	2.776E+01	1.516E+04	1.019E+00	4.348E-01	1.213E+02	8.151E-03
1984	3.640E+01	1.989E+04	1.336E+00	5.703E-01	1.591E+02	1.069E-02
1985	4.496E+01	2.456E+04	1.650E+00	7.044E-01	1.965E+02	1.320E-02
1986	5.344E+01	2.919E+04	1.962E+00	8.372E-01	2.336E+02	1.569E-02
1987	6.183E+01	3.378E+04	2.270E+00	9.686E-01	2.702E+02	1.816E-02
1988	7.014E+01	3.832E+04	2.574E+00	1.099E+00	3.065E+02	2.060E-02
1989	7.836E+01	4.281E+04	2.876E+00	1.228E+00	3.425E+02	2.301E-02
1990	8.650E+01	4.726E+04	3.175E+00	1.355E+00	3.781E+02	2.540E-02
1991	9.457E+01	5.166E+04	3.471E+00	1.481E+00	4.133E+02	2.777E-02
1992	1.025E+02	5.602E+04	3.764E+00	1.606E+00	4.482E+02	3.011E-02
1993	1.111E+02	6.070E+04	4.078E+00	1.741E+00	4.856E+02	3.263E-02
1994	1.192E+02	6.510E+04	4.374E+00	1.867E+00	5.208E+02	3.499E-02
1995	1.266E+02	6.915E+04	4.646E+00	1.983E+00	5.532E+02	3.717E-02
1996	1.335E+02	7.294E+04	4.901E+00	2.092E+00	5.836E+02	3.921E-02
1997	1.404E+02	7.672E+04	5.155E+00	2.200E+00	6.138E+02	4.124E-02
1998	1.488E+02	8.131E+04	5.463E+00	2.331E+00	6.504E+02	4.370E-02
1999	1.559E+02	8.517E+04	5.722E+00	2.442E+00	6.813E+02	4.578E-02
2000	1.630E+02	8.907E+04	5.985E+00	2.554E+00	7.126E+02	4.788E-02
2001	1.706E+02	9.318E+04	6.261E+00	2.672E+00	7.454E+02	5.008E-02
2002	1.786E+02	9.759E+04	6.557E+00	2.799E+00	7.807E+02	5.246E-02
2003	1.873E+02	1.023E+05	6.876E+00	2.935E+00	8.187E+02	5.501E-02
2004	1.953E+02	1.067E+05	7.170E+00	3.060E+00	8.537E+02	5.736E-02
2005	2.043E+02	1.116E+05	7.498E+00	3.200E+00	8.927E+02	5.998E-02
2006	2.133E+02	1.165E+05	7.830E+00	3.342E+00	9.322E+02	6.264E-02
2007	2.230E+02	1.219E+05	8.187E+00	3.494E+00	9.748E+02	6.550E-02
2008	2.313E+02	1.264E+05	8.490E+00	3.624E+00	1.011E+03	6.792E-02
2009	2.393E+02	1.307E+05	8.783E+00	3.748E+00	1.046E+03	7.026E-02
2010	2.486E+02	1.358E+05	9.125E+00	3.894E+00	1.086E+03	7.300E-02
2011	2.583E+02	1.411E+05	9.483E+00	4.047E+00	1.129E+03	7.586E-02
2012	2.666E+02	1.457E+05	9.787E+00	4.177E+00	1.165E+03	7.829E-02
2013	2.750E+02	1.502E+05	1.009E+01	4.308E+00	1.202E+03	8.076E-02
2014	2.834E+02	1.548E+05	1.040E+01	4.439E+00	1.239E+03	8.322E-02
2015	2.919E+02	1.595E+05	1.072E+01	4.573E+00	1.276E+03	8.572E-02
2016	3.005E+02	1.642E+05	1.103E+01	4.708E+00	1.313E+03	8.825E-02
2017	3.092E+02	1.689E+05	1.135E+01	4.844E+00	1.351E+03	9.080E-02
2018	3.179E+02	1.737E+05	1.167E+01	4.981E+00	1.390E+03	9.336E-02
2019	3.267E+02	1.785E+05	1.199E+01	5.119E+00	1.428E+03	9.595E-02
2020	3.356E+02	1.834E+05	1.232E+01	5.258E+00	1.467E+03	9.855E-02
2021	3.446E+02	1.882E+05	1.265E+01	5.398E+00	1.506E+03	1.012E-01
2022	3.536E+02	1.932E+05	1.298E+01	5.539E+00	1.545E+03	1.038E-01
2023	3.627E+02	1.981E+05	1.331E+01	5.681E+00	1.585E+03	1.065E-01
2024	3.718E+02	2.031E+05	1.365E+01	5.825E+00	1.625E+03	1.092E-01
2025	3.811E+02	2.082E+05	1.399E+01	5.970E+00	1.665E+03	1.119E-01
2026	3.904E+02	2.133E+05	1.433E+01	6.116E+00	1.706E+03	1.146E-01
2027	3.998E+02	2.184E+05	1.467E+01	6.263E+00	1.747E+03	1.174E-01
2028	4.093E+02	2.236E+05	1.502E+01	6.411E+00	1.789E+03	1.202E-01
2029	4.188E+02	2.288E+05	1.537E+01	6.561E+00	1.830E+03	1.230E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2030	4.285E+02	2.341E+05	1.573E+01	6.712E+00	1.873E+03	1.258E-01
2031	4.382E+02	2.394E+05	1.608E+01	6.865E+00	1.915E+03	1.287E-01
2032	4.480E+02	2.447E+05	1.644E+01	7.018E+00	1.958E+03	1.316E-01
2033	4.579E+02	2.502E+05	1.681E+01	7.173E+00	2.001E+03	1.345E-01
2034	4.679E+02	2.556E+05	1.717E+01	7.330E+00	2.045E+03	1.374E-01
2035	4.780E+02	2.611E+05	1.754E+01	7.488E+00	2.089E+03	1.404E-01
2036	4.882E+02	2.667E+05	1.792E+01	7.647E+00	2.133E+03	1.433E-01
2037	4.984E+02	2.723E+05	1.829E+01	7.808E+00	2.178E+03	1.464E-01
2038	5.088E+02	2.779E+05	1.868E+01	7.970E+00	2.224E+03	1.494E-01
2039	5.192E+02	2.837E+05	1.906E+01	8.134E+00	2.269E+03	1.525E-01
2040	5.298E+02	2.894E+05	1.945E+01	8.300E+00	2.315E+03	1.556E-01
2041	5.405E+02	2.953E+05	1.984E+01	8.467E+00	2.362E+03	1.587E-01
2042	5.512E+02	3.011E+05	2.023E+01	8.635E+00	2.409E+03	1.619E-01
2043	5.621E+02	3.071E+05	2.063E+01	8.806E+00	2.457E+03	1.651E-01
2044	5.731E+02	3.131E+05	2.104E+01	8.978E+00	2.505E+03	1.683E-01
2045	5.842E+02	3.191E+05	2.144E+01	9.151E+00	2.553E+03	1.715E-01
2046	5.953E+02	3.252E+05	2.185E+01	9.326E+00	2.602E+03	1.748E-01
2047	6.066E+02	3.314E+05	2.227E+01	9.503E+00	2.651E+03	1.781E-01
2048	6.181E+02	3.376E+05	2.269E+01	9.682E+00	2.701E+03	1.815E-01
2049	6.296E+02	3.439E+05	2.311E+01	9.863E+00	2.752E+03	1.849E-01
2050	6.412E+02	3.503E+05	2.354E+01	1.005E+01	2.802E+03	1.883E-01
2051	6.530E+02	3.567E+05	2.397E+01	1.023E+01	2.854E+03	1.918E-01
2052	6.649E+02	3.632E+05	2.441E+01	1.042E+01	2.906E+03	1.952E-01
2053	6.769E+02	3.698E+05	2.485E+01	1.060E+01	2.958E+03	1.988E-01
2054	6.890E+02	3.764E+05	2.529E+01	1.079E+01	3.011E+03	2.023E-01
2055	7.013E+02	3.831E+05	2.574E+01	1.099E+01	3.065E+03	2.059E-01
2056	7.137E+02	3.899E+05	2.620E+01	1.118E+01	3.119E+03	2.096E-01
2057	7.262E+02	3.967E+05	2.666E+01	1.138E+01	3.174E+03	2.132E-01
2058	7.388E+02	4.036E+05	2.712E+01	1.157E+01	3.229E+03	2.170E-01
2059	7.516E+02	4.106E+05	2.759E+01	1.177E+01	3.285E+03	2.207E-01
2060	7.645E+02	4.177E+05	2.806E+01	1.198E+01	3.341E+03	2.245E-01
2061	7.569E+02	4.135E+05	2.778E+01	1.186E+01	3.308E+03	2.223E-01
2062	7.494E+02	4.094E+05	2.751E+01	1.174E+01	3.275E+03	2.201E-01
2063	7.420E+02	4.053E+05	2.723E+01	1.162E+01	3.243E+03	2.179E-01
2064	7.346E+02	4.013E+05	2.696E+01	1.151E+01	3.210E+03	2.157E-01
2065	7.273E+02	3.973E+05	2.669E+01	1.139E+01	3.178E+03	2.136E-01
2066	7.200E+02	3.933E+05	2.643E+01	1.128E+01	3.147E+03	2.114E-01
2067	7.129E+02	3.894E+05	2.617E+01	1.117E+01	3.115E+03	2.093E-01
2068	7.058E+02	3.856E+05	2.591E+01	1.106E+01	3.084E+03	2.072E-01
2069	6.987E+02	3.817E+05	2.565E+01	1.095E+01	3.054E+03	2.052E-01
2070	6.918E+02	3.779E+05	2.539E+01	1.084E+01	3.023E+03	2.031E-01
2071	6.849E+02	3.742E+05	2.514E+01	1.073E+01	2.993E+03	2.011E-01
2072	6.781E+02	3.704E+05	2.489E+01	1.062E+01	2.964E+03	1.991E-01
2073	6.713E+02	3.668E+05	2.464E+01	1.052E+01	2.934E+03	1.971E-01
2074	6.647E+02	3.631E+05	2.440E+01	1.041E+01	2.905E+03	1.952E-01
2075	6.581E+02	3.595E+05	2.415E+01	1.031E+01	2.876E+03	1.932E-01
2076	6.515E+02	3.559E+05	2.391E+01	1.021E+01	2.847E+03	1.913E-01
2077	6.450E+02	3.524E+05	2.368E+01	1.010E+01	2.819E+03	1.894E-01
2078	6.386E+02	3.489E+05	2.344E+01	1.000E+01	2.791E+03	1.875E-01
2079	6.322E+02	3.454E+05	2.321E+01	9.905E+00	2.763E+03	1.857E-01
2080	6.260E+02	3.420E+05	2.298E+01	9.806E+00	2.736E+03	1.838E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	6.197E+02	3.386E+05	2.275E+01	9.708E+00	2.708E+03	1.820E-01
2082	6.136E+02	3.352E+05	2.252E+01	9.612E+00	2.682E+03	1.802E-01
2083	6.075E+02	3.319E+05	2.230E+01	9.516E+00	2.655E+03	1.784E-01
2084	6.014E+02	3.286E+05	2.208E+01	9.421E+00	2.628E+03	1.766E-01
2085	5.954E+02	3.253E+05	2.186E+01	9.328E+00	2.602E+03	1.748E-01
2086	5.895E+02	3.220E+05	2.164E+01	9.235E+00	2.576E+03	1.731E-01
2087	5.836E+02	3.188E+05	2.142E+01	9.143E+00	2.551E+03	1.714E-01
2088	5.778E+02	3.157E+05	2.121E+01	9.052E+00	2.525E+03	1.697E-01
2089	5.721E+02	3.125E+05	2.100E+01	8.962E+00	2.500E+03	1.680E-01
2090	5.664E+02	3.094E+05	2.079E+01	8.873E+00	2.475E+03	1.663E-01
2091	5.608E+02	3.063E+05	2.058E+01	8.785E+00	2.451E+03	1.647E-01
2092	5.552E+02	3.033E+05	2.038E+01	8.697E+00	2.426E+03	1.630E-01
2093	5.497E+02	3.003E+05	2.018E+01	8.611E+00	2.402E+03	1.614E-01
2094	5.442E+02	2.973E+05	1.997E+01	8.525E+00	2.378E+03	1.598E-01
2095	5.388E+02	2.943E+05	1.978E+01	8.440E+00	2.355E+03	1.582E-01
2096	5.334E+02	2.914E+05	1.958E+01	8.356E+00	2.331E+03	1.566E-01
2097	5.281E+02	2.885E+05	1.938E+01	8.273E+00	2.308E+03	1.551E-01
2098	5.228E+02	2.856E+05	1.919E+01	8.191E+00	2.285E+03	1.535E-01
2099	5.176E+02	2.828E+05	1.900E+01	8.109E+00	2.262E+03	1.520E-01
2100	5.125E+02	2.800E+05	1.881E+01	8.028E+00	2.240E+03	1.505E-01
2101	5.074E+02	2.772E+05	1.862E+01	7.949E+00	2.218E+03	1.490E-01
2102	5.023E+02	2.744E+05	1.844E+01	7.869E+00	2.195E+03	1.475E-01
2103	4.973E+02	2.717E+05	1.826E+01	7.791E+00	2.174E+03	1.460E-01
2104	4.924E+02	2.690E+05	1.807E+01	7.714E+00	2.152E+03	1.446E-01
2105	4.875E+02	2.663E+05	1.789E+01	7.637E+00	2.131E+03	1.432E-01
2106	4.826E+02	2.637E+05	1.772E+01	7.561E+00	2.109E+03	1.417E-01
2107	4.778E+02	2.610E+05	1.754E+01	7.486E+00	2.088E+03	1.403E-01
2108	4.731E+02	2.584E+05	1.737E+01	7.411E+00	2.068E+03	1.389E-01
2109	4.684E+02	2.559E+05	1.719E+01	7.337E+00	2.047E+03	1.375E-01
2110	4.637E+02	2.533E+05	1.702E+01	7.264E+00	2.027E+03	1.362E-01
2111	4.591E+02	2.508E+05	1.685E+01	7.192E+00	2.006E+03	1.348E-01
2112	4.545E+02	2.483E+05	1.668E+01	7.121E+00	1.987E+03	1.335E-01
2113	4.500E+02	2.458E+05	1.652E+01	7.050E+00	1.967E+03	1.321E-01
2114	4.455E+02	2.434E+05	1.635E+01	6.980E+00	1.947E+03	1.308E-01
2115	4.411E+02	2.410E+05	1.619E+01	6.910E+00	1.928E+03	1.295E-01
2116	4.367E+02	2.386E+05	1.603E+01	6.841E+00	1.909E+03	1.282E-01
2117	4.324E+02	2.362E+05	1.587E+01	6.773E+00	1.890E+03	1.270E-01
2118	4.281E+02	2.339E+05	1.571E+01	6.706E+00	1.871E+03	1.257E-01
2119	4.238E+02	2.315E+05	1.556E+01	6.639E+00	1.852E+03	1.244E-01
2120	4.196E+02	2.292E+05	1.540E+01	6.573E+00	1.834E+03	1.232E-01

LandGEM - Version 3.02

US EPA Office of Research and Development

CLEAN
AIR
TECHNOLOGY
CENTER

EPA

LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*year^{-1}*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the ith year (*Mg*)
t_{ij} = age of the jth section of waste mass M_i accepted in the ith year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2060**	
Landfill Closure Year (with 80-year limit)	**2092**	
Actual Closure Year (without limit)	***2092***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.010**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**20**	m^3/Mg
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2060	56,703	62,373	0	0
2061	57,445	63,190	56,703	62,373
2062	58,197	64,017	114,148	125,563
2063	58,959	64,855	172,345	189,579
2064	59,731	65,704	231,304	254,434
2065	60,512	66,564	291,034	320,138
2066	61,304	67,435	351,547	386,701
2067	62,107	68,318	412,851	454,136
2068	62,920	69,212	474,958	522,454
2069	63,743	70,118	537,878	591,666
2070	64,578	71,036	601,621	661,784
2071	65,423	71,965	666,199	732,819
2072	66,280	72,907	731,622	804,785
2073	67,147	73,862	797,902	877,692
2074	68,026	74,829	865,049	951,554
2075	68,916	75,808	933,075	1,026,383
2076	69,819	76,800	1,001,992	1,102,191
2077	70,732	77,806	1,071,810	1,178,991
2078	71,658	78,824	1,142,543	1,256,797
2079	72,596	79,856	1,214,201	1,335,621
2080	73,547	80,901	1,286,797	1,415,477
2081	74,509	81,960	1,360,344	1,496,378
2082	75,485	83,033	1,434,853	1,578,338
2083	76,473	84,120	1,510,337	1,661,371
2084	77,474	85,221	1,586,810	1,745,491
2085	78,488	86,336	1,664,284	1,830,712
2086	79,515	87,467	1,742,771	1,917,048
2087	80,556	88,611	1,822,286	2,004,515
2088	81,610	89,771	1,902,842	2,093,126
2089	82,679	90,946	1,984,452	2,182,898
2090	83,761	92,137	2,067,131	2,273,844
2091	84,857	93,343	2,150,892	2,365,981
2092	53,009	58,310	2,235,749	2,459,324
2093	0	0	2,288,758	2,517,634
2094	0	0	2,288,758	2,517,634
2095	0	0	2,288,758	2,517,634
2096	0	0	2,288,758	2,517,634
2097	0	0	2,288,758	2,517,634
2098	0	0	2,288,758	2,517,634
2099	0	0	2,288,758	2,517,634

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2100	0	0	2,288,758	2,517,634
2101	0	0	2,288,758	2,517,634
2102	0	0	2,288,758	2,517,634
2103	0	0	2,288,758	2,517,634
2104	0	0	2,288,758	2,517,634
2105	0	0	2,288,758	2,517,634
2106	0	0	2,288,758	2,517,634
2107	0	0	2,288,758	2,517,634
2108	0	0	2,288,758	2,517,634
2109	0	0	2,288,758	2,517,634
2110	0	0	2,288,758	2,517,634
2111	0	0	2,288,758	2,517,634
2112	0	0	2,288,758	2,517,634
2113	0	0	2,288,758	2,517,634
2114	0	0	2,288,758	2,517,634
2115	0	0	2,288,758	2,517,634
2116	0	0	2,288,758	2,517,634
2117	0	0	2,288,758	2,517,634
2118	0	0	2,288,758	2,517,634
2119	0	0	2,288,758	2,517,634
2120	0	0	2,288,758	2,517,634
2121	0	0	2,288,758	2,517,634
2122	0	0	2,288,758	2,517,634
2123	0	0	2,288,758	2,517,634
2124	0	0	2,288,758	2,517,634
2125	0	0	2,288,758	2,517,634
2126	0	0	2,288,758	2,517,634
2127	0	0	2,288,758	2,517,634
2128	0	0	2,288,758	2,517,634
2129	0	0	2,288,758	2,517,634
2130	0	0	2,288,758	2,517,634
2131	0	0	2,288,758	2,517,634
2132	0	0	2,288,758	2,517,634
2133	0	0	2,288,758	2,517,634
2134	0	0	2,288,758	2,517,634
2135	0	0	2,288,758	2,517,634
2136	0	0	2,288,758	2,517,634
2137	0	0	2,288,758	2,517,634
2138	0	0	2,288,758	2,517,634
2139	0	0	2,288,758	2,517,634

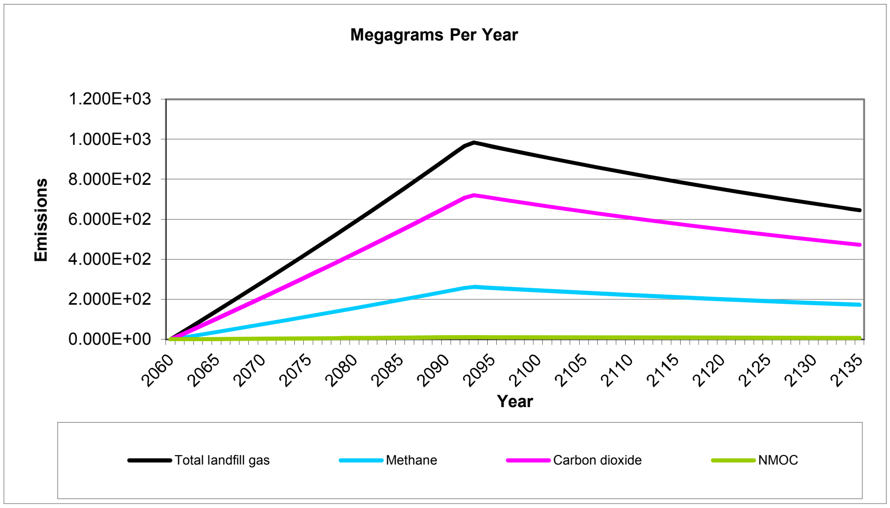
Pollutant Parameters

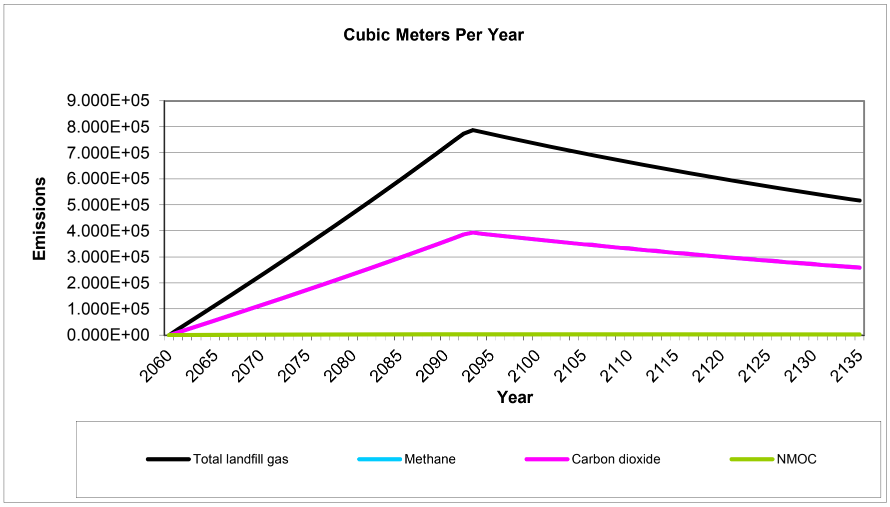
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

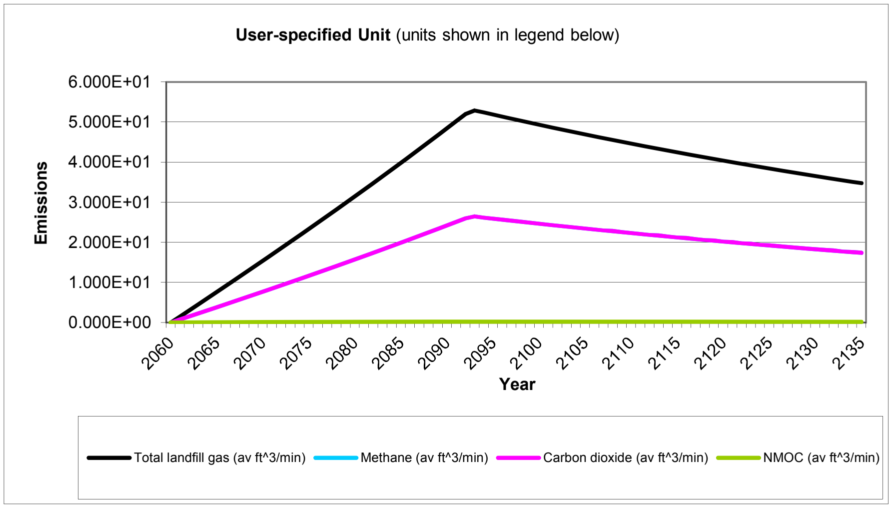
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
9.000E+05
8.000E+05
7.000E+05
6.000E+05
5.000E+05
4.000E+05
3.000E+05
2.000E+05
1.000E+05
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
6.000E+01
5.000E+01
4.000E+01
3.000E+01
2.000E+01
1.000E+01
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	2.820E+01	2.258E+04	1.517E+00	7.532E+00	1.129E+04	7.586E-01
2062	5.648E+01	4.523E+04	3.039E+00	1.509E+01	2.261E+04	1.519E+00
2063	8.486E+01	6.795E+04	4.566E+00	2.267E+01	3.398E+04	2.283E+00
2064	1.133E+02	9.076E+04	6.098E+00	3.027E+01	4.538E+04	3.049E+00
2065	1.419E+02	1.136E+05	7.635E+00	3.791E+01	5.682E+04	3.818E+00
2066	1.706E+02	1.366E+05	9.178E+00	4.557E+01	6.830E+04	4.589E+00
2067	1.994E+02	1.597E+05	1.073E+01	5.326E+01	7.983E+04	5.364E+00
2068	2.283E+02	1.828E+05	1.228E+01	6.098E+01	9.140E+04	6.141E+00
2069	2.573E+02	2.060E+05	1.384E+01	6.873E+01	1.030E+05	6.922E+00
2070	2.864E+02	2.294E+05	1.541E+01	7.651E+01	1.147E+05	7.706E+00
2071	3.157E+02	2.528E+05	1.699E+01	8.433E+01	1.264E+05	8.493E+00
2072	3.451E+02	2.763E+05	1.857E+01	9.218E+01	1.382E+05	9.284E+00
2073	3.746E+02	3.000E+05	2.016E+01	1.001E+02	1.500E+05	1.008E+01
2074	4.043E+02	3.237E+05	2.175E+01	1.080E+02	1.619E+05	1.088E+01
2075	4.341E+02	3.476E+05	2.336E+01	1.160E+02	1.738E+05	1.168E+01
2076	4.640E+02	3.716E+05	2.497E+01	1.240E+02	1.858E+05	1.248E+01
2077	4.941E+02	3.957E+05	2.659E+01	1.320E+02	1.978E+05	1.329E+01
2078	5.244E+02	4.199E+05	2.821E+01	1.401E+02	2.100E+05	1.411E+01
2079	5.548E+02	4.443E+05	2.985E+01	1.482E+02	2.221E+05	1.493E+01
2080	5.854E+02	4.688E+05	3.150E+01	1.564E+02	2.344E+05	1.575E+01
2081	6.162E+02	4.934E+05	3.315E+01	1.646E+02	2.467E+05	1.658E+01
2082	6.471E+02	5.181E+05	3.481E+01	1.728E+02	2.591E+05	1.741E+01
2083	6.782E+02	5.430E+05	3.649E+01	1.811E+02	2.715E+05	1.824E+01
2084	7.095E+02	5.681E+05	3.817E+01	1.895E+02	2.840E+05	1.909E+01
2085	7.409E+02	5.933E+05	3.986E+01	1.979E+02	2.966E+05	1.993E+01
2086	7.726E+02	6.186E+05	4.157E+01	2.064E+02	3.093E+05	2.078E+01
2087	8.044E+02	6.442E+05	4.328E+01	2.149E+02	3.221E+05	2.164E+01
2088	8.365E+02	6.698E+05	4.501E+01	2.234E+02	3.349E+05	2.250E+01
2089	8.688E+02	6.957E+05	4.674E+01	2.321E+02	3.478E+05	2.337E+01
2090	9.012E+02	7.217E+05	4.849E+01	2.407E+02	3.608E+05	2.424E+01
2091	9.339E+02	7.478E+05	5.025E+01	2.495E+02	3.739E+05	2.512E+01
2092	9.668E+02	7.742E+05	5.202E+01	2.582E+02	3.871E+05	2.601E+01
2093	9.836E+02	7.876E+05	5.292E+01	2.627E+02	3.938E+05	2.646E+01
2094	9.738E+02	7.797E+05	5.239E+01	2.601E+02	3.899E+05	2.620E+01
2095	9.641E+02	7.720E+05	5.187E+01	2.575E+02	3.860E+05	2.593E+01
2096	9.545E+02	7.643E+05	5.135E+01	2.550E+02	3.822E+05	2.568E+01
2097	9.450E+02	7.567E+05	5.084E+01	2.524E+02	3.784E+05	2.542E+01
2098	9.356E+02	7.492E+05	5.034E+01	2.499E+02	3.746E+05	2.517E+01
2099	9.263E+02	7.417E+05	4.984E+01	2.474E+02	3.709E+05	2.492E+01
2100	9.171E+02	7.343E+05	4.934E+01	2.450E+02	3.672E+05	2.467E+01
2101	9.079E+02	7.270E+05	4.885E+01	2.425E+02	3.635E+05	2.442E+01
2102	8.989E+02	7.198E+05	4.836E+01	2.401E+02	3.599E+05	2.418E+01
2103	8.900E+02	7.126E+05	4.788E+01	2.377E+02	3.563E+05	2.394E+01
2104	8.811E+02	7.055E+05	4.741E+01	2.354E+02	3.528E+05	2.370E+01
2105	8.723E+02	6.985E+05	4.693E+01	2.330E+02	3.493E+05	2.347E+01
2106	8.637E+02	6.916E+05	4.647E+01	2.307E+02	3.458E+05	2.323E+01
2107	8.551E+02	6.847E+05	4.600E+01	2.284E+02	3.423E+05	2.300E+01
2108	8.466E+02	6.779E+05	4.555E+01	2.261E+02	3.389E+05	2.277E+01
2109	8.381E+02	6.711E+05	4.509E+01	2.239E+02	3.356E+05	2.255E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2110	8.298E+02	6.645E+05	4.464E+01	2.216E+02	3.322E+05	2.232E+01
2111	8.215E+02	6.578E+05	4.420E+01	2.194E+02	3.289E+05	2.210E+01
2112	8.134E+02	6.513E+05	4.376E+01	2.173E+02	3.257E+05	2.188E+01
2113	8.053E+02	6.448E+05	4.333E+01	2.151E+02	3.224E+05	2.166E+01
2114	7.973E+02	6.384E+05	4.289E+01	2.130E+02	3.192E+05	2.145E+01
2115	7.893E+02	6.321E+05	4.247E+01	2.108E+02	3.160E+05	2.123E+01
2116	7.815E+02	6.258E+05	4.204E+01	2.087E+02	3.129E+05	2.102E+01
2117	7.737E+02	6.195E+05	4.163E+01	2.067E+02	3.098E+05	2.081E+01
2118	7.660E+02	6.134E+05	4.121E+01	2.046E+02	3.067E+05	2.061E+01
2119	7.584E+02	6.073E+05	4.080E+01	2.026E+02	3.036E+05	2.040E+01
2120	7.508E+02	6.012E+05	4.040E+01	2.006E+02	3.006E+05	2.020E+01
2121	7.434E+02	5.952E+05	3.999E+01	1.986E+02	2.976E+05	2.000E+01
2122	7.360E+02	5.893E+05	3.960E+01	1.966E+02	2.947E+05	1.980E+01
2123	7.286E+02	5.835E+05	3.920E+01	1.946E+02	2.917E+05	1.960E+01
2124	7.214E+02	5.777E+05	3.881E+01	1.927E+02	2.888E+05	1.941E+01
2125	7.142E+02	5.719E+05	3.843E+01	1.908E+02	2.860E+05	1.921E+01
2126	7.071E+02	5.662E+05	3.804E+01	1.889E+02	2.831E+05	1.902E+01
2127	7.001E+02	5.606E+05	3.767E+01	1.870E+02	2.803E+05	1.883E+01
2128	6.931E+02	5.550E+05	3.729E+01	1.851E+02	2.775E+05	1.865E+01
2129	6.862E+02	5.495E+05	3.692E+01	1.833E+02	2.747E+05	1.846E+01
2130	6.794E+02	5.440E+05	3.655E+01	1.815E+02	2.720E+05	1.828E+01
2131	6.726E+02	5.386E+05	3.619E+01	1.797E+02	2.693E+05	1.809E+01
2132	6.659E+02	5.332E+05	3.583E+01	1.779E+02	2.666E+05	1.791E+01
2133	6.593E+02	5.279E+05	3.547E+01	1.761E+02	2.640E+05	1.774E+01
2134	6.527E+02	5.227E+05	3.512E+01	1.744E+02	2.613E+05	1.756E+01
2135	6.462E+02	5.175E+05	3.477E+01	1.726E+02	2.587E+05	1.738E+01
2136	6.398E+02	5.123E+05	3.442E+01	1.709E+02	2.562E+05	1.721E+01
2137	6.334E+02	5.072E+05	3.408E+01	1.692E+02	2.536E+05	1.704E+01
2138	6.271E+02	5.022E+05	3.374E+01	1.675E+02	2.511E+05	1.687E+01
2139	6.209E+02	4.972E+05	3.341E+01	1.658E+02	2.486E+05	1.670E+01
2140	6.147E+02	4.922E+05	3.307E+01	1.642E+02	2.461E+05	1.654E+01
2141	6.086E+02	4.873E+05	3.274E+01	1.626E+02	2.437E+05	1.637E+01
2142	6.026E+02	4.825E+05	3.242E+01	1.609E+02	2.412E+05	1.621E+01
2143	5.966E+02	4.777E+05	3.210E+01	1.593E+02	2.388E+05	1.605E+01
2144	5.906E+02	4.729E+05	3.178E+01	1.578E+02	2.365E+05	1.589E+01
2145	5.847E+02	4.682E+05	3.146E+01	1.562E+02	2.341E+05	1.573E+01
2146	5.789E+02	4.636E+05	3.115E+01	1.546E+02	2.318E+05	1.557E+01
2147	5.732E+02	4.590E+05	3.084E+01	1.531E+02	2.295E+05	1.542E+01
2148	5.675E+02	4.544E+05	3.053E+01	1.516E+02	2.272E+05	1.527E+01
2149	5.618E+02	4.499E+05	3.023E+01	1.501E+02	2.249E+05	1.511E+01
2150	5.562E+02	4.454E+05	2.993E+01	1.486E+02	2.227E+05	1.496E+01
2151	5.507E+02	4.410E+05	2.963E+01	1.471E+02	2.205E+05	1.481E+01
2152	5.452E+02	4.366E+05	2.933E+01	1.456E+02	2.183E+05	1.467E+01
2153	5.398E+02	4.322E+05	2.904E+01	1.442E+02	2.161E+05	1.452E+01
2154	5.344E+02	4.279E+05	2.875E+01	1.427E+02	2.140E+05	1.438E+01
2155	5.291E+02	4.237E+05	2.847E+01	1.413E+02	2.118E+05	1.423E+01
2156	5.238E+02	4.195E+05	2.818E+01	1.399E+02	2.097E+05	1.409E+01
2157	5.186E+02	4.153E+05	2.790E+01	1.385E+02	2.076E+05	1.395E+01
2158	5.135E+02	4.112E+05	2.763E+01	1.372E+02	2.056E+05	1.381E+01
2159	5.084E+02	4.071E+05	2.735E+01	1.358E+02	2.035E+05	1.368E+01
2160	5.033E+02	4.030E+05	2.708E+01	1.344E+02	2.015E+05	1.354E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2161	4.983E+02	3.990E+05	2.681E+01	1.331E+02	1.995E+05	1.340E+01
2162	4.933E+02	3.950E+05	2.654E+01	1.318E+02	1.975E+05	1.327E+01
2163	4.884E+02	3.911E+05	2.628E+01	1.305E+02	1.956E+05	1.314E+01
2164	4.836E+02	3.872E+05	2.602E+01	1.292E+02	1.936E+05	1.301E+01
2165	4.787E+02	3.834E+05	2.576E+01	1.279E+02	1.917E+05	1.288E+01
2166	4.740E+02	3.795E+05	2.550E+01	1.266E+02	1.898E+05	1.275E+01
2167	4.693E+02	3.758E+05	2.525E+01	1.253E+02	1.879E+05	1.262E+01
2168	4.646E+02	3.720E+05	2.500E+01	1.241E+02	1.860E+05	1.250E+01
2169	4.600E+02	3.683E+05	2.475E+01	1.229E+02	1.842E+05	1.237E+01
2170	4.554E+02	3.647E+05	2.450E+01	1.216E+02	1.823E+05	1.225E+01
2171	4.509E+02	3.610E+05	2.426E+01	1.204E+02	1.805E+05	1.213E+01
2172	4.464E+02	3.574E+05	2.402E+01	1.192E+02	1.787E+05	1.201E+01
2173	4.419E+02	3.539E+05	2.378E+01	1.180E+02	1.769E+05	1.189E+01
2174	4.375E+02	3.504E+05	2.354E+01	1.169E+02	1.752E+05	1.177E+01
2175	4.332E+02	3.469E+05	2.331E+01	1.157E+02	1.734E+05	1.165E+01
2176	4.289E+02	3.434E+05	2.307E+01	1.146E+02	1.717E+05	1.154E+01
2177	4.246E+02	3.400E+05	2.285E+01	1.134E+02	1.700E+05	1.142E+01
2178	4.204E+02	3.366E+05	2.262E+01	1.123E+02	1.683E+05	1.131E+01
2179	4.162E+02	3.333E+05	2.239E+01	1.112E+02	1.666E+05	1.120E+01
2180	4.121E+02	3.300E+05	2.217E+01	1.101E+02	1.650E+05	1.108E+01
2181	4.080E+02	3.267E+05	2.195E+01	1.090E+02	1.633E+05	1.097E+01
2182	4.039E+02	3.234E+05	2.173E+01	1.079E+02	1.617E+05	1.087E+01
2183	3.999E+02	3.202E+05	2.151E+01	1.068E+02	1.601E+05	1.076E+01
2184	3.959E+02	3.170E+05	2.130E+01	1.058E+02	1.585E+05	1.065E+01
2185	3.920E+02	3.139E+05	2.109E+01	1.047E+02	1.569E+05	1.054E+01
2186	3.881E+02	3.107E+05	2.088E+01	1.037E+02	1.554E+05	1.044E+01
2187	3.842E+02	3.077E+05	2.067E+01	1.026E+02	1.538E+05	1.034E+01
2188	3.804E+02	3.046E+05	2.047E+01	1.016E+02	1.523E+05	1.023E+01
2189	3.766E+02	3.016E+05	2.026E+01	1.006E+02	1.508E+05	1.013E+01
2190	3.728E+02	2.986E+05	2.006E+01	9.959E+01	1.493E+05	1.003E+01
2191	3.691E+02	2.956E+05	1.986E+01	9.860E+01	1.478E+05	9.930E+00
2192	3.655E+02	2.926E+05	1.966E+01	9.762E+01	1.463E+05	9.831E+00
2193	3.618E+02	2.897E+05	1.947E+01	9.665E+01	1.449E+05	9.734E+00
2194	3.582E+02	2.869E+05	1.927E+01	9.569E+01	1.434E+05	9.637E+00
2195	3.547E+02	2.840E+05	1.908E+01	9.473E+01	1.420E+05	9.541E+00
2196	3.511E+02	2.812E+05	1.889E+01	9.379E+01	1.406E+05	9.446E+00
2197	3.476E+02	2.784E+05	1.870E+01	9.286E+01	1.392E+05	9.352E+00
2198	3.442E+02	2.756E+05	1.852E+01	9.193E+01	1.378E+05	9.259E+00
2199	3.408E+02	2.729E+05	1.833E+01	9.102E+01	1.364E+05	9.167E+00
2200	3.374E+02	2.701E+05	1.815E+01	9.011E+01	1.351E+05	9.076E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	2.067E+01	1.129E+04	7.586E-01	3.237E-01	9.032E+01	6.068E-03
2062	4.140E+01	2.261E+04	1.519E+00	6.485E-01	1.809E+02	1.216E-02
2063	6.219E+01	3.398E+04	2.283E+00	9.743E-01	2.718E+02	1.826E-02
2064	8.306E+01	4.538E+04	3.049E+00	1.301E+00	3.630E+02	2.439E-02
2065	1.040E+02	5.682E+04	3.818E+00	1.629E+00	4.546E+02	3.054E-02
2066	1.250E+02	6.830E+04	4.589E+00	1.959E+00	5.464E+02	3.671E-02
2067	1.461E+02	7.983E+04	5.364E+00	2.289E+00	6.386E+02	4.291E-02
2068	1.673E+02	9.140E+04	6.141E+00	2.621E+00	7.312E+02	4.913E-02
2069	1.886E+02	1.030E+05	6.922E+00	2.954E+00	8.241E+02	5.537E-02
2070	2.099E+02	1.147E+05	7.706E+00	3.289E+00	9.175E+02	6.164E-02
2071	2.314E+02	1.264E+05	8.493E+00	3.625E+00	1.011E+03	6.794E-02
2072	2.529E+02	1.382E+05	9.284E+00	3.962E+00	1.105E+03	7.427E-02
2073	2.746E+02	1.500E+05	1.008E+01	4.301E+00	1.200E+03	8.062E-02
2074	2.963E+02	1.619E+05	1.088E+01	4.642E+00	1.295E+03	8.701E-02
2075	3.181E+02	1.738E+05	1.168E+01	4.984E+00	1.390E+03	9.342E-02
2076	3.401E+02	1.858E+05	1.248E+01	5.328E+00	1.486E+03	9.987E-02
2077	3.622E+02	1.978E+05	1.329E+01	5.673E+00	1.583E+03	1.063E-01
2078	3.843E+02	2.100E+05	1.411E+01	6.021E+00	1.680E+03	1.129E-01
2079	4.066E+02	2.221E+05	1.493E+01	6.370E+00	1.777E+03	1.194E-01
2080	4.290E+02	2.344E+05	1.575E+01	6.721E+00	1.875E+03	1.260E-01
2081	4.516E+02	2.467E+05	1.658E+01	7.074E+00	1.974E+03	1.326E-01
2082	4.742E+02	2.591E+05	1.741E+01	7.429E+00	2.073E+03	1.393E-01
2083	4.970E+02	2.715E+05	1.824E+01	7.786E+00	2.172E+03	1.459E-01
2084	5.200E+02	2.840E+05	1.909E+01	8.145E+00	2.272E+03	1.527E-01
2085	5.430E+02	2.966E+05	1.993E+01	8.507E+00	2.373E+03	1.595E-01
2086	5.662E+02	3.093E+05	2.078E+01	8.870E+00	2.475E+03	1.663E-01
2087	5.896E+02	3.221E+05	2.164E+01	9.236E+00	2.577E+03	1.731E-01
2088	6.131E+02	3.349E+05	2.250E+01	9.604E+00	2.679E+03	1.800E-01
2089	6.367E+02	3.478E+05	2.337E+01	9.974E+00	2.783E+03	1.870E-01
2090	6.605E+02	3.608E+05	2.424E+01	1.035E+01	2.887E+03	1.940E-01
2091	6.845E+02	3.739E+05	2.512E+01	1.072E+01	2.991E+03	2.010E-01
2092	7.086E+02	3.871E+05	2.601E+01	1.110E+01	3.097E+03	2.081E-01
2093	7.208E+02	3.938E+05	2.646E+01	1.129E+01	3.150E+03	2.117E-01
2094	7.137E+02	3.899E+05	2.620E+01	1.118E+01	3.119E+03	2.096E-01
2095	7.066E+02	3.860E+05	2.593E+01	1.107E+01	3.088E+03	2.075E-01
2096	6.995E+02	3.822E+05	2.568E+01	1.096E+01	3.057E+03	2.054E-01
2097	6.926E+02	3.784E+05	2.542E+01	1.085E+01	3.027E+03	2.034E-01
2098	6.857E+02	3.746E+05	2.517E+01	1.074E+01	2.997E+03	2.013E-01
2099	6.789E+02	3.709E+05	2.492E+01	1.063E+01	2.967E+03	1.993E-01
2100	6.721E+02	3.672E+05	2.467E+01	1.053E+01	2.937E+03	1.974E-01
2101	6.654E+02	3.635E+05	2.442E+01	1.042E+01	2.908E+03	1.954E-01
2102	6.588E+02	3.599E+05	2.418E+01	1.032E+01	2.879E+03	1.935E-01
2103	6.522E+02	3.563E+05	2.394E+01	1.022E+01	2.851E+03	1.915E-01
2104	6.457E+02	3.528E+05	2.370E+01	1.012E+01	2.822E+03	1.896E-01
2105	6.393E+02	3.493E+05	2.347E+01	1.002E+01	2.794E+03	1.877E-01
2106	6.330E+02	3.458E+05	2.323E+01	9.916E+00	2.766E+03	1.859E-01
2107	6.267E+02	3.423E+05	2.300E+01	9.817E+00	2.739E+03	1.840E-01
2108	6.204E+02	3.389E+05	2.277E+01	9.719E+00	2.712E+03	1.822E-01
2109	6.143E+02	3.356E+05	2.255E+01	9.623E+00	2.685E+03	1.804E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2110	6.081E+02	3.322E+05	2.232E+01	9.527E+00	2.658E+03	1.786E-01
2111	6.021E+02	3.289E+05	2.210E+01	9.432E+00	2.631E+03	1.768E-01
2112	5.961E+02	3.257E+05	2.188E+01	9.338E+00	2.605E+03	1.750E-01
2113	5.902E+02	3.224E+05	2.166E+01	9.245E+00	2.579E+03	1.733E-01
2114	5.843E+02	3.192E+05	2.145E+01	9.153E+00	2.554E+03	1.716E-01
2115	5.785E+02	3.160E+05	2.123E+01	9.062E+00	2.528E+03	1.699E-01
2116	5.727E+02	3.129E+05	2.102E+01	8.972E+00	2.503E+03	1.682E-01
2117	5.670E+02	3.098E+05	2.081E+01	8.883E+00	2.478E+03	1.665E-01
2118	5.614E+02	3.067E+05	2.061E+01	8.794E+00	2.453E+03	1.648E-01
2119	5.558E+02	3.036E+05	2.040E+01	8.707E+00	2.429E+03	1.632E-01
2120	5.503E+02	3.006E+05	2.020E+01	8.620E+00	2.405E+03	1.616E-01
2121	5.448E+02	2.976E+05	2.000E+01	8.535E+00	2.381E+03	1.600E-01
2122	5.394E+02	2.947E+05	1.980E+01	8.450E+00	2.357E+03	1.584E-01
2123	5.340E+02	2.917E+05	1.960E+01	8.366E+00	2.334E+03	1.568E-01
2124	5.287E+02	2.888E+05	1.941E+01	8.282E+00	2.311E+03	1.552E-01
2125	5.234E+02	2.860E+05	1.921E+01	8.200E+00	2.288E+03	1.537E-01
2126	5.182E+02	2.831E+05	1.902E+01	8.118E+00	2.265E+03	1.522E-01
2127	5.131E+02	2.803E+05	1.883E+01	8.038E+00	2.242E+03	1.507E-01
2128	5.080E+02	2.775E+05	1.865E+01	7.958E+00	2.220E+03	1.492E-01
2129	5.029E+02	2.747E+05	1.846E+01	7.878E+00	2.198E+03	1.477E-01
2130	4.979E+02	2.720E+05	1.828E+01	7.800E+00	2.176E+03	1.462E-01
2131	4.930E+02	2.693E+05	1.809E+01	7.722E+00	2.154E+03	1.448E-01
2132	4.880E+02	2.666E+05	1.791E+01	7.646E+00	2.133E+03	1.433E-01
2133	4.832E+02	2.640E+05	1.774E+01	7.569E+00	2.112E+03	1.419E-01
2134	4.784E+02	2.613E+05	1.756E+01	7.494E+00	2.091E+03	1.405E-01
2135	4.736E+02	2.587E+05	1.738E+01	7.420E+00	2.070E+03	1.391E-01
2136	4.689E+02	2.562E+05	1.721E+01	7.346E+00	2.049E+03	1.377E-01
2137	4.642E+02	2.536E+05	1.704E+01	7.273E+00	2.029E+03	1.363E-01
2138	4.596E+02	2.511E+05	1.687E+01	7.200E+00	2.009E+03	1.350E-01
2139	4.551E+02	2.486E+05	1.670E+01	7.129E+00	1.989E+03	1.336E-01
2140	4.505E+02	2.461E+05	1.654E+01	7.058E+00	1.969E+03	1.323E-01
2141	4.460E+02	2.437E+05	1.637E+01	6.987E+00	1.949E+03	1.310E-01
2142	4.416E+02	2.412E+05	1.621E+01	6.918E+00	1.930E+03	1.297E-01
2143	4.372E+02	2.388E+05	1.605E+01	6.849E+00	1.911E+03	1.284E-01
2144	4.329E+02	2.365E+05	1.589E+01	6.781E+00	1.892E+03	1.271E-01
2145	4.286E+02	2.341E+05	1.573E+01	6.713E+00	1.873E+03	1.258E-01
2146	4.243E+02	2.318E+05	1.557E+01	6.647E+00	1.854E+03	1.246E-01
2147	4.201E+02	2.295E+05	1.542E+01	6.581E+00	1.836E+03	1.234E-01
2148	4.159E+02	2.272E+05	1.527E+01	6.515E+00	1.818E+03	1.221E-01
2149	4.117E+02	2.249E+05	1.511E+01	6.450E+00	1.800E+03	1.209E-01
2150	4.077E+02	2.227E+05	1.496E+01	6.386E+00	1.782E+03	1.197E-01
2151	4.036E+02	2.205E+05	1.481E+01	6.323E+00	1.764E+03	1.185E-01
2152	3.996E+02	2.183E+05	1.467E+01	6.260E+00	1.746E+03	1.173E-01
2153	3.956E+02	2.161E+05	1.452E+01	6.197E+00	1.729E+03	1.162E-01
2154	3.917E+02	2.140E+05	1.438E+01	6.136E+00	1.712E+03	1.150E-01
2155	3.878E+02	2.118E+05	1.423E+01	6.075E+00	1.695E+03	1.139E-01
2156	3.839E+02	2.097E+05	1.409E+01	6.014E+00	1.678E+03	1.127E-01
2157	3.801E+02	2.076E+05	1.395E+01	5.954E+00	1.661E+03	1.116E-01
2158	3.763E+02	2.056E+05	1.381E+01	5.895E+00	1.645E+03	1.105E-01
2159	3.726E+02	2.035E+05	1.368E+01	5.836E+00	1.628E+03	1.094E-01
2160	3.689E+02	2.015E+05	1.354E+01	5.778E+00	1.612E+03	1.083E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2161	3.652E+02	1.995E+05	1.340E+01	5.721E+00	1.596E+03	1.072E-01
2162	3.616E+02	1.975E+05	1.327E+01	5.664E+00	1.580E+03	1.062E-01
2163	3.580E+02	1.956E+05	1.314E+01	5.608E+00	1.564E+03	1.051E-01
2164	3.544E+02	1.936E+05	1.301E+01	5.552E+00	1.549E+03	1.041E-01
2165	3.509E+02	1.917E+05	1.288E+01	5.497E+00	1.533E+03	1.030E-01
2166	3.474E+02	1.898E+05	1.275E+01	5.442E+00	1.518E+03	1.020E-01
2167	3.439E+02	1.879E+05	1.262E+01	5.388E+00	1.503E+03	1.010E-01
2168	3.405E+02	1.860E+05	1.250E+01	5.334E+00	1.488E+03	9.999E-02
2169	3.371E+02	1.842E+05	1.237E+01	5.281E+00	1.473E+03	9.899E-02
2170	3.338E+02	1.823E+05	1.225E+01	5.228E+00	1.459E+03	9.801E-02
2171	3.304E+02	1.805E+05	1.213E+01	5.176E+00	1.444E+03	9.703E-02
2172	3.271E+02	1.787E+05	1.201E+01	5.125E+00	1.430E+03	9.607E-02
2173	3.239E+02	1.769E+05	1.189E+01	5.074E+00	1.416E+03	9.511E-02
2174	3.207E+02	1.752E+05	1.177E+01	5.023E+00	1.401E+03	9.416E-02
2175	3.175E+02	1.734E+05	1.165E+01	4.973E+00	1.388E+03	9.323E-02
2176	3.143E+02	1.717E+05	1.154E+01	4.924E+00	1.374E+03	9.230E-02
2177	3.112E+02	1.700E+05	1.142E+01	4.875E+00	1.360E+03	9.138E-02
2178	3.081E+02	1.683E+05	1.131E+01	4.826E+00	1.347E+03	9.047E-02
2179	3.050E+02	1.666E+05	1.120E+01	4.778E+00	1.333E+03	8.957E-02
2180	3.020E+02	1.650E+05	1.108E+01	4.731E+00	1.320E+03	8.868E-02
2181	2.990E+02	1.633E+05	1.097E+01	4.684E+00	1.307E+03	8.780E-02
2182	2.960E+02	1.617E+05	1.087E+01	4.637E+00	1.294E+03	8.692E-02
2183	2.931E+02	1.601E+05	1.076E+01	4.591E+00	1.281E+03	8.606E-02
2184	2.902E+02	1.585E+05	1.065E+01	4.545E+00	1.268E+03	8.520E-02
2185	2.873E+02	1.569E+05	1.054E+01	4.500E+00	1.255E+03	8.435E-02
2186	2.844E+02	1.554E+05	1.044E+01	4.455E+00	1.243E+03	8.352E-02
2187	2.816E+02	1.538E+05	1.034E+01	4.411E+00	1.231E+03	8.268E-02
2188	2.788E+02	1.523E+05	1.023E+01	4.367E+00	1.218E+03	8.186E-02
2189	2.760E+02	1.508E+05	1.013E+01	4.324E+00	1.206E+03	8.105E-02
2190	2.733E+02	1.493E+05	1.003E+01	4.281E+00	1.194E+03	8.024E-02
2191	2.705E+02	1.478E+05	9.930E+00	4.238E+00	1.182E+03	7.944E-02
2192	2.678E+02	1.463E+05	9.831E+00	4.196E+00	1.171E+03	7.865E-02
2193	2.652E+02	1.449E+05	9.734E+00	4.154E+00	1.159E+03	7.787E-02
2194	2.625E+02	1.434E+05	9.637E+00	4.113E+00	1.147E+03	7.709E-02
2195	2.599E+02	1.420E+05	9.541E+00	4.072E+00	1.136E+03	7.633E-02
2196	2.573E+02	1.406E+05	9.446E+00	4.031E+00	1.125E+03	7.557E-02
2197	2.548E+02	1.392E+05	9.352E+00	3.991E+00	1.114E+03	7.482E-02
2198	2.522E+02	1.378E+05	9.259E+00	3.952E+00	1.102E+03	7.407E-02
2199	2.497E+02	1.364E+05	9.167E+00	3.912E+00	1.091E+03	7.333E-02
2200	2.473E+02	1.351E+05	9.076E+00	3.873E+00	1.081E+03	7.260E-02

LandGEM - Version 3.02

US EPA Office of Research and Development

CLEAN
AIR
TECHNOLOGY
CENTER

EPA

LandGEM
Landfill Gas Emissions Model
Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o\left(\frac{M_i}{10}\right)e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)
M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1980**	
Landfill Closure Year (with 80-year limit)	**2059**	
Actual Closure Year (without limit)	***2059***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.020**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**120**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
1980	32,788	36,066	0	0
1981	32,788	36,066	32,788	36,066
1982	30,602	33,662	65,575	72,133
1983	30,602	33,662	96,177	105,795
1984	30,602	33,662	126,779	139,457
1985	30,602	33,662	157,381	173,119
1986	30,602	33,662	187,983	206,781
1987	30,602	33,662	218,585	240,443
1988	30,602	33,662	249,187	274,105
1989	30,602	33,662	279,789	307,767
1990	30,602	33,662	310,391	341,430
1991	30,602	33,662	340,992	375,092
1992	32,848	36,133	371,594	408,754
1993	31,414	34,555	404,443	444,887
1994	29,495	32,445	435,856	479,442
1995	28,160	30,976	465,351	511,886
1996	28,278	31,106	493,512	542,863
1997	33,566	36,923	521,789	573,968
1998	29,315	32,246	555,356	610,891
1999	29,840	32,824	584,670	643,137
2000	31,341	34,476	614,511	675,962
2001	33,535	36,889	645,852	710,437
2002	35,883	39,471	679,387	747,326
2003	33,870	37,257	715,270	786,797
2004	37,269	40,996	749,140	824,054
2005	38,009	41,810	786,409	865,050
2006	40,676	44,744	824,418	906,860
2007	35,941	39,535	865,095	951,604
2008	35,214	38,735	901,035	991,139
2009	40,107	44,117	936,249	1,029,874
2010	41,951	46,146	976,356	1,073,991
2011	37,235	40,959	1,018,307	1,120,138
2012	37,839	41,622	1,055,543	1,161,097
2013	38,121	41,933	1,093,381	1,202,719
2014	38,968	42,865	1,131,502	1,244,652
2015	39,479	43,426	1,170,471	1,287,518
2016	39,995	43,995	1,209,949	1,330,944
2017	40,519	44,571	1,249,944	1,374,939
2018	41,049	45,154	1,290,463	1,419,510
2019	41,587	45,745	1,331,513	1,464,664

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2020	42,131	46,344	1,373,099	1,510,409
2021	42,682	46,951	1,415,230	1,556,753
2022	43,241	47,565	1,457,912	1,603,704
2023	43,807	48,188	1,501,153	1,651,269
2024	44,380	48,819	1,544,961	1,699,457
2025	44,961	49,458	1,589,341	1,748,275
2026	45,550	50,105	1,634,302	1,797,733
2027	46,146	50,761	1,679,852	1,847,838
2028	46,750	51,425	1,725,999	1,898,598
2029	47,362	52,098	1,772,749	1,950,024
2030	47,982	52,780	1,820,111	2,002,122
2031	48,610	53,471	1,868,093	2,054,902
2032	49,246	54,171	1,916,703	2,108,374
2033	49,891	54,880	1,965,950	2,162,545
2034	50,544	55,599	2,015,841	2,217,425
2035	51,206	56,326	2,066,385	2,273,023
2036	51,876	57,064	2,117,591	2,329,350
2037	52,555	57,811	2,169,467	2,386,413
2038	53,243	58,567	2,222,022	2,444,224
2039	53,940	59,334	2,275,265	2,502,791
2040	54,646	60,111	2,329,204	2,562,125
2041	55,361	60,897	2,383,850	2,622,235
2042	56,086	61,694	2,439,212	2,683,133
2043	56,820	62,502	2,495,298	2,744,827
2044	57,564	63,320	2,552,118	2,807,329
2045	58,317	64,149	2,609,681	2,870,650
2046	59,081	64,989	2,667,999	2,934,798
2047	59,854	65,839	2,727,079	2,999,787
2048	60,637	66,701	2,786,933	3,065,627
2049	61,431	67,574	2,847,571	3,132,328
2050	62,235	68,459	2,909,002	3,199,902
2051	63,050	69,355	2,971,237	3,268,361
2052	63,875	70,263	3,034,287	3,337,716
2053	64,711	71,182	3,098,162	3,407,978
2054	65,558	72,114	3,162,873	3,479,161
2055	66,416	73,058	3,228,432	3,551,275
2056	67,286	74,014	3,294,848	3,624,333
2057	68,167	74,983	3,362,134	3,698,347
2058	69,059	75,965	3,430,301	3,773,331
2059	69,963	76,959	3,499,359	3,849,295

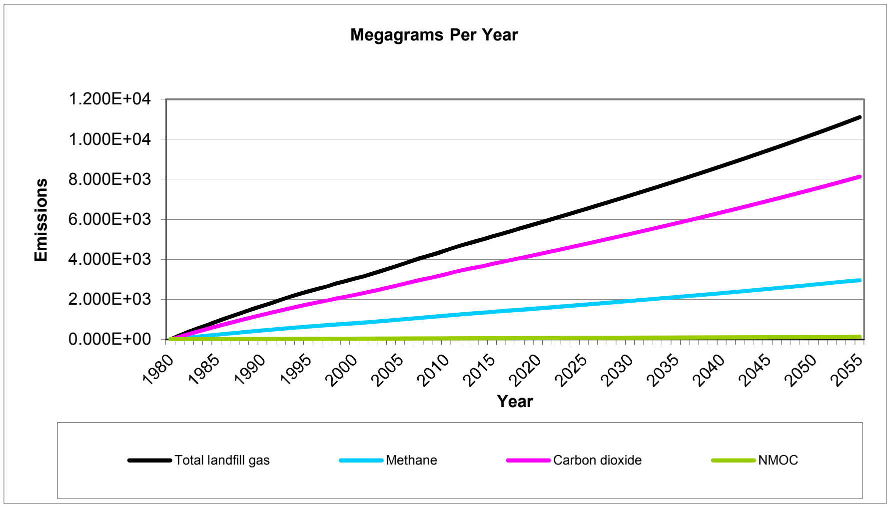
Pollutant Parameters

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

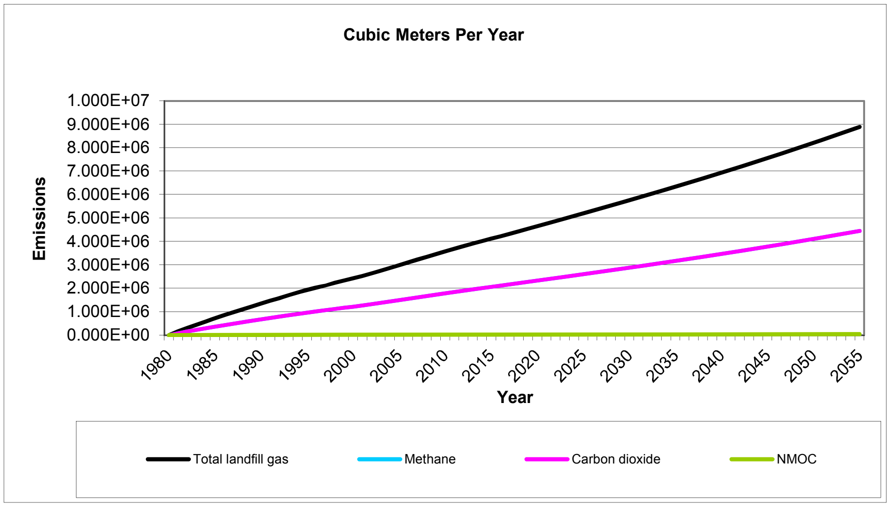
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

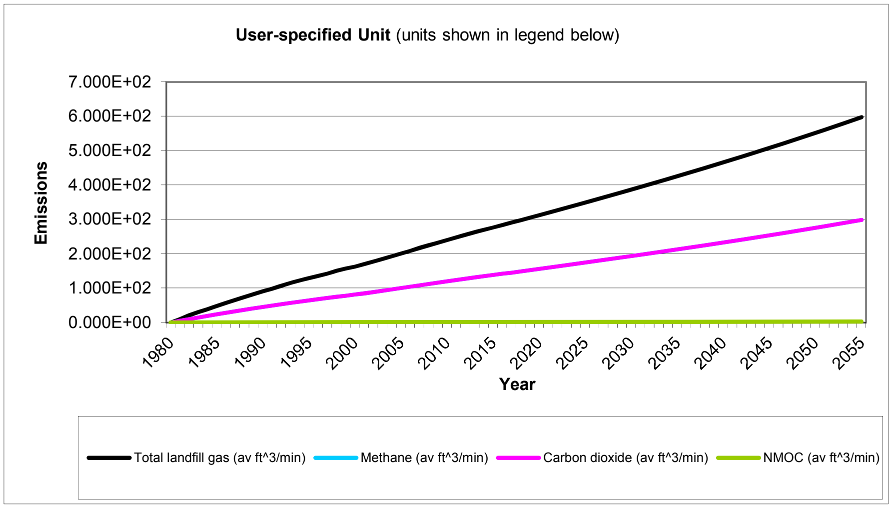
Graphs



Megagrams Per Year
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+03
0.000E+00
Emissions
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC



Cubic Meters Per Year
1.000E+07
9.000E+06
8.000E+06
7.000E+06
6.000E+06
5.000E+06
4.000E+06
3.000E+06
2.000E+06
1.000E+06
0.000E+00
Emissions
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas
Methane
Carbon dioxide
NMOC



User-specified Unit (units shown in legend below)
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
Emissions
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1980	0	0	0	0	0	0
1981	1.948E+02	1.560E+05	1.048E+01	5.203E+01	7.799E+04	5.240E+00
1982	3.857E+02	3.089E+05	2.075E+01	1.030E+02	1.544E+05	1.038E+01
1983	5.599E+02	4.483E+05	3.012E+01	1.495E+02	2.242E+05	1.506E+01
1984	7.306E+02	5.850E+05	3.931E+01	1.951E+02	2.925E+05	1.965E+01
1985	8.979E+02	7.190E+05	4.831E+01	2.398E+02	3.595E+05	2.416E+01
1986	1.062E+03	8.503E+05	5.713E+01	2.837E+02	4.252E+05	2.857E+01
1987	1.223E+03	9.791E+05	6.578E+01	3.266E+02	4.895E+05	3.289E+01
1988	1.380E+03	1.105E+06	7.426E+01	3.687E+02	5.526E+05	3.713E+01
1989	1.535E+03	1.229E+06	8.257E+01	4.099E+02	6.145E+05	4.129E+01
1990	1.686E+03	1.350E+06	9.072E+01	4.504E+02	6.751E+05	4.536E+01
1991	1.835E+03	1.469E+06	9.870E+01	4.900E+02	7.345E+05	4.935E+01
1992	1.980E+03	1.586E+06	1.065E+02	5.289E+02	7.928E+05	5.327E+01
1993	2.136E+03	1.710E+06	1.149E+02	5.705E+02	8.552E+05	5.746E+01
1994	2.280E+03	1.826E+06	1.227E+02	6.091E+02	9.130E+05	6.134E+01
1995	2.410E+03	1.930E+06	1.297E+02	6.438E+02	9.651E+05	6.484E+01
1996	2.530E+03	2.026E+06	1.361E+02	6.758E+02	1.013E+06	6.806E+01
1997	2.648E+03	2.120E+06	1.425E+02	7.073E+02	1.060E+06	7.123E+01
1998	2.795E+03	2.238E+06	1.504E+02	7.465E+02	1.119E+06	7.518E+01
1999	2.914E+03	2.333E+06	1.568E+02	7.783E+02	1.167E+06	7.838E+01
2000	3.033E+03	2.429E+06	1.632E+02	8.102E+02	1.214E+06	8.160E+01
2001	3.159E+03	2.530E+06	1.700E+02	8.439E+02	1.265E+06	8.499E+01
2002	3.296E+03	2.639E+06	1.773E+02	8.804E+02	1.320E+06	8.867E+01
2003	3.444E+03	2.758E+06	1.853E+02	9.199E+02	1.379E+06	9.265E+01
2004	3.577E+03	2.864E+06	1.924E+02	9.554E+02	1.432E+06	9.622E+01
2005	3.728E+03	2.985E+06	2.005E+02	9.957E+02	1.492E+06	1.003E+02
2006	3.879E+03	3.107E+06	2.087E+02	1.036E+03	1.553E+06	1.044E+02
2007	4.044E+03	3.239E+06	2.176E+02	1.080E+03	1.619E+06	1.088E+02
2008	4.178E+03	3.345E+06	2.248E+02	1.116E+03	1.673E+06	1.124E+02
2009	4.304E+03	3.447E+06	2.316E+02	1.150E+03	1.723E+06	1.158E+02
2010	4.457E+03	3.569E+06	2.398E+02	1.191E+03	1.785E+06	1.199E+02
2011	4.618E+03	3.698E+06	2.485E+02	1.234E+03	1.849E+06	1.242E+02
2012	4.748E+03	3.802E+06	2.555E+02	1.268E+03	1.901E+06	1.277E+02
2013	4.879E+03	3.907E+06	2.625E+02	1.303E+03	1.953E+06	1.312E+02
2014	5.009E+03	4.011E+06	2.695E+02	1.338E+03	2.005E+06	1.347E+02
2015	5.141E+03	4.117E+06	2.766E+02	1.373E+03	2.058E+06	1.383E+02
2016	5.274E+03	4.223E+06	2.837E+02	1.409E+03	2.111E+06	1.419E+02
2017	5.407E+03	4.330E+06	2.909E+02	1.444E+03	2.165E+06	1.455E+02
2018	5.540E+03	4.437E+06	2.981E+02	1.480E+03	2.218E+06	1.490E+02
2019	5.675E+03	4.544E+06	3.053E+02	1.516E+03	2.272E+06	1.527E+02
2020	5.809E+03	4.652E+06	3.126E+02	1.552E+03	2.326E+06	1.563E+02
2021	5.945E+03	4.760E+06	3.198E+02	1.588E+03	2.380E+06	1.599E+02
2022	6.080E+03	4.869E+06	3.271E+02	1.624E+03	2.434E+06	1.636E+02
2023	6.217E+03	4.978E+06	3.345E+02	1.661E+03	2.489E+06	1.672E+02
2024	6.354E+03	5.088E+06	3.419E+02	1.697E+03	2.544E+06	1.709E+02
2025	6.492E+03	5.198E+06	3.493E+02	1.734E+03	2.599E+06	1.746E+02
2026	6.630E+03	5.309E+06	3.567E+02	1.771E+03	2.655E+06	1.784E+02
2027	6.770E+03	5.421E+06	3.642E+02	1.808E+03	2.710E+06	1.821E+02
2028	6.910E+03	5.533E+06	3.718E+02	1.846E+03	2.767E+06	1.859E+02
2029	7.051E+03	5.646E+06	3.793E+02	1.883E+03	2.823E+06	1.897E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2030	7.193E+03	5.759E+06	3.870E+02	1.921E+03	2.880E+06	1.935E+02
2031	7.335E+03	5.874E+06	3.946E+02	1.959E+03	2.937E+06	1.973E+02
2032	7.479E+03	5.989E+06	4.024E+02	1.998E+03	2.994E+06	2.012E+02
2033	7.623E+03	6.104E+06	4.101E+02	2.036E+03	3.052E+06	2.051E+02
2034	7.769E+03	6.221E+06	4.180E+02	2.075E+03	3.110E+06	2.090E+02
2035	7.915E+03	6.338E+06	4.258E+02	2.114E+03	3.169E+06	2.129E+02
2036	8.063E+03	6.456E+06	4.338E+02	2.154E+03	3.228E+06	2.169E+02
2037	8.211E+03	6.575E+06	4.418E+02	2.193E+03	3.288E+06	2.209E+02
2038	8.361E+03	6.695E+06	4.498E+02	2.233E+03	3.347E+06	2.249E+02
2039	8.511E+03	6.816E+06	4.579E+02	2.273E+03	3.408E+06	2.290E+02
2040	8.663E+03	6.937E+06	4.661E+02	2.314E+03	3.469E+06	2.331E+02
2041	8.816E+03	7.060E+06	4.743E+02	2.355E+03	3.530E+06	2.372E+02
2042	8.971E+03	7.183E+06	4.826E+02	2.396E+03	3.592E+06	2.413E+02
2043	9.126E+03	7.308E+06	4.910E+02	2.438E+03	3.654E+06	2.455E+02
2044	9.283E+03	7.434E+06	4.995E+02	2.480E+03	3.717E+06	2.497E+02
2045	9.441E+03	7.560E+06	5.080E+02	2.522E+03	3.780E+06	2.540E+02
2046	9.601E+03	7.688E+06	5.165E+02	2.564E+03	3.844E+06	2.583E+02
2047	9.762E+03	7.817E+06	5.252E+02	2.607E+03	3.908E+06	2.626E+02
2048	9.924E+03	7.947E+06	5.339E+02	2.651E+03	3.973E+06	2.670E+02
2049	1.009E+04	8.078E+06	5.427E+02	2.695E+03	4.039E+06	2.714E+02
2050	1.025E+04	8.210E+06	5.516E+02	2.739E+03	4.105E+06	2.758E+02
2051	1.042E+04	8.344E+06	5.606E+02	2.783E+03	4.172E+06	2.803E+02
2052	1.059E+04	8.478E+06	5.697E+02	2.828E+03	4.239E+06	2.848E+02
2053	1.076E+04	8.614E+06	5.788E+02	2.873E+03	4.307E+06	2.894E+02
2054	1.093E+04	8.751E+06	5.880E+02	2.919E+03	4.376E+06	2.940E+02
2055	1.110E+04	8.890E+06	5.973E+02	2.965E+03	4.445E+06	2.987E+02
2056	1.128E+04	9.030E+06	6.067E+02	3.012E+03	4.515E+06	3.034E+02
2057	1.145E+04	9.171E+06	6.162E+02	3.059E+03	4.586E+06	3.081E+02
2058	1.163E+04	9.314E+06	6.258E+02	3.107E+03	4.657E+06	3.129E+02
2059	1.181E+04	9.458E+06	6.355E+02	3.155E+03	4.729E+06	3.177E+02
2060	1.199E+04	9.604E+06	6.453E+02	3.203E+03	4.802E+06	3.226E+02
2061	1.176E+04	9.413E+06	6.325E+02	3.140E+03	4.707E+06	3.162E+02
2062	1.152E+04	9.227E+06	6.200E+02	3.078E+03	4.613E+06	3.100E+02
2063	1.129E+04	9.044E+06	6.077E+02	3.017E+03	4.522E+06	3.038E+02
2064	1.107E+04	8.865E+06	5.957E+02	2.957E+03	4.433E+06	2.978E+02
2065	1.085E+04	8.690E+06	5.839E+02	2.899E+03	4.345E+06	2.919E+02
2066	1.064E+04	8.518E+06	5.723E+02	2.841E+03	4.259E+06	2.861E+02
2067	1.043E+04	8.349E+06	5.610E+02	2.785E+03	4.174E+06	2.805E+02
2068	1.022E+04	8.184E+06	5.499E+02	2.730E+03	4.092E+06	2.749E+02
2069	1.002E+04	8.022E+06	5.390E+02	2.676E+03	4.011E+06	2.695E+02
2070	9.819E+03	7.863E+06	5.283E+02	2.623E+03	3.931E+06	2.641E+02
2071	9.625E+03	7.707E+06	5.178E+02	2.571E+03	3.854E+06	2.589E+02
2072	9.434E+03	7.554E+06	5.076E+02	2.520E+03	3.777E+06	2.538E+02
2073	9.247E+03	7.405E+06	4.975E+02	2.470E+03	3.702E+06	2.488E+02
2074	9.064E+03	7.258E+06	4.877E+02	2.421E+03	3.629E+06	2.438E+02
2075	8.885E+03	7.114E+06	4.780E+02	2.373E+03	3.557E+06	2.390E+02
2076	8.709E+03	6.974E+06	4.686E+02	2.326E+03	3.487E+06	2.343E+02
2077	8.536E+03	6.836E+06	4.593E+02	2.280E+03	3.418E+06	2.296E+02
2078	8.367E+03	6.700E+06	4.502E+02	2.235E+03	3.350E+06	2.251E+02
2079	8.202E+03	6.567E+06	4.413E+02	2.191E+03	3.284E+06	2.206E+02
2080	8.039E+03	6.437E+06	4.325E+02	2.147E+03	3.219E+06	2.163E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	7.880E+03	6.310E+06	4.240E+02	2.105E+03	3.155E+06	2.120E+02
2082	7.724E+03	6.185E+06	4.156E+02	2.063E+03	3.093E+06	2.078E+02
2083	7.571E+03	6.063E+06	4.073E+02	2.022E+03	3.031E+06	2.037E+02
2084	7.421E+03	5.943E+06	3.993E+02	1.982E+03	2.971E+06	1.996E+02
2085	7.274E+03	5.825E+06	3.914E+02	1.943E+03	2.912E+06	1.957E+02
2086	7.130E+03	5.709E+06	3.836E+02	1.905E+03	2.855E+06	1.918E+02
2087	6.989E+03	5.596E+06	3.760E+02	1.867E+03	2.798E+06	1.880E+02
2088	6.851E+03	5.486E+06	3.686E+02	1.830E+03	2.743E+06	1.843E+02
2089	6.715E+03	5.377E+06	3.613E+02	1.794E+03	2.689E+06	1.806E+02
2090	6.582E+03	5.271E+06	3.541E+02	1.758E+03	2.635E+06	1.771E+02
2091	6.452E+03	5.166E+06	3.471E+02	1.723E+03	2.583E+06	1.736E+02
2092	6.324E+03	5.064E+06	3.402E+02	1.689E+03	2.532E+06	1.701E+02
2093	6.199E+03	4.964E+06	3.335E+02	1.656E+03	2.482E+06	1.668E+02
2094	6.076E+03	4.865E+06	3.269E+02	1.623E+03	2.433E+06	1.634E+02
2095	5.956E+03	4.769E+06	3.204E+02	1.591E+03	2.384E+06	1.602E+02
2096	5.838E+03	4.675E+06	3.141E+02	1.559E+03	2.337E+06	1.570E+02
2097	5.722E+03	4.582E+06	3.079E+02	1.528E+03	2.291E+06	1.539E+02
2098	5.609E+03	4.491E+06	3.018E+02	1.498E+03	2.246E+06	1.509E+02
2099	5.498E+03	4.402E+06	2.958E+02	1.468E+03	2.201E+06	1.479E+02
2100	5.389E+03	4.315E+06	2.899E+02	1.439E+03	2.158E+06	1.450E+02
2101	5.282E+03	4.230E+06	2.842E+02	1.411E+03	2.115E+06	1.421E+02
2102	5.178E+03	4.146E+06	2.786E+02	1.383E+03	2.073E+06	1.393E+02
2103	5.075E+03	4.064E+06	2.730E+02	1.356E+03	2.032E+06	1.365E+02
2104	4.975E+03	3.983E+06	2.676E+02	1.329E+03	1.992E+06	1.338E+02
2105	4.876E+03	3.905E+06	2.623E+02	1.302E+03	1.952E+06	1.312E+02
2106	4.779E+03	3.827E+06	2.571E+02	1.277E+03	1.914E+06	1.286E+02
2107	4.685E+03	3.751E+06	2.521E+02	1.251E+03	1.876E+06	1.260E+02
2108	4.592E+03	3.677E+06	2.471E+02	1.227E+03	1.839E+06	1.235E+02
2109	4.501E+03	3.604E+06	2.422E+02	1.202E+03	1.802E+06	1.211E+02
2110	4.412E+03	3.533E+06	2.374E+02	1.178E+03	1.766E+06	1.187E+02
2111	4.325E+03	3.463E+06	2.327E+02	1.155E+03	1.731E+06	1.163E+02
2112	4.239E+03	3.394E+06	2.281E+02	1.132E+03	1.697E+06	1.140E+02
2113	4.155E+03	3.327E+06	2.236E+02	1.110E+03	1.664E+06	1.118E+02
2114	4.073E+03	3.261E+06	2.191E+02	1.088E+03	1.631E+06	1.096E+02
2115	3.992E+03	3.197E+06	2.148E+02	1.066E+03	1.598E+06	1.074E+02
2116	3.913E+03	3.133E+06	2.105E+02	1.045E+03	1.567E+06	1.053E+02
2117	3.836E+03	3.071E+06	2.064E+02	1.025E+03	1.536E+06	1.032E+02
2118	3.760E+03	3.011E+06	2.023E+02	1.004E+03	1.505E+06	1.011E+02
2119	3.685E+03	2.951E+06	1.983E+02	9.844E+02	1.475E+06	9.914E+01
2120	3.612E+03	2.893E+06	1.943E+02	9.649E+02	1.446E+06	9.717E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1980	0	0	0	0	0	0
1981	1.428E+02	7.799E+04	5.240E+00	2.236E+00	6.239E+02	4.192E-02
1982	2.827E+02	1.544E+05	1.038E+01	4.428E+00	1.235E+03	8.301E-02
1983	4.103E+02	2.242E+05	1.506E+01	6.428E+00	1.793E+03	1.205E-01
1984	5.354E+02	2.925E+05	1.965E+01	8.388E+00	2.340E+03	1.572E-01
1985	6.581E+02	3.595E+05	2.416E+01	1.031E+01	2.876E+03	1.932E-01
1986	7.783E+02	4.252E+05	2.857E+01	1.219E+01	3.401E+03	2.285E-01
1987	8.961E+02	4.895E+05	3.289E+01	1.404E+01	3.916E+03	2.631E-01
1988	1.012E+03	5.526E+05	3.713E+01	1.585E+01	4.421E+03	2.971E-01
1989	1.125E+03	6.145E+05	4.129E+01	1.762E+01	4.916E+03	3.303E-01
1990	1.236E+03	6.751E+05	4.536E+01	1.936E+01	5.401E+03	3.629E-01
1991	1.345E+03	7.345E+05	4.935E+01	2.106E+01	5.876E+03	3.948E-01
1992	1.451E+03	7.928E+05	5.327E+01	2.273E+01	6.342E+03	4.261E-01
1993	1.565E+03	8.552E+05	5.746E+01	2.452E+01	6.842E+03	4.597E-01
1994	1.671E+03	9.130E+05	6.134E+01	2.618E+01	7.304E+03	4.907E-01
1995	1.767E+03	9.651E+05	6.484E+01	2.767E+01	7.720E+03	5.187E-01
1996	1.854E+03	1.013E+06	6.806E+01	2.905E+01	8.103E+03	5.445E-01
1997	1.941E+03	1.060E+06	7.123E+01	3.040E+01	8.481E+03	5.698E-01
1998	2.048E+03	1.119E+06	7.518E+01	3.209E+01	8.952E+03	6.015E-01
1999	2.135E+03	1.167E+06	7.838E+01	3.345E+01	9.332E+03	6.270E-01
2000	2.223E+03	1.214E+06	8.160E+01	3.482E+01	9.715E+03	6.528E-01
2001	2.315E+03	1.265E+06	8.499E+01	3.627E+01	1.012E+04	6.799E-01
2002	2.416E+03	1.320E+06	8.867E+01	3.784E+01	1.056E+04	7.093E-01
2003	2.524E+03	1.379E+06	9.265E+01	3.954E+01	1.103E+04	7.412E-01
2004	2.621E+03	1.432E+06	9.622E+01	4.107E+01	1.146E+04	7.698E-01
2005	2.732E+03	1.492E+06	1.003E+02	4.280E+01	1.194E+04	8.022E-01
2006	2.843E+03	1.553E+06	1.044E+02	4.454E+01	1.243E+04	8.349E-01
2007	2.964E+03	1.619E+06	1.088E+02	4.643E+01	1.295E+04	8.704E-01
2008	3.062E+03	1.673E+06	1.124E+02	4.797E+01	1.338E+04	8.991E-01
2009	3.155E+03	1.723E+06	1.158E+02	4.942E+01	1.379E+04	9.263E-01
2010	3.267E+03	1.785E+06	1.199E+02	5.117E+01	1.428E+04	9.592E-01
2011	3.385E+03	1.849E+06	1.242E+02	5.302E+01	1.479E+04	9.939E-01
2012	3.480E+03	1.901E+06	1.277E+02	5.451E+01	1.521E+04	1.022E+00
2013	3.576E+03	1.953E+06	1.312E+02	5.601E+01	1.563E+04	1.050E+00
2014	3.671E+03	2.005E+06	1.347E+02	5.750E+01	1.604E+04	1.078E+00
2015	3.768E+03	2.058E+06	1.383E+02	5.902E+01	1.647E+04	1.106E+00
2016	3.865E+03	2.111E+06	1.419E+02	6.055E+01	1.689E+04	1.135E+00
2017	3.963E+03	2.165E+06	1.455E+02	6.208E+01	1.732E+04	1.164E+00
2018	4.061E+03	2.218E+06	1.490E+02	6.361E+01	1.775E+04	1.192E+00
2019	4.159E+03	2.272E+06	1.527E+02	6.515E+01	1.818E+04	1.221E+00
2020	4.258E+03	2.326E+06	1.563E+02	6.670E+01	1.861E+04	1.250E+00
2021	4.357E+03	2.380E+06	1.599E+02	6.825E+01	1.904E+04	1.279E+00
2022	4.456E+03	2.434E+06	1.636E+02	6.981E+01	1.948E+04	1.309E+00
2023	4.556E+03	2.489E+06	1.672E+02	7.138E+01	1.991E+04	1.338E+00
2024	4.657E+03	2.544E+06	1.709E+02	7.295E+01	2.035E+04	1.367E+00
2025	4.758E+03	2.599E+06	1.746E+02	7.453E+01	2.079E+04	1.397E+00
2026	4.859E+03	2.655E+06	1.784E+02	7.613E+01	2.124E+04	1.427E+00
2027	4.961E+03	2.710E+06	1.821E+02	7.772E+01	2.168E+04	1.457E+00
2028	5.064E+03	2.767E+06	1.859E+02	7.933E+01	2.213E+04	1.487E+00
2029	5.167E+03	2.823E+06	1.897E+02	8.095E+01	2.258E+04	1.517E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2030	5.271E+03	2.880E+06	1.935E+02	8.258E+01	2.304E+04	1.548E+00
2031	5.376E+03	2.937E+06	1.973E+02	8.422E+01	2.349E+04	1.579E+00
2032	5.481E+03	2.994E+06	2.012E+02	8.586E+01	2.395E+04	1.609E+00
2033	5.587E+03	3.052E+06	2.051E+02	8.752E+01	2.442E+04	1.641E+00
2034	5.694E+03	3.110E+06	2.090E+02	8.919E+01	2.488E+04	1.672E+00
2035	5.801E+03	3.169E+06	2.129E+02	9.087E+01	2.535E+04	1.703E+00
2036	5.909E+03	3.228E+06	2.169E+02	9.257E+01	2.582E+04	1.735E+00
2037	6.018E+03	3.288E+06	2.209E+02	9.427E+01	2.630E+04	1.767E+00
2038	6.127E+03	3.347E+06	2.249E+02	9.599E+01	2.678E+04	1.799E+00
2039	6.238E+03	3.408E+06	2.290E+02	9.772E+01	2.726E+04	1.832E+00
2040	6.349E+03	3.469E+06	2.331E+02	9.946E+01	2.775E+04	1.864E+00
2041	6.461E+03	3.530E+06	2.372E+02	1.012E+02	2.824E+04	1.897E+00
2042	6.575E+03	3.592E+06	2.413E+02	1.030E+02	2.873E+04	1.931E+00
2043	6.689E+03	3.654E+06	2.455E+02	1.048E+02	2.923E+04	1.964E+00
2044	6.804E+03	3.717E+06	2.497E+02	1.066E+02	2.973E+04	1.998E+00
2045	6.919E+03	3.780E+06	2.540E+02	1.084E+02	3.024E+04	2.032E+00
2046	7.036E+03	3.844E+06	2.583E+02	1.102E+02	3.075E+04	2.066E+00
2047	7.154E+03	3.908E+06	2.626E+02	1.121E+02	3.127E+04	2.101E+00
2048	7.273E+03	3.973E+06	2.670E+02	1.139E+02	3.179E+04	2.136E+00
2049	7.393E+03	4.039E+06	2.714E+02	1.158E+02	3.231E+04	2.171E+00
2050	7.514E+03	4.105E+06	2.758E+02	1.177E+02	3.284E+04	2.207E+00
2051	7.636E+03	4.172E+06	2.803E+02	1.196E+02	3.337E+04	2.242E+00
2052	7.760E+03	4.239E+06	2.848E+02	1.216E+02	3.391E+04	2.279E+00
2053	7.884E+03	4.307E+06	2.894E+02	1.235E+02	3.446E+04	2.315E+00
2054	8.010E+03	4.376E+06	2.940E+02	1.255E+02	3.501E+04	2.352E+00
2055	8.137E+03	4.445E+06	2.987E+02	1.275E+02	3.556E+04	2.389E+00
2056	8.265E+03	4.515E+06	3.034E+02	1.295E+02	3.612E+04	2.427E+00
2057	8.394E+03	4.586E+06	3.081E+02	1.315E+02	3.668E+04	2.465E+00
2058	8.525E+03	4.657E+06	3.129E+02	1.335E+02	3.726E+04	2.503E+00
2059	8.656E+03	4.729E+06	3.177E+02	1.356E+02	3.783E+04	2.542E+00
2060	8.790E+03	4.802E+06	3.226E+02	1.377E+02	3.841E+04	2.581E+00
2061	8.616E+03	4.707E+06	3.162E+02	1.350E+02	3.765E+04	2.530E+00
2062	8.445E+03	4.613E+06	3.100E+02	1.323E+02	3.691E+04	2.480E+00
2063	8.278E+03	4.522E+06	3.038E+02	1.297E+02	3.618E+04	2.431E+00
2064	8.114E+03	4.433E+06	2.978E+02	1.271E+02	3.546E+04	2.383E+00
2065	7.953E+03	4.345E+06	2.919E+02	1.246E+02	3.476E+04	2.335E+00
2066	7.796E+03	4.259E+06	2.861E+02	1.221E+02	3.407E+04	2.289E+00
2067	7.641E+03	4.174E+06	2.805E+02	1.197E+02	3.340E+04	2.244E+00
2068	7.490E+03	4.092E+06	2.749E+02	1.173E+02	3.273E+04	2.199E+00
2069	7.342E+03	4.011E+06	2.695E+02	1.150E+02	3.209E+04	2.156E+00
2070	7.196E+03	3.931E+06	2.641E+02	1.127E+02	3.145E+04	2.113E+00
2071	7.054E+03	3.854E+06	2.589E+02	1.105E+02	3.083E+04	2.071E+00
2072	6.914E+03	3.777E+06	2.538E+02	1.083E+02	3.022E+04	2.030E+00
2073	6.777E+03	3.702E+06	2.488E+02	1.062E+02	2.962E+04	1.990E+00
2074	6.643E+03	3.629E+06	2.438E+02	1.041E+02	2.903E+04	1.951E+00
2075	6.512E+03	3.557E+06	2.390E+02	1.020E+02	2.846E+04	1.912E+00
2076	6.383E+03	3.487E+06	2.343E+02	9.999E+01	2.789E+04	1.874E+00
2077	6.256E+03	3.418E+06	2.296E+02	9.801E+01	2.734E+04	1.837E+00
2078	6.132E+03	3.350E+06	2.251E+02	9.607E+01	2.680E+04	1.801E+00
2079	6.011E+03	3.284E+06	2.206E+02	9.416E+01	2.627E+04	1.765E+00
2080	5.892E+03	3.219E+06	2.163E+02	9.230E+01	2.575E+04	1.730E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2081	5.775E+03	3.155E+06	2.120E+02	9.047E+01	2.524E+04	1.696E+00
2082	5.661E+03	3.093E+06	2.078E+02	8.868E+01	2.474E+04	1.662E+00
2083	5.549E+03	3.031E+06	2.037E+02	8.692E+01	2.425E+04	1.629E+00
2084	5.439E+03	2.971E+06	1.996E+02	8.520E+01	2.377E+04	1.597E+00
2085	5.331E+03	2.912E+06	1.957E+02	8.352E+01	2.330E+04	1.565E+00
2086	5.226E+03	2.855E+06	1.918E+02	8.186E+01	2.284E+04	1.534E+00
2087	5.122E+03	2.798E+06	1.880E+02	8.024E+01	2.239E+04	1.504E+00
2088	5.021E+03	2.743E+06	1.843E+02	7.865E+01	2.194E+04	1.474E+00
2089	4.921E+03	2.689E+06	1.806E+02	7.709E+01	2.151E+04	1.445E+00
2090	4.824E+03	2.635E+06	1.771E+02	7.557E+01	2.108E+04	1.417E+00
2091	4.728E+03	2.583E+06	1.736E+02	7.407E+01	2.066E+04	1.388E+00
2092	4.635E+03	2.532E+06	1.701E+02	7.261E+01	2.026E+04	1.361E+00
2093	4.543E+03	2.482E+06	1.668E+02	7.117E+01	1.985E+04	1.334E+00
2094	4.453E+03	2.433E+06	1.634E+02	6.976E+01	1.946E+04	1.308E+00
2095	4.365E+03	2.384E+06	1.602E+02	6.838E+01	1.908E+04	1.282E+00
2096	4.278E+03	2.337E+06	1.570E+02	6.702E+01	1.870E+04	1.256E+00
2097	4.194E+03	2.291E+06	1.539E+02	6.570E+01	1.833E+04	1.231E+00
2098	4.111E+03	2.246E+06	1.509E+02	6.439E+01	1.797E+04	1.207E+00
2099	4.029E+03	2.201E+06	1.479E+02	6.312E+01	1.761E+04	1.183E+00
2100	3.949E+03	2.158E+06	1.450E+02	6.187E+01	1.726E+04	1.160E+00
2101	3.871E+03	2.115E+06	1.421E+02	6.064E+01	1.692E+04	1.137E+00
2102	3.795E+03	2.073E+06	1.393E+02	5.944E+01	1.658E+04	1.114E+00
2103	3.719E+03	2.032E+06	1.365E+02	5.827E+01	1.626E+04	1.092E+00
2104	3.646E+03	1.992E+06	1.338E+02	5.711E+01	1.593E+04	1.071E+00
2105	3.574E+03	1.952E+06	1.312E+02	5.598E+01	1.562E+04	1.049E+00
2106	3.503E+03	1.914E+06	1.286E+02	5.487E+01	1.531E+04	1.029E+00
2107	3.433E+03	1.876E+06	1.260E+02	5.379E+01	1.501E+04	1.008E+00
2108	3.365E+03	1.839E+06	1.235E+02	5.272E+01	1.471E+04	9.883E-01
2109	3.299E+03	1.802E+06	1.211E+02	5.168E+01	1.442E+04	9.687E-01
2110	3.234E+03	1.766E+06	1.187E+02	5.065E+01	1.413E+04	9.495E-01
2111	3.169E+03	1.731E+06	1.163E+02	4.965E+01	1.385E+04	9.307E-01
2112	3.107E+03	1.697E+06	1.140E+02	4.867E+01	1.358E+04	9.123E-01
2113	3.045E+03	1.664E+06	1.118E+02	4.770E+01	1.331E+04	8.942E-01
2114	2.985E+03	1.631E+06	1.096E+02	4.676E+01	1.305E+04	8.765E-01
2115	2.926E+03	1.598E+06	1.074E+02	4.583E+01	1.279E+04	8.592E-01
2116	2.868E+03	1.567E+06	1.053E+02	4.493E+01	1.253E+04	8.421E-01
2117	2.811E+03	1.536E+06	1.032E+02	4.404E+01	1.229E+04	8.255E-01
2118	2.755E+03	1.505E+06	1.011E+02	4.317E+01	1.204E+04	8.091E-01
2119	2.701E+03	1.475E+06	9.914E+01	4.231E+01	1.180E+04	7.931E-01
2120	2.647E+03	1.446E+06	9.717E+01	4.147E+01	1.157E+04	7.774E-01

LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Glenmore Landfill

Date: Tuesday, March 24, 2015

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o\left(\frac{M_i}{10}\right)e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate (*$year^{-1}$*)

L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2060**	
Landfill Closure Year (with 80-year limit)	**2092**	
Actual Closure Year (without limit)	***2092***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**18,372,200**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.020**	*year $^{-1}$*
Potential Methane Generation Capacity, L_o	**120**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
2060	70,879	77,966	0	0
2061	71,806	78,987	70,879	77,966
2062	72,746	80,021	142,685	156,953
2063	73,698	81,068	215,431	236,974
2064	74,663	82,129	289,130	318,043
2065	75,640	83,205	363,793	400,172
2066	76,631	84,294	439,433	483,377
2067	77,634	85,397	516,064	567,670
2068	78,650	86,515	593,698	653,067
2069	79,679	87,647	672,347	739,582
2070	80,722	88,795	752,027	827,230
2071	81,779	89,957	832,749	916,024
2072	82,849	91,134	914,528	1,005,981
2073	83,934	92,327	997,377	1,097,115
2074	85,033	93,536	1,081,311	1,189,442
2075	86,146	94,760	1,166,344	1,282,978
2076	87,273	96,000	1,252,489	1,377,738
2077	88,416	97,257	1,339,763	1,473,739
2078	89,573	98,530	1,428,178	1,570,996
2079	90,745	99,820	1,517,751	1,669,526
2080	91,933	101,126	1,608,496	1,769,346
2081	93,137	102,450	1,700,430	1,870,472
2082	94,356	103,791	1,793,566	1,972,923
2083	95,591	105,150	1,887,922	2,076,714
2084	96,842	106,526	1,983,512	2,181,864
2085	98,110	107,921	2,080,354	2,288,390
2086	99,394	109,333	2,178,464	2,396,310
2087	100,695	110,764	2,277,858	2,505,644
2088	102,013	112,214	2,378,553	2,616,408
2089	103,348	113,683	2,480,566	2,728,622
2090	104,701	115,171	2,583,914	2,842,305
2091	106,071	116,679	2,688,615	2,957,476
2092	66,262	72,888	2,794,686	3,074,155
2093	0	0	2,860,948	3,147,043
2094	0	0	2,860,948	3,147,043
2095	0	0	2,860,948	3,147,043
2096	0	0	2,860,948	3,147,043
2097	0	0	2,860,948	3,147,043
2098	0	0	2,860,948	3,147,043
2099	0	0	2,860,948	3,147,043

WASTE ACCEPTANCE RATES (Continued)

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
2100	0	0	2,860,948	3,147,043
2101	0	0	2,860,948	3,147,043
2102	0	0	2,860,948	3,147,043
2103	0	0	2,860,948	3,147,043
2104	0	0	2,860,948	3,147,043
2105	0	0	2,860,948	3,147,043
2106	0	0	2,860,948	3,147,043
2107	0	0	2,860,948	3,147,043
2108	0	0	2,860,948	3,147,043
2109	0	0	2,860,948	3,147,043
2110	0	0	2,860,948	3,147,043
2111	0	0	2,860,948	3,147,043
2112	0	0	2,860,948	3,147,043
2113	0	0	2,860,948	3,147,043
2114	0	0	2,860,948	3,147,043
2115	0	0	2,860,948	3,147,043
2116	0	0	2,860,948	3,147,043
2117	0	0	2,860,948	3,147,043
2118	0	0	2,860,948	3,147,043
2119	0	0	2,860,948	3,147,043
2120	0	0	2,860,948	3,147,043
2121	0	0	2,860,948	3,147,043
2122	0	0	2,860,948	3,147,043
2123	0	0	2,860,948	3,147,043
2124	0	0	2,860,948	3,147,043
2125	0	0	2,860,948	3,147,043
2126	0	0	2,860,948	3,147,043
2127	0	0	2,860,948	3,147,043
2128	0	0	2,860,948	3,147,043
2129	0	0	2,860,948	3,147,043
2130	0	0	2,860,948	3,147,043
2131	0	0	2,860,948	3,147,043
2132	0	0	2,860,948	3,147,043
2133	0	0	2,860,948	3,147,043
2134	0	0	2,860,948	3,147,043
2135	0	0	2,860,948	3,147,043
2136	0	0	2,860,948	3,147,043
2137	0	0	2,860,948	3,147,043
2138	0	0	2,860,948	3,147,043
2139	0	0	2,860,948	3,147,043

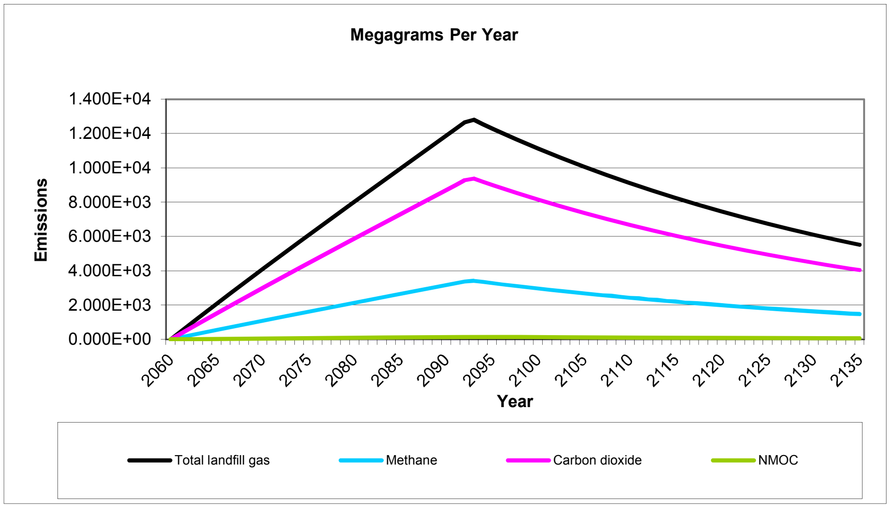
Pollutant Parameters

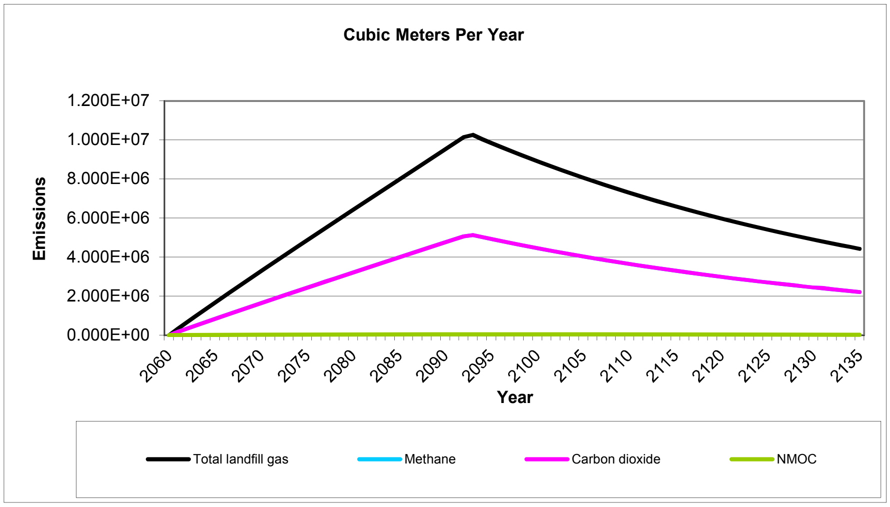
	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

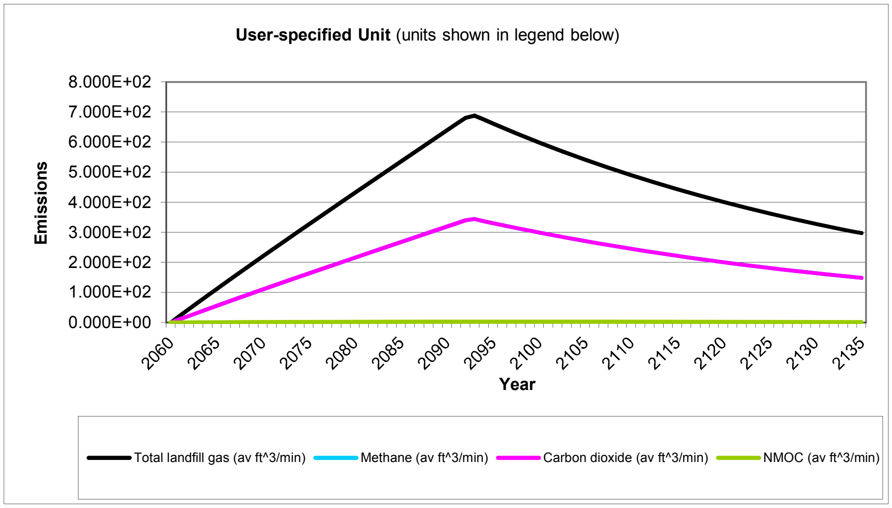
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
1.400E+04
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+03
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
1.200E+07
1.000E+07
8.000E+06
6.000E+06
4.000E+06
2.000E+06
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
8.000E+02
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	4.211E+02	3.372E+05	2.265E+01	1.125E+02	1.686E+05	1.133E+01
2062	8.393E+02	6.721E+05	4.516E+01	2.242E+02	3.360E+05	2.258E+01
2063	1.255E+03	1.005E+06	6.751E+01	3.352E+02	5.024E+05	3.376E+01
2064	1.668E+03	1.336E+06	8.973E+01	4.455E+02	6.678E+05	4.487E+01
2065	2.078E+03	1.664E+06	1.118E+02	5.552E+02	8.321E+05	5.591E+01
2066	2.487E+03	1.991E+06	1.338E+02	6.642E+02	9.956E+05	6.689E+01
2067	2.893E+03	2.316E+06	1.556E+02	7.726E+02	1.158E+06	7.781E+01
2068	3.297E+03	2.640E+06	1.774E+02	8.805E+02	1.320E+06	8.868E+01
2069	3.698E+03	2.962E+06	1.990E+02	9.879E+02	1.481E+06	9.949E+01
2070	4.099E+03	3.282E+06	2.205E+02	1.095E+03	1.641E+06	1.103E+02
2071	4.497E+03	3.601E+06	2.419E+02	1.201E+03	1.800E+06	1.210E+02
2072	4.894E+03	3.919E+06	2.633E+02	1.307E+03	1.959E+06	1.316E+02
2073	5.289E+03	4.235E+06	2.846E+02	1.413E+03	2.118E+06	1.423E+02
2074	5.683E+03	4.551E+06	3.058E+02	1.518E+03	2.275E+06	1.529E+02
2075	6.076E+03	4.865E+06	3.269E+02	1.623E+03	2.433E+06	1.634E+02
2076	6.467E+03	5.179E+06	3.479E+02	1.727E+03	2.589E+06	1.740E+02
2077	6.857E+03	5.491E+06	3.689E+02	1.832E+03	2.746E+06	1.845E+02
2078	7.247E+03	5.803E+06	3.899E+02	1.936E+03	2.901E+06	1.950E+02
2079	7.636E+03	6.114E+06	4.108E+02	2.040E+03	3.057E+06	2.054E+02
2080	8.023E+03	6.425E+06	4.317E+02	2.143E+03	3.212E+06	2.158E+02
2081	8.411E+03	6.735E+06	4.525E+02	2.247E+03	3.367E+06	2.263E+02
2082	8.797E+03	7.045E+06	4.733E+02	2.350E+03	3.522E+06	2.367E+02
2083	9.184E+03	7.354E+06	4.941E+02	2.453E+03	3.677E+06	2.471E+02
2084	9.570E+03	7.663E+06	5.149E+02	2.556E+03	3.832E+06	2.574E+02
2085	9.956E+03	7.972E+06	5.356E+02	2.659E+03	3.986E+06	2.678E+02
2086	1.034E+04	8.281E+06	5.564E+02	2.762E+03	4.140E+06	2.782E+02
2087	1.073E+04	8.590E+06	5.771E+02	2.865E+03	4.295E+06	2.886E+02
2088	1.111E+04	8.899E+06	5.979E+02	2.968E+03	4.449E+06	2.990E+02
2089	1.150E+04	9.208E+06	6.187E+02	3.071E+03	4.604E+06	3.093E+02
2090	1.189E+04	9.517E+06	6.394E+02	3.175E+03	4.759E+06	3.197E+02
2091	1.227E+04	9.827E+06	6.603E+02	3.278E+03	4.913E+06	3.301E+02
2092	1.266E+04	1.014E+07	6.811E+02	3.381E+03	5.068E+06	3.405E+02
2093	1.280E+04	1.025E+07	6.888E+02	3.420E+03	5.126E+06	3.444E+02
2094	1.255E+04	1.005E+07	6.751E+02	3.352E+03	5.024E+06	3.376E+02
2095	1.230E+04	9.849E+06	6.618E+02	3.285E+03	4.925E+06	3.309E+02
2096	1.206E+04	9.654E+06	6.487E+02	3.220E+03	4.827E+06	3.243E+02
2097	1.182E+04	9.463E+06	6.358E+02	3.157E+03	4.732E+06	3.179E+02
2098	1.158E+04	9.276E+06	6.232E+02	3.094E+03	4.638E+06	3.116E+02
2099	1.135E+04	9.092E+06	6.109E+02	3.033E+03	4.546E+06	3.054E+02
2100	1.113E+04	8.912E+06	5.988E+02	2.973E+03	4.456E+06	2.994E+02
2101	1.091E+04	8.735E+06	5.869E+02	2.914E+03	4.368E+06	2.935E+02
2102	1.069E+04	8.563E+06	5.753E+02	2.856E+03	4.281E+06	2.877E+02
2103	1.048E+04	8.393E+06	5.639E+02	2.800E+03	4.196E+06	2.820E+02
2104	1.027E+04	8.227E+06	5.528E+02	2.744E+03	4.113E+06	2.764E+02
2105	1.007E+04	8.064E+06	5.418E+02	2.690E+03	4.032E+06	2.709E+02
2106	9.871E+03	7.904E+06	5.311E+02	2.637E+03	3.952E+06	2.655E+02
2107	9.675E+03	7.748E+06	5.206E+02	2.584E+03	3.874E+06	2.603E+02
2108	9.484E+03	7.594E+06	5.103E+02	2.533E+03	3.797E+06	2.551E+02
2109	9.296E+03	7.444E+06	5.002E+02	2.483E+03	3.722E+06	2.501E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2110	9.112E+03	7.296E+06	4.902E+02	2.434E+03	3.648E+06	2.451E+02
2111	8.932E+03	7.152E+06	4.805E+02	2.386E+03	3.576E+06	2.403E+02
2112	8.755E+03	7.010E+06	4.710E+02	2.338E+03	3.505E+06	2.355E+02
2113	8.581E+03	6.872E+06	4.617E+02	2.292E+03	3.436E+06	2.308E+02
2114	8.411E+03	6.736E+06	4.526E+02	2.247E+03	3.368E+06	2.263E+02
2115	8.245E+03	6.602E+06	4.436E+02	2.202E+03	3.301E+06	2.218E+02
2116	8.082E+03	6.471E+06	4.348E+02	2.159E+03	3.236E+06	2.174E+02
2117	7.922E+03	6.343E+06	4.262E+02	2.116E+03	3.172E+06	2.131E+02
2118	7.765E+03	6.218E+06	4.178E+02	2.074E+03	3.109E+06	2.089E+02
2119	7.611E+03	6.095E+06	4.095E+02	2.033E+03	3.047E+06	2.047E+02
2120	7.460E+03	5.974E+06	4.014E+02	1.993E+03	2.987E+06	2.007E+02
2121	7.313E+03	5.856E+06	3.934E+02	1.953E+03	2.928E+06	1.967E+02
2122	7.168E+03	5.740E+06	3.856E+02	1.915E+03	2.870E+06	1.928E+02
2123	7.026E+03	5.626E+06	3.780E+02	1.877E+03	2.813E+06	1.890E+02
2124	6.887E+03	5.515E+06	3.705E+02	1.840E+03	2.757E+06	1.853E+02
2125	6.750E+03	5.405E+06	3.632E+02	1.803E+03	2.703E+06	1.816E+02
2126	6.617E+03	5.298E+06	3.560E+02	1.767E+03	2.649E+06	1.780E+02
2127	6.486E+03	5.193E+06	3.489E+02	1.732E+03	2.597E+06	1.745E+02
2128	6.357E+03	5.091E+06	3.420E+02	1.698E+03	2.545E+06	1.710E+02
2129	6.231E+03	4.990E+06	3.353E+02	1.664E+03	2.495E+06	1.676E+02
2130	6.108E+03	4.891E+06	3.286E+02	1.632E+03	2.445E+06	1.643E+02
2131	5.987E+03	4.794E+06	3.221E+02	1.599E+03	2.397E+06	1.611E+02
2132	5.868E+03	4.699E+06	3.157E+02	1.568E+03	2.350E+06	1.579E+02
2133	5.752E+03	4.606E+06	3.095E+02	1.536E+03	2.303E+06	1.547E+02
2134	5.638E+03	4.515E+06	3.034E+02	1.506E+03	2.257E+06	1.517E+02
2135	5.527E+03	4.426E+06	2.974E+02	1.476E+03	2.213E+06	1.487E+02
2136	5.417E+03	4.338E+06	2.915E+02	1.447E+03	2.169E+06	1.457E+02
2137	5.310E+03	4.252E+06	2.857E+02	1.418E+03	2.126E+06	1.428E+02
2138	5.205E+03	4.168E+06	2.800E+02	1.390E+03	2.084E+06	1.400E+02
2139	5.102E+03	4.085E+06	2.745E+02	1.363E+03	2.043E+06	1.372E+02
2140	5.001E+03	4.004E+06	2.691E+02	1.336E+03	2.002E+06	1.345E+02
2141	4.902E+03	3.925E+06	2.637E+02	1.309E+03	1.963E+06	1.319E+02
2142	4.805E+03	3.847E+06	2.585E+02	1.283E+03	1.924E+06	1.293E+02
2143	4.710E+03	3.771E+06	2.534E+02	1.258E+03	1.886E+06	1.267E+02
2144	4.616E+03	3.697E+06	2.484E+02	1.233E+03	1.848E+06	1.242E+02
2145	4.525E+03	3.623E+06	2.435E+02	1.209E+03	1.812E+06	1.217E+02
2146	4.435E+03	3.552E+06	2.386E+02	1.185E+03	1.776E+06	1.193E+02
2147	4.347E+03	3.481E+06	2.339E+02	1.161E+03	1.741E+06	1.170E+02
2148	4.261E+03	3.412E+06	2.293E+02	1.138E+03	1.706E+06	1.146E+02
2149	4.177E+03	3.345E+06	2.247E+02	1.116E+03	1.672E+06	1.124E+02
2150	4.094E+03	3.279E+06	2.203E+02	1.094E+03	1.639E+06	1.101E+02
2151	4.013E+03	3.214E+06	2.159E+02	1.072E+03	1.607E+06	1.080E+02
2152	3.934E+03	3.150E+06	2.116E+02	1.051E+03	1.575E+06	1.058E+02
2153	3.856E+03	3.088E+06	2.075E+02	1.030E+03	1.544E+06	1.037E+02
2154	3.780E+03	3.026E+06	2.033E+02	1.010E+03	1.513E+06	1.017E+02
2155	3.705E+03	2.967E+06	1.993E+02	9.896E+02	1.483E+06	9.966E+01
2156	3.631E+03	2.908E+06	1.954E+02	9.700E+02	1.454E+06	9.769E+01
2157	3.559E+03	2.850E+06	1.915E+02	9.508E+02	1.425E+06	9.575E+01
2158	3.489E+03	2.794E+06	1.877E+02	9.319E+02	1.397E+06	9.386E+01
2159	3.420E+03	2.738E+06	1.840E+02	9.135E+02	1.369E+06	9.200E+01
2160	3.352E+03	2.684E+06	1.804E+02	8.954E+02	1.342E+06	9.018E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
2161	3.286E+03	2.631E+06	1.768E+02	8.777E+02	1.316E+06	8.839E+01
2162	3.221E+03	2.579E+06	1.733E+02	8.603E+02	1.289E+06	8.664E+01
2163	3.157E+03	2.528E+06	1.698E+02	8.432E+02	1.264E+06	8.492E+01
2164	3.094E+03	2.478E+06	1.665E+02	8.265E+02	1.239E+06	8.324E+01
2165	3.033E+03	2.429E+06	1.632E+02	8.102E+02	1.214E+06	8.159E+01
2166	2.973E+03	2.381E+06	1.600E+02	7.941E+02	1.190E+06	7.998E+01
2167	2.914E+03	2.334E+06	1.568E+02	7.784E+02	1.167E+06	7.840E+01
2168	2.856E+03	2.287E+06	1.537E+02	7.630E+02	1.144E+06	7.684E+01
2169	2.800E+03	2.242E+06	1.506E+02	7.479E+02	1.121E+06	7.532E+01
2170	2.744E+03	2.198E+06	1.477E+02	7.331E+02	1.099E+06	7.383E+01
2171	2.690E+03	2.154E+06	1.447E+02	7.186E+02	1.077E+06	7.237E+01
2172	2.637E+03	2.111E+06	1.419E+02	7.043E+02	1.056E+06	7.094E+01
2173	2.585E+03	2.070E+06	1.391E+02	6.904E+02	1.035E+06	6.953E+01
2174	2.533E+03	2.029E+06	1.363E+02	6.767E+02	1.014E+06	6.815E+01
2175	2.483E+03	1.989E+06	1.336E+02	6.633E+02	9.943E+05	6.680E+01
2176	2.434E+03	1.949E+06	1.310E+02	6.502E+02	9.746E+05	6.548E+01
2177	2.386E+03	1.911E+06	1.284E+02	6.373E+02	9.553E+05	6.418E+01
2178	2.339E+03	1.873E+06	1.258E+02	6.247E+02	9.364E+05	6.291E+01
2179	2.292E+03	1.836E+06	1.233E+02	6.123E+02	9.178E+05	6.167E+01
2180	2.247E+03	1.799E+06	1.209E+02	6.002E+02	8.996E+05	6.045E+01
2181	2.203E+03	1.764E+06	1.185E+02	5.883E+02	8.818E+05	5.925E+01
2182	2.159E+03	1.729E+06	1.162E+02	5.767E+02	8.644E+05	5.808E+01
2183	2.116E+03	1.695E+06	1.139E+02	5.652E+02	8.473E+05	5.693E+01
2184	2.074E+03	1.661E+06	1.116E+02	5.541E+02	8.305E+05	5.580E+01
2185	2.033E+03	1.628E+06	1.094E+02	5.431E+02	8.140E+05	5.469E+01
2186	1.993E+03	1.596E+06	1.072E+02	5.323E+02	7.979E+05	5.361E+01
2187	1.953E+03	1.564E+06	1.051E+02	5.218E+02	7.821E+05	5.255E+01
2188	1.915E+03	1.533E+06	1.030E+02	5.115E+02	7.666E+05	5.151E+01
2189	1.877E+03	1.503E+06	1.010E+02	5.013E+02	7.514E+05	5.049E+01
2190	1.840E+03	1.473E+06	9.898E+01	4.914E+02	7.366E+05	4.949E+01
2191	1.803E+03	1.444E+06	9.702E+01	4.817E+02	7.220E+05	4.851E+01
2192	1.768E+03	1.415E+06	9.510E+01	4.721E+02	7.077E+05	4.755E+01
2193	1.733E+03	1.387E+06	9.322E+01	4.628E+02	6.937E+05	4.661E+01
2194	1.698E+03	1.360E+06	9.137E+01	4.536E+02	6.799E+05	4.568E+01
2195	1.665E+03	1.333E+06	8.956E+01	4.446E+02	6.665E+05	4.478E+01
2196	1.632E+03	1.307E+06	8.779E+01	4.358E+02	6.533E+05	4.389E+01
2197	1.599E+03	1.281E+06	8.605E+01	4.272E+02	6.403E+05	4.302E+01
2198	1.568E+03	1.255E+06	8.434E+01	4.187E+02	6.277E+05	4.217E+01
2199	1.537E+03	1.230E+06	8.267E+01	4.105E+02	6.152E+05	4.134E+01
2200	1.506E+03	1.206E+06	8.104E+01	4.023E+02	6.031E+05	4.052E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2060	0	0	0	0	0	0
2061	3.086E+02	1.686E+05	1.133E+01	4.834E+00	1.349E+03	9.062E-02
2062	6.151E+02	3.360E+05	2.258E+01	9.636E+00	2.688E+03	1.806E-01
2063	9.197E+02	5.024E+05	3.376E+01	1.441E+01	4.019E+03	2.701E-01
2064	1.222E+03	6.678E+05	4.487E+01	1.915E+01	5.342E+03	3.589E-01
2065	1.523E+03	8.321E+05	5.591E+01	2.386E+01	6.657E+03	4.473E-01
2066	1.822E+03	9.956E+05	6.689E+01	2.855E+01	7.965E+03	5.351E-01
2067	2.120E+03	1.158E+06	7.781E+01	3.321E+01	9.265E+03	6.225E-01
2068	2.416E+03	1.320E+06	8.868E+01	3.785E+01	1.056E+04	7.094E-01
2069	2.711E+03	1.481E+06	9.949E+01	4.246E+01	1.185E+04	7.959E-01
2070	3.004E+03	1.641E+06	1.103E+02	4.706E+01	1.313E+04	8.821E-01
2071	3.296E+03	1.800E+06	1.210E+02	5.163E+01	1.440E+04	9.678E-01
2072	3.587E+03	1.959E+06	1.316E+02	5.619E+01	1.567E+04	1.053E+00
2073	3.876E+03	2.118E+06	1.423E+02	6.072E+01	1.694E+04	1.138E+00
2074	4.165E+03	2.275E+06	1.529E+02	6.525E+01	1.820E+04	1.223E+00
2075	4.453E+03	2.433E+06	1.634E+02	6.975E+01	1.946E+04	1.308E+00
2076	4.740E+03	2.589E+06	1.740E+02	7.425E+01	2.071E+04	1.392E+00
2077	5.026E+03	2.746E+06	1.845E+02	7.873E+01	2.196E+04	1.476E+00
2078	5.311E+03	2.901E+06	1.950E+02	8.320E+01	2.321E+04	1.560E+00
2079	5.596E+03	3.057E+06	2.054E+02	8.766E+01	2.446E+04	1.643E+00
2080	5.880E+03	3.212E+06	2.158E+02	9.212E+01	2.570E+04	1.727E+00
2081	6.164E+03	3.367E+06	2.263E+02	9.656E+01	2.694E+04	1.810E+00
2082	6.448E+03	3.522E+06	2.367E+02	1.010E+02	2.818E+04	1.893E+00
2083	6.731E+03	3.677E+06	2.471E+02	1.054E+02	2.942E+04	1.976E+00
2084	7.014E+03	3.832E+06	2.574E+02	1.099E+02	3.065E+04	2.060E+00
2085	7.296E+03	3.986E+06	2.678E+02	1.143E+02	3.189E+04	2.143E+00
2086	7.579E+03	4.140E+06	2.782E+02	1.187E+02	3.312E+04	2.226E+00
2087	7.862E+03	4.295E+06	2.886E+02	1.232E+02	3.436E+04	2.309E+00
2088	8.145E+03	4.449E+06	2.990E+02	1.276E+02	3.559E+04	2.392E+00
2089	8.427E+03	4.604E+06	3.093E+02	1.320E+02	3.683E+04	2.475E+00
2090	8.710E+03	4.759E+06	3.197E+02	1.365E+02	3.807E+04	2.558E+00
2091	8.994E+03	4.913E+06	3.301E+02	1.409E+02	3.931E+04	2.641E+00
2092	9.278E+03	5.068E+06	3.405E+02	1.453E+02	4.055E+04	2.724E+00
2093	9.382E+03	5.126E+06	3.444E+02	1.470E+02	4.100E+04	2.755E+00
2094	9.197E+03	5.024E+06	3.376E+02	1.441E+02	4.019E+04	2.701E+00
2095	9.014E+03	4.925E+06	3.309E+02	1.412E+02	3.940E+04	2.647E+00
2096	8.836E+03	4.827E+06	3.243E+02	1.384E+02	3.862E+04	2.595E+00
2097	8.661E+03	4.732E+06	3.179E+02	1.357E+02	3.785E+04	2.543E+00
2098	8.490E+03	4.638E+06	3.116E+02	1.330E+02	3.710E+04	2.493E+00
2099	8.321E+03	4.546E+06	3.054E+02	1.304E+02	3.637E+04	2.444E+00
2100	8.157E+03	4.456E+06	2.994E+02	1.278E+02	3.565E+04	2.395E+00
2101	7.995E+03	4.368E+06	2.935E+02	1.252E+02	3.494E+04	2.348E+00
2102	7.837E+03	4.281E+06	2.877E+02	1.228E+02	3.425E+04	2.301E+00
2103	7.682E+03	4.196E+06	2.820E+02	1.203E+02	3.357E+04	2.256E+00
2104	7.530E+03	4.113E+06	2.764E+02	1.180E+02	3.291E+04	2.211E+00
2105	7.380E+03	4.032E+06	2.709E+02	1.156E+02	3.226E+04	2.167E+00
2106	7.234E+03	3.952E+06	2.655E+02	1.133E+02	3.162E+04	2.124E+00
2107	7.091E+03	3.874E+06	2.603E+02	1.111E+02	3.099E+04	2.082E+00
2108	6.951E+03	3.797E+06	2.551E+02	1.089E+02	3.038E+04	2.041E+00
2109	6.813E+03	3.722E+06	2.501E+02	1.067E+02	2.978E+04	2.001E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3 /year)	(av ft^3/min)	(Mg/year)	(m^3 /year)	(av ft^3/min)
2110	6.678E+03	3.648E+06	2.451E+02	1.046E+02	2.919E+04	1.961E+00
2111	6.546E+03	3.576E+06	2.403E+02	1.025E+02	2.861E+04	1.922E+00
2112	6.416E+03	3.505E+06	2.355E+02	1.005E+02	2.804E+04	1.884E+00
2113	6.289E+03	3.436E+06	2.308E+02	9.852E+01	2.749E+04	1.847E+00
2114	6.165E+03	3.368E+06	2.263E+02	9.657E+01	2.694E+04	1.810E+00
2115	6.043E+03	3.301E+06	2.218E+02	9.466E+01	2.641E+04	1.774E+00
2116	5.923E+03	3.236E+06	2.174E+02	9.279E+01	2.589E+04	1.739E+00
2117	5.806E+03	3.172E+06	2.131E+02	9.095E+01	2.537E+04	1.705E+00
2118	5.691E+03	3.109E+06	2.089E+02	8.915E+01	2.487E+04	1.671E+00
2119	5.578E+03	3.047E+06	2.047E+02	8.738E+01	2.438E+04	1.638E+00
2120	5.468E+03	2.987E+06	2.007E+02	8.565E+01	2.390E+04	1.606E+00
2121	5.359E+03	2.928E+06	1.967E+02	8.396E+01	2.342E+04	1.574E+00
2122	5.253E+03	2.870E+06	1.928E+02	8.229E+01	2.296E+04	1.543E+00
2123	5.149E+03	2.813E+06	1.890E+02	8.066E+01	2.250E+04	1.512E+00
2124	5.047E+03	2.757E+06	1.853E+02	7.907E+01	2.206E+04	1.482E+00
2125	4.947E+03	2.703E+06	1.816E+02	7.750E+01	2.162E+04	1.453E+00
2126	4.849E+03	2.649E+06	1.780E+02	7.597E+01	2.119E+04	1.424E+00
2127	4.753E+03	2.597E+06	1.745E+02	7.446E+01	2.077E+04	1.396E+00
2128	4.659E+03	2.545E+06	1.710E+02	7.299E+01	2.036E+04	1.368E+00
2129	4.567E+03	2.495E+06	1.676E+02	7.154E+01	1.996E+04	1.341E+00
2130	4.476E+03	2.445E+06	1.643E+02	7.013E+01	1.956E+04	1.314E+00
2131	4.388E+03	2.397E+06	1.611E+02	6.874E+01	1.918E+04	1.288E+00
2132	4.301E+03	2.350E+06	1.579E+02	6.738E+01	1.880E+04	1.263E+00
2133	4.216E+03	2.303E+06	1.547E+02	6.604E+01	1.842E+04	1.238E+00
2134	4.132E+03	2.257E+06	1.517E+02	6.473E+01	1.806E+04	1.213E+00
2135	4.050E+03	2.213E+06	1.487E+02	6.345E+01	1.770E+04	1.189E+00
2136	3.970E+03	2.169E+06	1.457E+02	6.220E+01	1.735E+04	1.166E+00
2137	3.892E+03	2.126E+06	1.428E+02	6.096E+01	1.701E+04	1.143E+00
2138	3.815E+03	2.084E+06	1.400E+02	5.976E+01	1.667E+04	1.120E+00
2139	3.739E+03	2.043E+06	1.372E+02	5.857E+01	1.634E+04	1.098E+00
2140	3.665E+03	2.002E+06	1.345E+02	5.741E+01	1.602E+04	1.076E+00
2141	3.592E+03	1.963E+06	1.319E+02	5.628E+01	1.570E+04	1.055E+00
2142	3.521E+03	1.924E+06	1.293E+02	5.516E+01	1.539E+04	1.034E+00
2143	3.452E+03	1.886E+06	1.267E+02	5.407E+01	1.508E+04	1.014E+00
2144	3.383E+03	1.848E+06	1.242E+02	5.300E+01	1.479E+04	9.935E-01
2145	3.316E+03	1.812E+06	1.217E+02	5.195E+01	1.449E+04	9.738E-01
2146	3.251E+03	1.776E+06	1.193E+02	5.092E+01	1.421E+04	9.545E-01
2147	3.186E+03	1.741E+06	1.170E+02	4.991E+01	1.393E+04	9.356E-01
2148	3.123E+03	1.706E+06	1.146E+02	4.893E+01	1.365E+04	9.171E-01
2149	3.061E+03	1.672E+06	1.124E+02	4.796E+01	1.338E+04	8.989E-01
2150	3.001E+03	1.639E+06	1.101E+02	4.701E+01	1.311E+04	8.811E-01
2151	2.941E+03	1.607E+06	1.080E+02	4.608E+01	1.285E+04	8.637E-01
2152	2.883E+03	1.575E+06	1.058E+02	4.516E+01	1.260E+04	8.466E-01
2153	2.826E+03	1.544E+06	1.037E+02	4.427E+01	1.235E+04	8.298E-01
2154	2.770E+03	1.513E+06	1.017E+02	4.339E+01	1.211E+04	8.134E-01
2155	2.715E+03	1.483E+06	9.966E+01	4.253E+01	1.187E+04	7.973E-01
2156	2.661E+03	1.454E+06	9.769E+01	4.169E+01	1.163E+04	7.815E-01
2157	2.609E+03	1.425E+06	9.575E+01	4.087E+01	1.140E+04	7.660E-01
2158	2.557E+03	1.397E+06	9.386E+01	4.006E+01	1.118E+04	7.509E-01
2159	2.506E+03	1.369E+06	9.200E+01	3.926E+01	1.095E+04	7.360E-01
2160	2.457E+03	1.342E+06	9.018E+01	3.849E+01	1.074E+04	7.214E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2161	2.408E+03	1.316E+06	8.839E+01	3.772E+01	1.052E+04	7.071E-01
2162	2.360E+03	1.289E+06	8.664E+01	3.698E+01	1.032E+04	6.931E-01
2163	2.314E+03	1.264E+06	8.492E+01	3.624E+01	1.011E+04	6.794E-01
2164	2.268E+03	1.239E+06	8.324E+01	3.553E+01	9.911E+03	6.659E-01
2165	2.223E+03	1.214E+06	8.159E+01	3.482E+01	9.715E+03	6.528E-01
2166	2.179E+03	1.190E+06	7.998E+01	3.413E+01	9.523E+03	6.398E-01
2167	2.136E+03	1.167E+06	7.840E+01	3.346E+01	9.334E+03	6.272E-01
2168	2.093E+03	1.144E+06	7.684E+01	3.280E+01	9.149E+03	6.147E-01
2169	2.052E+03	1.121E+06	7.532E+01	3.215E+01	8.968E+03	6.026E-01
2170	2.011E+03	1.099E+06	7.383E+01	3.151E+01	8.791E+03	5.906E-01
2171	1.972E+03	1.077E+06	7.237E+01	3.089E+01	8.617E+03	5.789E-01
2172	1.933E+03	1.056E+06	7.094E+01	3.027E+01	8.446E+03	5.675E-01
2173	1.894E+03	1.035E+06	6.953E+01	2.967E+01	8.279E+03	5.562E-01
2174	1.857E+03	1.014E+06	6.815E+01	2.909E+01	8.115E+03	5.452E-01
2175	1.820E+03	9.943E+05	6.680E+01	2.851E+01	7.954E+03	5.344E-01
2176	1.784E+03	9.746E+05	6.548E+01	2.795E+01	7.797E+03	5.239E-01
2177	1.749E+03	9.553E+05	6.418E+01	2.739E+01	7.642E+03	5.135E-01
2178	1.714E+03	9.364E+05	6.291E+01	2.685E+01	7.491E+03	5.033E-01
2179	1.680E+03	9.178E+05	6.167E+01	2.632E+01	7.343E+03	4.933E-01
2180	1.647E+03	8.996E+05	6.045E+01	2.580E+01	7.197E+03	4.836E-01
2181	1.614E+03	8.818E+05	5.925E+01	2.529E+01	7.055E+03	4.740E-01
2182	1.582E+03	8.644E+05	5.808E+01	2.479E+01	6.915E+03	4.646E-01
2183	1.551E+03	8.473E+05	5.693E+01	2.430E+01	6.778E+03	4.554E-01
2184	1.520E+03	8.305E+05	5.580E+01	2.381E+01	6.644E+03	4.464E-01
2185	1.490E+03	8.140E+05	5.469E+01	2.334E+01	6.512E+03	4.376E-01
2186	1.461E+03	7.979E+05	5.361E+01	2.288E+01	6.383E+03	4.289E-01
2187	1.432E+03	7.821E+05	5.255E+01	2.243E+01	6.257E+03	4.204E-01
2188	1.403E+03	7.666E+05	5.151E+01	2.198E+01	6.133E+03	4.121E-01
2189	1.376E+03	7.514E+05	5.049E+01	2.155E+01	6.012E+03	4.039E-01
2190	1.348E+03	7.366E+05	4.949E+01	2.112E+01	5.893E+03	3.959E-01
2191	1.322E+03	7.220E+05	4.851E+01	2.070E+01	5.776E+03	3.881E-01
2192	1.295E+03	7.077E+05	4.755E+01	2.029E+01	5.661E+03	3.804E-01
2193	1.270E+03	6.937E+05	4.661E+01	1.989E+01	5.549E+03	3.729E-01
2194	1.245E+03	6.799E+05	4.568E+01	1.950E+01	5.439E+03	3.655E-01
2195	1.220E+03	6.665E+05	4.478E+01	1.911E+01	5.332E+03	3.582E-01
2196	1.196E+03	6.533E+05	4.389E+01	1.873E+01	5.226E+03	3.511E-01
2197	1.172E+03	6.403E+05	4.302E+01	1.836E+01	5.123E+03	3.442E-01
2198	1.149E+03	6.277E+05	4.217E+01	1.800E+01	5.021E+03	3.374E-01
2199	1.126E+03	6.152E+05	4.134E+01	1.764E+01	4.922E+03	3.307E-01
2200	1.104E+03	6.031E+05	4.052E+01	1.729E+01	4.824E+03	3.242E-01

Attachment 2

Landfill Gas Manifold Pipe Sizing Calcs

Calculation of LFG in ring header

	Phase I,II, III		
Max LFG produced in 2092 =	45,296,874 m3 /yr=	86.18 m3/min=	3043.46 ft3/min
Phase I & II	9,480,383 m3 /yr=	18.04 m3/min=	636.98 ft3/min
Phase III	35,816,491 m3 /yr=	68.14 m3/min=	2406.48 ft3/min
	Phase I,II, III		
Assume 90% for recovery	40,767,187 m3 /yr=	77.56 m3/min=	2739.12 ft3/min
Phase I & II	8,532,345 m3 /yr=	16.23 m3/min=	573.28 ft3/min
Phase III	32,234,842 m3 /yr=	61.33 m3/min=	2165.83 ft3/min

total number pipe in Phase III =	193
each pipe produces =	0.32 m3/min
	11.22 SCFM
half go east, half go west	
each pipe to east =	5.61 SCFM

Option 1 **100.00% LFG from East side of Phase III goes south**

For node E-2		
	62 pipes =	347.88 SCFM
	69 pipes =	387.16 SCFM
	62 pipes =	347.88 SCFM
total		1082.92 SCFM
For node W-4		
	62 pipes =	347.88 SCFM
	69 pipes =	387.16 SCFM
	54 pipes =	302.99 SCFM
total		1038.03 SCFM
For node W-3		
	8 pipes =	44.89 SCFM
		2165.83 SCFM
total number pipe in Phase II =		71
each pipe produces =		0.23 m3/min
		8.07 SCFM
half go east, half go west		
each pipe to east =		4.04 SCFM
For node W2		
	36 pipes =	145.34 SCFM
For node W1		
	35 pipes =	141.30 SCFM
Total from south end =		2452.48 SCFM
Total from north end		
For node E1		
	71 pipes =	286.64 SCFM
all togelther =		2739.12 SCFM

Option 2 **50.00% LFG from East side of Phase III goes south**

For node E-2		
	62 pipes =	173.94 SCFM
	69 pipes =	193.58 SCFM
	62 pipes =	173.94 SCFM
total		541.46 SCFM
For node W-4		
	62 pipes =	347.88 SCFM
	69 pipes =	387.16 SCFM
	54 pipes =	302.99 SCFM
total		1038.03 SCFM
For node W-3		
	8 pipes =	44.89 SCFM
		1624.38 SCFM
total number pipe in Phase II =		71
each pipe produces =		0.23 m3/min
		8.07 SCFM
half go east, half go west		
each pipe to east =		4.04 SCFM
For node W2		
	36 pipes =	145.34 SCFM
For node W1		
	35 pipes =	141.30 SCFM
Total from south end =		1911.02 SCFM
Total from north end		
For node E-2		
	62 pipes =	173.94 SCFM
	69 pipes =	193.58 SCFM
	62 pipes =	173.94 SCFM
total		541.46 SCFM
For node E1		
	71 pipes =	286.64 SCFM
all togelther =		2739.12 SCFM

TITLE: Mueller Equation Calcs

PROJECT: **Kelowna Glemore Landfill**

PROJECT NO.:

Pressure Change max (in H2O / 1ft. pipe)	0.005	
Pressure Drop safety factor	1.5	
Pipe Expansion factor (in./in./F)	0.0001	(HDPE)
Max Temp change (degrees F)	90	

Scenario 1 **100% of LFG on the east side of Phase III goes south**

From south side to blower

LOCATION	HORIZONTAL LENGTH (m.)	HORIZONTAL LENGTH (ft.)	SLOPE (%)	Q (SCFM)	SUM Q (SCFM)	REQ'D d (in.)	ACTUAL d (in.)	ACTUAL (P2-P1)/FT.	REQ'D PIPE LENGTH	SUM P2-P1 (in H2O)	FLOW VELOCITY (ft/sec.)
E-2 to W-4	1070	3,510	1	1,083	1083.0	10.34	17.550	0.00041	3548	1.44	10.74
Node W-4	50D	73	1	0	1083.0	10.34	17.550	0.00041	74	1.47	10.74
W-4 to W-3	320	1,050	1	1,038	2121.0	13.23	17.550	0.00131	1061	2.86	21.04
Node W-3	50D	73	1	0	2121.0	13.23	17.550	0.00131	74	2.96	21.04
W-3 to W-2	250	820	1	45	2166.0	13.33	17.550	0.00136	829	4.09	21.49
Node W-2	50D	73	1	0	2166.0	13.33	17.550	0.00136	74	4.19	21.49
W-2 to W-1	610	2,001	1	145	2311.0	13.65	17.550	0.00152	2023	7.26	22.93
Node W-1	50D	0	1	0	2311.0	13.65	17.550	0.00152	0	7.26	22.93

Assume 20" SDR 17; ID = 17.55

From North Side to blower

LOCATION	HORIZONTAL LENGTH (m.)	HORIZONTAL LENGTH (ft.)	SLOPE (%)	Q (SCFM)	SUM Q (SCFM)	REQ'D d (in.)	ACTUAL d (in.)	ACTUAL (P2-P1)/FT.	REQ'D PIPE LENGTH	SUM P2-P1 (in H2O)	FLOW VELOCITY (ft/sec.)	
E-2 to E-1	810	2,657	1	0	0.0	0.00	9.430	0.00000	2686	0.00	0.00	
Node E-1	50D	39	1	0	0.0	0.00	9.430	0.00000	40	0.00	0.00	
E-1 to W-1	1160	3,805	1	286	286.0	6.34	9.430	0.00076	3846	2.93	9.83	
Node W-1	50D	39	1	0	286.0	6.34	9.430	0.00076	40	2.96	9.83	
							9.430					
								Assume 10" SDR 17; ID = 9.43"				
W1 to blower												
Phase 1 come in	15	49	1	141	2452.3	13.95	17.550	0.00169	50	7.35	24.33	
North side join in	15	49	1	286	2738.3	14.53	17.550	0.00204	50	7.45	27.17	*

Assume 20" SDR 17; ID 17.55

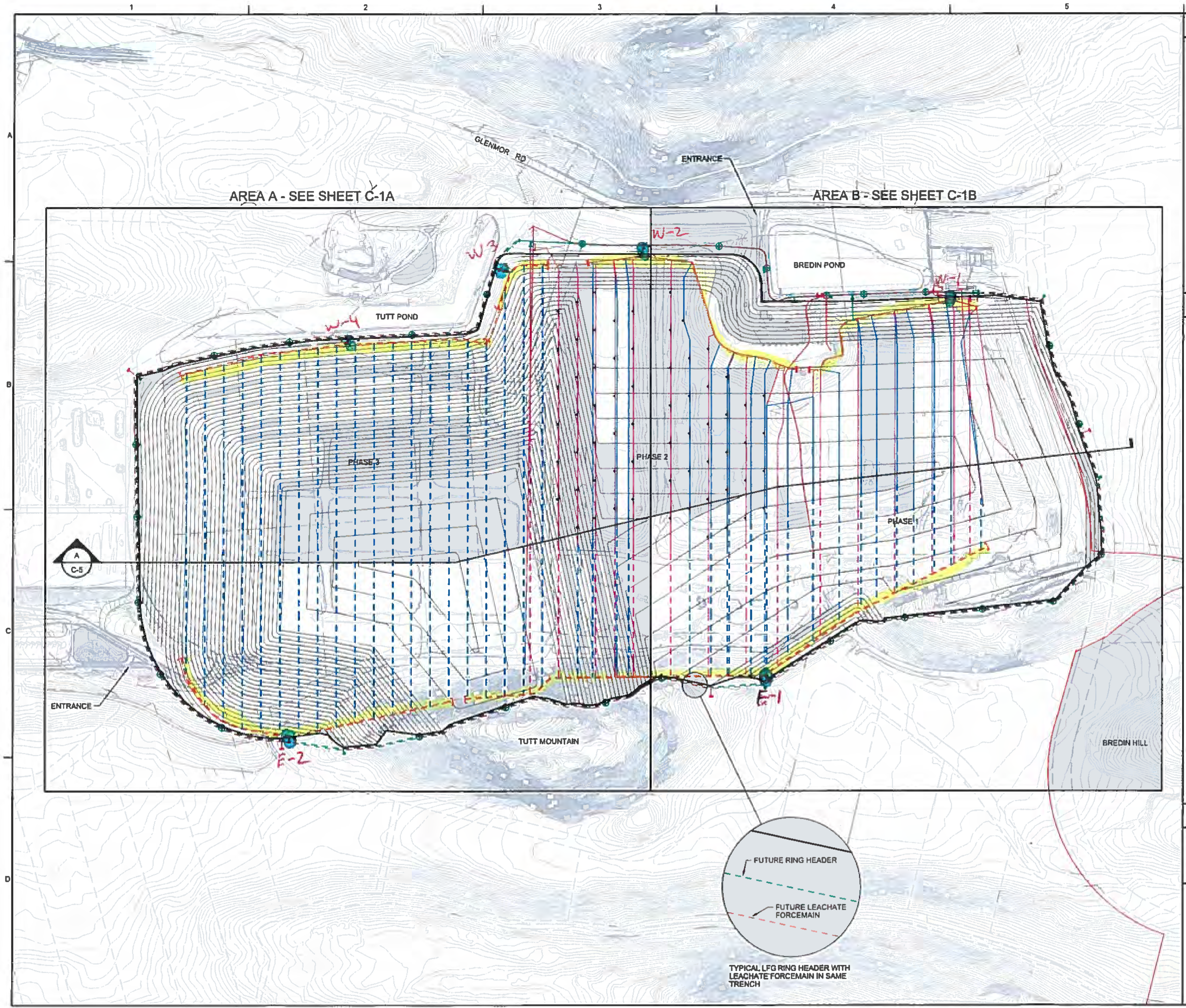
*May require a small section of 24" pipe if in counter-current flow regime here

Scenario 2 **50% of LFG on the east side of Phase III goes south**

From south side to blower

LOCATION	HORIZONTAL LENGTH (m.)	HORIZONTAL LENGTH (ft.)	SLOPE (%)	Q (SCFM)	SUM Q (SCFM)	REQ'D d (in.)	ACTUAL d (in.)	ACTUAL (P2-P1)/FT.	REQ'D PIPE LENGTH	SUM P2-P1 (in H2O)	FLOW VELOCITY (ft/sec.)

E-2 to W-4				1070	3,510	1	541	541.0	8.01	15.800	0.00020	3548	0.71	6.62	
Node W-4				50D	66	1	0	541.0	8.01	15.800	0.00020	67	0.72	6.62	
W-4 to W-3				320	1,050	1	1,038	1579.0	11.87	15.800	0.00129	1061	2.09	19.33	
Node W-3				50D	66	1	0	1579.0	11.87	15.800	0.00129	67	2.18	19.33	
W-3 to W-2				250	820	1	45	1624.0	11.99	15.800	0.00135	829	3.30	19.88	
Node W-2				50D	66	1	0	1624.0	11.99	15.800	0.00135	67	3.39	19.88	
W-2 to W-1				610	2,001	1	145	1769.0	12.38	15.800	0.00157	2023	6.57	21.65	
Node W-1				50D	66	1	0	1769.0	12.38	15.800	0.00157	67	6.68	21.65	
										15.800					
											Assume 18" SDR 17; ID 15.8				
From North side to blower															
				HORIZONTAL	HORIZONTAL	SLOPE	Q	SUM Q	REQ'D	ACTUAL	ACTUAL	REQ'D PIPE	SUM P2-P1	FLOW	
LOCATION				LENGTH (m.)	LENGTH (ft.)	(%)	(SCFM)	(SCFM)	d (in.)	d (in.)	(P2-P1)/FT.	LENGTH	(in H2O)	VELOCITY	
														(ft/sec.)	
E-2 to E-1				810	2,657	1	541	541.0	8.01	11.190	0.00103	2686	2.76	13.20	
Node E-1				50D	47	1	0	541.0	8.01	11.190	0.00103	47	2.81	13.20	
E-1 to W-1				1160	3,805	1	286	827.0	9.36	11.190	0.00215	3846	11.07	20.18	
Node W-1				50D	47	1	0	827.0	9.36	11.190	0.00215	47	11.17	20.18	
										11.190					
											Assume 12" SDR 17; ID = 11.19"				
W1 to blower															
Phase 1 come in				15	49	1	141.3	1910.3	12.73	17.550	0.00109	50	6.73	18.95	
North side join in				15	49	1	828.0	2738.3	14.53	17.550	0.00204	50	6.83	27.17	*
											Assume 20" SDR 17; ID 17.55				
						*May require a small section of 24" pipe if in counter-current flow regime here									



6

SHEET NOTES

1. FUTURE LFG RING HEADER AND LEACHATE FORCEMAIN LINES TO BE PLACED IN THE SAME TRENCH. CONDENSATE TRAPS TO BE INSTALLED AT LFG HEADER LOW POINTS.
2. EXISTING TOPOGRAPHY SOURCE: 2012 AERIAL MAPPING PROVIDED BY CITY OF KELOWNA.
3. FUTURE LGTs SHOWN FOR FIRST TWO ROWS ONLY. ALL SUBSEQUENT ROWS WILL STAGGER THE PREVIOUS ROWS PER SECTION A/C-5.

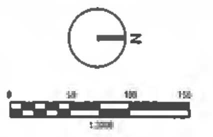
LEGEND

GAS HEADER ALIGNMENT
LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
LGT
LEACHATE COLLECTION
GAS SUBHEADER
FUTURE GAS HEADER
FUTURE LGT TWINNED WITH LEACHATE RECIRCULATION PIPE
FUTURE LGT
FUTURE LEACHATE COLLECTION
FUTURE GAS SUBHEADER
CONDENSATE TRAP
450 CONTOUR FROM 2012 AERIAL TOPO
450 CONTOUR FROM TABLE TOP FILL PLAN 2014
PROPERTY/LEGAL LINE
GAS WELL
ULTIMATE FILL PLAN WASTE LIMITS
LFG HEADER CLEANOUT/ INSPECTION RISER
BLIND FLANGE FOR FUTURE CONNECTION
CAP
VALVE
LEACHATE PUMP STATION/BOOSTER

* SYMBOLS ON ALL SHEETS MAY APPEAR EXAGGERATED FOR READABILITY

ABBREVIATIONS

LGT	LANDFILL GAS TRENCH
LFG	LANDFILL GAS



CH2MHILL.

CITY OF KELOWNA

CIVIL
OVERALL SITE PLAN

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

NO.	DATE	REVISION	BY	APVD

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD
R1

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL.

DATE	DEC 2014
PROJ	653224
DWG	C-1
SHEET	1 of 8

FILENAME: 005-C-2001_653224.dgn
PLOT DATE: 2015\03\13
PLOT TIME: 1:48:20 PM

Appendix E
Seismic Hazard Data

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , April 05, 2018

Site Coordinates: 49.9544 North 119.4179 West

User File Reference: Glenmore Landfill

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.275	0.171	0.091	0.054	0.137

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.060	0.134	0.188
Sa(0.5)	0.040	0.085	0.117
Sa(1.0)	0.024	0.049	0.066
Sa(2.0)	0.014	0.029	0.039
PGA	0.034	0.071	0.097

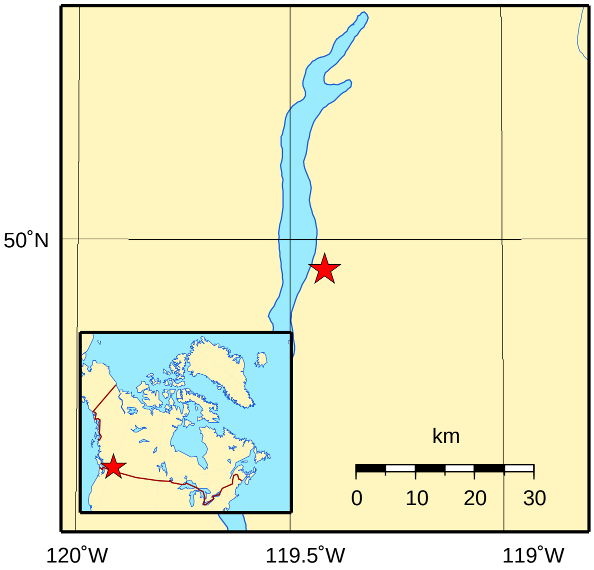
References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information



Aussi disponible en français

Natural Resources Canada   Ressources naturelles Canada

Canada

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

April 05, 2018

Site: 49.9544 N, 119.4179 W User File Reference: Glenmore Landfill

Requested by: ,

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.075	0.112	**0.140**	0.136	**0.118**	**0.088**	**0.062**	**0.028**	**0.0088**	**0.065**	**0.114**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.0091	0.028	0.045
Sa(0.1)	0.013	0.040	0.065
Sa(0.2)	0.021	0.057	0.086
Sa(0.3)	0.026	0.062	0.089
Sa(0.5)	0.025	0.057	0.081
Sa(1.0)	0.018	0.043	0.061
Sa(2.0)	0.011	0.027	0.040
Sa(5.0)	0.0036	0.010	0.016
Sa(10.0)	0.0015	0.0038	0.0056
PGA	0.0084	0.025	0.040
PGV	0.018	0.048	0.072

References

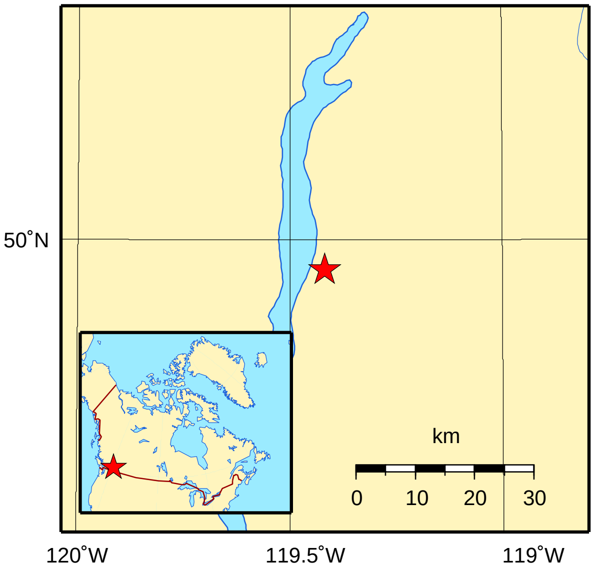
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Natural Resources Canada Ressources naturelles Canada

Canada

Appendix F

Fire Safety and Emergency Plan

FIRE SAFETY AND EMERGENCY CONTINGENCY PLAN

GLENMORE LANDFILL
KELOWNA, BRITISH COLUMBIA

Prepared For: GLENMORE LANDFILL
2710-2720 John Hindle Drive
Kelowna, British Columbia

SEPTEMBER 11, 2018
REF. NO. 084612 (04) Appendix F

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

REVISIONS

DATE	REVISION NO.	AUTHOR/COMPANY	

1.0 INTRODUCTION

The operators of the Glenmore Landfill (Site) in compliance with British Columbia Occupational Health and Safety (B.C. OH&S) Regulation 296/97 Part 4, s.4.13-4.18 (Emergency Preparedness and Response) and Part 5, s.5.97-5.102 (Emergency Procedures) and Section 2.8 of the British Columbia Fire Code, have developed the following Fire Safety and Emergency Contingency Plan based on an assessment of the risks identified on-site. This plan documents the potential hazards and sets out the safety measures, roles, responsibilities, procedures, and parties to be contacted in the event of a medical or environmental emergency, or the occurrence of any of the identified hazardous situations.

The Site is located within the city limits of Kelowna BC at 2710-2720 John Hindle Road approximately 11.4 kilometres (km) northeast of the city centre. The Landfill is owned and operated by the City.

The Landfill currently operates under operational certificate (OC) 12218. The Landfill accepts residential waste; industrial, commercial, and institutional waste; and construction and demolition waste.

The following sections detail the Fire Safety and Emergency Contingency Plan for waste disposal operations at Landfill. It is essential that site personnel be prepared in the event of an emergency. Emergencies can take many forms. The potential health and safety concerns identified in this plan include illnesses or injuries, chemical exposure, fires, explosions, spills, leaks, releases of harmful contaminants, or sudden changes in weather. The following sections outline the general procedures for dealing with emergency situations that may potentially be experienced at the Site.

This Plan will be reviewed by all on-Site personnel and kept at the Landfill. Emergency information presented herein, will be posted at the Site in locations where it can readily be seen. This Plan will be reviewed at least once annually by the owner/operator of the landfill, in consultation with the employee health and safety representative, to ensure that it remains effective and accurate as a Fire Safety and Emergency Contingency Plan.

Additional supporting information is available on the City's internal website, including:

- Corporate Emergency Response Plan;
- Incident Reporting and Notification Guideline; and
- Incident Notification and Reporting Flow Chart.

2.0 EMERGENCY CONTACTS

This page is to be posted with the hospital road map in conspicuous workplace locations.

Fire:	911
Police:	911
Ambulance:	911
Poison Control Center:	1-800-567-8911
Hospital:	250-862-4000 Kelowna General Hospital 2268 Pandosy Street Kelowna, BC V1Y 1T2

Directions to Kelowna General Hospital (see Figure 2.1):

- Head southeast on Landfill Entrance Road toward John Hindle Drive
- Turn right onto John Hindle Drive
- Turn left onto Glenmore Road
- Turn right onto Bernard Avenue
- Turn left onto Burtch Road
- Turn right onto Springfield Road
- Continue onto Cadder Avenue
- Turn left onto Pandosy Street
- Turn right to arrive at Kelowna General Hospital

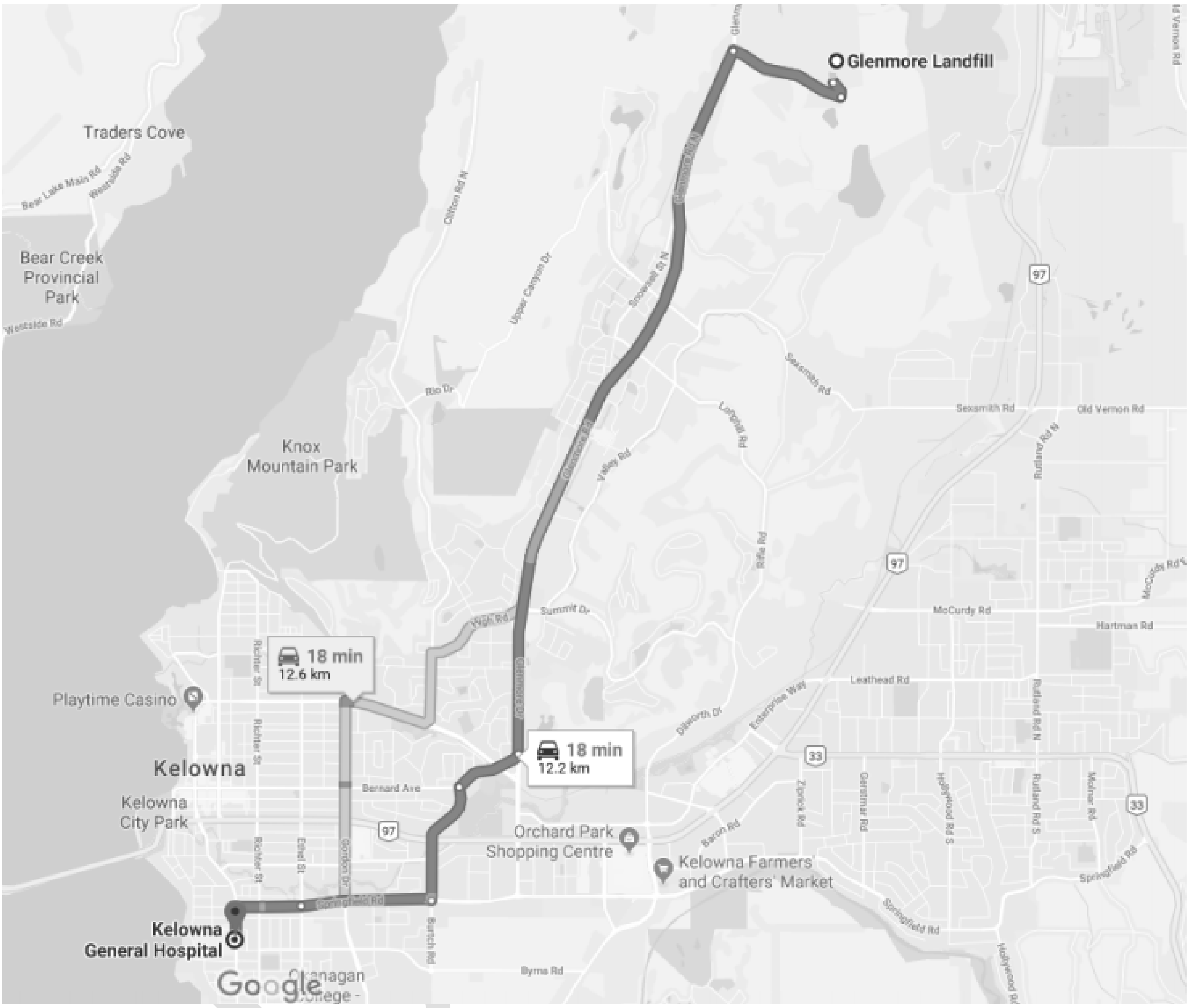
Provincial Emergency Program (PEP), 24 hour Spill Reporting:	1-800-663-3456
MOE Regional Waste Manager	250-490-8200
Ministry of Forest, Lands and Natural Resources	250-490-8200
Fire Department	250-469-8801
Forest Fire Reporting	1-800-663-5555 *5555 Cellular

City of Kelowna

Supervisor (Scott Hoekstra)	250-826-3014
Supervisor (Gord Light)	250-469-8795
On Call Environmental Technologists	250-317-6741 or 250-870-8179
City Safety Advisor	250-863-3513

FIGURE 2.1
EMERGENCY HOSPITAL ROUTE

TO BE POSTED IN CONSPICUOUS AREAS OF THE WORKPLACE



Map Data/Image Source: Google Maps, 2018

3.0 EMERGENCY EQUIPMENT AVAILABLE ON SITE

The following emergency equipment is available at the scale house, admin building and maintenance shop:

- First aid kit (Level 2 Kit) – Admin building
- 20 pound Class A, B, and C dry chemical fire extinguishers
- Air horns
- Telephone – Scale house and Admin building

All Site vehicles and equipment, are all equipped with Class A, B, and C dry chemical fire extinguishers. Spill kits are located by the fueling station and at the Household Hazardous Waste bunker.

A suitable water pump with appropriate length of hose will be kept available on-site at all time to pump water for emergency use. The landfill also has a water tank for the bin truck that can be used seasonally and a hydroseeder that can be used year round other than in extreme cold.

The facility is equipped with potable water for emergency use which may be accessed by stand pipes and hydrants located throughout the Landfill.

4.0 EMERGENCY ROUTES AND ASSEMBLY POINTS

The City will ensure that emergency exit routes and assembly points are marked on Site by clear signage and in accordance with municipal and provincial requirements.

5.0 MEDICAL EMERGENCIES

The City will employ, and assign to the Site, a competent and authorized representative, herein referred to as the HSO (Health and Safety Officer). A Site Health & Safety Representative will also be selected. The Site Supervisor or designate will be present at the Landfill during normal operating hours.

The City will ensure that all on-Site personnel, as a minimum, are equipped with the appropriate first aid materials and supplies and personnel protective equipment (PPE), and clothing required by municipal and provincial regulations. Safety and emergency equipment and PPE and clothing will be stored in a readily accessible location when not in use and kept clean and well maintained. The location of the equipment will be marked by clear signage.

Emergency and first-aid equipment will be placed at or near the active work area of the Landfill during normal operating hours. A list of the emergency and first aid equipment available at the Site and where this equipment is located is provided in Section 3.0 of this Plan.

As a minimum, the City will designate at least one person who is trained in basic first aid and CPR as the First Aid Attendant, to be on-Site at all times. This person may perform other duties, but will be immediately available to render first aid when required.

In the event of injury requiring immediate first-aid / medical attention to on-Site personnel, the City "First Aid Workplace Injury Response Procedure" Standard Work Practice should be followed.

The First Aid Attendant will fill out a First Aid Report and an Incident Investigation will be completed as per City SWPs.

6.0 FIRE OR EXPLOSION

All fire fighting equipment present at the Site shall be regularly inspected (monthly minimum) and maintained in accordance with manufacturer's recommendation and a record of these inspections will be kept on Site. The Landfill Site should have year-round and immediate access to a water supply capable of a sustained flow of water for firefighting purposes that exceeds 4,000 liters per minute or suitable alternative fire equipment.

Attachment A of this plan includes the City of Kelowna Fire Response Landfill Safe Work Procedure, which is stored on the City internal network and may be amended from time to time.

ADMINISTRATION BUILDING FIRE

The Landfill Administration Building has a separate Fire Safety Plan specific to this building. Copies of this Plan are in the Supervisors offices and in the Photocopier room.

LANDFILL FIRES

The risk of landfill fires can be reduced through the implementation of appropriate landfill operational practices including the following:

- Placement of daily/intermediate cover material.
- Adequate stockpiling of soil material for daily/intermediate cover and fire control.
- Availability and maintenance of appropriate equipment for fire control.
- Prohibition of smoking and unpermitted hot work on and around the Landfill.
- Visible inspection of wastes
- Ongoing educational information

Should a landfill fire occur, the nature of the fire should determine the response. A surface fire should be extinguished by isolating the load on fire and smothering the fire with cover soil. A fire within the landfill should be extinguished through a combination of cover soil and potentially water suppression. Excavating waste in the vicinity of a landfill fire may allow oxygen intrusion into the waste further feeding the fire and should not occur outside of an approved fire response plan.

In the event of an uncontrolled fire, explosion, release of hazardous material, or the need for emergency evacuation, the following procedures will be followed:

- Notify all workers on Site by sounding the air horn alarm and with radio contact

- Site personnel will report immediately to the upwind safe assembly area and the Site Supervisor will confirm the safe evacuation of all workers from the hazardous area (muster stations include the admin building and tech trailer)
- Notify the Kelowna Fire Department (KFD)/ emergency services immediately
- Notify the HSO
- Notify any on site contractors, adjacent workplaces or residences which may be affected by exposure (**Note:** notification of the public must be in conformity with the requirements of municipal and provincial agencies (BC Reg. 296/97, s.5.100))
    - City Communications department may be able to assist in notifications
- Site personnel will position themselves at the entrance gate and such other safe locations as to effectively direct the Fire Department to the location of the uncontrolled fire or hazardous circumstances
- Site personnel will advise the KFD Incident Commander of the location, nature, and identification of any hazardous materials at the Site as per the Inventory of Hazardous Substances maintained at the Site (see Section 10.0)
- If the Site Supervisor determines that it is safe to do so, before the KFD arrives, site personnel may:
    - Use fire equipment available on Site
    - Remove or isolate flammable or other hazardous materials that may contribute to the fire
- If the Incident Commander determines that it is safe to do so, Site personnel may assist the KFD
- Complete a City of Kelowna Incident Investigation

7.0 SPILLS OR LEAKS

The City will ensure that all on-Site personnel have received the appropriate Work Place Hazardous Materials Information System (WHMIS) training as required by provincial regulations. The City will ensure that personnel assigned to spill clean-up and re-entry duties have been trained in the safe procedures and use of personal protective equipment appropriate to the spill conditions. Written procedures for clean up and record of training will be maintained on Site. The City will ensure that PPE and related clean-up equipment is readily available on Site and maintained in good condition. The City of Kelowna has a WHMIS Program Guide and a WHMIS SWP

In the event of a spill or leak, site personnel will follow the following procedures. Notify the Site Supervisor and/or HSO of the accidental release. Contact the KFD Hazmat department.

- Report off-Site spills and releases of hydrocarbon contaminated soils or contaminated water to Provincial Emergency Program (PEP) and the B.C. Ministry of Environment in accordance with the B.C. Spill Reporting Regulation
    - **B.C. Emergency Management: 800-663-3456**
- Locate the source of the spillage, determine the degree of hazard associated with the clean-up activities, and if it can be done safely, stop the flow or release of the contaminant
- Contain and recover the spilled materials, in a safe manner as appropriate
- Safe Work Procedures can be found on the City internal website

Where volumes of spilled or leaked material exceed those specified in the BC Spill Reporting Regulation (B.C. Reg. 263/90) (Attached as Table 1) a report shall be made to PEP including the following information. Reportable limits should be confirmed at least annually during the revision of the report.

- 1) The reporting person's name and telephone number
- 2) The name and telephone number of the person who caused the spill
- 3) The location and time of the spill,
- 4) The type and quantity of the substance spilled,
- 5) The cause and effect of the spill,
- 6) Details of action taken or proposed to comply with section 3,
- 7) a description of the spill location and of the area surrounding the spill,
- 8) The details of further action contemplated or required,

- 9) The names of agencies on the scene, and
- 10) The names of other persons or agencies advised concerning the spill.

If the spill is not reportable, under the B.C. Spill Reporting Regulation a Notification of Independent Remediation Initiation form, Site Risk Classification Report Form, and Exposure Pathway Questionnaire is required and the independent remediation may be initiated.

If the spill is reportable, under the B.C. Spill Reporting Regulation, a B.C. Ministry of Environment case manager will be appointed to guide remediation requirements.

A City of Kelowna incident investigation will also be completed.

8.0 INCLEMENT WEATHER

The following special procedures will be implemented during periods of severe weather, such as high winds, rain, electrical storms, thermal inversions, and winter conditions.

High Winds

If winds become excessive, the following control measures will be implemented at the Landfill to ensure that dust and litter does not become problematic or hazardous:

- Low speed limits will be enforced
- All vehicle traffic transporting waste to and around the Landfill will be appropriately loaded to prevent debris from blowing out of the vehicle
- Landfilling activities will be reduced
- Soil handling operations will be suspended
- If dry conditions warrant, water (dust suppressant) will be applied to roadways and borrow areas, and if required, to the active disposal area
- Personnel will wear appropriate respiratory and eye protection

Rain and Electrical Storms

Rain: is not expected to adversely affect operations; therefore the Landfill will be operated during all but extremely excessive rain periods. If access roads become impassable due to heavy rain, they will be graded and granular material or wood chips will be added as necessary to maintain and improve operating conditions.

Electrical Storms: In the event of an electrical storm, all operations will be suspended until the storm subsides and personnel will take safe shelter in the Administration Building. All electrical powered equipment will be immediately shut down in a manner that will not endanger personnel. Site personnel should reference the City “General Lightning SWP”.

Winter Conditions

During winter operations, the City will undertake advanced planning for site preparation/access, snow removal, and the stockpiling and storage of waste cover material.

The following procedures will be taken during winter weather conditions:

- Reference the City “Thermal Stress Program Guide”
- The City will ensure that all on-Site personnel are suitably clothed for working in winter conditions and monitor ongoing conditions to minimize the potential for cold related stress/hypothermia or take breaks in a heated environment when required.
- During severe winter conditions the HSO will provide appropriate direction to on-site personnel, regarding the continuance or curtailing of Landfill operations
- Site equipment will be cleaned and maintained on a daily basis to ensure safe operation during periods of cold or extreme weather
- Snow accumulation will be removed from the access roads and working areas prior to and during each day’s landfilling activities, as required to maintain safe working conditions
- Sanding equipment and de-icing agents will be available
- All runoff from snow, which has contacted waste or soil in the Landfill will be managed as leachate and controlled accordingly

9.0 EMERGENCY PROCEDURES TRAINING & DRILLS

The following training requirements will be followed as written in the B.C. OH&S Reg. 296/97 Part 4, s.4.16:

- All workers must be given adequate instruction in fire prevention and emergency evacuation procedures applicable to their workplace
- Workers assigned firefighting duties must be given adequate training by a qualified instructor in suppression methods, fire prevention, emergency procedures, company organization and chain of command, and firefighting crew safety and communications applicable to their workplace
- Retraining must occur once per year
- A worker not covered by B.C. OH&S Reg. 296/97 Part 31 (Firefighting), who is assigned firefighting duties, must be physically capable of performing the duties assigned safely and effectively, before being permitted to do them
- At least once per year, emergency drills must be conducted to ensure worker awareness and effectiveness of the exit routes and procedures
- A record of the drills is to be kept at the Admin Building

10.0 HAZARDOUS SUBSTANCE INVENTORY & NOTIFICATION OF FIRE DEPARTMENT

The City will maintain a Hazardous Substance Inventory (Inventory) at the Site. The Inventory will include safe handling methods for all hazardous substances that are stored at the Site in quantities that may endanger workers in an emergency. The Inventory will include such materials as WHMIS controlled products, explosives, pesticides, radioactive materials, hazardous wastes, and will provide the nature, location, quantity and Safety Data Sheets (SDS) for the material (SDS's can be downloaded from the City internal website "Insight".

As part of Site operations, the City performs visual inspections of all waste loads received at the Site and any material not authorized for discharge or temporary storage at Site pending off-Site disposal at the Site is rejected by the operator and sent off Site for disposal. As such, the Inventory is limited to materials that are stored on Site for use by the City.

The Inventory is to be kept up to date and located in an area readily accessible by personnel during an emergency. The City of Kelowna Health and Safety Branch shall be notified of any significant changes to the Inventory.

Table 1

Reportable Limits for Spills and Releases
Fire and Emergency Contingency Plan
Glenmore Landfill
City of Kelowna

Substance spilled[1]	**Specified amount**[1]
Explosives Class 1 as defined in section 2.9 of the Federal Regulations	Any quantity that could pose a danger to public safety or 50 kg
Flammable Gases Class 2.1 other than natural gas, as defined in section 2.14 (a) of the Federal Regulations	10 kg
Non-Flammable and Non-Toxic Gases Class 2.2 as defined in section 2.14 (b) of the Federal Regulations	10 kg
Toxic Gases Class 2.3 as defined in section 2.14 (c) of the Federal Regulations	5 kg
Flammable Liquids Class 3 as defined in section 2.18 of the Federal Regulations	100 L
Flammable Solids Class 4 as defined in section 2.20 of the Federal Regulations	25 kg
Oxidizing Substances Class 5.1 as defined in section 2.24 (a) of the Federal Regulations	50 kg or 50 L
Organic Peroxides Class 5.2 as defined in section 2.24 (b) of the Federal Regulations	1 kg or 1 L
Toxic Substances Class 6.1 as defined in section 2.27 (a) of the Federal Regulations	5 kg or 5 L
Infectious Substances Class 6.2 as defined in section 2.27 (b) of the Federal Regulations	1 kg or 1 L, or less if the waste poses a danger to public safety or the environment
Radioactive Materials Class 7 as defined in section 2.37 of the Federal Regulations	Any quantity that could pose a danger to public safety and an emission level greater than the emission level established in section 20 of the "Packaging and Transport of Nuclear Substances Regulations"
Corrosives Class 8 as defined in section 2.40 of the Federal Regulations	5 kg or 5 L
Miscellaneous Products, Class 9 Substances or Organisms as defined in section 2.43 of the Federal Regulations	25 kg or 25 L
Waste containing dioxin as defined in section 1 of the Hazardous Waste Regulation	1 kg or 1 L, or less if the waste poses a danger to public safety or the environment
Leachable toxic waste as defined in section 1 of the Hazardous Waste Regulation	25 kg or 25 L
Waste containing polycyclic aromatic hydrocarbons as defined in section 1 of the hazardous Waste Regulation	5 kg or 5 L
Waste asbestos as defined in section 1 of the Hazardous Waste Regulation	50 kg
Waste oil as defined in section 1 of the Hazardous Waste Regulation	100 L
Waste containing a pest control product as defined in section 1 of the Hazardous Waste Regulation	5 kg or 5 L
PCB Wastes as defined in section 1 of the Hazardous Waste Regulation	25 kg or 25 L
Waste containing tetrachloroethylene as defined in section 1 of the Hazardous Waste Regulation	50 kg or 50 L
Biomedical waste as defined in section 1 of the Hazardous Waste Regulation	1 kg or 1 L, or less if the waste poses a danger to public safety or the environment
A hazardous waste as defined in section 1 of the Hazardous Waste Regulation and not covered under items preceding items	25 kg or 25 L
A substance, not covered by preceding items, that can cause pollution	200 kg or 200 L
Natural gas	10 kg, if there is a breakage in a pipeline or fitting operated above 100 psi that results in a sudden and uncontrolled release of natural gas

NOTES:
(1) Substance definitions and reportable spill amounts from BC Spill Reporting Regulation (B.C. Reg. 263/90 including amendments upto B.C. Reg 376/2008, December 9,2008), current to May 2, 2017

Federal Regulations: The Transportation of Dangerous Goods Regulations made under the *Transportation of Dangerous Goods Act* (Canada)
Hazardous Waste Regulation: B.C. Reg. 63/88.

Appendix G
LFG Management Facilities Design Plan

Landfill Gas Management Facilities Design Plan (Final)

Glenmore Landfill Site

Prepared for

City of Kelowna

January 2012

CH2MHILL.

2100, Metrotower II, 4720 Kingsway Suite 2100
Burnaby, BC V5H 4N2

Contents

Exhibits

Appendixes

Acronyms and Abbreviations

°C	degrees Celsius
µm	micrometre
amsl	above mean sea level
BC MOE	BC Ministry of Environment
BC MOE LFG Guideline	The LFG Generation Assessment Procedure Guidance Report
BC	British Columbia
CH2M HILL	CH2M HILL Canada Limited
cm	centimetre
CSDP	Comprehensive Site Development Plan
m	metre
m^3	cubic metre
m^3/h	cubic metres per hour
m^3/yr	cubic metres per year
mm	millimetre
GHG	greenhouse gas
GJ	Gigajoules
HPDE	high-density polyethylene
IT	Information technology
km	kilometre
kW	kilowatt
LEL	lower explosive limit
LFG	landfill gas
LPS	Leachate Pumping Station
MOE	Ministry of Environment
MSW	municipal solid waste
NMOC	non-methane organic compounds
NPRI	National Pollutant Release Inventory
O&M	operation and maintenance
PLC	programmable logic controller

PSA	pressure swing technology
RDCO	Regional District of Central Okanagan
SCADA	supervisory control and data acquisition
scfm	standard cubic feet per minute
SDR	standard dimension ratio
the Site	Glenmore Landfill
the Assessment	initial LFG generation assessment
the City	City of Kelowna
the Regulation	Landfill Gas management Regulation, approved and ordered December 8, 2008
USEPA	United States Environmental Protection Agency

1 Introduction

On December 8, 2008, a new regulation for the management of landfill gas (LFG) at British Columbia (BC) regulated landfill sites was ordered and approved by the BC Ministry of Environment (BC MOE). Per the Landfill Gas Management Regulation (the Regulation), a regulated landfill site is a landfill site that has 100,000 tonnes or more of municipal solid waste (MSW), or has received 10,000 or more tonnes of MSW annually for disposal into the landfill site in any calendar year after 2008 (BC MOE, 2008). The City of Kelowna (the City) owns and operates the Glenmore landfill (the Site). There are approximately 3 million tonnes of MSW currently in place at the Site. The total amount of MSW landfilled at the Site in 2011 was approximately 106,000 tonnes. Thus, per the Regulation, the Site is a regulated landfill.

Under the new Regulation, a qualified professional is required to conduct an initial LFG generation assessment (the Assessment). The City retained CH2M HILL Canada Limited (CH2M HILL) to conduct the Assessment for the Site to comply with the Regulation. The Assessment and associated report have been conducted in accordance with Regulation requirements and submitted to the BC MOE director within the Regulation's regulated schedule.

Per the Regulation, if the results of the Assessment using the BC MOE calculation tool show that the quantity of methane produced by the landfill in the calendar year preceding the Assessment (2009) was greater than 1,000 tonnes, the landfill owner must submit a LFG Management Facilities Design Plan (The Plan) to the director no later than 1 year after the submission of the Assessment report to the BC MOE director, which is prior to January 1, 2012.

As indicated in Exhibit 6 of the Assessment, the quantity of methane produced at the Site in the year preceding the Assessment was approximately 3,797 tonnes.

The following report has been prepared in accordance with the Landfill Gas Management Facilities Design Guidelines, prepared for the BC MOE by CH2M HILL on behalf of the City and in accordance with the requirements of the Regulation, and approved and ordered on December 8, 2008.

This report has been prepared by a qualified professional and meets the requirements of Section 7(2) of the Regulation.

2 Site Conditions and Design Objectives

2.1 Site Conditions

The Site services approximately 188,644 people residing in the eastern half of the Central Okanagan Regional District. The Site is owned and operated by the City; has an estimated total capacity of 10.2 million tonnes (14,609,000 cubic metres [m^3]); and is expected to reach capacity by 2050, based on current filling plans. The Site has been in operation since 1967 and had received approximately 3 million tonnes of solid waste by the end of 2011.

The Site is on Glenmore Road approximately 1.5 kilometres (km) east of Okanagan Lake and 9 km northeast of the Kelowna city centre. It is situated in a narrow, flat-bottomed valley that is bordered on the west and east by tree-covered ridges and on the north and south by agricultural lands. The ridge to the northeast of the Site is known locally as Bredin Hill, while the southeast ridge is known as Tutt Mountain. Elevations on the landfill site vary from approximately 438 to 460 m above mean sea level (amsl), while the ridges that form the valley walls rise to over 550 m amsl.

This area was once a shallow slough known locally as Alki Lake at the downstream end of what is essentially a closed drainage basin (there is no surface water outflow). Topographically, this is the lowest area in the basin and serves as a collection point for the majority of the surface runoff from the basin.

Over the past several decades, the northern portion of the slough has been completely infilled and now serves as the active landfill area. The slough's southern portion also received waste for a number of years, but it has been inactive since the early 1980s. This area is referred to in the remainder of this report as the Slough.

The Site began operations with infilling Alki Lake and progressed northward into what is now known as Phase 1/Phase 2. In the early 2000s, the Phase 1 North Expansion was constructed to optimize the amount of airspace for Phase 1. Refuse disposal at the Site is currently conducted in the central portion of the active filling area (Phase 2).

2.2 Landfill Operations

Refuse disposal at the landfill is currently conducted in the northern and central portions of the active filling area (Phases 1 and 2) using above grade landfill cells. These cells are constructed on the previous waste surface by placing and compacting waste and subsequently covering it with a layer of soil; this constitutes one lift of waste. Once the area has been covered with one lift (approximately 3 m high), a second lift is constructed on top of the preceding lift using the same methodology. This filling method is anticipated to continue until the landfill has reached its final design elevation.

Large recyclable objects, such as white goods (for example, appliances like washing machines, refrigerators, and stoves), scrap metal, drywall, and wood wastes, are stockpiled in designated areas on the east side of the landfill. Wood wastes are chipped and used in the City's composting operations or forwarded to a co-generation facility north of Vernon. Other materials are removed from the Site by private recycling firms. A recycling area equipped with containers to receive smaller, separated recyclable materials is also on the west side of the landfill near the Site entrance.

A windrow composting operation was established over an inactive area on the northern portion (Phase 1) of the Site. Leaf and yard waste, as well as ground brush and trees diverted from the landfill, was initially processed in this area. This location was only temporary, and has now been relocated to the new composting pad south of Phase 3, completed in 2010. Landfilling of waste in Phase 1 resumed in 2011.

Several filling options have been evaluated for the Site. Based on the evaluations, a filling proposal was included in part of the Comprehensive Site Development Plan (CSDP), 2008. This proposal provides approximately 21,750,000 m^3 of airspace. Given the projected rate at which MSW is generated in the region, and the closure of the Westside Landfill, it is anticipated that this airspace will provide slightly less than 75 years of disposal capacity for the Central Okanagan Region. However, modifications to the filling plan and future changes in waste generation rates may extend or decrease the life of the landfill. The detailed filling strategy and sequence for each phase of landfill development will be reviewed annually by City staff.

Surface runoff from the covered areas of the landfill and from surrounding lands is collected in a network of ditches that drain into two irrigation ponds on the west side of the landfill. The pond at the northwest corner of the Site is known as the Bredin Pond, and the southwest pond is called the Tutt Pond. Water collected in these ponds is used by two local farmers for irrigating cropland north and south of the Site.

An active LFG collection system was installed in Phases 1 and 2 of the Site (see Appendix A). Section 3 describes in further detail the current LFG management and beneficial use systems as well as planned LFG system expansions.

2.3 Design Objectives

The City had undertaken a comprehensive approach to LFG management at the Site prior to The Regulation. The Plan was based on industry standards and best management practices. As a result, the LFG facilities align with the design standards, performance objectives, and performance standards summarized in Table 1.1 of the Landfill Gas Management Facilities Design Guidelines, prepared for the BC MOE by Conestoga-Rovers & Associates (CRA), March 2010. As the Site is a regulated landfill, a LFG collection system has been designed and installed in a phased approach to maximize the collection of generated LFG. The LFG extraction control plant was designed for Phase 1 and Phase 2 filling areas and has been implemented to aid reduction of greenhouse gas (GHG) emissions primarily through current and future beneficial uses and thermal destruction through flaring as a secondary measure. See Section 3.5 for a detailed description of the utilization and combustion system.

2.3.1 Landfill Gas Generation Assessment 2010 Results

An Assessment was completed in 2010 in accordance with the *BC MOE LFG Guideline,* Section 7 Landfill Generation Assessment Reporting. Exhibit 2-1 shows the annual methane production using the BC MOE calculation tool.

EXHIBIT 2-1

Annual Methane Production Using the BC MOE Calculation Tool for the Glenmore Landfill

Estimated Quantity of Methane Produced	Year	Tonnes Per Year
In the year preceding the Assessment	2009	3,797
In the year of the Assessment	2010	3,912
One year after the Assessment	2011	4,038
Two years after the Assessment	2012	4,163
Three years after the Assessment	2013	4,287
Four years after the Assessment	2014	4,411

According to the calculation tool results, 3,797 tonnes of methane were generated in 2009, which corresponds to approximately a 661 cubic metres per hour (m^3/h) or a 389 standard cubic feet per metre (scfm) methane generation rate. Using a typical LFG composition of 50 percent methane and 50 percent carbon dioxide by volume, this corresponds to a 1,322 m^3/h (778 scfm) LFG generation rate in 2009.

2.3.2 Landfill Gas Migration Control Measures – Onsite Health and Safety

The safety requirement is to control methane gas so it does not exceed 5 percent by volume (the lower explosive limit [LEL] of methane in air) at the property boundary, or 25 percent of the LEL (1.25 percent methane by volume in air) in any onsite structure.

To monitor the presence of LFG above the waste in place (for both final and temporary cover areas) as well as the perimeter outside the waste boundary, annual LFG surface emissions monitoring is conducted. This landfill surface emission monitoring event is conducted using a calibrated Draeger Multiwarn 2, 4-gas portable LFG detector at a height of approximately 10 to 15 centimetres (cm) above the surface of the landfill. Samples are taken over a 60 by 60 meter, 250 point grid covering the entire landfill. The most recent sampling event occurred in October, 2011. No methane, carbon dioxide, or hydrogen sulphide emission readings were recorded in any location within the monitoring grid.

A calibrated Draeger Multiwarn 2, handheld 4-gas analyzer is used monthly to monitor the presence of methane, hydrogen sulphide, and carbon dioxide within the onsite structures. Currently, a number of administration buildings on site are portable, pre-engineered buildings with elevated, above grade floor structures with no attached foundations, allowing a ventilated air space between the base of the building and the existing ground surface. All buildings at the Site are to be assessed and reviewed in 2012 to look at the requirement and feasibility of installing continuous, combustible gas measurement equipment where necessary.

An assessment will be undertaken in 2012 to review areas where subsurface LFG monitoring probes should be installed to monitor areas at the property boundary for the presence of methane.

2.3.3 Leachate Control System

Leachate generated by the waste in Phases 1 and 2 is collected in a leachate sump at the base of the northwest corner of Phase 1. Leachate is then transferred by gravity to the Leachate Pumping Station (LPS) at the northwest corner of Phase 1. In 2009, a collection trench running east-west was constructed along the Phase 1 and Phase 2 boundary. The trench, equipped with a perforated pipe, collects leachate by gravity and transfers it to the LPS. Leachate is then transferred from the LPS to the wastewater treatment facility for offsite treatment.

The City has completed a field pilot test to demonstrate the feasibility of leachate recirculation at the landfill. This test involved leachate collected at the LPS and periodically injected into perforated horizontal LFG collection pipes over the high-density polyethylene (HDPE)-lined cell at the north end of the Site. The objective of the test was to evaluate subsurface moisture distribution, settlement, and gas production. Following completion of the testing phase, controlled leachate recirculation was recommended as being feasible at the Site to enhance biodegradation of the organic fraction of the waste and increase the LFG generation rate. A leachate recirculation system and monitoring plan is currently being designed for both the Stage 1 and Stage 2 areas.

3 Landfill Gas Management Facilities Design

Section 3 presents the information required under Sections 7(2)(a) and 7(2)(d) of the Regulation.

3.1 Collection Well Field

3.1.1 Phase 1 Landfill Gas Control System Design in 2002

The CSDP prepared in 2001 included details of the proposed future development of the Site and an initial review of LFG management. LFG generation modelling conducted using default input parameters indicated that the emissions of non-methane organic compounds (NMOC) would exceed 150 tonnes per year and an LFG control system would be required to meet provincial requirements outlined in BC MOE's *Landfill Criteria for Municipal Solid Waste* (1993). As part of the City's proactive approach to LFG management, CH2M HILL was subsequently retained to design an LFG control system for Phase 1 of the Site. In July 2002, CH2M HILL prepared the *Glenmore Landfill Gas Pre-Design Report*, which outlined the design basis for LFG control at the Site and presented the pre-design for the Phase 1 filling area with expansion consideration for the future waste filling Phases 2 and 3 at the Site. Detailed design of the LFG collection system in the Phase 1 area was completed in 2003, and construction of initial horizontal gas collectors and the header system was ongoing with active landfilling operations from 2004 to 2007. Detailed design drawings for Phase 1 are presented in Appendix B.

3.1.2 Phase 2 Landfill Gas Control System Design in 2006

In October 2004, CH2M HILL prepared the *Phase 2 LFG Management Pre-Design Report (Addendum 1 – Glenmore LFG Pre-Design Report)*, which presented the preliminary design layouts and concepts for the Phase 2 filling area. The Phase 2 LFG recovery system would tie into the existing Phase 1 system via an extended 400 millimetres (mm) diameter perimeter ring manifold. Detailed design for the Phase 2 landfill area was completed in mid-2005. The combined LFG control system for Phases 1and 2 was designed based on a LFG flow rate capacity of 11.9 million cubic metres per year (m^3/yr) (800 scfm). Interim gas control is provided by a 600 m^3/h (350 scfm) blower flare station commissioned in November 2005. Electrical power is also generated using LFG at the Site to provide alternative energy to fuel three grid-connected 30 kilowatt (kW) Capstone microturbines. Current power station capacity is 90 kW. See Section 3.5 for a detailed description of the utilization/combustion system.

Landfilling in Phase 2 commenced in early 2006, and construction of the Phase 2 LFG control system commenced shortly after, with the installation of the initial lower lift section vertical and horizontal gas collectors. Phase 2 LFG control will be provided via a temporary LFG manifold connector combining LFG recovery from Phases 1 and 2.

Under the existing, approved design plan, the Phase 1 and 2 lands are constrained to a maximum height of 470 m, with the maximum slope of the final cover to be no greater than 15 percent. Under the existing filling plan, including the existing constraints, Phase 1 will be completed by July 2013 and Phase 2 will be completed by July 2018.

Detailed design drawings for Phase 2 are in Appendix C.

3.1.3 Phase 3 Landfill Gas Control System Concept

The conceptual design for the Phase 3 LFG collection system also involves the placement of 150 mm diameter HDPE standard dimension ratio (SDR) 11 perforated pipes in collection trenches in the refuse. The horizontal collectors would be spaced approximately 60 m apart, following the east-to-west path that was used for the Phase 1 and 2 collectors. The first series of horizontal collectors would be laid in a trench in the waste mass following the placement of the first 5 to 6 m lifts of waste across Phase 3. The next series of horizontal collectors would be offset by 30 m and installed immediately following the next 6 m overlying waste lift. The conceptual plan view of the proposed LFG collection system in Phase 3 and the conceptual north/south cross-section view are shown Appendix D, Figures 3-7 through 3-9 (CSDP, 2007).

A ring header system is proposed to be installed around Phase 3. The horizontal collection pipes would be connected to the main header system, which would be tied into the Phase 2 collection system via the main collection header pipe at the east and west ends, as shown in Figure 3-7 in Appendix D (CSDP, 2007).

3.1.4 Horizontal Collection Trench Design

Horizontal gas collectors should be in areas where active filling occurs, or will soon occur, and will result in a refuse thickness greater than 6 m. This will surround the collectors with waste and allow them to function effectively without drawing in air when placed under vacuum. The vast majority of gas emissions are expected in the active and future filling areas, rather than in the older areas of the landfill. This is because the previously filled areas have already spent much of their gas-generating potential, based on age of waste and level of biodegradation.

The existing LFG collection system for Phase 1 and the planned LFG collection system for Phase 2 incorporated LFG collection via horizontal gas collectors constructed using perforated HDPE pipes. The primary advantage of using horizontal LFG collectors is that LFG can be collected relatively early, following the placement of 5 to 6 m of initial waste lifts. The installation of the horizontal LFG recovery system is incorporated as part of the landfill operations.

The Phase 1 and 2 LFG horizontal collectors consist of 150 mm diameter HDPE SDR 11 perforated pipes. Expansion(slip) joints, consisting of 200 mm diameter collars (joints), were incorporated into the design to accommodate landfill settlement and eliminate the need for fusion welding of the perforated gas pipes. The Phase 2 LFG recovery system will be tied into the existing Phase 1 recovery system via an extended 400 mm diameter perimeter ring manifold. A temporary connector is currently used, and will continue to be until the landfill final contours and grading has been completed.

LFG recovery trench design details are presented in Drawing D1 in Appendix C.

3.1.5 Vertical Extraction Well Design

A total of 64 vertical extraction wells were installed in the Phase 2 area to collect LFG from the area where waste had been placed prior to the installation of any horizontal collectors. The vertical wells are spaced 60 m apart and are connected directly to the associated horizontal collector. The primary advantage of using vertical wells is that LFG can be collected from the old area with several lifts of waste.

The Phase 2 LFG vertical wells consist of 100 mm and 50 mm diameter HDPE SDR 17 perforated pipes embedded in 280 mm borehole with pea gravel. A telescoping joint was incorporated into the design to accommodate landfill settlement and to eliminate the need for fusion welding of the perforated gas pipes.

Details of the vertical extraction wells are presented in Drawing D3 in Appendix C.

3.1.6 Collection Field Piping Design

The LFG collection field provides access to the disposal waste to collect the LFG from the waste disposal area through horizontal collection trenches and vertical extraction wells, and to transport the LFG to the LFG treatment facility.

A phased approach is used to construct the LFG system. Horizontal gas collectors would be placed in areas where active filling is occurring, or will soon occur, and will result in a refuse thickness of greater than 6 m, while vertical extraction wells would be installed in area where waste had been placed prior to the installation of horizontal collectors.

At the end of each run of the horizontal gas collector is a vaulted well that houses a gate valve to balance the collection field, and sample ports for gas quality and velocity monitoring. The 150 mm HDPE laterals connect the vaulted well and the LFG collection field to the ring header. The wellheads are currently above grade and will not be completed in below grade vaults until final cover has been placed.

A ring header system will also be installed in Phase 3 and along the east side of the future Phase 1 extension along Bredin Hill. Each of the horizontal collection pipes will be connected to the main ring header system.

All three phases of the collection system will eventually be tied to each other via the main collection header pipe. Currently, Phases 1 and 2 are temporarily connected on the west side by a 150 mm HDPE pipe.

A gas collection piping inventory can be found in Appendix E.

3.1.7 Leachate Collection System Connections

Existing leachate collection facilities at the Site include a piped connection between the leachate collection pond and a pump station at the north end of Bredin Pond. Collected leachate is discharged through a force main to an offsite sanitary sewer. There are capped stub outs on the leachate lines leading to the pump station for future connections to the system.

A swale and French drain has been constructed along a portion of the north end of the Site to intercept surface and shallow groundwater. The collected uncontaminated water drains to Bredin Pond.

The *North Area Development and South Area Closure* report (UMA, 1996) proposed the installation of pumped vertical wells for leachate collection in portions of the existing fill area with a large thickness of waste. This would reduce the leachate level to an elevation of approximately 437 m amsl or less. The report estimated that approximately 20 vertical wells would be required, but the spacing would need to be verified based on the drawdown cone of each well. Monitoring wells may need to be installed between the vertical pumping wells if verification of leachate levels is needed.

Subsequent to the UMA assessment, Golder Associates and Earth Tech were retained by the City in 2005 to design and construct the Phase 1 and 2 leachate collection system. The recommended system consisted of a collection trench running east-west along the Phase 2 and 3 boundaries. A perforated pipe in the collection trench would drain towards a centralized pump station that conveys the leachate via force main to the northwest corner of Phase 2. At that point, the leachate joins and flows via gravity to a pipe that runs east to west along the Phase 1 and 2 boundary, and flows north via gravity to the leachate pump station at the north east corner of Bredin Pond.

3.2 Condensate Management

Generally speaking, LFG is saturated with water vapour and condensate may form in the LFG management system. The purpose of the condensate management is mainly to remove and collect condensate forming in the LFG piping network and direct it to the leachate collection system for disposal as leachate.

The temperature in the landfill is usually above the ambient temperature – typically in the range of 30 to 50 degrees Celsius (°C). As the LFG reaches the surface and flows through the lateral and header, the gas temperature will drop until it reaches dew point, forming condensate. Condensate must be removed from the piping system to prevent any interfering of gas flow. Condensate collected in the LFG main header is usually directed to the leachate collection system for disposal as leachate.

The LFG headers are sloped to accommodate gravity drainage of condensate toward condensate traps (see Drawing D2 in Appendixes A and B).

3.3 Landfill Gas Extraction Plant

The LFG extraction plant extracts, transports, and combusts the LFG collected from the LFG collection field and houses the mechanical and electrical components required to extract and destroy the LFG (that is, the LFG blower and open flare).

The blower/flare station consists of a series of skid-mounted units with a modular expansion of capacity over time to parallel the filling plans and projected LFG generation. The modular expansion will incorporate inlet condensate knockout, control valves, blower system, and open flare.

Currently, one centrifugal blower draws the LFG from the Site and routes the gas to the flare system for thermal destruction. The upper design capacity for the blower/flare facility was in the 600 m^3/h (350 scfm) range to provide enough capacity for the current flow rate. Additional blowers can be added when Phase 3 kicks in.

Drawing P4 in Appendix C provides blower-flare station tie-in details.

Specific information can be found in the manufacturer's operation and maintenance (O&M) manuals.

3.4 Metering Equipment

Metering information for the flare/blower and utilization systems at the landfill site can be found in the LFG Specialties, and Capstone O&M manuals.

3.5 Landfill Gas Utilization/Combustion System

3.5.1 Existing Utilization/Combustion System

The existing LFG Utilization/ Combustion system consists of beneficial use through electrical generation and thermal destruction through flaring. There are three 30 kW Capstone C30 MicroTurbine generator units onsite producing a maximum installed capacity of 90 kW. These generators consume approximately 65 m^3/h (38 scfm) of the recovered LFG. The City uses the power generated to power the parasitic load of the recovery facility, with any excess power being exported to the grid, per an agreement with Fortis BC. The remaining LFG, which is recovered but not used for power generation, is thermally destroyed through an onsite flare system with a design capacity of 600 m^3/h (350 scfm).

An LFG conditioning system is installed upstream of the MicroTurbines to reduce the moisture content, compress the gas, and reduce contaminants such as siloxane. The system consists of a coalescing filter to remove the initial free water and particulates greater than 0.3 micrometres (µm), a calcium chloride filter that reduces about 20 percent of the moisture content, a fuel gas compressor, and a polymorphous graphite siloxane removal system.

The City intends to keep the MicroTurbines in operation and to keep the flare as a back-up for use during downtime of the LFG utilization system (including downtime for maintenance, repairs, or other potential shut-down situations).

3.5.2 Future Utilization/Combustion System

It is the City's intention to increase its LFG use and reduce energy consumption and GHG emissions. The City is currently in the pre-design stage of a biomethane project with FortisBC that will upgrade the recovered LFG to meet pipeline-quality gas specifications, then convey the gas to FortisBC's natural gas distribution network.

The LFG will be upgraded using pressure swing technology (PSA). PSA uses material like activated carbon or zeolites to absorb and desorb certain gases as the gas pressure changes. For this application, the technology captures carbon dioxide and removes it from the biogas. For the Site's LFG, the proposed process is described as follows:

1. Raw LFG will pass through a knockout drum to remove moisture and then through a hydrogen sulphide system to reduce hydrogen sulphide concentration.
2. The pre-treated LFG will then be compressed, cooled, and sent to a coalescent filter to remove oil from compressors and liquids.
3. Reusable adsorbent media will remove volatile organic compounds and siloxanes
4. High pressure pre-treated LFG will enter the PSA unit, where the carbon dioxide is adsorbed and the methane passes through
5. High-purity methane will be produced and sent to the Fortis BC pipeline.
6. The PSA exhaust will be thermally destroyed to remove trace methane and contaminants before being released to the atmosphere.

The initial module will be sized to process 425 m^3/h (or 250 scfm), but the overall upgrading facility will be sized for 850 m^3/h (or 500 scfm). With 425 m^3/h of LFG, biomethane production will be approximately 51,000 Gigajoules (GJ) per year. The LFG Upgrading Facility will be the primary GHG emission control system and will be located near the existing blower/flare station. The candlestick flare will provide 100 percent back-up for thermal destruction during shutdown for LFG Upgrading Facility O&M.

The design of the project is scheduled to commence in 2012.

4 System Installation, Operation, and Maintenance

Section 4 presents the information required under Sections 7(2)(b) of the Regulation.

4.1 System Installation

The system installation schedule is determined by the waste volumes in place, and the disposal rates. As noted in Section 3, Phase 1 was designed in 2002, Phase 2 in 2006 and is still undergoing expansions and system upgrades. Phase 3 is currently in the conceptual design stage. Utilization of the LFG was added in 2006 with the installation of grid-connected microturbines for electrical power generation. The biomethane project described in Section 3.5.2 is still in the planning stages and, depending on final contract negotiations, is anticipated to come online in 2013. Appendix E shows the dates on which the collection system piping was installed.

Each phase of the LFG collection system has been constructed and installed per design drawings and specifications designed by a professional engineer registered in BC. All major equipment installation and maintenance has been completed in accordance with the manufacturer's recommendations.

4.2 General Operation and Maintenance

4.2.1 Operation and Maintenance Tasks

O&M tasks for the LFG collection system are performed on a daily or, weekly, monthly, and annual basis depending on the task itself. These tasks include, but are not limited to the following:

Daily or Routine Operations

- Visual inspection of blower/flare station and power generation system
- Review of data and continuous recording
- Adjustment of recovery wells and balancing of the system
- Daily reports of average LFG system parameters and records of non-planned and O&M activities
- Review of responsibilities for after hours and on call system alarm duties
- Review of health and safety requirements
- Leachate recirculation in Phase 1 and condensate management of the LFG collection system (inspections and monitoring daily or weekly as required)

Monthly Operations

- Recovery well survey and recording of well field data (including wellhead surveys records for composition, pressure, temperature, and adjustments made)
- Full well field system inspection, including observations of landfill operations and cover affecting LFG recovery
- Leachate recirculation in Phase 1
- Monthly reporting of data
- Condensate handling and volume recording
- Downloading of data from the blower/flare system programmable logic controller (PLC) and utilization system
- Planned maintenance of the blower/flare station and MicroTurbine and fuel gas processing system (including media replacement)

- Responses to un-planned maintenance for LFG collection system, blower-flare station, and utilization systems
- Responses to odour issues
- Repair of wellheads and system maintenance

Annual Operations

- LFG surface emission testing and reporting
- Sampling for third party lab analysis (including LFG, condensate, and trace contaminants), annual equipment preventative maintenance
- Leachate recirculation annual reporting
- Coordination, startup, and commissioning of well field system expansion
- Training for LFG operations and updating of the health and safety requirements
- Annual reporting (includes Federal under National Pollutant Release Inventory [NPRI] reporting for national GHG emission inventory, under regulatory requirements, GHG verification, and City requirements)
- Budgeting and O&M planning for the year (operations and coordination with future expansions) with the Site supervisor
- LFG utilization system O&M (including planned and unplanned maintenance) and reporting

For detailed O&M procedures for the LFG collection system, refer to *The Solid Waste Association of North America (SWANA) Landfill Gas Operation and Maintenance Manual of Practice, 2002.*

The LFG Specialties O&M manual should be consulted for procedures pertaining to the blower flare system. Capstone's O&M manual for the MicroTurbines should be consulted for O&M procedures. Both manuals are available onsite.

4.2.2 Wellfield Operating Parameters

The five primary operating parameters that must be monitored monthly in the gas collection system are methane content (percentage by volume), oxygen content (percentage by volume), nitrogen content (percentage by volume on a balance gas basis), flow rate (m^3/h or equivalent), and static pressure. The carbon dioxide concentration (percentage by volume), water level, and temperature (°C) should also be measured to check the primary operating parameters. Performance operating standards have been established for oxygen and nitrogen content and are outlined below:

- Oxygen concentration in LFG should be maintained below 2 percent. Oxygen readings above this level could indicate intrusion of air the well and should be monitored closely. The LFG flow rate from a well with oxygen concentrations in this range should be decreased if concentrations are above 2 percent. Oxygen content will not exceed 2.5 percent by volume at any extraction well.
- Nitrogen concentration in the LFG collection system wells should be maintained below 15 percent by volume. Nitrogen readings above this level could indicate air intrusion into the waste mass and recovery well and should be monitored closely.

4.2.3 Blower/Flare Station Operating Parameters

The main operating parameters associated with the blower flare station are the percent methane content of the LFG, as well as the percent oxygen content. The percent methane must remain higher than a pre determined level set by the operator to ensure continuous efficient collection of LFG from the landfill site. The percent oxygen must remain less than 2 percent at all times. If the oxygen content exceeds 2 percent, the blower/flare control system will trigger an alarm as well as an automatic call-out to the system operator. A round of field monitoring must follow as soon as practicably possible in order to resolve the high oxygen content. On a safety basis, the flare system is automatically shut down if the oxygen content received at the station content is greater than 2.5 percent. The flare thermocouple temperature is also monitored on a continual basis to ensure that the LFG is continuously destroyed. If the thermocouple temperature falls below the set point, the flare will automatically attempt to re-ignite. Blower amperage is monitored for surge protection and blower inlet vacuum pressure is also monitored.

The blower/flare station PLC continuously records the methane, oxygen, flow rate, flare temperature and blower amperage. This is logged and downloaded by the operator at set intervals.

The data logging shall be at a frequency of not greater than 5 minutes to ensure continuous LFG recovery and thermal destruction.

5 System Optimization

Section 5 presents the information required under Sections 7(2)(c) of the Regulation.

For an active waste disposal site like the Site, that incorporates active LFG collection, flaring, and a utilization system, and which gains new wells and LFG infrastructure annually, it is essential to have field support available to optimize LFG management during the 24-hour continuous operation.

There is currently one fulltime staff member dedicated to the LFG management at the Site. Plans to add additional staff are under review, based on the requirement for the proposed LFG biomethane project. Field staff should be available to react in a timely manner to changes in the LFG wells, system outages, or upsets causing down time. The increased man-hours will allow the O&M procedures mentioned in Section 4 to be performed adequately and will provide support to additional operational and monitoring programs such as leachate recirculation and water quality monitoring program.

The City is also working internally with their information technology (IT) department to integrate the LFG blower/flare/utilization system with their current supervisory control and data acquisition (SCADA) system. This will increase data management efficiency.

6 Additional Information

Section 6 presents the information required under Sections 7(2)(e) of the Regulation.

No additional information has been requested by the director at this time.

7 References

British Columbia Ministry of Environment (BC MOE). 1993. Landfill Criteria for Municipal Solid Waste.

British Columbia Ministry of Environment (BC MOE). 2008. Landfill Gas Management Regulation. Province of BC, ordered and approved December 8, 2008.

CH2M HILL Canada Limited (CH2M HILL). 2001. Comprehensive Site Development Plan Glenmore Landfill. Prepared for the City of Kelowna. August.

CH2M HILL Canada Limited (CH2M HILL). 2002. Glenmore Landfill Gas Pre-Design Report.

CH2M HILL Canada Limited (CH2M HILL). 2004. Phase 2 LFG Management Pre-Design Report (Addendum 1 – Glenmore LFG Pre-Design Report). October.

CH2M HILL Canada Limited (CH2M HILL). 2008. Comprehensive Site Development Plan Glenmore Landfill. Prepared for the City of Kelowna. June

CH2M HILL Canada Limited (CH2M HILL). 2009. Technical Memorandum, Landfill Gas Power Generation Transitioning Feasibility – Glenmore Landfill. Prepared for the City of Kelowna. February.

CH2M HILL Canada Limited (CH2M HILL). 2010. Annual quantity of waste at the Site, Landfill Gas Generation Assessment Report (Final), Glenmore landfill site, prepared for the City of Kelowna. December.

CH2M HILL Canada Limited (CH2M HILL. 2010. Technical Memorandum, Findings of Initial Landfill Gas Generation Assessment Report – Westside Landfill, Regional District of Central Okanagan (RDCO). Prepared for The RDCO. May.

City of Kelowna. 2007a. *Glenmore Landfill Operations, 2007 Year-end summary and Fourth Quarter Report*, prepared by the City of Kelowna. 2007.

City of Kelowna. 2007b. 2006 Glenmore Landfill Annual Report, prepared for the City of Kelowna. June.

City of Kelowna. 2008.*City of Kelowna Glenmore Landfill Operations, 2008 Year-end summary and Fourth Quarter Report, prepared by the City of Kelowna*. 2008.

The City of Kelowna. 2010. *Glenmore Landfill, Refuse Type Total Report for year 2007, 2008, and 2009*. Prepared for The City of Kelowna.

Conestoga-Rovers & Associates (CRA. 2009. *Landfill Gas Generation Assessment Procedure Guidance Report*, prepared by Conestoga-Rovers & Associates for the BC MOE. March.

Conestoga-Rovers & Associates (CRA). 2010. *Landfill Gas Management Facilities Design Guidelines*, prepared by Conestoga-Rovers & Associates for the BC MOE. March.

Regional Waste Reduction Office. 2008. *Glenmore Landfill Waste Audit Report,* April 28 - May 2, 2008, July.

Solid Waste Association of North America (SWANA). 2002. Landfill Gas Operation and Maintenance Manual of Practice.

UMA. 1996. North Area Development and South Area Closure Report.

United States Environmental Protection Agency (USEPA). 2010. *Project Development Handbook, of The Landfill Methane Outreach Program*. http://www.epa.gov/lmop/publications-tools/handbook.html. Accessed on November 1, 2010

8 Signatures

This signature page fulfills the requirements of Section 7(1)(f)of the Regulation. For inquiries, please contact Chuck Smith at Chuck.Smith@ch2m.com.

Prepared by:

Scott Krenz, EIT (AB)

Caroline Theoret, P.Eng.

Certified /Approved by:

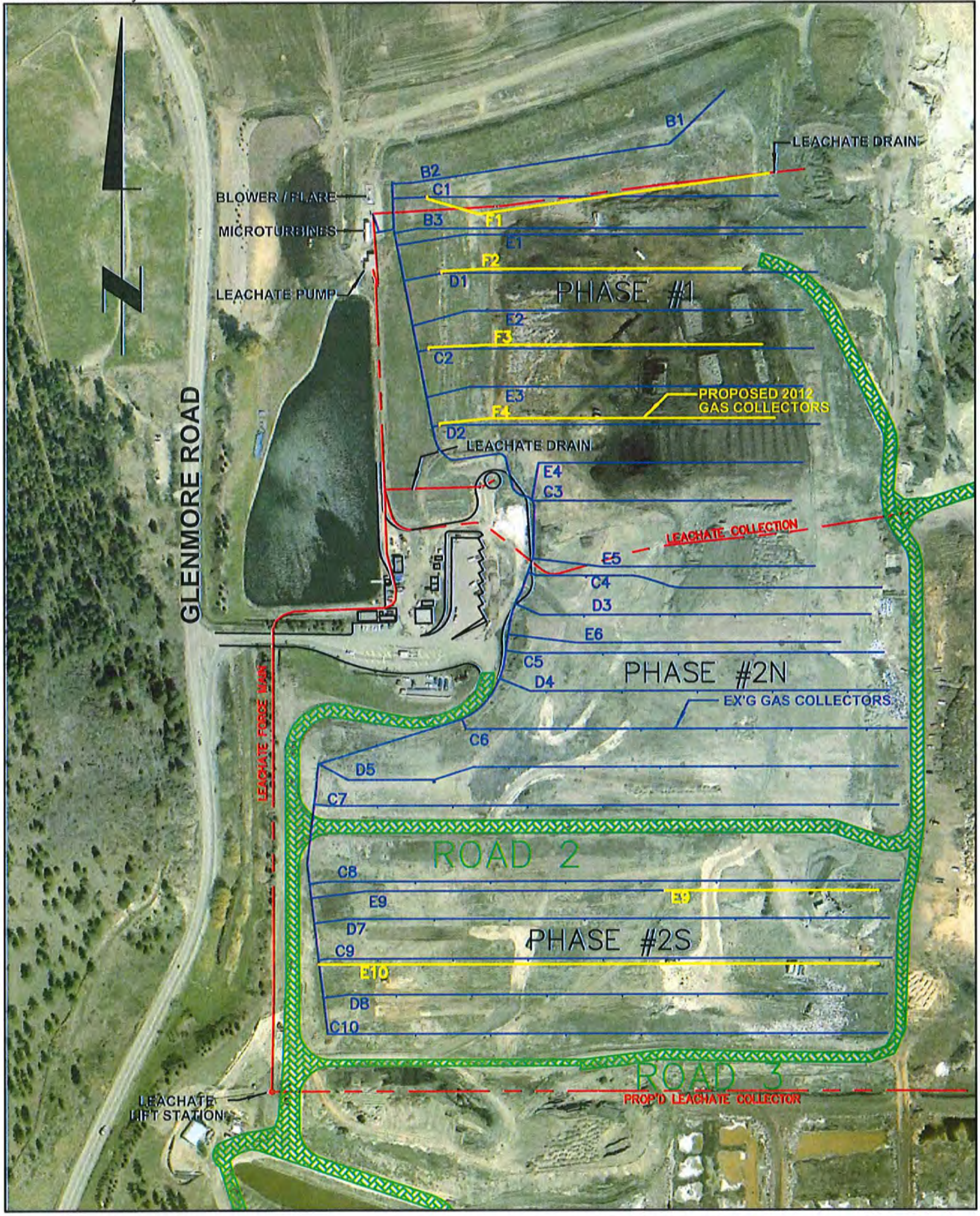
C.J. (Chuck) Smith, P.Eng .

Appendix A
Phase 1 and 2 Existing Conditions Drawings

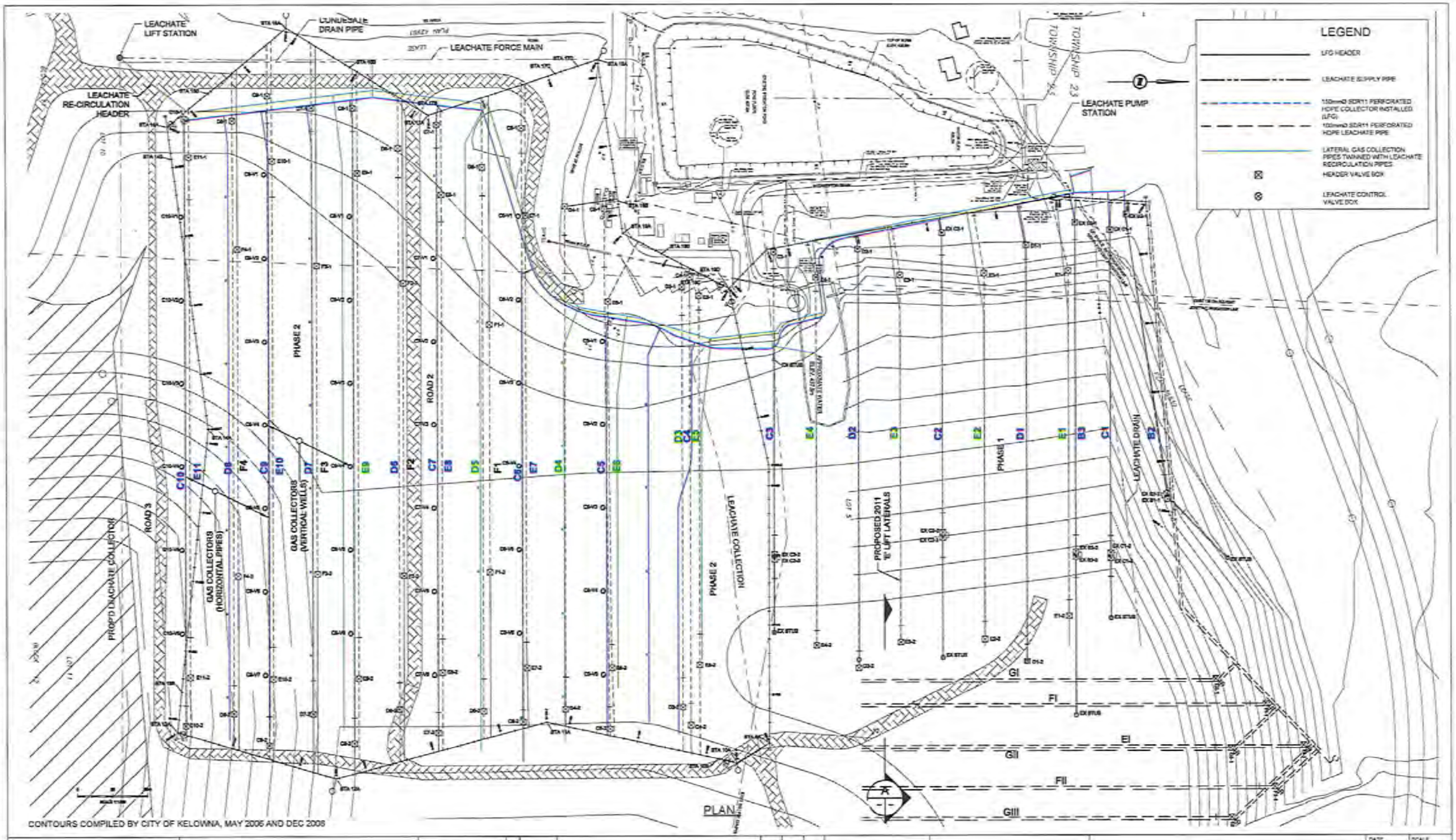
GAS COLLECTION SYSTEM

Source: The City of Kelowna

As of December 2011



FILE LOCATION: I:\Projects\2011\Landfill 11\Gas pipes\Gas Collection Map.dwg PRINTED ON: 12/22/2011 12:58 PM



CONTOURS COMPILED BY CITY OF KELOWNA, MAY 2006 AND DEC 2008

REUSE OF DOCUMENTS
THIS DRAWING IS OF A CONFIDENTIAL NATURE AND SHALL NOT BE REPRODUCED IN ANY MANNER, NOR USED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN PERMISSION OF CH2MHILL CANADA LIMITED.

THIS DRAWING IS NOT APPROVED FOR CONSTRUCTION UNLESS IT BEARS A SIGNED AND DATED ENGINEERS STAMP, AFFIXED ON OR AFTER THE DATE OF THE LAST REVISION.

VERIFY SCALES

BAR IS 20mm LONG ON ORIGINAL DRAWING.

0 20

IF NOT 20mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	REVISIONS	BY	CHK'D	APP'D
1	25/02/2011	ISSUED FOR CLIENT REVIEW	MS	RL	

ENGINEER

CH2MHILL

CITY OF KELOWNA

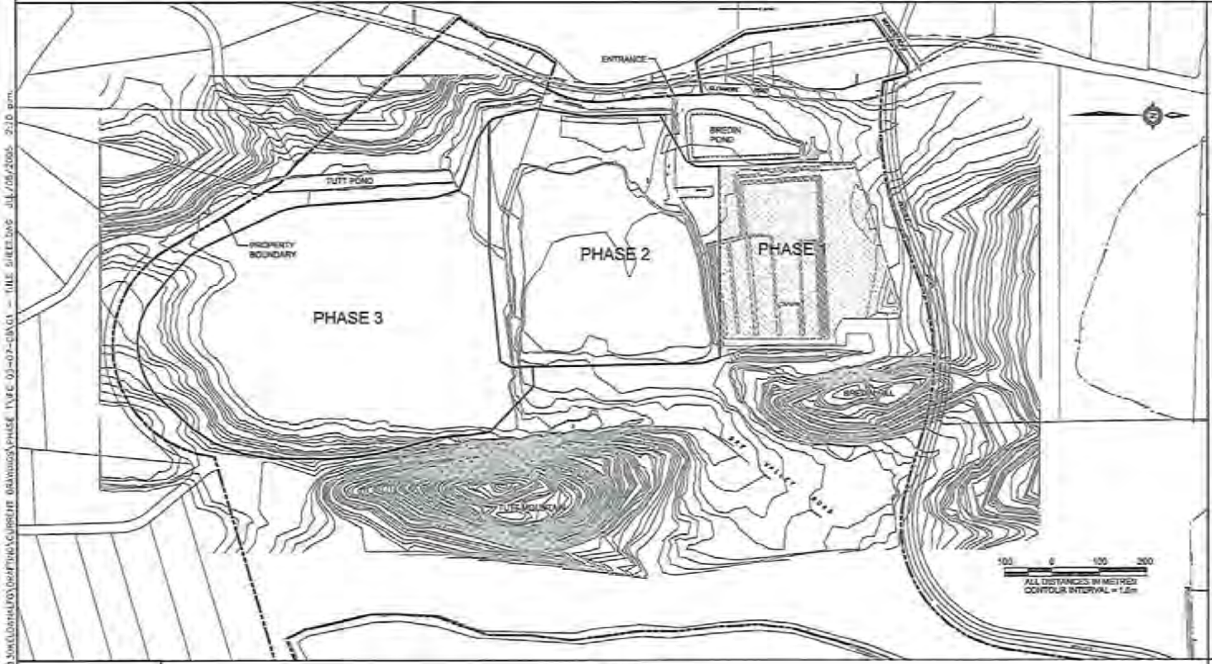
PHASE 1 / PHASE 2 LFG WELLFIELD AND PIPING
EXISTING CONDITIONS
HEADER PLAN

DATE 2011.02.21	SCALE AS SHOWN
DRAWN SES	REV. NO. △
PROJECT NO. 417808	
DRAWING NO. FIGURE 1	

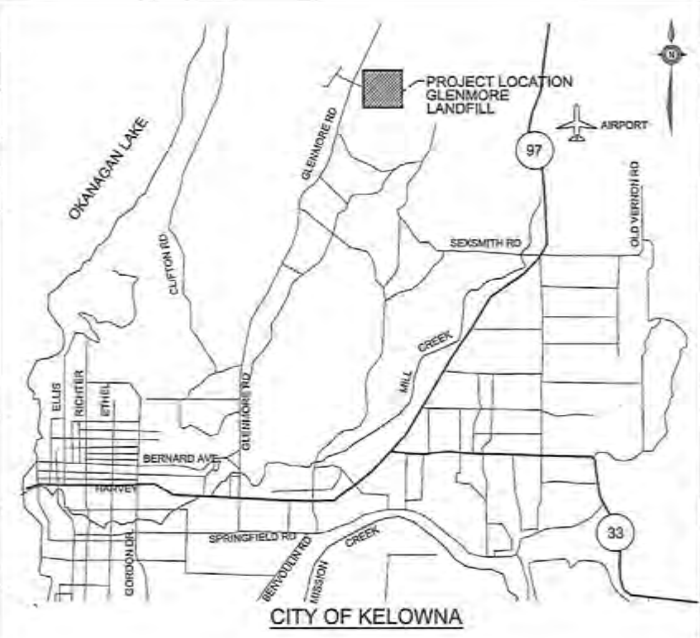
Appendix B
Phase 1 Detailed Design Drawings

CITY OF KELOWNA
GLENMORE LANDFILL

PHASE 1 NORTH LANDFILL GAS COLLECTION SYSTEM
REVISIONS TO DEC 2002 TENDER SET - JULY 2005



VICINITY MAP



PROJECT LOCATION

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RLJ	KEW	CS	MS
0	05-02-23	ISSUE FOR 90% REVIEW	RLJ	KEW	CS	MS

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

GENERAL
PHASE 1
VICINITY MAP AND KEY PLAN

SHEET 1 OF 11
DWG G1
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

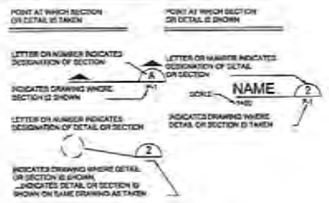
GENERAL LEGEND OF SYMBOLS

ABBREVIATIONS

CTR, CNTR	CENTRE	%	PERCENT
DET	DETAIL	PI	POINT OF INTERSECTION
DIA	DIAMETER	PL	PLATE
DWG	DRAWING	PVI	POINT OF VERTICAL
EG	EXISTING GROUND	REQD	REQUIRED
EL, ELEV	ELEVATION	SCH	SCHEDULE
EXIST	EXISTING	SHT	SHEET
EXP	EXPANSION	SIM	SIMILAR
FG	FINISH GRADE	SOC	SOCKET
G.S.E.	GROUND SURFACE ELEV.	SPECS	SPEED
HDPE	HIGH DENSITY POLYETHYLENE	S.S.	STAINLESS STEEL
I.E.	INVERT ELEVATION	STA	STATION
LCS	LEACHATE CONTROL SYSTEM	STL	STEEL
LFG	LANDFILL GAS	THRD	THREADED
MAX	MAXIMUM	TYP	TYPICAL
MFR	MANUFACTURER	W	WITH
MH	MANHOLE		
MIN	MINIMUM		
MIL	1/1000 INCH		
NTS	NOT TO SCALE		
MTL	MATERIAL		

GENERAL NOTES

SECTION AND DETAIL DESIGNATION



INDEX TO DRAWINGS

INCLUDED IN SET	DRAWING NO.	DRAWING TITLE
		GENERAL
●	G1	PHASE 1 - VICINITY MAP AND KEY PLAN
●	G2	PHASE 1 - SHEET INDEX, LEGEND, AND ABBREVIATIONS
		LANDFILL GAS WELLFIELD AND PIPING
	W1	SITE PLAN
●	P1	PHASE 1 - PLAN
●	P2	PHASE 1 - HEADER - PLAN & PROFILE
●	P3	PHASE 1 - SECTION - SOUTH TO NORTH
●	P4	PHASE 1 - SECTION ALONG COLLECTOR C2
●	P5	PHASE 1 - SECTION ALONG COLLECTOR D2
●	P6	PHASE 1 - SECTION ALONG COLLECTOR E2
●	D1	PHASE 1 - LANDFILL GAS DETAILS
●	D2	PHASE 1 - LANDFILL GAS DETAILS
●	D3	PHASE 1 - LANDFILL GAS DETAILS
		FLARE STATION NOTE: REVISED FOR NEW FLARE STATION LOCATION SEE FEBRUARY 2005 PHASE 2 LFG COLLECTION SYSTEM DESIGN
	M1	BLOWER FLARE STATION PFD
	M2	BLOWER FLARE STATION P&ID
	F1	BLOWER FLARE STATION SITE PLAN
	F2	BLOWER FLARE STATION PLAN
	F3	BLOWER FLARE STATION SECTION 1
	F4	BLOWER FLARE STATION SECTION 2
	F5	BLOWER FLARE STATION SECTIONS & DETAILS
	E1	BLOWER FLARE STATION ELECTRICAL - SINGLE LINE DIAGRAM & PANEL SCHEDULE
	E2	BLOWER FLARE STATION INSTRUMENTATION LAYOUT
	E3	BLOWER FLARE STATION POWER LIGHTING & GROUNDING LAYOUT
	E4	BLOWER FLARE STATION CABLE TRAY LAYOUT
	S1	BLOWER SKID BLDG & SECTIONS

C. J. SMITH

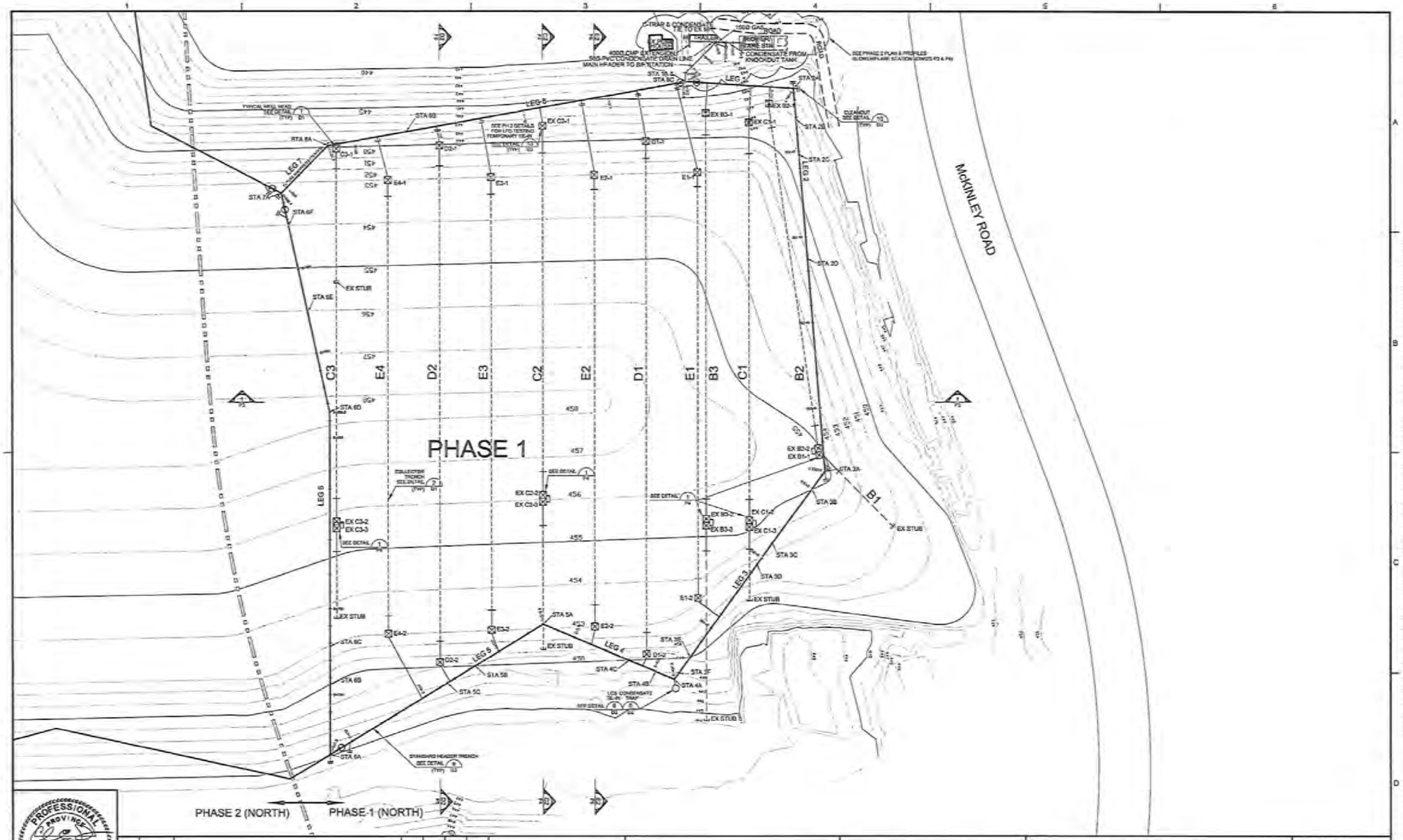
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RJJ	KEW	CG	MB
0	05-02-23	ISSUE FOR 60% REVIEW	RJJ	KEW	CG	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

GENERAL
PHASE 1
SHEET INDEX, LEGEND, AND ABBREVIATIONS

SHEET 2 OF 11
DWG G2
DATE DEC 2004
PROJ 323443



PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

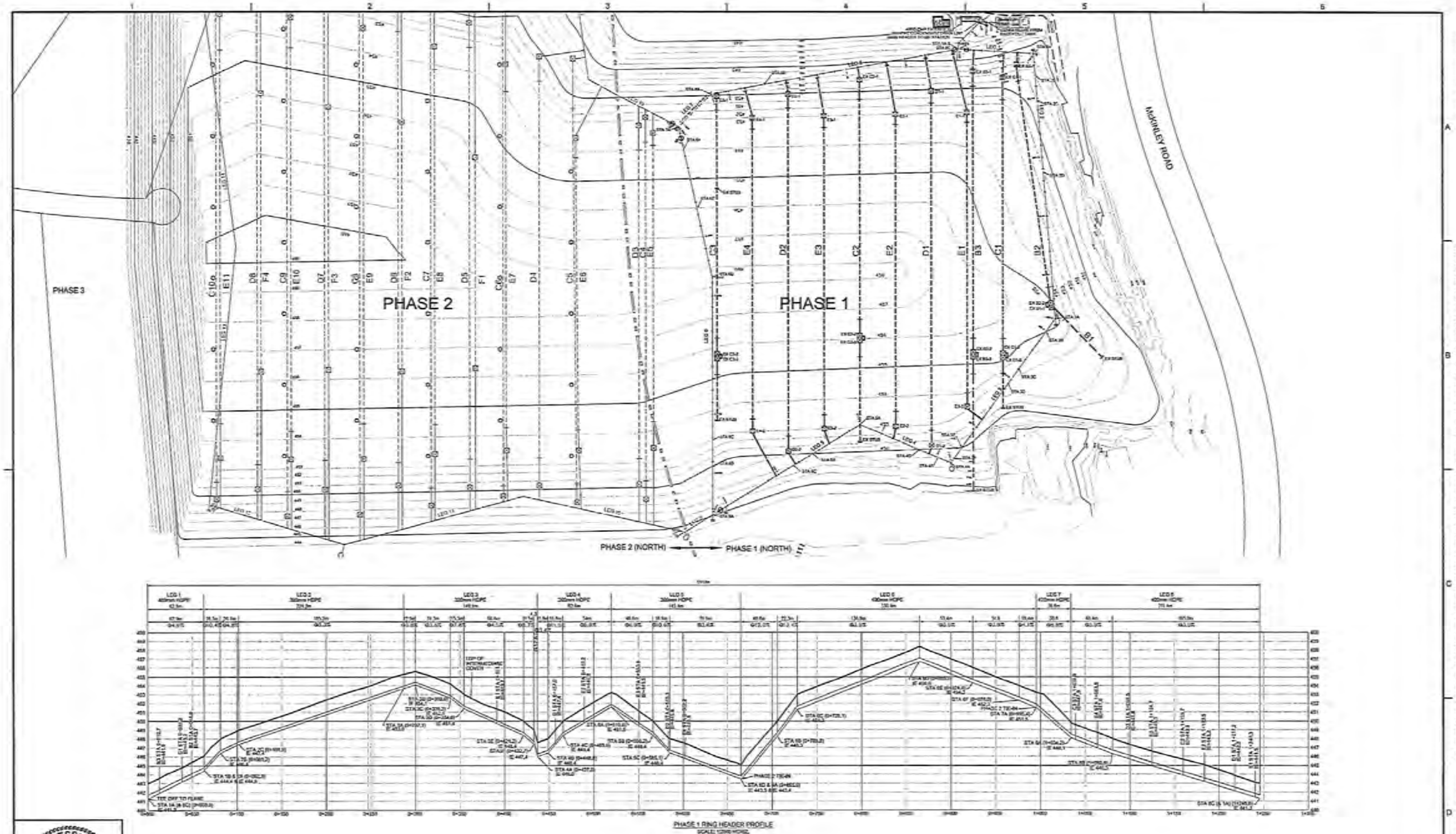
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
PLAN

SHEET 3 OF 11
DWG P1
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.



PHASE 1 RING HEADER PROFILE

C.J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

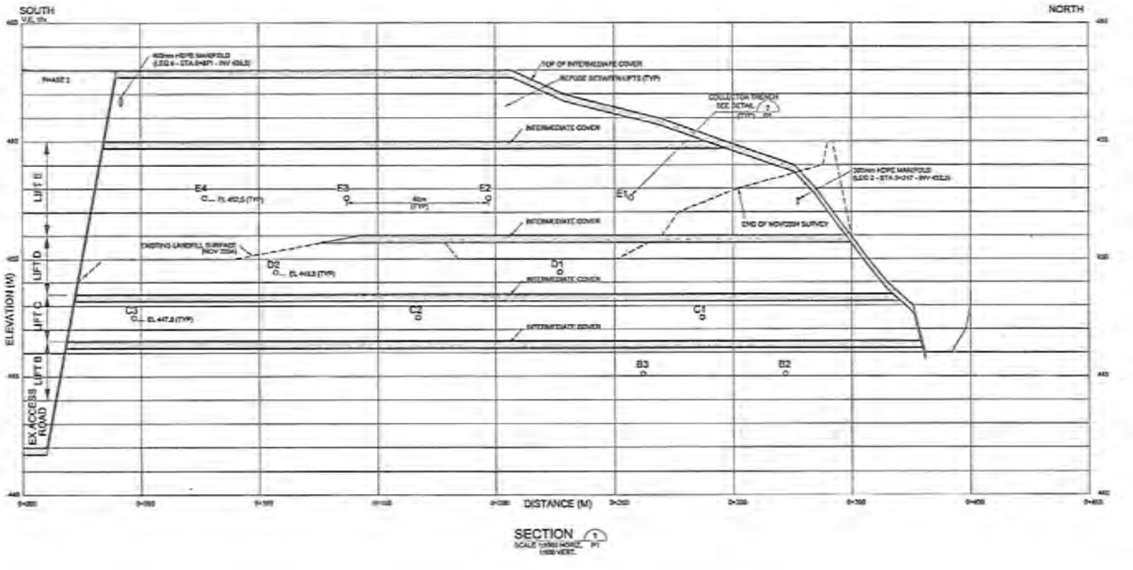
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
HEADER - PLAN & PROFILE

SHEET 4 OF 11
DWG P2
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.



SECTION ①
SCALE 1:2000 HORIZ. P1
1:200 VERT.

1	05-07-08	ISSUE FOR CONSTRUCTION	RLJ	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RLJ	KEW	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

C. J. SMITH
July 8, 2005

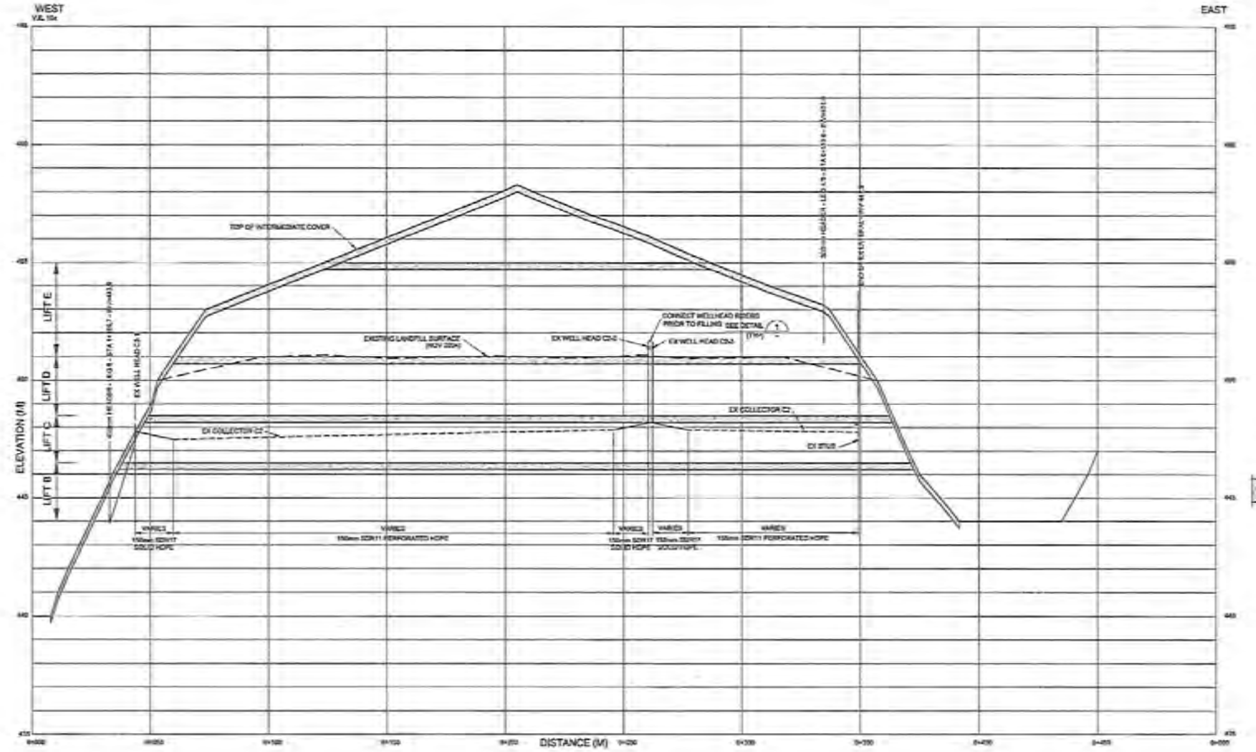
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

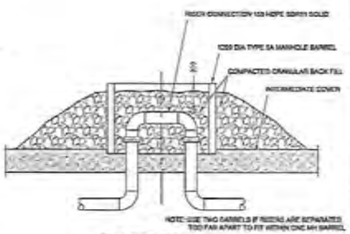
LFG WELLFIELD AND PIPING
PHASE 1
SECTION - SOUTH TO NORTH

SHEET	5 OF 11
DWG	P3
DATE	DEC 2004
PROJ	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.



SECTION C2
SCALE 1:1000 HORIZ. P1
1:100 VERT.



NOTE: USE TWO BARRELS IF RISERS ARE SEPARATED TOO FAR APART TO FIT WITHIN ONE MH BARREL.

DUAL RISER TIE-IN DETAIL - BURIED 1
N.T.S.

C. J. SMITH
July 8, 2005

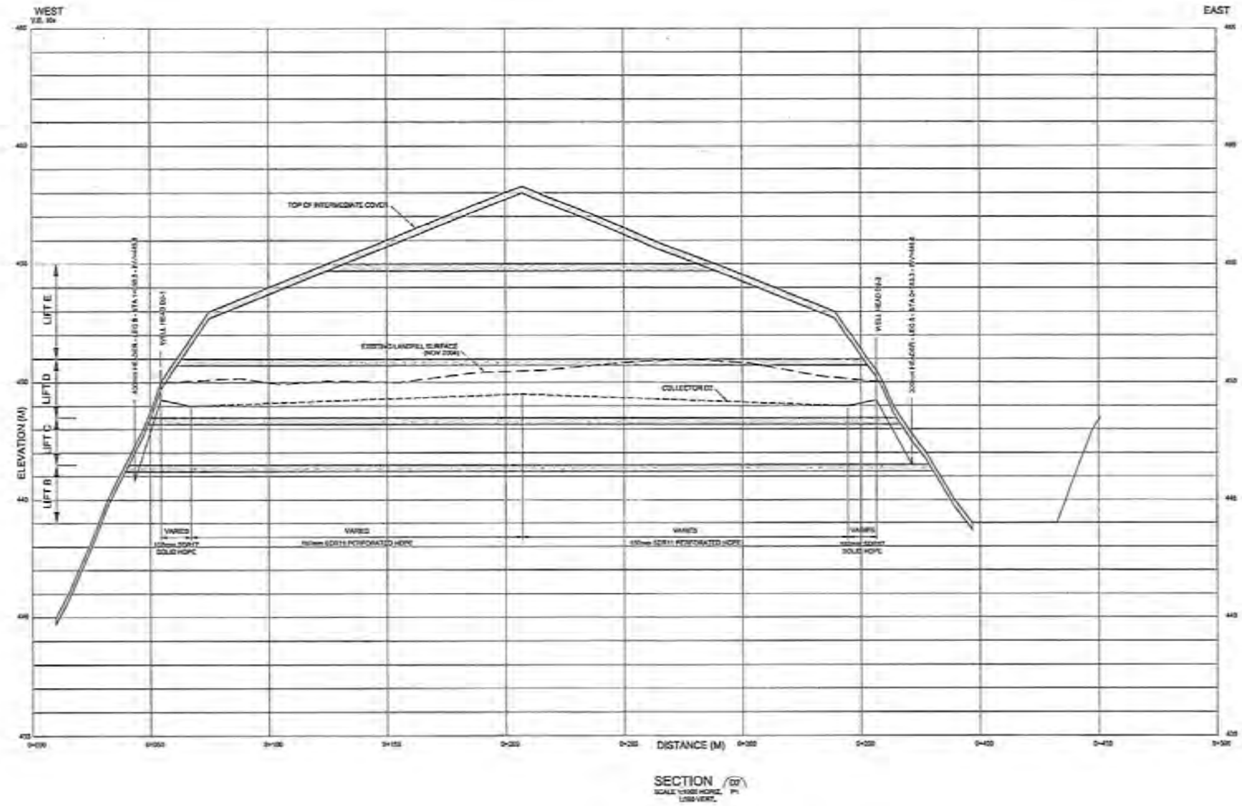
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-05	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
SECTION ALONG COLLECTOR C2 ALIGNMENT

SHEET 6 OF 11
DWG P4
DATE DEC 2004
PROJ 323443



SECTION D2/P5
SCALE 1:1000 HORIZ.
1:200 VERT.

C. J. SMITH
July 8, 2005

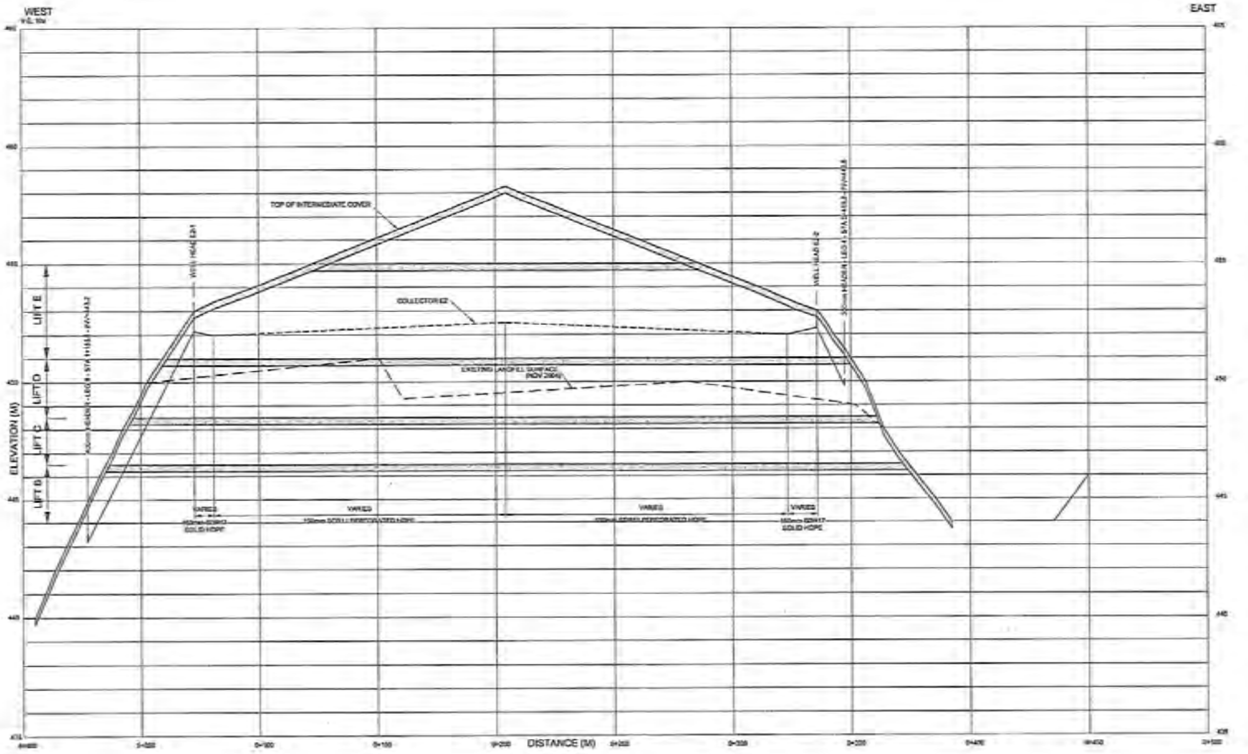
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
SECTION ALONG COLLECTOR D2 ALIGNMENT

SHEET 7 OF 11
DWG P5
DATE DEC 2004
PROJ 323443



SECTION E2
SCALE 1:1000 HORIZ.
1:500 VERT.

C.J. SMITH
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-02-23	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

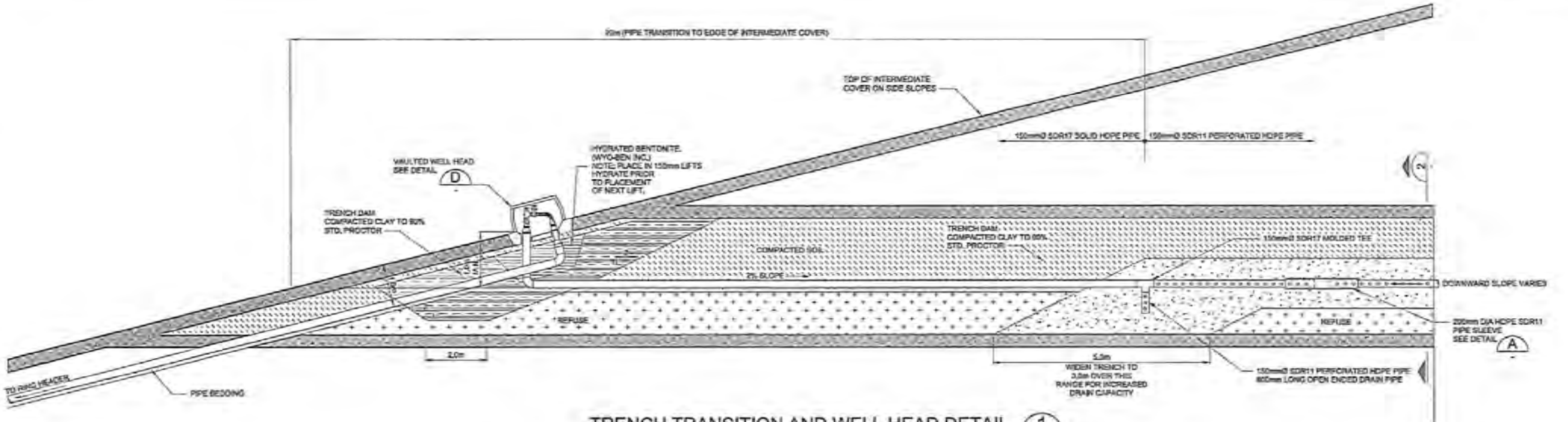
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
SECTION ALONG COLLECTOR E2 ALIGNMENT

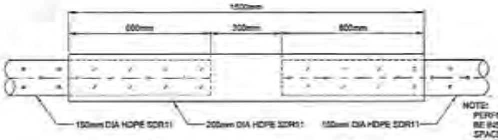
SHEET 8 OF 11
DWG P6
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.



TRENCH TRANSITION AND WELL HEAD DETAIL (1)

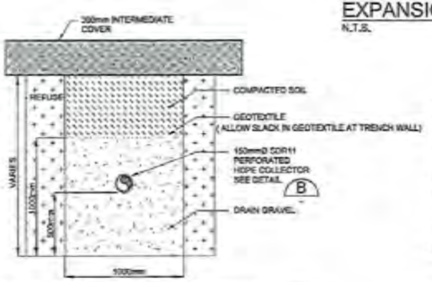
SCALE 1:50 P1



NOTE:
PERFORATED 150mm DIA. PIPE SHALL BE INSTALLED WITH A 300mm GAP OR SPACE WITH A 200mm DIA HDPE SLEEVE AT INTERVALS NOT EXCEEDING 20m FOR EXPANSION / CONTRACTION.

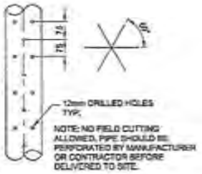
PERFORATED LFG COLLECTOR EXPANSION / CONTRACTION SLEEVE (A)

N.T.S.



LFG COLLECTOR TRENCH IN REFUSE (2)

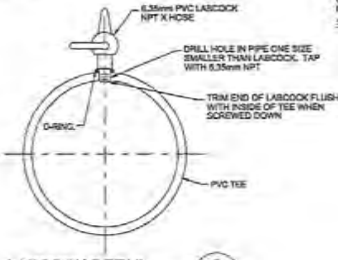
NTS P1,D1, P3



NOTE: NO FIELD CUTTING ALLOWED. PIPE SHOULD BE PERFORATED BY MANUFACTURER OR CONTRACTOR BEFORE DELIVERED TO SITE.

PERFORATION DETAIL (B)

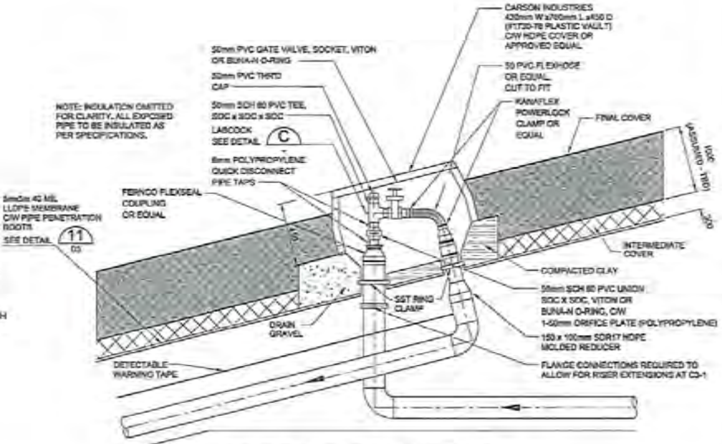
NTS



LABCOCK DETAIL (C)

NTS

NOTE: INSULATION OMITTED FOR CLARITY. ALL EXPOSED PIPE TO BE INSULATED AS PER SPECIFICATIONS.



VAULTED WELL HEAD DETAIL AT FINAL COVER (D)

N.T.S.

M.S. BUDZIK

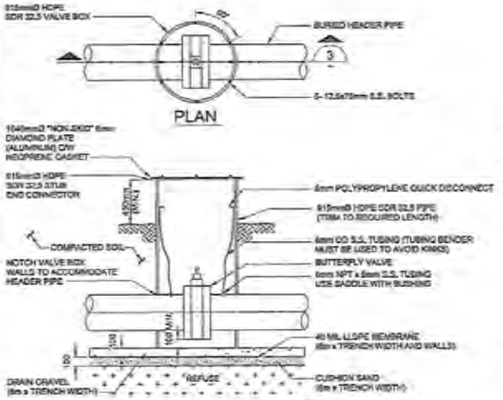
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
2	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
1	05-02-23	ISSUE FOR 90% REVIEW; DETAIL D MODIFIED	RJ	KEW	CS	MB
0	12/4/02	ISSUED FOR TENDER	MS	TL	CS	BCT
B	12/2/02	GENERAL REVISION - MOVE CLAY DAM	MS	TL	CS	BCT

CH2MHILL
"Responsible Solutions for a Sustainable Future"

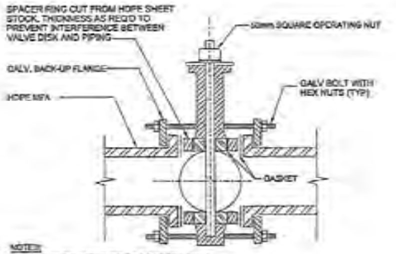
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
LANDFILL GAS DETAILS

SHEET 9 OF 11
DWG D1
DATE AUG. 2002
PROJ 121182

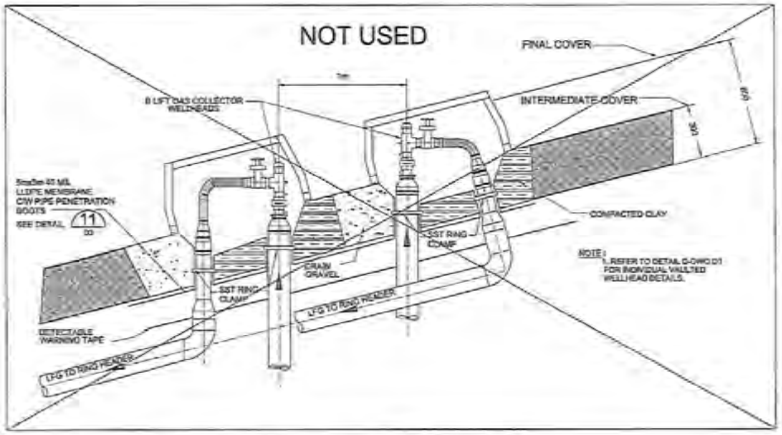


HEADER VALVE BOX (3)
NTS

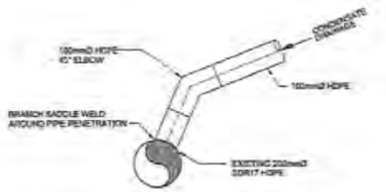


NOTES:
1. PROVIDE SPACER RINGS AS NECESSARY BETWEEN VALVE FACE AND MOLDED FLANGE ADAPTER SO THAT PIPE WALL DOES NOT INTERFERE WITH VALVE OPERATION.

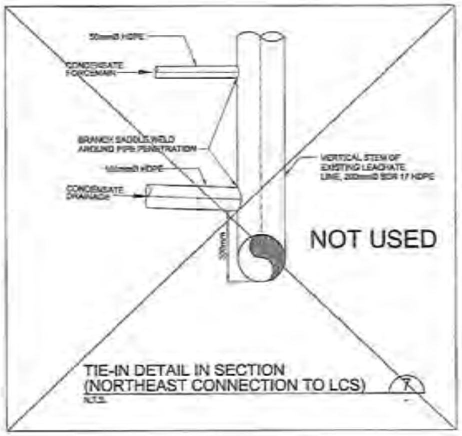
BUTTERFLY VALVE INSTALLATION (4)
NTS



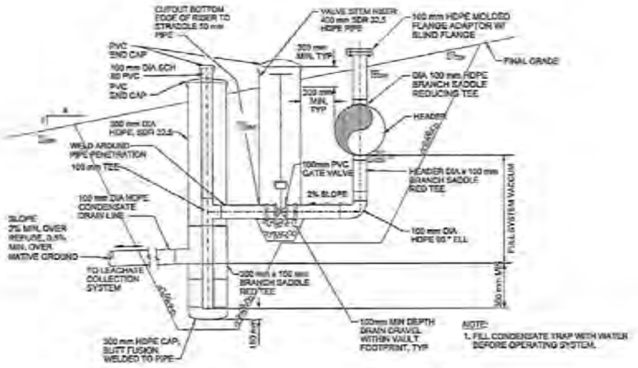
DUAL VAULTED WELL HEAD DETAIL (5)
SCALE N.T.S. P1



TIE-IN DETAIL IN SECTION (WEST CONNECTION TO LCS) (6)
N.T.S.



TIE-IN DETAIL IN SECTION (NORTHEAST CONNECTION TO LCS) (7)
N.T.S.



NOTE:
1. FILL CONDENSATE TRAP WITH WATER BEFORE OPERATING SYSTEM.

CONDENSATE TRAP TYPE A (8)
NTS P1

W.S.BUBZIK

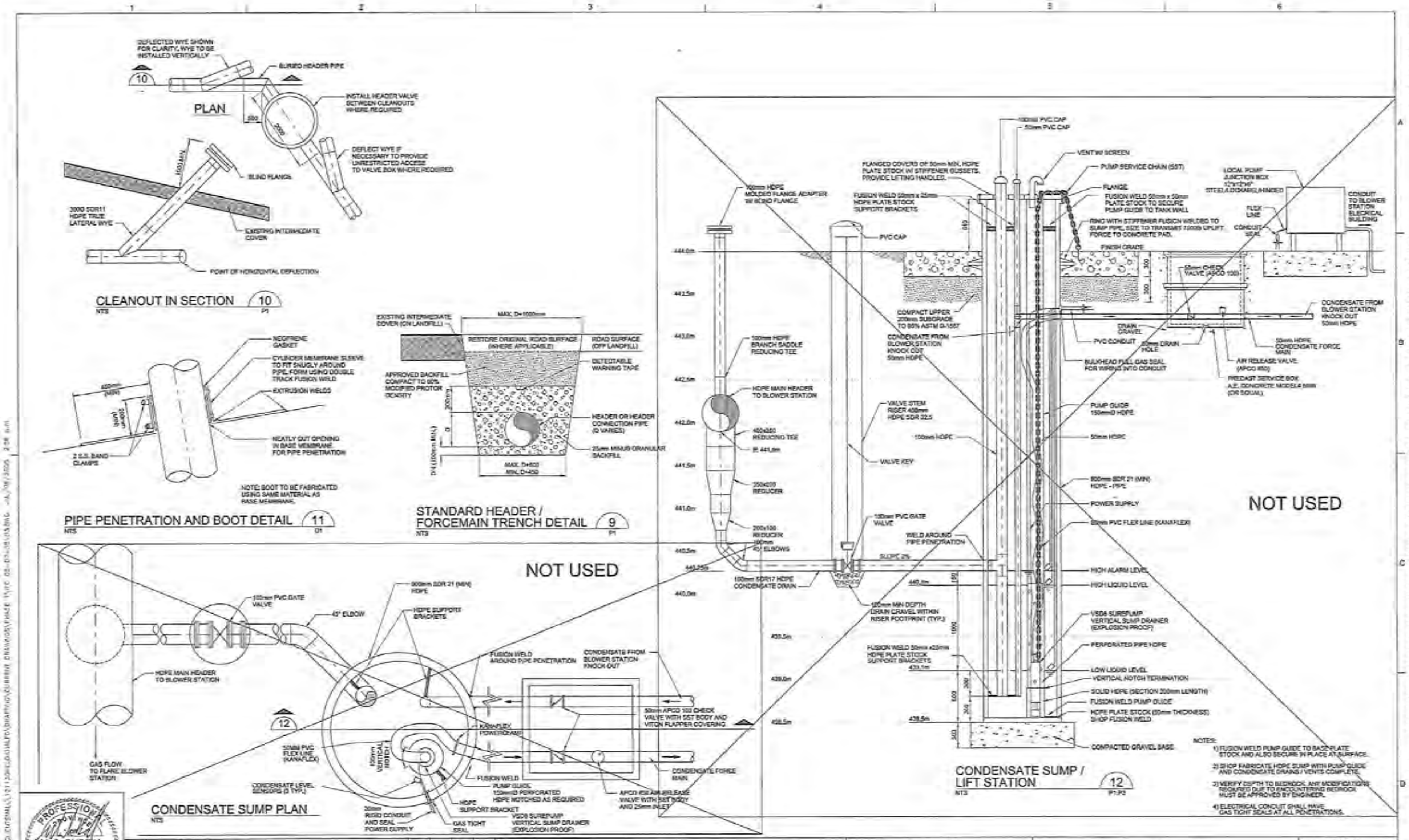
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
2	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
1	05-02-23	ISSUE FOR 90% REVIEW; DETAIL 7 SHOWN AS "NOT USED"	RJ	KEW	CS	MB
0	12/4/02	ISSUED FOR TENDER	MB	TL	CS	BCT
B	12/2/02	ADD DUAL VAULTED WELLHEAD DETAIL	MB	TL	CS	BCT

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
LANDFILL GAS DETAILS

SHEET 10 OF 11
DWG D2
DATE AUG. 2002
PROJ 121182



NOTES:

1) FUSION WELD PUMP GUIDE TO BASE PLATE STOCK AND ALSO SECURE IN PLACE AT SURFACE.
2) SHOP FABRICATE HDPE SUMP WITH PUMP GUIDE AND CONDENSATE DRAINS / VENTS COMPLETE.
3) VERIFY DEPTH TO BEDROCK. ANY MODIFICATIONS REQUIRED DUE TO ENCOUNTERING BEDROCK MUST BE APPROVED BY ENGINEER.
4) ELECTRICAL CONDUIT SHALL HAVE GAS TIGHT SEALS AT ALL PENETRATIONS.

PROFESSIONAL ENGINEER
M. S. BUDZIK
BRITISH COLUMBIA
TL 8/05

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
2	05-07-08	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
1	05-02-23	ISSUE FOR 99% REVIEW; DETAIL D MODIFIED	RLI	KEW	CS	MB
0	12/4/02	ISSUED FOR TENDER	MB	TL	CS	BCT
B	12/2/02	REVISED CONDENSATE SUMP LIFT STATION	MB	TL	CS	BCT

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

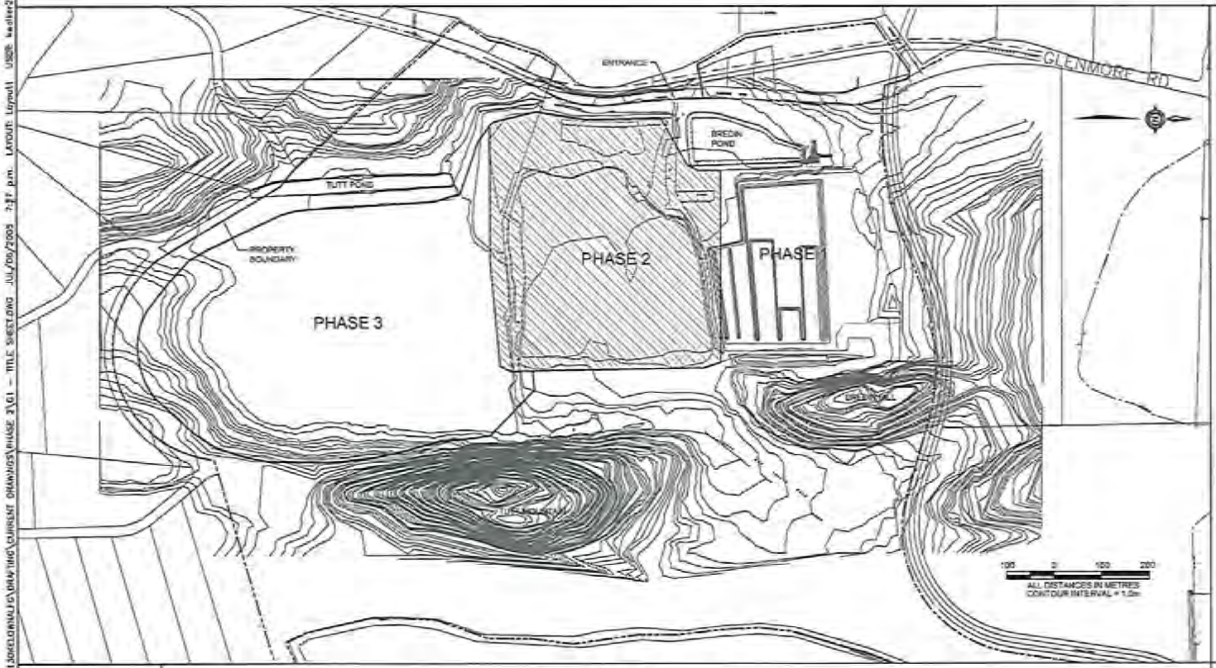
LFG WELLFIELD AND PIPING
PHASE 1
LANDFILL GAS DETAILS

SHEET 11 OF 11
DWG D3
DATE AUG, 2002
PROJ 121182

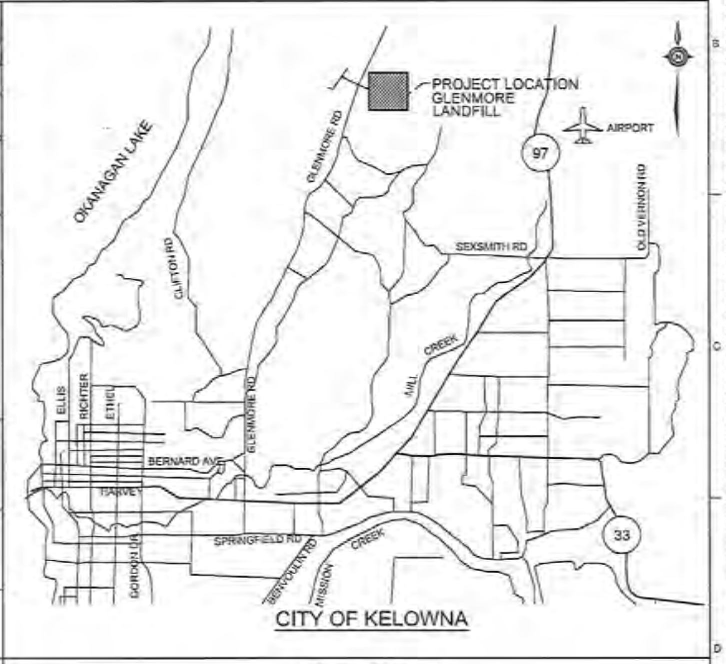
Appendix C
Phase 2 Detailed Design Drawings

CITY OF KELOWNA
GLENMORE LANDFILL

PHASE 2 LANDFILL GAS COLLECTION SYSTEM
JULY 2005



VICINITY MAP



PROJECT LOCATION

C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

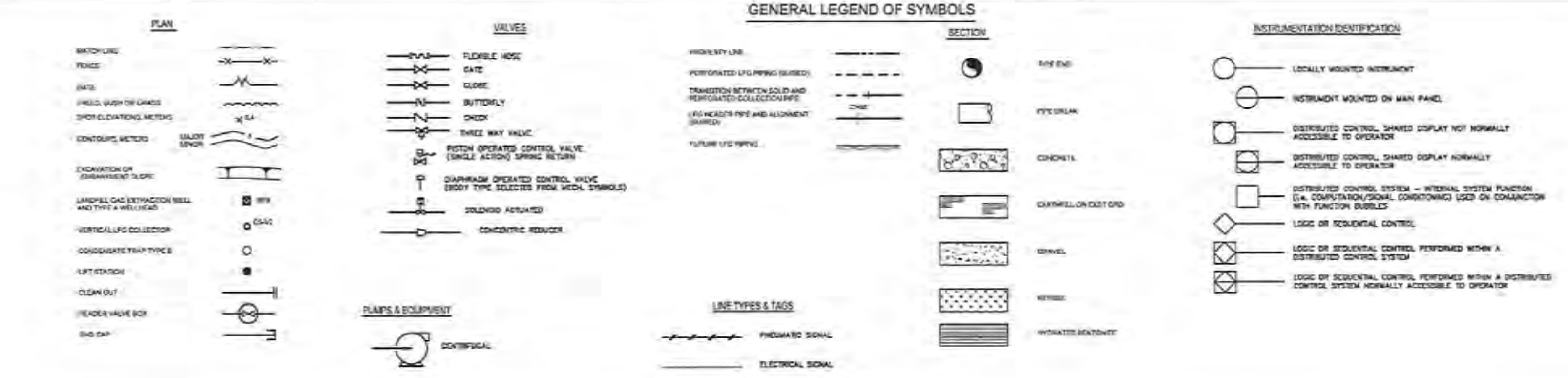
GENERAL
PHASE 2
VICINITY MAP AND KEY PLAN

SHEET	1 OF 22
DWG	G1
DATE	DEC 2004
PROJ.	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

O:\ATTILIATECLICNTS\ALL\121130KELOWNA\G\DRAFTING\CURRENT DRAWINGS\PHASE 2\G1 - TITLE SHEET.DWG JUL/06/2005 7:27 p.m. LAYOUT: Layout1 USER: kedler2

GENERAL LEGEND OF SYMBOLS



ABBREVIATIONS

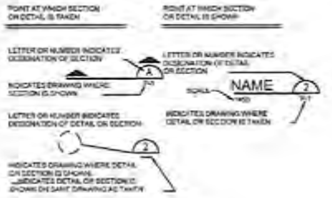
CTR, CNTR	CENTRE	%	PERCENT
C.S.	CARBON STEEL	PI	POINT OF INTERSECTION
DET	DETAIL	PL	PLATE
DIA.	DIAMETER	PVI	POINT OF VERTICAL
DWG.	DRAWING	REQ'D	REQUIRED
EG	EXISTING GROUND	SCH.	SCHEDULE
EL, ELEV	ELEVATION	SHT	SHEET
EX	EXISTING	SIM	SIMILAR
EXP	EXPANSION	SOC.	SOCKET
FG	FINISH GRADE	SPEC'S	SPECS
G.S.	GROUND SURFACE ELEV.	S.S.	STAINLESS STEEL
HDPE	HIGH DENSITY POLYETHYLENE	STA.	STATION
I.L.	INVERT ELEVATION	STL.	STEEL
LCS	LEACHATE COLLECTION SYSTEM	THR'D	THREADED
LFG	LANDFILL GAS	TYP	TYPICAL
MAX	MAXIMUM	W/	WITH
MFR	MANUFACTURER		
MH	MANHOLE		
MIN	MINIMUM		
[illegible]	[illegible]		
NTS	NOT TO SCALE		
MTL	MATERIAL		

GENERAL NOTES

1. UNLESS OTHERWISE NOTED, ALL COORDINATES AND ELEVATIONS ARE EXPRESSED IN METRES AND ALL DIMENSIONS ARE EXPRESSED IN MILLIMETRES.

2. DESIGN CONTOURS SHOWN ON DRAWINGS REPRESENT TOP OF INTERMEDIATE COVER.

SECTION AND DETAIL DESIGNATION



INDEX TO DRAWINGS

INCLUDED IN SET	DRAWING NO.	DRAWING TITLE
		GENERAL
●	G1	PHASE 2 - VICINITY MAP AND KEY PLAN
●	G2	PHASE 2 - SHEET INDEX, LEGEND, AND ABBREVIATIONS
		LANDFILL GAS WELLFIELD AND PIPING
●	P1	PHASE 2 - PLAN
●	P2	PHASE 2 - HEADER - PLAN & PROFILE
●	P3	PHASE 2 - PLAN - BLOWER/FLARE STATION TIE IN
●	P4	PHASE 2 - PROFILE - BLOWER/FLARE STATION TIE IN
●	P5	PHASE 2 - SECTION - SOUTH TO NORTH
●	P6	PHASE 2 - SECTION ALONG COLLECTOR C7 ALIGNMENT
●	P7	PHASE 2 - SECTION ALONG COLLECTOR C6 ALIGNMENT
●	P8	PHASE 2 - SECTION ALONG COLLECTOR [illegible] ALIGNMENT
●	D1	PHASE 2 - LANDFILL GAS DETAILS
●	D2	PHASE 2 - LANDFILL GAS DETAILS
●	D3	PHASE 2 - LANDFILL GAS DETAILS
		FLARE STATION
●	M1	PHASE 2 - BLOWER FLARE STATION PFD
●	M2	PHASE 2 - BLOWER FLARE STATION P&ID
●	F1	PHASE 2 - BLOWER FLARE STATION SITE PLAN
●	F2	PHASE 2 - BLOWER FLARE STATION PLAN
●	F3	PHASE 2 - BLOWER FLARE STATION SECTIONS
●	F4	PHASE 2 - BLOWER FLARE FUTURE PHASE 3 EXPANSION
	F5	PHASE 2 - BLOWER FLARE STATION SECTIONS & DETAILS
●	E1	PHASE 2 - BLOWER FLARE STATION ELECTRICAL - SINGLE LINE DIAGRAM & PANEL SCHEDULE
	E2	PHASE 2 - BLOWER FLARE STATION INSTRUMENTATION LAYOUT
●	E3	PHASE 2 - BLOWER FLARE STATION POWER, LIGHTING & GROUNDING LAYOUT
	E4	PHASE 2 - BLOWER FLARE STATION CABLE TRAY LAYOUT
●	E5	PHASE 2 - BLOWER FLARE STATION ELECTRICAL RACK LAYOUT
	S1	PHASE 2 - BLOWER SHED ELEV & SECTIONS

C. J. SMITH

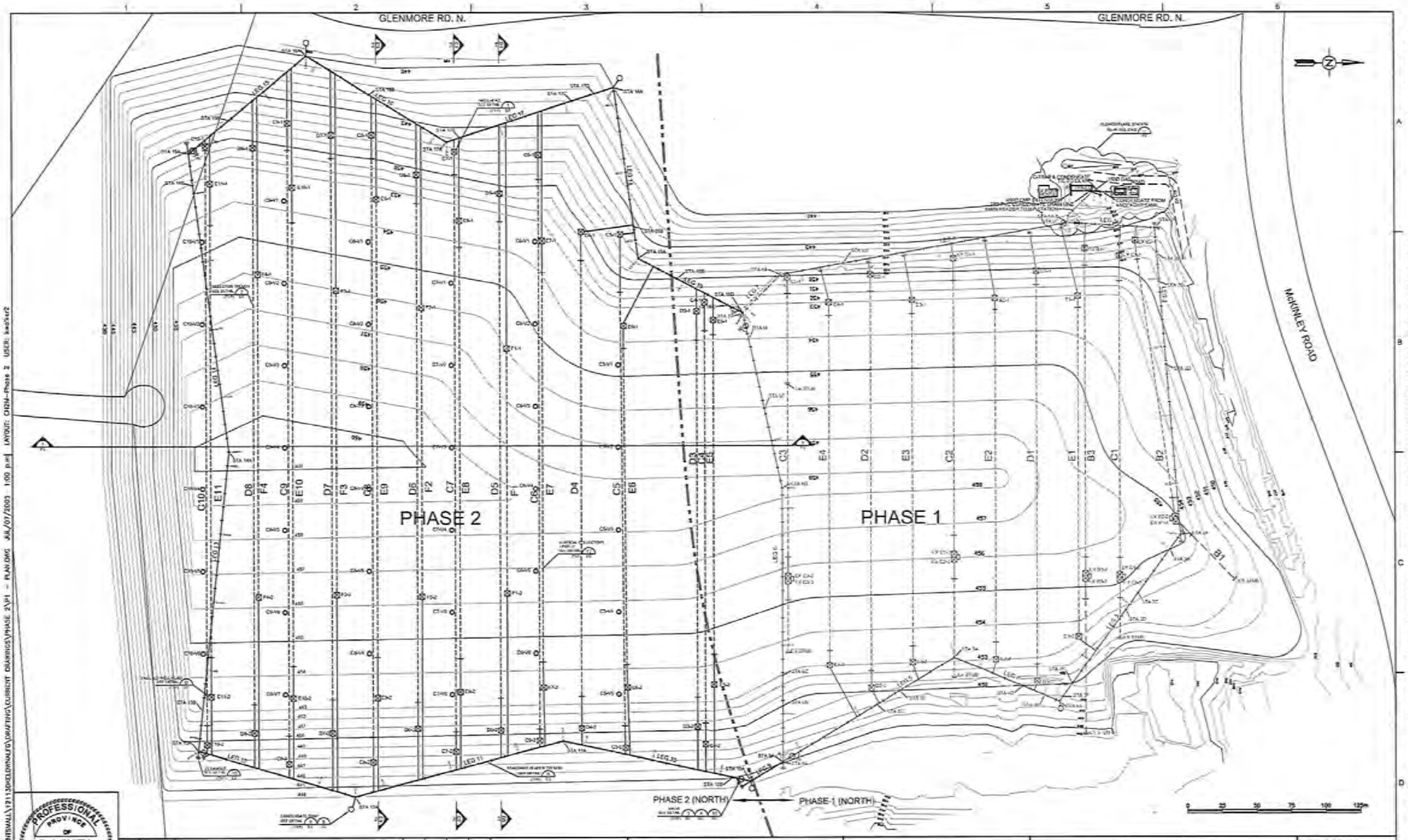
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RIJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RIJ	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

GENERAL
PHASE 2
SHEET INDEX, LEGEND, AND ABBREVIATIONS

SHEET 2 OF 22
DWG G2
DATE DEC 2004
PROJ 323443



1	05-07-06	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
PLAN

SHEET	3 OF 22
DWG	P1
DATE	DEC 2004
PROJ	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

G:\AFFILIATECLIENTSMALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P1 - PLAN.DWG JUL/07/2005 1:00 p.m. LAYOUT: CH2M–Phase 2 USER: kwalker2

C. J. SMITH
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 60% REVIEW	RJ	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

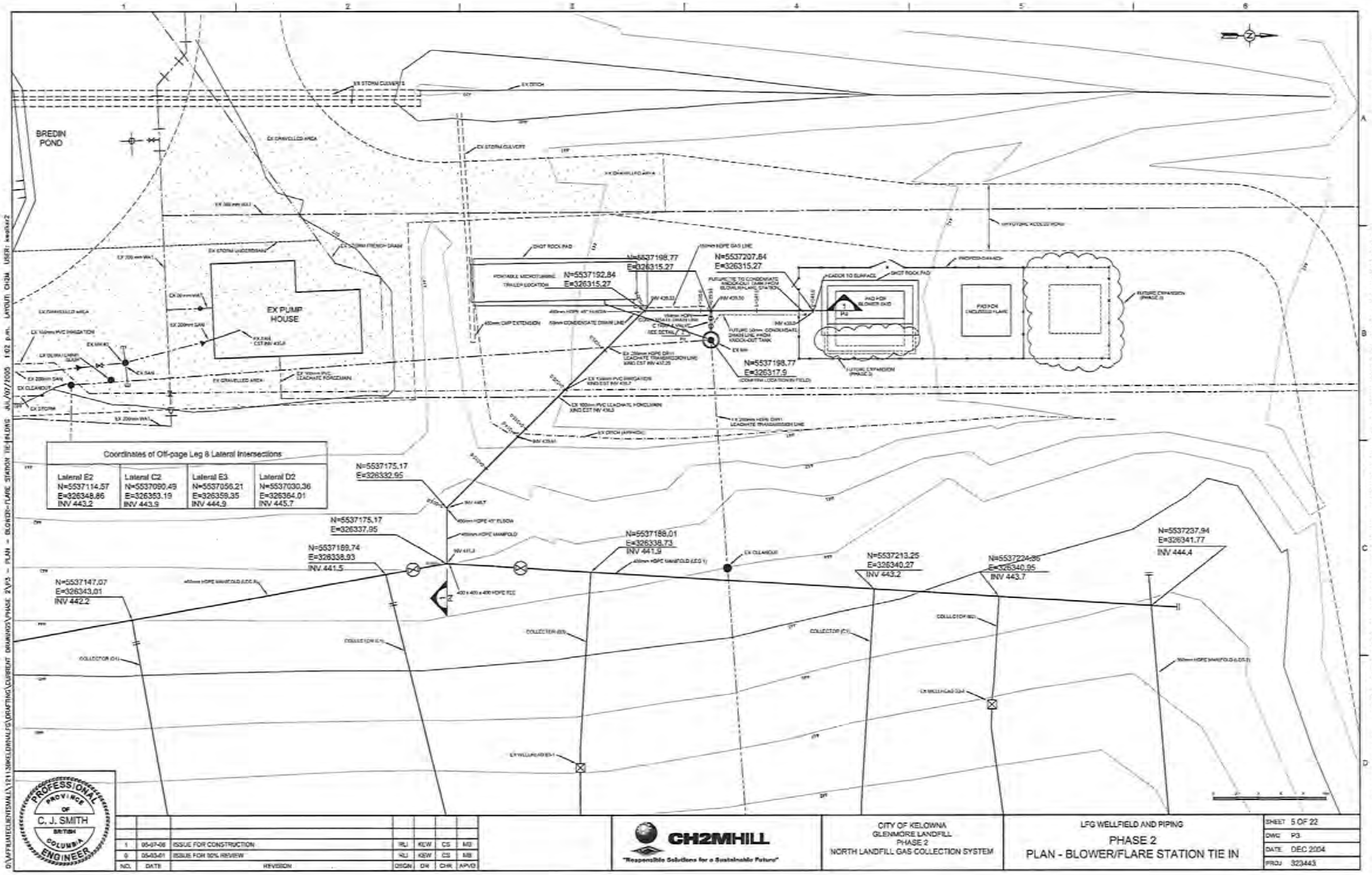
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
HEADER - PLAN & PROFILE

SHEET 4 OF 22
DWG P2
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

O:\AFFILIATCLIENTSMALL\121130KELOWNA\LFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P2 - HEADER - PLAN & PROFILE.DWG JUL/07/2005 1:01 p.m. LAYOUT: CH2M USER: kwalker2



Coordinates of Off-page Leg 8 Lateral Intersections

Lateral E2	Lateral C2	Lateral E3	Lateral D2
N=5537114.57	N=5537090.49	N=5537056.21	N=5537030.36
E=326348.86	E=326353.19	E=326359.35	E=326364.01
INV 443.2	INV 443.9	INV 444.9	INV 445.7

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

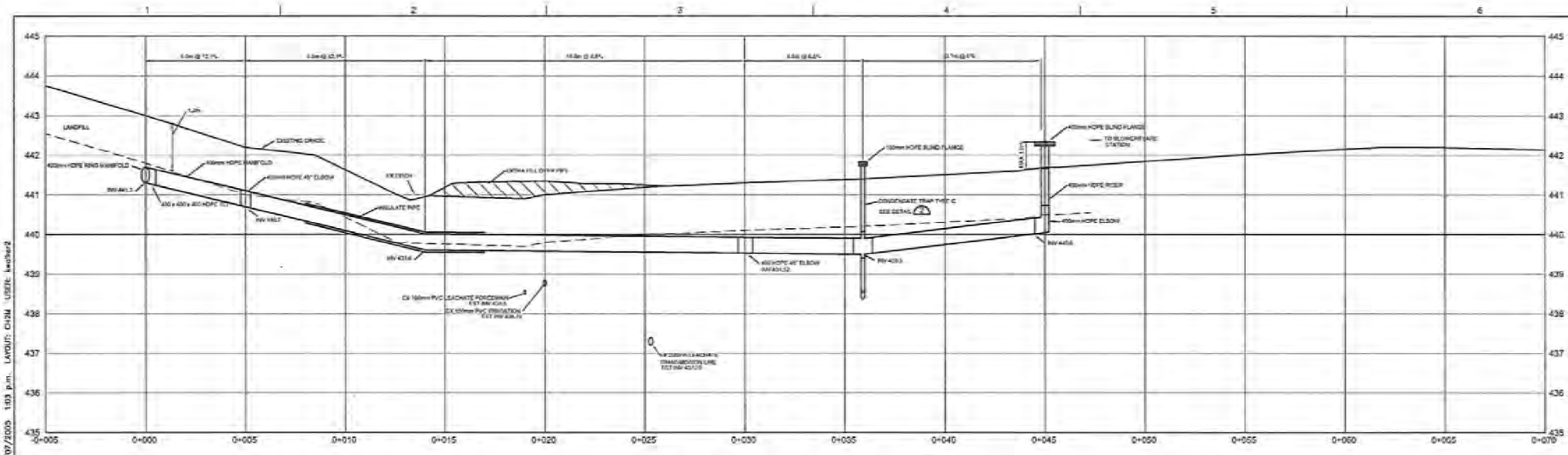
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
PLAN - BLOWER/FLARE STATION TIE IN

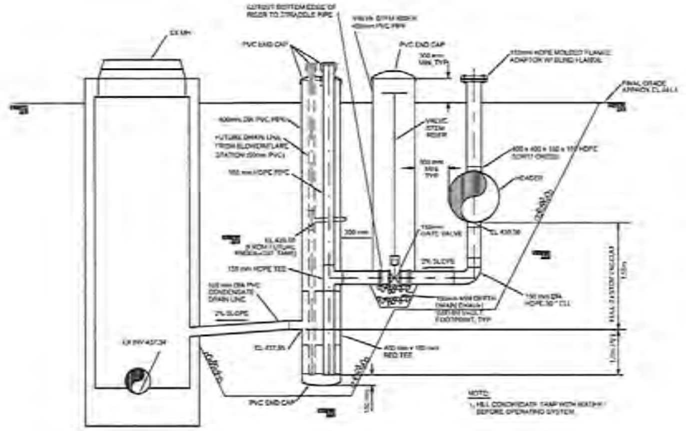
SHEET	5 OF 22
DWG	P3
DATE	DEC 2004
PROJ	323443



SECTION THROUGH 400mm HDPE MANIFOLD (1)

P3

SCALE: 1:100
VERT. 1:50



DETAIL - CONDENSATE TRAP TYPE C (2)

NTS

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-05	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

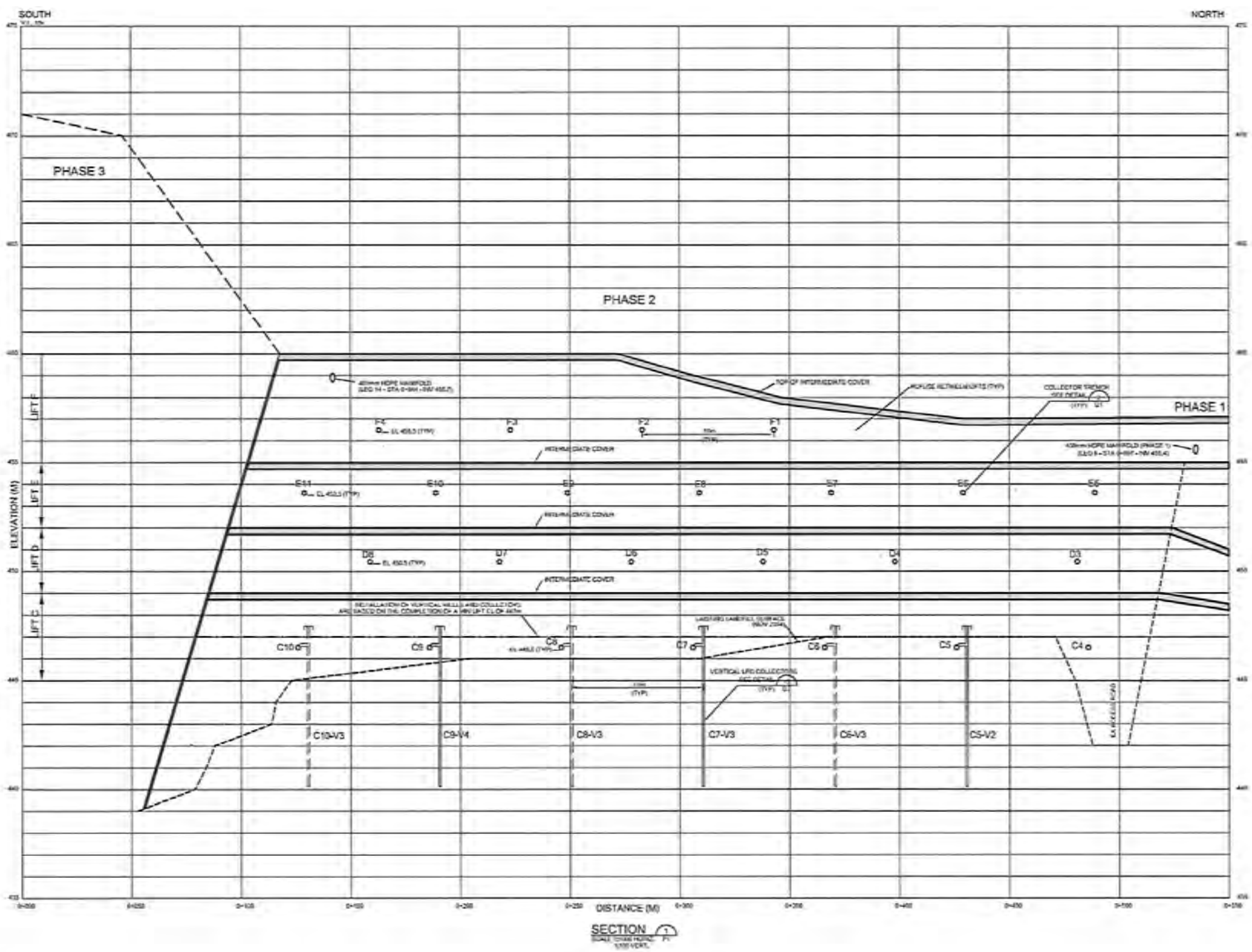
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
PROFILES - BLOWER/FLARE STATION TIE IN

SHEET	6 OF 22
DWG	P4
DATE	DEC 2004
PROJ	323443

O:\AFFILIATECLIENTSMALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P4 - PROFILES - BLOWER-FLARE STATION TIE-IN.DWG JUL/07/2005 1:03 p.m. LAYOUT: CH2M USER: kwalker2



SECTION 1

1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RU	KEW	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

C. J. SMITH

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

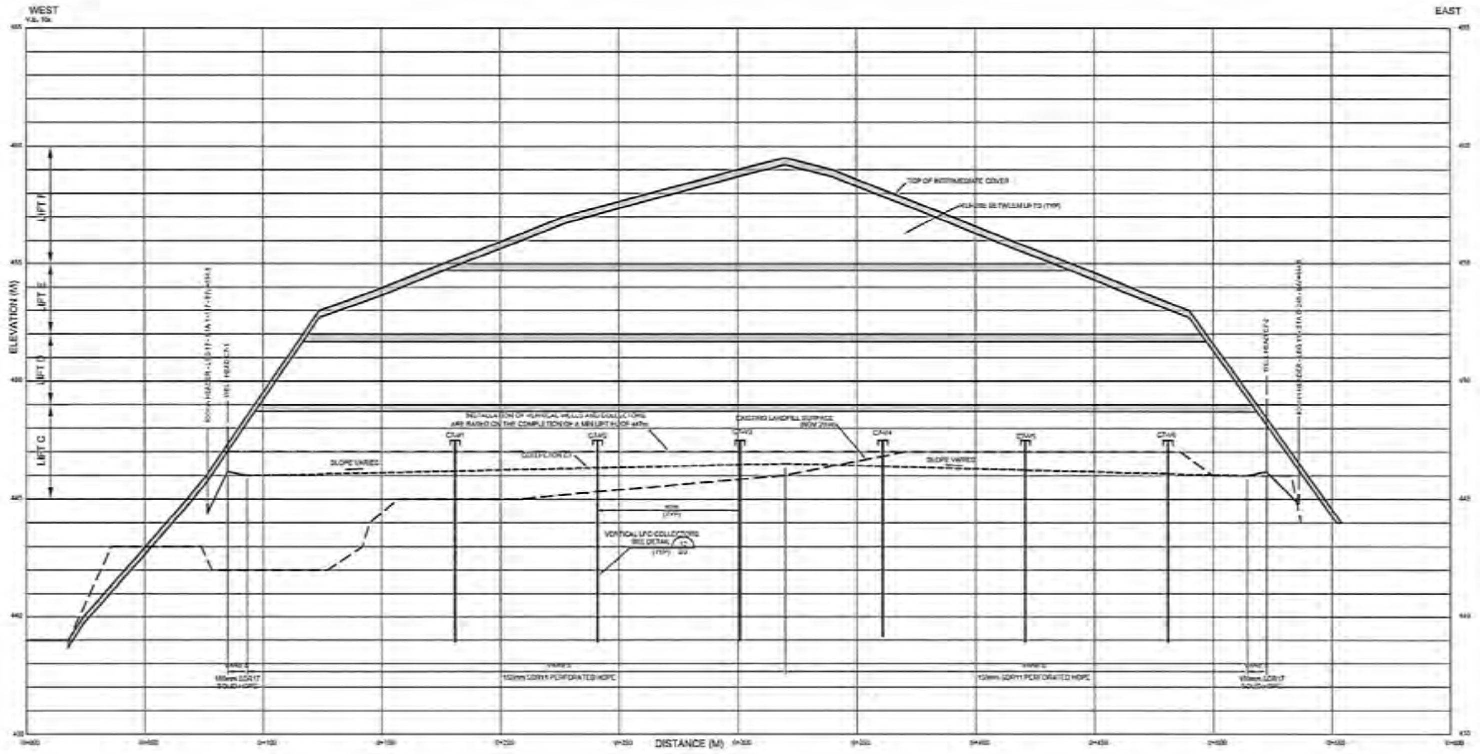
LFG WELLFIELD AND PIPING

PHASE 2
SECTION - SOUTH TO NORTH

SHEET	7 OF 22
DWG	P5
DATE	DEC 2004
PROJ	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

Q:\AFFILIATE\CLIENTS\WALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P5 - SECTION - SOUTH TO NORTH.DWG JUL/07/2005 1:03 p.m. LAYOUT: CH2M - Phase 2 South to North Section USER: kwalker2



SECTION C7

O:\AFFILIATECLIENTS\ALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P6 – SECTION ALONG COLLECTOR C7.DWG | JUL/07/2005 1:04 p.m. LAYOUT: CH2N – Section C7 USER: kwalker2

C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB

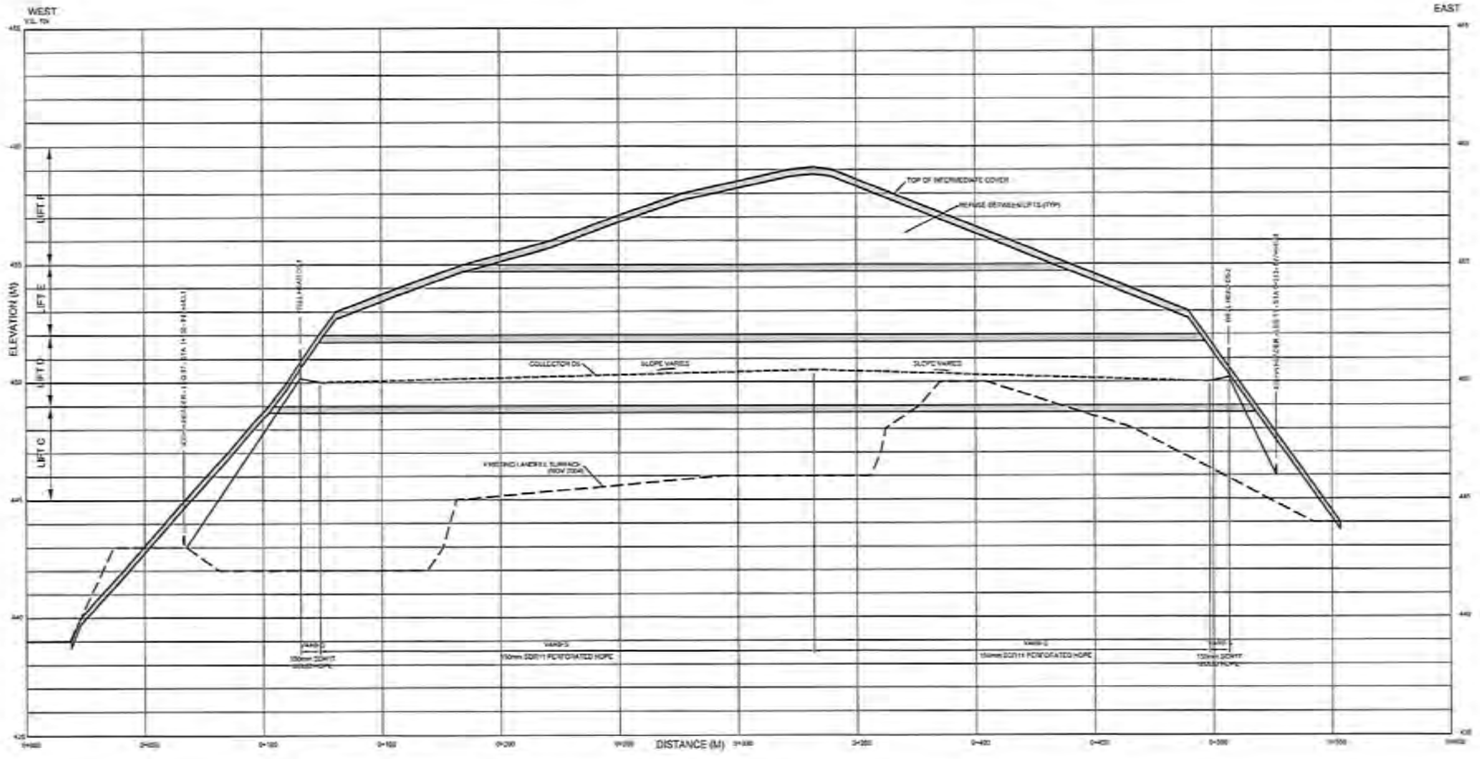
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
SECTION ALONG COLLECTOR C7 ALIGNMENT

SHEET	8 OF 22
DWG.	P6
DATE	DEC 2004
PROJ.	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.



SECTION (D5)

C. J. SMITH

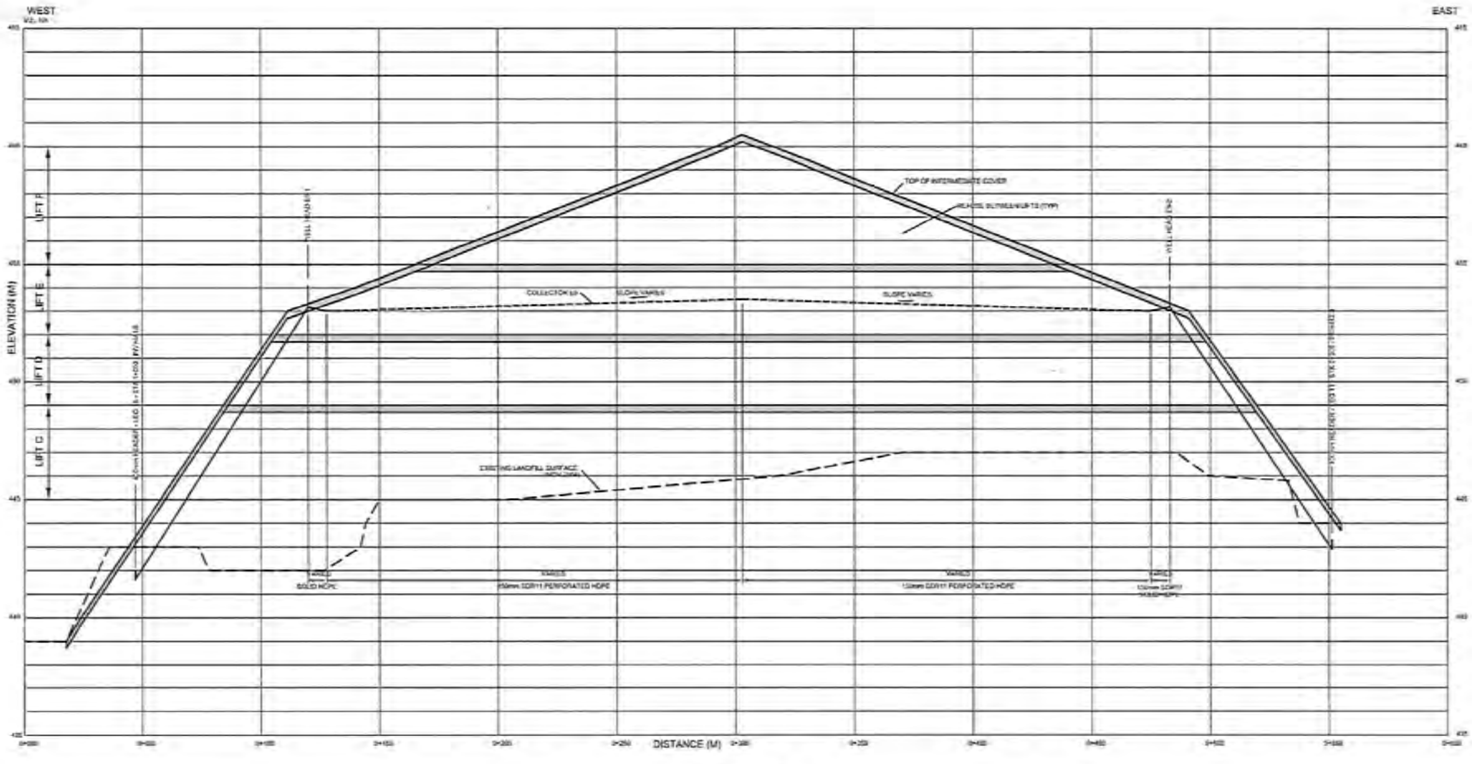
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
SECTION ALONG COLLECTOR D5 ALIGNMENT

SHEET 9 OF 22
DWG P7
DATE DEC 2004
PROJ 323443



SECTION (E9)

C. J. SMITH

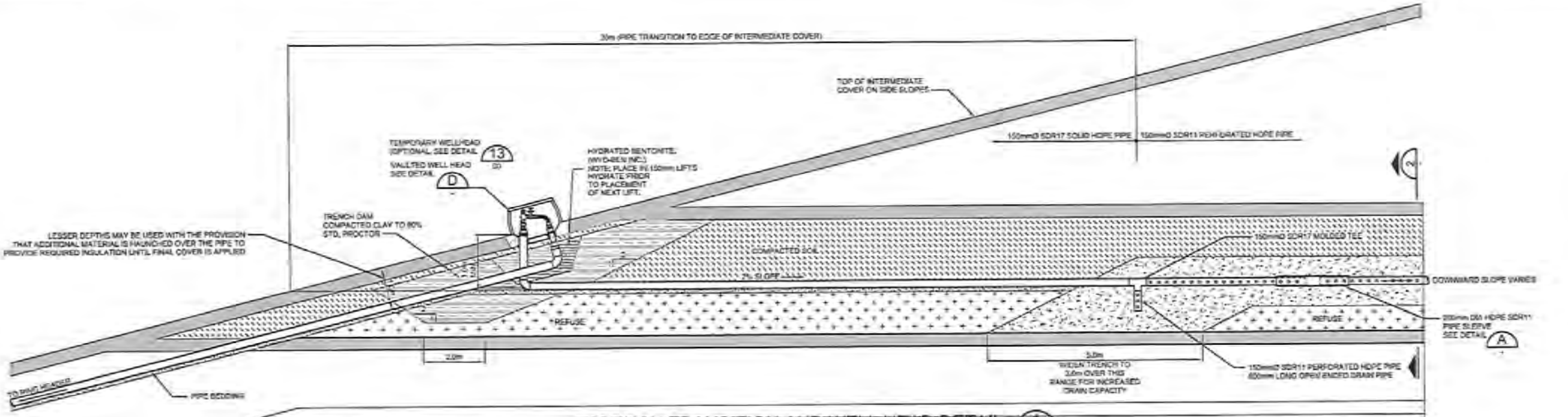
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 50% REVIEW	RJ	KEW	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

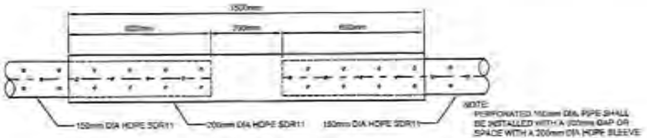
LFG WELLFIELD AND PIPING
PHASE 2
SECTION ALONG COLLECTOR E9 ALIGNMENT

SHEET 10 OF 22
DWG P8
DATE DEC 2004
PROJ 323443



TRENCH TRANSITION AND WELL HEAD DETAIL (1) P1

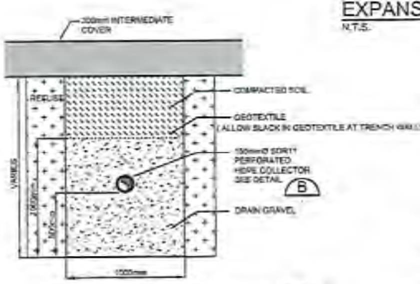
SCALE 1:50



NOTE:
PERFORATED 150mm DIA PIPE SHALL BE INSTALLED WITH A 200mm GAP OR SPACE WITH A 200mm DIA HDPE SLEEVE AT INTERVALS NOT EXCEEDING 20m FOR EXPANSION / CONTRACTION.

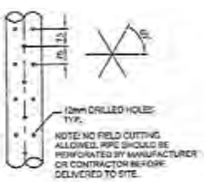
PERFORATED LFG COLLECTOR EXPANSION / CONTRACTION SLEEVE (A)

N.T.S.



LFG COLLECTOR TRENCH IN REFUSE (2) P1/2/1, P2

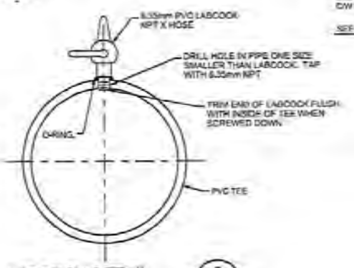
NTS



NOTE: NO FIELD CUTTING ALLOWED. PIPE SHOULD BE PERFORATED BY MANUFACTURER OR CONTRACTOR BEFORE DELIVERED TO SITE.

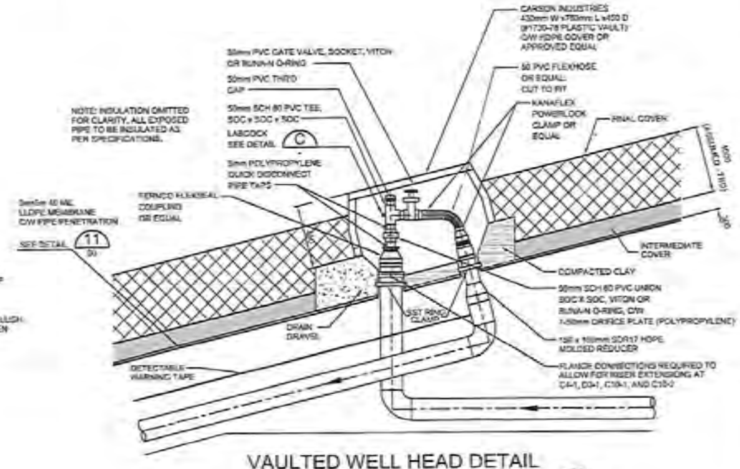
PERFORATION DETAIL (B)

NTS



LABCOCK DETAIL (C)

NTS



NOTE: INSULATION OMITTED FOR CLARITY. ALL EXPOSED PIPE TO BE INSULATED AS PER SPECIFICATIONS.

VAULTED WELL HEAD DETAIL AT FINAL COVER (D)

N.T.S.

C. J. SMITH

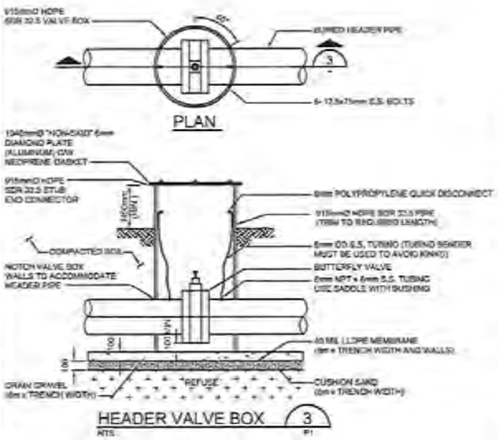
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

CH2MHILL
"Responsible Solutions for a Sustainable Future"

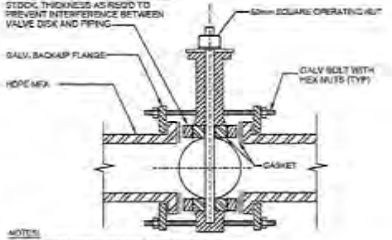
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
LANDFILL GAS DETAILS

SHEET 11 OF 22
DWG D1
DATE DEC 2004
PROJ 323443

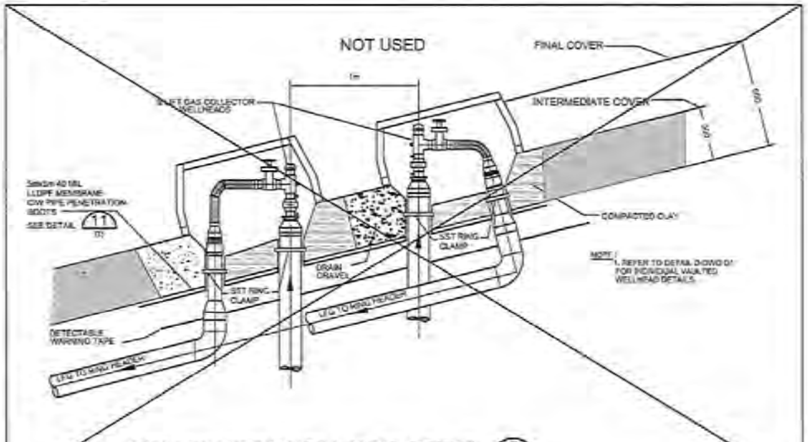


HEADER VALVE BOX (3)
NTS
P1



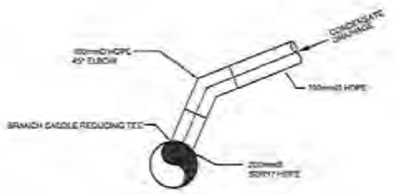
NOTES:
1. PROVIDE SPACER RINGS AS NECESSARY BETWEEN VALVE FACE AND MOLDED FLANGE ADAPTER SO THAT PIPE WALL DOES NOT INTERFERE WITH VALVE OPERATION.

BUTTERFLY VALVE INSTALLATION (4)
NTS
P1



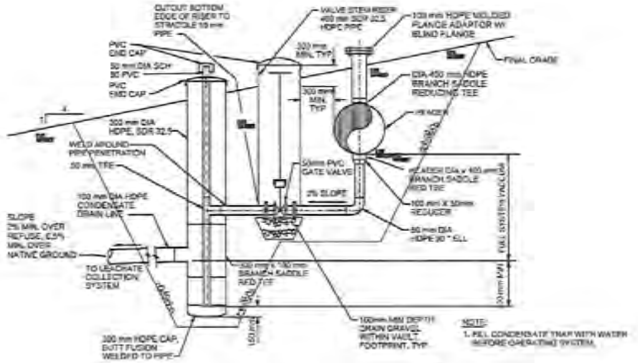
NOTE:
1. REFER TO DETAIL D-DWG D? FOR INDIVIDUAL VAULTED WELLHEAD DETAILS.

DUAL VAULTED WELL HEAD DETAIL (5)
SCALE N.T.S.
P1



NOTE:
1. DETAIL MAY CHANGE IN FUTURE DEPENDING ON FINAL DESIGN OF LEACHATE COLLECTION SYSTEM.

TIE-IN DETAIL IN SECTION
(WEST CONNECTION TO LCS) (6)
N.T.S.
P1



NOTE:
1. FILL CONDENSATE TRAP WITH WATER BEFORE OPERATING SYSTEM.

CONDENSATE TRAP TYPE A-1 (8)
NTS
P1

PROFESSIONAL ENGINEER
C. J. SMITH
PROVINCE OF BRITISH COLUMBIA

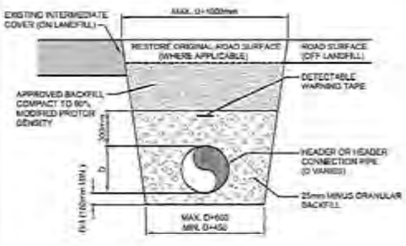
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
0	05-03-01	ISSUE FOR 99% REVIEW	RU	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

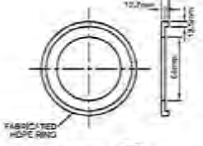
LFG WELLFIELD AND PIPING
PHASE 2
LANDFILL GAS DETAILS

SHEET 12 OF 22
DWG D2
DATE DEC 2004
PROJ 323443

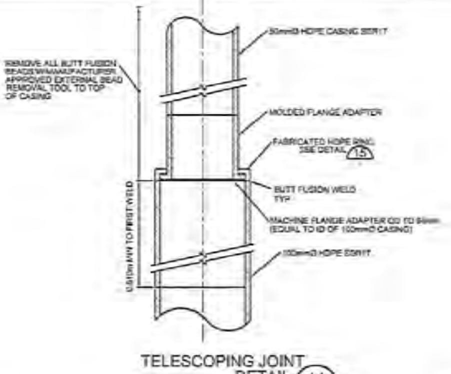


STANDARD HEADER DETAIL 9

NTS P1

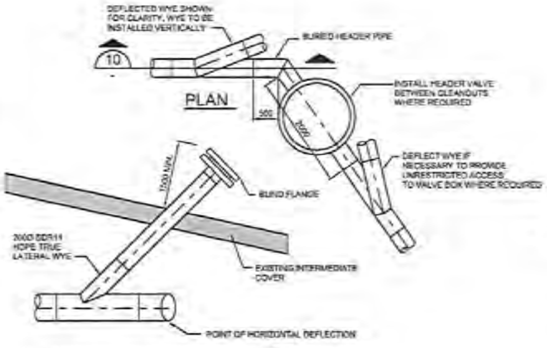


DETAIL 15



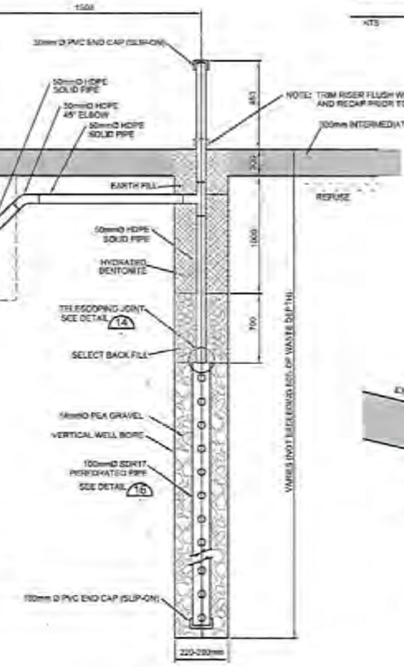
TELESCOPING JOINT DETAIL 14

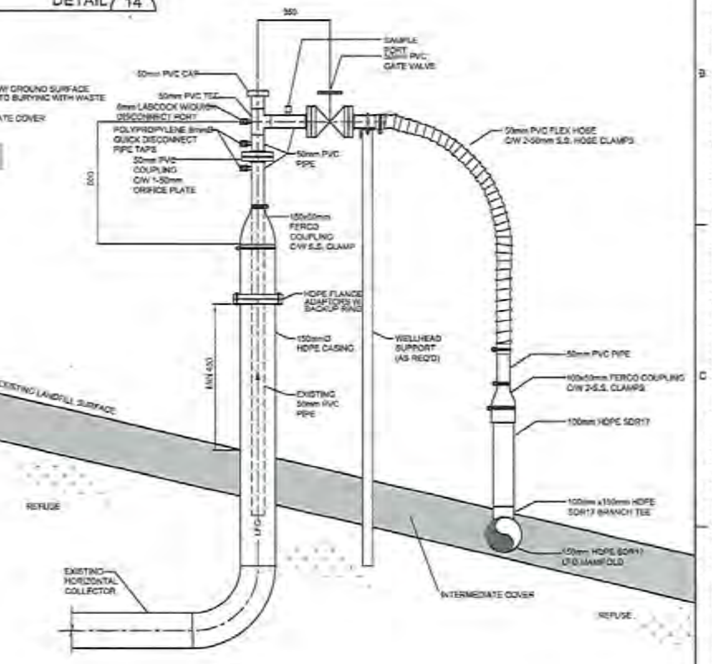
NTS

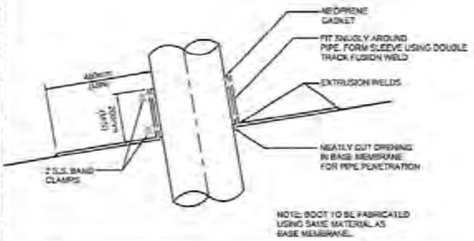


CLEANOUT IN SECTION 10

NTS P1



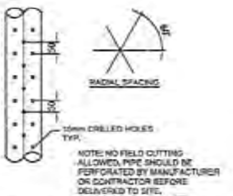




NOTE: BOOT TO BE FABRICATED USING SAME MATERIAL AS BASE MEMBRANE.

PIPE PENETRATION AND BOOT DETAIL 11

NTS D1



NOTE: NO FIELD CUTTING ALLOWED, PIPE SHOULD BE PERFORATED BY MANUFACTURER OR CONTRACTOR BEFORE DELIVERED TO SITE.

PERFORATION DETAIL 16

NTS

VERTICAL LFG COLLECTOR IN REFUSE AND TIE-IN 12

NTS P1

TEMPORARY ABOVE GRADE LFG TIE-IN DETAIL 13

NTS P-1

C. J. SMITH

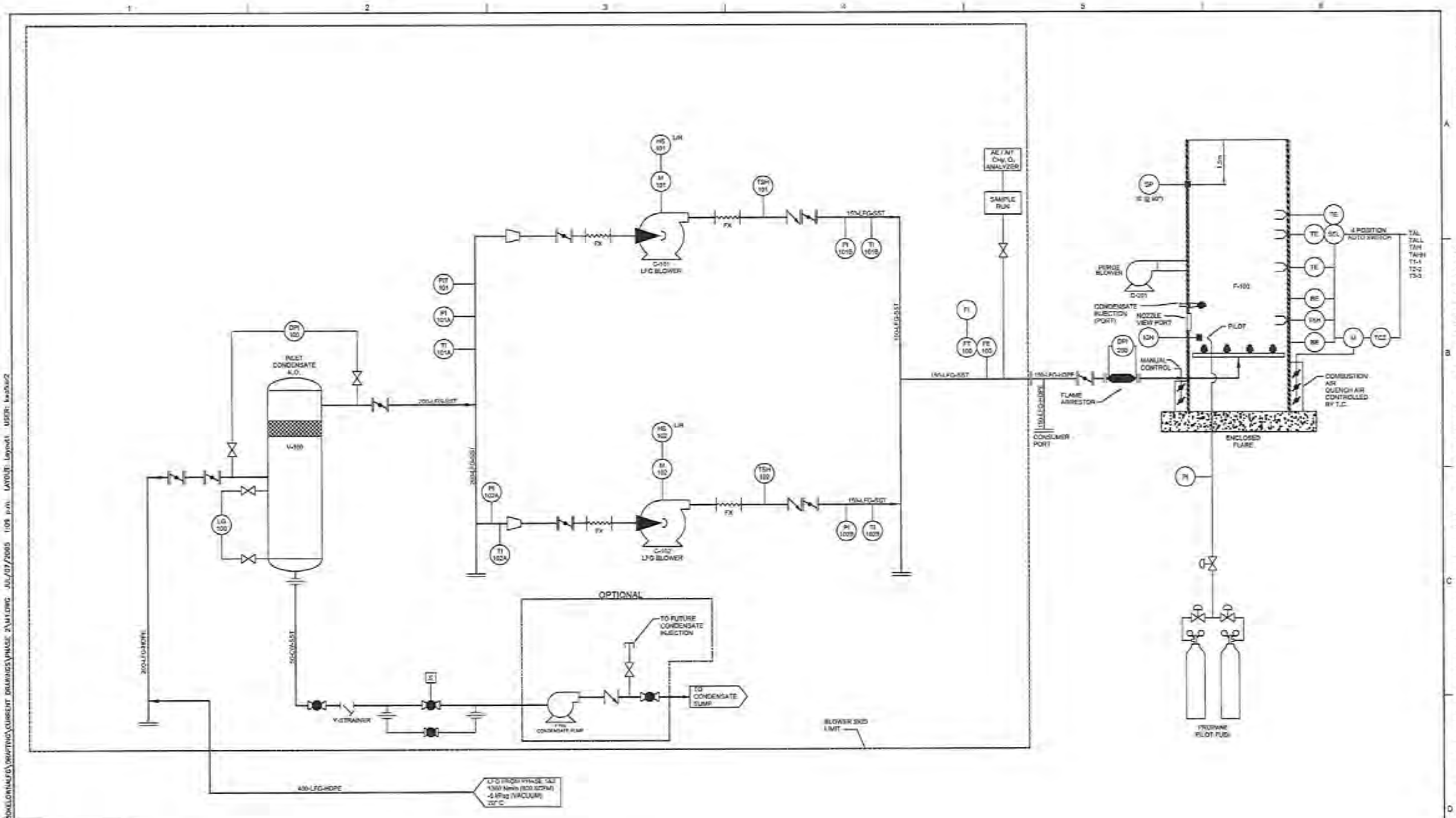
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
0	05-01-03	ISSUE FOR 90% REVIEW	RU	KEW	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
LANDFILL GAS DETAILS

SHEET	13 OF 22
DWG	D3
DATE	DEC 2004
PROJ	323443



C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJL	KEW	CS	MB
0	05-03-01	ISSUE FOR 60% REVIEW	NB	TL	CS	MB

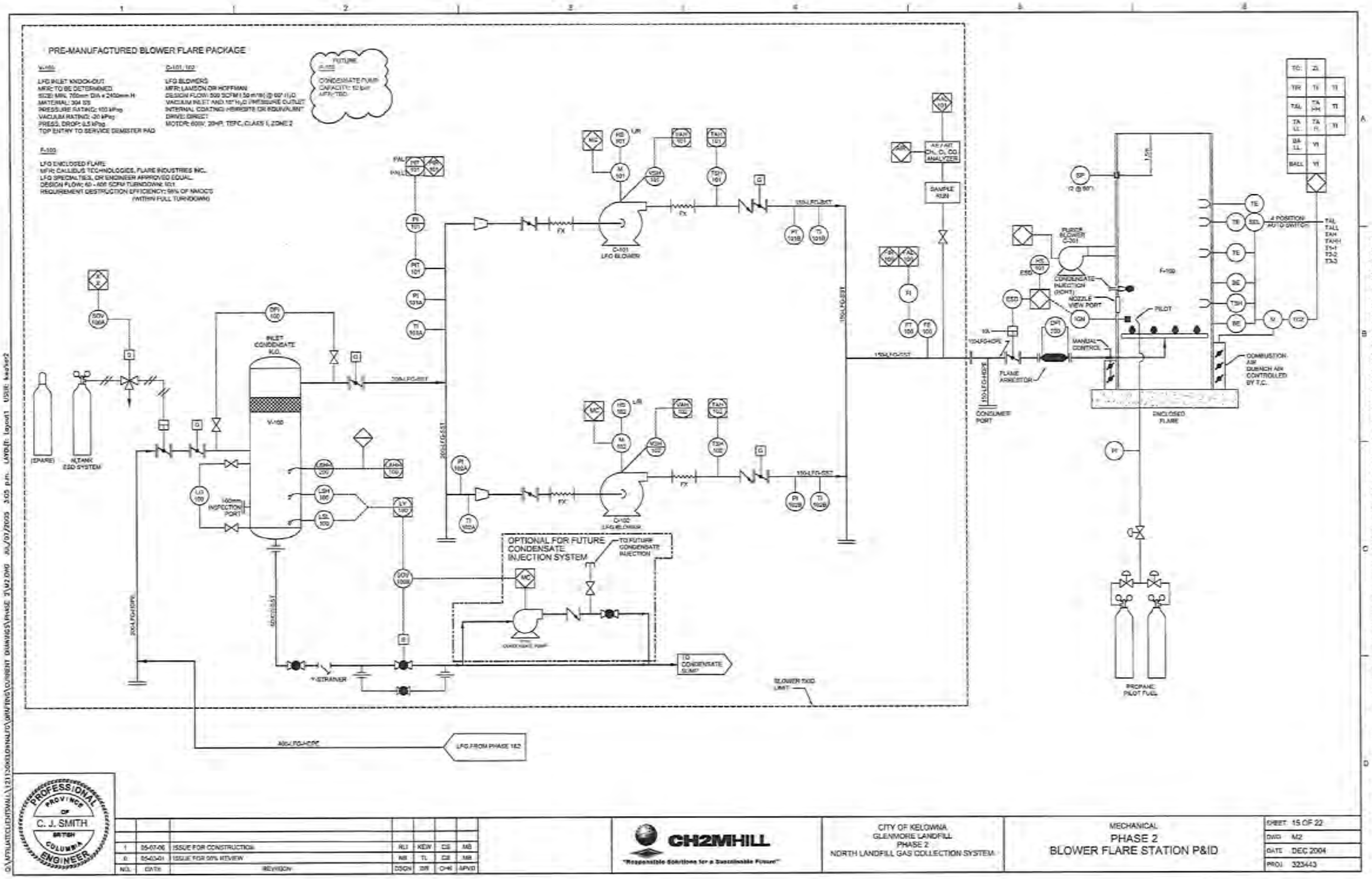
CH2MHILL

"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION PFD

SHEET 14 OF 22
DWG M1
DATE DEC 2004
PROJ 323443



NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 50% REVIEW	NB	TL	CS	MB

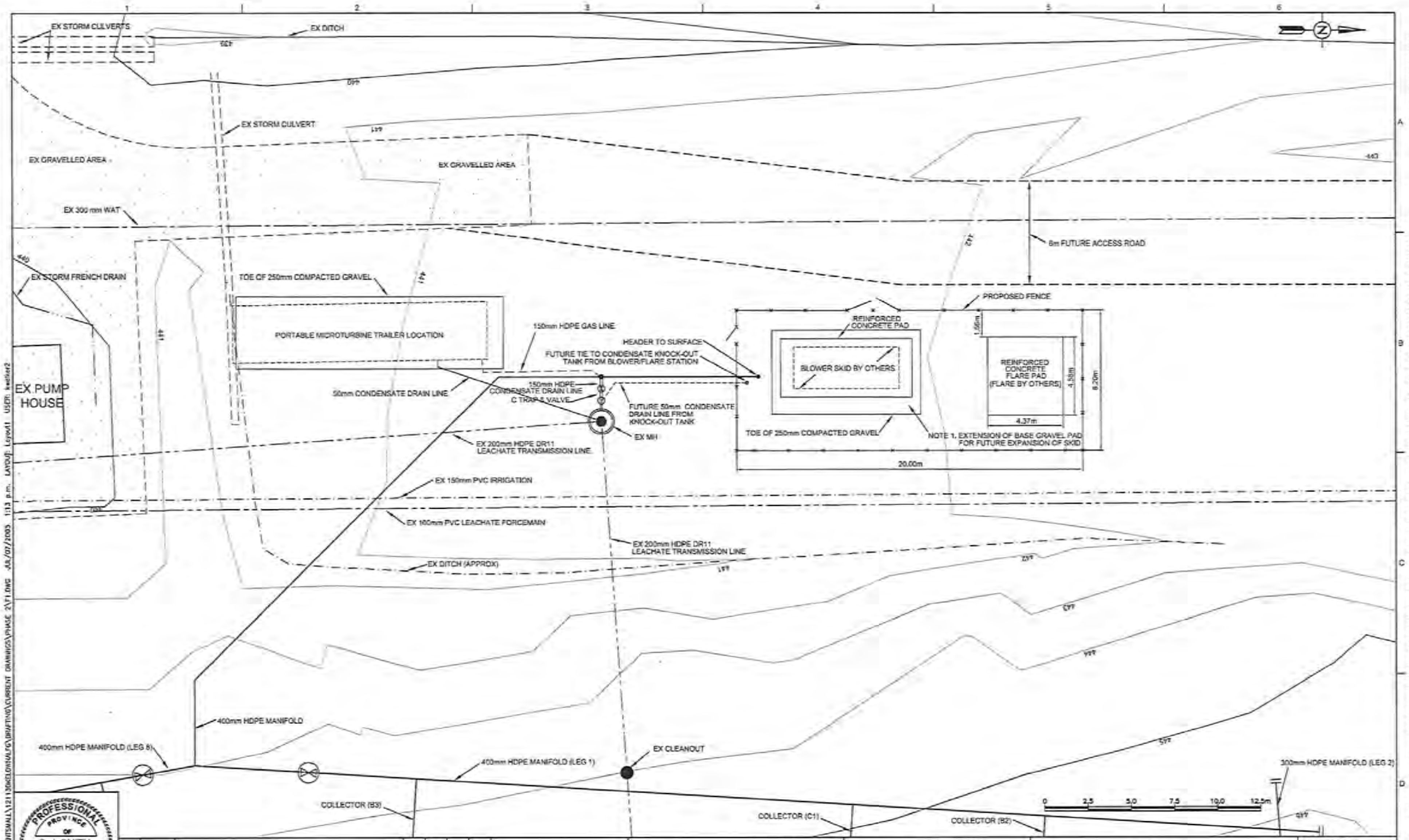
C. J. SMITH

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION P&ID

SHEET 15 OF 22
DWG M2
DATE DEC 2004
PROJ 323443



PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW		KEW		

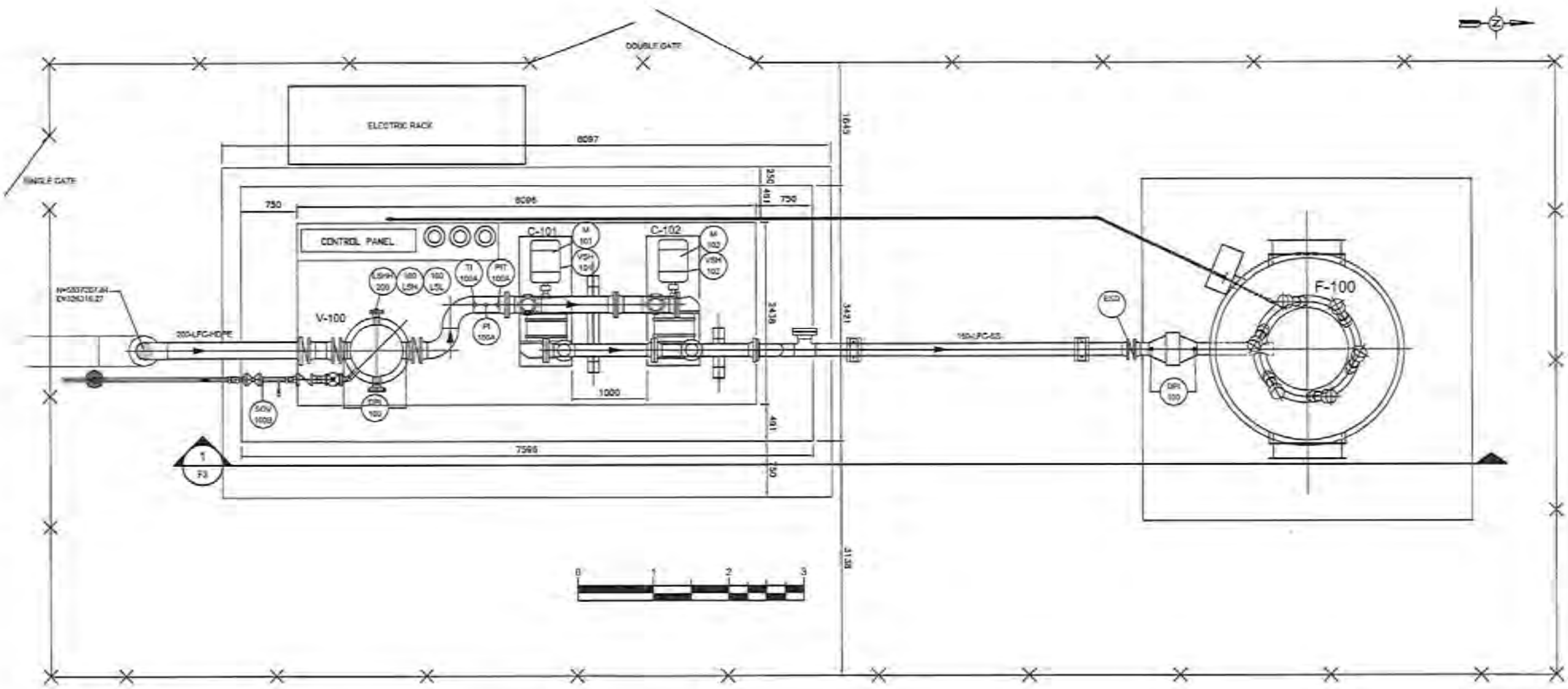
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION SITE PLAN

SHEET 16 OF 22
DWG F1
DATE FEB 2005
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED



PLAN

1:100

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-05	ISSUE FOR CONSTRUCTION	MU	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	MB	TL	CS	MB

C. J. SMITH

CH2MHILL

"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION PLAN

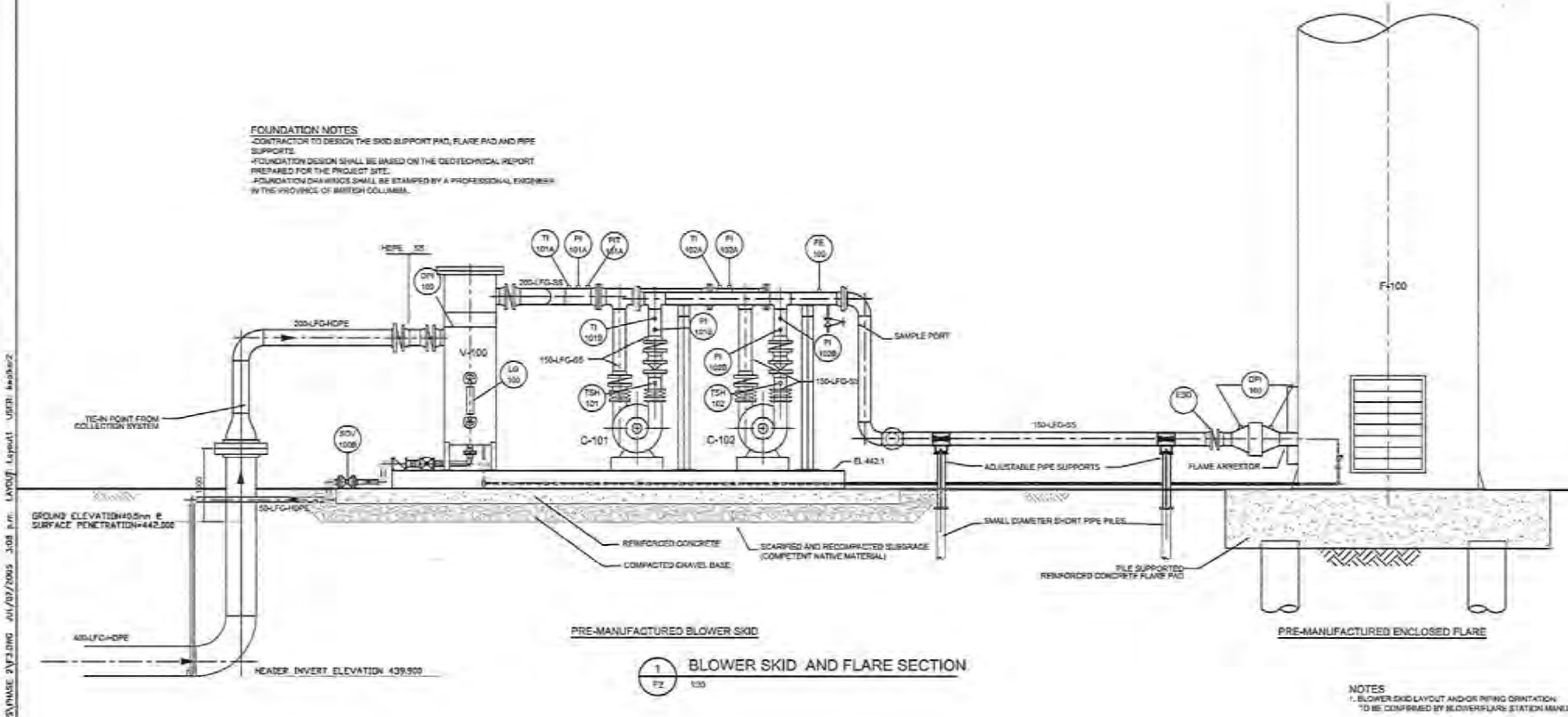
SHEET 17 OF 22
DWG F2
DATE DEC 2004
PROJ 329443

FOUNDATION NOTES

-CONTRACTOR TO DESIGN THE SKID SUPPORT PAD, FLARE PAD AND PIPE SUPPORTS.

-FOUNDATION DESIGN SHALL BE BASED ON THE GEOTECHNICAL REPORT PREPARED FOR THE PROJECT SITE.

-FOUNDATION DRAWINGS SHALL BE STAMPED BY A PROFESSIONAL ENGINEER IN THE PROVINCE OF BRITISH COLUMBIA.



BLOWER SKID AND FLARE SECTION

1
F2
1:30

NOTES

1. BLOWER SKID LAYOUT AND/OR PIPING ORIENTATION TO BE CONFIRMED BY BLOWER/FLARE STATION MANUFACTURER

PROFESSIONAL
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH
ENGINEER

1	05-07-06	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
0	05-03-01	ISSUE FOR 50% REVIEW	MB	TL	CS	MB
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

CH2MHILL
"Responsible Solutions for a Sustainable Future"

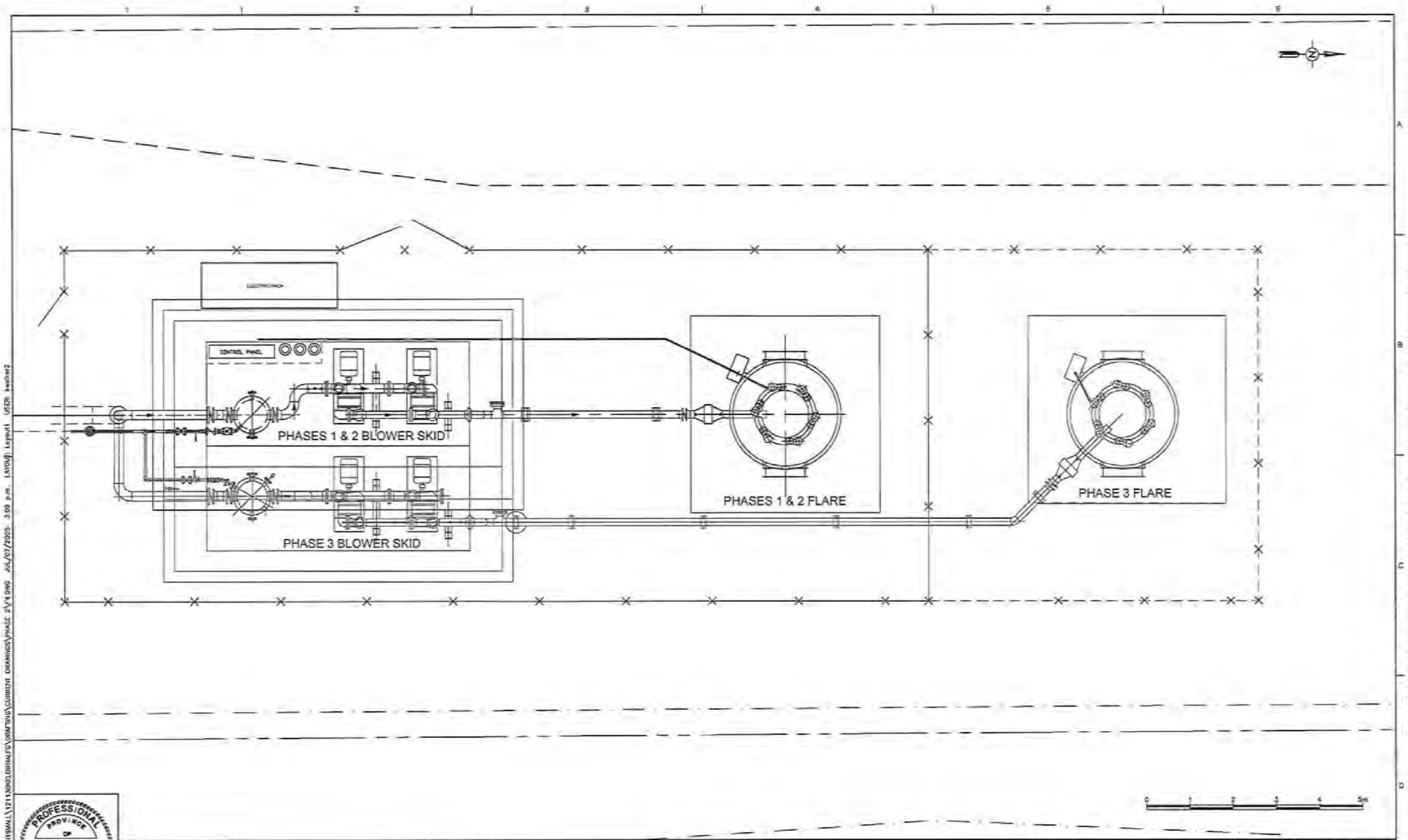
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION SECTION 1

SHEET	18 OF 22
DWG	F3
DATE	DEC 2004
PROJ	323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED

G:\AFFILIATED\CLIENTSMALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\F3.DWG JUL/07/2005 3:08 p.m. LAYOUT: Layout1 USER: kwalker2



C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	NB	TL	CS	NB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

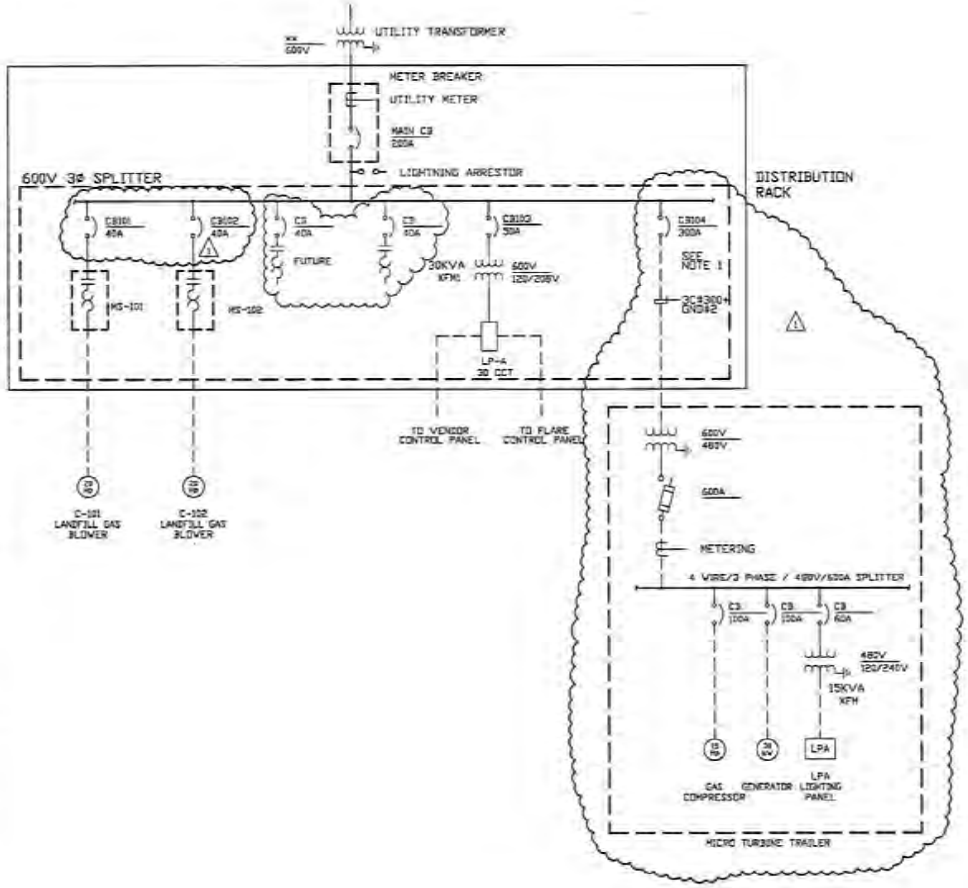
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION
FUTURE PHASE 3 EXPANSION

SHEET 19 OF 22
DWG F4
DATE DEC 2004
PROJ 323443

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL CANADA LIMITED AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL CANADA LIMITED.

[illegible]\DRAFTING\CURRENT DRAWINGS\PHASE 2\F4.DWG JUL/07/2005 3:09 p.m. LAYOUT: Layout1 USER: kwalker2



VOLTS 120/208
PHASE 3
WIRE 4
FEEDER ______

MAIN BUS 300 AMPS

PANEL "A"
30 CCT. DISTRIBUTION PANEL

LOCATION ELECTRICAL BUILDING
MFG. # ===

LOCATION	KILOWATTS			BRK	CCT NO.	A B C	CCT NO.	BRK	KILOWATTS			LOCATION
	ØA	ØB	ØC						ØA	ØB	ØC	
PLANT OUTDOOR LIGHTS			-	15	1		2	15	-			FLARE PANEL POWER
SPARE		-		15	3		4	15		-		CONTROL PANEL POWER
* PROPANE LINE HEAT TRACE	-			20	5		6	15			-	PURGE BLOWER
* LFG INLET PIPE HEAT TRACE			-	20	7		8	15	-			OUTDOOR RECEPTACLE ON RACK *
* LFG OUTLET PIPE HEAT TRACE		-		20	9		10	-		-		OUTDOOR RECEPTACLE ON SKID *
SPARE	-			15	11		12	-			-	SPACE
SPARE			-	15	13		14	-	-			
SPACE		-		-	15		16	-		-		
	-			-	17		18	-			-	
			-	-	19		20	-	-			
		-		-	21		22	-		-		
	-			-	23		24	-			-	
			-	-	25		26	-	-			
		-		-	27		28	-		-		
	-			-	29		30	-			-	
				TOTAL KW			TOTAL KW					

TOTAL WATTAGE = A ______ + B ______ + C ______ = ______ WATTS

* DENOTES GFI BREAKERS

NOTE 1 300A CB104 BASED ON ULTIMATE FUTURE UPPER POWER GENERATION LIMIT OF MICROTURBINE TRAILER.
(LASER CURRENT CAPACITY, 150A CB104 IS ADEQUATE).

L. D. LLEWELLYN

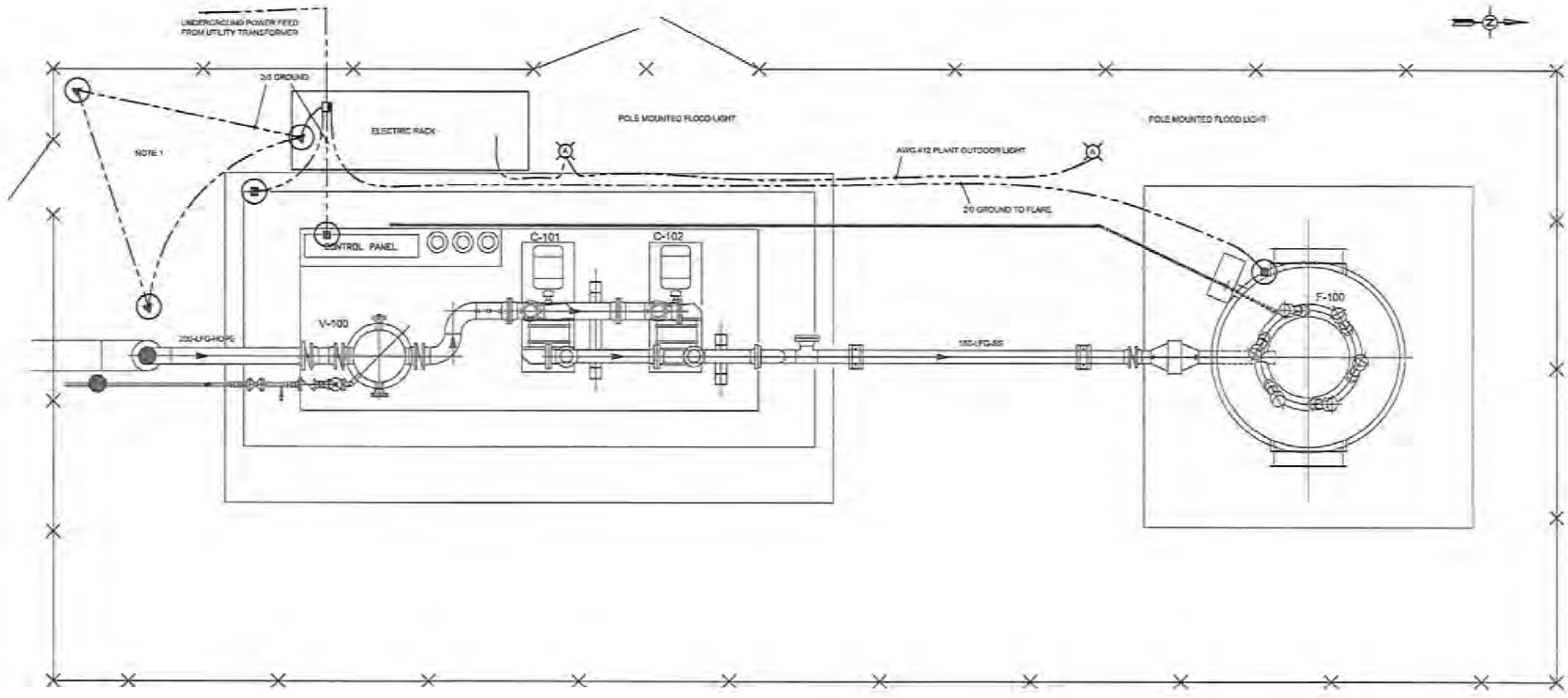
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
2	05-07-06	ISSUE FOR CONSTRUCTION	LL	PF	CS	MB
1	05-05-24	CB101, CB102 UPDATE; CB104 UPDATE FOR MICROTURBINE TRAILER	LL	PF	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	LL	TL	CS	MB

CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASES 1 & 2
NORTH LANDFILL GAS COLLECTION SYSTEM

ELECTRICAL
PHASE 1 & 2
SINGLE LINE DIAGRAM AND PANEL SCHEDULE

SHEET 20 OF 22
DWG E-1
DATE DEC 2004
PROJ 323443



PLAN

1:100

0 1 2 3

⊙	GROUND TAP CONNECTION
⊡	BUILDING/EQUIP. GROUND CONNECTION
▷	GROUND ROD
▄	SERVICE GROUND

NOTES:

1. GROUND RODS 3 @ 10' APART

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	LL	PF	CS	MS
B	05-03-01	ISSUE FOR 90% REVIEW	LL	PF	CS	MS

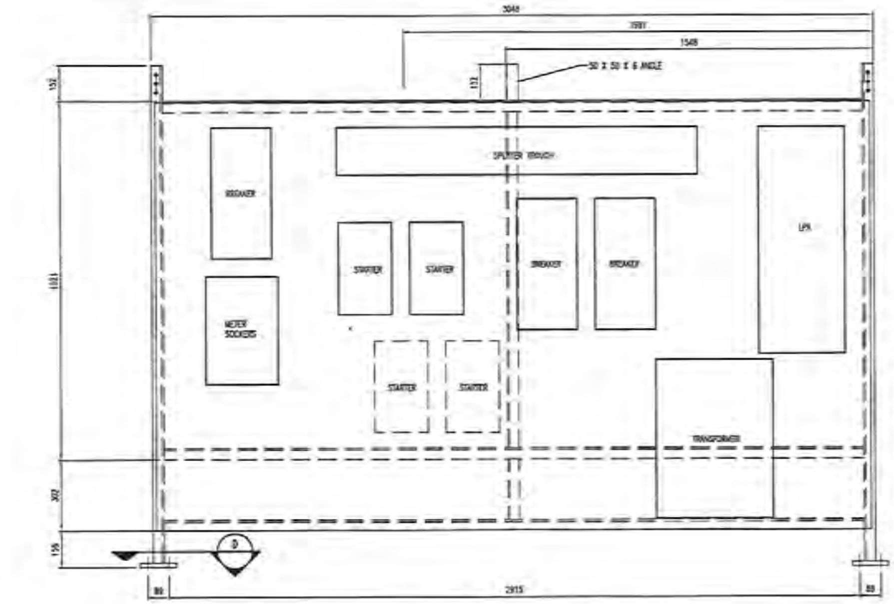
L. D. LLEWELLYN

CH2MHILL
"Responsible Solutions for a Sustainable Future"

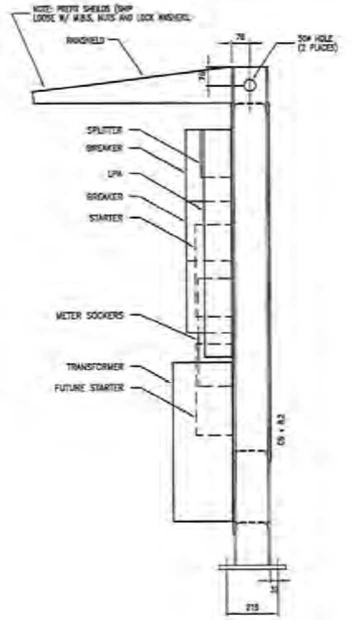
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

ELECTRICAL
PHASE 2
BLOWER FLARE STATION
POWER, LIGHTING & GROUNDING LAYOUT

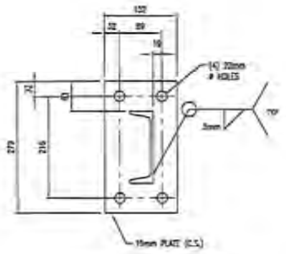
SHEET 21 OF 22
DWG E3
DATE DEC 2004
PROJ 323443



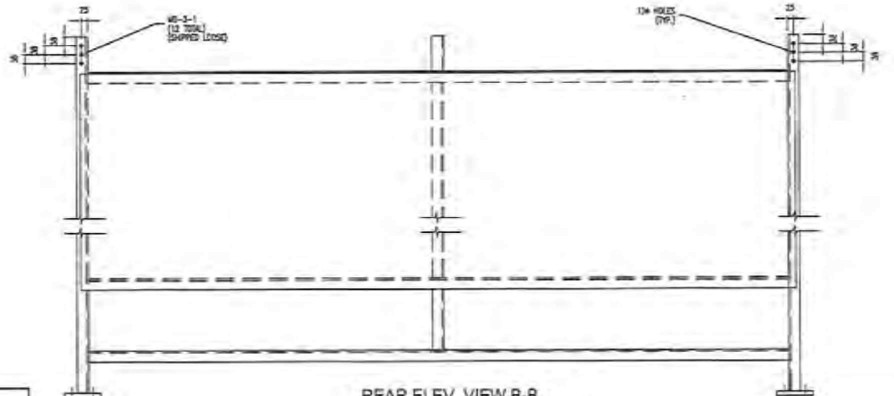
FRONT ELEV. VIEW A-A



SIDE VIEW C-C

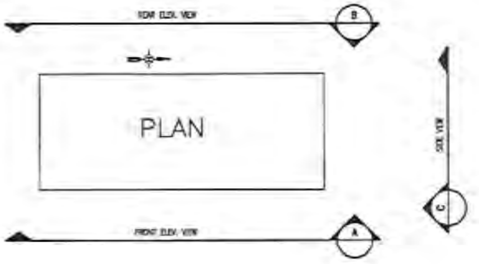


SECTION D-D



REAR ELEV. VIEW B-B

(NITROGEN LINE REMOVED FOR CLARITY)



PROFESSIONAL ENGINEER
L. D. LLEWELLYN
PROVINCE OF BRITISH COLUMBIA

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	LL	PF	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	LL	PF	CS	MB

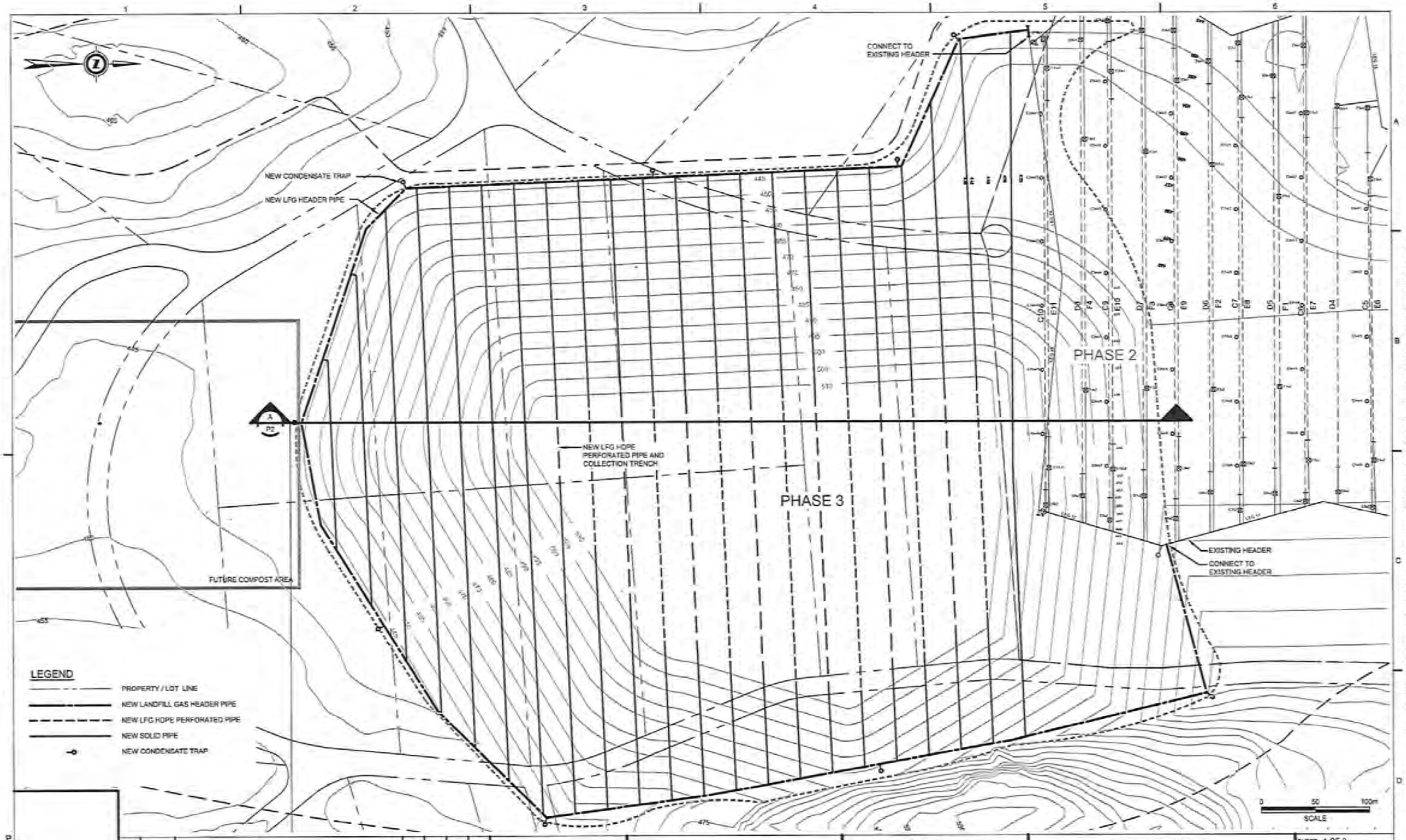
CH2MHILL
"Responsible Solutions for a Sustainable Future"

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

ELECTRICAL
PHASE 2
BLOWER FLARE STATION
ELECTRICAL RACK LAYOUT

SHEET 22 OF 22
DWG E5
DATE DEC 2004
PROJ 323443

Appendix D
Phase 3 Conceptual Design Drawings



A	09-11-07	ISSUE FOR REVIEW	MR	DF	-	-
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

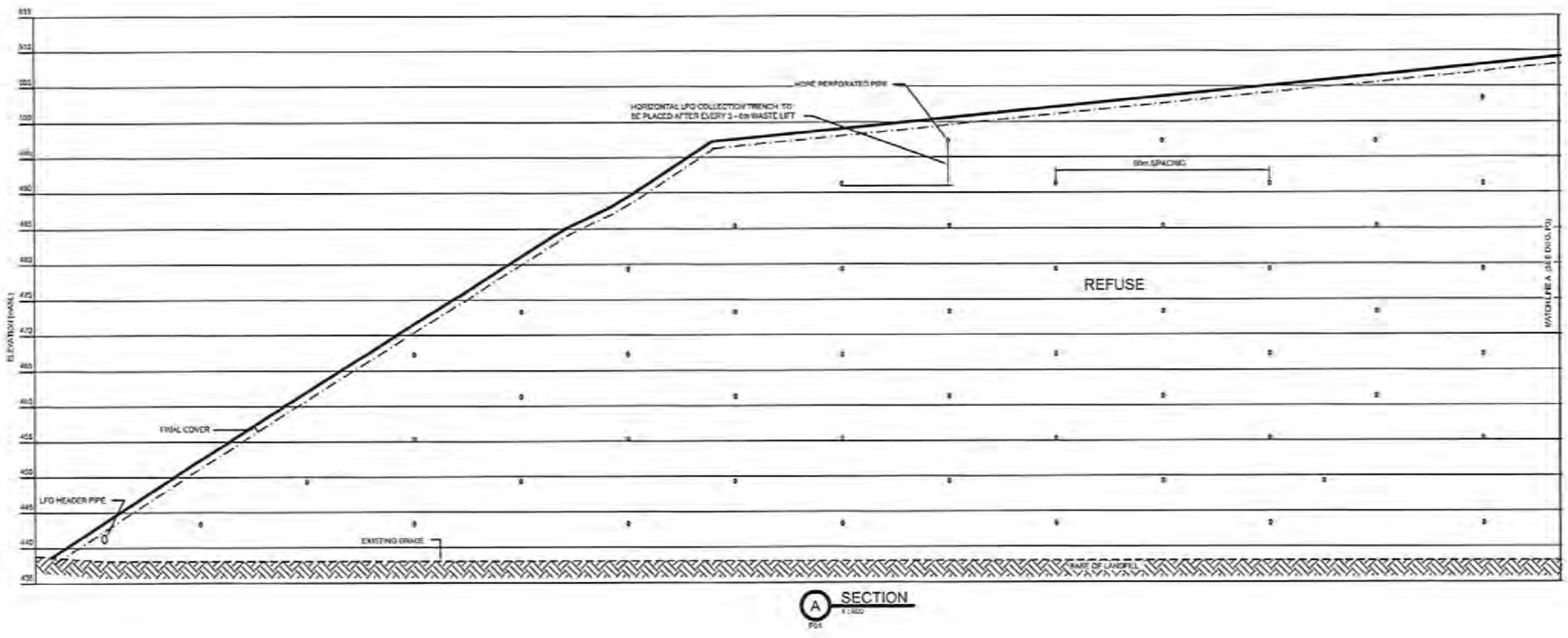
CH2MHILL

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 3
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
FIGURE 3-7
PHASE 3
PLAN

SHEET 1 OF 3
DWG P1
DATE NOV. 2007
PROJ ____

P01 PHASE3.DWG



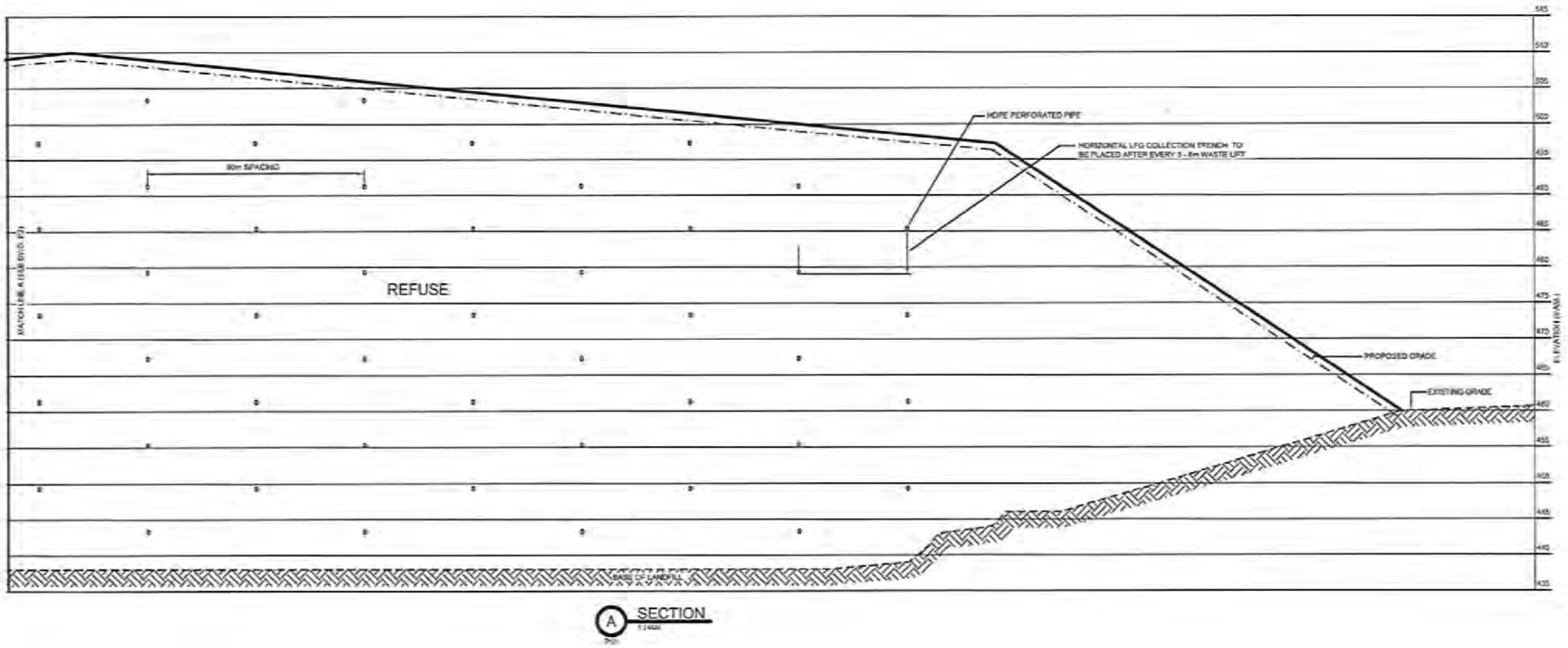
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
A	09-11-07	ISSUE FOR REVIEW	NR	DF	-	-

CH2MHILL

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 3
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
FIGURE 3-8
PHASE 3
SECTION A (PART 1 OF 2)

SHEET	2 OF 3
DWG	P2
DATE	NOV. 2007
PROJ	356294



A	20-11-07	ISSUE FOR REVIEW	NR	DF	-	-
NO.	DATE	REVISION	DESGN	DR	CHK	APVD

CH2MHILL

CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 3
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
FIGURE 3-9
PHASE 3
SECTION A (PART 2 OF 2)

SHEET 3 OF 3
DWG P3
DATE NOV. 2007
PROJ 356294

P01 PHASE3.DWG

Appendix E
Collection System Piping Inventory

Source: The City of Kelowna

December 2011

					Gas collectors (m)										Vertical wells			
	Lateral	Northing	Invert elev		2004	2005	2006	2007	2008	2009	2010	2011	2012	Length	# of Wells	Depth (m)	Total (m)	Laterals
Phase 1	B1	37,253	447.4		60									60				
	B2	37,223	446.0		206									206				8
	C1	37,212	448.5			277								277				22
	F1	37,198	456.0	233 est									233	233				43
	B3	37,187	445.0		357									357				14
	E1	37,182	453.5									280		280				44
	F2	37,155	456.0	207 est									207	207				31
	D1	37,152	450.3				297							297				31
	E2	37,122	453.5									268		268				34
	F3	37,095	456.0	221 est									221	221				45
	C2	37,092	447.8			305								305				10
	E3	37,062	453.5									272		272				23
	D2	37,032	449.3				300							300				8
	F4	37,037	456.0	228 est									228	228				39
	E4	36,990	453.5									231		231				8
	F5	36,960		130 est										0				
	C3	36,972	447.0			205								205				1
Phase 2N	E5	36,920	453.0	34 est								181		181				19
	C4	36,903	445.0						276					276				8
	D3	36,882	447.5								254			254	4	14	56	22
	E6	36,860	453.0	28 est								196		196				28
	C5	36,852	444.0						287					287	4	7	28	14
	D4	36,822	447.5								268			268	5	14	70	27
	E7	36,800		258 est										0				
	C6	36,792	444.0						351					351	6	7	42	9
	D5	36,762	447.5								398			398	6	14	84	23
	E8	36,740		364 est										0				
	C7	36,732	444.0						464					464	7	7	49	11
Phase 2S	D6	36,702		434 est										0				
	C8	36,672	444.0					425	40					465	6	7	42	15
	E9	36,664	454.5	134 est								228	134	362				55
	D7	36,642	447.5						300		138			438	6	11	66	27
	C9	36,611	444.0					359	100					459	7	7	49	8
	E10	36,606	454.5	368 est									368	368				48
	D8	36,582	447.5						300		133			433	7	11	77	20
	C10	36,551	444.0					455						455	6	7	42	1
					623	787	597	1239	2118	0	1191	1656	1391	9602	64		605	694
														horizontal			vertical	

368 (indicates leachate recirc pipe doubled with gas collection pipe)

total 10207

CH2MHILL®

Appendix H
Surface Water Management Plan

Memorandum

Draft for Review

July 16, 2018

To:	City of Kelowna	Ref. No.:	084612-22
From:	Paul Farquharson AScT/cs/04	Tel:	604-214-0510
CC:	Deacon Liddy/Dave Engstrom		

Subject: **Conceptual Surface Water Management Plan**
Glenmore Landfill

1. Introduction

GHD Limited (GHD) has prepared this memorandum for the City of Kelowna (City) to present a summary of the design and analysis undertaken in support of the surface water management plan (SWMP) for the Glenmore Landfill (Site). The designs and analysis presented in this memorandum is based on conceptual design drawings prepared for inclusion in the Updated DOCP and includes the following:

- Relevant site specific background information
- Surface water management plan (SWMP) design criteria
- Hydrologic characterization and assessment
- Recommendations and SWMP design features (i.e. ditches and culverts)

2. Background and Site Description

The Site is located in the City of Kelowna, British Columbia (BC) on John Hindle Drive as illustrated on Figure 1. The elevation of site ranges from 438 metres to 536 m above mean sea level (m AMSL). The average annual precipitation measured at the nearby Kelowna Airport weather station (Station No. 1123970) is 386.9 millimetres (mm) per year according to Climate Normals from 1981-2010.

The Site is located within a valley (Glenmore Valley) with currently no natural outlet for surface water runoff. GHD understands that all surface runoff, shallow groundwater discharge and seeps/springs, generated from the landfill and the contributing drainage area to the north of the Site is collected within a series of the Surface Water Management (SWM) Ponds (Bredin Pond, Slough, Tutt Pond and the Northeast Pond). Runoff that enter the SWM Ponds consists of runoff from the landfill site and supporting area, and from surface water run-on from off-Site upstream catchment areas. Accumulated surface water runoff that collects within the SWM Ponds is discharged through evaporation, infiltration (minimal due to soil conditions) and active pumping (used for irrigation). Surface water management at the current site is documented within the following reports:

- Surface water Management Plan, Glenmore Landfill, CH2M Hill (Dec. 2006)
- Surface water and Groundwater Management Strategy, City of Kelowna Glenmore Landfill, Golder Associates (July, 2016)

The landfill is situated directly on clay or till with a thickness of 7 metres (m), which overlays a 5 m thick layer of sand and gravel. Below the sand and gravel layer is a 25 m thick layer of till before reaching bedrock (CH2MHILL, 2008). The clay or till surface layer has relatively low infiltration rates and produces high peak discharge during storm events.

GHD is currently developing an updated DOCP for the Site including updated fill plan and contours which necessitate the development of revised surface water management infrastructure. Designs components contained in the DOCP pertinent to the SWMP include the installation of a final cover system and the construction of a series perimeter channels and pipes. The final cover will consist of a vegetated, low permeability barrier system over the waste. Installation of the final cover system will result in increased surface water runoff when compared to pre-development conditions. Perimeter ditches will collect and convey surface runoff from the landfill and direct it to a SWM Pond.

The updated fill plan has been prepared and construction of lined landfill cells over the slough as shown on Figure 1. GHD has assumed that all surface waters will flow to the three remaining SWM ponds - Bredin Pond, Northeast Pond, and Tutt Pond. Full development of the landfill will result in an increase in runoff volume generated within the valley. There are various methods to manage the increase in runoff volumes as a result of the full development of the landfill, which are discussed in the Conclusions and Recommendations section of this memorandum.

3. SWMP Objectives and Design Criteria

3.1 SWMP Strategy

The surface water management strategy for the Site consists of the following:

1. As best as possible, run-off from off-site areas will be collected by an interceptor swale, stored within a proposed SWM Pond, identified herein as the North SWM Pond, and diverted around the Site within a buried pipe such that it does not combine with Site runoff. Off-Site surface water will discharged south of the Site to a location that ultimately discharges to the headwaters of Brandt Creek; however, the discharge flow pathway has yet to be determined.
2. Site runoff will be collected in a series of perimeter swales and culverts and directed to the existing Bredin Pond which flows toward the proposed South Pond. The existing Tutt Pond will be abandoned and replaced with a trapezoidal channel. Runoff that enters the South Pond will pumped to the proposed City stormwater sewer along Glenmore Road.
3. GHD understand the Northeast Pond is classified as a dam, which will be abandoned in the future. Due to the configuration of the landfill perimeter swale and surrounding topography, the Northeast

Pond will be modified as a dry-pond that will receive runoff from a portion of the eastern landfill and an off-Site area located to the east/ northeast of the Pond. Runoff collected within the Northeast Pond will discharge to the proposed South Pond via a gravity sewer.

The surface water management strategy was developed to facilitate the landfill cover system design and size the conveyance features (i.e. channels and culverts) to convey the peak flow generated from a design storm event. The SWMP makes assumptions that the runoff can be directed to two outlets located south of the Site and to a proposed storm sewer along Glenmore Road, both of which have not been assessed or designed. The size of the proposed SWM Ponds are for planning purposes only as their size is directly related to the acceptable discharge limits to the outlets. GHD also recommends that a surface water management strategy for the off-Site watersheds be developed and consider the proposed works within this SWMP.

3.2 SWMP Design Criteria

The designs developed in this memorandum have been prepared to meet regulatory guidelines contained in the Landfill Criteria for Municipal Solid Waste, second edition (Landfill Criteria) (BC Ministry of Environment, 2016) and to:

1. Ensure that the runoff/discharge associated with Site land use and operations will not adversely impact receiving waters downstream. For this Site, there is currently no discharge to a downstream receiving water. Therefore, this memorandum provides the estimated runoff volumes that will discharge from the Site, under the final development condition, for the various design storms to enable future design and planning of channels to downstream receiving waters.
2. Ensure that surface water management channels and ponds provide sufficient capacity and durability to convey runoff from the contributing watershed through the Site in a manner that does not cause erosion or possible damage to the Site.

In order to meet the objectives, GHD prepared a hydrologic model to assess the performance of the surface water management works for the 5-, 10-, and 100-year design storm events. GHD combined modelling with the following criteria adapted from guidelines contained in the Landfill Criteria and best management practices (BMPs) to develop the designs:

A. In accordance with the Landfill Criteria, surface water management infrastructure has been designed to meet the following criteria:

   - Be designed to convey the discharge from the landfill and the landfill support areas to accommodate the runoff of a 1:100-year, 24-hour storm event.
   - Maintain a positive grade to prevent sedimentation and maintain hydraulic design capacity. Ditches shall be designed to accommodate localized settlement (no grade reversals).
   - Be armored (rip rap, erosion control matting, or vegetative cover) to prevent erosion of ditch bottom and side slopes.
   - Make allowances for additional water that may result from snowmelt.

B. In accordance with the BC Supplement to TAC (Transportation Association of Canada) Geometric Design Guide 2007 Edition (Tab 10-1000 Hydraulics Chapter) (BCMOT, 2007) surface water management channels shall have the following characteristics (exceptions noted below):

- The maximum recommended depth of flow within a channel is 0.6 m. As an alternative, erosion control protection along the channel may be recommended based on the shear stress resulting from the flow depths greater than 0.6 m.
- The recommended minimum freeboard is 0.3 m for small drainage channels.
- Typical channel side slopes range between 2:1 (H:V) to 5:1.

C. In addition, the stormwater management system was designed to meeting the flowing criteria:

- The stormwater management system was designed using the 24-hour, 5-year, 10-year and 100-year synthetic design storm with a Type II distribution.

4. Hydrologic Assessment

The hydrologic assessment provides an estimate of the surface water runoff peak discharge and volume that is generated within the contributing drainage area of the Site, under various design storm events. The design storm events are synthetic rainfall events that are based upon the local historical rainfall data, collected by Environment Canada, which is used to generate Intensity-Duration-Frequency Reports (IDF) reports. The design storm modelling approach is used to design the SWM conveyance features (i.e. ditches and pipes) which convey runoff to the SWM ponds.

4.1 Model Overview

A hydrologic assessment of the Site watershed was completed to provide estimates of the peak discharge that is expected to occur within the proposed channels. The hydrologic assessment was completed by developing a hydrologic model of the Site to estimate the runoff volume and discharge rate generated for post-development condition. The stormwater modelling for the Site was conducted using the software program PCSWMM 2017 developed by Computational Hydraulics International (CHI). PCSWMM uses the USEPA SWMM5 engine (currently version 5.1.011), and is a spatial decision support system for the USEPA SWMM5 program. The USEPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model that can be used for either single event or long-term (continuous) simulation of runoff quantity and quality.

PCSWMM allows modelling of runoff and conceptual design of drainage works such as piping network, open channel (rivers, creeks and ditches), weirs, dams, orifices, and storage/detention units. The computer model uses hydrologic and hydraulic methods to calculate and route hydrographs. The model requires input of a hyetograph, topographical features (catchment area, width, slope and hydraulic roughness), soil parameters, ground cover conditions (land use and vegetation cover) and drainage paths (channels, rivers, pipes and storage units).

4.2 Design Storms

The design of the stormwater management system is based upon the development of synthetic design storms that are developed using the return-period rainfall depths derived from the Kelowna Airport IDF reports developed by Environment Canada.

The Kelowna Airport IDF curve report is provided within Attachment A and is based upon 34 years of data (1969-2004). The station characteristics are provided below:

Table 4.1 Kelowna Airport Meteorological Station

Item	Attribute
Station Name	Kelowna Airport
Climate ID	1123970
Latitude	49 57'22"N
Longitude	119 22'40"W
Elevation	429.5 m
Period of Record	1969-2004

Synthetic design storms were created for the 5-year, 10-year, and 100-year, 24 hour storm event using the Soil Conservation Service's Type II distribution which is appropriate for this geographic area. Rainfall parameters representing design storms are listed in the attached Table 1.

4.3 Hydrologic Model

The SWMP was developed for the full landfill closure condition. The landfill cover will be fully vegetated and consist of the following:

- Geosynthetic clay liner (GCL) with equivalent performance to 0.6 m barrier layer with hydraulic conductivity of $1x10^{-5}$ cm/s or less
- 0.45 m minimum common fill layer (relatively permeable)
- 0.15 m minimum topsoil layer with vegetative cover

The design of the SWMP plan assumed a small amount of storage capacity within topsoil, vegetative, and drainage layers of the landfill final cover system. Within the model, the depression storage and infiltration parameters are considered conservative. For example, the depression storage on the landfill cover is 2.5 mm which accounts for rainfall captured within the vegetation cover and depressions within the topsoil layer. The infiltration parameters are also conservative because the landfill cover system generates a relative high runoff coefficient relative to other land covers, which typically use parameters similar to a pasture.

For analysis, the landfill cover system was divided into a series of catchments. The catchment boundary delineation is presented on Figure 2 for the model extent and Figure 3 for the landfill area. Corresponding catchment model input parameters are summarized in Table 2 for the post development condition. Runoff from the pre-development condition was assumed to be zero and was not modelled.

The model was developed to route runoff generated from each catchment to a series of channels, which will convey runoff away from the landfill cover. A flow schematic, describing the SWM conveyance features (i.e. channels, ponds) and flow direction is presented in Figure 4.

4.4 Perimeter Ditches and Culverts

The perimeter ditches around the landfill follow the overall surrounding land slope and grade along the toe of the landfill cover system. The slopes ranged from approximately 0.007, in the area of Tutt Pond to 20.6 percent, where the cover system ends along a steep incline. The following two types of perimeter ditches are considered within the SWMP:

- Perimeter Ditches (PD) that are not adjacent to an access road are a trapezoidal ditch with a bottom widths of 1 m with 3H:1V side slopes. The Manning's Roughness Coefficient assumed for ditches was 0.035. The perimeter ditches with a slope in excess of approximately 2 percent, generating an excessive shear stress or supercritical flow, will require erosion protection (e.g. channel lining with energy dissipaters) and further assessed at the detailed design stage.
- Perimeter ditches bounded by an access road (MD) collect runoff from the cover system and discharge under the access road, via a corrugated metal culvert (MC), to a perimeter ditch. MD-ditches are a trapezoidal ditch with a bottom widths of 0.5 m with 3H:1V side slopes. The Manning's Roughness Coefficient assumed for ditches was 0.035.

Various culverts will to convey runoff under the perimeter access roads to the ponds. The following culvert are considered within the SWMP:

- Culverts under the access road (MC) are corrugated steel pipes and range in size between 600 mm to 825 mm in diameter.
- The outlet structures from the Bredin Pond, Northeast Pond, North Pond are corrugated metal pipes.
- The gravity sewers that receive runoff from the Northeast dry-pond and North Pond have a very low gradient and extended length and are proposed to be high density polyethylene (n-value of 0.013). A 750 mm diameter pipe is required to convey runoff from the Northeast dry-pond to the South pond. A 600 mm diametre pipe is required to divert runoff around the Site from the North Pond to the southern limit of the Site.

Culverts with high slopes will be further evaluated at the detailed design stage and may require drop manholes or energy dissipation structures.

4.5 SWM Pond Configuration

The hydrologic assessment was completed for the final development condition, where the landfill extends over the existing sloughs on the south side of the Site. Under this condition all landfill surface runoff is collected within the three remaining SWM ponds: Bredin Pond, Northeast Dry Pond, and the South Pond. Tutt Pond is abandoned and converted to a low gradient trapezoidal channel. The runoff from the Bredin Pond and the Northeast Dry Pond discharges to the South Pond which routes runoff to the future Glenmore Road storm pipe via a pump station. For the purpose of this SWMP, GHD has assumed the pump station has a maximum pumping capacity of 400 litres per second. The overall performance of the pump station will need to be confirmed at the detailed design stage, as it will directly affect the necessary storage volume required in the SWM Ponds.

The detailed design of the SWM Ponds will need to be completed using a water balance model or long-term continuous simulation that considers snow-melt and multiple rainfall events. The ponds were modelled for the design storms, described above, assuming the pond water levels are at the invert elevations of the outlet structures with limited storage capacity. The pond stage-storage characteristics are based upon the information contained within the Golder report and should be considered as approximate until such time that a detailed bathymetric and topographic survey can be provided.

The Bredin Pond collects runoff landfill catchments S106 to S109. The Bredin Pond was analyzed based upon its current area, with an active storage depth of 1.02 m. Bredin Pond discharges via a single outlet pipe, BP_OUTLET, to a channel (PD-01 to PD-04), that flows to the South Pond.

The Northeast Pond is a dry pond that is located within the existing valley with an approximate area of 45,000 square meters. The Northeast Pond collects runoff from landfill catchments S110 and S111 and valley catchment S206. The Northeast Pond was analyzed with an active storage depth of 1.0 m. An outlet structure consisting of a 450 mm diameter culvert, NEP_OUTLET, which discharges to a 750 mm HDPE culvert, NEP_P01. The HDPE culvert discharges to the South Pond.

The South Pond will require an area of 11,500 square meters and 2.0-metre active storage depth. The South Pond collects runoff from landfill catchments S105 to S106 and landfill support areas S201 to S204, in addition to the discharge from the Bredin Pond and the Northeast Pond. A pump station with a maximum capacity of 400 litres per second will discharge runoff from the South Pond to the future Glenmore Road gravity storm sewer.

The North Pond will require an area of approximately 29,500 square meters and an active storage depth of 2.0 metres. The North Pond accepts runoff from an interceptor channel that capture runoff from the upstream catchment areas, identified as S301 and S302. Runoff from the North Pond is controlled via a 525-mm diameter pipe to a 600-mm long HDPE gravity sewer that discharges south of the Site.

4.6 Modelling Results

Table 3 and Table 4 provides a summary of the estimated peak discharge rates and total runoff volume, respectively, from each catchment for the post development condition during the 5-year, 10-year, and 100-year design storm events. Table 5 provides the calculated maximum flow rates, velocities, and depths for channels and ponds.

The model also calculates the peak discharge within the channels. A summary of the channel characteristics and performance is provided in Table 6. High gradient ditches and ditches with higher flow depth will require an engineered lining system to prevent erosion and scour. Ditch lining is recommended for any ditch that would have an estimated shear stress in excess of 50 Pascal’s (U.S. Soil Conservation Service Channel Design Handbook for Retardance Class C Vegetation) during the 100-Year event. In addition, at the detailed design stage, a scour assessment at each culvert outlet will be required to determine appropriate erosion protection requirements or other energy dissipating measures.

During the 100-year storm event, the SWM ponds provide storage capacity and serve to attenuate discharge to the Site outfall. Table 7 provides a summary of the pond performance during the various design storms. The pond stage-storage relationships and outfall structures should be optimized at the detailed design stage using bathymetric and topographic survey data. With this data, a detailed analysis of the SWM Ponds can be used to determine if they have sufficient capacity to handle the 100-year storm event and discharge in an acceptable manner.

Table 8 provides a summary of the total runoff volume generated for the various storm events. During the 100-year storm event the estimated volume of runoff from the landfill cover system (100-series catchments) and the total contributing drainage area is approximately 20,600 and 38,000 cubic meters, respectively.

Hydrologic model output files are provided in Attachment B.

5. Recommendations

The surface water management infrastructure designs and analysis provided within this memorandum is conceptual and designed to satisfy the design criteria to the extent practicable. The following assessments are recommended as next steps in developing the surface water management plan for the Site:

- The Northeast Pond dam structure is planned to be decommissioned. GHD has modified the area such that it will not capture a runoff volume in excess of what is required to trigger the Dam Safety Regulation (i.e. less than 1 metre). Also, alignment of the culvert modelled in the SWMP is under the future landfill of approximately 70 m in depth. The depth of waste should be considered in the design of the foundation and cover for the pipe or alternate routing should be considered.
- This SWMP makes several significant assumption regarding how runoff will be discharged from the Site. Design of the Glenmore Road gravity sewer or an assessment of the receiving watercourses south of the Site are not considered within this SWMP.
- Based upon GHD’s experience across Canada the IDF curves are typically used to design a SWM system. The subcatchment parameters used within the model are considered typical parameters. The model results indicate approximately 2 centimeters of rainfall (50 % of the rainfall) is captured on the landfill cover system, which is considered conservative. To verify that frozen or saturated ground surface conditions will have a negligible impact on the infiltration rate, consider performing a more thorough analysis to compare storm frequencies and the season in which they typically occur and the effects of snowmelt on the SWM system.
- A downstream assessment of impacts from post-development runoff in excess of the pre-development runoff from the Site cannot be completed at this time. GHD recommends the model be further refined and a detailed evaluation of the SWM pond performance be completed when the City is able to develop a comprehensive surface water management strategy for the whole valley (i.e. from Robert Lake to Brandt Creek).

6. References

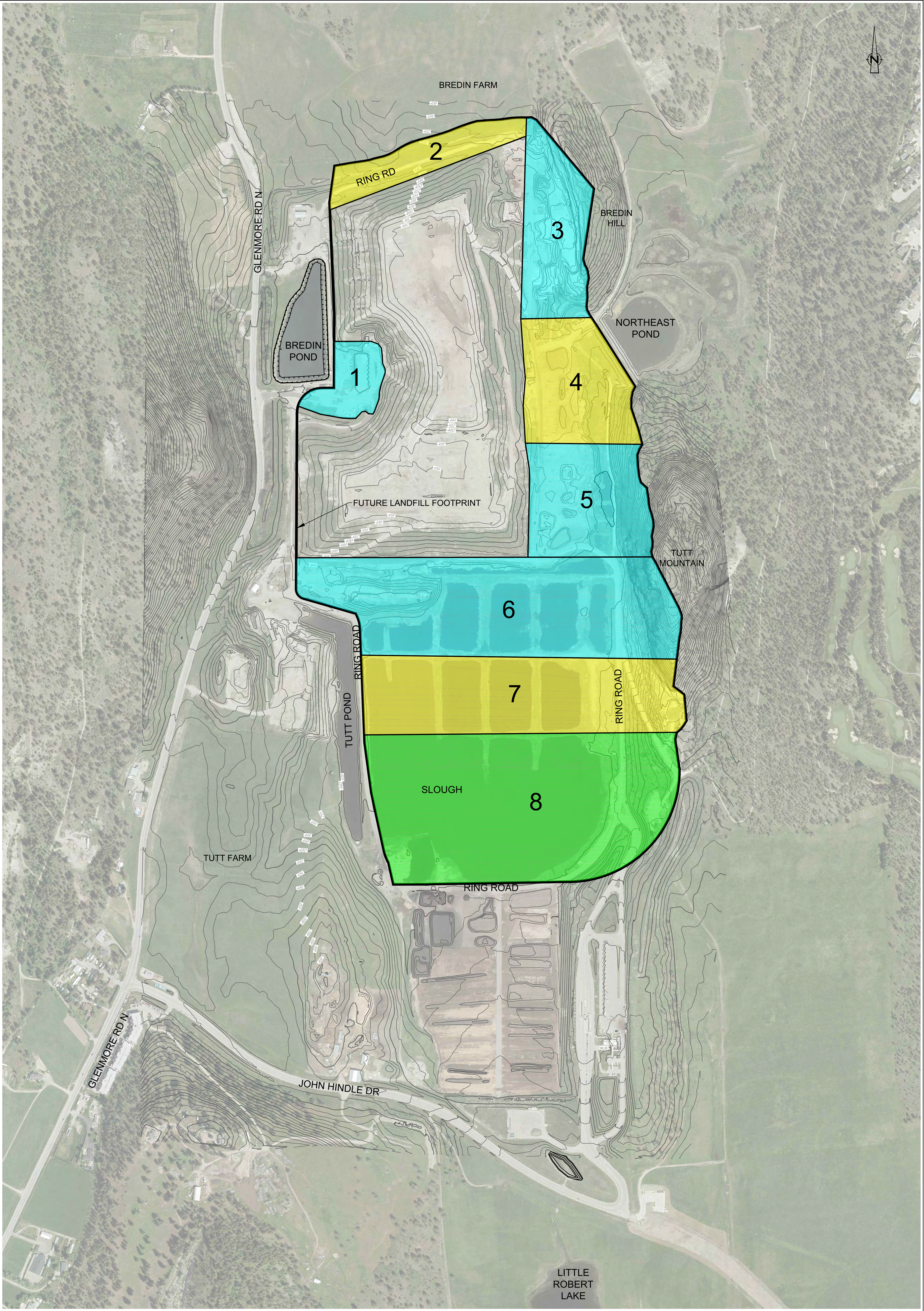
BC Ministry of Environment, June 2016, Landfill Criteria for Municipal Solid Waste, Second Edition, British Columbia

BC Ministry of Transportation, 2007, Supplement to TAC (Transportation Association of Canada) Geometric Design Guide 2007 Edition

Computational Hydraulics Inc. (CHI) User's Guide to SWMM5, Guelph, Ontario, Canada

Computational Hydraulics Inc. (CHI). 2011. PCSWMM User's Manual, Guelph, Ontario, Canada

CH2MHILL, June 2008, Comprehensive Site Development Plan: Glenmore Landfill



Bar is 20mm on original
size drawing
0 20mm

Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

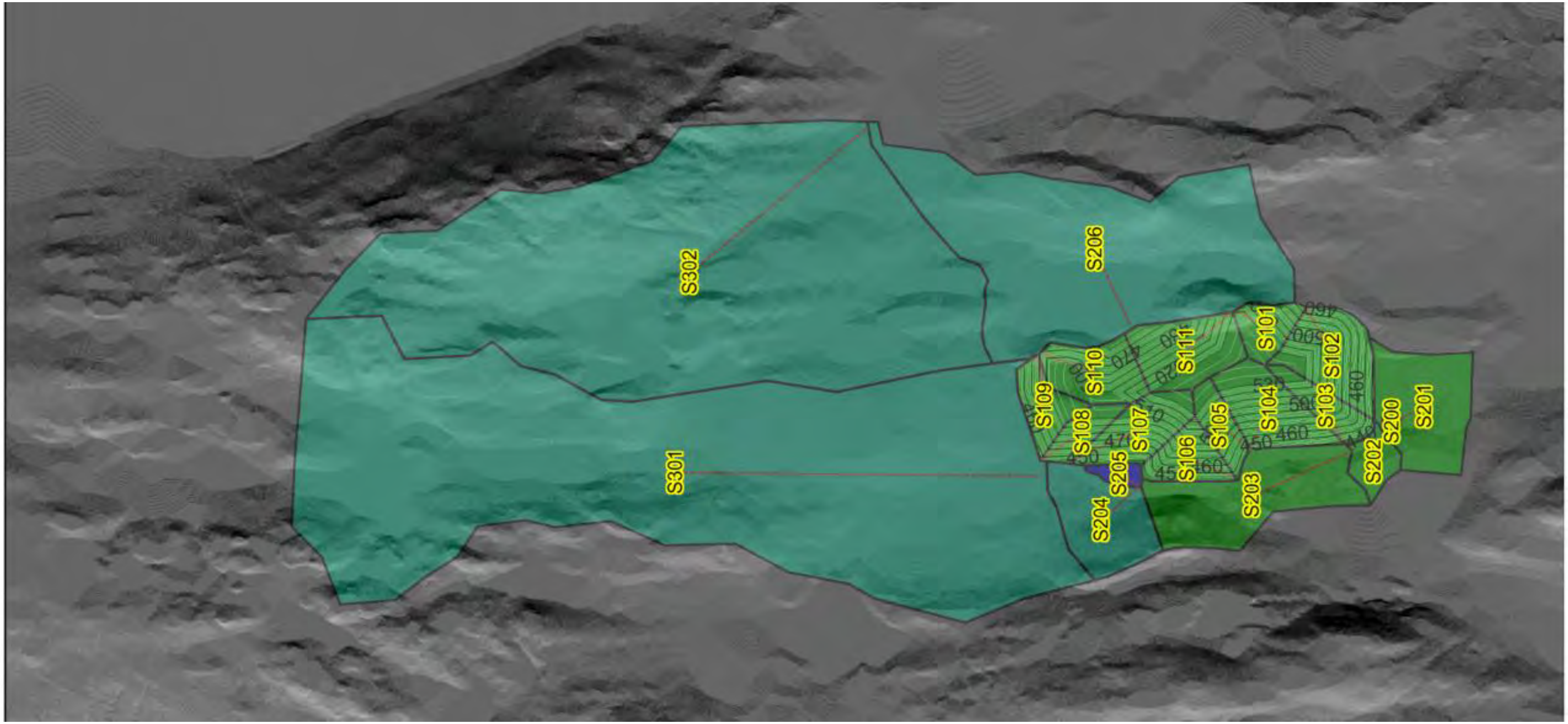
Drawn	S.BRIGGS	Designer	D.TURNER
Drafting Check	D.TURNER	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-03-01
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client CITY OF KELOWNA - GLENMORE LANDFILL
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title LANDFILL AREAS

Project No. 084612-22

Original Size ANSI D
Sheet No. FIGURE-01
Sheet 1 of 2

Plot Date: 1 March 2018 - 4:39 PM
Plotted By: Stephen Briggs
CAD File: I:\CAD\080000\084612\084612-MEMO\084612-22(MEMO3)GN\084612-22(MEMO3)GN-CA001.dwg

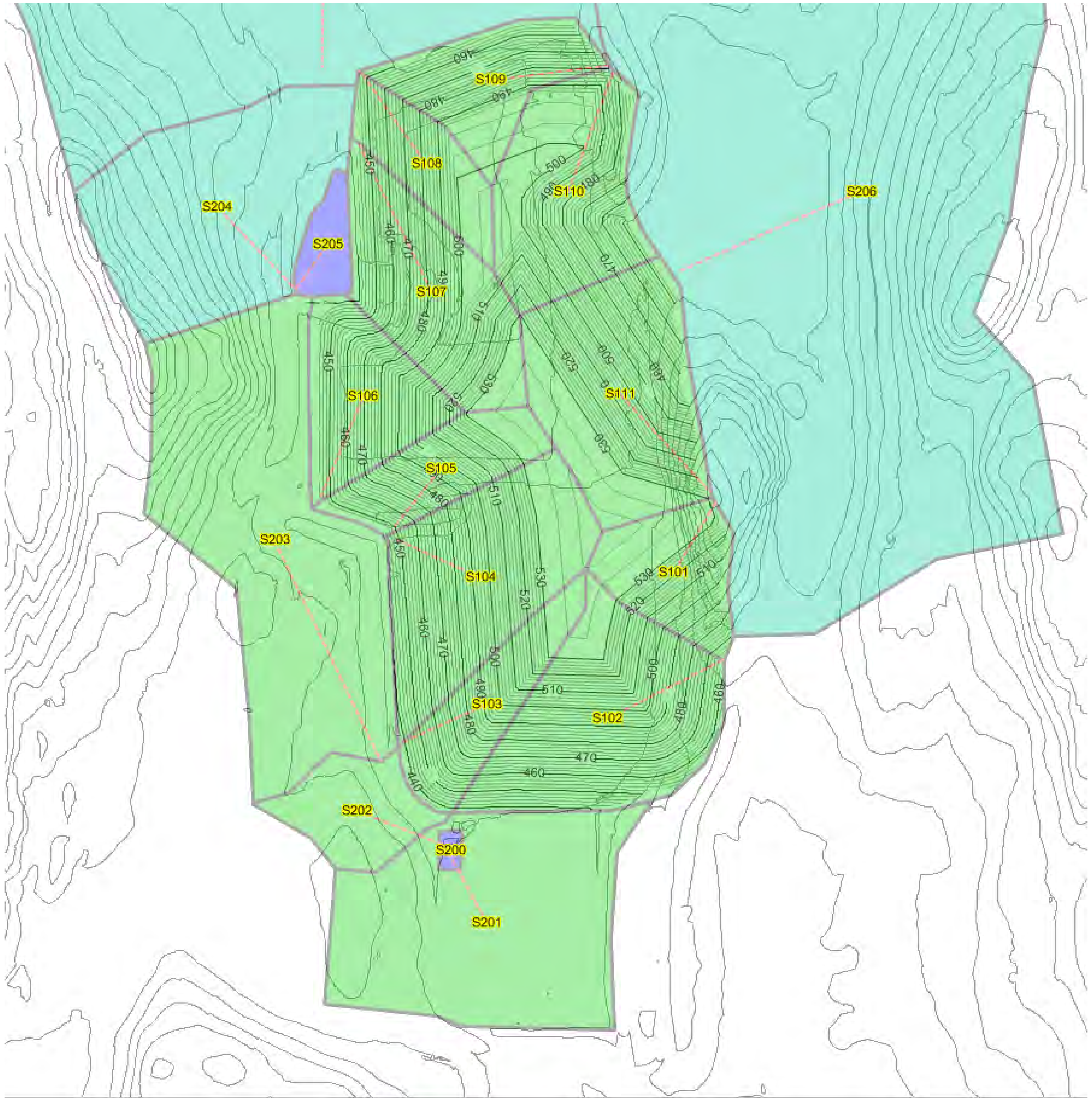


City of Kelowna
Glenmore Landfill
Design, Operation and Closure Plan - Surface Water Management Plan

PCSWMM MODEL EXTENTS

084612-22
3/9/2018

FIGURE NO. 2

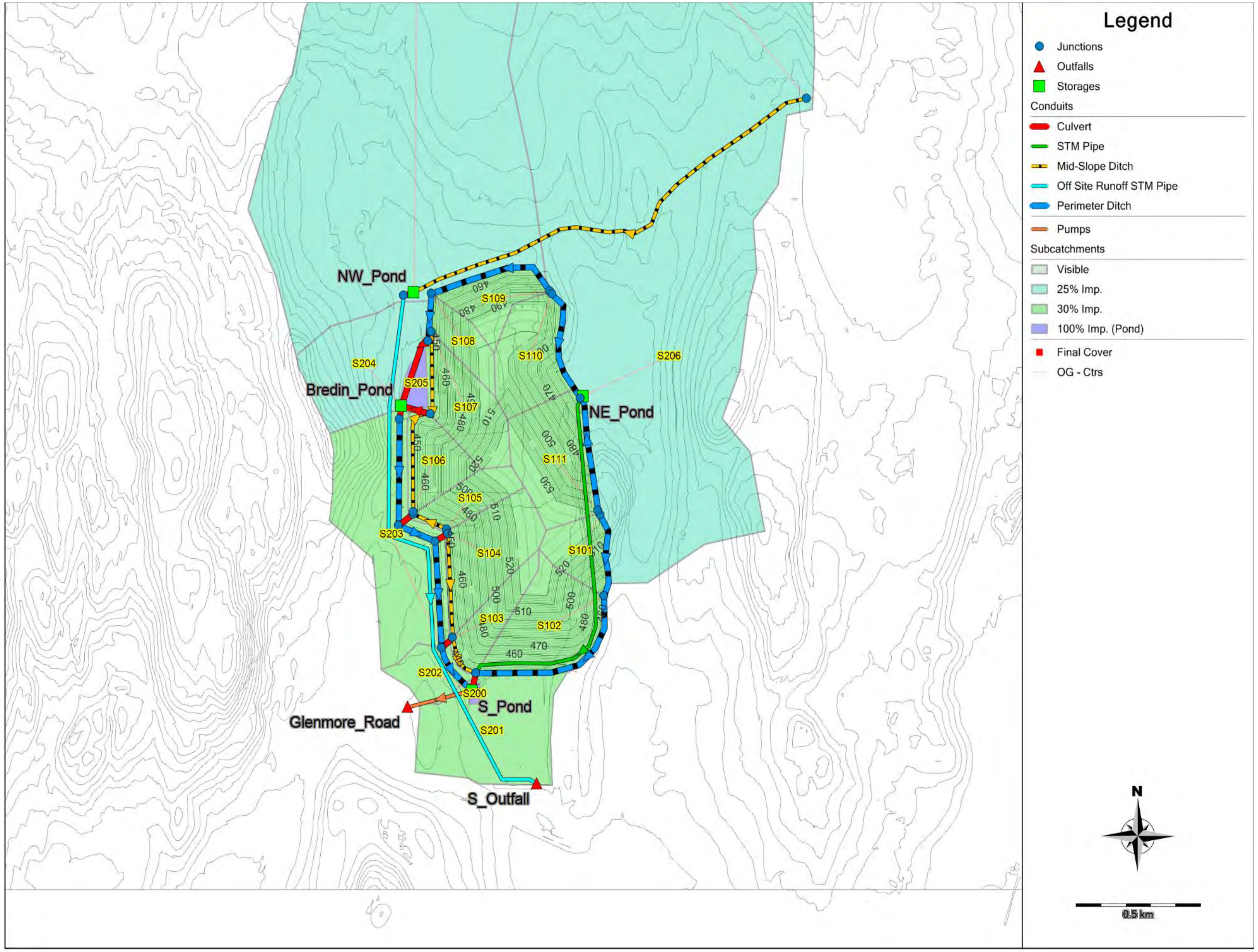


City of Kelowna
Glenmore Landfill
Design, Operation and Closure Plan - Surface Water Management Plan

LANDFILL SUBCATCHMENT AREAS USED IN THE PCSWMM MODEL

084612-22
3/9/2018

FIGURE NO. 3



City of Kelowna
Glenmore Landfill
Design, Operation and Closure Plan - Surface Water Management Plan
PCSWMM MODEL SCHEMATIC

084612-22
3/9/2018

FIGURE NO. 4

Table 1

Design Storm Parameters
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Return Period	Type	Depth (mm)	Peak Intensity (mm/hr)	Duration (hour)
5-year	SCS Type II	28.0	38.38	24
10-year	SCS Type II	31.4	43.04	24
100-year	SCS Type II	41.9	57.43	24

Notes:

1. 5-year, 10-year and 100-year design storm depths obtained from Environment Canada intensity-duration-frequency data for the Kelowna Airport (ID 1123970) IDF Station.

Table 2

Catchment Parameters
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Subcatchment Parameters

Subcatchment ID	Area (ha)	Flow length (m)	Slope (%)	Imperviousness (%)	Manning' n		Depression Storage		Infiltration	
					Impervious (-)	Pervious (-)	Impervious (mm)	Pervious (mm)	Maximum (mm/hr)	Minimum (mm/hr)
S101	5.61	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S102	13.79	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S103	5.64	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S104	12.51	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S105	5.30	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S106	6.97	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S107	10.05	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S108	4.49	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S109	6.61	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S110	10.56	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S111	13.38	400	30	30	0.01	0.35	0.05	0.2	7.60	1.30
S200	1.15	230	1	100	0.01	0.10	0.05	0.1	3.00	0.50
S201	19.55	480	2	30	0.02	0.35	0.05	0.2	72.50	3.25
S202	4.78	285	4	30	0.02	0.35	0.05	0.2	72.50	3.25
S203	27.36	420	14	30	0.02	0.35	0.05	0.2	72.50	3.25
S204	16.89	3565	3	25	0.02	0.40	1.00	4.0	72.50	3.25
S205	1.90	100	1	100	0.01	0.35	0.00	0.0	72.50	3.25
S206	102.14	850	5	25	0.02	0.40	1.00	4.0	72.50	3.25
S301	293.53	3166	3	25	0.02	0.40	1.00	4.0	72.50	3.25
S302	245.66	2672	5	25	0.02	0.40	1.00	4.0	72.50	3.25
Total	**807.88**									

Table 3

Catchment Peak Discharge
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Subcatchment ID	5-year (m^3/s)	10-year (m^3/s)	100-year (m^3/s)
S101	0.24	0.28	0.40
S102	0.59	0.69	0.99
S103	0.24	0.28	0.41
S104	0.54	0.62	0.90
S105	0.23	0.26	0.38
S106	0.30	0.35	0.50
S107	0.43	0.50	0.72
S108	0.19	0.22	0.32
S109	0.28	0.33	0.48
S110	0.45	0.53	0.76
S111	0.58	0.67	0.96
S200	0.08	0.09	0.12
S201	0.45	0.52	0.75
S202	0.14	0.16	0.23
S203	0.81	0.93	1.37
S204	0.17	0.20	0.30
S205	0.16	0.18	0.25
S206	1.88	2.14	3.06
S301	3.16	3.69	5.46
S302	3.23	3.74	5.46

Table 4

Catchment Total Runoff
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Subcatchment ID	5-year		10-year		100-year	
	Runoff Volume (m^3)	Runoff Coefficient (-)	Runoff Volume (m^3)	Runoff Coefficient (-)	Runoff Volume (m^3)	Runoff Coefficient (-)
S101	890	0.57	1040	0.59	1500	0.64
S102	2190	0.57	2550	0.59	3680	0.64
S103	900	0.57	1040	0.59	1500	0.64
S104	1990	0.57	2310	0.59	3330	0.64
S105	840	0.57	980	0.59	1410	0.64
S106	1110	0.57	1290	0.59	1860	0.64
S107	1600	0.57	1860	0.59	2680	0.64
S108	720	0.57	830	0.59	1200	0.64
S109	1050	0.57	1220	0.59	1760	0.64
S110	1680	0.57	1950	0.59	2820	0.64
S111	2130	0.57	2470	0.59	3570	0.64
S200	320	1.00	360	1.00	480	1.00
S201	1640	0.30	1880	0.31	2920	0.36
S202	400	0.30	470	0.31	770	0.39
S203	2320	0.30	2700	0.31	4530	0.40
S204	1140	0.24	1280	0.24	1760	0.25
S205	530	1.00	600	1.00	800	1.00
S206	6890	0.24	7760	0.24	11260	0.26
S301	19800	0.24	22300	0.24	30600	0.25
S302	16580	0.24	18670	0.24	25860	0.25

Notes:
1. S204, S205 and S206 are the SWM Ponds and have a runoff coefficient of 1.0.

Table 5

Channel & Culvert Characteristics
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

				5-Year Storm			10-Year Storm			100-Year Storm		
Channel Section	**Length (m)**	**Slope (m/m)**	**Depth / Diameter (mm)**	**Max. Flowrate (m^3/s)**	**Max. Velocity (m/s)**	**Capacity**	**Max. Flowrate (m^3/s)**	**Max. Velocity (m/s)**	**Capacity**	**Max. Flowrate (m^3/s)**	**Max. Velocity (m/s)**	**Capacity**
BP_OUTLET	12	0.005	450	0.097	0.920	89%	0.117	0.980	107%	0.168	1.230	154%
MC01_x2	16	0.031	825	1.034	1.630	38%	1.204	1.630	44%	1.642	1.840	60%
MC02	16	0.158	600	0.135	0.700	10%	0.144	0.730	11%	0.196	0.820	15%
MC03	16	0.703	600	0.157	1.510	6%	0.180	1.540	6%	0.251	1.640	9%
MC04	16	0.300	600	0.201	1.980	11%	0.224	2.010	12%	0.326	2.010	18%
MC05	12	0.031	825	0.461	1.620	34%	0.461	1.620	34%	0.660	1.620	48%
MD01	177	0.017	500	0.408	0.760	26%	0.493	0.770	31%	0.753	0.970	48%
MD02	400	0.018	500	0.348	1.060	22%	0.405	1.090	25%	0.596	1.180	37%
MD03	426	0.009	500	0.261	0.540	22%	0.304	0.550	26%	0.447	0.620	38%
MD04	147	0.027	500	0.221	0.790	11%	0.256	0.800	13%	0.371	0.800	19%
MD05	319	0.006	500	0.383	0.690	40%	0.446	0.700	47%	0.653	0.750	69%
NEP_OUTLET	12	0.008	450	0.106	1.150	75%	0.123	1.150	87%	0.190	1.230	134%
NEP_P01	1450	0.003	750	0.476	1.380	84%	0.535	1.400	94%	0.599	1.420	105%
NWP_OUTLET	6	0.084	525	0.493	2.280	73%	0.506	2.340	75%	0.544	2.510	81%
OFFS_DITCH	1829	0.014	1000	2.091	1.600	23%	2.436	1.660	27%	3.626	1.830	41%
OFFS_PIPE	2422	0.004	600	0.379	1.540	101%	0.381	1.540	102%	0.389	1.540	104%
PC01	277	0.005	750	0.293	1.070	69%	0.338	1.100	80%	0.433	1.190	102%
PD01	208	0.005	1000	0.768	0.850	15%	0.891	0.890	17%	1.355	1.000	26%
PD02	409	0.001	1000	0.207	0.260	10%	0.247	0.270	12%	0.390	0.340	19%
PD03	159	0.001	1000	0.153	0.270	6%	0.181	0.280	7%	0.262	0.280	10%
PD04	409	0.001	1000	0.097	0.280	3%	0.117	0.290	4%	0.168	0.320	6%
PD05	182	0.028	1000	0.411	0.700	3%	0.479	0.720	4%	0.706	0.740	6%
PD06	536	0.064	1000	0.258	1.150	1%	0.300	1.190	2%	0.438	1.320	2%
PD07	445	0.087	1000	0.425	0.820	2%	0.493	0.850	2%	0.717	0.910	3%
PD08	416	0.207	1000	0.555	1.120	2%	0.642	1.160	2%	0.931	1.250	3%
PD09	719	0.032	1000	0.713	1.020	5%	0.831	1.040	6%	1.224	1.070	9%
PD10	323	0.205	1000	0.233	1.000	1%	0.270	1.030	1%	0.392	1.140	1%

Table 6

Channel & Culvert Characteristics
100 Year Design Storm
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Channel Characteristics & Performance Summary

									100-Year Storm Event				
Channel Section	Length (m)	Slope (m/m)	Cross-Section (-)	Depth (m)	Bottom Width (m)	Left Side Slope (H:V)	Right Side Slope (H:V)	Hydraulic Roughness (-)	Max. Flowrate (m^3/s)	Max. Velocity (m/s)	Max. Depth (m)	Minimum Freeboard (m)	Max. Shear Stress (Pa)
BP_OUTLET	12	0.005	CIRCULAR	0.450	0.000	0.000	0.000	0.024	0.168	1.230	0.360	0.00	N/A
MC01_x2	16	0.031	CIRCULAR	0.825	0.000	0.000	0.000	0.024	1.642	1.840	0.644	0.00	N/A
MC02	16	0.158	CIRCULAR	0.600	0.000	0.000	0.000	0.024	0.196	0.820	0.480	0.00	N/A
MC03	16	0.703	CIRCULAR	0.600	0.000	0.000	0.000	0.024	0.251	1.640	0.366	0.00	N/A
MC04	16	0.300	CIRCULAR	0.600	0.000	0.000	0.000	0.024	0.326	2.010	0.354	0.00	N/A
MC05	12	0.031	CIRCULAR	0.825	0.000	0.000	0.000	0.024	0.660	1.620	0.602	0.00	N/A
MD01	177	0.017	TRAPEZOIDAL	0.500	0.500	3.000	3.000	0.035	0.753	0.970	0.430	0.07	71
MD02	400	0.018	TRAPEZOIDAL	0.500	0.500	3.000	3.000	0.035	0.596	1.180	0.340	0.16	58
MD03	426	0.009	TRAPEZOIDAL	0.500	0.500	3.000	3.000	0.035	0.447	0.620	0.415	0.09	38
MD04	147	0.027	TRAPEZOIDAL	0.500	0.500	3.000	3.000	0.035	0.371	0.800	0.365	0.14	97
MD05	319	0.006	TRAPEZOIDAL	0.500	0.500	3.000	3.000	0.035	0.653	0.750	0.465	0.04	29
NEP_OUTLET	12	0.008	CIRCULAR	0.450	0.000	0.000	0.000	0.024	0.190	1.230	0.450	0.00	N/A
NEP_P01	1450	0.003	CIRCULAR	0.750	0.000	0.000	0.000	0.013	0.599	1.420	0.750	0.00	N/A
NWP_OUTLET	6	0.084	CIRCULAR	0.525	0.000	0.000	0.000	0.024	0.544	2.510	0.525	0.00	N/A
OFFS_DITCH	1829	0.014	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	3.626	1.830	0.660	0.34	88
OFFS_PIPE	2422	0.004	CIRCULAR	0.600	0.000	0.000	0.000	0.013	0.389	1.540	0.504	0.00	N/A
PC01	277	0.005	CIRCULAR	0.750	0.000	0.000	0.000	0.024	0.433	1.190	0.578	0.00	N/A
PD01	208	0.005	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	1.355	1.000	0.530	0.47	25
PD02	409	0.001	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.390	0.340	0.550	0.45	4
PD03	159	0.001	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.262	0.280	0.420	0.58	5
PD04	409	0.001	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.168	0.320	0.290	0.71	4
PD05	182	0.028	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.706	0.740	0.550	0.45	148
PD06	536	0.064	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.438	1.320	0.210	0.79	133
PD07	445	0.087	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.717	0.910	0.470	0.53	403
PD08	416	0.207	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.931	1.250	0.460	0.54	933
PD09	719	0.032	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	1.224	1.070	0.600	0.40	188
PD10	323	0.205	TRAPEZOIDAL	1.000	1.000	3.000	3.000	0.035	0.392	1.140	0.220	0.78	443

Table 7

Surface Water Pond Performance Summary
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Bredin Pond

Design Storm	Peak Inflow (m^3/s)	SWM Pond Discharge (m^3/s)	Maximum Depth (m)	Maximum Elevation (AMSL m)	Maximum Storage (m^3)	Minimum Freeboard (m)
5-Year	0.99	0.10	3.19	438.99	22,380	0.66
10-Year	1.10	0.12	3.24	439.04	22,987	0.61
100-Year	1.47	0.17	3.40	439.20	24,962	0.45

Northeast Pond

Design Storm	Peak Inflow (m^3/s)	SWM Pond Release Rate (m^3/s)	Maximum Depth (m)	Maximum Elevation (AMSL m)	Maximum Storage (m^3)	Minimum Freeboard (m)
5-Year	1.98	0.10	0.34	441.24	8,195	0.66
10-Year	2.24	0.11	0.36	441.26	8,916	0.64
100-Year	3.18	0.15	0.47	441.37	12,065	0.53

Northwest Pond

Design Storm	Peak Inflow (m^3/s)	SWM Pond Release Rate (m^3/s)	Maximum Depth (m)	Maximum Elevation (AMSL m)	Maximum Storage (m^3)	Minimum Freeboard (m)
5-Year	4.74	0.49	1.36	446.36	36,008	2.14
10-Year	5.56	0.51	1.47	446.47	39,200	2.03
100-Year	8.35	0.54	1.86	446.86	50,386	1.64

South Pond

Design Storm	Peak Inflow (m^3/s)	SWM Pond Release Rate (m^3/s)	Maximum Depth (m)	Maximum Elevation (AMSL m)	Maximum Storage (m^3)	Minimum Freeboard (m)
5-Year	2.29	0.40	0.87	436.37	7,776	1.13
10-Year	2.48	0.40	1.07	436.57	9,822	0.93
100-Year	3.69	0.40	1.80	437.30	17,570	0.20

Table 8

Total Model Runoff Summary
Conceptual Surface Water Management Plan
Glenmore Landfill
Kelowna, British Columbia

Glenmore Road

Design Storm	Peak Discharge (m^3/s)	Runoff Volume (m^3)
5-Year	0.40	30,805
10-Year	0.40	34,981
100-Year	0.40	50,030

South Outfall

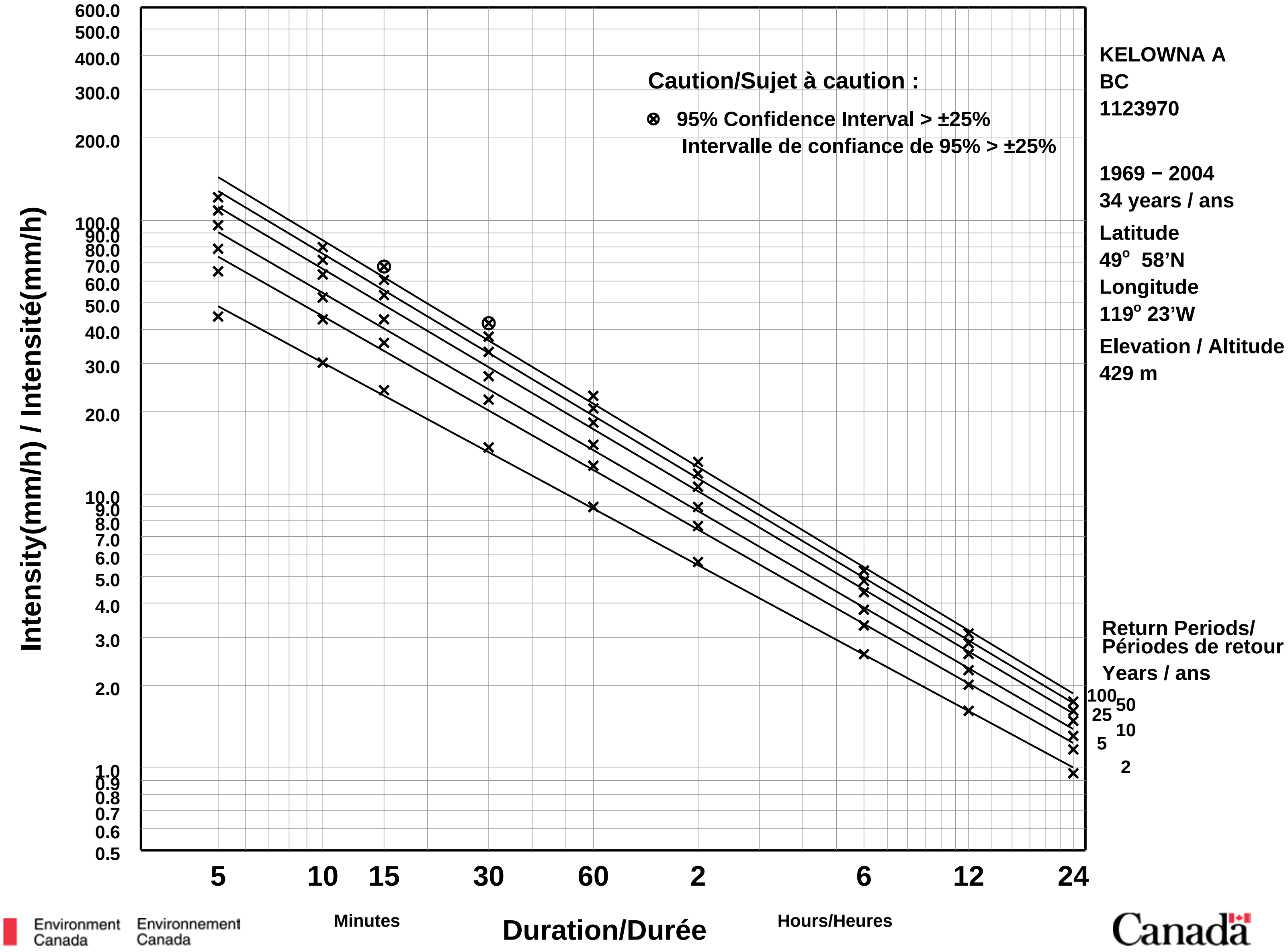
Design Storm	Peak Discharge (m^3/s)	Runoff Volume (m^3)
5-Year	0.38	34,515
10-Year	0.38	39,027
100-Year	0.39	54,209

Attachment A
Kelowna Airport IDF Curve Report

Short Duration Rainfall Intensity−Duration−Frequency Data

2014/12/21

Données sur l’intensité, la durée et la fréquence des chutes de pluie de courte durée



KELOWNA A
BC
1123970

1969 − 2004
34 years / ans
Latitude
49° 58’N
Longitude
119° 23’W
Elevation / Altitude
429 m

Environment Canada Environnement Canada

Canada

```
                   Environment Canada/Environnement Canada

         Short Duration Rainfall Intensity-Duration-Frequency Data
        Données sur l'intensité, la durée et la fréquence des chutes
                            de pluie de courte durée

                Gumbel - Method of moments/Méthode des moments

                                   2014/12/21

================================================================================

 KELOWNA A                                              BC        1123970

 Latitude:  49 58'N    Longitude: 119 23'W   Elevation/Altitude: 429        m

 Years/Années :  1969 - 2004          # Years/Années :     34

================================================================================

********************************************************************************

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

********************************************************************************

          Year  5 min 10 min 15 min 30 min    1 h    2 h    6 h   12 h   24 h
         Année
          1969    1.8    2.8    3.6    4.1    5.8    9.9   15.5   17.0   17.0
          1970    4.6    8.4   12.4   17.3   17.3   17.3   19.6   20.8   21.8
          1971    2.5    4.3    4.6    5.3    6.3    8.9   11.9   16.3   17.8
          1972    4.3    5.3    6.1    6.1    9.9    9.9   11.4   12.2   15.7
          1973    2.8    3.6    3.8    4.6    6.9    9.1   15.5   21.3   28.4
          1974    4.1    6.9    7.4    7.4    8.4    8.4   11.4   20.6   21.1
          1975    4.3    4.6    5.3    9.4   11.7   13.7   18.5   20.8   20.8
          1976    2.3    3.3    4.1    7.4    9.9   12.4   14.5   19.6   23.6
          1977    3.0    4.8    5.6    6.1    6.6    8.1    9.9   11.7   16.0
          1978    3.0    3.9    4.0    5.6    7.6    9.0   16.3   23.3   27.0
          1979    2.2    3.1    3.4    5.1    7.3   11.6   12.4   13.2   18.5
          1980    3.9    4.9    4.9    5.6    7.1    8.4   18.1   20.5   28.0
          1981    4.5    6.1    7.8   13.2   16.2   17.6   21.4   21.4   21.4
          1982    4.8    7.8    9.5   10.3   12.3   14.6   16.2   25.2   29.4
          1983    4.0    4.9    6.5    7.8    8.5   13.6   15.4   15.4   17.7
          1984    3.6    5.0    5.2    7.2    9.3   10.8   19.8   29.6   30.0
          1985    5.2    7.3    8.8    9.8   10.2   10.2   16.8   24.3   35.9
          1986    2.5    3.8    5.6    7.0    7.1    9.3   19.2   22.5   27.2
          1987    3.9    5.1    5.4    7.0   10.5   14.6   19.8   23.5   29.9
          1988    2.5    3.7    4.5    7.0    9.1   12.0   15.0   19.7   24.0
          1989    4.9    6.2    6.4    6.7    8.8   13.3   17.2   25.7   25.7
          1990    8.8   10.3   10.7   13.0   14.5   20.7   26.5   29.0   33.8
          1991    2.8    3.8    4.4    5.2    6.2    6.6    9.1   13.2   20.2
          1992    3.8    4.2    4.2    5.0    6.3   10.4   15.0   28.4   32.2
          1993    6.7    9.2   13.4   16.1   16.6   16.6   17.2   21.1   24.1
          1994    3.4    3.7    3.7    4.3    5.3    9.0   14.9   20.2   20.2
          1995    3.9    4.3    4.7    5.7    6.3    9.1   13.4   18.5   22.8
          1996    1.9    2.7    3.8    4.8    6.7   10.6   19.7   22.4   24.3
          1997   11.1   13.2   17.2   19.3   22.1   28.9   33.8   33.8   33.8
          1998    3.2    4.7    6.8    7.9   10.3   11.2   12.9   14.5   16.4
          1999    4.1    6.0    7.3    9.0    9.5   12.6   16.6   18.1   27.5
```

```
          2000    4.0    5.2    5.6    5.6    5.8    9.0  -99.9  -99.9   32.2
          2001    3.7    4.9    6.6    7.2    8.1   10.4   11.7   12.5   20.1
          2002    2.6    3.3    4.0    4.8    6.3    7.4   11.2   13.0   16.8
          2003    7.9   11.9   14.2   18.7   20.2   20.2   20.2   20.2   20.2
          2004    2.6    3.0    4.0    4.6    7.2    8.4  -99.9  -99.9   18.4
        ---------------------------------------------------------------------
        # Yrs.     36     36     36     36     36     36     34     34     36
        Années
          Mean    4.0    5.4    6.5    8.1    9.7   12.1   16.4   20.3   23.9
       Moyenne
     Std. Dev.    1.9    2.5    3.3    4.1    4.2    4.5    4.8    5.4    5.8
    Écart-type
         Skew.   2.01   1.58   1.69   1.58   1.52   1.87   1.50   0.36   0.40
   Dissymétrie
      Kurtosis   7.87   5.40   5.62   4.80   4.88   7.53   7.22   3.19   2.29

          *-99.9 Indicates Missing Data/Données manquantes

 Warning: annual maximum amount greater than 100-yr return period amount
 Avertissement : la quantité maximale annuelle excède la quantité
                 pour une période de retour de 100 ans
          Year/Année      Duration/Durée       Data/Données          100-yr/ans
                1997               5 min               11.1                10.1
                1997              15 min               17.2                17.0
                1997               2 h                 28.9                26.2
                1997               6 h                 33.8                31.6

********************************************************************************

Table 2a : Return Period Rainfall Amounts (mm)
           Quantité de pluie (mm) par période de retour

********************************************************************************

 Duration/Durée        2        5       10       25       50      100   #Years
                  yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   Années
          5 min      3.7      5.4      6.6      8.0      9.1     10.1       36
         10 min      5.0      7.3      8.7     10.6     12.0     13.3       36
         15 min      6.0      8.9     10.9     13.3     15.2     17.0       36
         30 min      7.4     11.1     13.5     16.5     18.8     21.1       36
          1 h        9.0     12.7     15.2     18.3     20.6     22.9       36
          2 h       11.3     15.3     18.0     21.3     23.8     26.2       36
          6 h       15.6     19.9     22.7     26.3     28.9     31.6       34
         12 h       19.4     24.2     27.3     31.3     34.3     37.2       34
         24 h       22.9     28.0     31.4     35.6     38.8     41.9       36

********************************************************************************

Table 2b :

 Return Period Rainfall Rates (mm/h) - 95% Confidence limits
 Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

********************************************************************************

 Duration/Durée        2        5       10       25       50      100   #Years
                  yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   yr/ans   Années
          5 min     44.6     65.2     78.8     96.0    108.8    121.5       36
                +/-   7.0 +/- 11.8 +/- 15.9 +/- 21.4 +/- 25.6 +/- 29.9       36
         10 min     30.2     43.5     52.3     63.5     71.7     79.9       36
```

```
                +/-  4.5 +/-  7.6 +/- 10.3 +/- 13.8 +/- 16.6 +/- 19.3       36
         15 min     24.0     35.7     43.5     53.3     60.6     67.9       36
                +/-  4.0 +/-  6.7 +/-  9.1 +/- 12.2 +/- 14.6 +/- 17.0       36
         30 min     14.8     22.1     27.0     33.1     37.6     42.1       36
                +/-  2.5 +/-  4.2 +/-  5.6 +/-  7.6 +/-  9.1 +/- 10.6       36
          1 h        9.0     12.7     15.2     18.3     20.6     22.9       36
                +/-  1.3 +/-  2.1 +/-  2.9 +/-  3.9 +/-  4.6 +/-  5.4       36
          2 h        5.7      7.7      9.0     10.6     11.9     13.1       36
                +/-  0.7 +/-  1.1 +/-  1.5 +/-  2.1 +/-  2.5 +/-  2.9       36
          6 h        2.6      3.3      3.8      4.4      4.8      5.3       34
                +/-  0.2 +/-  0.4 +/-  0.6 +/-  0.8 +/-  0.9 +/-  1.1       34
         12 h        1.6      2.0      2.3      2.6      2.9      3.1       34
                +/-  0.1 +/-  0.2 +/-  0.3 +/-  0.4 +/-  0.5 +/-  0.6       34
         24 h        1.0      1.2      1.3      1.5      1.6      1.7       36
                +/-  0.1 +/-  0.1 +/-  0.2 +/-  0.2 +/-  0.3 +/-  0.3       36

********************************************************************************

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************

       Statistics/Statistiques      2      5     10     25     50    100
                               yr/ans yr/ans yr/ans yr/ans yr/ans yr/ans
      Mean of RR/Moyenne de RR   14.8   21.5   25.9   31.5   35.6   39.7
    Std. Dev. /Écart-type (RR)   15.2   22.3   27.1   33.1   37.5   41.9
        Std. Error/Erreur-type    1.6    3.5    4.8    6.6    7.9    9.2
               Coefficient (A)    8.9   12.2   14.5   17.3   19.3   21.4
         Exponent/Exposant (B) -0.685 -0.723 -0.738 -0.753 -0.761 -0.767
 Mean % Error/% erreur moyenne    3.0    5.1    6.0    6.8    7.3    7.7
```

Attachment B

PCSWMM Model Outputs

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
--------------------------------------------------------------

Create proposed conditions scenario for final Landfill closure plan.
Include external pond to accept drainage from western catchment & diversion ditch to direct dra
Create SWM pond for Landfill Drainage & outlet west to the storm sewer under Glenmore Rd. N. vi


*************
Element Count
*************
Number of rain gages ...... 3
Number of subcatchments ... 20
Number of nodes ........... 28
Number of links ........... 29
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                    Data       Recording
Name                 Data Source                    Type       Interval 
------------------------------------------------------------------------
100yr_SCS_Type_II_41.9mm SCS_Type_II_41.9mm             INTENSITY    6 min.
10yr_SCS_Type_II_31.4mm SCS_Type_II_31.4mm             INTENSITY    6 min.
5yr_SCS_Type_II_28mm SCS_Type_II_28mm               INTENSITY    6 min.


********************
Subcatchment Summary
********************
Name                           Area     Width   %Imperv    %Slope Rain Gage            Outlet    
-----------------------------------------------------------------------------------------------
S101                           5.61    140.18     30.00   30.0000 5yr_SCS_Type_II_28mm PJ10                
S102                          13.79    344.86     30.00   30.0000 5yr_SCS_Type_II_28mm PJ09                
S103                           5.64    140.93     30.00   30.0000 5yr_SCS_Type_II_28mm MJ01                
S104                          12.51    312.68     30.00   30.0000 5yr_SCS_Type_II_28mm MJ02                
S105                           5.30    132.56     30.00   30.0000 5yr_SCS_Type_II_28mm MJ04                
S106                           6.97    174.20     30.00   30.0000 5yr_SCS_Type_II_28mm J1                  
S107                          10.05    251.15     30.00   30.0000 5yr_SCS_Type_II_28mm MJ05                
S108                           4.49    112.37     30.00   30.0000 5yr_SCS_Type_II_28mm PJ05                
S109                           6.61    165.30     30.00   30.0000 5yr_SCS_Type_II_28mm PJ06                
S110                          10.56    263.98     30.00   30.0000 5yr_SCS_Type_II_28mm PJ07                
S111                          13.38    334.49     30.00   30.0000 5yr_SCS_Type_II_28mm PJ08                
S200                           1.15     50.00    100.00    0.5000 5yr_SCS_Type_II_28mm S_Pond              
S201                          19.55    407.29     30.00    2.0000 5yr_SCS_Type_II_28mm S_Pond              
S202                           4.78    167.86     30.00    4.0000 5yr_SCS_Type_II_28mm S_Pond              
S203                          27.36    651.31     30.00   14.0000 5yr_SCS_Type_II_28mm PJ01                
S204                          16.89     47.39     25.00    3.0000 5yr_SCS_Type_II_28mm Bredin_Pond         
S205                           1.90    189.91    100.00    0.5000 5yr_SCS_Type_II_28mm Bredin_Pond         
S206                         102.14   1201.64     25.00    5.0000 5yr_SCS_Type_II_28mm NE_Pond             
S301                         293.53    927.14     25.00    3.0000 5yr_SCS_Type_II_28mm NW_Pond             
S302                         245.66    919.40     25.00    5.0000 5yr_SCS_Type_II_28mm JCW                 


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                 Type                 Elev.     Depth      Area    Inflow  
-------------------------------------------------------------------------------
```

```
CW_CTRL_MH           JUNCTION            445.00      3.00       0.0
J01                  JUNCTION            437.00      1.00       0.0
J02                  JUNCTION            440.00      2.10       0.0
J03                  JUNCTION            440.80      2.00       0.0
J05                  JUNCTION            439.00      1.50       0.0
J1                   JUNCTION            443.00      1.00       0.0
JCW                  JUNCTION            471.00      1.00       0.0
MJ01                 JUNCTION            440.00      1.00       0.0
MJ02                 JUNCTION            447.00      1.00       0.0
MJ03                 JUNCTION            443.00      1.00       0.0
MJ04                 JUNCTION            447.00      1.00       0.0
MJ05                 JUNCTION            441.00      1.00       0.0
PJ01                 JUNCTION            437.50      1.00       0.0
PJ02                 JUNCTION            437.80      1.00       0.0
PJ03                 JUNCTION            438.00      2.00       0.0
PJ04                 JUNCTION            438.57      2.05       0.0
PJ05                 JUNCTION            445.00      1.00       0.0
PJ06                 JUNCTION            479.50      1.00       0.0
PJ07                 JUNCTION            479.50      1.00       0.0
PJ08                 JUNCTION            525.00      1.00       0.0
PJ09                 JUNCTION            460.00      1.00       0.0
PJ10                 JUNCTION            525.00      1.00       0.0
Glenmore_Road        OUTFALL             440.00      0.00       0.0
S_Outfall            OUTFALL             436.00      0.60       0.0
Bredin_Pond          STORAGE             435.80      3.85       0.0
NE_Pond              STORAGE             440.90      1.00       0.0
NW_Pond              STORAGE             445.00      3.50       0.0
S_Pond               STORAGE             435.50      2.00       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
BP_OUTLET        Bredin_Pond      PJ04             CONDUIT           12.0    0.5000    0.0240
MC01_x2          J01              S_Pond           CONDUIT           16.0    3.1265    0.0240
MC02             MJ01             PJ01             CONDUIT           16.0   15.8193    0.0240
MC03             MJ02             PJ02             CONDUIT           16.0   70.2802    0.0240
MC04             MJ03             PJ03             CONDUIT           16.0   30.0173    0.0240
MC05             J05              Bredin_Pond      CONDUIT           12.0    3.0848    0.0240
MD01             MJ01             J01              CONDUIT          177.5    1.6906    0.0350
MD02             MJ02             MJ01             CONDUIT          399.7    1.7517    0.0350
MD03             J1               J05              CONDUIT          425.9    0.9392    0.0350
MD04             MJ04             MJ03             CONDUIT          146.9    2.7234    0.0350
MD05             MJ05             J05              CONDUIT          318.9    0.6271    0.0350
NEP_OUTLET       NE_Pond          J03              CONDUIT           12.0    0.8334    0.0240
NEP_P01          J03              J01              CONDUIT         1450.0    0.2621    0.0130
NWP_OUTLET       NW_Pond          CW_CTRL_MH       CONDUIT            6.0    8.3624    0.0240
OFFS_DITCH       JCW              NW_Pond          CONDUIT         1829.3    1.3668    0.0350
OFFS_PIPE        CW_CTRL_MH       S_Outfall        CONDUIT         2422.2    0.3716    0.0130
PC01             J02              Bredin_Pond      CONDUIT          277.1    0.4944    0.0240
PD01             PJ01             S_Pond           CONDUIT          208.3    0.4800    0.0350
PD02             PJ02             PJ01             CONDUIT          408.8    0.0734    0.0350
PD03             PJ03             PJ02             CONDUIT          158.5    0.1262    0.0350
PD04             PJ04             PJ03             CONDUIT          408.6    0.1395    0.0350
PD05             PJ05             J02              CONDUIT          181.9    2.7500    0.0350
PD06             PJ06             PJ05             CONDUIT          536.5    6.4440    0.0350
PD07             PJ07             J03              CONDUIT          444.6    8.7374    0.0350
PD08             PJ08             J03              CONDUIT          415.9   20.6747    0.0350
PD09             PJ09             J01              CONDUIT          719.4    3.1989    0.0350
PD10             PJ10             PJ09             CONDUIT          323.3   20.5243    0.0350
S_Pond_Pump      S_Pond           Glenmore_Road    TYPE4 PUMP
W1               Bredin_Pond      PJ04             WEIR
```

```
*********************
Cross Section Summary
*********************
                                      Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape               Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
BP_OUTLET        CIRCULAR             0.45     0.16     0.11     0.45        1     0.11
MC01_x2          CIRCULAR             0.82     0.53     0.21     0.82        2     1.38
MC02             CIRCULAR             0.60     0.28     0.15     0.60        1     1.32
MC03             CIRCULAR             0.60     0.28     0.15     0.60        1     2.79
MC04             CIRCULAR             0.60     0.28     0.15     0.60        1     1.82
MC05             CIRCULAR             0.82     0.53     0.21     0.82        1     1.37
MD01             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.56
MD02             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.59
MD03             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.17
MD04             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.98
MD05             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     0.95
NEP_OUTLET       CIRCULAR             0.45     0.16     0.11     0.45        1     0.14
NEP_P01          CIRCULAR             0.75     0.44     0.19     0.75        1     0.57
NWP_OUTLET       CIRCULAR             0.53     0.22     0.13     0.53        1     0.67
OFFS_DITCH       TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     8.93
OFFS_PIPE        CIRCULAR             0.60     0.28     0.15     0.60        1     0.37
PC01             CIRCULAR             0.75     0.44     0.19     0.75        1     0.42
PD01             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     5.29
PD02             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.07
PD03             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.71
PD04             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.85
PD05             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    12.66
PD06             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    19.39
PD07             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    22.57
PD08             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.72
PD09             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    13.66
PD10             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.60


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ 02/21/2018 00:00:00
Ending Date .............. 02/25/2018 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:10
Wet Time Step ............ 00:00:10
Dry Time Step ............ 00:00:10
```

```
Routing Time Step ........ 5.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 4
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......        22.621        28.000
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........        15.979        19.779
Surface Runoff ...........         6.473         8.013
Final Storage ............         0.168         0.209
Continuity Error (%) .....        -0.000


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         6.473        64.728
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         6.532        65.321
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         3.535        35.346
Final Stored Volume ......         3.469        34.685
Continuity Error (%) .....         0.067


*************************
Highest Continuity Errors
*************************
Node J02 (1.83%)


***************************
Time-Step Critical Elements
***************************
Link NWP_OUTLET (58.58%)
Link NEP_OUTLET (13.27%)


********************************
Highest Flow Instability Indexes
********************************
Link MC01_x2 (6)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     3.02 sec
Maximum Time Step           :     5.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
Percent Not Converging      :     0.00
```

```
***************************
Subcatchment Runoff Summary
***************************

-----------------------------------------------------------------------------------------------
                                Total      Total      Total      Total      Total       Total     Pea
                               Precip      Runon       Evap      Infil     Runoff      Runoff   Runof
Subcatchment                       mm         mm         mm         mm         mm    10^6 ltr      CM
-----------------------------------------------------------------------------------------------
S101                            28.00       0.00       0.00      12.08      15.91        0.89     0.2
S102                            28.00       0.00       0.00      12.08      15.91        2.19     0.5
S103                            28.00       0.00       0.00      12.08      15.91        0.90     0.2
S104                            28.00       0.00       0.00      12.07      15.91        1.99     0.5
S105                            28.00       0.00       0.00      12.07      15.91        0.84     0.2
S106                            28.00       0.00       0.00      12.08      15.91        1.11     0.3
S107                            28.00       0.00       0.00      12.07      15.91        1.60     0.4
S108                            28.00       0.00       0.00      12.08      15.91        0.72     0.1
S109                            28.00       0.00       0.00      12.08      15.91        1.05     0.2
S110                            28.00       0.00       0.00      12.08      15.91        1.68     0.4
S111                            28.00       0.00       0.00      12.08      15.91        2.13     0.5
S200                            28.00       0.00       0.00       0.00      27.95        0.32     0.0
S201                            28.00       0.00       0.00      19.57       8.41        1.64     0.4
S202                            28.00       0.00       0.00      19.53       8.45        0.40     0.1
S203                            28.00       0.00       0.00      19.52       8.47        2.32     0.8
S204                            28.00       0.00       0.00      21.00       6.75        1.14     0.1
S205                            28.00       0.00       0.00       0.00      28.00        0.53     0.1
S206                            28.00       0.00       0.00      21.00       6.75        6.89     1.8
S301                            28.00       0.00       0.00      21.00       6.75       19.80     3.1
S302                            28.00       0.00       0.00      21.00       6.75       16.58     3.2


******************
Node Depth Summary
******************

---------------------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max    Reported
                                 Depth    Depth      HGL   Occurrence   Max Depth
Node                 Type       Meters   Meters   Meters  days hr:min      Meters
---------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.25     0.90   445.90     0  15:49        0.90
J01                  JUNCTION     0.13     0.67   437.67     0  12:15        0.67
J02                  JUNCTION     0.03     0.56   440.56     0  12:07        0.56
J03                  JUNCTION     0.14     0.52   441.32     0  12:05        0.52
J05                  JUNCTION     0.04     0.55   439.55     0  12:09        0.55
J1                   JUNCTION     0.01     0.26   443.26     0  12:00        0.26
JCW                  JUNCTION     0.05     0.54   471.54     0  12:11        0.54
MJ01                 JUNCTION     0.01     0.28   440.28     0  12:00        0.28
MJ02                 JUNCTION     0.01     0.25   447.25     0  11:54        0.25
MJ03                 JUNCTION     0.01     0.33   443.33     0  12:01        0.33
MJ04                 JUNCTION     0.01     0.19   447.19     0  11:54        0.19
MJ05                 JUNCTION     0.02     0.34   441.34     0  12:00        0.34
PJ01                 JUNCTION     0.09     0.52   438.02     0  12:01        0.52
PJ02                 JUNCTION     0.10     0.35   438.15     0  12:17        0.35
PJ03                 JUNCTION     0.08     0.26   438.26     0  12:07        0.26
PJ04                 JUNCTION     0.07     0.20   438.77     0  14:48        0.20
PJ05                 JUNCTION     0.01     0.20   445.20     0  12:00        0.20
PJ06                 JUNCTION     0.01     0.12   479.62     0  11:55        0.12
PJ07                 JUNCTION     0.01     0.15   479.65     0  11:54        0.15
PJ08                 JUNCTION     0.01     0.14   525.14     0  11:54        0.14
PJ09                 JUNCTION     0.01     0.26   460.26     0  12:00        0.26
PJ10                 JUNCTION     0.00     0.09   525.09     0  11:54        0.09
Glenmore_Road        OUTFALL      0.00     0.00   440.00     0  00:00        0.00
```

```
S_Outfall            OUTFALL       0.19     0.40   436.40     0  15:49        0.40
Bredin_Pond          STORAGE       2.96     3.19   438.99     0  14:39        3.19
NE_Pond              STORAGE       0.17     0.34   441.24     0  13:56        0.34
NW_Pond              STORAGE       0.80     1.36   446.36     0  15:49        1.36
S_Pond               STORAGE       0.12     0.87   436.37     0  15:24        0.87


*******************
Node Inflow Summary
*******************

-----------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total       Fl
                                Lateral    Total  Time of Max      Inflow      Inflow     Balan
                                 Inflow   Inflow   Occurrence      Volume      Volume       Err
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Perce
-----------------------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.000    0.493    0  13:32           0        34.5       0.0
J01                  JUNCTION     0.000    1.569    0  12:00           0        18.5       0.1
J02                  JUNCTION     0.000    0.411    0  12:00           0        1.77       1.8
J03                  JUNCTION     0.000    0.978    0  11:54           0        14.1       0.3
J05                  JUNCTION     0.000    0.644    0  12:00           0        2.73       0.8
J1                   JUNCTION     0.300    0.300    0  11:54        1.11        1.11      -0.9
JCW                  JUNCTION     3.231    3.231    0  12:00        16.6        16.6       2.9
MJ01                 JUNCTION     0.243    0.585    0  11:54       0.897        2.26      -0.2
MJ02                 JUNCTION     0.539    0.539    0  11:54        1.99        1.99      -0.1
MJ03                 JUNCTION     0.000    0.221    0  11:54           0       0.844       0.0
MJ04                 JUNCTION     0.228    0.228    0  11:54       0.844       0.844      -0.0
MJ05                 JUNCTION     0.433    0.433    0  11:54         1.6         1.6      -0.6
PJ01                 JUNCTION     0.807    0.998    0  11:54        2.32        9.99      -0.0
PJ02                 JUNCTION     0.000    0.279    0  12:00           0        7.04       0.3
PJ03                 JUNCTION     0.000    0.208    0  12:02           0        6.41      -0.0
PJ04                 JUNCTION     0.000    0.097    0  14:38           0        5.58       0.1
PJ05                 JUNCTION     0.194    0.443    0  11:54       0.715        1.77      -0.1
PJ06                 JUNCTION     0.285    0.285    0  11:54        1.05        1.05      -0.0
PJ07                 JUNCTION     0.455    0.455    0  11:54        1.68        1.68      -0.4
PJ08                 JUNCTION     0.576    0.576    0  11:54        2.13        2.13      -0.3
PJ09                 JUNCTION     0.594    0.826    0  11:54        2.19        3.09      -0.9
PJ10                 JUNCTION     0.242    0.242    0  11:54       0.892       0.892      -0.0
Glenmore_Road        OUTFALL      0.000    0.400    0  12:00           0        30.8       0.0
S_Outfall            OUTFALL      0.000    0.379    0  15:49           0        34.5       0.0
Bredin_Pond          STORAGE      0.318    0.986    0  12:03        1.67        24.2      -0.0
NE_Pond              STORAGE      1.877    1.975    0  12:00        6.89        11.6      -0.0
NW_Pond              STORAGE      3.164    4.744    0  12:02        19.8        48.7      -0.8
S_Pond               STORAGE      0.656    2.293    0  12:00        2.37        30.9       0.1


**********************
Node Surcharge Summary
**********************

Surcharging occurs when water rises above the top of the highest conduit.
---------------------------------------------------------------------
                                             Max. Height   Min. Depth
                                 Hours       Above Crown    Below Rim
Node                 Type      Surcharged        Meters       Meters
---------------------------------------------------------------------
CW_CTRL_MH           JUNCTION       14.29         0.305        2.095


*********************
Node Flooding Summary
*********************
```

```
No nodes were flooded.


**********************
Storage Volume Summary
**********************

-----------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maxi
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outf
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min
-----------------------------------------------------------------------------------------------
Bredin_Pond             19.569      64     0     0        22.380      73       0  14:39      0.
NE_Pond                  3.881      12     0     0         8.195      25       0  13:56      0.
NW_Pond                 20.698      20     0     0        36.008      36       0  15:49      0.
S_Pond                   1.007       5     0     0         7.776      39       0  15:24      0.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                       Flow       Avg       Max       Total
                       Freq      Flow      Flow      Volume
Outfall Node           Pcnt       CMS       CMS    10^6 ltr
-----------------------------------------------------------
Glenmore_Road         99.75     0.100     0.400      30.805
S_Outfall             96.38     0.124     0.379      34.515
-----------------------------------------------------------
System                98.06     0.224     0.779      65.321


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
-----------------------------------------------------------------------------
BP_OUTLET            CONDUIT     0.097     0  14:38      0.92    0.89    0.63
MC01_x2              CONDUIT     1.034     0  12:15      1.63    0.38    0.62
MC02                 CONDUIT     0.135     0  12:00      0.70    0.10    0.66
MC03                 CONDUIT     0.157     0  11:54      1.51    0.06    0.45
MC04                 CONDUIT     0.201     0  12:00      1.98    0.11    0.39
MC05                 CONDUIT     0.461     0  12:04      1.62    0.34    0.52
MD01                 CONDUIT     0.408     0  12:00      0.76    0.26    0.78
MD02                 CONDUIT     0.348     0  11:54      1.06    0.22    0.53
MD03                 CONDUIT     0.261     0  12:00      0.54    0.22    0.76
MD04                 CONDUIT     0.221     0  11:54      0.79    0.11    0.51
MD05                 CONDUIT     0.383     0  12:00      0.69    0.40    0.83
NEP_OUTLET           CONDUIT     0.106     0  12:04      1.15    0.75    0.85
NEP_P01              CONDUIT     0.476     0  12:05      1.38    0.84    0.78
NWP_OUTLET           CONDUIT     0.493     0  13:32      2.28    0.73    1.00
OFFS_DITCH           CONDUIT     2.091     0  12:12      1.60    0.23    0.51
OFFS_PIPE            CONDUIT     0.379     0  15:49      1.54    1.01    0.84
PC01                 CONDUIT     0.293     0  12:08      1.07    0.69    0.59
PD01                 CONDUIT     0.768     0  12:01      0.85    0.15    0.41
PD02                 CONDUIT     0.207     0  12:17      0.26    0.10    0.42
PD03                 CONDUIT     0.153     0  12:07      0.27    0.06    0.30
PD04                 CONDUIT     0.097     0  14:48      0.28    0.03    0.22
PD05                 CONDUIT     0.411     0  12:00      0.70    0.03    0.37
```

```
PD06                 CONDUIT     0.258     0  11:55       1.15    0.01    0.16
PD07                 CONDUIT     0.425     0  11:54       0.82    0.02    0.33
PD08                 CONDUIT     0.555     0  11:54       1.12    0.02    0.32
PD09                 CONDUIT     0.713     0  12:00       1.02    0.05    0.43
PD10                 CONDUIT     0.233     0  11:54       1.00    0.01    0.17
S_Pond_Pump          PUMP        0.400     0  12:00               1.00
W1                   WEIR        0.000     0  00:00                       0.00


***************************
Flow Classification Summary
***************************

-------------------------------------------------------------------------------------
                    Adjusted    ---------- Fraction of Time in Flow Class ----------
                     /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
-------------------------------------------------------------------------------------
BP_OUTLET               1.00   0.00  0.00  0.00  0.99  0.00  0.00  0.00  0.00  0.00
MC01_x2                 1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  0.99
MC02                    1.00   0.00  0.13  0.00  0.86  0.00  0.00  0.00  0.00  1.00
MC03                    1.00   0.00  0.38  0.00  0.60  0.02  0.00  0.00  0.00  1.00
MC04                    1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  1.00
MC05                    1.00   0.00  0.19  0.00  0.71  0.00  0.00  0.10  0.00  0.99
MD01                    1.00   0.00  0.14  0.00  0.86  0.00  0.00  0.00  0.99  0.00
MD02                    1.00   0.10  0.29  0.00  0.62  0.00  0.00  0.00  0.46  0.00
MD03                    1.00   0.02  0.03  0.00  0.94  0.00  0.00  0.00  0.41  0.00
MD04                    1.00   0.00  0.21  0.00  0.79  0.00  0.00  0.00  0.99  0.00
MD05                    1.00   0.01  0.01  0.00  0.98  0.00  0.00  0.00  0.40  0.00
NEP_OUTLET              1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.00  0.63
NEP_P01                 1.00   0.00  0.00  0.00  0.99  0.01  0.00  0.00  0.05  0.00
NWP_OUTLET              1.00   0.02  0.00  0.00  0.94  0.03  0.00  0.00  0.00  0.80
OFFS_DITCH              1.00   0.02  0.00  0.00  0.14  0.00  0.00  0.84  0.15  0.00
OFFS_PIPE               1.00   0.02  0.00  0.00  0.97  0.01  0.00  0.00  0.00  0.00
PC01                    1.00   0.00  0.14  0.00  0.76  0.00  0.00  0.10  0.00  0.87
PD01                    1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  0.00
PD02                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.14  0.00
PD03                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.99  0.00
PD04                    1.00   0.00  0.01  0.00  0.98  0.00  0.00  0.00  0.97  0.00
PD05                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.49  0.00
PD06                    1.00   0.01  0.29  0.00  0.70  0.01  0.00  0.00  0.77  0.00
PD07                    1.00   0.00  0.26  0.00  0.74  0.00  0.00  0.00  1.00  0.00
PD08                    1.00   0.00  0.30  0.00  0.70  0.00  0.00  0.00  1.00  0.00
PD09                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.99  0.00
PD10                    1.00   0.01  0.40  0.00  0.59  0.00  0.00  0.00  0.84  0.00


*************************
Conduit Surcharge Summary
*************************

----------------------------------------------------------------------------
                                                         Hours        Hours
                       --------- Hours Full --------   Above Full   Capacity
Conduit                Both Ends  Upstream  Dnstream   Normal Flow   Limited
----------------------------------------------------------------------------
MD01                        0.01      0.01      1.08      0.01         0.01
MD03                        0.01      0.01      0.43      0.01         0.01
MD05                        0.01      0.01      0.43      0.01         0.01
NEP_OUTLET                  0.01      0.01      0.55      0.01         0.01
NWP_OUTLET                 14.57     15.74     14.64      0.01         0.10
OFFS_PIPE                   0.01     14.29      0.01     11.47         0.01
```

```
***************
Pumping Summary
***************

---------------------------------------------------------------------------------------------
                                                   Min       Avg       Max     Total     Power
                     Percent   Number of          Flow      Flow      Flow    Volume     Usage
Pump                Utilized   Start-Ups           CMS       CMS       CMS  10^6 ltr     Kw-hr
---------------------------------------------------------------------------------------------
S_Pond_Pump            99.58           1          0.00      0.10      0.40    30.805    344.37


Analysis begun on:  Fri Jul 13 17:11:13 2018
Analysis ended on:  Fri Jul 13 17:11:23 2018
Total elapsed time: 00:00:10
```

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
--------------------------------------------------------------

Create proposed conditions scenario for final Landfill closure plan.
Include external pond to accept drainage from western catchment & diversion ditch to direct dra
Create SWM pond for Landfill Drainage & outlet west to the storm sewer under Glenmore Rd. N. vi


*************
Element Count
*************
Number of rain gages ...... 3
Number of subcatchments ... 20
Number of nodes ........... 28
Number of links ........... 29
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                    Data       Recording
Name                 Data Source                    Type       Interval 
------------------------------------------------------------------------
100yr_SCS_Type_II_41.9mm SCS_Type_II_41.9mm             INTENSITY    6 min.
10yr_SCS_Type_II_31.4mm SCS_Type_II_31.4mm             INTENSITY    6 min.
5yr_SCS_Type_II_28mm SCS_Type_II_28mm               INTENSITY    6 min.


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------
S101                       5.61    140.18     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ10
S102                      13.79    344.86     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ09
S103                       5.64    140.93     30.00   30.0000 10yr_SCS_Type_II_31.4mm MJ01
S104                      12.51    312.68     30.00   30.0000 10yr_SCS_Type_II_31.4mm MJ02
S105                       5.30    132.56     30.00   30.0000 10yr_SCS_Type_II_31.4mm MJ04
S106                       6.97    174.20     30.00   30.0000 10yr_SCS_Type_II_31.4mm J1
S107                      10.05    251.15     30.00   30.0000 10yr_SCS_Type_II_31.4mm MJ05
S108                       4.49    112.37     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ05
S109                       6.61    165.30     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ06
S110                      10.56    263.98     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ07
S111                      13.38    334.49     30.00   30.0000 10yr_SCS_Type_II_31.4mm PJ08
S200                       1.15     50.00    100.00    0.5000 10yr_SCS_Type_II_31.4mm S_Pond
S201                      19.55    407.29     30.00    2.0000 10yr_SCS_Type_II_31.4mm S_Pond
S202                       4.78    167.86     30.00    4.0000 10yr_SCS_Type_II_31.4mm S_Pond
S203                      27.36    651.31     30.00   14.0000 10yr_SCS_Type_II_31.4mm PJ01
S204                      16.89     47.39     25.00    3.0000 10yr_SCS_Type_II_31.4mm Bredin_Po
S205                       1.90    189.91    100.00    0.5000 10yr_SCS_Type_II_31.4mm Bredin_Po
S206                     102.14   1201.64     25.00    5.0000 10yr_SCS_Type_II_31.4mm NE_Pond
S301                     293.53    927.14     25.00    3.0000 10yr_SCS_Type_II_31.4mm NW_Pond
S302                     245.66    919.40     25.00    5.0000 10yr_SCS_Type_II_31.4mm JCW


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                 Type                 Elev.     Depth      Area    Inflow  
-------------------------------------------------------------------------------
```

```
CW_CTRL_MH           JUNCTION            445.00      3.00       0.0
J01                  JUNCTION            437.00      1.00       0.0
J02                  JUNCTION            440.00      2.10       0.0
J03                  JUNCTION            440.80      2.00       0.0
J05                  JUNCTION            439.00      1.50       0.0
J1                   JUNCTION            443.00      1.00       0.0
JCW                  JUNCTION            471.00      1.00       0.0
MJ01                 JUNCTION            440.00      1.00       0.0
MJ02                 JUNCTION            447.00      1.00       0.0
MJ03                 JUNCTION            443.00      1.00       0.0
MJ04                 JUNCTION            447.00      1.00       0.0
MJ05                 JUNCTION            441.00      1.00       0.0
PJ01                 JUNCTION            437.50      1.00       0.0
PJ02                 JUNCTION            437.80      1.00       0.0
PJ03                 JUNCTION            438.00      2.00       0.0
PJ04                 JUNCTION            438.57      2.05       0.0
PJ05                 JUNCTION            445.00      1.00       0.0
PJ06                 JUNCTION            479.50      1.00       0.0
PJ07                 JUNCTION            479.50      1.00       0.0
PJ08                 JUNCTION            525.00      1.00       0.0
PJ09                 JUNCTION            460.00      1.00       0.0
PJ10                 JUNCTION            525.00      1.00       0.0
Glenmore_Road        OUTFALL             440.00      0.00       0.0
S_Outfall            OUTFALL             436.00      0.60       0.0
Bredin_Pond          STORAGE             435.80      3.85       0.0
NE_Pond              STORAGE             440.90      1.00       0.0
NW_Pond              STORAGE             445.00      3.50       0.0
S_Pond               STORAGE             435.50      2.00       0.0


************
Link Summary
************
Name             From Node        To Node          Type                Length    %Slope Roughness
---------------------------------------------------------------------------------------------
BP_OUTLET        Bredin_Pond      PJ04             CONDUIT               12.0    0.5000    0.0240
MC01_x2          J01              S_Pond           CONDUIT               16.0    3.1265    0.0240
MC02             MJ01             PJ01             CONDUIT               16.0   15.8193    0.0240
MC03             MJ02             PJ02             CONDUIT               16.0   70.2802    0.0240
MC04             MJ03             PJ03             CONDUIT               16.0   30.0173    0.0240
MC05             J05              Bredin_Pond      CONDUIT               12.0    3.0848    0.0240
MD01             MJ01             J01              CONDUIT              177.5    1.6906    0.0350
MD02             MJ02             MJ01             CONDUIT              399.7    1.7517    0.0350
MD03             J1               J05              CONDUIT              425.9    0.9392    0.0350
MD04             MJ04             MJ03             CONDUIT              146.9    2.7234    0.0350
MD05             MJ05             J05              CONDUIT              318.9    0.6271    0.0350
NEP_OUTLET       NE_Pond          J03              CONDUIT               12.0    0.8334    0.0240
NEP_P01          J03              J01              CONDUIT             1450.0    0.2621    0.0130
NWP_OUTLET       NW_Pond          CW_CTRL_MH       CONDUIT                6.0    8.3624    0.0240
OFFS_DITCH       JCW              NW_Pond          CONDUIT             1829.3    1.3668    0.0350
OFFS_PIPE        CW_CTRL_MH       S_Outfall        CONDUIT             2422.2    0.3716    0.0130
PC01             J02              Bredin_Pond      CONDUIT              277.1    0.4944    0.0240
PD01             PJ01             S_Pond           CONDUIT              208.3    0.4800    0.0350
PD02             PJ02             PJ01             CONDUIT              408.8    0.0734    0.0350
PD03             PJ03             PJ02             CONDUIT              158.5    0.1262    0.0350
PD04             PJ04             PJ03             CONDUIT              408.6    0.1395    0.0350
PD05             PJ05             J02              CONDUIT              181.9    2.7500    0.0350
PD06             PJ06             PJ05             CONDUIT              536.5    6.4440    0.0350
PD07             PJ07             J03              CONDUIT              444.6    8.7374    0.0350
PD08             PJ08             J03              CONDUIT              415.9   20.6747    0.0350
PD09             PJ09             J01              CONDUIT              719.4    3.1989    0.0350
PD10             PJ10             PJ09             CONDUIT              323.3   20.5243    0.0350
S_Pond_Pump      S_Pond           Glenmore_Road    TYPE4 PUMP
W1               Bredin_Pond      PJ04             WEIR
```

```
*********************
Cross Section Summary
*********************
                                      Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape               Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
BP_OUTLET        CIRCULAR             0.45     0.16     0.11     0.45        1     0.11
MC01_x2          CIRCULAR             0.82     0.53     0.21     0.82        2     1.38
MC02             CIRCULAR             0.60     0.28     0.15     0.60        1     1.32
MC03             CIRCULAR             0.60     0.28     0.15     0.60        1     2.79
MC04             CIRCULAR             0.60     0.28     0.15     0.60        1     1.82
MC05             CIRCULAR             0.82     0.53     0.21     0.82        1     1.37
MD01             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.56
MD02             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.59
MD03             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.17
MD04             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.98
MD05             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     0.95
NEP_OUTLET       CIRCULAR             0.45     0.16     0.11     0.45        1     0.14
NEP_P01          CIRCULAR             0.75     0.44     0.19     0.75        1     0.57
NWP_OUTLET       CIRCULAR             0.53     0.22     0.13     0.53        1     0.67
OFFS_DITCH       TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     8.93
OFFS_PIPE        CIRCULAR             0.60     0.28     0.15     0.60        1     0.37
PC01             CIRCULAR             0.75     0.44     0.19     0.75        1     0.42
PD01             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     5.29
PD02             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.07
PD03             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.71
PD04             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.85
PD05             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    12.66
PD06             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    19.39
PD07             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    22.57
PD08             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.72
PD09             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    13.66
PD10             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.60


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ 02/21/2018 00:00:00
Ending Date .............. 02/25/2018 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:10
Wet Time Step ............ 00:00:10
Dry Time Step ............ 00:00:10
```

```
Routing Time Step ........ 5.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 4
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......        25.367        31.400
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........        17.845        22.089
Surface Runoff ...........         7.354         9.103
Final Storage ............         0.168         0.209
Continuity Error (%) .....        -0.000


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         7.353        73.534
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         7.401        74.009
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         3.535        35.346
Final Stored Volume ......         3.479        34.786
Continuity Error (%) .....         0.078


*************************
Highest Continuity Errors
*************************
Node J02 (1.90%)
Node PJ09 (-1.04%)
Node NW_Pond (-1.01%)


***************************
Time-Step Critical Elements
***************************
Link NWP_OUTLET (57.35%)
Link NEP_OUTLET (13.08%)
Link BP_OUTLET (3.68%)


********************************
Highest Flow Instability Indexes
********************************
Link MC01_x2 (7)
Link MC05 (1)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     3.02 sec
Maximum Time Step           :     5.00 sec
```

```
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
Percent Not Converging      :     0.00


***************************
Subcatchment Runoff Summary
***************************

-----------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total     Pea
                         Precip      Runon       Evap      Infil     Runoff      Runoff   Runof
Subcatchment                 mm         mm         mm         mm         mm    10^6 ltr      CM
-----------------------------------------------------------------------------------------------
S101                      31.40       0.00       0.00      12.92      18.47        1.04     0.2
S102                      31.40       0.00       0.00      12.92      18.47        2.55     0.6
S103                      31.40       0.00       0.00      12.92      18.47        1.04     0.2
S104                      31.40       0.00       0.00      12.92      18.47        2.31     0.6
S105                      31.40       0.00       0.00      12.92      18.47        0.98     0.2
S106                      31.40       0.00       0.00      12.92      18.47        1.29     0.3
S107                      31.40       0.00       0.00      12.92      18.47        1.86     0.5
S108                      31.40       0.00       0.00      12.92      18.47        0.83     0.2
S109                      31.40       0.00       0.00      12.92      18.47        1.22     0.3
S110                      31.40       0.00       0.00      12.92      18.47        1.95     0.5
S111                      31.40       0.00       0.00      12.92      18.47        2.47     0.6
S200                      31.40       0.00       0.00       0.00      31.35        0.36     0.0
S201                      31.40       0.00       0.00      21.79       9.60        1.88     0.5
S202                      31.40       0.00       0.00      21.59       9.80        0.47     0.1
S203                      31.40       0.00       0.00      21.51       9.88        2.70     0.9
S204                      31.40       0.00       0.00      23.55       7.60        1.28     0.2
S205                      31.40       0.00       0.00       0.00      31.40        0.60     0.1
S206                      31.40       0.00       0.00      23.55       7.60        7.76     2.1
S301                      31.40       0.00       0.00      23.55       7.60       22.30     3.6
S302                      31.40       0.00       0.00      23.55       7.60       18.67     3.7


******************
Node Depth Summary
******************

---------------------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max    Reported
                                 Depth    Depth      HGL   Occurrence   Max Depth
Node                 Type       Meters   Meters   Meters  days hr:min      Meters
---------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.28     1.01   446.01     0  16:08        1.01
J01                  JUNCTION     0.13     0.74   437.74     0  12:15        0.74
J02                  JUNCTION     0.03     0.63   440.63     0  12:08        0.63
J03                  JUNCTION     0.14     0.58   441.38     0  12:06        0.58
J05                  JUNCTION     0.04     0.61   439.61     0  12:09        0.61
J1                   JUNCTION     0.01     0.28   443.28     0  12:00        0.28
JCW                  JUNCTION     0.05     0.58   471.58     0  12:10        0.58
MJ01                 JUNCTION     0.01     0.30   440.30     0  12:00        0.30
MJ02                 JUNCTION     0.01     0.27   447.27     0  11:54        0.27
MJ03                 JUNCTION     0.02     0.39   443.39     0  12:00        0.39
MJ04                 JUNCTION     0.01     0.20   447.20     0  11:54        0.20
MJ05                 JUNCTION     0.02     0.36   441.36     0  12:00        0.36
PJ01                 JUNCTION     0.10     0.55   438.05     0  12:01        0.55
PJ02                 JUNCTION     0.10     0.38   438.18     0  12:16        0.38
PJ03                 JUNCTION     0.08     0.29   438.29     0  12:08        0.29
PJ04                 JUNCTION     0.07     0.23   438.80     0  14:43        0.23
PJ05                 JUNCTION     0.01     0.22   445.22     0  12:00        0.22
PJ06                 JUNCTION     0.01     0.13   479.63     0  11:55        0.13
PJ07                 JUNCTION     0.01     0.16   479.66     0  11:54        0.16
```

```
PJ08                 JUNCTION     0.01     0.15   525.15     0  11:54        0.15
PJ09                 JUNCTION     0.01     0.28   460.28     0  12:00        0.28
PJ10                 JUNCTION     0.00     0.09   525.09     0  11:54        0.09
Glenmore_Road        OUTFALL      0.00     0.00   440.00     0  00:00        0.00
S_Outfall            OUTFALL      0.20     0.40   436.40     0  16:08        0.40
Bredin_Pond          STORAGE      2.96     3.24   439.04     0  14:32        3.24
NE_Pond              STORAGE      0.18     0.36   441.26     0  13:58        0.36
NW_Pond              STORAGE      0.83     1.47   446.47     0  16:08        1.47
S_Pond               STORAGE      0.15     1.07   436.57     0  15:53        1.07


*******************
Node Inflow Summary
*******************

-----------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Fl
                                Lateral    Total  Time of Max      Inflow      Inflow     Balan
                                 Inflow   Inflow   Occurrence      Volume      Volume       Err
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Perce
-----------------------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.000    0.506     0  13:04           0          39       0.0
J01                  JUNCTION     0.000    1.827     0  12:00           0        20.7       0.2
J02                  JUNCTION     0.000    0.479     0  12:00           0        2.05       1.9
J03                  JUNCTION     0.000    1.134     0  11:54           0        15.6       0.3
J05                  JUNCTION     0.000    0.750     0  12:00           0        3.16       0.9
J1                   JUNCTION     0.347    0.347     0  11:54        1.29        1.29      -0.8
JCW                  JUNCTION     3.741    3.741     0  12:00        18.7        18.7       3.4
MJ01                 JUNCTION     0.281    0.679     0  11:54        1.04        2.62      -0.1
MJ02                 JUNCTION     0.623    0.623     0  11:54        2.31        2.31      -0.0
MJ03                 JUNCTION     0.000    0.256     0  11:54           0        0.98       0.1
MJ04                 JUNCTION     0.264    0.264     0  11:54       0.979       0.979      -0.1
MJ05                 JUNCTION     0.501    0.501     0  11:54        1.86        1.85      -0.6
PJ01                 JUNCTION     0.928    1.161     0  11:54         2.7        11.6      -0.0
PJ02                 JUNCTION     0.000    0.320     0  12:00           0        8.19       0.3
PJ03                 JUNCTION     0.000    0.234     0  12:01           0        7.46      -0.0
PJ04                 JUNCTION     0.000    0.117     0  14:32           0        6.49       0.1
PJ05                 JUNCTION     0.224    0.515     0  11:54        0.83        2.05      -0.1
PJ06                 JUNCTION     0.329    0.329     0  11:54        1.22        1.22      -0.0
PJ07                 JUNCTION     0.526    0.526     0  11:54        1.95        1.95      -0.4
PJ08                 JUNCTION     0.667    0.667     0  11:54        2.47        2.47      -0.3
PJ09                 JUNCTION     0.687    0.955     0  11:54        2.55        3.58      -1.0
PJ10                 JUNCTION     0.279    0.279     0  11:54        1.04        1.04      -0.0
Glenmore_Road        OUTFALL      0.000    0.400     0  11:58           0          35       0.0
S_Outfall            OUTFALL      0.000    0.381     0  16:08           0          39       0.0
Bredin_Pond          STORAGE      0.365    1.103     0  12:00        1.88        25.1      -0.0
NE_Pond              STORAGE      2.141    2.241     0  12:00        7.76        12.5      -0.0
NW_Pond              STORAGE      3.687    5.556     0  12:01        22.3        53.1      -0.9
S_Pond               STORAGE      0.757    2.475     0  11:58        2.71          35       0.0


**********************
Node Surcharge Summary
**********************

Surcharging occurs when water rises above the top of the highest conduit.
---------------------------------------------------------------------
                                             Max. Height   Min. Depth
                                 Hours       Above Crown    Below Rim
Node                 Type      Surcharged         Meters       Meters
---------------------------------------------------------------------
CW_CTRL_MH           JUNCTION       17.96          0.413        1.987
```

```
*********************
Node Flooding Summary
*********************

No nodes were flooded.


**********************
Storage Volume Summary
**********************

-----------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maxi
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outf
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min
-----------------------------------------------------------------------------------------------
Bredin_Pond             19.612      64     0     0        22.987      75       0  14:32       0.
NE_Pond                  3.985      12     0     0         8.916      28       0  13:58       0.
NW_Pond                 21.456      21     0     0        39.200      39       0  16:08       0.
S_Pond                   1.319       7     0     0         9.822      50       0  15:53       0.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                       Flow       Avg       Max       Total
                       Freq      Flow      Flow      Volume
Outfall Node           Pcnt       CMS       CMS    10^6 ltr
-----------------------------------------------------------
Glenmore_Road         99.77     0.106     0.400      34.981
S_Outfall             96.64     0.133     0.381      39.027
-----------------------------------------------------------
System                98.20     0.239     0.781      74.008


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
-----------------------------------------------------------------------------
BP_OUTLET            CONDUIT     0.117     0  14:32      0.98    1.07    0.70
MC01_x2              CONDUIT     1.204     0  12:19      1.63    0.44    0.68
MC02                 CONDUIT     0.144     0  11:55      0.73    0.11    0.71
MC03                 CONDUIT     0.180     0  11:54      1.54    0.06    0.49
MC04                 CONDUIT     0.224     0  12:00      2.01    0.12    0.45
MC05                 CONDUIT     0.461     0  12:30      1.62    0.34    0.57
MD01                 CONDUIT     0.493     0  12:00      0.77    0.31    0.80
MD02                 CONDUIT     0.405     0  11:54      1.09    0.25    0.57
MD03                 CONDUIT     0.304     0  12:00      0.55    0.26    0.78
MD04                 CONDUIT     0.256     0  11:54      0.80    0.13    0.58
MD05                 CONDUIT     0.446     0  12:00      0.70    0.47    0.86
NEP_OUTLET           CONDUIT     0.123     0  12:05      1.15    0.87    0.89
NEP_P01              CONDUIT     0.535     0  12:06      1.40    0.94    0.87
NWP_OUTLET           CONDUIT     0.506     0  13:04      2.34    0.75    1.00
OFFS_DITCH           CONDUIT     2.436     0  12:11      1.66    0.27    0.55
OFFS_PIPE            CONDUIT     0.381     0  16:08      1.54    1.02    0.84
PC01                 CONDUIT     0.338     0  12:08      1.10    0.80    0.66
PD01                 CONDUIT     0.891     0  12:01      0.89    0.17    0.44
```

```
PD02                 CONDUIT     0.247     0  12:16       0.27    0.12    0.45
PD03                 CONDUIT     0.181     0  12:08       0.28    0.07    0.33
PD04                 CONDUIT     0.117     0  14:43       0.29    0.04    0.24
PD05                 CONDUIT     0.479     0  12:00       0.72    0.04    0.41
PD06                 CONDUIT     0.300     0  11:55       1.19    0.02    0.17
PD07                 CONDUIT     0.493     0  11:54       0.85    0.02    0.36
PD08                 CONDUIT     0.642     0  11:54       1.16    0.02    0.35
PD09                 CONDUIT     0.831     0  12:00       1.04    0.06    0.48
PD10                 CONDUIT     0.270     0  11:54       1.03    0.01    0.18
S_Pond_Pump          PUMP        0.400     0  11:58               1.00
W1                   WEIR        0.000     0  00:00                       0.00


***************************
Flow Classification Summary
***************************

-------------------------------------------------------------------------------------
                    Adjusted    ---------- Fraction of Time in Flow Class ----------
                     /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
-------------------------------------------------------------------------------------
BP_OUTLET               1.00   0.00  0.00  0.00  0.99  0.00  0.00  0.00  0.00  0.00
MC01_x2                 1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  0.99
MC02                    1.00   0.00  0.14  0.00  0.85  0.00  0.00  0.00  0.00  1.00
MC03                    1.00   0.00  0.40  0.00  0.58  0.02  0.00  0.00  0.00  1.00
MC04                    1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  1.00
MC05                    1.00   0.00  0.20  0.00  0.70  0.00  0.00  0.10  0.00  0.99
MD01                    1.00   0.00  0.14  0.00  0.86  0.00  0.00  0.00  0.99  0.00
MD02                    1.00   0.10  0.30  0.00  0.60  0.00  0.00  0.00  0.47  0.00
MD03                    1.00   0.02  0.03  0.00  0.94  0.00  0.00  0.00  0.41  0.00
MD04                    1.00   0.00  0.22  0.00  0.77  0.00  0.00  0.00  0.99  0.00
MD05                    1.00   0.01  0.01  0.00  0.98  0.00  0.00  0.00  0.40  0.00
NEP_OUTLET              1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.00  0.61
NEP_P01                 1.00   0.00  0.00  0.00  0.99  0.01  0.00  0.00  0.03  0.00
NWP_OUTLET              1.00   0.02  0.00  0.00  0.95  0.03  0.00  0.00  0.00  0.77
OFFS_DITCH              1.00   0.02  0.00  0.00  0.17  0.00  0.00  0.81  0.19  0.00
OFFS_PIPE               1.00   0.02  0.00  0.00  0.97  0.01  0.00  0.00  0.00  0.00
PC01                    1.00   0.00  0.15  0.00  0.74  0.00  0.00  0.10  0.00  0.87
PD01                    1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  0.00
PD02                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.13  0.00
PD03                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.98  0.00
PD04                    1.00   0.00  0.01  0.00  0.98  0.00  0.00  0.00  0.98  0.00
PD05                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.49  0.00
PD06                    1.00   0.01  0.30  0.00  0.68  0.01  0.00  0.00  0.77  0.00
PD07                    1.00   0.00  0.27  0.00  0.73  0.00  0.00  0.00  1.00  0.00
PD08                    1.00   0.00  0.32  0.00  0.68  0.00  0.00  0.00  1.00  0.00
PD09                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.99  0.00
PD10                    1.00   0.01  0.42  0.00  0.56  0.00  0.00  0.00  0.84  0.00


*************************
Conduit Surcharge Summary
*************************

----------------------------------------------------------------------------
                                                         Hours        Hours
                       --------- Hours Full --------   Above Full   Capacity
Conduit                Both Ends  Upstream  Dnstream   Normal Flow   Limited
----------------------------------------------------------------------------
BP_OUTLET                   0.01      0.01      0.01       2.81         0.01
MD01                        0.01      0.01      1.32       0.01         0.01
MD03                        0.01      0.01      0.66       0.01         0.01
MD05                        0.01      0.01      0.66       0.01         0.01
```

```
NEP_OUTLET                  0.01      0.01      0.80      0.01         0.01
NWP_OUTLET                 18.21     19.06     18.29      0.01         0.09
OFFS_PIPE                   0.01     17.95      0.01     15.36         0.01


***************
Pumping Summary
***************

-----------------------------------------------------------------------------------------------
                                                Min       Avg       Max     Total     Power
                      Percent   Number of      Flow      Flow      Flow    Volume     Usage
Pump                 Utilized   Start-Ups       CMS       CMS       CMS  10^6 ltr     Kw-hr
-----------------------------------------------------------------------------------------------
S_Pond_Pump             99.62           1      0.00      0.11      0.40    34.981    378.69


Analysis begun on:  Fri Jul 13 17:10:12 2018
Analysis ended on:  Fri Jul 13 17:10:21 2018
Total elapsed time: 00:00:09
```

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
--------------------------------------------------------------

Create proposed conditions scenario for final Landfill closure plan.
Include external pond to accept drainage from western catchment & diversion ditch to direct dra
Create SWM pond for Landfill Drainage & outlet west to the storm sewer under Glenmore Rd. N. vi


*************
Element Count
*************
Number of rain gages ...... 3
Number of subcatchments ... 20
Number of nodes ........... 28
Number of links ........... 29
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                    Data       Recording
Name                 Data Source                    Type       Interval
------------------------------------------------------------------------
100yr_SCS_Type_II_41.9mm SCS_Type_II_41.9mm             INTENSITY    6 min.
10yr_SCS_Type_II_31.4mm SCS_Type_II_31.4mm             INTENSITY    6 min.
5yr_SCS_Type_II_28mm SCS_Type_II_28mm               INTENSITY    6 min.


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------
S101                       5.61    140.18     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ10
S102                      13.79    344.86     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ09
S103                       5.64    140.93     30.00   30.0000 100yr_SCS_Type_II_41.9mm MJ01
S104                      12.51    312.68     30.00   30.0000 100yr_SCS_Type_II_41.9mm MJ02
S105                       5.30    132.56     30.00   30.0000 100yr_SCS_Type_II_41.9mm MJ04
S106                       6.97    174.20     30.00   30.0000 100yr_SCS_Type_II_41.9mm J1
S107                      10.05    251.15     30.00   30.0000 100yr_SCS_Type_II_41.9mm MJ05
S108                       4.49    112.37     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ05
S109                       6.61    165.30     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ06
S110                      10.56    263.98     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ07
S111                      13.38    334.49     30.00   30.0000 100yr_SCS_Type_II_41.9mm PJ08
S200                       1.15     50.00    100.00    0.5000 100yr_SCS_Type_II_41.9mm S_Pond
S201                      19.55    407.29     30.00    2.0000 100yr_SCS_Type_II_41.9mm S_Pond
S202                       4.78    167.86     30.00    4.0000 100yr_SCS_Type_II_41.9mm S_Pond
S203                      27.36    651.31     30.00   14.0000 100yr_SCS_Type_II_41.9mm PJ01
S204                      16.89     47.39     25.00    3.0000 100yr_SCS_Type_II_41.9mm Bredin_P
S205                       1.90    189.91    100.00    0.5000 100yr_SCS_Type_II_41.9mm Bredin_P
S206                     102.14   1201.64     25.00    5.0000 100yr_SCS_Type_II_41.9mm NE_Pond
S301                     293.53    927.14     25.00    3.0000 100yr_SCS_Type_II_41.9mm NW_Pond
S302                     245.66    919.40     25.00    5.0000 100yr_SCS_Type_II_41.9mm JCW


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                 Type                 Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
```

```
CW_CTRL_MH           JUNCTION            445.00      3.00       0.0
J01                  JUNCTION            437.00      1.00       0.0
J02                  JUNCTION            440.00      2.10       0.0
J03                  JUNCTION            440.80      2.00       0.0
J05                  JUNCTION            439.00      1.50       0.0
J1                   JUNCTION            443.00      1.00       0.0
JCW                  JUNCTION            471.00      1.00       0.0
MJ01                 JUNCTION            440.00      1.00       0.0
MJ02                 JUNCTION            447.00      1.00       0.0
MJ03                 JUNCTION            443.00      1.00       0.0
MJ04                 JUNCTION            447.00      1.00       0.0
MJ05                 JUNCTION            441.00      1.00       0.0
PJ01                 JUNCTION            437.50      1.00       0.0
PJ02                 JUNCTION            437.80      1.00       0.0
PJ03                 JUNCTION            438.00      2.00       0.0
PJ04                 JUNCTION            438.57      2.05       0.0
PJ05                 JUNCTION            445.00      1.00       0.0
PJ06                 JUNCTION            479.50      1.00       0.0
PJ07                 JUNCTION            479.50      1.00       0.0
PJ08                 JUNCTION            525.00      1.00       0.0
PJ09                 JUNCTION            460.00      1.00       0.0
PJ10                 JUNCTION            525.00      1.00       0.0
Glenmore_Road        OUTFALL             440.00      0.00       0.0
S_Outfall            OUTFALL             436.00      0.60       0.0
Bredin_Pond          STORAGE             435.80      3.85       0.0
NE_Pond              STORAGE             440.90      1.00       0.0
NW_Pond              STORAGE             445.00      3.50       0.0
S_Pond               STORAGE             435.50      2.00       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
BP_OUTLET        Bredin_Pond      PJ04             CONDUIT           12.0    0.5000    0.0240
MC01_x2          J01              S_Pond           CONDUIT           16.0    3.1265    0.0240
MC02             MJ01             PJ01             CONDUIT           16.0   15.8193    0.0240
MC03             MJ02             PJ02             CONDUIT           16.0   70.2802    0.0240
MC04             MJ03             PJ03             CONDUIT           16.0   30.0173    0.0240
MC05             J05              Bredin_Pond      CONDUIT           12.0    3.0848    0.0240
MD01             MJ01             J01              CONDUIT          177.5    1.6906    0.0350
MD02             MJ02             MJ01             CONDUIT          399.7    1.7517    0.0350
MD03             J1               J05              CONDUIT          425.9    0.9392    0.0350
MD04             MJ04             MJ03             CONDUIT          146.9    2.7234    0.0350
MD05             MJ05             J05              CONDUIT          318.9    0.6271    0.0350
NEP_OUTLET       NE_Pond          J03              CONDUIT           12.0    0.8334    0.0240
NEP_P01          J03              J01              CONDUIT         1450.0    0.2621    0.0130
NWP_OUTLET       NW_Pond          CW_CTRL_MH       CONDUIT            6.0    8.3624    0.0240
OFFS_DITCH       JCW              NW_Pond          CONDUIT         1829.3    1.3668    0.0350
OFFS_PIPE        CW_CTRL_MH       S_Outfall        CONDUIT         2422.2    0.3716    0.0130
PC01             J02              Bredin_Pond      CONDUIT          277.1    0.4944    0.0240
PD01             PJ01             S_Pond           CONDUIT          208.3    0.4800    0.0350
PD02             PJ02             PJ01             CONDUIT          408.8    0.0734    0.0350
PD03             PJ03             PJ02             CONDUIT          158.5    0.1262    0.0350
PD04             PJ04             PJ03             CONDUIT          408.6    0.1395    0.0350
PD05             PJ05             J02              CONDUIT          181.9    2.7500    0.0350
PD06             PJ06             PJ05             CONDUIT          536.5    6.4440    0.0350
PD07             PJ07             J03              CONDUIT          444.6    8.7374    0.0350
PD08             PJ08             J03              CONDUIT          415.9   20.6747    0.0350
PD09             PJ09             J01              CONDUIT          719.4    3.1989    0.0350
PD10             PJ10             PJ09             CONDUIT          323.3   20.5243    0.0350
S_Pond_Pump      S_Pond           Glenmore_Road    TYPE4 PUMP
W1               Bredin_Pond      PJ04             WEIR
```

```
*********************
Cross Section Summary
*********************
                                      Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape               Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
BP_OUTLET        CIRCULAR             0.45     0.16     0.11     0.45        1     0.11
MC01_x2          CIRCULAR             0.82     0.53     0.21     0.82        2     1.38
MC02             CIRCULAR             0.60     0.28     0.15     0.60        1     1.32
MC03             CIRCULAR             0.60     0.28     0.15     0.60        1     2.79
MC04             CIRCULAR             0.60     0.28     0.15     0.60        1     1.82
MC05             CIRCULAR             0.82     0.53     0.21     0.82        1     1.37
MD01             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.56
MD02             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.59
MD03             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.17
MD04             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     1.98
MD05             TRAPEZOIDAL          0.50     1.00     0.27     3.50        1     0.95
NEP_OUTLET       CIRCULAR             0.45     0.16     0.11     0.45        1     0.14
NEP_P01          CIRCULAR             0.75     0.44     0.19     0.75        1     0.57
NWP_OUTLET       CIRCULAR             0.53     0.22     0.13     0.53        1     0.67
OFFS_DITCH       TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     8.93
OFFS_PIPE        CIRCULAR             0.60     0.28     0.15     0.60        1     0.37
PC01             CIRCULAR             0.75     0.44     0.19     0.75        1     0.42
PD01             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     5.29
PD02             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.07
PD03             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.71
PD04             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1     2.85
PD05             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    12.66
PD06             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    19.39
PD07             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    22.57
PD08             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.72
PD09             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    13.66
PD10             TRAPEZOIDAL          1.00     4.00     0.55     7.00        1    34.60


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
Flow Routing Method ...... DYNWAVE
Starting Date ............ 02/21/2018 00:00:00
Ending Date .............. 02/25/2018 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:00:10
Wet Time Step ............ 00:00:10
Dry Time Step ............ 00:00:10
```

```
Routing Time Step ........ 5.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 4
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......        33.850        41.900
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........        23.254        28.784
Surface Runoff ...........        10.428        12.908
Final Storage ............         0.169         0.209
Continuity Error (%) .....        -0.000


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......        10.427       104.274
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........        10.424       104.240
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         3.535        35.346
Final Stored Volume ......         3.522        35.222
Continuity Error (%) .....         0.113


*************************
Highest Continuity Errors
*************************
Node J02 (2.06%)
Node NW_Pond (-1.32%)
Node PJ09 (-1.14%)
Node J05 (1.05%)


***************************
Time-Step Critical Elements
***************************
Link NWP_OUTLET (54.88%)
Link NEP_OUTLET (23.16%)
Link BP_OUTLET (5.58%)


********************************
Highest Flow Instability Indexes
********************************
Link MC01_x2 (8)
Link MC05 (1)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     2.88 sec
```

```
Maximum Time Step           :     5.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
Percent Not Converging      :     0.00


***************************
Subcatchment Runoff Summary
***************************

-----------------------------------------------------------------------------------------------
                          Total      Total      Total      Total      Total       Total    Pea
                         Precip      Runon       Evap      Infil     Runoff      Runoff  Runof
Subcatchment                 mm         mm         mm         mm         mm    10^6 ltr     CM
-----------------------------------------------------------------------------------------------
S101                      41.90       0.00       0.00      15.22      26.66        1.50    0.4
S102                      41.90       0.00       0.00      15.22      26.66        3.68    0.9
S103                      41.90       0.00       0.00      15.22      26.66        1.50    0.4
S104                      41.90       0.00       0.00      15.22      26.66        3.33    0.9
S105                      41.90       0.00       0.00      15.22      26.66        1.41    0.3
S106                      41.90       0.00       0.00      15.22      26.66        1.86    0.5
S107                      41.90       0.00       0.00      15.22      26.66        2.68    0.7
S108                      41.90       0.00       0.00      15.22      26.66        1.20    0.3
S109                      41.90       0.00       0.00      15.22      26.66        1.76    0.4
S110                      41.90       0.00       0.00      15.22      26.66        2.82    0.7
S111                      41.90       0.00       0.00      15.22      26.66        3.57    0.9
S200                      41.90       0.00       0.00       0.00      41.85        0.48    0.1
S201                      41.90       0.00       0.00      26.97      14.92        2.92    0.7
S202                      41.90       0.00       0.00      25.69      16.20        0.77    0.2
S203                      41.90       0.00       0.00      25.34      16.55        4.53    1.3
S204                      41.90       0.00       0.00      31.24      10.40        1.76    0.3
S205                      41.90       0.00       0.00       0.00      41.90        0.80    0.2
S206                      41.90       0.00       0.00      30.62      11.03       11.26    3.0
S301                      41.90       0.00       0.00      31.22      10.42       30.60    5.4
S302                      41.90       0.00       0.00      31.12      10.52       25.86    5.4


******************
Node Depth Summary
******************

---------------------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max    Reported
                                 Depth    Depth      HGL   Occurrence   Max Depth
Node                 Type       Meters   Meters   Meters  days hr:min      Meters
---------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.43     1.38   446.38     0  17:13        1.38
J01                  JUNCTION     0.15     0.94   437.94     0  12:13        0.94
J02                  JUNCTION     0.04     0.89   440.89     0  12:11        0.89
J03                  JUNCTION     0.16     0.81   441.61     0  12:16        0.81
J05                  JUNCTION     0.05     0.80   439.80     0  12:09        0.80
J1                   JUNCTION     0.02     0.33   443.33     0  12:00        0.33
JCW                  JUNCTION     0.06     0.69   471.69     0  12:08        0.69
MJ01                 JUNCTION     0.02     0.36   440.36     0  12:00        0.36
MJ02                 JUNCTION     0.02     0.33   447.33     0  11:54        0.33
MJ03                 JUNCTION     0.02     0.53   443.53     0  12:00        0.53
MJ04                 JUNCTION     0.01     0.24   447.24     0  11:54        0.24
MJ05                 JUNCTION     0.02     0.43   441.43     0  12:00        0.42
PJ01                 JUNCTION     0.09     0.66   438.16     0  12:01        0.66
PJ02                 JUNCTION     0.13     0.48   438.28     0  12:13        0.48
PJ03                 JUNCTION     0.09     0.37   438.37     0  12:10        0.37
PJ04                 JUNCTION     0.08     0.27   438.84     0  14:43        0.27
PJ05                 JUNCTION     0.01     0.26   445.26     0  12:00        0.26
PJ06                 JUNCTION     0.01     0.17   479.67     0  11:55        0.17
```

```
PJ07                 JUNCTION     0.01     0.20   479.70     0  11:54        0.20
PJ08                 JUNCTION     0.01     0.18   525.18     0  11:54        0.18
PJ09                 JUNCTION     0.02     0.33   460.33     0  12:00        0.33
PJ10                 JUNCTION     0.00     0.11   525.11     0  11:54        0.11
Glenmore_Road        OUTFALL      0.00     0.00   440.00     0  00:00        0.00
S_Outfall            OUTFALL      0.23     0.41   436.41     0  17:13        0.41
Bredin_Pond          STORAGE      2.98     3.40   439.20     0  14:33        3.40
NE_Pond              STORAGE      0.20     0.47   441.37     0  14:26        0.47
NW_Pond              STORAGE      0.97     1.86   446.86     0  17:13        1.86
S_Pond               STORAGE      0.37     1.80   437.30     0  17:42        1.80


*******************
Node Inflow Summary
*******************

-----------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Fl
                                Lateral    Total  Time of Max      Inflow      Inflow     Balan
                                 Inflow   Inflow   Occurrence      Volume      Volume       Err
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Perce
-----------------------------------------------------------------------------------------------
CW_CTRL_MH           JUNCTION     0.000    0.544     0  12:31           0        54.2       0.0
J01                  JUNCTION     0.000    2.569     0  12:00           0        28.6       0.1
J02                  JUNCTION     0.000    0.706     0  12:00           0        2.97       2.1
J03                  JUNCTION     0.000    1.647     0  11:54           0        21.3       0.3
J05                  JUNCTION     0.000    1.100     0  12:00           0        4.56       1.0
J1                   JUNCTION     0.502    0.502     0  11:54        1.86        1.86      -0.6
JCW                  JUNCTION     5.462    5.462     0  12:00        25.9        25.9       4.0
MJ01                 JUNCTION     0.406    0.993     0  11:54         1.5        3.79      -0.1
MJ02                 JUNCTION     0.901    0.901     0  11:54        3.33        3.33      -0.0
MJ03                 JUNCTION     0.000    0.371     0  11:54           0        1.42       0.1
MJ04                 JUNCTION     0.382    0.382     0  11:54        1.41        1.41      -0.1
MJ05                 JUNCTION     0.724    0.724     0  11:54        2.68        2.68      -0.4
PJ01                 JUNCTION     1.366    1.677     0  11:54        4.53        17.4       0.2
PJ02                 JUNCTION     0.000    0.457     0  12:00           0        11.9       0.3
PJ03                 JUNCTION     0.000    0.346     0  12:01           0        10.8      -0.0
PJ04                 JUNCTION     0.000    0.168     0  14:33           0        9.42       0.1
PJ05                 JUNCTION     0.324    0.751     0  11:54         1.2        2.96      -0.2
PJ06                 JUNCTION     0.476    0.476     0  11:54        1.76        1.76      -0.0
PJ07                 JUNCTION     0.760    0.760     0  11:54        2.82        2.82      -0.6
PJ08                 JUNCTION     0.964    0.964     0  11:54        3.57        3.57      -0.4
PJ09                 JUNCTION     0.994    1.383     0  11:54        3.68        5.17      -1.1
PJ10                 JUNCTION     0.404    0.404     0  11:54         1.5         1.5      -0.0
Glenmore_Road        OUTFALL      0.000    0.400     0  11:51           0          50       0.0
S_Outfall            OUTFALL      0.000    0.389     0  17:13           0        54.2       0.0
Bredin_Pond          STORAGE      0.519    1.469     0  12:00        2.55        28.1      -0.1
NE_Pond              STORAGE      3.060    3.175     0  12:00        11.3        16.4      -0.0
NW_Pond              STORAGE      5.459    8.354     0  12:00        30.6        68.2      -1.3
S_Pond               STORAGE      1.103    3.688     0  11:59        4.17        50.1      -0.0


**********************
Node Surcharge Summary
**********************

Surcharging occurs when water rises above the top of the highest conduit.
----------------------------------------------------------------------
                                             Max. Height   Min. Depth
                                 Hours       Above Crown    Below Rim
Node                 Type      Surcharged         Meters       Meters
----------------------------------------------------------------------
CW_CTRL_MH           JUNCTION       29.07          0.783        1.617
```

```
*********************
Node Flooding Summary
*********************

No nodes were flooded.


**********************
Storage Volume Summary
**********************

-----------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maxi
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outf
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min
-----------------------------------------------------------------------------------------------
Bredin_Pond             19.887      65     0     0        24.962      81       0  14:33      0.
NE_Pond                  4.686      14     0     0        12.065      37       0  14:26      0.
NW_Pond                 25.445      25     0     0        50.386      50       0  17:13      0.
S_Pond                   3.463      18     0     0        17.570      89       0  17:42      0.


***********************
Outfall Loading Summary
***********************

-----------------------------------------------------------
                       Flow       Avg       Max       Total
                       Freq      Flow      Flow      Volume
Outfall Node           Pcnt       CMS       CMS    10^6 ltr
-----------------------------------------------------------
Glenmore_Road         99.82     0.141     0.400      50.030
S_Outfall             97.34     0.168     0.389      54.209
-----------------------------------------------------------
System                98.58     0.309     0.789     104.240


********************
Link Flow Summary
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
-----------------------------------------------------------------------------
BP_OUTLET            CONDUIT     0.168     0  14:33      1.23    1.54    0.80
MC01_x2              CONDUIT     1.642     0  12:13      1.84    0.60    0.78
MC02                 CONDUIT     0.196     0  11:55      0.82    0.15    0.80
MC03                 CONDUIT     0.251     0  11:54      1.64    0.09    0.61
MC04                 CONDUIT     0.326     0  12:00      2.01    0.18    0.59
MC05                 CONDUIT     0.660     0  12:09      1.62    0.48    0.73
MD01                 CONDUIT     0.753     0  12:00      0.97    0.48    0.86
MD02                 CONDUIT     0.596     0  11:54      1.18    0.37    0.68
MD03                 CONDUIT     0.447     0  12:00      0.62    0.38    0.83
MD04                 CONDUIT     0.371     0  11:54      0.80    0.19    0.73
MD05                 CONDUIT     0.653     0  12:00      0.75    0.69    0.93
NEP_OUTLET           CONDUIT     0.190     0  12:14      1.23    1.34    1.00
NEP_P01              CONDUIT     0.599     0  11:59      1.42    1.05    1.00
NWP_OUTLET           CONDUIT     0.544     0  12:31      2.51    0.81    1.00
OFFS_DITCH           CONDUIT     3.626     0  12:09      1.83    0.41    0.66
OFFS_PIPE            CONDUIT     0.389     0  17:13      1.54    1.04    0.84
PC01                 CONDUIT     0.433     0  12:11      1.19    1.02    0.77
```

```
PD01                 CONDUIT     1.355     0  12:01      1.00    0.26    0.53
PD02                 CONDUIT     0.390     0  12:15      0.34    0.19    0.55
PD03                 CONDUIT     0.262     0  12:09      0.28    0.10    0.42
PD04                 CONDUIT     0.168     0  14:43      0.32    0.06    0.29
PD05                 CONDUIT     0.706     0  12:00      0.74    0.06    0.55
PD06                 CONDUIT     0.438     0  11:55      1.32    0.02    0.21
PD07                 CONDUIT     0.717     0  11:54      0.91    0.03    0.47
PD08                 CONDUIT     0.931     0  11:54      1.25    0.03    0.46
PD09                 CONDUIT     1.224     0  12:00      1.07    0.09    0.60
PD10                 CONDUIT     0.392     0  11:54      1.14    0.01    0.22
S_Pond_Pump          PUMP        0.400     0  11:51              1.00
W1                   WEIR        0.000     0  00:00                      0.00


***************************
Flow Classification Summary
***************************

-------------------------------------------------------------------------------------
                    Adjusted    ---------- Fraction of Time in Flow Class ----------
                     /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
Conduit               Length   Dry   Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
-------------------------------------------------------------------------------------
BP_OUTLET               1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.00  0.00
MC01_x2                 1.00   0.00  0.00  0.00  0.17  0.00  0.00  0.83  0.00  0.91
MC02                    1.00   0.00  0.19  0.00  0.81  0.00  0.00  0.00  0.00  1.00
MC03                    1.00   0.00  0.46  0.00  0.52  0.01  0.00  0.00  0.00  1.00
MC04                    1.00   0.00  0.00  0.00  0.00  0.00  0.00  1.00  0.00  1.00
MC05                    1.00   0.00  0.24  0.00  0.67  0.00  0.00  0.09  0.00  0.94
MD01                    1.00   0.00  0.19  0.00  0.81  0.00  0.00  0.00  0.99  0.00
MD02                    1.00   0.12  0.34  0.00  0.53  0.00  0.00  0.00  0.47  0.00
MD03                    1.00   0.02  0.03  0.00  0.95  0.00  0.00  0.00  0.42  0.00
MD04                    1.00   0.00  0.26  0.00  0.73  0.00  0.00  0.00  0.99  0.00
MD05                    1.00   0.01  0.01  0.00  0.98  0.00  0.00  0.00  0.40  0.00
NEP_OUTLET              1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.00  0.52
NEP_P01                 1.00   0.00  0.00  0.00  0.99  0.01  0.00  0.00  0.07  0.00
NWP_OUTLET              1.00   0.01  0.00  0.00  0.96  0.03  0.00  0.00  0.00  0.66
OFFS_DITCH              1.00   0.01  0.00  0.00  0.28  0.00  0.00  0.71  0.31  0.00
OFFS_PIPE               1.00   0.02  0.00  0.00  0.98  0.00  0.00  0.00  0.00  0.00
PC01                    1.00   0.00  0.19  0.00  0.72  0.00  0.00  0.09  0.00  0.88
PD01                    1.00   0.00  0.00  0.00  0.18  0.00  0.00  0.82  0.00  0.18
PD02                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.13  0.00
PD03                    1.00   0.00  0.00  0.00  1.00  0.00  0.00  0.00  0.89  0.00
PD04                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.98  0.00
PD05                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.50  0.00
PD06                    1.00   0.01  0.36  0.00  0.62  0.01  0.00  0.00  0.77  0.00
PD07                    1.00   0.00  0.32  0.00  0.68  0.00  0.00  0.00  1.00  0.00
PD08                    1.00   0.00  0.38  0.00  0.62  0.00  0.00  0.00  1.00  0.00
PD09                    1.00   0.00  0.01  0.00  0.99  0.00  0.00  0.00  0.99  0.00
PD10                    1.00   0.01  0.49  0.00  0.50  0.00  0.00  0.00  0.85  0.00


*************************
Conduit Surcharge Summary
*************************

----------------------------------------------------------------------------
                                                         Hours        Hours
                       --------- Hours Full --------   Above Full   Capacity
Conduit                Both Ends  Upstream  Dnstream   Normal Flow   Limited
----------------------------------------------------------------------------
BP_OUTLET                   0.01      6.67      0.01      9.09         0.01
MC01_x2                     0.01      0.64      0.01      0.01         0.01
MC02                        0.01      0.01      0.29      0.01         0.01
```

```
MD01                        0.01      0.01      1.94      0.01         0.01
MD03                        0.01      0.01      1.12      0.01         0.01
MD04                        0.01      0.01      0.12      0.01         0.01
MD05                        0.01      0.01      1.12      0.01         0.01
NEP_OUTLET                  0.52      4.05      1.71      4.99         0.08
NEP_P01                     0.53      0.53      0.92      0.32         0.01
NWP_OUTLET                 29.30     29.83     29.38      0.01         0.07
OFFS_PIPE                   0.01     29.07      0.01     26.58         0.01
PC01                        0.01      0.47      0.01      0.30         0.01


***************
Pumping Summary
***************

-----------------------------------------------------------------------------------------------
                                                Min       Avg       Max     Total     Power
                      Percent   Number of      Flow      Flow      Flow    Volume     Usage
Pump                 Utilized   Start-Ups       CMS       CMS       CMS  10^6 ltr     Kw-hr
-----------------------------------------------------------------------------------------------
S_Pond_Pump             99.69           1      0.00      0.14      0.40    50.030    472.24


Analysis begun on:  Fri Jul 13 17:07:26 2018
Analysis ended on:  Fri Jul 13 17:07:35 2018
Total elapsed time: 00:00:09
```

Appendix I

Leachate Management Plan

Memorandum

Draft for Review

July 13, 2018

To:	Scott Hoekstra, Kevin Wahl	Ref. No.:	084612-22
From:	Dan Turner, Deacon Liddy/cs/03	Tel:	604-214-0510

Subject: **Leachate Management Plan**
Glenmore Landfill
Kelowna, British Columbia

1. Introduction

GHD was retained by the City of Kelowna (City) to prepare a Leachate Management Plan (LMP) for the Glenmore Landfill (Landfill or Site) located in Kelowna, British Columbia (BC).

The Landfill currently operates under the existing Operational Certificate 12218, provided in Attachment A. The Site has been managed in accordance with the Comprehensive Site Development Plan prepared by CH2M Hill in June 2008. GHD is in the process of preparing a Design Operation and Closure Plan (DOCP) for the Site and this LMP has been prepared for use in the DOCP. This LMP has been prepared to provide short-term and long-term solutions for leachate collection, storage, treatment, and disposal at the Site. This LMP has been prepared in accordance with the BC Ministry of Environment (MOE) Landfill Criteria for Municipal Solid Waste, June 2016.

1.1 Background

The Glenmore Landfill is the long-term disposal and waste management centre for the City of Kelowna and serves communities within the Regional District of Central Okanagan. The estimated lifespan is greater than 75 years. Filling is currently taking place in the Phase 1 and 2 area on the existing waste footprint. Phase 1 and 2 comprise the northern and middle portions of the Landfill and have approximately 2 to 3 years of capacity remaining on the current waste footprint.

In 2016, the new Site entrance works were commissioned at the southeast corner of the Site and use of the former public drop-off area adjacent to Phase 1 was discontinued.

The long-term development plan is to extend the footprint of Phase 1 over the former drop-off area and east to Bredin Hill, extend Phase 2 east to Tutt Mountain, and develop Phase 3 south of Phase 2. Generally, the fill progression will be from north to south.

1.2 Objectives

The objectives of the leachate management plan are to provide methods for Landfill leachate collection, treatment, and disposal; estimate leachate generation rates; forecast leachate quality; and identify the discharge requirements that are protective of groundwater, surface water, and the receiving environment.

2. Leachate Management Works

This section presents an overview of current and planned Landfill leachate management works for the short term fill plan and long-term Site development through to post-closure. In general, the leachate management works will be constructed as the Landfill is developed and will include leachate collection, storage, and conveyance systems.

2.1 Existing Conditions

The existing Landfill footprint includes Phase 1 and Phase 2 areas. These areas are constructed with a natural control liner system that includes greater than 2 metres of in-situ native clay with a hydraulic conductivity of between 10^{-6} and 10^{-9} cm/s (CH2MHill, 2008). Vertical groundwater flow throughout the Site is generally noted to be upwards provided the leachate level is maintained at an elevation at or below 437 m above mean sea level (AMSL).

Leachate collection within the existing areas of Phase 1 and Phase 2 consists of the following components:

- A 0.3 m thick leachate collection system and perforated collection pipe within the lined northern expansion area.
- A perforated leachate collection pipe oriented east-west across the central portion of Phase 1 and Phase 2 that drains to the west.
- A perforated leachate collection pipe oriented east-west installed between the Phase 2 and Phase 3 boundary that drains to the western leachate lift station.

2.2 Development Conditions

Future development will be completed within the Phase 1, Phase 2, and Phase 3 footprints, beginning first with Phase 1 and Phase 2. The approximate limits of staged development areas for the remainder of the Landfill development are provided in Figure 1. In accordance with the ongoing development of the DOCP, future landfill areas will be completed with a base liner and leachate collection system comprised of the following from bottom to top:

- Geosynthetic clay liner (GCL)
- 60-mil High Density Polyethylene (HDPE) liner
- Non-woven geotextile
- 0.3 m of drainage blanket with leachate collection piping
- Woven geotextile

Perforated leachate collection laterals will be installed within the granular drainage layer and converge on perforated leachate collection pipes. Leachate will be collected and pumped to the existing on-Site pre-treatment system prior to discharge to the sewer.

Final cover will be applied in segments once waste reaches target elevations. Estimated final cover application areas are shown on Figure 2.

3. Leachate Quantity

Leachate generation rates change over time as the Landfill is developed and various types of cover are applied. An understanding of forecasted leachate generation rates throughout Landfill development assists in determining appropriate leachate management methods and contingency plans. Since the Site currently discharges pre-treated leachate to the City sanitary sewer, an understanding of the forecasted quantity of pre-treated leachate being discharged to the sewer is also necessary to ensure sufficient sewer capacity is available for residential developments in the area. Efforts to reduce leachate generation therefore also increase the sanitary sewer capacity for residential development. The following sections provide the forecasted leachate generation rates for the Site.

3.1 HELP Model and Forecasted Leachate Generation

The following section presents estimated leachate generation rates for operation, closure and post-closure periods. Leachate generation rate estimates were developed to support the development of the design and operation procedures for Landfill leachate collection and treatment systems.

Leachate generation modeling was completed using the Hydraulic Evaluation of Landfill Performance (HELP) model. The HELP model is a quasi-two-dimensional hydrologic model for conducting water balance analyses of Landfills, cover systems, and other solid waste containment facilities. It is a long-accepted, standard model for Landfill cover performance developed by the United States Army Corp of Engineers. The HELP model uses local, historical precipitation data and design characteristics from the Landfill cover systems to estimate precipitation infiltration rates through the Landfill cover surface into the waste mound. Since the Landfill is designed to collect leachate using the various leachate collection systems, all infiltrated precipitation is considered as leachate for the purposes of leachate generation estimates.

The HELP model provides infiltration rates per unit area based on the type of cover that is applied and the liner details. To calculate leachate generation forecasts, infiltration rates have been developed for daily cover, intermediate cover, and final cover conditions in landfill areas with an engineered liner and natural control liner areas.

- Daily cover is modelled with a relatively porous soil with a thickness of 150 millimetres (mm).
- Interim cover is modelled with a relatively porous soil with a thickness of 300 mm.
- Final Cover is modelled with 150 mm of topsoil, 450 mm of common fill (relatively porous), a non-woven geotextile and a geosynthetic clay liner.

- The natural control liner is modelled with 300 mm of drain sand, and 2000 mm of in-situ clay based on the Comprehensive Site Development Plan (CH2MHill, 2008).
- The engineered base liner is modelled with non-woven geotextile, 300 mm of drain sand, non-woven geotextile, HDPE geomembrane, and a GCL.

The resulting average monthly infiltration rates are provided in Table 3.1, below.

Table 3.1 HELP Model Leachate Generation Rates

	Generation Rate 1 Daily Cover – Engineered Liner	Generation Rate 2 Intermediate Cover - Engineered Liner	Generation Rate 3 Daily Cover – Natural Control Liner	Generation Rate 4 Intermediate Cover - Natural Control Liner	Generation Rate 5 Final Cover
Jan	5.1037	19.6897	15.199	17.376	1.0016
Feb	9.9522	19.1083	17.653	18.554	0.6618
Mar	20.1399	16.1701	18.517	18.016	0.6709
Apr	38.2281	21.7127	27.239	24.831	1.2603
May	15.5009	9.8961	5.889	6.441	1.2717
Jun	7.8124	7.3867	8.408	7.909	1.0794
Jul	10.5322	11.6938	12.742	12.430	1.1565
Aug	14.8883	14.2065	15.965	15.178	1.2613
Sep	15.8857	14.9962	14.602	14.813	1.2061
Oct	11.5375	11.0707	9.313	9.644	1.1366
Nov	11.6222	9.9840	13.914	11.851	1.0650
Dec	14.3340	19.8666	16.302	18.714	1.2194
TOTAL	175.54	175.7814	175.74	175.76	12.99
Note: All values in mm per square meter area					

Since the landfill is constructed in a natural geological low point and final cover is not anticipated to be constructed until the majority of the landfill footprint is constructed (therefore surface water runoff from the Landfill will not be managed as clean runoff), the runoff values for daily and intermediate cover were included in the leachate generation rates included in Table 3.1. Furthermore, it is understood that the hydrogeologic conditions beneath the Landfill footprint result in an upward hydraulic gradient. The HELP model generally accounts for percolation through the liner system, thereby slightly reducing the leachate collection rates. Since there is an upward gradient, this percolation rate has been included in the rates shown in Table 3.1. Further discussion of the affect of groundwater and surface water on the leachate generation rate is provided in Section 3.2.

A review of Table 3.1 shows the following:

- There is very minimal difference in the leachate generation rates between the two types of liner systems. This is because the percolation rates through the liner systems have been included in the rates shown in Table 3.1 due to the upward hydraulic gradient.

- The intermediate cover leachate generation rates are similar to those for daily cover. Some months have higher generation rates due to the reduced seasonal evaporation rates and some have lower generation rates due to decreased hydraulic conductivity of the cover layer. However the primary reason for the similarity is because runoff has been included in the leachate generation rate for both types of cover.
- Final cover reduces leachate generation and monthly generation rates are much more consistent.

As a comparative analysis, GHD also modelled the leachate generation rates using a clay final cover with a hydraulic conductivity of 10^{-5} cm/s. The resulting annual leachate generation rate for the clay final cover regardless of the base liner construction is 133.57 mm/m^2. Compared to the annual leachate generation rate for final cover constructed with GCL shown in Table 3.1 of 12.99 mm/m^2, areas with final cover constructed of clay will generate approximately ten times the amount of leachate as areas completed with final cover constructed with GCL. Given the significant reduction in leachate generation between these two types of final cover, and the potential scarcity of clay material for final cover construction, a GCL final cover is recommended for future Landfill development.

During the development of the Landfill, some areas will be open (daily cover), some will be complete with interim cover, and some will be closed with final cover as shown in Figure 2. The Landfill areas provided in Figure 1 are used to develop the Landfill development stages. Table 1 provides the surface area for each type of cover for each Phase of the Landfill for each Stage of development. By applying the HELP model infiltration rates to the appropriate areas of the Landfill Phases based on their development status, the monthly quantity of generated leachate is obtained for each Stage of Landfill development and is provided in Table 2.

3.2 Current Flow Rates

The flow rates from Leachate Lift Station 3 from August 2016 through January 2018 are provided in Figure 3. The maximum flow rate is shown at 500 m^3/day and the average flow rate is shown at 190 m^3/day. Compared to the current forecasted leachate generation rates, there is a discrepancy compared to those forecasted by the HELP model. This is likely due to the influence of groundwater exfiltration through the Landfill base and from the collection of surface water in the leachate collection system. As described in the Surface Water and Groundwater Management Strategy prepared by Golder Associates in 2016, the amount of leachate generation has increased in the past few years along with the amount of groundwater observed in the slough area, south of the current Landfill footprint (Golder Associates, 2016).

Table 3.2 presents the average daily leachate flow rates from Leachate Lift Station 3 for each month based on the data shown in Figure 3 and compares to the forecasted current leachate generation rates. The rates show that some of the estimated leachate generation rates are close to the actual observed rates. However, the remaining months show the actual leachate generation rate to be significantly higher than the forecasted rate. The difference is estimated to be due to the influence of groundwater and surface water on the leachate generation rate.

Table 3.2 Groundwater Influence on Leachate Generation

Month	Average Leachate Lift Station 3 Flow Rate (m^3/day)	Forecasted Leachate Generation Rate – Current Footprint (m^3/day)	Estimated Groundwater and Surface Water Influence on Leachate Generation
January	176	167	
February	176	202	
March	158	180	
April	217	261	
May	368	63	
June	272	83	
July	221	124	
August	165	153	
September	173	152	
October	161	95	
November	206	127	
December	184	180	
Average Monthly Flow	206	149	57

3.3 Combined Forecasted Leachate Generation Rates

Due to the observed discrepancy between forecasted leachate generation rates and observed leachate generation rates, the forecasted leachate generation rates need to be corrected to include consideration of the groundwater and surface water influences. The forecasted leachate generation rates from Table 2 were modified to include the estimated groundwater and surface water influence on leachate generation using the difference between the current annual average and the forecasted annual average from Table 3.2. Based on the current layout of the Landfill and leachate collection system, the slough is likely contributing to the current leachate generation. Therefore the values in Table 3.2 for the current footprint are not likely to increase over time with the development of Phase 3.

Table 3 provides the resulting combined forecasted leachate generation rates using the estimated groundwater and surface water influence value from Table 3.2 with a range of +/- 50% to estimate the effect of excessively dry and wet years.

The forecasted average daily leachate generation rates in Table 3 show a minimum generation rate ranging from 91 to 120 m^3/day during current landfilling (May); a maximum generation rate ranging from 507 to 564 m^3/day (April once the entirety of Phase 3 is developed); and a post-closure generation rate ranging from 48 to 124 m^3/day, with an average of 89 m^3/day.

4. Leachate Quality

The following section presents an analysis of Landfill leachate quality. The analysis was used in the development of leachate management and treatment/disposal design options. Leachate samples are collected on a routine basis as part of the Site monitoring program. Leachate samples were provided from the 2016 monitoring program. These leachate samples were collected from the locations identified in Table 4.1.

Table 4.1 Leachate Sample Locations

Location	Description	Number of Samples
MH3	North Pump house Manhole west side of Phase 1	4
MH1	P1 Leachate Manhole southwest corner of Phase 1	4
Wet Well	S Leachate Wet Well southwest corner of Phase 2 (Lift Station 2)	4

The chemical composition of leachate is highly variable, changing over both space and time with changing landfill conditions. As leachate chemistry is dependent on landfill conditions, it is unique to each landfill and as such, a monitoring program to characterize the quality of the leachate generated at the landfill should be maintained to continually evaluate the current leachate quality as the Landfill is developed.

4.1 Analysis of Landfill Leachate Quality

The analytical results from existing Landfill leachate samples collected during the 2016 monitoring program are summarized in Table 4. Table 4 summarizes the leachate parameters used to forecast leachate quality and provides the minimum and maximum values as well as the average of all samples collected from each location in 2016. Evaluation of these results provides an indication of the variation in leachate strength across the Site.

Based on the analytical results from leachate samples collected from the existing Landfill, the following conclusions are evident:

- Leachate strength varies across the Site.
- Moderate concentrations of alkalinity, Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), phosphorus, and sulphide are present throughout the landfill, however the concentration of alkalinity, COD, TDS, phosphorus, and sulphide in leachate collected at the southwest corner of Phase 2 are significantly higher than those present throughout the rest of the Landfill which is generally correlated to younger waste.
- Most parameters show a moderate leachate strength when compared to typical landfill leachate in BC, however the alkalinity and TDS concentrations in leachate collected at the southwest corner of Phase 2 are representative of a strong leachate.
- Iron and manganese concentrations are generally low compared to typical landfill leachate in BC.

- The historical Quail Ridge results represent the combined leachate quality post pre-treatment and shows that the system is capable of significantly reducing sulphide concentration and generally increases nitrate concentration.
- The leachate quality is generally representative of an aged waste.

4.2 Forecasted Leachate Quality

Based on the available data for the current leachate quality, there is a variation in leachate strength observed between the older waste and the younger waste areas. This trend is likely to continue as new waste is brought to the Site. However, through a staged approach to landfill development, the open area of the Landfill, where the newest waste is placed, will remain relatively consistent. This will lead to the composition of leachate shifting slightly towards older leachate, more consistent with what is currently observed at MH1 and MH3.

Furthermore, the leachate generation is currently impacted by the accumulated groundwater and surface water within the slough thereby diluting the leachate concentration. As the waste footprint grows, the proportion of groundwater and surface water within the leachate will decrease, resulting in a more concentrated leachate.

It is also noted that the leachate recirculation pilot program described in Section 5.2.1 is intended to increase in-situ moisture content and promote anaerobic digestion of the waste. This may result in an increase to organic concentrations in leachate such as ammonia and biochemical oxygen demand (BOD). This, coupled with the forecasted increased proportion of leachate generated from older waste, and the reduced dilution by groundwater and surface water will likely result in leachate concentrations slightly increasing over time. The forecasted leachate quality is presented in Table 4.2.

Table 4.2 Forecasted Leachate Quality

Parameter	Concentration Range (mg/L)
pH	7.5 – 8.5
Alkalinity	5,000 – 10,000
BOD	200 - 500
COD	500 – 1,200
Ammonia	50 – 250
Chloride	250 – 1,000
Phosphorus	1 – 10
Sulphide	50 – 300
TDS	3,000 – 30,000
Iron	0.1 – 0.5
Manganese	0.1 – 1

5. Leachate Storage, Treatment, and Disposal Systems

Leachate will be collected within the various Landfill Phases as described in Section 2. The following presents the storage, treatment, and disposal options for the Site.

5.1 Existing Infrastructure

Existing leachate collection infrastructure is described in Section 2.1. Collected leachate is conveyed to the leachate pre-treatment system through the following lift stations:

- Leachate Lift Station #1 located west of Phase 1
- Leachate Lift Station #2 located in the southwest corner of Phase 2
- Leachate Lift Station #3 located at the leachate pre-treatment system

These lift stations convey leachate to the leachate pre-treatment system and ultimately to the City sanitary sewer. The leachate pre-treatment system is used to reduce odour in the leachate prior to discharge to the sewer. This is completed through the reduction of hydrogen sulphide concentrations using an aerator and biofilter. Based on the leachate quality review, the sulphide concentrations in combined leachate samples collected from the sanitary sewer discharge are significantly lower than those in the raw leachate (99.8% reduction), indicating the system is functioning well.

Discharge to a sanitary sewer following pre-treatment is expected to continue to be a feasible long-term leachate management solution, provided the pre-treatment system is capable of managing long-term leachate flow rates. As such, an alternative analysis for leachate management options is not included in this LMP. However, the following information has been provided to illustrate potential alternatives and contingency management options and the requirements to implement each.

5.2 On-Site Treatment Effluent Requirements

If on-Site treatment of leachate with direct discharge to the natural environment is completed, the effluent discharged from the treatment system would require an approval from ENV and effluent limits and objectives would need to be established. Effluent limits are not-to-exceed values that regulate the compliance of a treatment system and effluent objectives are operational targets used to maintain ideal treatment conditions. This Section identifies some federal and provincial guidelines and regulations that may be used to develop effluent limits and objectives for an on-Site leachate treatment system if one were to be developed.

Per the BC MOE Landfill Criteria for Municipal Solid Waste June 2016 guideline, if leachate is discharged to groundwater it must meet the applicable groundwater quality standards as specified by the director. If leachate is discharged to surface water, it must meet the applicable surface water quality standards as specified by the director. Potentially applicable standards are described in the subsections below. Due to the nature of the native low-permeability Site soils and the upward groundwater gradient, discharge to the groundwater isn’t considered practical at the Site.

Furthermore, discharge to the sanitary sewer, as is currently completed at the Site, is regulated by the City sewer bylaw.

Wastewater Systems Effluent Regulations

The Wastewater Systems Effluent Regulations (WSER) was enacted under the Fisheries Act. The WSER applies to wastewater systems which deposit effluent containing prescribed deleterious substances, and that is designed to collect 100 cubic metres (m^3) per day or more of influent. The deleterious substances specified in the WSER include Carbonaceous Biochemical Oxygen Demand (CBOD), total suspended solids (TSS), total chlorine, and un-ionized ammonia. The LTF effluent will contain concentrations of CBOD, TSS and un-ionized ammonia and will be designed with a capacity greater than 100 m^3/day.

The WSER only applies to wastewater treatment systems on industrial, commercial or institutional sites for which the collected influent volume consists of more than 50% blackwater and greywater, combined. Although this would not be applicable for an on-Site treatment system, the WSER limits are used for reference.

The effluent limits in the WSER that are potentially applicable for consideration when developing effluent limits are:

- CBOD < 25 mg/L
- TSS < 25 mg/L
- Un-ionized ammonia < 1.25 mg/L, expressed as nitrogen (N) at 15 degrees Celsius

It should be noted that the WSER also contains criteria for acute lethality; however, the acute lethality limit in the WSER only applies to systems with a capacity greater than 2,500 m^3/day. Since this capacity is significantly greater than that of any on-Site treatment system would be for this Site, this criterion will not be considered.

Canadian Council of Ministers of the Environment Canadian Environmental Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CEQGs) have been developed to provide nationally endorsed goals or performance indicators for water quality based on the protection of aquatic life and agriculture. The CCME CEQGs provide numerical guidelines for an extensive list of general chemistry parameters, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and metals.

The numerical guidelines have been developed as a tool to assess the quality of a water source and evaluate the effectiveness of point source controls, but not as criteria for point-source effluent discharges. They are also developed without consideration for regional or site-specific conditions and are more applicable to federal owned/regulated lands, rather than land under provincial jurisdiction, and are therefore not directly applicable for use in developing effluent limits for an on-Site treatment system.

Health Canada Guidelines for Canadian Drinking Water Quality

The Health Canada Guidelines for Canadian Drinking Water Quality (DWQGs) have been developed for contaminants that could lead to an adverse health effect in humans, could be expected to be found in a large number of drinking water supplies in Canada, and could be detected at a level that is potentially significant to human health. Numerical guidelines are available for microbiological, chemical, physical and radiological parameters. Numerical guidelines are presented as maximum acceptable concentrations (MACs) for health based considerations, aesthetic objectives (AOs) for aesthetic considerations, and operational guidance values (OGs) for operational considerations.

Since the DWQGs have been developed for application in drinking water systems (i.e. post treatment for human consumption), they are not directly applicable to the on-Site treatment system effluent.

British Columbia Contaminated Sites Regulation

The Environmental Management Act (EMA) (SBC October 2003) governs contaminated sites in British Columbia (BC) and is administered by BC Ministry of Environment (MOE). The enabling regulation under the EMA is the CSR and the Hazardous Waste Regulation (HWR), (B.C. Reg. 63/88, and as amended). The EMA, CSR and HWR address the identification, investigation, remediation, and monitoring of sites that have former or current CSR Schedule 2 Activities, and/or are contaminated by a hazardous waste or substance at a concentration that exceeds the CSR environmental quality standards for soil, groundwater, surface water, vapour, and sediment.

The CSR contains numerical standards provided in Schedules 1 through 11. CSR standards are applicable to groundwater greater than 10 m from the high water mark of an aquatic receiving environment, soil, soil vapour, surface water, and sediment. The CSR may be considered applicable if an on-Site treatment system were to discharge to the groundwater at the Site.

British Columbia Approved and Working Water Quality Guidelines

The British Columbia Approved Water Quality Guidelines (WQGs) have been approved by the Province for use as environmental benchmarks of safe levels of specific substances. The BC Working WQGs provide benchmarks for those substances that have not yet been formally endorsed by the Province. The BC WQGs provide safe concentrations of substances based on the water use, including drinking water and fresh water aquatic life. The BC MOE Landfill Criteria for Municipal Solid Waste – Second Edition (June 2016) includes the WQGs as water quality criteria that should be considered.

The BC WQGs contain numerical guidelines for: general chemistry parameters including nitrogenous parameters, nutrients, chloride, organic carbon and solids, metals, VOCs, PAHs, and Polychlorinated Biphenyls (PCBs).

The BC Approved and Working WQGs are considered appropriate objectives for the water quality discharged from the Site to within 10 m of an aquatic receiving environment if an on-Site treatment system were developed with such a discharge location.

Table 5.1 provides a summary of the potential effluent objectives and/or limits that could be used for an on-Site treatment system depending on the effluent receiving environment based on the guidelines and regulations discussed above.

Table 5.1 Summary of Potential Effluent Guidelines and Regulations

Parameter	Units	Limit	Regulation/Guideline
Alkalinity	mg/L	-	Not regulated
Ammonia	mg-N/L	≤1.25[1]	WSER
Nitrate	mg-N/L	≤3.7[2]	BC WQG
Biological Oxygen Demand	mg/L	≤25	WSER
Chemical Oxygen Demand	mg/L	-	Not regulated
Chloride (Dissolved)	mg/L	120[3]	CCME
pH	-	6.5-9	CCME
Sulphide	mg/L	-	Not regulated
Sulphate	mg/L	128[4]	BC WQG
Temperature		±1°C[5]	BC WQG
Total Dissolved Solids	mg/L	-	Not regulated
Total Iron (Fe)	mg/L	1[6]	BC WQG
Total Manganese (Mn)	mg/L	≤0.77[7]	BC WQG
Total Suspended Solids	mg/L	≤25	WSER
Dissolved Oxygen	mg/L	≥5[8]	BC WQG

Sources:

CCME: (Canadian Council of Ministers of the Environment, 1999)
BC WQG: (British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture, 2017)
WSER: (SOR/2012-139, 2012)

Notes:

1: The ammonia limit is calculated as $\frac{\text{total ammonia}}{1+10^{9.56-\text{pH}}}$ at 15°C
2: Long term limit; the maximum point concentration is 32.8 mg-N/L
3: Long term limit; short term is 640 mg/L. BC guidelines are looser: 150 and 600 mg/L for long and short term, respectively (British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture, 2017)
4: Strictest scenario, amount is relaxed as hardness increases, to 218, 309, and 429 mg/L for hardness at least 31, 76, 181 mg/L as $CaCO_3$ respectively
5: Temperature is based on ambient temperature and varies greatly dependent on wildlife in the receiving body
6: The limit for dissolved iron is 0.35 mg/L. Both limits are short term (i.e. 96 hour averaging period)
7: The amount shown is the strictest enforcement. The Mn limit is calculated, in the long term (i.e. 30 day averaging period) as $0.605 + 0.0044 \cdot \text{hardness}$ for hardness expressed in mg/L as $CaCO_3$ and between 37-450 mg/L, and in the short term (i.e. 96 hour averaging period) as $0.54 + 0.01102 \cdot \text{hardness}$ for hardness between 25-259 mg/L as $CaCO_3$
8: DO regulations are stricter in fish spawning habitat

Regional Background Water Quality

Discharge to the natural environment, whether groundwater or surface water, should also consider the background water quality. Where background water quality is below the applicable water quality standards, such as those listed in Table 5.1, the regulatory limits are appropriate for consideration. Where background water quality exceeds the applicable regulatory limits, care should be taken not to further impair the water quality.

The 2016 Glenmore Landfill Annual Report prepared by Golder Associates January 27, 2017 indicates that background groundwater quality is based on groundwater monitoring wells GL0-1, GL0-2, and 09BH03.

Water quality results from samples collected from these background groundwater quality wells in 2016 are provided in Table 5.2, below.

Table 5.2 Background Groundwater Quality

	GL0-1	GL0-2	09BH03
	5/24/2016	5/24/2016	5/24/2016
COD	<20	<20	21
TDS	673	700	1980
Ammonia	0.0384	0.208	<0.005
Chloride	7.1	6.8	<10
Nitrate	0.065	<0.025	0.69
Sulphate	346	310	909
Chromium	<0.0005	<0.0005	0.0164
Iron	<0.030	0.205	<0.03
Manganese	0.1	0.183	<0.01
Magnesium	64.2	67.5	130
Phosphorus	<0.30	<0.30	<0.3
Sodium	66.9	56.7	400

Notes: Source - (City of Kelowna, 2017)
All results in mg/L

No background surface water results are provided in the 2016 Annual Report. If surface water discharge is considered for an on-Site treatment system, water quality for the existing surface water body should be determined prior to development of final effluent requirements.

City of Kelowna Sanitary/Storm Drain Regulation Bylaw

The City Bylaw No. 6618-90, entitled Sanitary Sewer/Storm Drain Regulation Bylaw (Sewer Bylaw), dated December 12, 2011 includes a series of standards for wastewater discharged to the sanitary sewer. Standards include Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), TSS, Oil and Grease, pH, odourous substances, and several metals. Under the current leachate pre-treatment system, leachate is discharged to the sanitary sewer and must meet these standards. These standards are listed in Table 5.3, which is only applicable for sewer discharge and should not be considered for direct environmental discharge.

Table 5.3 City of Kelowna Sewer Bylaw Standards

Parameter	Units	One-Day Composite Sample Limit	Two-Hour Composite Samples Limit	Grab Sample Limit
BOD	mg/L	500	1,000	2,000
COD	mg/L	750	1,500	3,000
TSS	mg/L	600	1,200	2,400
Oil and Grease	mg/L	150	300	600
pH	Std. units	-	5.5-10.5	5-11
Aluminum	mg/L	50	100	200
Arsenic	mg/L	1	2	4
Boron	mg/L	50	100	200
Cadmium	mg/L	0.2	0.4	0.8
Chromium	mg/L	4	8	16
Cobalt	mg/L	5	10	20
Copper	mg/L	2	4	8
Cyanide	mg/L	1	2	4
Iron	mg/L	10	20	40
Lead	mg/L	1	2	4
Manganese	mg/L	5	10	20
Mercury	mg/L	0.05	0.1	0.2
Molybdenum	mg/L	1	2	4
Nickel	mg/L	2	4	8
Phenols	mg/L	1	2	4
Phosphorus	mg/L	12.5	25	50
Silver	mg/L	1	2	4
Sulphate	mg/L	1,500	3,000	6,000
Sulphide	mg/L	1	2	4
Tin	mg/L	5	10	20
Zinc	mg/L	3	6	12

5.2.1 Recirculation

Recirculating leachate to landfill takes advantage of the field capacity of the waste material to store moisture, allowing temporary storage of leachate with little added infrastructure. Leachate recirculation still requires infrastructure to store, pump, and distribute leachate; it is not necessarily a low-capital option. Additionally, recirculation can enhance biological processes, acting as a bioreactor landfill, leading to enhanced biogas production, faster stabilization, and a lower toxicity and mobility of contaminants in leachate (US Environmental Protection Agency, 2017). However, care must be taken not to saturate the waste, which inhibits degradation, can damage pipes and wells in the landfill, and can lead to geotechnical instability. Care must also be taken to avoid differential settlement due to unequal application of leachate and leachate outbreaks due to build-ups. Leachate recirculation should be stopped when it ceases to improve the leachate quality, enhance gas production, or accelerate stabilization; at this point the leachate must be managed with another method (Ohio Environmental Protection Agency, 2014).

Leachate recirculation is not a long-term, comprehensive option of managing leachate when used alone. However, when used to enhance biodegradation of waste and thereby reduce leachate quantities requiring removal from the Site, recirculation can be used to the benefit of the landfill.

The Site has developed a leachate recirculation program that uses the landfill gas (LFG) collection piping to re-distribute leachate to the Landfill. A pilot program has been completed and the results have shown leachate recirculation has increased the production of LFG (primarily methane) for use in the Fortis BC bio-gas plant. LFG horizontal collection piping has been twinned to facilitate leachate recirculation. Over 7,500 metres of recirculation piping have been installed within Phase 1 and Phase 2 (City of Kelowna, 2017).

As noted above, care should be taken not to over saturate the waste during recirculation. Further to the inhibition of degradation, waste saturation will limit the infiltration capacity of the waste surrounding the gas collection horizontals and cause leachate to build up, thus preventing the collection of LFG. Based on the results of the pilot program and the generally low leachate generation rates (due to low annual precipitation in the region), leachate recirculation is included as a method of leachate management for the Site.

5.2.2 Additional Contingency On-Site Treatment and Discharge

Specific design details for the on-Site leachate pre-treatment system, including the design capacity, were not available during the preparation of this LMP. Based on the results of the 2016 Annual Report, the leachate flows shown in Figure 3 for 2016 are evidently well managed in the existing leachate pre-treatment system based on the leachate quality results from the sanitary sewer discharge location. This indicates that leachate flows up to approximately 300 m^3/day can be discharged to the sanitary sewer. If additional pre-treatment capacity were required to continue discharge to the City sanitary sewer, the existing system could be expanded through construction of a parallel expansion.

Additional viable treatment options for hydrogen sulphide removal include aeration through an aeration tank or air stripper. Aeration will reduce sulphide concentrations and may be used to reduce BOD, ammonia, and oxidisable metals (such as iron and manganese), although the forecasted leachate quality does not indicate these parameters to be of concern when compared to the Sewer Bylaw standards. Note that aeration may significantly increase TSS and therefore filtration or coagulation and flocculation would also be required so as not to exceed the Sewer Bylaw TSS standard.

6. Leachate Management Contingency Plans

Leachate management contingency plans are required when a condition prevents the proper collection, storage and/or disposal/treatment of leachate at the Site. The following identify the contingency measures that have been incorporated into this LMP.

Clogging

Clogging of the leachate collection system could occur due to high suspended solids concentrations or biofouling. If the leachate collection system for a given area clogs, leachate may no longer be removable from the cell under normal operating conditions and additional leachate head will build up on the liner. In addition to potential additional leachate leakage through the liner, a build-up of leachate may result in additional odour concerns.

If a system is clogged, the cleanout pipes can be uses to investigate and flush as necessary to unclog the leachate collection system. Leachate collection piping should be inspected and cleaned annually to prevent clogging.

Pump Failure

Lift station pumps are used to convey leachate to the pre-treatment system prior to discharge to the sanitary sewer. Pump failure could result in a backlog of leachate to be managed on-Site. For areas complete with an engineered liner, leachate can be stored to a maximum 0.3 m.

Multiple lift stations exist at the Site, meaning failure of one pump does not affect leachate collection across the entire Landfill. Redundant pumps (either operated in lead/lag or duty/standby) can provide backup pumping in the event of a pump failure. Procurement and storage of an “on-the-shelf” pump, ready to be installed in the event of a pump failure can also provide sufficient contingency to manage a pump failure.

Pre-Treatment System Upset

The discharge of leachate from the Site is contingent on de-odorizing the leachate prior to discharge to the sanitary sewer. If the leachate pre-treatment system malfunctions, leachate can no longer be removed from the Site. Development of a leachate disposal contingency plan to identify an alternate disposal method in the event of an upset will provide enough time to allow the pre-treatment system to be repaired. Leachate disposal contingencies include trucking and recirculation. Recirculation systems are in place at the Site and are intended to remain a component of leachate management long-term. A trucking location would need to be identified and may include the City wastewater treatment plant (the ultimate leachate disposal system through the sanitary sewer).

In addition to the above, expansion of the pre-treatment system through development of additional, parallel treatment trains would also provide additional capacity in the event of an upset to an individual system.

7. Conclusions and Recommendations

The following conclusions can be drawn from the LMP:

- The leachate generation rates are affected by groundwater exfiltration and surface water intrusion.
- Forecasted leachate generation rates range from 48 m^3/day to 564 m^3/day with an average post closure leachate generation rate of 89 m^3/day.
- The engineered liner is expected to increase the amount of leachate collected and contained in the Landfill.
- The leachate quality is expected to remain relatively stable.
- The existing leachate pre-treatment system is managing current leachate generation rates and is expected to continue to be a viable leachate management solution.
- Leachate recirculation will result in increased biodegradation of the waste and can also be used as an additional leachate management solution.

GHD recommends that the City complete the following activities to maintain the LMP:

- Continue to collect samples for leachate quality quarterly to create an understanding of quality trends and variation across the Site.
- Collect leachate samples from lined landfill areas to better differentiate the quality from the natural control areas. This will help to continue to forecast leachate quality.
- Maintain records of leachate flow rates.
- Apply GCL as final cover.
- Evaluate the current pre-treatment system compared to the forecasted peak leachate generation rates and investigate other sulphide removal options for potential expansion of the pre-treatment system.
- Update the LMP every 10 years to determine how leachate generation rates and quality are changing over time.

8. References

B.C. Reg. 87/2012. (2016, February 29). Retrieved from Environmental Management Act - Municipal Wastewater Regulation: http://www.bclaws.ca/civix/document/id/lc/statreg/87_2012#section96

British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. (2017, January). Retrieved from BC Ministry of Environment: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

Canadian Council of Ministers of the Environment. (1999). *Water Quality Guidelines for the Protection of Aquatic Life.* Retrieved from Canadian Council of Ministers of the Environment: http://st-ts.ccme.ca/en/index.html?chems=all&chapters=1

CH2MHill. (2008, June). Comprehensive Site Development Plan.

City of Kelowna. (2017, March 14). 2016 Glenmore Landfill Annual Report.

DAS Environmental Expert GmbH. (2017). *Processes for Landfill Leachate Treatment.* Retrieved from DAS Environmental Expert: http://www.das-europe.com/wastewater-treatment-landfill-leachate.html

Golder Associates. (2016, July). Surface Water and Groundwater Management Strategy.

Hydromantis Inc. (2006). *Review of the State of Knowledge of Municipal Effluent Science and Research.* Retrieved from Canadian Council of Ministers of the Environment: http://www.ccme.ca/files/Resources/municipal_wastewater_efflent/pn_1357_csr_rvw_emerge_tech_bmp.pdf

IPPTS Associates Consulting. (n.d.). *Chemical Oxidation of Leachate.* Retrieved from IPPTS Associates Consulting: http://www.leachate.eu/

Mazille, F., & Spuhler, D. (2011). *Coagulation-Flocculation.* Retrieved from Sustainable Sanitation and Water Management: https://www.sswm.info/content/coagulation-flocculation

Mojiri, A., Aziz, H., Aziz, S., & Zaman, N. (2012, July). Review on Municipal Landfill Leachate and Sequencing Batch Reactor (SBR) Technique. *Archives des Sciences, 65*(7).

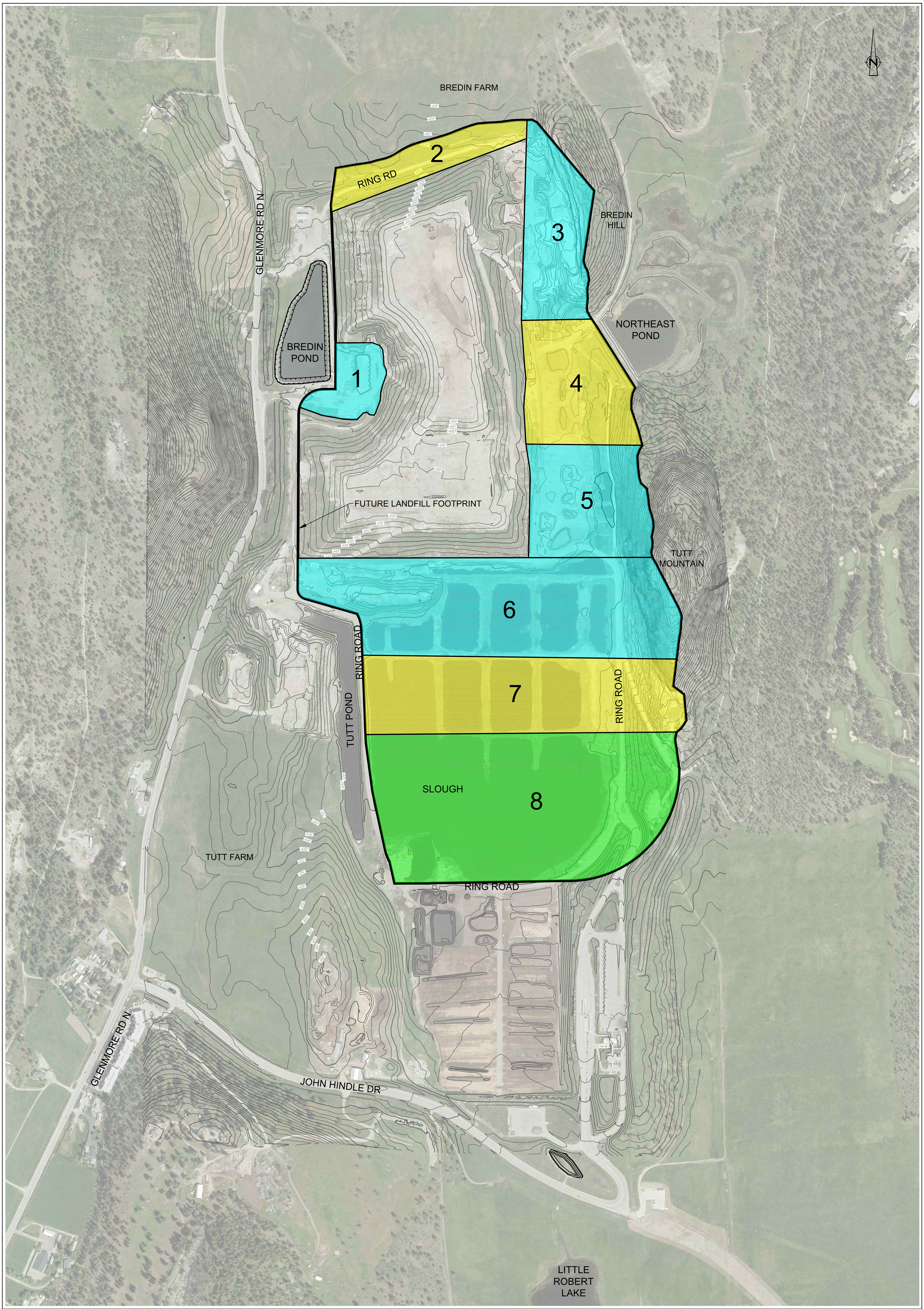
Ohio Environmental Protection Agency. (2014, October). *Leachate Recirculation at Solid Waste Landfills.* Retrieved from Ohio Environmental Protection Agency: http://www.epa.ohio.gov/portals/34/document/guidance/gd_602.pdf

SOR/2012-139. (2012, June 9). Retrieved from Wastewater Systems Effluent Regulations : http://laws-lois.justice.gc.ca/eng/regulations/SOR-2012-139/FullText.html

Steensen, M. (1997). Chemical oxidation for the treatment of leachate -process comparison and results from full-scale plants. *Water Science and Technology, 35*(4), pp. 249-256.

US Environmental Protection Agency. (2003, June). *Wastewater Technology Fact Sheet: Screening and Grit Removal.* Retrieved from US Environmental Protection Agency: https://www3.epa.gov/npdes/pubs/final_sgrit_removal.pdf

US Environmental Protection Agency. (2017, January 3). *Bioreactor Landfills.* Retrieved from US Environmental Protection Agency: https://www.epa.gov/landfills/bioreactor-landfills



Bar is 20mm on original
size drawing
0 20mm

Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn	S.BRIGGS	Designer	D.TURNER
Drafting Check	D.TURNER	Design Check	D.LIDDY
Project Manager	D.LIDDY	Date	2018-03-01
This document shall not be used for construction unless signed and sealed for construction.		Scale	1:3500

Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL DESIGN, OPERATIONS AND CLOSURE PLAN

Title
LANDFILL AREAS

Project No. 084612-22

Original Size ANSI D

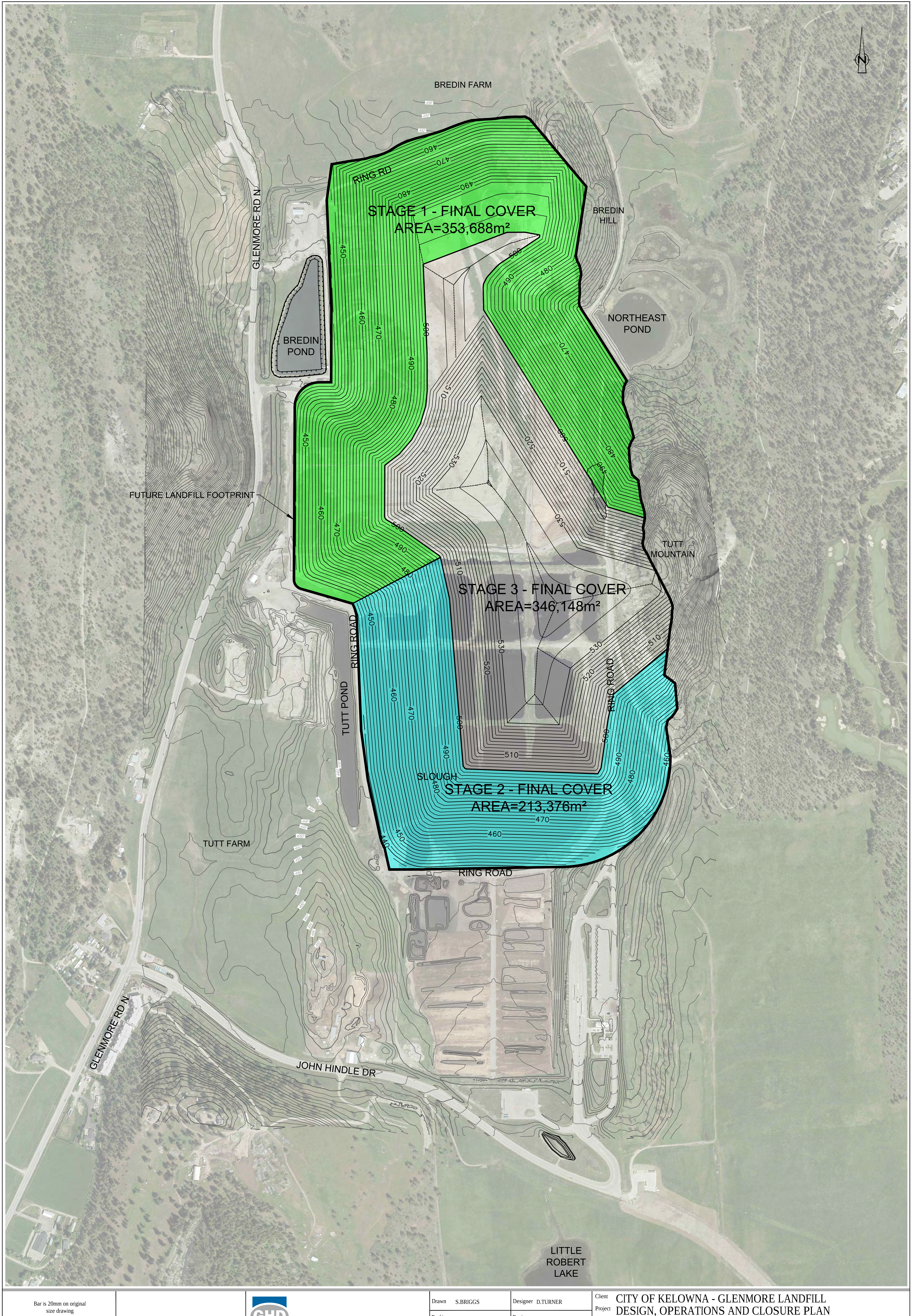
Sheet No. FIGURE-01

Sheet 1 of 2

Plot Date: 1 March 2018 - 4:39 PM

Plotted By: Stephen Briggs

CAD File: I:\CAD\080000\084612\084612-MEMO\084612-22(MEMO3)GN\084612-22(MEMO3)GN-CA001.dwg



Bar is 20mm on original size drawing

0 20mm

Reuse of Documents

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of GHD and shall not be reused in whole or in part for any other project without GHD's written authorization.

É 2018 GHD

GHD Limited
10271 Shellbridge Way Suite 165
Richmond British Columbia V6X 2W8 Canada
T 604 214 0510 **F** 604 214 0525 **W** www.ghd.com

Drawn S.BRIGGS

Designer D.TURNER

Drafting Check D.TURNER

Design Check D.LIDDY

Project Manager D.LIDDY

Date 2018-03-01

This document shall not be used for construction unless signed and sealed for construction.

Scale 1:3500

Client CITY OF KELOWNA - GLENMORE LANDFILL

Project DESIGN, OPERATIONS AND CLOSURE PLAN

Title FINAL COVER AREAS

Project No. 084612-22

Original Size ANSI D

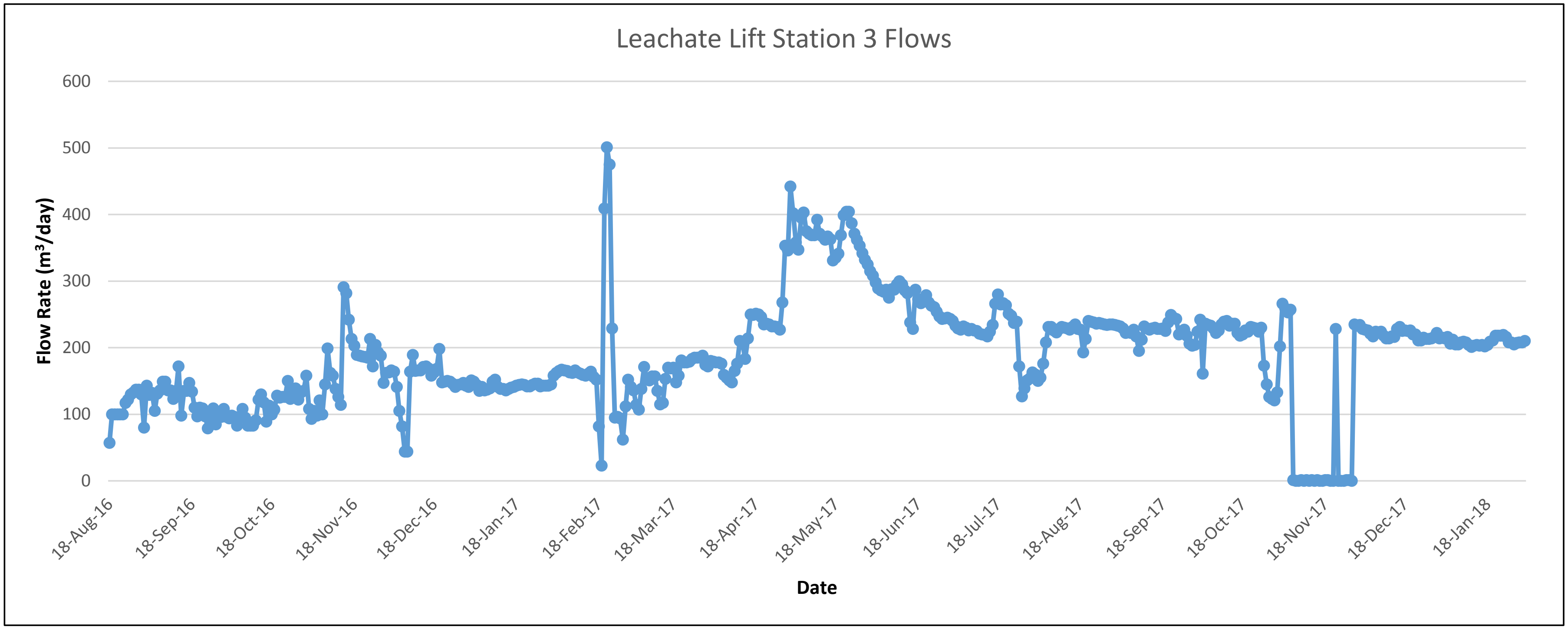
Sheet No. FIGURE-02

Sheet 2 of 2

Plot Date: 1 March 2018 - 5:45 PM

Plotted By: Stephen Briggs

CAD File: I:\CAD\080000\084612\084612-MEMO\084612-22(MEMO3)GN\084612-22(MEMO3)GN-CA002.dwg



Maximum Flow Rate	500	m^3/Day
Average Flow Rate	190	m^3/Day

CITY OF KELOWNA, BRITISH COLUMBIA
GLENMORE LANDFILL

LEACHATE LIFT STATION 3 FLOWS

84612

3/2/2018

FIGURE NO. 3

Table 1

Landfill Development Areas
Leachate Management Plan
Glenmore Landfill
Kelowna, British Columbia

Development Scenario	Area (m^2)	Cumulative Area (m^2)	Area for Given Type of Cover (m^2)						
			Phase 1/2			Phase 3			
			Phase 1/2 Daily Cover	Phase 1/2 Intermediate Cover	Phase 1/2 Final Cover	Slough Surface Area	Phase 3 Daily Cover	Phase 3 Intermediate Cover	Phase 3 Final Cover
Current Footprint	308000	308000	80000	228000	0	411,000	0	0	0
Area 1 Fill	+17000	325,000	80,000	245,000	0	411,000	0	0	0
Area 2 Fill	+26000	351,000	80,000	271,000	0	411,000	0	0	0
Area 3 Fill	+46000	397,000	80,000	317,000	0	411,000	0	0	0
Area 4 Fill	+51000	448,000	80,000	368,000	0	411,000	0	0	0
Area 5 Fill	+54000	502,000	80,000	422,000	0	411,000	0	0	0
P3 - Area 6 Fill	+139000	641,000	0	148,000	354,000	272,000	80,000	59,000	0
P3 - Area 7 Fill	+99000	740,000	0	148000	354,000	173,000	80,000	158,000	0
P3 - Area 8 Fill	+173000	913,000	0	148000	354,000	0	80,000	331,000	0
P2&3 - 500 to 523m	0	913,000	40,000	108,000	354,000	0	40,000	158,111	213,000
Post Closure	0	913,000	0	0	502,000	0	0	0	411,000

Notes:
Daily cover areas listed keep active fill area to less than 80,000 square meters per 2016 Landfill Criteria

Table 2

Forecasted Leachate Generation Rates
Leachate Management Plan
Glenmore Landfill
Kelowna, British Columbia

	Current Footprint	Area 1 Fill	Area 2 Fill	Area 3 Fill	Area 4 Fill	Area 5 Fill	P3 - Area 6 Fill	P3 - Area 7 Fill	P3 - Area 8 Fill	P2&3 - 500 to 523m	Post Closure
January	167	152	168	197	230	264	145	208	318	205	29
February	202	191	209	240	275	312	175	243	361	232	22
March	180	193	207	231	258	286	176	228	318	207	20
April	261	303	322	355	392	431	282	354	479	315	38
May	63	93	101	116	132	149	104	136	191	124	37
June	83	85	92	103	115	129	87	111	154	109	33
July	124	125	135	152	171	192	122	159	225	154	34
August	153	158	170	191	214	239	152	198	277	188	37
September	152	163	176	199	225	252	159	209	295	196	37
October	95	107	116	132	151	170	110	145	207	138	33
November	127	127	135	151	168	186	122	155	212	149	32
December	180	186	202	232	264	299	178	242	352	228	36
Minimum	**63**	**85**	**92**	**103**	**115**	**129**	**87**	**111**	**154**	**109**	**20**
Maximum	**261**	**303**	**322**	**355**	**392**	**431**	**282**	**354**	**479**	**315**	**38**
Average	**149**	**157**	**169**	**192**	**216**	**242**	**151**	**199**	**282**	**187**	**32**

Notes:

All Values in m^3/day

Table 3

Combined Forecasted Leachate Generation Rates
Leachate Management Plan
Glenmore Landfill
Kelowna, British Columbia

Combined Forecasted Leachate Generation Rates - Average Groundwater and Surface Water Influence

	Current Footprint	Area 1 Fill	Area 2 Fill	Area 3 Fill	Area 4 Fill	Area 5 Fill	P3 - Area 6 Fill	P3 - Area 7 Fill	P3 - Area 8 Fill	P2&3 - 500 to 523m	Post Closure
January	224	209	225	254	287	321	202	265	375	262	86
February	259	248	266	297	332	369	232	300	418	289	79
March	237	250	264	288	315	343	233	285	375	264	77
April	318	360	379	412	449	488	339	411	536	372	95
May	120	150	158	173	189	206	161	193	248	181	94
June	140	142	149	160	172	186	144	168	211	166	90
July	181	182	192	209	228	249	179	216	282	211	91
August	210	215	227	248	271	296	209	255	334	245	94
September	209	220	233	256	282	309	216	266	352	253	94
October	152	164	173	189	208	227	167	202	264	195	90
November	184	184	192	208	225	243	179	212	269	206	89
December	237	243	259	289	321	356	235	299	409	285	93
Minimum	**120**	**142**	**149**	**160**	**172**	**186**	**144**	**168**	**211**	**166**	**77**
Maximum	**318**	**360**	**379**	**412**	**449**	**488**	**339**	**411**	**536**	**372**	**95**
Average	**206**	**214**	**226**	**249**	**273**	**299**	**208**	**256**	**339**	**244**	**89**

Combined Forecasted Leachate Generation Rates - 150% Groundwater and Surface Water Influence

	Current Footprint	Area 1 Fill	Area 2 Fill	Area 3 Fill	Area 4 Fill	Area 5 Fill	P3 - Area 6 Fill	P3 - Area 7 Fill	P3 - Area 8 Fill	P2&3 - 500 to 523m	Post Closure
January	253	237	254	283	315	350	231	293	403	291	115
February	287	277	294	326	361	397	261	328	446	318	107
March	266	279	292	316	343	371	262	314	404	293	105
April	347	388	407	441	477	517	368	439	564	400	124
May	148	178	187	201	218	235	190	221	276	209	123
June	168	171	177	188	201	214	173	197	240	195	118
July	210	211	220	238	257	277	207	245	310	240	120
August	238	243	255	276	300	324	238	283	362	274	123
September	237	249	262	285	310	337	245	294	381	281	122
October	180	192	202	218	236	255	195	231	293	223	119
November	213	212	221	236	253	271	207	240	298	235	118
December	265	271	288	317	350	384	264	327	438	314	121
Minimum	**148**	**171**	**177**	**188**	**201**	**214**	**173**	**197**	**240**	**195**	**105**
Maximum	**347**	**388**	**407**	**441**	**477**	**517**	**368**	**439**	**564**	**400**	**124**
Average	**234**	**242**	**255**	**277**	**302**	**328**	**237**	**284**	**368**	**273**	**118**

Combined Forecasted Leachate Generation Rates - 50% Groundwater and Surface Water Influence

	Current Footprint	Area 1 Fill	Area 2 Fill	Area 3 Fill	Area 4 Fill	Area 5 Fill	P3 - Area 6 Fill	P3 - Area 7 Fill	P3 - Area 8 Fill	P2&3 - 500 to 523m	Post Closure
January	196	180	197	226	258	293	174	236	346	234	58
February	230	220	237	269	304	340	204	271	389	261	50
March	209	222	235	259	286	314	205	257	347	236	48
April	290	331	350	384	420	460	311	382	507	343	67
May	91	121	130	144	161	178	133	164	219	152	66
June	111	114	120	131	144	157	116	140	183	138	61
July	153	154	163	181	200	220	150	188	253	183	63
August	181	186	198	219	243	267	181	226	305	217	66
September	180	192	205	228	253	280	188	237	324	224	65
October	123	135	145	161	179	198	138	174	236	166	62
November	156	155	164	179	196	214	150	183	241	178	61
December	208	214	231	260	293	327	207	270	381	257	64
Minimum	**91**	**114**	**120**	**131**	**144**	**157**	**116**	**140**	**183**	**138**	**48**
Maximum	**290**	**331**	**350**	**384**	**420**	**460**	**311**	**382**	**507**	**343**	**67**
Average	**177**	**185**	**198**	**220**	**245**	**271**	**180**	**227**	**311**	**216**	**61**

Notes:

All Values in m^3/day

Table 4

Landfill Leachate Quality
Leachate Management Plan
Glenmore Landfill
Kelowna, British Columbia

Parameters	Min	Max	Average MH1	Average MH3	Average Lift Station 2	Average Overall	Typical Landfill Leachate[(1)]
pH (pH units)	7.45	8.32	7.89	7.81	8.05	7.91	6.5 - 8.5
Alkalinity (total as CaCo3)	934	24600	2348	3181	10715	5415	100 – 7,000
Chemical oxygen demand	46	1110	225	432	867	508	50 – 9,000
Dissolved organic carbon	13.8	268	63.5	113	195	124	-
Total Dissolved Solids	1580	30700	3638	4808	15115	7853	10 – 8,500
Ammonia (as N)	11.4	192	41.3	81.8	138	87.0	5 – 1,300
Chloride	168	890	323	453	567	448	-
Nitrate (as N)	0.17	5.71	2.12	5.71	<0.5	3.31	-
Nitrite (as N)	0.028	0.215	0.078	0.165	0.03	0.099	-
Orthophosphate, Total	0.222	22	0.399	1.48	9.85	3.91	-
Phosphorous, Dissolved	<0.3	10.4	2.07	3.50	6.23	4.16	0.5 – 10
Sulphate	252	2920	646	702	1352	900	-
Sulphide as S	0.023	275	8.09	43.9	148	66.5	-
Sulfide (as H2S), Dissolved	0.024	292	8.59	46.6	157	70.6	-
Iron	0.07	0.276	0.168	0.106	0.07	0.130	0.5 – 150
Manganese	0.09	0.86	0.550	0.358	0.392	0.433	0.05 – 10

Notes:
All in mg/L unless noted otherwise
(1) - Based on GHD's experience with landfill leachate in BC and Alberta

Attachment A

Operational Certificate 12218

BRITISH
COLUMBIA

June 29, 2015

Tracking Number: 60825
Authorization Number: 12218

REGISTERED MAIL

City of Kelowna
City Hall
1435 Water Street
Kelowna BC V1Y 1J4

Dear Operational Certificate Holder:

Enclosed is Amended Operational Certificate 12218 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 Southern Interior Region - Okanagan. Plans, data and reports pertinent to the operational certificate are to be submitted to the Director, Environmental Protection, at Ministry of Environment, Regional Operations, Southern Interior Region - Okanagan, 102 Industrial Pl., Penticton, BC V2A 7C8.

Ministry of Environment
Environmental Protection Division
102 Industrial Pl.
Penticton, BC V2A 7C8
Southern Interior Region - Okanagan
Telephone: (250) 490-8200
Facsimile: (250) 490-2231

Yours truly,

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

Enclosure

cc: Environment Canada
Regional District of Central Okanagan

BRITISH
COLUMBIA

**MINISTRY OF
ENVIRONMENT**

OPERATIONAL CERTIFICATE

12218

Under the Provisions of the Environmental Management Act

CITY OF KELOWNA

**City Hall
1435 Water Street
Kelowna BC V1Y 1J4**

is authorized to manage waste and recyclable material from the Regional District of Central Okanagan and environs including the Big White area, at the Glenmore Landfill located 9 kilometres north-east of the Kelowna city centre, 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 Operational Certificate is issued pursuant to the provisions of Section 28 of the *Environmental Management Act*. This Operational Certificate supersedes all previous versions of Operational Certificate 12218 issued under the authority of the *Waste Management Act and the Environmental Management Act.*

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

1. AUTHORIZED DISCHARGES

1.1 This section applies to the discharge of refuse from municipal, commercial and light industrial sources to a sanitary landfill known as the Glenmore Landfill. The site reference number for this discharge is E104956.

1.1.1 The maximum authorized rate of waste discharge is 170,000 tonnes annually. The maximum quantity of waste discharged must not exceed the design capacity of the landfill as specified in an approved Design and Operations Plan. The final footprint and profile of the discharged waste must be within that specified in the Design and Operations Plan and approximately as shown on the attached locations map.

Date issued:	December 8, 2000
Date amended: (most recent)	June 29, 2015

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

1.1.2 The characteristics of the waste discharged to the landfill are those of municipal solid waste as defined in the *Environmental Management Act* and other waste as may be authorized by the Director.

1.1.3 The following types of wastes must not be discharged:

(1) Hazardous wastes, other than those specifically approved for disposal to authorized landfills, as defined in the Hazardous Waste Regulation under the *Environmental Management Act*.

(2) Anatomical, pathological, and untreated biomedical wastes as defined in the *Guidelines for the Management of Biomedical Wastes in Canada* (Canadian Council of Ministers of the Environment, February 1992). With exception of the limited biomedical wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw.

(3) Bulk liquids and semi-solid wastes, which contain free liquids, as determined by US EPA Method 9095A Paint Filter Liquids Test, Test Methods for Evaluating Solid Wastes-Physical/Chemical Methods (EPA Publication No. Sw-846).

(4) Hog fuel, log yard debris and chipped wood waste. The reuse of these materials for temporary roads, dust control or a component of alternative daily cover is permitted.

(5) Recyclable materials, including automobiles, white goods, other large metallic objects and tires, as directed by the Director.

(6) Dead animals and slaughter house, fish hatchery and farming wastes or cannery wastes and by-products with the exception of slaughter waste from small (less than 200 bird) independent backyard chicken farms. Limited biomedical and carcass wastes described within the City of Kelowna Solid Waste Management Regulation Bylaw will also be accepted.

Burial of these wastes in dedicated locations (i.e. avoiding co-disposal) at the landfill site may be authorized by the Director only if there is no other viable alternative such as treatment/disposal, recycling, reprocessing or composting.

The viability of alternatives is to be determined by the Director based on submission of cost data by the holder of the Operational Certificate. For those cases in which the dedicated disposal of otherwise prohibited wastes is authorized, the specific on-site location of the disposal must 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.

1.1.4 Notwithstanding the requirements of section 1.1.3(1) the disposal of waste asbestos in compliance with the requirements of Section 40 of the Hazardous Waste Regulation under the *Environmental Management Act* is hereby authorized.

1.1.5 Notwithstanding the requirements of section 1.1.3(1), the deposit of hydrocarbon contaminated soils below the Hazardous Waste Regulation criteria is authorized at this landfill subject to the following conditions:

(1) Soil contaminated with hydrocarbons must be deposited in layers less than 0.3 meters; and

(2)Soil contaminated with hydrocarbons must be deposited a minimum of 1.2 meters above the seasonal high groundwater level and a minimum of 2.0 meters below the final grade of the landfill to prevent the impact on groundwater and any future vegetation on the site.

1.1.6 Composting of yard waste must be in accordance with the Organic Matter Recycling Regulation under the *Environmental Management Act*.

1.1.7 The discharged waste must originate from within the Regional District of Central Okanagan and Big White area, subject to the following:

(a) Waste discharged to this landfill must satisfy the requirements of the Central Okanagan Regional District Solid Waste Management Plan.

(b)Waste discharged to this landfill must not contravene the Regional Solid Waste Management Plan of the Regional District from which the waste originated.

1.1.8 The works authorized are a sanitary landfill and related appurtenances as specified in the approved Design and Operations Plan The landfill and any new works must be operated to meet or surpass the requirements for a sanitary landfill as described in the *BC Landfill Criteria for Municipal Solid Waste* unless otherwise approved by the Director.

1.1.9 Municipal solid waste that has value for the purposes of reuse or reprocessing must be considered recyclable material. Recyclable materials may be diverted from disposal and temporarily stored at the landfill facility prior to removal from the site. The nature of the recyclable material authorized for storage at the landfill facility must be to the satisfaction of the Director.

2. OPERATING REQUIREMENTS

2.1 Design, Operations and Closure Plans

2.1.1 The City must submit a Design, Operations and Closure Plan prepared by a suitably qualified professional for approval by the Director by June 30, 2016, and a Financial Security Plan by June 30, 2017. The Design, Operations and Closure Plan must address, but not be limited to, each of the subsections in the Landfill Criteria for Municipal Solid Waste unless otherwise approved by the Director, including performance, siting, design, operational, closure and post-closure criteria. The facilities must be developed, operated and closed in accordance with the Design, Operations and Closure Plan. Should there be any inconsistency between this Operation Certificate and the Design, Operations and Closure Plan, this Operational Certificate must take precedence.

2.1.2 The Design, Operations and Closure plans must be reviewed every 5 years throughout the operating life of the landfill and updated to encompass the next 10 years of landfill operation and/or post-closure activities. The updated landfill design, operating and closure plans must be prepared by a professional engineer or geoscientist licensed to practice in the province of British Columbia and knowledgeable in such matters. The updated plans must be submitted to the Director for approval and must include any information relevant to the design, operations, closure and post-closure care of the landfill.

2.1.3 The landfill facility must be constructed and maintained in accordance with the approved Design, Operations and Closure plans and subject to the conditions set therein. A knowledgeable professional engineer must carry out field reviews of the landfill construction and installation of works. As-constructed drawings of the landfill and all works, including elevations relative to a common datum, must be submitted (or retained on site) to the Director. The as-constructed drawings must be sealed by a professional engineer or geoscientist who is licensed to practice in the province of British Columbia and knowledgeable in the appropriate field of study.

2.1.4 Written authorization from the Director must be obtained prior to implementing any changes to the approved plans. Based on any information obtained in connection with this facility, the Director may require revision of, or addition to, the design, operations and closure plans.

2.1.5 The following design, operations and closure plans are approved:

(1) Comprehensive Site Development Plan for Glenmore landfill, dated August 2001, prepared by CH2MHill.

(2) Comprehensive Site Development Plan for Glenmore landfill, dated June 2008, prepared by CH2MHill.

(3) Landfill Gas Management Facilities Design Plan (Final) Glenmore Landfill site, dated January 2012, prepared by CH2MHill

2.1.6 In accordance with Section 40 of the *Environmental Management Act* and Part 2 of the Contaminated Sites Regulation, the Operational Certificate holder must submit a site profile to the Director at least ten days prior to decommissioning the facilities authorized in Section 1.

2.2 Qualified Professionals

All information, including plans, drawings, assessments, investigations, surveys, programs and reports, must be certified by a qualified professional. As-built plans and drawings of the facilities and works must be certified by a qualified professional

2.2.1 "qualified professional" means a person who:

(a) is registered in British Columbia with his or her appropriate professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association; and

(b) through suitable education, experience, accreditation and knowledge may be reasonably relied on to provide advice within his or her area of expertise as it relates to this Operational Certificate

2.3 Maintenance of Works and Emergency Procedures

The authorized works must be inspected regularly and maintained in good working order. In the event of an emergency or condition beyond the control of the City of Kelowna including, but not limited to, unauthorized fires arising from spontaneous combustion or other causes, or detection of surfacing leachate on the property, the City of Kelowna must take appropriate remedial action and notify the Regional Ministry Office. The Director may reduce or suspend operations to protect the environment until the authorized works has been restored, and/or corrective steps taken to prevent unauthorized discharges.

2.4 Additional Information, Facilities or Works

The Director may, in writing, require investigations, surveys, the submission of additional information, and the construction of additional facilities or works. The Director may also, in writing, amend the information, including plans, drawings, assessments, investigations, surveys, programs and reports, required by this Operational Certificate. Any amendments to the information are without effect unless the Director has approved of such amendments in writing.

2.5 Landfill Site Development

2.5.1 In accordance with the approved Design, Operations and Closure Plan, surface water diversions and groundwater drainage works must be installed to prevent surface water run-off and groundwater seepage from entering the waste discharge area. The effect of sediment transport from areas upgradient and within the landfill site must be considered when designing, installing and maintaining the surface water diversion system. Diversion and drainage structures must be maintained by the Operational Certificate Holders on a regular basis to the satisfaction of the Director.

2.5.2 A berm of suitable material must be constructed to limit visibility of the active waste discharge area where practical for travellers using the Glenmore Road and John Hindle Drive.

2.5.3 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.

2.6 Waste Compaction and Coverage

2.6.1 The City must ensure that waste deposition and compaction meets or exceeds the requirements specified in the latest version of the Landfill Criteria for Municipal Solid Waste for daily, intermediate and final cover unless otherwise approved by the Director. Control must be exercised to ensure keeping freshly deposited refuse in a well defined and small/manageable working face.

Discharged wastes must be compacted and cover material applied as outlined in section 2.6. Wastes must be compacted and covered on a continuous basis. However, if operations are reduced to less than 24 hours per day, then provisions such as security, fencing, and/or other measures approved by the Director must be deployed to prevent wildlife access. All wastes must be covered within 24 hours of discharge to the landfill.

2.6.2 The area of the active landfill working face must be minimized as much as possible. Wastes must be spread in thin layers of 60 centimetres, or less, on the working face and compacted. A compacted layer of at least 15 centimetres of suitable soils, or a functionally equivalent depth of other cover material acceptable to the Director, must be placed on all exposed compacted waste.

2.6.3 An intermediate cover of at least 30 centimetres of compacted soils, or a functionally equivalent depth of other cover material acceptable to the Director, must be applied on any areas of the active landfill site to which waste will not be discharged for a period of 30 days or more.

2.6.4 Final cover must be installed within 180 days of completion of the landfill to the final elevations as specified in the approved plans. Completed portions of the landfill must progressively receive final cover during the active life of the landfill. Final cover must consist of at least 1 metre of low permeability compacted mineral soil, overlain by at least 15 centimetres of topsoil capable of supporting indigenous vegetation. With the written approval of the Director, the topsoil used for this final covering may be mixed with conditioning agents such as sludge (biosolids), compost and the like to add organics and improve the moisture holding capacity and nutrient value of the soil. Final cover must be constructed and maintained with adequate drainage and erosion controls and seeded with suitable grasses.

2.6.5 The Director may vary the frequency of covering when freezing conditions adversely affect normal operation.

2.7 Landfill Management

2.7.1 The landfill must be supervised to the satisfaction of the Director. Landfill supervisors must be trained in landfill operations pertaining to the conditions of this Operational Certificate and the approved design, operating and closure plans. Personnel must be trained to industry standards and at least one employee of the City must be trained and certified as a Manager of Landfill Operations or a British Columbia Qualified Landfill Operator by the Solid Waste Association of North America or equivalent.

2.7.2 Access to the site must be controlled and supervised. All access points must have locking gates and must be locked during periods when supervision is not available.

2.7.3 Public scavenging and salvaging of waste at the landfill site is prohibited. Designated safe areas for reuse as identified by the City of Kelowna will be permitted.

2.7.4 Designated areas must be maintained for the storage of recyclable materials. These designated area(s) must be separate from the active landfill area and must be maintained free of litter. Storage of recyclable materials at the landfill site must be limited to a reasonable length of time subject to the approval of the Director.

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

2.7.5 Litter and wind strewn waste must be controlled by limiting the area of the working face, installing a wind blown litter collection fence in a location which is in the anticipated prevailing downwind direction of the landfill working face, instituting a regular litter pickup, general good site maintenance practises or any other measures required by the Director.

2.7.6 The landfill must be operated in a manner acceptable to the Director to reduce the potential of public nuisance.

2.7.7 The landfill must be operated so as not to create a significant threat to public health or safety, with respect to landfill gas, odours, unauthorized access, roads, traffic, airport activity, noise, dust, litter, vectors, or wildlife attraction using methods and materials acceptable to the Director.

2.7.8 Open burning of waste is prohibited. It is recognized that open burning may be required at the landfill when volumes of wood waste stored at the landfill become large, or shipping wastes to offsite solutions become unfeasible. The City will apply to the Director for a burning permit as needed.

2.7.9 The landfill must be operated so as to minimize the attraction of nuisance wildlife and disease vectors such as birds and rodents by applying adequate cover to the waste and by maintaining the site free of litter. Additional control measures may be specified by the Director if wildlife and/or vector attraction to the site becomes a public safety hazard.

2.7.10 The landfill works must be inspected on a regular basis by the landfill supervisor. In the event of an emergency or any condition, which prevents continuing operation of the approved method of landfill operation and control, or results in non-compliance with the terms and conditions of this Operational Certificate, the Director must be notified immediately and appropriate remedial action taken.

2.7.11 The Director may require future upgrading of the landfill control works to protect the environment during the operating life of the landfill and for a minimum post-closure period of 25 years.

2.8 Ground and Surface Water Quality Impairment

The quality of ground and surface water at the property boundary must not exceed the appropriate (e.g.freshwater aquatic life, drinking water, etc.) water quality criteria in the British Columbia Approved Water Quality Guidelines and A Compendium of Working Water Quality Guidelines for British Columbia, as amended from time to time, or their replacements approved by the Director in writing. Where natural background water quality exceeds the appropriate water quality criteria, the quality of ground and surface water at the property boundary must not exceed natural background water quality. Water quality criteria from other jurisdictions can only be used for contaminants which have not been dealt with in the British Columbia Guidelines. After considering existing and potential future uses of ground and surface water, a qualified professional may recommend the appropriate water quality criteria. The appropriate water quality criteria are subject to the approval of the Director in writing.

If excursions result to the specified water quality criteria, the Director may require that leachate management control measures or works be undertaken. Terms of reference for any leachate management study and/or design work is subject to the authorization of the Director.

2.9 Landfill Gas Management

The Landfill must not cause combustible gas concentrations to exceed the lower explosive limit in soils at the property boundary or 20% of the lower explosive limit at or in on-site or off-site structures.

The City must ensure that the facility is in compliance with the requirements of the Landfill Gas Management Regulation under the *Environmental Management Act*.

3. MONITORING

3.1 Environmental Protection Monitoring

The City must implement and maintain ground, surface water, leachate collection sump fluids and landfill gas monitoring programs prepared by a qualified professional in accordance with the monitoring programs approved in the Design, Operations and Closure plans approved by the Director. The monitoring programs must identify potential environmental impacts of the authorized facility and must address but not be limited to the Landfill Criteria for Municipal Solid Waste and Guidelines for Environmental Monitoring. It must take into consideration results from previous monitoring programs and any other investigations conducted at the site to ensure that early detection of potential impacts is possible.

The monitoring programs must be reviewed in the annual report required under section 4.2. Based on the information submitted in the annual report, or any other information obtained in connection with this site, the Director may vary the frequency, location and analyses of ground and surface water, leachate collection sump fluid and landfill gas sampling.

3.2 Management of Leachate Collection System Fluid

Leachate collection sump fluid levels must be monitored and fluid removed from the leachate collection system as specified in the approved design, operating and closure plans. A sample of fluid from each of the leachate collection sumps must be collected on a quarterly basis and laboratory analyses obtained for the leachate indicator parameters identified in the monitoring program. The Director may vary the location and frequency of sampling and analyses of leachate collection system fluid should conditions warrant. Fluid recovered from the leachate collection system may be used within the landfill footprint for irrigation, dust suppression and/or re-circulated within the buried waste as well as directed to the Kelowna Wastewater Treatment facility unless otherwise directed by the Director. Other methods of treatment and/or disposal of the leachate collection sump fluids must have the prior approval of the Director.

3.3 Groundwater Contamination by Leachate

Should it be determined that leachate is being generated and carried in the groundwater or surface water and, in the opinion of the Director, requires interception and treatment, appropriate remedial measures as approved by the Director must be implemented.

4. REPORTING

4.1 Interim Reporting and Record Keeping

The leachate collection sump fluid level readings, groundwater elevation and combustible gas monitoring data, and the sump fluid, groundwater and gas sampling analyses results must be available for inspection at the Glenmore Landfill office. Data from monitoring and sample analysis must be submitted to the Director with the annual report in accordance with section 7.2. Between annual reporting events, the Director must be promptly informed of any significant changes from long term trends observed in the parameters that are monitored.

4.2 Annual Report

An annual report must be electronically submitted by March 31 of each year for the previous calendar year of landfill operation or post-closure activities. The report should contain the Annual Environmental Monitoring Report and the Annual Operation Report.

The Annual Environmental Monitoring Report must include:

- Results of the environmental monitoring program.
- Data tabulation, comparison to performance criteria, interpretation, trend analysis, graphs, etc.
- Identification of any current or predicted future non-compliance with performance criteria.
- Conclusions, recommendation and proposed changes to the environmental monitoring program.

The Annual Operation Report should include at a minimum:

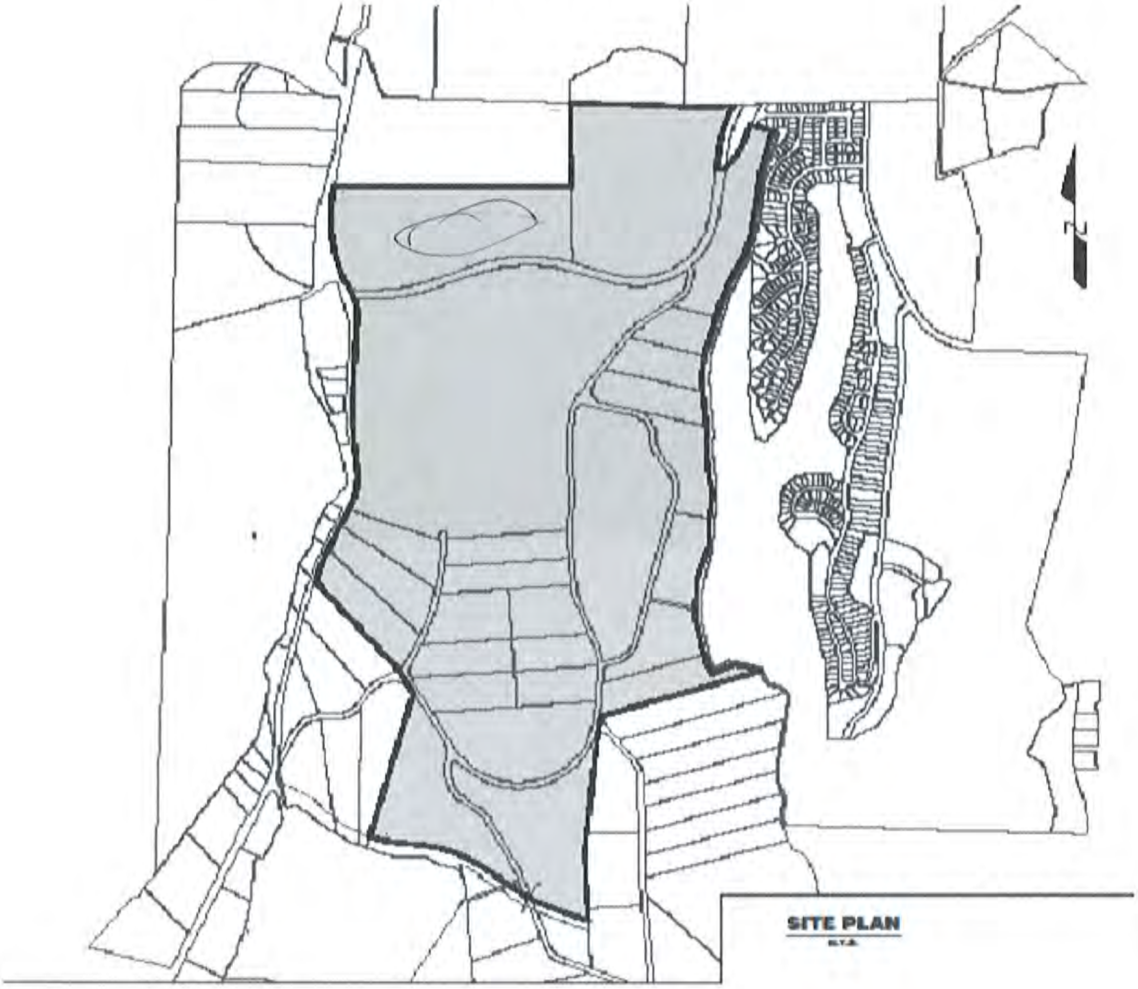
- Total volume, tonnage, and types of waste discharged into the landfill for the year.
- Types and tonnages of waste that were not directly disposed of into the landfill such as recycled, composted, etc.
- Leachate quantities collected, treated and discharged.
- Landfill gas quantities collected, flared and utilized. If applicable, an annual report should be done in the format required by the Landfill Gas Management Regulation and submitted either separately or as a part of the Annual Report.
- Operational plan for the next 12 months.
- Remaining site life and capacity.
- Closure works completed.
- Any changes from approved reports, plans and specifications.
- Any complaints received and the action taken as a result of a complaint.
- Financial Security Plan update.
- Identification of any non-compliance with the Solid Waste Management Plan, operational certificate and a proposed action plan

and schedule to measure the performance of the proposed measures in achieving compliance.

- If possible: compaction, waste to cover ratio and airspace utilization factor.

Copies of the annual report must be provided to the public library in Kelowna and posted on the Operational Certificate holder's web sites.

SITE PLAN



Date issued: December 8, 2000
Date amended: June 29, 2015
(most recent)

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

LOCATION MAP

Date issued: December 8, 2000
Date amended: June 29, 2015
(most recent)

Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

Appendix J
LFG Generation Assessment (2016)

FINAL REPORT

Landfill Gas Collection Efficiency Study –Glenmore Landfill Site

Prepared for

City of Kelowna

March 2017

ch2m:

540 12th Avenue SW
Calgary, AB T2R 0H4
CANADA

Contents

Tables

Figures

Appendixes

Acronyms and Abbreviations

°C	degree Celsius
amsl	above mean sea level
Assessment	LFG generation assessment
BC	British Columbia
BC MOE LFG Design Guidelines	*2010 Landfill Gas Management Facilities Design Guidelines*
BC MOE	BC Ministry of Environment
BC MOE LFG Guideline	*LFG Generation Assessment Procedure Guidelines*
CE	collection efficiency
CH2M HILL Canada Limited	CH2M
City	City of Kelowna
ICI	Institutional, Commercial, Industrial
CRA	Conestoga-Rovers & Associates
kg/m^3	kilogram per cubic metre
km	kilometre
LFG	landfill gas
m	metre
m^3	cubic metre
m^3/h	cubic metre per hour
m^3/y	cubic metre per year
mm	millimetre
MSW	municipal solid waste
NIR	*National Inventory Report: Greenhouse Gas Sources and Sinks in Canada*
RDCO	Regional District of Central Okanagan
Regulation	*Landfill Gas Management Regulation*, approved and ordered December 8, 2008
scfm	standard cubic feet per minute
Site	Glenmore Landfill
tcy	tonnage per capita per year

Introduction

This report was prepared by CH2M HILL Canada Limited (CH2M) to provide the City of Kelowna (City) with the estimated landfill gas (LFG) collection system efficiency for 2016, using up-to-date waste composition and waste filling data (CH2M, 2010; City, 2011, 2012, 2013, 2014, 2015; personal communication with D. Enevoldson, 2017). The LFG recovery was assessed, along with the factors influencing actual LFG generation and recovery at the Glenmore Landfill (Site). The collection system's efficiency was also calculated using the formulas contained within the BC Ministry of the Environment's (BC MOE's) *LFG Management Facilities Design Guidelines* (CRA, 2010).

1.1 Site Conditions

The Site services approximately 195,523 people residing in the eastern half of the Regional District of Central Okanagan (RDCO) (City, 2015). The Site is owned and operated by the City; has an estimated available airspace of 26,246,000 cubic metres [m^3] (CH2M, 2014); and is expected to reach capacity by 2079 (City, 2015). The Site has been in operation since 1966 and had received approximately 3.6 million tonnes of solid waste by the end of 2016 (CH2M, 2010; City, 2011, 2012, 2013, 2014, 2015; Personal communication with D. Enevoldson (February 15, 2017)).

The Site is located on Glenmore Road approximately 1.5 kilometres (km) east of Okanagan Lake and 9 km northeast of the Kelowna city centre. It is situated in a narrow, flat-bottomed valley that is bordered on the west by Glenmore Road, east by tree-covered ridges, north by agricultural lands, and south by John Hindle Drive. The ridge to the northeast of the Site is known locally as Bredin Hill, while the southeastern ridge is known as Tutt Mountain. Elevations on the Site vary from approximately 438 to 460 metres (m) above mean sea level (amsl), while the ridges that form the valley walls rise to over 550 m amsl (CH2M, 2012).

This area was once a shallow slough known locally as Alki Lake at the downstream end of what is essentially a closed drainage basin (there is no surface water outflow). Topographically, this is the lowest area in the basin and serves as a collection point for the majority of the surface runoff from the basin (CH2M, 2012).

Over the past several decades, the northern portion of the slough has been completely infilled and now serves as the active landfill area. The slough's southern portion also received waste for a number of years, but it has been inactive since the early 1980's (CH2M, 2012). This area is referred to in the remainder of this report as Phase 3.

The Site began operations with infilling Alki Lake and progressed northward into what is now known as Phase 1/Phase 2. In the early 2000s, the Phase 1 North Expansion was constructed to optimize the amount of airspace for Phase 1. Refuse disposal at the Site is currently ongoing within the central portion of the active filling area (Phase 2) (CH2M, 2012).

SECTION 2

Regulatory Framework

On December 8, 2008, a regulation for the management of LFG at British Columbia (BC) regulated landfill sites was ordered and approved by the BC MOE. In accordance with the *Landfill Gas Management Regulation* (Regulation), a regulated landfill site is a landfill site that has 100,000 tonnes or more of municipal solid waste (MSW), or has received 10,000 or more tonnes of MSW annually for disposal into the landfill site in any calendar year after 2008 (BC MOE, 2008). There are approximately 3 million tonnes of MSW currently in place at the Site. The total amount of MSW landfilled at the Site in 2016 was approximately 154,500 tonnes (personal communication with D. Enevoldson, February 15, 2017); therefore, per the Regulation, the Site is a regulated landfill.

Under the Regulation, a qualified professional is required to conduct an initial LFG generation assessment (Assessment) using his or her knowledge with respect to solid waste and LFG management to select models for LFG estimation, assess results, and provide required recommendations. The Assessment must be conducted in accordance with the most recent edition of LFG guidance documents, as approved by the BC MOE Director. The guidance documents include the *Landfill Gas Generation Assessment Procedure Guidelines* (BC MOE LFG Guideline) that was prepared by Conestoga-Rovers & Associates (CRA), dated March 2009, and the Landfill Gas Generation Estimation Tool (Tool) (BC MOE, 2014). Both are available on the BC MOE website and must be used in the preparation of Assessments (CRA, 2009). The City submitted its first LFG generation assessment report in 2010 (CH2M, 2010).

LFG Generation Assessment Methodology

The following sections present the information required in the Regulation, in accordance with the BC MOE LFG Guideline, Section 4, Information Collection and Synthesis.

3.1 Annual Waste Buried

Table 3-1 presents the estimated annual amount of MSW disposed of at the Site between 1986 and 2016, as well as the projected volume of waste to be disposed at the Site for 4 years after the Assessment, which corresponds to the year 2020. Although wastes have been disposed at the Site since 1966, Table 3-1 shows tonnages from 1986, as required to estimate the LFG generation using the simulation tool recommended by BC MOE.

The quantity of wastes disposed at the Site between 1986 and 2009 was based on the *Landfill Gas Generation Assessment Report* (CH2M, 2010). Tonnes of refuse disposed at the Site between 2010 and 2015 are based on the annual reports for those years (City, 2011, 2012, 2013, 2014, 2015). The 2016 tonnage was based on personal communication with D. Enevoldson (February 15, 2017). Quantities of waste to be disposed of at the Site between 2017 and 2020 were projected based on the following assumptions:

- Population increase of 1.92 percent in 2016, which is the average population increment between 2013 and 2015.
- Population increase of 1.89 percent between 2017 and 2020, which is the average population increment between 2014 to 2016.
- Tonnage per capita per year (tcy) of 0.71 for the City's services area, which is the average tonnage between 2014 to 2016.

Table 3-1. Annual Quantity of Waste Disposed at the Site

Years	Waste Disposed tonnes*	Cumulative Waste Disposed tonnes
1986	87,434	87,434
1987	87,434	174,868
1988	87,434	262,302
1989	87,434	349,736
1990	87,434	437,170
1991	87,434	524,604
1992	93,852	618,456
1993	89,753	708,209
1994	84,272	792,481
1995	80,458	872,939
1996	80,794	953,733
1997	95,904	1,049,637
1998	83,756	1,133,393
1999	85,258	1,218,651

Table 3-1. Annual Quantity of Waste Disposed at the Site

Years	Waste Disposed tonnes*	Cumulative Waste Disposed tonnes
2000	89,547	1,308,198
2001	95,815	1,404,013
2002	102,522	1,506,535
2003	96,772	1,603,307
2004	106,483	1,709,790
2005	108,597	1,818,387
2006	116,218	1,934,605
2007	102,688	2,037,293
2008	100,611	2,137,904
2009	114,590	2,252,494
2010	119,861	2,372,355
2011	106,387	2,478,742
2012	108,110	2,586,852
2013	108,917	2,695,769
2014	123,178	2,818,947
2015	136,115	2,955,062
2016	154,510	3,109,572
2017	143,185	3,252,757
2018	145,888	3,398,644
2019	148,642	3,547,286
2020	151,448	3,698,735

Notes:

* The quantity of wastes disposed at the Site between 1986 and 2009 was based on the *Landfill Gas Generation Assessment Report* (CH2M, 2010). Tonnes of refuse disposed at the Site between 2010 and 2015 are based on the City's landfill annual reports for those years (City, 2010; 2011; 2012; 2013; 2014; and 2015). The 2016 quantity of wastes disposed at the Site was based on personal communication with D. Enevoldson (February 15, 2017). Quantities of waste to be disposed of at the Site between 2017 and 2020 were projected based on population growth.

3.2 Waste Composition

The most updated waste composition information is obtained from the *2013 Waste Composition Study of Regional District of Central Okanagan (RDCO)* (Morrison Hershfield Ltd., 2016). The waste composition of garbage collected at curbside from resident is shown in Figure 1, while the waste composition of Institutional, Commercial, Industrial (ICI) garbage is shown in Figure 2.

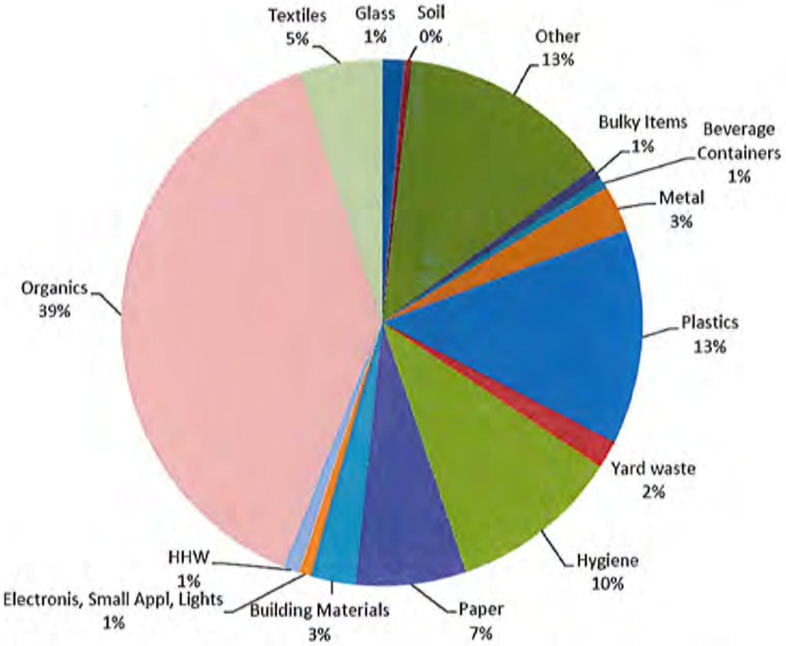


Figure 3-1. Waste Composition of Garbage Collected at Curbside from Residents

Source: Figure extracted from the 2013 Waste Composition Study of Regional District of Central Okanagan (RDCO) (Morrison Hershfield Ltd., 2016)

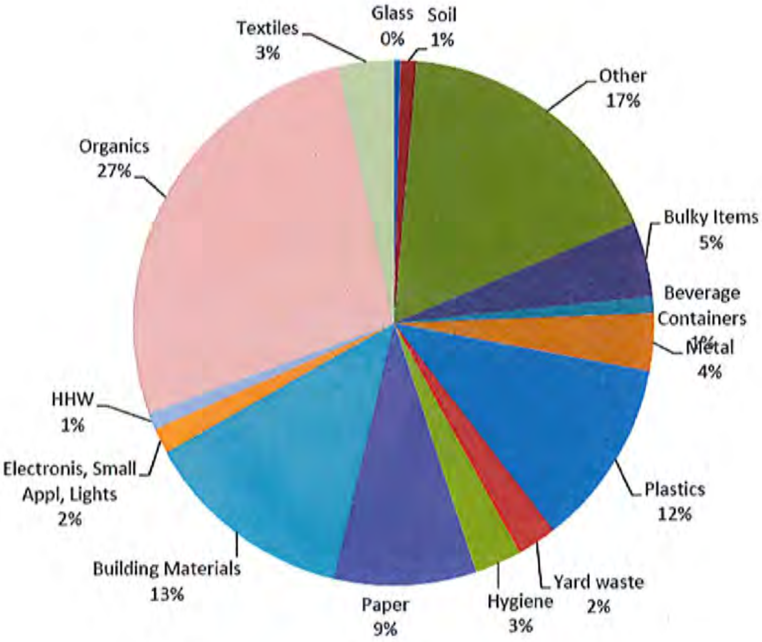


Figure 3-2. Waste Composition of ICI Garbage

Source: Figure extracted from the 2013 Waste Composition Study of Regional District of Central Okanagan (RDCO) (Morrison Hershfield Ltd., 2016)

3.3 Waste Categories

Characterization according to waste type is required to follow the BC MOE LFG Guideline. Waste must be characterized into three categories: relatively inert, moderately decomposable, and decomposable.

The 2016 waste tonnage and composition percentage (personal communication with D. Enevoldson [February 15, 2017]) for the site are as follows:

	Tonnes	Percentage
Residential (Cart) Garbage	37,176	24.06%
Commercial (ICI) Garbage	50,016	32.37%
Construction/Demo debris	44,684	28.92%
Contaminated soil	13,722	8.88%
Other	8,912	5.77%

Based on the *2013 Waste Composition Study of Regional District of Central Okanagan (RDCO)* (Morrison Hershfield Ltd., 2016), the buried waste at the Site is categorized as follows:

- Decomposable waste: 19 percent
- Moderately decomposable waste: 54 percent
- Relatively inert waste: 27 percent

3.4 Climate

The average annual precipitation of the nearest meteorological station (Kelowna A #1123970; located at the Kelowna airport) is 386.9 millimeters (mm) based on Canadian Climate Normals between 1981 and 2010 (Government of Canada, 2017).

For the purpose of the Assessment, the average annual precipitation data of the station Kelowna A was used for calculation the methane generation rate.

3.5 Waste Tonnage by Category

Table 3-2 presents the historical and projected waste tonnages, as well as the waste type category, as described in Section 3.2.

Table 3-2. Waste Tonnage by Category

Years	Waste Disposed tonnes	Relatively Inert (27%) tonnes	Moderately Decomposable (54%) tonnes	Decomposable (19%) tonnes
1986	87,434	23,607	47,214	16,612
1987	87,434	23,607	47,214	16,612
1988	87,434	23,607	47,214	16,612
1989	87,434	23,607	47,214	16,612
1990	87,434	23,607	47,214	16,612
1991	87,434	23,607	47,214	16,612
1992	93,852	25,340	50,680	17,832
1993	89,753	24,233	48,467	17,053
1994	84,272	22,753	45,507	16,012

Table 3-2. Waste Tonnage by Category

Years	Waste Disposed tonnes	Relatively Inert (27%) tonnes	Moderately Decomposable (54%) tonnes	Decomposable (19%) tonnes
1995	80,458	21,724	43,447	15,287
1996	80,794	21,814	43,629	15,351
1997	95,904	25,894	51,788	18,222
1998	83,756	22,614	45,228	15,914
1999	85,258	23,020	46,039	16,199
2000	89,547	24,178	48,355	17,014
2001	95,815	25,870	51,740	18,205
2002	102,522	27,681	55,362	19,479
2003	96,772	26,128	52,257	18,387
2004	106,483	28,750	57,501	20,232
2005	108,597	29,321	58,642	20,633
2006	116,218	31,379	62,758	22,081
2007	102,688	27,726	55,452	19,511
2008	100,611	27,165	54,330	19,116
2009	114,590	30,939	61,879	21,772
2010	119,861	32,362	64,725	22,774
2011	106,387	28,724	57,449	20,214
2012	108,110	29,190	58,379	20,541
2013	108,917	29,408	58,815	20,694
2014	123,178	33,258	66,516	23,404
2015	136,115	36,751	73,502	25,862
2016	154,510	41,718	83,435	29,357
2017	143,185	38,660	77,320	27,205
2018	145,888	39,390	78,779	27,719
2019	148,642	40,133	80,267	28,242
2020	151,448	40,891	81,782	28,775

Notes:

Second column data is from Table 3-1; other data are from calculations.

3.6 LFG Generation Model

Methane production at the Site was estimated using the Tool as specified by the BC MOE LFG Guideline. The model is based on a first-order kinetic decomposition rate equation for quantifying emissions from the decomposition of wastes in MSW landfills. Table 3-3 presents the parameters required to run the model.

Table 3-3. Input Parameters used in the Tool

	LFG Generation Model
Input Parameters or Constants	**BC MOE LFG Guideline /Calculation Tool**
First year of historical data used	1986
Year of Assessment	2016
Annual waste tonnage	Annual waste acceptance from 1986 to 2016 Annual waste tonnages for relatively inert, moderately decomposable, and decomposable wastes
k	methane generation rate
Methane generation rates	For relatively inert, moderately decomposable, and decomposable wastes
Lo	Potential methane generation capacity
Waste types	Relatively inert, moderately decomposable, and decomposable wastes

The following assumptions were used in the Tool:

- Lag time before start of gas production: 1 year
- Methane by volume: 50 percent
- Carbon dioxide by volume: 50 percent
- Methane density at 1 atmosphere, 25 degrees Celsius (°C): 0.6557 kilogram per cubic metre (kg/m^3)
- Carbon dioxide density, 25°C: 1.7988 kg/m^3

3.7 Model Input Parameters Used and Justification

3.7.1 Methane Generation Rate (k)

Input parameters used for the constant, k, are based on the BC MOE LFG Guideline, Table 5.2.

According to the annual precipitation (386.9 mm, as mentioned in Section 3.3), the model uses k-values for this site are as follows:

- 0.01/year (y) for relatively inert waste
- 0.02/y for moderately decomposable waste
- 0.05/y for decomposable waste

However, the *National Inventory Report 1990-2011: Greenhouse Gas Sources and Sinks in Canada* (NIR) (Environment Canada, 2013) adopted a new methodology in 2011, which uses a new formula to calculate k-value from precipitation. No further revision on this methodology was found in the current edition of NIR (NIR, 2016). With the NIR new methodology, the k-value for the precipitation of 386.9 mm is 0.010. Proportionally, the new k-value for each category is as follows:

- 0.00375/y for relatively inert waste
- 0.00750/y for moderately decomposable waste
- 0.01875/y for decomposable waste

3.7.2 Methane Generation Potential (L_o)

The input parameters used for the L_o-value are based on the BC MOE LFG Guideline, Table 5.1. For this Site, the model uses the following L_o-values:

- 20 m^3 methane/metric tonne of waste for relatively inert waste
- 120 m^3 methane/metric tonne of waste for moderately decomposable waste
- 160 m^3 methane/metric tonne of waste for decomposable waste

3.7.3 Water Addition Factor

According to the BC MOE LFG Guideline, Section 5.4, the selected k-value should be corrected based on the landfill's operations and maintenance practices, including stormwater management, cover properties, and the extent of leachate recirculation or stormwater injection. Based on Table 5.3 of the BC MOE LFG Guideline, the water addition factor appropriate for the Site conditions in 2016 is 1.0. The reasons are as follows:

- There is partial infiltration of stormwater into the waste.

There is very little recirculation of leachate into the waste in the Phase 1 North Expansion area since the Leachate Recirculation Pilot program introduced in 2007.

SECTION 4

LFG Model Results

This section presents the results of the updated Assessment, in accordance with the Regulation and the BC MOE LFG Guideline, Section 7, Landfill Generation Assessment Reporting. Table 4-1 presents the updated annual methane production using the Tool (see Appendix A).

Table 4-1. Annual Methane Production Using the BC MOE Calculation Tool for the Glenmore Landfill

Estimated Quantity of Methane Produced	Year	Tonnes Per Year
In the year preceding the Assessment	2015	1,675
In the year of the Assessment	2016	1,749
1 year after the Assessment	2017	1,835
2 years after the Assessment	2018	1,912
3 years after the Assessment	2019	1,990
4 years after the Assessment	2020	2,068

According to the calculation tool results, 1,749 tonnes of methane were generated in 2016, which corresponds to approximately 304 cubic metres per hour (m^3/h) or a 179 standard cubic feet per metre (scfm) methane generation rate. Using a typical LFG composition of 50 percent methane and 50 percent carbon dioxide by volume, The LFG generation rate in 2016 is about 607 m^3/h (358 scfm).

SECTION 5

LFG Collection System Efficiency

This section presents the information required under Sections 7(2)(b) of the Regulation.

5.1 LFG Collection system Installation

The City has operated an active LFG collection and flare system since 2005. The system installation schedule is determined by the waste volumes in place and the disposal rates. Phase 1 LFG collection system was designed in 2002, and Phase 2 in 2006, which is currently undergoing LFG collection system expansions and system upgrades. Phase 3 is currently in the conceptual design stage. The system included a LFG utilization package in the form of 3 capstone C-30 microturbines. The microturbine was decommissioned and removed in 2013. A biogas plant (biomethane) was constructed in partnership with FortisBC in 2014, which upgrades LFG to pipeline quality renewable natural gas (RNG). Commissioning of the new biomethane plant, is ongoing with facility startup currently planned for the summer of 2016 (City, 2015).

5.2 2016 LFG Collection Data

In 2016, there were 2,567,607 m^3 of LFG destroyed through flaring and 198,250 m^3 of LFG was processed through the Fortis Biogas Plant for beneficial use by FortisBC (personal communication with D. Enevoldson, February 6, 2017).

5.3 2016 Flare Operational Efficiency

There will be expected downtime for the flare system based on routine and preventative maintenance requirements, system upgrades, as well as unexpected downtime due to unpredictable events, such as equipment and power failures. Annual downtimes in non-continuous flaring can contribute to reducing the LFG collection efficiency. Based on the facility operations data provided by the City, the flare was down for 141 times during 2016 with total downtime of 10,621 minutes. It is understood that approximate 2,400 minutes of this downtime was for the biogas plant operation. Therefore, the actual downtime was 8,221 minutes which corresponds to approximately 1.6 percent of total time (527,040 minutes in 2016 [leap year]) or less than 6 days, which would be within a reasonable timeframe. The downtime for the flare was attributed to routine equipment maintenance, biomethane facility trial operations, and additional system upgrades undertaken at the blower/flare facility.

5.4 2016 LFG Collection Efficiency

In accordance with the BC MOE LFG Design Guidelines, collection efficiency (CE) is calculated based on the following equation:

$CE = (Q_c/Q_p)*100\%$

Where:

CE = collection efficiency expressed as a percentage (%)

Q_c = normalized average collected flow rate of LFG in the given calendar year (m^3/h)

Q_p = estimated generated LFG flow rate in given calendar year (m^3/h), which is calculated according to the Tool

The normalized average collected flow rate of LFG (Q_c) is calculated according to:

$Q_c = Q_a * C_m/50\%$

Where:

Q_a = average measured LFG flow rate (m^3/h)

C_m = annual average methane concentration measured during LFG management system uptime at a central collection point near the blower or combustion/utilization device of the LFG management system expressed as a percentage (%)

The average measured LFG flow rate (Q_a) is measured according to the following:

$Q_a = V_{LFG}/(24*366)$

Where:

V_{LFG} = total volume of LFG collected in the calendar year 2016 (cubic metres per year [m^3/y]); 2016 was a leap year with 366 days

Based on this formula:

$Q_a = V_{LFG}/(24*366)$
$Q_a = 2,765,857m^3/(24*366\ hr)$
$= 314.87\ m^3/h$

$Q_p = 5,335,509m^3/(24*366\ hr)$
$= 607.41\ m^3/h$ for 2016

Based on record data:

$Q_c = Q_a*\ C_m/50\%$
$= 314.87*55.35\%/50\%$
$= 348.57\ m^3/h$

$CE = (Q_c/Q_p)*100\%$
$= (348.57/607.41)*100\%$
$= 57.39\%$

The final CE of the LFG collection system is estimated to be 57 percent.

5.5 Discussion and Conclusion

With k values calculated using Environment Canada (2013) updated methodology to replace the k values provided in the BC MOE LFG Guideline, the calculated 2016 CE for the LFG collection system at the site was 57 percent. Site-specific data review indicates that the following factors may reduce the overall CE:

- Oxidation of methane through the landfill cover (temporary or final) is not included in the calculation of LFG collection system efficiency (based on the BC LFG Management Facilities Design Manual), and if applied would increase the LFG system CE. The thicker the cover, the more oxidation occurs.
- System downtime is not included in the calculation of LFG collection system efficiency. Data record indicates that there was 1.6 percent downtime.
- LFG generation rates are affected by shallow waste depth (Rajaram et al., 2011). In a deep landfill, it is expected that the waste retains more moisture at depth, providing better conditions for increasing LFG generation rates (Garg et al., 2006). Also, the deeper the waste inside a landfill, the more insulation may be improved and temperature increase; therefore, accelerating the actual rate of methane generation (Huitric and Rosales, 2005). Currently the deepest waste depth is approximately 24 m. With the increased waste depth in the future, and application of final cover the CE would continue to improve.

- Another Site condition that affects LFG generation rates is air ingression. Leakage from the surface or side slopes through the temporary cover or cracks in the surface in a cell within the active extraction system can result in air ingression. The magnitude of such an air ingression can be significant if the vacuum applied is drawing more gas than can be replenished by gas production. LFG wells in areas that are effected by excessive air ingression, inhibit the activity of the methane-producing anaerobic bacteria, while increasing the activity of the carbon dioxide aerobic bacteria; hence, tends to provide an over-estimation of LFG production.
- In the past, asbestos pits were constructed within Phase 2, providing a potential pathway for air ingression into the waste. These shallow open pits within the waste can also contribute to a lower LFG efficiency at the Site.
- The LFG collection system is made up of horizontal collectors, which are installed at the top of each waste lift. These LFG collectors are generally not operable without extensive air ingression until at least one lift of waste is completed above the overlying the horizontal collector. They will become more efficient gas collectors over time: once more waste lifts are completed and the final cover being placed, the collectors are buried deeper within the cell.

SECTION 6

Limitation

The findings and conclusions of this report are based on information provided by the City, which is assumed to be correct, and certain assumptions, as outlined in the report. Except as provided for in this report, CH2M has made no independent investigation as to the accuracy or completeness of the information obtained from secondary sources during completion of this work. In some cases, however, information data gaps exist. The interpretation and findings of this report were limited in these situations.

References

BC Ministry of Environment (BC MOE). 2008. *Landfill Gas Management Regulation*. Province of BC, ordered and approved December 8, 2008.

BC Ministry of Environment (BC MOE). 2014. *Landfill Gas Generation Estimation Tool.* http://www2.gov.bc.ca/gov/content/environment/waste-management/garbage/landfills. Accessed March 6, 2017.

CH2M HILL Canada Limited (CH2M). 2009. *Leachate Recirculation Pilot Test – Waste Moisture Analysis and Update.*

CH2M HILL Canada Limited (CH2M). 2010. *Landfill Gas Generation Assessment Report – Glenmore Landfill Site.*

CH2M HILL Canada Limited (CH2M). 2012. *Landfill Gas Management Facilities Design Plan – Glenmore Landfill Site*. January.

CH2M HILL Canada Limited (CH2M). 2014. *Ultimate Long Term Filling Plan and Development Considerations for the Glenmore Landfill.*

City of Kelowna (City). 2011. *2010 Glenmore Landfill Annual Report.*

City of Kelowna (City). 2012. *2011 Glenmore Landfill Annual Report.*

City of Kelowna (City). 2013. *2012 Glenmore Landfill Annual Report.*

City of Kelowna (City). 2014. *2013 Glenmore Landfill Annual Report.*

City of Kelowna (City). 2015. *2014 Glenmore Landfill Annual Report.*

City of Kelowna (City). 2016. *2015 Glenmore Landfill Annual Report.*

Conestoga-Rovers & Associates (CRA). 2009. *Landfill Gas Generation Assessment Procedure Guidelines.* Prepared for the BC MOE. March.

Conestoga-Rovers & Associates (CRA). 2010. *Landfill Gas Management Facilities Design Guidelines.* Prepared for the BC MOE. March.

Environment Canada. 2013. *National Inventory Report 1990-2011: Greenhouse Gas Sources and Sinks in Canada.* http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php. Accessed March 6, 2017.

Environment Canada. 2016. *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada.* http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php. Accessed March 6, 2017.

Garg, A., G. Achari, and R.C. Joshi. 2006. *A Model to Estimate the Methane Generation Rate Constant in Sanitary Landfills Using Fuzzy Synthetic Evaluation*. Waste Management & Research. V. 24. pp. 363-375.

Government of Canada. 2017. *Canadian Climate Normals between 1981 and 2010.* http://climate.weather.gc.ca/climate_normals/index_e.html?StationName=red%20deer&SearchType=BeginsWith&StnId=2133. Accessed March 1, 2017.

Huitric, R.L., and M.A. Rosales. 2005. *Determining the Reliability of Landfill Methane Projections. Proceedings of the SWANA 10th Annual Landfill Gas Symposium and Solid Waste Manager*. Boulder, Colorado. June.

Morrison Hershfield Ltd. 2016. *Solid Waste Management Plan Update – Stage 1 Report Regional District of Central Okanagan.*

Rajaram, Vasudevan, Faisal Zia Siddiqui, and Mohd Emran Khan. 2011. *From Landfill Gas to Energy: Technologies and Challenges.* CRC Press.

SECTION 8

Signatures

R.S.O. LI

March 13, 2017

Prepared by: ______________________________

Raymond Li, Ph.D., P.Eng. (Alberta and British Columbia)

Appendix A

BC MOE's Methane Generation Estimation Tool Results for the Glenmore Landfill Site

Year of Assessment	2016		LFG Management Regulation Reference
Annual Tonnage in Preceding Year	136,115	(tonnes/year)	4-2-a
Total waste in Place in Preceding Year	2,955,062	(tonnes/year)	4-2-c
Methane generation in Preceding Year	1,675	(tonnes CH4/year)	4-2-d

Next Five Years	Waste Tonnage (tonnes)	Methane Generation (tonnes CH4/year)	
2016	154,510	1,749	4-2-b & 4-2-e
2017	143,185	1,835	4-2-b & 4-2-e
2018	145,888	1,912	4-2-b & 4-2-e
2019	148,642	1,990	4-2-b & 4-2-e
2020	151,448	2,068	4-2-b & 4-2-e

	Relatively Inert	Moderately Decomposable	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH4/tonne
lag time before start of gas production, lag =	1	years		
Historical Data Used (years)	30			
1st Year of Historical Data Used	1986			
4 Years after Reporting Year	2020			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density) - 1atm, 25C	0.6557	kg/m^3	(25C,SP)	
carbon dioxide (density)	1.7988	kg/m^3	(25C,SP)	

				Waste Tonnage			Methane Generation Rate, k			
Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Relatively Inert (tonnes)	Moderately Decomposable (tonnes)	Decomposable (tonnes)	Relatively Inert (year^{-1})	Moderately Decomposable (year^{-1})	Decomposable (year^{-1})	Annual Methane Production (tonnes/yr)
1986	1	87,434	87,434	23,607	47,214	16,612	0.00	0.01	0.02	0.00
1987	2	87,434	174,868	23,607	47,214	16,612	0.00	0.01	0.02	61.33
1988	3	87,434	262,302	23,607	47,214	16,612	0.00	0.01	0.02	121.85
1989	4	87,434	349,736	23,607	47,214	16,612	0.00	0.01	0.02	181.57
1990	5	87,434	437,170	23,607	47,214	16,612	0.00	0.01	0.02	240.50
1991	6	87,434	524,604	23,607	47,214	16,612	0.00	0.01	0.02	298.65
1992	7	93,852	618,456	25,340	50,680	17,832	0.00	0.01	0.02	356.04
1993	8	89,753	708,209	24,233	48,467	17,053	0.00	0.01	0.02	417.18
1994	9	84,272	792,481	22,753	45,507	16,012	0.00	0.01	0.02	474.64
1995	10	80,458	872,939	21,724	43,447	15,287	0.00	0.01	0.02	527.51
1996	11	80,794	953,733	21,814	43,629	15,351	0.00	0.01	0.02	577.01
1997	12	95,904	1,049,637	25,894	51,788	18,222	0.00	0.01	0.02	626.12
1998	13	83,756	1,133,393	22,614	45,228	15,914	0.00	0.01	0.02	685.18
1999	14	85,258	1,218,651	23,020	46,039	16,199	0.00	0.01	0.02	734.96
2000	15	89,547	1,308,198	24,178	48,355	17,014	0.00	0.01	0.02	785.15
2001	16	95,815	1,404,013	25,870	51,740	18,205	0.00	0.01	0.02	837.71
2002	17	102,522	1,506,535	27,681	55,362	19,479	0.00	0.01	0.02	893.99
2003	18	96,772	1,603,307	26,128	52,257	18,387	0.00	0.01	0.02	954.25
2004	19	106,483	1,709,790	28,750	57,501	20,232	0.00	0.01	0.02	1009.71
2005	20	108,597	1,818,387	29,321	58,642	20,633	0.00	0.01	0.02	1071.27
2006	21	116,218	1,934,605	31,379	62,758	22,081	0.00	0.01	0.02	1133.52
2007	22	102,688	2,037,293	27,726	55,452	19,511	0.00	0.01	0.02	1200.32
2008	23	100,611	2,137,904	27,165	54,330	19,116	0.00	0.01	0.02	1256.78
2009	24	114,590	2,252,494	30,939	61,879	21,772	0.00	0.01	0.02	1311.07
2010	25	119,861	2,372,355	32,362	64,725	22,774	0.00	0.01	0.02	1374.48
2011	26	106,387	2,478,742	28,724	57,449	20,214	0.00	0.01	0.02	1440.78
2012	27	108,110	2,586,852	29,190	58,379	20,541	0.00	0.01	0.02	1496.78
2013	28	108,917	2,695,769	29,408	58,815	20,694	0.00	0.01	0.02	1553.30
2014	29	123,178	2,818,947	33,258	66,516	23,404	0.00	0.01	0.02	1609.67
2015	30	136,115	2,955,062	36,751	73,502	25,862	0.00	0.01	0.02	1675.33
2016	31	154,510	3,109,572	41,718	83,435	29,357	0.00	0.01	0.02	1749.25
2017	32	143,185	3,252,757	38,660	77,320	27,205	0.00	0.01	0.02	1835.13
2018	33	145,888	3,398,644	39,390	78,779	27,719	0.00	0.01	0.02	1911.97
2019	34	148,642	3,547,286	40,133	80,267	28,242	0.00	0.01	0.02	1989.74
2020	35	151,448	3,698,735	40,891	81,782	28,775	0.00	0.01	0.02	2068.47

Calculation of average k value based on 2016 National Inventory Report 1990-2014

Relatively Inert (year^{-1})	Moderately Decomposable (year^{-1})	Decomposable (year^{-1})	Avg k value for all waste types (year^{-1})	
0.010	0.020	0.050	0.02666667	Based on BC MOE 2009 Guideline Table 5.2
0.00375 (by proportional)	0.00750 (by proportional)	0.01875 (by proportional)	0.01000000	Base on Table A3-64 of 2016 National Inventory for Moose Jaw of Saskatchwan (388.9mm precipitation) which has the closest precipitation number with those of Kelowna (387mm)

Final k = avg k *1.0 (water addition factor) with water addition factor =1.0

Appendix K
Contaminating Lifespan Calculations

Appendix K - Contaminating Lifespan Calculations

Ammonia (1st Order)
British Columbia WQG

Freshwater Aquatic Life Guidelines
Maximum Anticipated Concentration

C_t	0.102	mg/L	Target concentration
C_B	250	mg/L	Maxmium concentration
λ	0.1	y^{-1}	
t	78.04	y	Time to reduce below Criteria
t	79	y	Time, rounded up
C_o	0.09	mg/L	Check at t (rounded up)

Note: This calculation uses the highest concentration projected for the Site

Note: First order decay rate obtained from Lu et al., 1981, Leachate Production and Management from Municipal Landfill: Summary and Assessment, Land Disposal: Municipal Solid Waste – Proceedings of the Seventh Annual Research Symposium, EPA 600/9 81, pp. 1 17, 1981

Ammonia (1st Order)
British Columbia WQG

Freshwater Aquatic Life Guidelines
Mean Anticipated Concentration

C_t	0.102	mg/L	Target concentration
C_B	99	mg/L	Mean concentration
λ	0.1	y^{-1}	
t	68.77	y	Time to reduce below Criteria
t	69	y	Time, rounded up
C_o	0.10	mg/L	Check at t (rounded up)

Note: This calculation uses the average concentration found in leachate samples collected from the Site

Note: First order decay rate obtained from Lu et al., 1981, Leachate Production and Management from Municipal Landfill: Summary and Assessment, Land Disposal: Municipal Solid Waste – Proceedings of the Seventh Annual Research Symposium, EPA 600/9 81, pp. 1 17, 1981

Appendix K - Contaminating Lifespan Calculations

Chloride (1st Order)
British Columbia CSR and WQGs

Irrigation Water Standards/Guidelines
Maximum Anticipated Concentration

C_t	100	mg/L	
C_B	1,000	mg/L	Maximum concentration
λ	0.065	y^{-1}	
t	35.42	y	Time to reduce below Criteria
t	36	y	Time, rounded up
C_o	96.33	mg/L	Check at t (rounded up)

Note: This calculation uses the highest concentration projected for the Site

Note: First order decay rate obtained from Lu et al., 1981, Leachate Production and Management from Municipal Landfill: Summary and Assessment, Land Disposal: Municipal Solid Waste – Proceedings of the Seventh Annual Research Symposium, EPA 600/9 81, pp. 1 17, 1981

Chloride (1st Order)
British Columbia CSR and WQGs

Irrigation Water Standards/Guidelines
Mean Anticipated Concentration

C_t	100	mg/L	
C_B	507	mg/L	Mean concentration
λ	0.065	y^{-1}	
t	24.97	y	Time to reduce below Criteria
t	25	y	Time, rounded up
C_o	99.81	mg/L	Check at t (rounded up)

Note: This calculation uses the average concentration found in leachate samples collected from the Site

Note: First order decay rate obtained from Lu et al., 1981, Leachate Production and Management from Municipal Landfill: Summary and Assessment, Land Disposal: Municipal Solid Waste – Proceedings of the Seventh Annual Research Symposium, EPA 600/9 81, pp. 1 17, 1981

Appendix K - Contaminating Lifespan Calculations - Rowe Model (1995)

		CSR IW			CSR DW			
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Units**	**Comments**
C_t	100	100	100	250	250	250	mg/L	Target concentration
C_t	0.1	0.1	0.1	0.25	0.25	0.25	kg/m^3	Target concentration
q_o	0.013	0.013	0.013	0.013	0.013	0.013	m/y	Average rate of infiltration
p	0.0014	0.0014	0.002	0.0014	0.0014	0.002	-	Proportion of total waste mass that is chloride
A_o	346,148	346,148	346,148	346,148	346,148	346,148	m^2	Unit area^2
$V_{landfill}$	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	m^3	Volume of landfill
V_{cover}	207,689	207,689	207,689	207,689	207,689	207,689	m^3	Volume of cover
V_o	8,792,311	8,792,311	8,792,311	8,792,311	8,792,311	8,792,311	m^3	Volume of waste
C_o	1000	507.00	1000	1000	507.00	1000	mg/L	Chloride concentration (peak or average)
C_o	1	0.507	1	1	0.507	1	kg/m^3	Chloride concentration (peak or average)
H_w	32	32	32	32	32	32	m	Maximum waste thickness
r_{dw}	720	720	720	720	720	720	kg/m^3	Dry density of waste
M_o	6,330,464,064	6,330,464,064	6,330,464,064	6,330,464,064	6,330,464,064	6,330,464,064	kg	
H_r	25.60	50.50	36.58	25.60	50.50	36.58	m	Reference height of leachate
k	0.0655	0.0653	0.0654	0.0655	0.0653	0.0654	y^{-1}	
k	0.0655	0.0653	0.0654	0.0655	0.0653	0.0654	y^{-1}	
t	**35.15**	**24.88**	**35.23**	**21.16**	**10.83**	**21.21**	**years**	

Scenario 1 Maximum chloride concentration, average proportion of chloride in waste
Scenario 2 Average chloride concentration, average proportion of chloride in waste
Scenario 3 Maximum chloride concentration, maximum proportion of chloride in waste

Notes: Based on Rowe calculations - Rowe, R.K., 1995 *Leachate Characteristics for MSW Landfills*

Appendix L
Environmental Monitoring Plan Specifications

Table L-1

Leachate Parameters
2018 Design, Operations and Closure Plan
Glenmore Landfill
City of Kelowna

	Units
Field Parameters	
Conductivity, field	mS/cm
Dissolved Oxygen (DO), field	mg/L
Oxidation Reduction Potential (ORP), field	millivolts
pH, field	s.u.
Temperature, field	Deg C
General Chemistry	
Alkalinity, total (as CaCO3)	mg/L
Dissolved Organic Carbon (DOC) (dissolved)	mg/L
Total Dissolved Solids (TDS)	mg/L
Bromide	mg/L
Chemical oxygen demand (COD)	mg/L
Chloride	mg/L
Fluoride	mg/L
Hardness	mg/L
pH, lab	s.u.
Sulfate	mg/L
Sulphide	mg/L
Nutrients	
Ammonia-N	mg/L
Nitrate (as N)	mg/L
Nitrite (as N)	mg/L
Orthophosphate	mg/L
Phosphorus	mg/L
Dissolved Metals	
CSR Dissolved Metals (incl. mercury)	mg/L
Hydrocarbons	
PAH/LEPH/HEPH	mg/L
VOCs	mg/L
VPH	mg/L

Notes:

PAH - polycyclic aromatic hydrocarbons
LEPH - light extractable petroleum hydrocarbons
HEPH - heavy extractable petroleum hydrocarbons
VOCs - volatile organic compounds
VPH - volatile petroleum hydrocarbons

Table L-2

Groundwater Parameters
2018 Design, Operations and Closure Plan
Glenmore Landfill
City of Kelowna

	Units
Field Parameters	
Conductivity, field	mS/cm
Dissolved Oxygen (DO), field	mg/L
Oxidation Reduction Potential (ORP), field	millivolts
pH, field	s.u.
Temperature, field	Deg C
General Chemistry	
Alkalinity, total (as CaCO3)	mg/L
Dissolved Organic Carbon (DOC) (dissolved)	mg/L
Total Dissolved Solids (TDS)	mg/L
Bromide	mg/L
Chemical oxygen demand (COD)	mg/L
Chloride	mg/L
Fluoride	mg/L
Hardness	mg/L
pH, lab	s.u.
Sulfate	mg/L
Nutrients	
Ammonia-N	mg/L
Nitrate (as N)	mg/L
Nitrite (as N)	mg/L
Orthophosphate	mg/L
Dissolved Metals	
CSR Dissolved Metals (incl. mercury)	mg/L
Extra Parameters	
Sulphide (as H2S)[1]	mg/L
Speciated non-chlorinated phenols[2]	mg/L

Table L-3

Surface Water Parameters
2018 Design, Operations and Closure Plan
Glenmore Landfill
City of Kelowna

	Units
Field Parameters	
Conductivity, field	uS/cm
Dissolved Oxygen (DO), field	mg/L
Oxidation Reduction Potential (ORP), field	millivolts
pH, field	s.u.
Temperature, field	Deg C
General Chemistry	
Alkalinity, total (as CaCO3)	mg/L
Total Organic Carbon (TOC)	mg/L
Total Dissolved Solids (TDS)	mg/L
Total Suspended Solids (TSS)	mg/L
Bromide	mg/L
Chemical oxygen demand (COD)	mg/L
Chloride	mg/L
Conductivity, lab	uS/cm
Fluoride	mg/L
Hardness	mg/L
pH, lab	s.u.
Phosphorus	mg/L
Sulfate	mg/L
Sulphide	mg/L
Nutrients	
Ammonia-N	mg/L
Nitrate (as N)	mg/L
Nitrite (as N)	mg/L
Orthophosphate	mg/L
Total kjeldahl nitrogen (TKN)	mg/L
Total phosphorus	mg/L
Total Metals	
CSR Total Metals (incl. mercury)	mg/L
Microbial	
Total coliforms	MPN/100 mL
Fecal coliforms	MPN/100 mL

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

Deacon Liddy
Deacon.Liddy@ghd.com
604.248.3671

Roxanne Hasior
Roxanne.Hasior@ghd.com
604.248.3932

www.ghd.com