City of Kelowna
Regular Council Meeting
AGENDA

Monday, February 25, 2019
1:30 pm
Council Chamber
City Hall, 1435 Water Street

Pages

1. Call to Order

This meeting is open to the public and all representations to Council form part of the public record. A live audio and video feed is being broadcast and recorded by CastaNet and a delayed broadcast is shown on Shaw Cable.

2. Confirmation of Minutes 5 - 10

3. Development Application Reports & Related Bylaws

3.1 McClain Rd 4159, Z18-0123 - Daniel Rae Dorssers and Christyane Ramonde Dorssers 11 - 23

To consider a Staff recommendation to NOT rezone the subject property that would facilitate the conversion of an existing accessory building into a carriage house.

3.2 Altura Rd 30, Z18-0102 - David & Camille Harkins 24 - 29

To consider a development application to rezone to the RU2c – Medium Lot Housing with Carriage House zone to facilitate a proposed Carriage House on the subject property.

3.3 Altura Rd 30, BL11759 (Z18-0102) - David & Camille Harkins 30 - 30

To give Bylaw No. 11759 first reading in order to rezone the subject property from the RU2 – Medium Lot Housing zone to RU2c Medium Lot Housing with Carriage House zone.

3.4 Short-Term Rental Accommodation Regulations 31 - 80

To amend the Zoning Bylaw by creating a new short-term rental accommodation use with associated regulations, adding the use to select zones with residential and mixed-use commercial uses, and removing the existing apartment hotels use.

3.5 Short-Term Rental Accommodation Non-Conforming Use Provisions 81 - 84

To provide clarity on those properties that quality for non-conforming use provisions for short-term rental accommodation.

3.6 Short Term Rental Accommodation, BL11766 (TA19-0007) - City of Kelowna 85 - 96

To give Bylaw No. 11766 first reading in order to amend Zoning Bylaw No. 8000 with short-term rental accommodation updates.

3.7 Pandosy St 2565 - 2579, Z17-0113 Extension - 1018545 BC Ltd, Inc No BC1018545 97 - 98

To extend the deadline for adoption of Rezoning Bylaw No. 11562 to March 20, 2020.

4. Bylaws for Adoption (Development Related)

4.1 4610 Darin Place, Z17-0054 (BL11463) - Randall Schmidt and Josephine Pirolli 99 - 99

To adopt Bylaw No. 11463 in order to rezone the subject property from RU1 - Large Lot Housing zone to the RU1c - Large Lot Housing with Carriage House zone.

4.2 Cross Rd 1967, 1969 & 1973 Z17-0083 (BL11603) - Maxwell House Developments Ltd, Glen Park Village Inc & City of Kelowna 100 - 101

To adopt Bylaw No. 11603 in order to rezone the subject properties as per Map A.

4.3 170 & 230 Nickel Road, Z17-0039 (BL11429) - 554764 BC Ltd 102 - 102

To amend at third reading and adopt Bylaw No. 11429 in order to rezone the subject property from RU1 - Large Lot Housing zone to the RM3 - Low Density Multiple Housing zone.

5. Non-Development Reports & Related Bylaws

5.1 Remedial Action Orders To Address Slope Instability and Unsafe Conditions 103 - 237

To impose Remedial Action Orders to rectify slope instability and unsafe condition at 2045 Loseth Road and 2001 Kloppenburg Court, which are both urgent and of high-consequence.

5.2 Kelowna International Airport Airport Improvement Fee Memorandum of Agreement Amendment 238 - 242

To obtain Council's approval to amend the Airport Improvement Fee Memorandum of Agreement (the AIF MOA).

5.3 Kelowna International Airport Bylaw Amendment 243 - 244

To obtain Council's approval to amend City of Kelowna Airport Fees Bylaw 7982.

5.4 BL11763 - Amendment No. 34 to Airport Fees Bylaw No. 7982 245 - 246

To give Bylaw No. 11763 first, second and third readings in order to amend the Airport Fees Bylaw No. 7982.

5.5 Kelowna-Kasugai Sister City Association Sponsor Agreement 247 - 255

To consider executing a Sponsor Agreement with the Kelowna-Kasugai Sister City Association to establish the roles and objectives of the Sister City sponsor organization's relationship with Kasugai, Japan (the Sister City).

5.6 2019 Heritage Grants Program Agreement 256 - 272

To consider executing a Grant Administration Agreement with the Central Okanagan Heritage Society to administer and adjudicate the Heritage Grants Program on behalf of the City of Kelowna.

5.7 Budget Amendment for the Rehabilitation of City Park Water Park 273 - 275

To amend the 2019 Fiancial Plan to support the restoration of City Park Water Park to an operational condition for the 2019 season.

5.8 Update on Kelowna Joint Water Committee 276 - 278

To update Council on the status and activities of the Kelowna Joint Water Committee

5.9 Water System Integration Policy 279 - 285

To formalize the vision and policy for city-wide integrated water distribution systems for domestic and agricultural users and to enable actions leading to development of a city-wide water system for the City of Kelowna.

5.10 South Okanagan Mission Agricultural Users Local Area Service – Certificate of Sufficiency 286 - 289

To receive the Certificate of Sufficiency for the South Okanagan Mission Agricultural Users Local Area Service from the customers involved in the South Okanagan Mission Irrigation Distribution Water Integration Project and to forward the Establishment and Loan Authorization Bylaws for reading consideration.

5.11 BL11745 - South Okanagan Mission Agricultural Users Local Area Service Establishment Bylaw 290 - 292

To give Bylaw No. 11745 first, second and third readings in order to establish the South Okanagan Mission Agricultural Users Local Area Service.

5.12 BL11746 - South Okanagan Mission Agricultural Users Loan Authorization Bylaw 293 - 294

To give Bylaw No. 11746 first, second and third readings in order to borrow for the South Okanagan Mission Agricultural Users Local Area Service.

5.13 Development Cost Charges Bylaw No. 11755 Amendment No.4 to Development Cost Charge Bylaw No.10515 295 - 311

To inform Council about the proposed changes to the Development Cost Charge Bylaw and receive direction from Council to submit the bylaw for Ministry approval prior to returning to Council for adoption.

5.14 BL11755 - Amendment No. 4 to Development Cost Charge Bylaw No. 10515 312 - 313

To give Bylaw No. 11755 first, second and third readings in order to amend Development Cost Charge Bylaw No. 10515.

5.15 Landfill Design Operations and Closure Plan (DOCP) 314 - 848

The purpose of this report is to present Council with the new Landfill Design Operations and Closure Plan report, and request approval to submit this report to the Province to meet the conditions in Operational Certificate 12218.

6. Bylaws for Adoption (Non-Development Related)

6.1 Saucier Rd (Adjacent to 1690), BL11740 - Road Closure Bylaw 849 - 850

Mayor to invite anyone in the public gallery who deems themselves affected by the proposed road closure to come forward.
To adopt Bylaw No. 11740 in order to authorize the City to permanently close and remove the highway dedication of a portion of Highway adjacent to Saucier Road.

6.2 Saucier Rd (Adjacent to 1651), BL11741 - Road Closure Bylaw 851 - 852

Mayor to invite anyone in the public gallery who deems themselves affected by the proposed road closure to come forward.
To adopt Bylaw No. 11741 in order to authorize the City to permanently close and remove the highway dedication of a portion of Highway adjacent to Saucier Road.

7. Mayor and Councillor Items

8. Termination

City of Kelowna

Regular Council Meeting

Minutes

Date:	Monday, February 11, 2019
Location:	Council Chamber City Hall, 1435 Water Street
Members Present	Mayor Colin Basran, Councillors Maxine Dehart, Ryan Donn, Gail Given, Charlie Hodge, Brad Sieben and Luke Stack
Members Absent	Councillors Mohini Singh and Loyal Wooldridge
Staff Present	City Manager, Doug Gilchrist; City Clerk, Stephen Fleming; Acting Divisional Director, Community Planning & Strategic Investments, Derek Edstrom*; Community Planning Department Manager, Ryan Smith*; Suburban and Rural Planning Manager, Dean Strachan*; Long Range Policy Planning Manager, James Moore*; Sustainability Coordinator, Michelle Kam*, Divisional Director, Infrastructure, Alan Newcombe*; Integrated Transportation Department Manager, Rafael Villarreal Pacheco*; Transportation Engineer Planning & Development, Chad Williams*; Sport & Event Services Manager, Doug Nicholas*; Event Development Supervisor, Chris Babcock*; Legislative Coordinator (Confidential), Clint McKenzie*; Legislative Coordinator (Confidential), Rebecca Van Huizen
Guests	Matt Vader*, Chair of the Okanagan Rail Trail Committee (ORTC); Peter Chataway*, Advisory Board Member, Central Okanagan Heritage Society

(*denotes partial attendance)

1. Call to Order

Mayor Basran called the meeting to order at 1:32 p.m.

Mayor Basran advised that the meeting is open to the public and all representations to Council form part of the public record. A live audio and video feed is being broadcast and recorded by CastaNet and a delayed broadcast is shown on Shaw Cable.

2. Confirmation of Minutes

<u>Moved By Councillor Hodge/Seconded By Councillor Donn</u>

(R0126/19/02/11) THAT the Minutes of the Regular Meetings of February 4, 2019 be confirmed as circulated.

Carried

3. Public in Attendance

3.1 Central Okanagan Heritage Society

Peter Chataway, Advisory Board Member, COHS, displayed a PowerPoint presentation summarizing the 2018 Grants program and responded to questions from Council.

Moved By Councillor Donn/Seconded By Councillor Given

(R0127/19/02/11) THAT Council receives, for information, the annual update from the Committee, Central Okanagan Heritage Society, dated February 11, 2019.

Carried

4. Development Application Reports & Related Bylaws

4.1 Taylor Rd 545, Z18-0114 - Jessica Michelle Rypstra

Staff displayed a PowerPoint presentation providing an overview of the application and responded to questions from Council.

Moved By Councillor Sieben/Seconded By Councillor Donn

(R0128/19/02/11) THAT Rezoning Application No. Z18-0114 to amend the City of Kelowna Zoning Bylaw No. 8000 by changing the zoning classification of Lot 1 Section 22 TWP 26 ODYD Plan 28651 located at 545 Taylor Road, Kelowna BC from the RU1 – Large Lot Housing zone to the RU1c – Large Lot Housing with Carriage House zone be considered by Council;

AND THAT the Rezoning Bylaw be forwarded to a Public Hearing for further consideration;

AND THAT final adoption of the Rezoning Bylaw be considered subsequent to the outstanding conditions of approval as set out in Attachment "A" attached to the Report from the Community Planning Department dated February 25, 2019;

AND FURTHER THAT final adoption of the Rezoning Bylaw be considered subsequent to the approval of the Ministry of Transportation and Infrastructure.

Carried

4.2 Taylor Rd 545, BL11757 (Z18-0114) - Jessica Michelle Rypstra

Moved By Councillor Dehart/Seconded By Councillor Stack

(R0129/19/02/11) That Bylaw No. 11757 be read a first time.

Carried

4.3 Pier Mac Way 1945, DP18-0168 - Stretch Construction Ltd., Inc.No. A0102923

Staff displayed a PowerPoint presentation providing an overview of the application and responded to questions from Council.

Moved By Councillor Donn/Seconded By Councillor Stack

(R0130/19/02/11) THAT Council authorize the issuance of Development Permit No. for Lot 1, District Lot 32 and Section 14, Township 23, ODYD, Plan EPP64961, located at 1945 Pier Mac Way, Kelowna, BC, subject to the following:

1. The dimensions and siting of the building to be constructed on the land be in general accordance with Schedule A;
2. The exterior design and finish of the building to be constructed on the land be in general accordance with Schedule B;
3. Landscaping to be provided on the land to be in general accordance with Schedule C;
4. That the applicant be required to post with the City, a Landscape Performance Security deposit in the form of a "Letter of Credit" in the amount of 125% of the estimated value of the landscaping, as determined by a professional landscaper (Schedule C);
5. That the applicant be required to complete the requirements of Attachment A as attached to the Report from Development Engineering dated August 9, 2018.

AND THAT the applicant be required to complete the above noted conditions of Council's approval of the Development Permit Application in order for the permit to be issued;

AND FURTHER THAT the Development Permit be valid for two (2) years from the date of Council approval, with no opportunity to extend.

Carried

4.4 Rescinding Housing Agreement Authorization Bylaw No. 9999

Councillor Stack declared a perceived a conflict of interest as his employer applies for housing agreements and left the meeting at 1:46 pm.

Moved By Councillor Dehart/Seconded By Councillor Hodge

(R0131/19/02/11) THAT Council receives, for information, the Report from the City Clerk, dated February 11, 2019 pertaining to the rescindment of Housing Agreement Authorization Bylaw No. 9999;

AND THAT Council gives reading consideration to Bylaw No. 11758 being Housing Agreement Authorization Bylaw No. 9999 Rescinding Bylaw No. 11758.

Carried

4.5 BL11758 - Rescinding Housing Agreement Authorization Bylaw No. 9999

Moved By Councillor Dehart/Seconded By Councillor Donn

(R0132/19/02/11) To give Bylaw No. 11758 first, second and third readings.

Carried

Councillor Stack returned to the meeting at 1:47 pm.

5. Bylaws for Adoption (Development Related)

5.1 Taylor Crescent 2414, BL11735 (Z18-0100) - Mark E. A. Danielson and Erin A. Cram

Moved By Councillor Hodge/Seconded By Councillor Given

(R0133/19/02/11) THAT Bylaw No. 11735 be adopted.

Carried

6. Non-Development Reports & Related Bylaws

6.1 Hospital Area Plan – Phase II – Transportation and Land Use

Staff displayed a PowerPoint presentation providing an overview of the Phase II Plan and responded to questions from Council.

Moved By Councillor Given/Seconded By Councillor Dehart

(R0134/19/02/11) THAT Council receives, for information, the report from the Policy and Planning Department dated January 28, 2019, with respect to the Hospital Area Plan – Phase II;

AND THAT staff bring back for Council consideration at the appropriate time, amendments to the Official Community Plan, Zoning Bylaw 8000, and the Capital Plan (transportation) as outlined in the Hospital Area Plan – Phase II Transportation and Land Use report from the Policy and Planning Department, dated January 28, 2019.

Carried

6.2 Okanagan Rail Trail Update

Staff introduced the Chair of the Okanagan Rail Trail Committee, Matt Vader, and responded to questions from Council.

Guest, Matt Vader, displayed a PowerPoint presentation providing a Committee update, summarizing the joint principles that relate to the entire corridor and responded to questions from Council.

Moved By Councillor Donn/Seconded By Councillor Hodge

(R0135/19/02/11) THAT Council receives, for information, the report from the Sustainability Coordinator and Development Engineering Manager, dated February 11, 2019, with respect to the Okanagan Rail Trail Update;

AND THAT Council receives, for information, the presentation from the Chair of the Okanagan Rail Trail Committee (ORTC);

AND THAT Council approves the principles of the Okanagan Rail Trail Maintenance Standards Guidelines.

AND THAT Council approves the principles of the Okanagan Rail Trail Brand Identity and logo attributes and direct City of Kelowna ORTC rep(s) to work with ORTC to finalize a logo that meets these attributes;

AND THAT Council endorse the Friends of the Okanagan Rail Trail (FORT) MOU and authorize the City of Kelowna ORTC rep(s) to execute on behalf of the City of Kelowna.

Carried

6.3 Canyon Falls Park Slope Stability

Staff summarized the slope stability issues, spoke to the reasons for the budget amendment and responded to questions from Council.

Moved By Councillor Stack/Seconded By Councillor Donn

> **(R0136/19/02/11)** THAT Council receive, for information, the Canyon Falls Park Slope Stability report from the Infrastructure Division Director, dated February 11, 2019;
>
> AND THAT the 2019 Financial Plan be amended to include up to $125,000 currently held in reserve for the Gopher Creek Pre-Design and Land Acquisition capital project to cover the additional costs incurred for the Canyon Falls Park Slope Stability Assessment.

Carried

6.4 Budget Amendments for the Pedestrian/Cycle Overpass and Multi-Use Path Capital Project & the John Hindle Drive (2,3,4) DCC Road Capital Project

Staff summarized the reasons for the budget amendment as a result of the grant.

Moved By Councillor Sieben/Seconded By Councillor Donn

> **(R0137/19/02/11)** THAT Council receives for information, the report from the Divisional Director, Infrastructure dated February 11, 2019, regarding the Pedestrian/Cycle Overpass and Multi-Use Path capital project & the John Hindle Drive (2,3,4) DCC Road capital project;
>
> AND THAT the 2018 Financial Plan be amended to increase the John Hindle Drive Pedestrian/Cycle Overpass and Multi-Use Path project from $1.5M to $1.8M with funding from the Arterial Roads reserve;
>
> AND THAT the 2018 Financial Plan be amended to reflect the receipt of up to $900k from the BikeBC grant program and the removal of $1.2M in developer contribution which will be contributed to the Arterial Roads reserve to meet grant requirements for the John Hindle Drive Pedestrian/Cycle Overpass and Multi-Use Path project;
>
> AND THAT the 2018 Financial Plan be amended to reflect the change in City funding to include funding up to $300k from Arterial Roads reserve for the John Hindle Drive Pedestrian/Cycle Overpass and Multi-Use Path project;
>
> AND THAT the 2018 Financial Plan be amended to include the transfer of approximately $570k of remaining budgets from the partnering John Hindle Drive DCC ($261k) and John Hindle Way Phase 3 Land ($309) projects to the John Hindle (2,3,4) DCC Roads project;
>
> AND FURTHER THAT the 2018 Financial Plan be amended to include up to $486k from the Arterial Roads reserve, up to $97k from the Landfill reserve, and to reduce the DCC funding budget by $36k to correct the DCC funding splits and cover final John Hindle (2,3,4) DCC Roads project costs.

Carried

6.5 Active Transportation Corridors Progress Update

Staff displayed a PowerPoint presentation updating Council on the Active Transportation Corridors and responded to questions from Council.

Moved By Councillor Sieben/Seconded By Councillor Stack

(R0138/19/02/11) THAT Council receives, for information, the report from the Transportation Engineering Manager dated February 11, 2019, with respect to Active Transportation Corridors Progress Update.

Carried

6.6 2018 Kelowna Outdoor Events Summary

Staff displayed a PowerPoint presentation summarizing the 2018 Outdoor Events.

Moved By Councillor Given/Seconded By Councillor Donn

(R0139/19/02/11) THAT Council receives, for information, the report from the Event Development Supervisor dated February 11, 2019 regarding the 2018 Outdoor Event season.

AND THAT Council endorses, in principle, the updated Event & Festival Framework, as outlined in Appendix B in the report from the Event Development Supervisor dated February 11, 2019.

Carried

7. Mayor and Councillor Items

Councillor Dehart:
-Attended URBA, Knights of Columbus evening and the 90th Annual Spring Lantern Festival.

Councillor Donn:
-Noted the First Minister of Scotland was in Ottawa, Ontario and opened their new Scottish Government office in Ottawa.

Councillor Hodge:
-Noted that Tuesday February 26th the Downtown Kelowna Association After 5 Event will be held at the Yacht Club.
-Mentioned that the Downtown Kelowna Association has openings for board nominations starting March 18th.
-Will also attend his first Library Board Meeting next week.

Councillor Given:
-Attended the Sports Hero Awards event along with the Mayor and Councillor Donn last week.

Mayor Basran:
-Acknowledged Pacific Sport Okanagan for their support of the Sports Hero Awards.
-Commented on road safety concerns with recent weather.

8. Termination

This meeting was declared terminated at 3:15 p.m.

Mayor Basran

City Clerk

sf/rvh

REPORT TO COUNCIL

Date:	February 25, 2019		
RIM No.	1250-30		
To:	City Manager		
From:	Community Planning Department (KB)		
Application:	Z18-0123	**Owner:**	Daniel Rae Dorssers Christyane Ramonde Dorssers
Address:	4159 McClain Road	**Applicant:**	Daniel Rae Dorssers
Subject:	Rezoning Application		

Existing OCP Designation: REP – Resource Protection Area

Existing Zone: RR1 – Rural Residential 1

Proposed Zone: RR1c – Rural Residential 1 with Carriage House

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1.0 Recommendation

THAT Rezoning Application No. Z18-0123 to amend the City of Kelowna Zoning Bylaw No. 8000 by changing the zoning classification of Lot 2 Sections 2 and 3 Township 26 Osoyoos Division Yale District Plan KAP91355, located at 4159 McClain Road, Kelowna, BC from the RR1 – Rural Residential 1 zone to the RR1C – Rural Residential 1 with Carriage House zone NOT be considered by Council.

2.0 Purpose

To consider a Staff recommendation to NOT rezone the subject property that would facilitate the conversion of an existing accessory building into a carriage house.

3.0 Community Planning

Community Planning Staff do not recommend support to rezone the subject property to facilitate the conversion of an existing accessory building to a carriage house. The proposed rezoning application does not comply with City policies in the Official Community Plan (OCP) and City of Kelowna Agriculture Plan. The property is not located within an urban area of the City and it is outside of the OCP Permanent Growth Boundary. Further, the City's Agriculture Plan (2017) recognizes existing policies and regulations to protect agricultural land, but further recommends that to strengthen the OCP that carriage houses are prohibited outside of the Permanent Growth Boundary.

The objectives of the Resource Protection Area (REP) include:

- To protect the REP for agriculture as well as environmental objectives;
- Avoid densification of the REP; and to
- Direct urban uses within the Permanent Growth Boundary.

An adjacent property on McClain Road was rezoned from RR1 – Rural Residential 1 to RR1c – Rural Residential 1 with Carriage House in May 2018. For this specific parcel, Staff wrote in the Report to Council (file Z18-0009) for this rezoning application that their recommendation for this file only due to an error in the City's mapping system that led to incorrect advice being provided, and that Staff's recommendation for that specific property represented a fair compromise. This same advice was not provided to this property.

The accessory building that the applicant is proposing to convert to a carriage house was received a building permit in 2016, and an occupancy permit in January 2018. As included in Attachment A – Applicant's Letter of Rationale, the applicant indicated that Staff communicated policies of non-support for a carriage house in this location at this time, and the approved building permit drawings were stamped to indicate that the accessory structure was not permitted to be used as a dwelling unit.

The applicant has confirmed the completion of neighbourhood notification in accordance with Council Policy No. 367.

An Alternate Recommendation of support has been included in this report under Section 8.0 for Council's consideration.

4.0 Proposal

4.1 Background

There is an existing single family dwelling and an accessory building on the subject property. The existing accessory building (that is proposed to be converted to a carriage house) received a building permit in 2016, and an occupancy permit in January 2018.

Should Council support the rezoning application, the existing accessory building would be converted to a carriage house, in general accordance with Attachment B.

4.2 Project Description

The applicant is requesting permission to rezone and then convert an existing accessory building to a carriage house. It would not require any variances to the Zoning Bylaw.

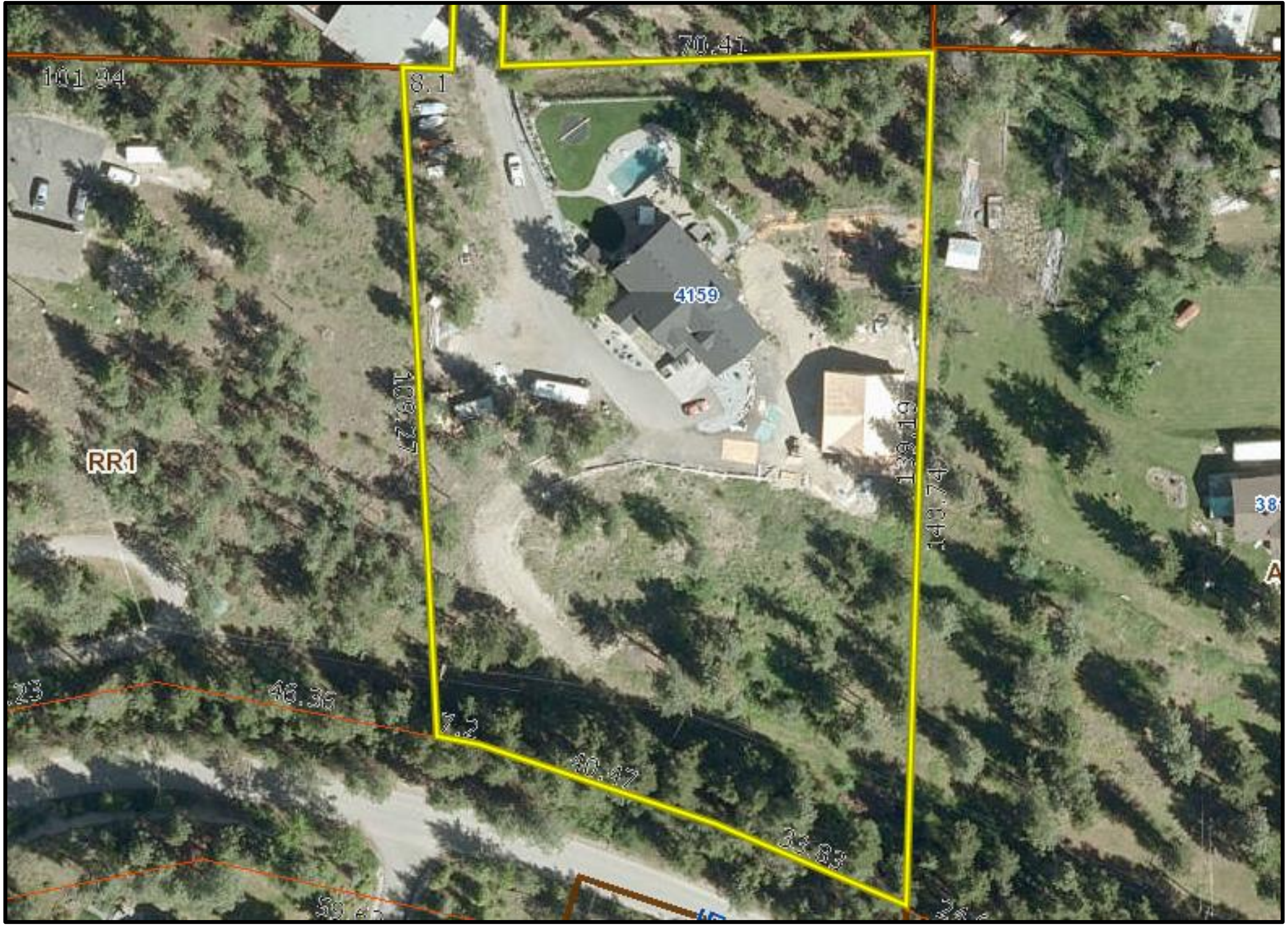
4.3 Site Context

The subject property is a panhandle shaped lot, accessed off McClain Road, with a portion of property line adjacent to Jean Road. It is approximately 2.69 acres (10,886 m^2) in area. It is located in the City's Southeast Kelowna OCP Sector, and is located outside of the City's permanent growth boundary. It is not located within the Agricultural Land Reserve (ALR), but properties to the north across McClain Road are located within the ALR. The walk score of the subject property is 0, indicating that almost all errands require a car.

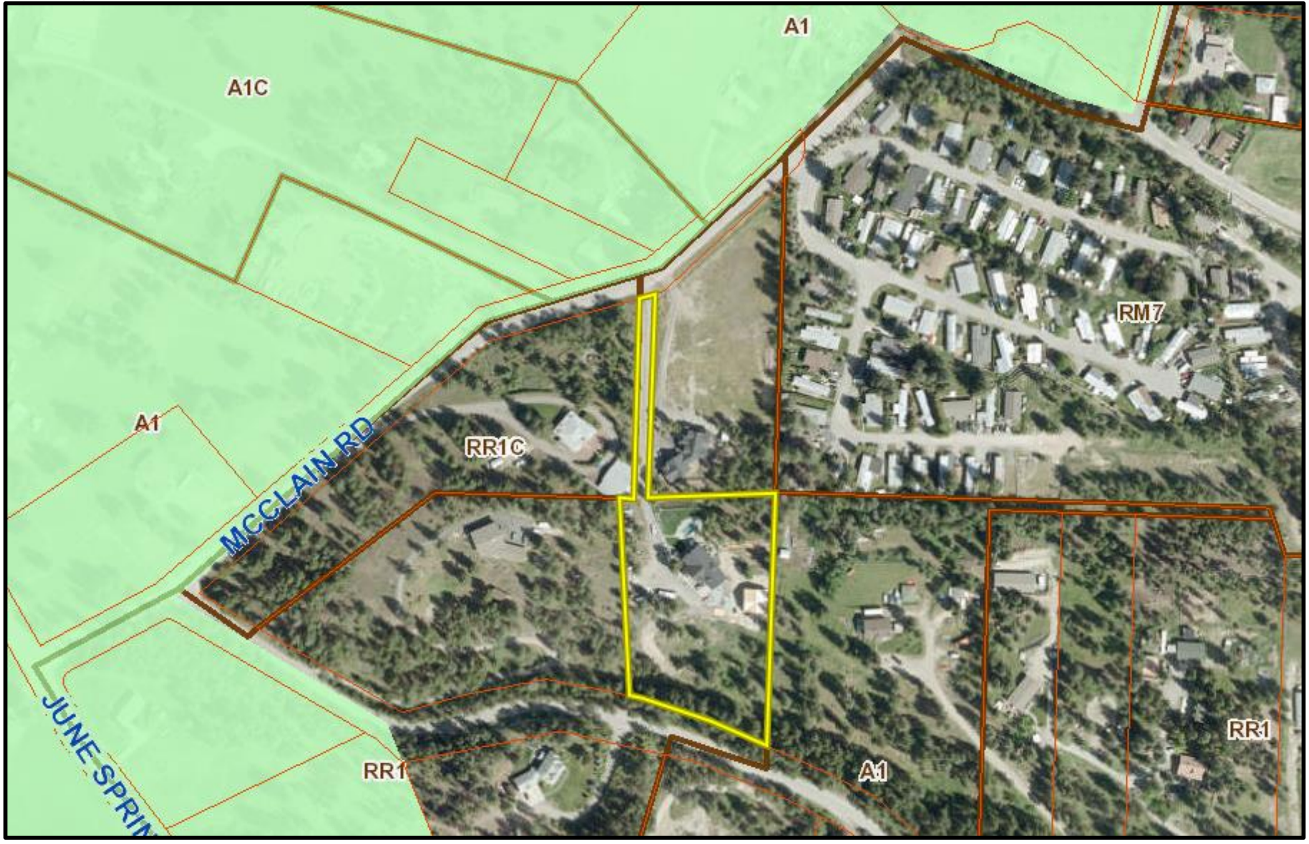
Specifically, adjacent land uses are as follows:

Orientation	Zoning	Land Use
North	RR1 – Rural Residential 1 A1 – Agriculture 1	Rural Residential Agriculture
East	RM7 – Mobile Home Park A1 – Agriculture 1	Rural Residential
South	RR1– Rural Residential 1 A1 – Agriculture 1	Rural Residential
West	RR1– Rural Residential 1 RR1c– Rural Residential 1 with Carriage House	Rural Residential

Subject Property Map: 4159 McClain Road



Zoning and ALR Map: 4159 McClain Road



5.0 Current Development Policies

5.1 Kelowna Official Community Plan (OCP)

OCP Chapter 1: Introduction

Goals for a Sustainable Future

> Contain Urban Growth. Reduce greenfield urban sprawl and focus growth in compact, connected and mixed-use (residential and commercial) urban and village centres.

OCP Chapter 4: Future Land Use

Resource Protection Area (REP)

> Rural land preserved for agricultural, environmental and recreational purposes, including the ALR, other resource lands with environmental value and protected natural open spaces, including private open space, steeply sloped lands, Natural Environment/Hazardous Condition DP Areas, and other natural features such as watercourses, water bodies, wetlands, plant and wildlife habitat, and significant aesthetic value. Allowable uses would be agriculture / resource use including farming, forestry, wood lots and silviculture as well as public or private open space on lands considered environmentally sensitive or hazardous (steep slopes). Generally land areas within this designation (whether they are within the permanent growth boundary or not) will not be supported for exclusion from the ALR or for more intensive development than that allowed under current zoning regulations, except in specific circumstances where the City of Kelowna will allow exceptions to

satisfy civic objectives for the provision of park/recreation uses. Non-ALR land outside the Permanent Growth Boundary will not be supported for any further parcelization.

Permanent Growth Boundary (PGB)

Lands within the permanent growth boundary may be considered for urban uses within the 20-year planning horizon ending 2030. Lands designated as Future Urban Reserve within the permanent growth boundary may be considered for urban uses beyond 2030. Lands outside the permanent growth boundary will not be supported for urban uses. Non-ALR land outside the Permanent Growth Boundary will not be supported for any further parcelization.

Objective 5.3 Focus development to designated growth areas

Policy .2 Compact Urban Form. Develop a compact urban form that maximizes the use of existing infrastructure and contributes to energy efficient settlement patterns.

Objective 5.33 Protect and enhance local agriculture

Policy .3 Urban Uses. Direct urban uses to lands within the urban portion of the Permanent Growth Boundary, in the interest of reducing development and speculative pressure on agricultural lands.

Policy .8 Housing in Agricultural Areas. Discourage residential development (both expansions and new developments) in areas isolated within agricultural environments (both ALR and non-ALR).

OCP Chapter 15: Farm Protection DP Guidelines

Objectives

- Protect farm land and farm operations;
- Minimize the impact of urban encroachment and land use conflicts on agricultural land;
- Minimize conflicts created by activities designated as farm use by ALC regulation and non-farm uses within agricultural areas.

Guidelines

- On properties located adjacent to agricultural lands, design buildings to reduce impact from activities associated with farm operations.
- On agricultural and non-agricultural lands, establish and maintain a landscape buffer along the agricultural and/or property boundary, except where development is for a permitted farm use that will not encourage public attendance and does not concern additional residences (including secondary suites).
- Design any subdivision or urban development of land to reduce densities and the intensity of uses gradually towards the boundary of agricultural lands.

5.2 Agriculture Plan (2017)

Official Community Plan Recommendations

Carriage Houses. Prohibit carriage houses outside the Permanent Growth Boundary.

Zoning Bylaw Recommendations

Remove Carriage Houses as a Permitted Use on Farmland. Remove the carriage house as a permitted use with the ALR/A1 zoning. Require a non-farm use application to the ALC with any carriage house application in the ALR.

6.0 Technical Comments

6.1 Development Engineering Department

See Attachment C – City of Kelowna Memorandum

6.2 Interior Health Authority

See Attachment D – Interior Health Memorandum

7.0 Application Chronology

Date of Application Received:	December 11, 2018
Date Public Consultation Completed:	January 7, 2019

8.0 Alternate Recommendation

THAT Rezoning Application No. Z18-0123 to amend the City of Kelowna Zoning Bylaw No. 8000 by changing the zoning classification of Lot 2 Sections 2 and 3 Township 26 Osoyoos Division Yale District Plan KAP91355, located at 4159 McClain Road, Kelowna, BC from the RR1 – Rural Residential 1 zone to the RR1c – Rural Residential 1 with Carriage House zone, be considered by Council;

AND THAT the Rezoning Bylaw be forwarded to a Public Hearing for further consideration.

Report prepared by:	Kimberly Brunet, Planner
Reviewed by:	Dean Strachan, Suburban and Rural Planning Manager
Reviewed by:	Ryan Smith, Community Planning Department Manager
Approved for Inclusion:	Derek Edstrom, Acting Divisional Director, Community Planning & Strategic Investments

Attachments:

Attachment A – Applicant's Letter of Rationale
Attachment B – Site Plan and Floor Plans
Attachment C – City of Kelowna Memorandum
Attachment D – Interior Health Memorandum

ATTACHMENT A
This forms part of application
Z18-0123
Planner Initials KB
City of Kelowna
COMMUNITY PLANNING

Letter of rationale for rezoning of 4159 McClain Rd.

Attn:

City of Kelowna Development proposal staff.

The proposed one bedroom suite is situated above a workshop in the home office space built in 2016/17 under building permit # BP 53014.

When applying for this permit I was informed by City staff in the building department that a carriage house would not be supported by the city so I proceeded with the building of my shop with home office space above and a “not to be used as a dwelling” stipulation applied to the issuance of the permit.

Shortly afterward, a similar development permit was approved on a neighboring property at 4185 McClain Rd. for the same use I was intending contrary to what I was led to believe.

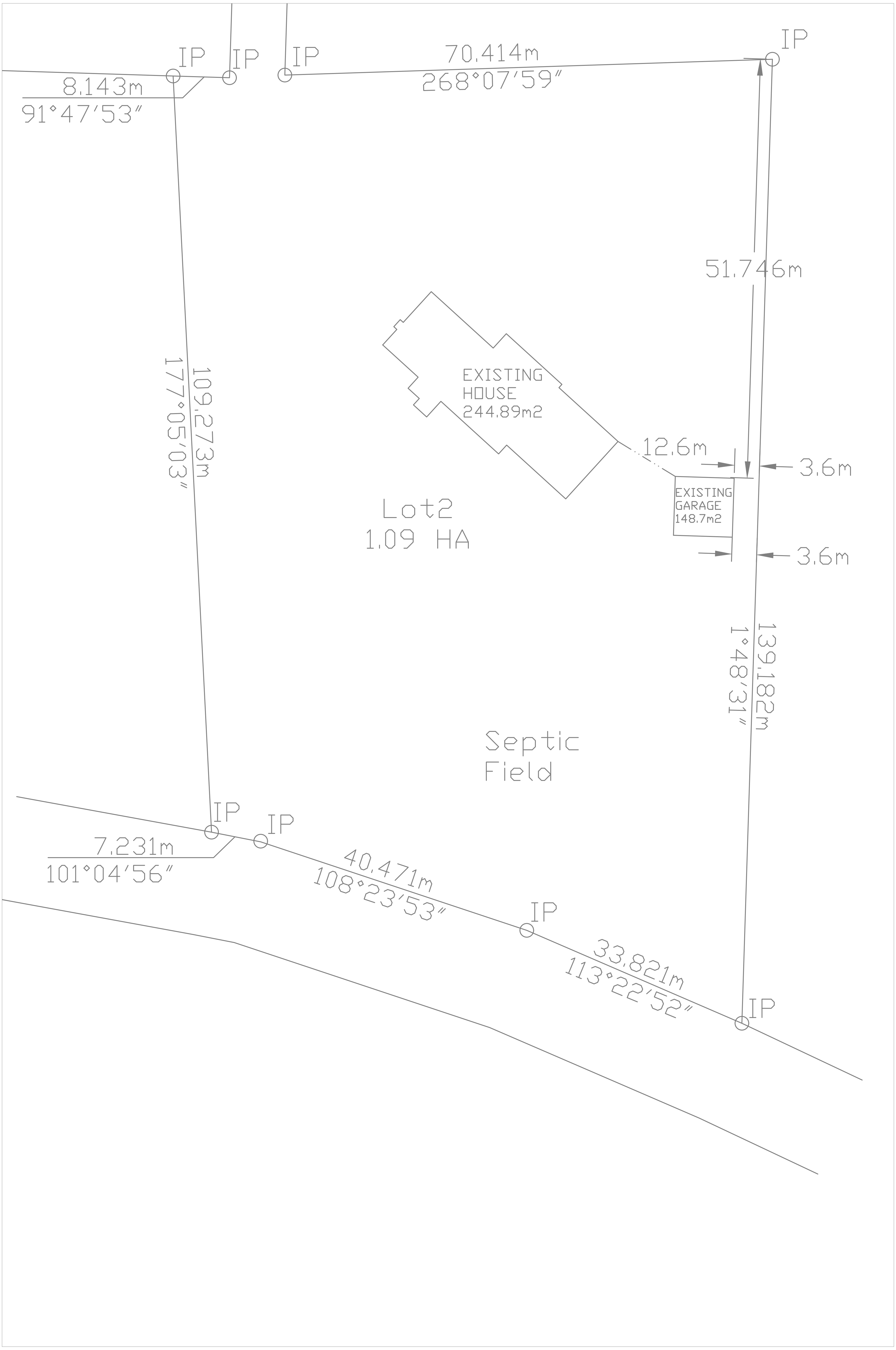
I am now proceeding with the rezoning of my property from RR1 to RR1c to develop a dwelling for family members as I have two sons who have a slim chance of affording to live in the valley without financial support.

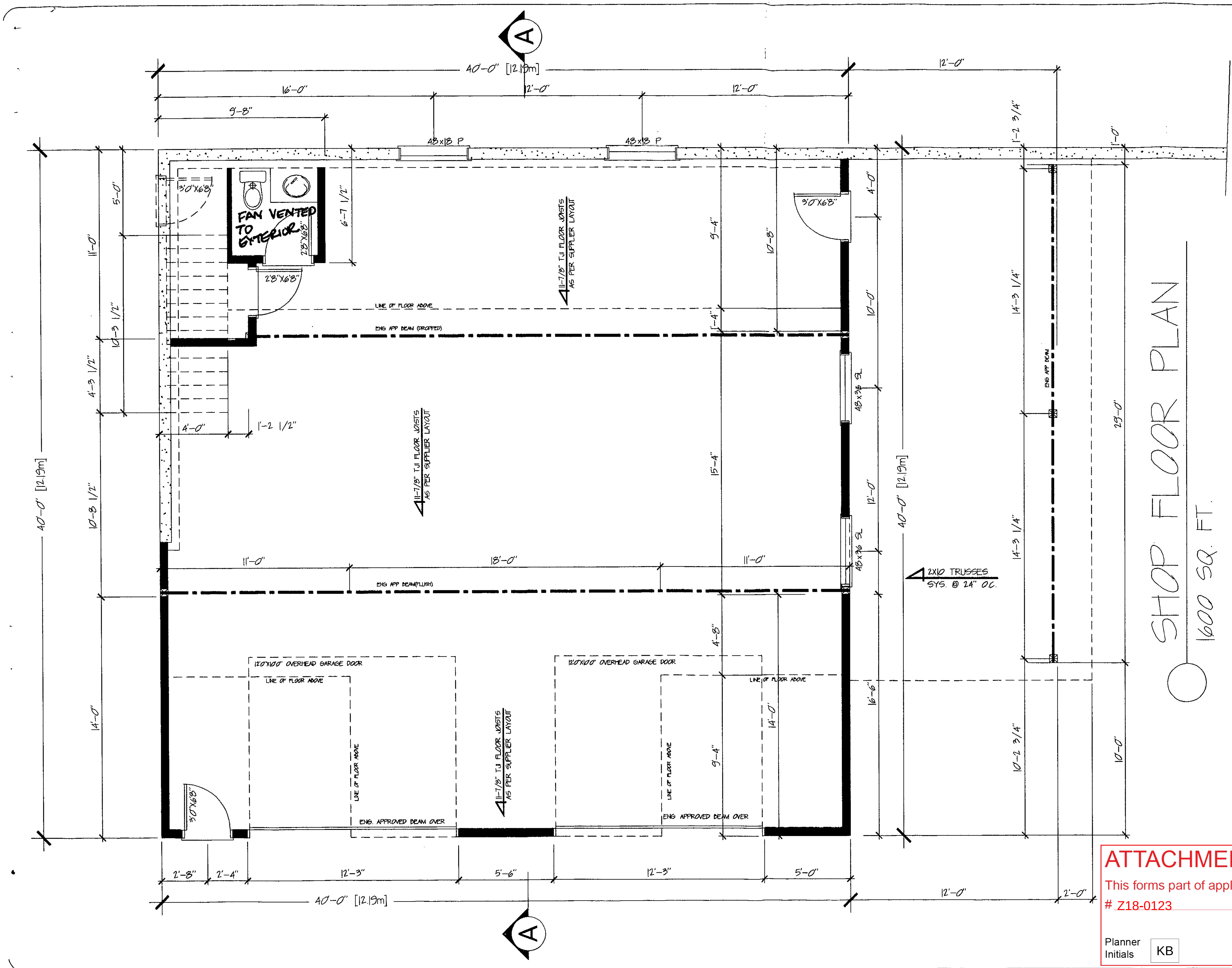
Thank you for your consideration.

Dan Dorssers
4159 McClain Rd.
Kelowna B C

ATTACHMENT B
This forms part of application
Z18-0123
Planner Initials KB
City of Kelowna
COMMUNITY PLANNING

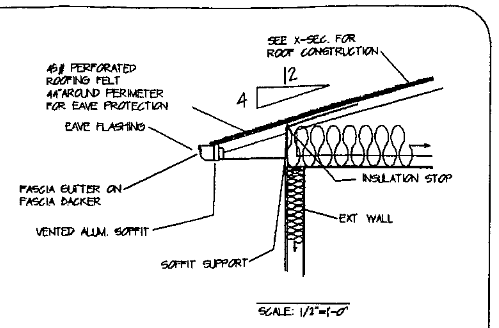
4159 McClain Rd Kelowna BC





SHOP FLOOR PLAN

1600 SQ. FT.



SCALE: 1/2"=1'-0"

TANRYE Homes and Designs
2868 Salish Road
West Kelowna, BC (250)864-8784
tanryehomesanddesigns@shaw.ca

TANRYE Homes and Designs
2868 SALISH ROAD
WEST KELOWNA B.C.
(250) 864-8784

PROJECT TITLE
DORSSER SHOP

SHEET TITLE
FLOOR PLAN

PROJECT No.
LOT 2

STREET ADDRESS
4159 McCLAIN ROAD

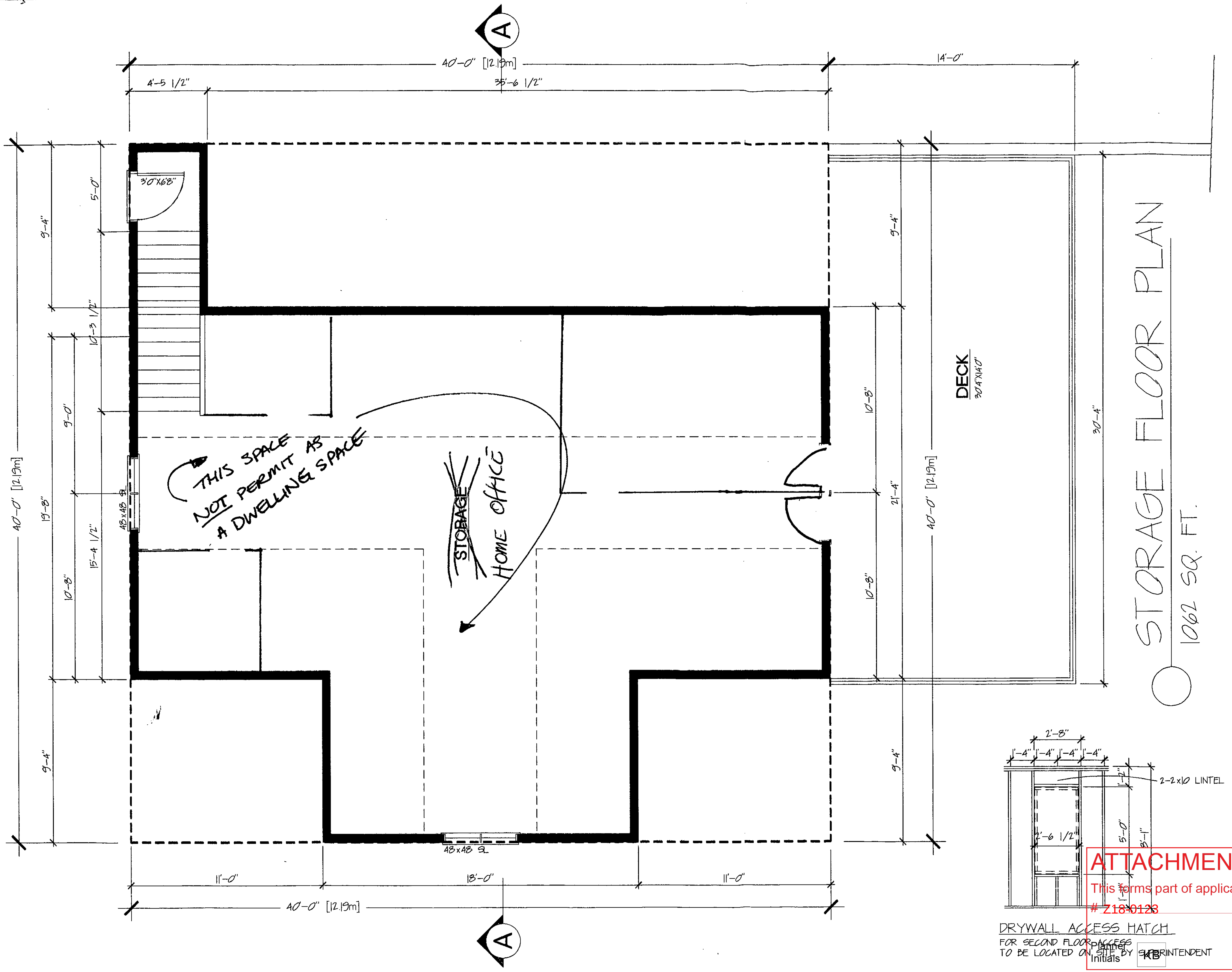
SCALE
3/16"=1'0"

3/6

DATE
MAR. 2016

ATTACHMENT B
This forms part of application
Z18-0123
Planner Initials KB
City of Kelowna
COMMUNITY PLANNING

53014

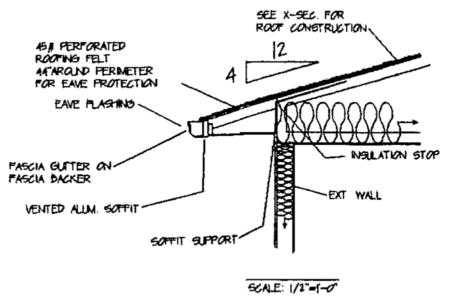


STORAGE FLOOR PLAN

1062 SQ. FT.

DRYWALL ACCESS HATCH

FOR SECOND FLOOR ACCESS
TO BE LOCATED ON SITE BY SUPERINTENDENT



SCALE: 1/2"=1'-0"

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TANRYE Homes and Designs
2868 SALISH ROAD
WEST KELOWNA B.C.
(250) 864-8784

PROJECT TITLE
DORSSER SHOP

SHEET TITLE
UPPER FLOOR PLAN

PROJECT No.
LOT 2

STREET ADDRESS
4159 McCLAIN ROAD

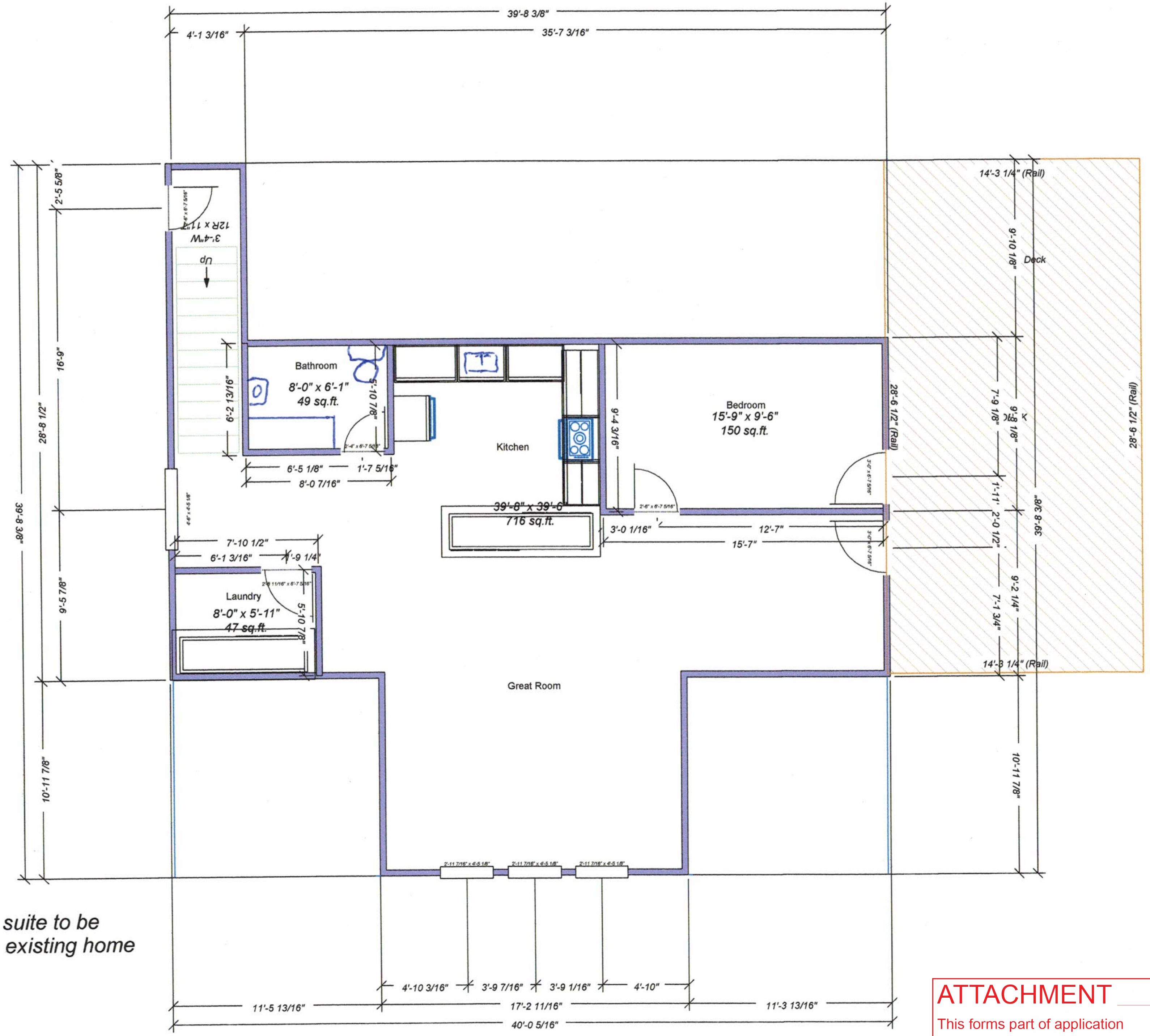
SCALE
3/16"=1'0"

4/6

DATE
MAR. 2016

ATTACHMENT B
This forms part of application
Z18-0123
Planner Initials KB
City of Kelowna
COMMUNITY PLANNING

53014



One bedroom suite to be constructed in existing home office space.

4159 McClain Rd Carriage house floor plan (962 sq.ft)

ATTACHMENT B

This forms part of application

Z18-0123

Planner Initials KB

City of Kelowna
COMMUNITY PLANNING

ATTACHMENT C
This forms part of application
Z18-0123
City of Kelowna
COMMUNITY PLANNING
Planner Initials KB

CITY OF KELOWNA

MEMORANDUM

Date: January 14 2019

File No.: Z18-0123

To: Land Use Management Department (TH)

From: Development Engineering Manager

Subject: 4159 McClain Rd Plan 91355 lot 2 Carriage House

Development Engineering has the following comments and requirements associated with this application to rezone from RR1 to RR1c.

1. <u>Domestic Water</u>

   This property is currently serviced with a 25mm-diameter water service. Fire Protection and servicing requirements will be reviewed by Building & Permitting. One metered water service will supply both the main residence and the Carriage House.

2. <u>Sanitary Sewer</u>

   Municipal sanitary sewer servicing is not currently available to this property. Sanitary sewage is currently handled by on-site wastewater disposal system(s) The existing disposal system must be proved out by a Licenced Wastewater Practitioner and reviewed by the Interior Health Authority and Building & Permitting.

3. <u>Electric Power and Telecommunication Services</u>

   It is the applicant's responsibility to make a servicing application with the respective electric power, telephone and cable transmission companies to arrange for service upgrades to these services which would be at the applicant's cost.

4. <u>Access and Parking Requirements</u>

   The existing driveway access will be utilized for the proposed Carriage House.

James Kay, P.Eng.
Development Engineering Manager
JF

ATTACHMENT D
This forms part of application
Z18-0123
City of Kelowna
COMMUNITY PLANNING
Planner Initials KB

Interior Health
Every person matters

January 24, 2019

City of Kelowna
1435 Water St
Kelowna BC
V1Y 1J4

planninginfo@kelowna.ca

Dear Ms. Brunet:

Re: Z18-0123 Rezoning from RR1 to RR1C McClain Rd

Thank you for the opportunity to provide comments on proposed rezoning noted above.
Interior Health encourages planned growth areas that adhere to planning principles which promote wellbeing in a community by encouraging housing plans, climate action plans, transportation design plans while acknowledging the environmental and economic constraints.
Sustainable onsite sewerage systems could pose environmental and economic constraints for this parcel. Development in this area will probably encourage the use of private vehicles due to safety and distance to commute. The reliance on private vehicles can reduce a residents' ability to have an active lifestyle, physical activity and opportunities to access amenities.
The drinking water supply system has recently been acquired by the City of Kelowna therefore planned growth should coincide with improvements to the system.
Interior Health supports land development in areas where access to amenities, work, recreation, and daily activities encourage healthy lifestyles therefore improving the health and wellbeing of the population.
The issue of a lack of available and affordable housing has been noted in many areas and is recognized by Interior Health as one of the key factors which affect human health.

Thank you for the opportunity to review and comment.

Yours Sincerely

C Audet

Clare Audet
Environmental Health Officer – Healthy Community Development

Bus: (250) 851-7340 Fax; (250) 851-7341
hbe@interiorhealth.ca
www.interiorhealth.ca

Population Health Healthy Built Environment
519 Columbia Street
Kamloops, BC, V2C 2T8

REPORT TO COUNCIL

Date: February 25th 2019

RIM No. 0920-20

To: City Manager

From: Community Planning Department (LKC)

Application: Z18-0102 **Owner:** Harkins, David & Harkins, Camille

Address: 30 Altura Rd **Applicant:** Urban Options Planning

Subject: Rezoning Application

Existing OCP Designation: S2RES – Single/Two Unit Residential

Existing Zone: RU2 – Medium Lot Housing

Proposed Zone: RU2c – Medium Lot Housing with Carriage House

1.0 Recommendation

THAT Rezoning Application No. Z18-0102 to amend the City of Kelowna Zoning Bylaw No.8000 by changing the zoning classification of Lot 1 Section 32 Township 26 ODYD Plan 35716, located at 30 Altura Rd, Kelowna, BC from the RU2- Medium Lot Housing Zone to the RU2c – Medium Lot Housing with Carriage House zone be considered by Council;

AND THAT the Rezoning Bylaw be forwarded to a Public hearing for further consideration;

2.0 Purpose

To consider a development application to rezone to the RU2c – Medium Lot Housing with Carriage House zone to facilitate a proposed Carriage House on the subject property.

3.0 Community Planning

Staff are recommending support for the proposed rezoning of the subject property to RU2c – Medium Lot Housing with Carriage House Zone as it is consistent with the Official Community Plan (OCP) Future Land Use designation and infill growth policies for the subject property. The property is located within the Permanent Growth Boundary, is fully serviced, and is located near Knox Mountain Park. The subject property has a Walk Score of 20 as almost all errands require a car, however, there are few transit stops near the subject property.

4.0 Proposal

4.1 Background

The subject property is adjacent to both Altura Road and Monte Road. There is a single family dwelling and accessory building on the property. Driveway access is provided from Altura Road. The existing accessory structure is proposed to remain as part of this application. The existing accessory building is a single car garage with a studio located above the garage. The room does not include a kitchen or a bathroom. The proposed rezoning is necessary to permit the development of a Carriage House on the property.

4.2 Project Description

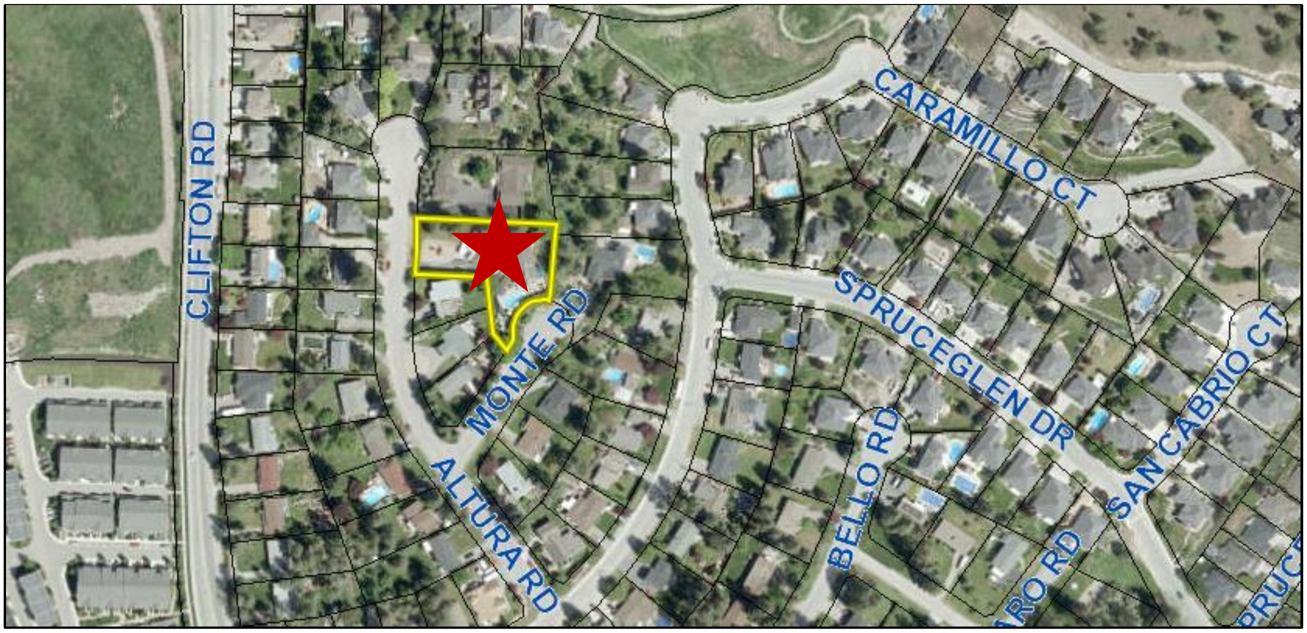
A one and a half story Carriage House is proposed to be located on the west portion of the lot, between Altura Rd and the existing accessory building. A Development Variance Permit application has been received to vary section 6.5.3 (a) of the Zoning Bylaw to increase the maximum allowable lot coverage for accessory building footprint from 90m² to 117m² as the existing accessory building is proposed to remain on the property.

A second Variance to reduce the front yard setback from 9.0m to 5.5m is also required. The Variance is required to utilize the existing driveway, respect the existing slope on the site, and to avoid a utility right-of way. A similar variance was granted for the adjacent property at 38 Altura Road in 2012 which allowed an accessory structure to be placed 6.0m from the front property line. Neither variance is expected to have a negative impact on the surrounding properties.

4.3 Site Context

The subject property is located in the Glenmore neighbourhood. The subject property is surrounded by properties zoned RR3 – Rural Residential, RR3c – Rural Residential with Carriage House, and RU1 – Large Lot Housing.

Subject Property Map: 30 Altura Rd.



5.0 Current Development Policies

5.1 Kelowna Official Community Plan (OCP)

Development Process

Compact Urban Form.[1] Develop a compact urban form that maximizes the use of existing infrastructure and contributes to energy efficient settlement patterns. This will be done by increasing densities (approximately 75 - 100 people and/or jobs located within a 400 metre walking distance of transit stops is required to support the level of transit service) through development, conversion, and re-development within Urban Centres (see Map 5.3) in particular and existing areas as per the provisions of the Generalized Future Land Use Map 4.1.

Carriage Houses & Accessory Apartments.[2]

Support Carriage Houses and accessory apartments through appropriate zoning regulations.

6.0 Technical Comments

6.1 Development Engineering Department

See Attached Development Memorandum Dated September 20, 2018

7.0 Application Chronology

Date of Application Received:	August 24, 2018
Date Public Consultation Completed:	October 30, 2018

Report prepared by:	Levan King Cranston, Planner 1
Reviewed by:	Dean Strachan, Manager of Suburban and Rural Planning
Approved for Inclusion:	Ryan Smith, Community Planning Department Manager

Attachments:

Schedule A: Site Plan
Schedule B: Application Letter
Schedule C: Development Engineering Memo

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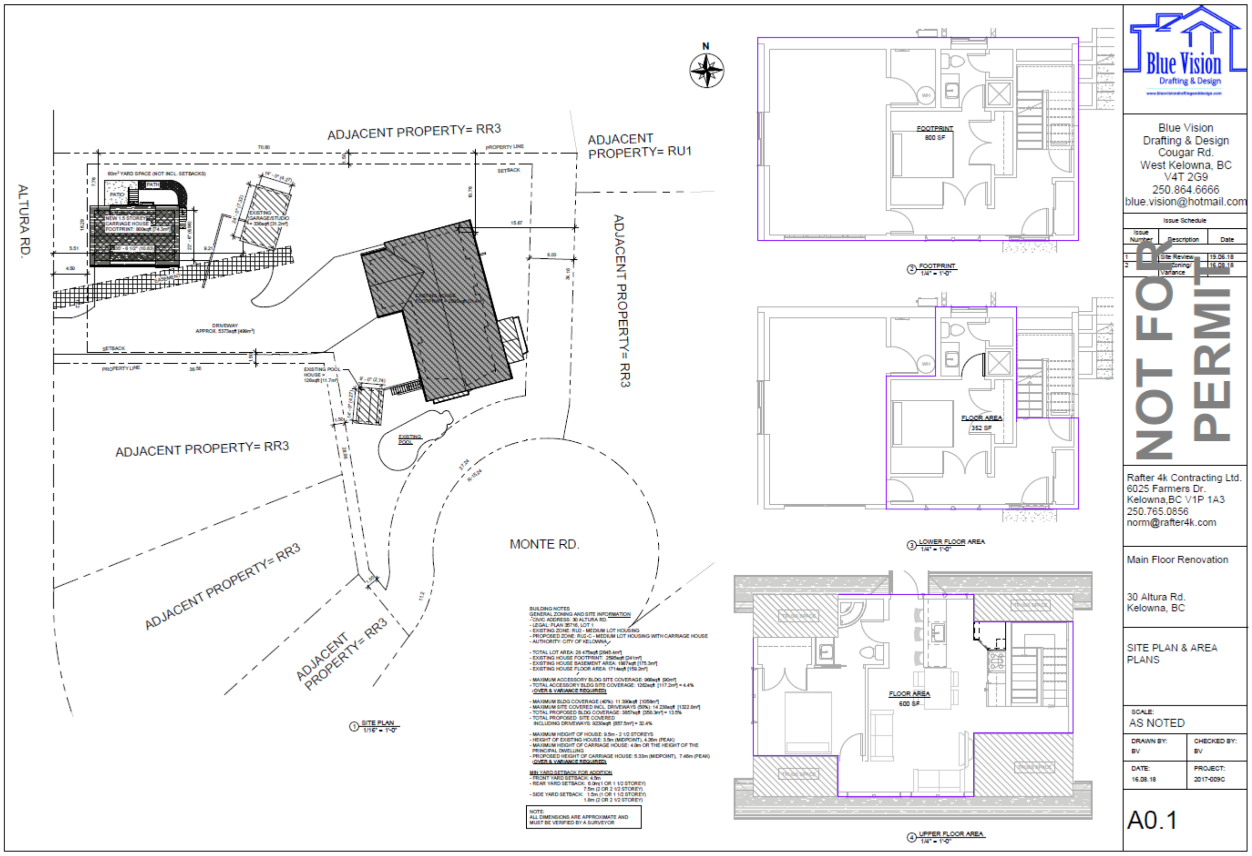
[1] City of Kelowna Official Community Plan, Policy 5.2.3 (Development Process Chapter).

[2] City of Kelowna Official Community Plan, Policy 5.22.12 (Development Process Chapter).

SCHEDULE A – Site Plan

Subject: 30 Altura Rd. (Application Z18-0102)



BUILDING NOTES
GENERAL ZONING AND SITE INFORMATION
- CIVIC ADDRESS: 30 ALTURA RD.
- LEGAL: PLAN 35716, LOT 1
- EXISTING ZONE: RU2 - MEDIUM LOT HOUSING
- PROPOSED ZONE: RU2-C - MEDIUM LOT HOUSING WITH CARRIAGE HOUSE
- AUTHORITY: CITY OF KELOWNA

- TOTAL LOT AREA: 28 475sqft [2645.4m²]
- EXISTING HOUSE FOOTPRINT: 2595sqft [241m²]
- EXISTING HOUSE BASEMENT AREA: 1887sqft [175.3m²]
- EXISTING HOUSE FLOOR AREA: 1714sqft [159.2m²]

- MAXIMUM ACCESSORY BLDG SITE COVERAGE: 968sqft [90m²]
- TOTAL ACCESSORY BLDG SITE COVERAGE: 1262sqft [117.2m²] = 4.4%
(OVER & VARIANCE REQUIRED)

- MAXIMUM BLDG COVERAGE (40%): 11 390sqft [1058m²]
- MAXIMUM SITE COVERED INCL. DRIVEWAYS (50%): 14 238sqft [1322.8m²]
- TOTAL PROPOSED BLDG COVERAGE: 3857sqft [358.3m²] = 13.5%
- TOTAL PROPOSED SITE COVERED INCLUDING DRIVEWAYS: 9230sqft [857.5m²] = 32.4%

- MAXIMUM HEIGHT OF HOUSE: 9.5m - 2 1/2 STOREYS
- HEIGHT OF EXISTING HOUSE: 3.5m (MIDPOINT), 4.26m (PEAK)
- MAXIMUM HEIGHT OF CARRIAGE HOUSE: 4.8m OR THE HEIGHT OF THE PRINCIPAL DWELLING
- PROPOSED HEIGHT OF CARRIAGE HOUSE: 5.33m (MIDPOINT), 7.46m (PEAK)
(OVER & VARIANCE REQUIRED)

MIN YARD SETBACK FOR ADDITION
- FRONT YARD SETBACK: 4.5m
- REAR YARD SETBACK: 6.0m(1 OR 1 1/2 STOREY)
7.5m (2 OR 2 1/2 STOREY)
- SIDE YARD SETBACK: 1.5m (1 OR 1 1/2 STOREY)
1.8m (2 OR 2 1/2 STOREY)

NOTE:
ALL DIMENSIONS ARE APPROXIMATE AND MUST BE VERIFIED BY A SURVEYOR

Blue Vision
Drafting & Design
Cougar Rd.
West Kelowna, BC
V4T 2G9
250.864.6666
blue.vision@hotmail.com

Issue Schedule

Issue Number	Description	Date
1	Site Review	19.06.18
2	Zoning/ Variance	16.08.18

Rafter 4k Contracting Ltd.
6025 Farmers Dr.
Kelowna,BC V1P 1A3
250.765.0856
norm@rafter4k.com

Main Floor Renovation

30 Altura Rd.
Kelowna, BC

SITE PLAN & AREA PLANS

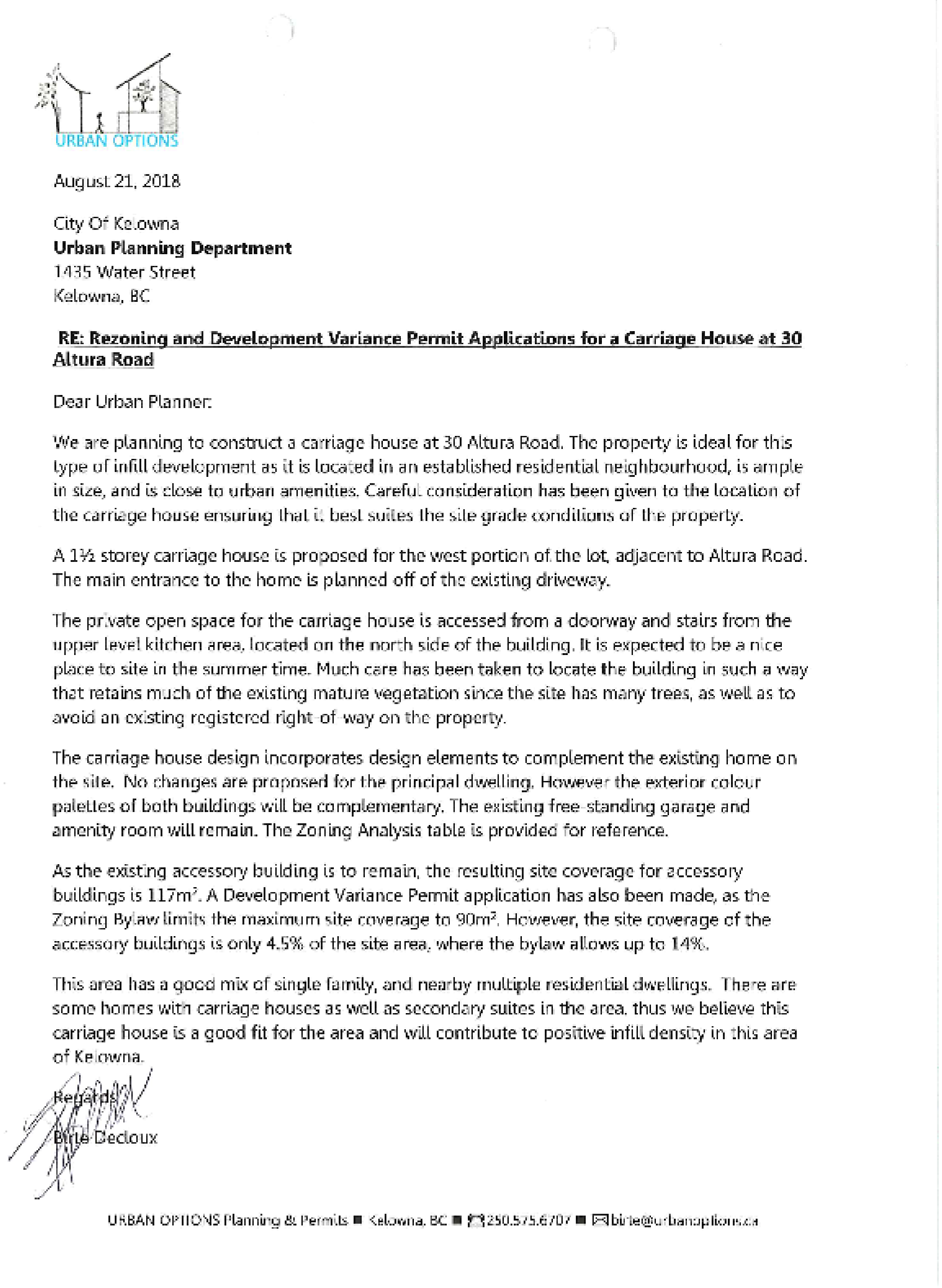
SCALE: AS NOTED

DRAWN BY: BV
CHECKED BY: BV
DATE: 16.08.18
PROJECT: 2017-009C

A0.1

SCHEDULE B – Application Letter

Subject: 30 Altura Rd. (Application Z18-0102)



URBAN OPTIONS

August 21, 2018

City Of Kelowna
Urban Planning Department
1435 Water Street
Kelowna, BC

RE: Rezoning and Development Variance Permit Applications for a Carriage House at 30 Altura Road

Dear Urban Planner:

We are planning to construct a carriage house at 30 Altura Road. The property is ideal for this type of infill development as it is located in an established residential neighbourhood, is ample in size, and is close to urban amenities. Careful consideration has been given to the location of the carriage house ensuring that it best suites the site grade conditions of the property.

A 1½ storey carriage house is proposed for the west portion of the lot, adjacent to Altura Road. The main entrance to the home is planned off of the existing driveway.

The private open space for the carriage house is accessed from a doorway and stairs from the upper level kitchen area, located on the north side of the building. It is expected to be a nice place to site in the summer time. Much care has been taken to locate the building in such a way that retains much of the existing mature vegetation since the site has many trees, as well as to avoid an existing registered right-of-way on the property.

The carriage house design incorporates design elements to complement the existing home on the site. No changes are proposed for the principal dwelling. However the exterior colour palettes of both buildings will be complementary. The existing free-standing garage and amenity room will remain. The Zoning Analysis table is provided for reference.

As the existing accessory building is to remain, the resulting site coverage for accessory buildings is 117m². A Development Variance Permit application has also been made, as the Zoning Bylaw limits the maximum site coverage to 90m². However, the site coverage of the accessory buildings is only 4.5% of the site area, where the bylaw allows up to 14%.

This area has a good mix of single family, and nearby multiple residential dwellings. There are some homes with carriage houses as well as secondary suites in the area. thus we believe this carriage house is a good fit for the area and will contribute to positive infill density in this area of Kelowna.

Regards

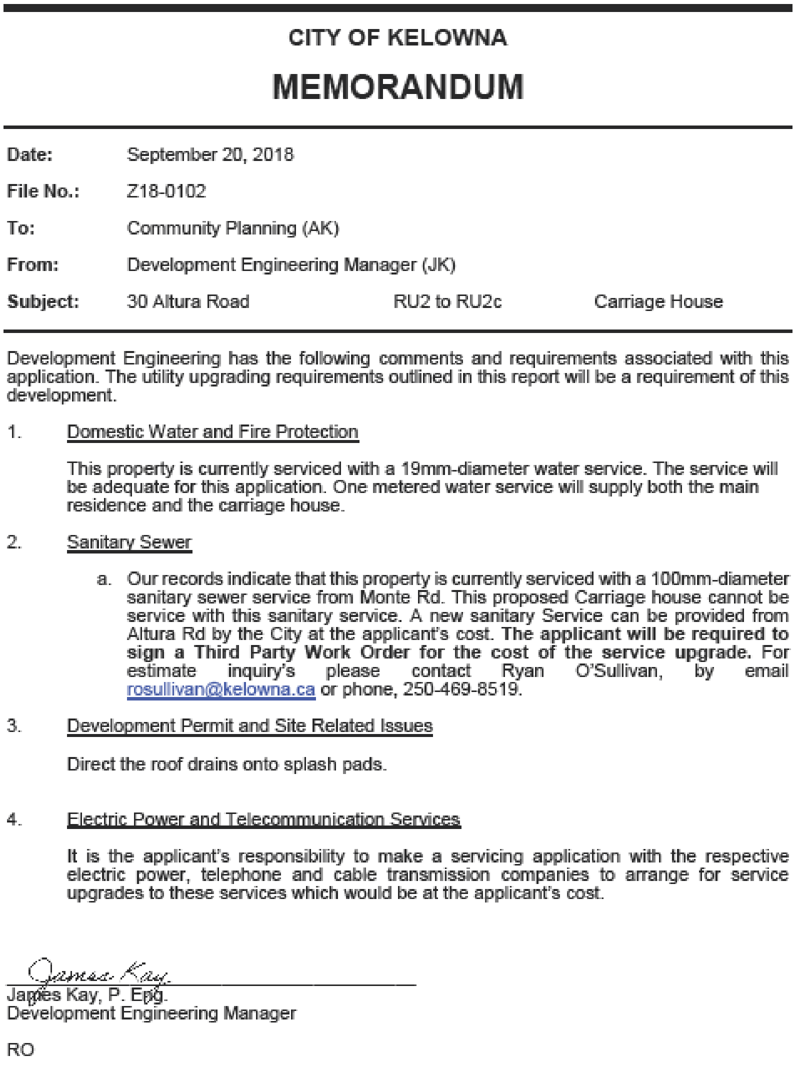
Birte Decloux

URBAN OPTIONS Planning & Permits ■ Kelowna, BC ■ ☎250.575.6707 ■ ✉birte@urbanoptions.ca

SCHEDULE C – Development Engineering Memo

City of Kelowna

Subject: 30 Altura Rd. (Application Z18-0102)



CITY OF KELOWNA

MEMORANDUM

Date: September 20, 2018

File No.: Z18-0102

To: Community Planning (AK)

From: Development Engineering Manager (JK)

Subject: 30 Altura Road RU2 to RU2c Carriage House

Development Engineering has the following comments and requirements associated with this application. The utility upgrading requirements outlined in this report will be a requirement of this development.

1. Domestic Water and Fire Protection

   This property is currently serviced with a 19mm-diameter water service. The service will be adequate for this application. One metered water service will supply both the main residence and the carriage house.

2. Sanitary Sewer

   a. Our records indicate that this property is currently serviced with a 100mm-diameter sanitary sewer service from Monte Rd. This proposed Carriage house cannot be service with this sanitary service. A new sanitary Service can be provided from Altura Rd by the City at the applicant's cost. **The applicant will be required to sign a Third Party Work Order for the cost of the service upgrade.** For estimate inquiry's please contact Ryan O'Sullivan, by email rosullivan@kelowna.ca or phone, 250-469-8519.

3. Development Permit and Site Related Issues

   Direct the roof drains onto splash pads.

4. Electric Power and Telecommunication Services

   It is the applicant's responsibility to make a servicing application with the respective electric power, telephone and cable transmission companies to arrange for service upgrades to these services which would be at the applicant's cost.

James Kay.

James Kay, P. Eng.
Development Engineering Manager

RO

CITY OF KELOWNA

BYLAW NO. 11759

Z18-0102 - 30 Altura Road

A bylaw to amend the "City of Kelowna Zoning Bylaw No. 8000".

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. THAT City of Kelowna Zoning Bylaw No. 8000 be amended by changing the zoning classification of Lot 1 Section 32 Township 26 ODYD Plan 35716, located at Altura Rd, Kelowna, BC from the RU2- Medium Lot Housing Zone to the RU2c – Medium Lot Housing with Carriage House zone.

2. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first time by the Municipal Council this

Considered at a Public Hearing on the

Read a second and third time by the Municipal Council this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Report to Council

Date: February 25, 2018

File: 1200-40

To: City Manager

From: Laura Bentley, Community Planning Supervisor

Subject: Short-Term Rental Accommodation Regulations

Recommendation:

THAT Zoning Bylaw Text Amendment Application No. TA19-0007 to amend City of Kelowna Zoning Bylaw No. 8000 as outlined in the Report from the Community Planning Department dated February 25, 2018 be considered by Council;

AND THAT the Zoning Bylaw Text Amending Bylaw be forwarded to a Public Hearing for further consideration;

AND FURTHER THAT final adoption of the Zoning Bylaw Text Amending Bylaw be considered subsequent to the approval of the Ministry of Transportation and Infrastructure.

Purpose:

To amend the Zoning Bylaw by creating a new short-term rental accommodation use with associated regulations, adding the use to select zones with residential and mixed-use commercial uses, and removing the existing apartment hotels use.

Background:

Staff propose the amendments to the Zoning Bylaw to implement new regulations for short-term rental accommodation in Kelowna. The regulations aim to balance the desire to allow short-term rentals as an option for tourists and visitors with the need to protect for long-term rentals and to limit impacts on neighbouring properties. Establishing these regulations will help provide clarity to residents about how short-term rentals can be operated. The amendments define short-term rental accommodation as a new use, identify more specific regulations associated with it, and introduce it as a principal or secondary use in the appropriate zones. The amendments also remove the 'apartment hotels' use from the Zoning Bylaw.

On December 3, 2018, Council directed staff to proceed with preparing bylaws to implement the proposed short-term rental accommodation regulations and licensing requirements related to the regulations. The proposed regulations were based on the guiding principles Council endorsed on July 16, 2018 as well as best practice research and input from residents and stakeholders.

The guiding principles that directed the development of the short-term rental regulations are based on Kelowna's housing context, concerns about potential nuisance impacts in residential areas, and establishing a fair approach among short-term accommodation providers. The three guiding principles endorsed by Council are:

1. Ensure short-term rental accommodations do not impact the long-term rental housing supply in a negative way.
2. Ensure short-term rental accommodations are good neighbours.
3. Ensure equity among short-term accommodation providers.

In July 2018, staff also proposed limiting short-term rentals to an operator's principal residence, with the exception of select commercial areas. This has been carried through to the regulations with some adjustments based on stakeholder and resident feedback. Generally speaking, the regulations would introduce short-term rental accommodation as a new secondary use in an operator's principal residence in single / two unit residential, multi-unit residential, and mixed-use commercial zones. They would also remove the apartment hotel use that currently exists in the C4, C7 and some comprehensive development zones, replacing it with short-term rental accommodation as a secondary use and limited to an operator's principal residence. Only certain tourist commercial areas could continue to have short-term rentals as a principal use and not in an operator's principal residence.

The regulations are summarized in the two tables below, with further details outlined in Schedule 'A'. It should be noted that while preparing the specific bylaw amendments, staff made some refinements to what was previously proposed to provide further clarity and alignment with the objectives, as follows:

- To better define principal residency, the regulations state that the short-term rental operator must reside at that dwelling unit for more than 240 days (8 months) of the year. This is consistent with the principal residency requirement to operate a home-based business.
- Provided a dwelling unit in a multi-family development (e.g. townhouse, apartment) has two parking spaces, an additional parking space would not be needed for short-term rental accommodation. Where short-term rental accommodation is a principal use, parking requirements would follow those for apartment housing in that zone.
- Instead of creating a new subzone for properties zoned RM6 – High Rise Apartment Housing where short-term rentals are not limited to the operator's principal residence, the bylaw identifies the properties on Sunset Drive where the site-specific use regulations apply.
- To provide more options for short-term accommodation near Kelowna General Hospital, the HD2 – Hospital and Health Support Services allows short-term rentals as a principal use.
- The CD14 – Comprehensive High Tech Business Campus zone (Landmark area) does not allow any residential uses outside of apartment hotels. Since the apartment hotels use is being removed and the area is developed without apartment hotels, short-term rental accommodation is not being added to this zone.

Zone Category	Principal Use	Secondary Use
Rural residential (RR1-RR3)		✓
Single/two unit residential (RU1-RU6, RH1, RH2)		✓
Single/two unit residential – health services transitional & comprehensive development (HD3, CD2, CD4, CD10)		✓
Multi-unit residential (RU7, RM1-RM6, RH3)		✓
Multi-unit residential – health services transitional & comprehensive development (HD3, CD1, CD2, CD3, CD5, CD17, CD22, CD26, CD27)		✓
Mixed-use commercial (C3-C8)		✓
Tourist commercial (C9) & health district (HD2)	✓	
McKinley Beach (CD18) & Hiawatha (CD24)	✓[1]	✓

[1] Principal use in CD18 Area I Village Centre (Hilltown) and CD24 Area A only.

Regulation	Rural and single / two unit residential	Multi-unit residential & commercial	Principal use (C9, HD2, parts of CD18 & CD24)
Maximum # of adults per bedroom / sleeping unit	2	2	2
Maximum # of bedrooms / sleeping units	3	2	3
Maximum # of bookings at a time	1	1	1
Minimum # of parking spaces	1 space per 2 sleeping units	1 space per 2 sleeping units[1]	Follow zone's apartment housing requirements
Allowed in secondary suites / carriage houses	No	n/a	n/a
Business license	Yes	Yes[2]	Yes[2]
Operator's principal residence	Yes	Yes[3]	No

[1] In multi-family developments, parking for short-term rental accommodation does not need to be in addition to the principal dwelling unit where the unit has two parking spaces.
[2] A higher business license fee is applicable where it is not the operator's principal residence.
[3] Properties zoned RM6 along Sunset Drive are not restricted to the operator's principal residence.

Non-Conforming Uses

Should Council move the proposed Zoning Bylaw amendments to Public Hearing, staff will present Council with information regarding non-conforming use provisions. Specifically, staff reviewed several projects that are currently in-stream to determine whether or not they qualify for non-conforming use protection under the *Local Government Act*. This information will be provided in a separate report.

Next Steps

Should the proposed Zoning Bylaw amendments be adopted, those looking to operate a short-term rental would be required to apply for and be issued a business license prior to operating. Staff will focus on informing residents of the rules they must abide by, with the intent of achieving compliance through licensing and monitoring that will be supported by a third party short-term rental compliance company. Enforcement will be pursued as needed for those properties not in compliance.

Staff will also review and report back to Council after two tourist seasons following implementation of new regulations. Staff have received further comments from residents and stakeholders since the proposed regulations were brought forward on December 3, 2018. A review presents an opportunity to consider how the regulations are working, as well as to explore whether or not other suggestions should be incorporated into the regulation of short-term rental accommodation. Furthermore, the industry continues to evolve, and a review gives staff and Council the opportunity to review the regulations as they relate to ongoing changes in the accommodation industry.

Existing Policy:
OCP Goal 2. Address Housing Needs of All Residents. Address housing needs of all residents by working towards an adequate supply of a variety of housing.
Healthy Housing Strategy Action: Update regulations to protect the rental stock from the impacts of short-term rentals.

Financial/Budgetary Considerations:
Estimated $320,000 annually for business licensing and enforcement (approved in budget). Business license fees to support cost recovery.

Personnel Implications:
One new License and Bylaw Inspection Officer and one new Administrative Clerk needed to support licensing needs associated with short-term rental accommodation (approved in budget). The positions will be shared with the need for additional resources to support demands of new cannabis retail sales establishments and cannabis production facilities.

Considerations not applicable to this report:
Internal Circulation
Legal/Statutory Authority
Legal/Statutory Procedural Requirements

Submitted by:
L. Bentley, Community Planning Supervisor

Approved for inclusion: R. Smith, Community Planning Department Manager

Attachments:
Schedule 'A' – Short-Term Rental Accommodation Zoning Bylaw No. 8000 Text Amendments

cc:
G. Wise, Business License Manager
D. Gazley, Bylaw Services Manager
K. O'Rourke, Community Communications Manager
M. Kam, Sustainability Coordinator

Schedule A – Short-Term Rental Accommodation Zoning Bylaw No. 8000 Text Amendments

Part I – Text Amendment Table

No.	Section	Relevant Existing	Proposed	Explanation
1.	2 – Interpretation 2.3 General Definitions	**APARTMENT HOTELS** means **apartment housing** having a principal common entrance, cooking facilities and furnishings within each **dwelling**. This does not include any **commercial uses** except when specifically permitted in the **zone**.	~~**APARTMENT HOTELS** means **apartment housing** having a principal common entrance, cooking facilities and furnishings within each **dwelling**. This does not include any **commercial uses** except when specifically permitted in the **zone**.~~	Remove definition of apartment hotels. To be replaced with new definition for short-term rental accommodation and all references revised accordingly.
2.	2 – Interpretation 2.3 General Definitions	**RESIDENTIAL ZONES** means any zones described in Sections 12 and 13 of this bylaw, or any CD zone in which the predominant use as determined by its general purpose and list of permitted uses is of a residential nature, and in which the minimum tenancy period is at least 1 month.	**RESIDENTIAL ZONES** means any zones described in Sections 12 and 13 of this bylaw, or any CD zone in which the predominant use as determined by its general purpose and list of permitted uses is of a residential nature, and in which the minimum tenancy period is at least 1 month, except for **short-term rental accommodation** as a **secondary use**.	Keep the minimum tenancy period of one month for residential zones and clarify that the new short-term rental accommodation use is an exception to that definition, provided it is carried out in accordance with the relevant regulations.
3.	2 – Interpretation 2.3 General Definitions	n/a	**SHORT-TERM RENTAL ACCOMMODATION** means the **use** of a **dwelling** unit or one or more **sleeping units** within a **dwelling** unit for temporary overnight accommodation for a period of 29 days or less. This **use** does not include **bed and**	Define new use for short-term rental accommodation as distinct from residential use, which has a minimum tenancy period of 30 days.

No.	Section	Relevant Existing	Proposed	Explanation
			breakfast homes, hotels or **motels**.	
4.	6.5 – Accessory Development 6.5.2 Accessory Buildings in Non-Residential Zones	(c) Not withstanding Section 6.5.2(a), one half bathroom with a toilet and sink is permitted to a maximum area of 3 m^2. Bedrooms and / or full bathrooms are not permitted within an **accessory building or structure**, except one full bathroom is permitted in an **accessory building or structure** used exclusively as a pool house.	(c) Not withstanding Section 6.5.2(a), one half bathroom with a toilet and sink is permitted to a maximum area of 3 m^2. **Bedrooms, sleeping units** and / or full bathrooms are not permitted within an **accessory building or structure**, except one full bathroom is permitted in an **accessory building or structure** used exclusively as a pool house.	Clarify that no space for sleeping is permitted in accessory buildings. Sleeping units and bedrooms are defined separately in the Zoning Bylaw.
5.	6.5 – Accessory Development 6.5.3 Accessory Buildings in Residential Zones	(h) One half bathroom with a toilet and sink is permitted to a maximum area of 3 m^2. Bedrooms and / or full bathrooms are not permitted, except one full bathroom is permitted in an **accessory building or structure** used exclusively as a pool house.	(h) One half bathroom with a toilet and sink is permitted to a maximum area of 3 m^2. **Bedrooms, sleeping units** and / or full bathrooms are not permitted, except one full bathroom is permitted in an **accessory building or structure** used exclusively as a pool house.	Clarify that no space for sleeping is permitted in accessory buildings. Sleeping units and bedrooms are defined separately in the Zoning Bylaw.
6.	8 – Parking and Loading Table 8.1 – Parking Schedule, Residential and Residential Related	**Apartment Hotels** 1.0 spaces per **sleeping unit**; 1.0 spaces per 7 **dwelling** units which shall be	*See Part II*	Replace parking requirements for apartment hotels with short-term rental accommodation. Where short-term rentals are a secondary use, one medium parking space would need to be provided for every two sleeping units. Any operator in

No.	Section	Relevant Existing	Proposed	Explanation
		designated as visitor **parking spaces**		multiple dwelling housing (lot with three units or more) must have at least two parking spaces to operate short-term rental accommodation. Where short-term rentals are a principal use, the parking requirements would be the same as what is required for apartment housing in a given zone. See Part II for details.
7.	9.6 Bed and Breakfast Homes	9.6.1 Bed and breakfast homes shall comply with the following regulations: (c) The licensed operator or a **bed and breakfast home** must reside in the **dwelling** in which the bed and breakfast operation is located.	9.6.1 Bed and breakfast homes shall comply with the following regulations: (c) The licensed operator of a **bed and breakfast home** must reside in the **dwelling** in which the bed and breakfast operation is located and be on-site when the **bed and breakfast home** is operating.	Clarify requirements that the operator must be present when guests are staying at a bed and breakfast home.
8.	9.6 Bed and Breakfast Homes	9.6.3 All **bed and breakfast homes** shall comply with the other provisions of this Bylaw, the BC **Building** Code, the **Agricultural Land Commission** General Order No. 1157/93 where applicable, and other fire and health regulations.	9.6.3 All **bed and breakfast homes** shall comply with the other provisions of this Bylaw, the BC Building Code, the Agricultural Land Reserve Use, Subdivision and Procedure Regulation where applicable, and other fire and health regulations.	Update reference to relevant ALC regulations for bed and breakfast homes.
9.	9 – Specific Use Regulations	n/a	9.17 Short-Term Rental Accommodation *See Part III*	Add new use-specific regulations that outline principal residency, restriction

No.	Section	Relevant Existing	Proposed	Explanation
				for secondary suites and carriage houses, limits on number of adults and number of rooms used, maximum booking per unit, and requirement for a business license. See Part III for details.
10.	12 – Rural Residential Zones 12.1.3 RR1 Secondary Uses 12.2.3 RR2 Secondary Uses 12.3.3 RR3 Secondary Uses	n/a	Add in appropriate location: **<u>short-term rental accommodation</u>**<u>, subject to section 9.17 of this Bylaw</u>	Add short-term rental accommodation as a secondary use in all rural residential zones. Renumber accordingly.
11.	13 – Urban Residential Zones 13.1.3 RU1 Secondary Uses 13.2.3 RU2 Secondary Uses 13.3.3 RU3 Secondary Uses 13.4.3 RU4 Secondary Uses 13.5.3 RU5 Secondary Uses 13.6.3 RU6 Secondary Uses 13.7.3 RM1 Secondary Uses 13.8.3 RM2 Secondary Uses 13.9.3 RM3 Secondary Uses 13.10.3 RM4 Secondary Uses 13.11.3 RM5 Secondary Uses 13.14.4 RH1 Secondary Uses 13.15.4 RH2 Secondary Uses	n/a	Add in appropriate location: **<u>short-term rental accommodation</u>**<u>, subject to section 9.17 of this Bylaw</u>	Add short-term rental accommodation as a secondary use in all urban residential zones except RM6, which is addressed below, and RM7, which is for mobile home parks. Renumber accordingly.

No.	Section	Relevant Existing	Proposed	Explanation
	13.16.4 RH3 Secondary Uses 13.17.3 RU7 Secondary Uses			
12.	13.12 RM6 – High Rise Apartment Housing 13.12.3 Secondary Uses	(e) **hotel/motel accommodation within a multiple residential unit**	~~(e) **hotel/motel accommodation within a multiple residential unit**~~ (j) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Replace hotel/motel accommodation within a multiple residential unit use with short-term rental accommodation as a secondary use.
13.	13.12 RM6 – High Rise Apartment Housing	n/a	**13.12.8 Site Specific Uses and Regulations** *See Part IV*	Add new site-specific regulations for RM6 properties on Sunset Drive to continue to allow for short-term rental accommodation as a secondary use that is not restricted to the operator's principal residence. This is in lieu of a new RM6 subzone for the area. See Part IV for details.
14.	14 – Commercial Zones 14.3.3 C3 Secondary Uses 14.5.3 C5 Secondary Uses	n/a	(h) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use in the Community Commercial and Transition Commercial zones.
15.	14.4 C4 – Urban Centre Commercial 14.4.2 Principal Uses	(c) **apartment hotels**	~~(c) **apartment hotels**~~	Remove apartment hotels as a principal use.
16.	14.4 C4 – Urban Centre Commercial	n/a	(f) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use.

No.	Section	Relevant Existing	Proposed	Explanation
	14.4.3 Secondary Uses			
17.	14.4 C4 – Urban Centre Commercial 14.4.5 Development Regulations	(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys** in the South Pandosy and Rutland Urban Centres. In the Springfield/Highway 97 Urban Centre, maximum **height** is the lesser of 15.0 m or 4 **storeys**, except that for **hotels**, **apartment hotels** and **apartment housing** it shall be the lesser of 37.0 m or 12 **storeys**. In all other areas, the maximum **height** shall be the lesser of 15.0 m or 4 **storeys.** For mixed-use developments located in Urban Centres, where parking is located entirely below natural grade and provides a co-op / car sharing program, and provides a **public courtyard** and **green roof**, the maximum building height shall be the lesser of 25.0 m or 7 **storeys**.	(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys** in the South Pandosy and Rutland Urban Centres. In the ~~Springfield/Highway 97~~ Midtown Urban Centre, maximum **height** is the lesser of 15.0 m or 4 **storeys**, except that for **hotels**~~**, apartment hotels**~~ and **apartment housing** it shall be the lesser of 37.0 m or 12 **storeys**. In all other areas, the maximum **height** shall be the lesser of 15.0 m or 4 **storeys.** For mixed-use developments located in Urban Centres, where parking is located entirely below natural grade and provides a co-op / car sharing program, and provides a **public courtyard** and **green roof**, the maximum building height shall be the lesser of 25.0 m or 7 **storeys**.	Remove reference to apartment hotels as a building type for height regulations.
18.	14.6 C6 – Regional Commercial 14.6.3 Secondary Uses	(c) **apartment hotels**	~~(c) **apartment hotels**~~ (i) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add short-term rental accommodation as a secondary use.

No.	Section	Relevant Existing	Proposed	Explanation
19.	14.6 C6 – Regional Commercial 14.6.5 Development Regulations	(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys** except for **hotels**, **apartment hotels** and **apartment housing**, shall be the lesser of 37.0 m or 12 **storeys**.	(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys**, except for **hotels**~~, **apartment hotels**~~ and **apartment housing**, it shall be the lesser of 37.0 m or 12 **storeys**.	Remove reference to apartment hotels as a building type for height regulations.
20.	14.6 C6 – Regional Commercial 14.6.6 Other Regulations	(a) Apartment housing, **apartment hotels**, and **hotels** shall be developed according to the provisions of the RM6 **zone**.	(a) **Apartment housing**~~,~~ ~~**apartment hotels**,~~ and **hotels** shall be developed according to the provisions of the RM6 **zone**.	Remove reference to apartment hotels as a building type for other regulations.
21.	14.7 C7 – Central Business Commercial 14.7.2 Principal Uses	(c) **apartment hotels**	~~(c) **apartment hotels**~~	Remove apartment hotels as a principal use.
22.	14.7 C7 – Central Business Commercial 14.7.3 Secondary Uses	n/a	(e) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use.
23.	14.8 C8 – Convention Hotel Commercial 14.8.3 Secondary Uses	(c) **apartment hotel**	~~(c) **apartment hotels**~~ (n) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add short-term rental accommodation as a secondary use. Renumber accordingly.
24.	14.9 C9 – Tourist Commercial 14.9.2 Principal Uses	(c) **apartment hotels**	~~(c) **apartment hotels**~~ (h) **multiple dwelling housing** (l) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add multiple dwelling housing and short-term rental accommodation as principal uses, to ensure these continue to be permitted uses. Renumber accordingly.
25.	14.9 C9 – Tourist Commercial	(a) The maximum **floor area ratio** is 0.5 except it is 1.5 for **apartment hotels** and **hotels**.	(a) The maximum **floor area ratio** is 0.5 except it is 1.5 for ~~**apartment hotels**~~ **multiple**	Replace references to apartment hotels with multiple dwelling housing and

No.	Section	Relevant Existing	Proposed	Explanation
	14.9.5 Development Regulations	(b) The maximum **height** is the lessor of 11.0 m or 2 **storeys** except 22.0 m or 6 **storeys** for **apartment hotels** and **hotels**.	**dwelling housing, short-term rental accommodation** and **hotels**. (b) The maximum **height** is the ~~lessor~~ lesser of 11.0 m or 2 **storeys** except it is 22.0 m or 6 **storeys** for ~~**apartment hotels**~~ **multiple dwelling housing, short-term rental accommodation** and **hotels**.	short-term rental accommodation to reflect the change in terms. Clarify other terms to be consistent with other sections of the Zoning Bylaw.
26.	14.9 C9 – Tourist Commercial 14.9.6 Other Regulations	(e) **Apartment hotels**, **hotels**, and **motels** are permitted only when connected to **urban services**.	(e) ~~**Apartment hotels**~~ **Multiple dwelling housing, short-term rental accommodation**, **hotels**, and **motels** are permitted only when connected to **urban services**.	Replace references to apartment hotels with multiple dwelling housing and short-term rental accommodation to reflect the change in terms.
27.	17.2 HD2 – Hospital and Health Support Services 17.2.2.1 Principal Uses	n/a	(i) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a principal use for the HD2 – Hospital and Health Support Services area east of Kelowna General Hospital to support accommodation options for families of hospital patients.
28.	17.2 HD2 – Hospital and Health Support Services 17.2.3.1 Secondary Uses	(c) **apartment hotel**	~~(c) **apartment hotel**~~	Remove apartment hotels as a secondary use, being added as a principal use. Renumber accordingly.
29.	17.2 HD2 – Hospital and Health Support Services 17.2.6 Parking Regulations specific to the HD2 Zone	(a) All residential, residential related uses, **apartment hotel** and **hotel** uses shall be calculated as 1 **parking space** per **dwelling** unit.	(a) All residential, residential related uses, ~~**apartment hotel**~~ and **hotel** uses shall be calculated as 1 **parking space** per **dwelling** unit.	Remove reference to apartment hotels as a building type for parking regulations.

No.	Section	Relevant Existing	Proposed	Explanation
		(b) Leasable areas that are not used for residential, residential related, **apartment hotel** and **hotel** uses shall be calculated as requiring 1.75 stalls per 100 m² of **gross floor area**.	(b) Leasable areas that are not used for residential, residential related, ~~**apartment hotel**~~ and **hotel** uses shall be calculated as requiring 1.75 stalls per 100 m² of **gross floor area**.	
30.	17.2 HD2 – Hospital and Health Support Services 17.2.7 Other Regulations	(f) **Apartment hotel** and **hotel** use shall only be permitted when secondary to **multiple dwelling housing** or **congregate housing**.	~~(f) **Apartment hotel** and **hotel** use shall only be permitted when secondary to **multiple dwelling housing** or **congregate housing**.~~	Remove reference to apartment hotels being secondary to multiple dwelling housing because short-term rental accommodation is being added as a principal use.
31.	17.3 HD3 – Health Services Transitional	n/a	17.3.2 **~~Principal~~ Uses** 17.3.2.2 The **secondary uses** in this zone are: (e) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Rename the section for clarity and add short-term rental accommodation as a secondary use.
32.	18 – Schedule B – Comprehensive Development Zones CD1 – Comprehensive Development One 1.3 Secondary Uses CD2 – Kettle Valley Comprehensive Residential Development 1.3 Secondary Uses CD3 – Comprehensive Development Three 1.2 Permitted Uses, Area 1 Secondary Uses	n/a	Add in appropriate location: **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use in Comprehensive Development zones where residential uses are permitted as a principal use. Renumber accordingly.

No.	Section	Relevant Existing	Proposed	Explanation
	CD4 – Comprehensive Small Lot Residential 1.3 Secondary Uses CD5 – Multi-Purpose Facility 1.3 Secondary Uses CD10 – Heritage Cultural 1.3 Secondary Uses CD17 – Mixed Use Commercial – High Density 1.2 Secondary Uses CD27 – Valley Land Subdivision 1.3 Secondary Uses			
33.	CD14 – Comprehensive High Tech Business Campus 1.3 Secondary Uses	(d) **apartment hotels**	~~(d) **apartment hotels**~~	Remove apartment hotels as a permitted use and do not add short-term rental accommodation. The purpose of the zone does not include residential or tourist commercial uses.
34.	CD14 – Comprehensive High Tech Business Campus 1.6 Other Regulations	(e) **Apartment Housing** is allowed only above the **first storey** and requires access to grade separate from the **commercial uses.** (f) **Apartment Housing** and **apartment hotels** shall provide a minimum area of 6 m² of **private open space** per **bachelor dwelling**, 10 m² of **private open space** per **one bedroom dwelling**, and 15 m²	~~(e) **Apartment Housing** is allowed only above the **first storey** and requires access to grade separate from the **commercial uses.**~~ ~~(f) **Apartment Housing** and **apartment hotels** shall provide a minimum area of 6 m² of **private open space** per **bachelor dwelling**, 10 m² of **private open space** per **one bedroom dwelling**, and 15 m²~~	Remove regulations for apartment housing and apartment hotels as these will no longer be uses in the zone.

No.	Section	Relevant Existing	Proposed	Explanation
		of **private open space** per **dwelling** with more than **one bedroom**.	~~of **private open space** per **dwelling** with more than **one bedroom**.~~	
35.	CD17 – Mixed Use Commercial – High Density 1.1 Principal Uses	(d) **apartment hotels**	~~(d) **apartment hotels**~~ (k) **multiple dwelling housing**	Remove apartment hotels and add multiple dwelling housing, to ensure multiple dwelling housing (e.g. apartments) continues to be a permitted use. Renumber accordingly.
36.	CD17 – Mixed Use Commercial – High Density 1.2 Secondary Uses	(a) **apartment housing**	~~(a) **apartment housing**~~ (b) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment housing as a secondary use, which is captured under multiple dwelling housing that is being added as a principal use (see above). Add short-term rental accommodation as a secondary use and renumber accordingly.
37.	CD18 – McKinley Beach Comprehensive Resort Development 1.2(a) AREA I Village Centre	**Principal Uses:** (a) **apartment hotels**	**Principal Uses:** ~~(a) **apartment hotels**~~ (n) **multiple dwelling housing** (aa) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add multiple dwelling housing and short-term rental accommodation as principal uses. Renumber accordingly. In the McKinley Beach development, short-term rental accommodation would only be a principal use in the Village Centre (Hilltown) area of the McKinley Beach development.
38.	CD18 – McKinley Beach Comprehensive Resort Development	**Principal Uses:** (a) **apartment hotels**	**Principal Uses:** ~~(a) **apartment hotels**~~ (e) **multiple dwelling housing**	Remove apartment hotels and add multiple dwelling housing as a principal use, to ensure

No.	Section	Relevant Existing	Proposed	Explanation
	1.2(b) AREA 2 Winery and Resort Accommodation		**Secondary Uses:** (i) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	multiple dwelling housing (e.g. apartments) continues to be a permitted use. Add short-term rental accommodation as a secondary use. Renumber all accordingly.
39.	CD18 – McKinley Beach Comprehensive Resort Development 1.2(c) AREA III Hillside Resort Accommodation	**Principal Uses:** (a) **apartment hotels**	**Principal Uses:** ~~(a) **apartment hotels**~~ **Secondary Uses:** (e) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels as a principal use and add short-term rental accommodation as a secondary use. Renumber all accordingly.
40.	CD18 – McKinley Beach Comprehensive Resort Development 1.2(d) AREA IV Waterfront Resort Accommodation	**Principal Uses:** (a) **apartment hotels**	**Principal Uses:** ~~(a) **apartment hotels**~~ (g) **multiple dwelling housing** **Secondary Uses:** (i) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add multiple dwelling housing as a principal use, to ensure multiple dwelling housing (e.g. apartments) continues to be a permitted use. Add short-term rental accommodation as a secondary use. Renumber all accordingly.
41.	CD18 – McKinley Beach Comprehensive Resort Development 1.3 Development Regulations	(g) Resort accommodation which allows for short-term stays is made up of two types: Type A: Attached apartment hotel, hotel, congregate housing, motel units or row housing units (units in buildings exceeding 4 units with common	(g) Dwelling units or resort accommodation which allows for short-term stays is made up of two types: Type A: Attached apartment ~~hotel~~, hotel, congregate housing, motel units or row housing units (units in buildings exceeding 4	Remove requirement for developments of four units or less to have a common on-site or off-site reservation centre to operate short-term rental accommodations. This supports a consistent approach to short-term rental accommodation in residential units across Kelowna and better reflects the

No.	Section	Relevant Existing	Proposed	Explanation
		amenities) – maximum area of 150m² per unit floor area net. Type B: Single detached housing with or without secondary suites, semi-detached housing, row housing with four units or less, with amenities that may be in separate buildings. The maximum gross floor area is 350m² per unit (excluding garages). The main floor footprint (excluding garage) may not exceed 175m² per unit (excluding garages). Type B units must be served by a common on-site or off-site reservation centre(s).	units with common amenities) – maximum area of 150m² per unit floor area net. Type B: Single detached housing with or without secondary suites, semi-detached housing, row housing with four units or less, with amenities that may be in separate buildings. The maximum gross floor area is 350m² per unit (excluding garages). The main floor footprint (excluding garage) may not exceed 175m² per unit (excluding garages). ~~Type B units must be served by a common on-site or off-site reservation centre(s).~~	development in the McKinley Beach area.
42.	CD22 – Central Green Comprehensive Development Zone 1.4 Central Green General Regulations	(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exceptions for: Sub-Section **9.2 – Home Based Businesses, Minor**; Sub-Section **9.3 – Home Based Businesses, Major**; and Sub-Section **9.10 – Agriculture, Urban**	(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exceptions for: Sub-Section **9.2 – Home Based Businesses, Minor**; Sub-Section **9.3 – Home Based Businesses, Major**; ~~and~~ Sub-Section **9.10 – Agriculture, Urban**; and Sub-Section **9.17 – Short-Term Rental Accommodation.**	Add regulation that specific use provisions for short-term rental accommodation apply to the CD22 zone.

No.	Section	Relevant Existing	Proposed	Explanation
43.	CD22 – Central Green Comprehensive Development Zone 7.2 Principal Uses in Sub-Areas A & B	(e) **apartment hotels**	~~(e) **apartment hotels**~~	Remove apartment hotels as a principal use. Short-term rental accommodation would only be a secondary use in the CD22 zone (see below).
44.	CD22 – Central Green Comprehensive Development Zone 7.3 Secondary Uses in Sub-Areas A & B 8.1 Permitted Uses in Sub-Areas C & G, Secondary Uses 9.1 Permitted Uses in Sub-Area D, Secondary Uses 10.1 Permitted Uses in Sub-Areas E & F, Secondary Uses 11.1 Permitted Uses in Sub-Area H, Secondary Uses	n/a	Add in appropriate location: **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use in all CD22 sub-areas and renumber accordingly.
45.	CD24 – Comprehensive Development Zone 1.4 General Regulations of the Comprehensive Site	(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exception of: Sub-Section **9.2 – Home Based Business, Minor**; Sub-Section **9.3 – Home Based Business, Major.**	(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exception of: Sub-Section **9.2 – Home Based Business, Minor**; Sub-Section **9.3 – Home Based Business, Major**~~.~~; and Sub-Section **9.17 – Short-Term Rental Accommodation.**	Add regulation that specific use provisions for short-term rental accommodation apply to the CD24 zone.

No.	Section	Relevant Existing	Proposed	Explanation
46.	CD24 – Comprehensive Development Zone 7.2.1 Principal Uses in Sub-Area A	a) **apartment hotels**	~~a) **apartment hotels**~~ h) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Remove apartment hotels and add short-term rental accommodation as a principal use. Renumber accordingly. In the Hiawatha development, short-term rental accommodation would only be a principal use in Area A.
47.	CD24 – Comprehensive Development Zone 7.6 Private Open Space	A minimum area of 7.5 m^2 of private open space shall be provided per **bachelor dwelling, apartment hotel unit, or congregate housing bedroom**; 15 m^2 of **private open space** shall be provided per **1 bedroom dwelling**, and 25 m^2 of **private open space** shall be provided per **dwelling** with more than **1 bedroom**, except for hotel where no minimum private open space is required.	A minimum area of 7.5 m^2 of private open space shall be provided per **bachelor dwelling,** ~~**apartment hotel**~~ **short-term rental accommodation unit, or congregate housing bedroom**; 15 m^2 of **private open space** shall be provided per **1 bedroom dwelling**, and 25 m^2 of **private open space** shall be provided per **dwelling** with more than **1 bedroom**, except for hotel where no minimum private open space is required.	Replace reference to apartment hotels with short-term rental accommodation.
48.	CD24 – Comprehensive Development Zone 8.2.1 Secondary Uses in Sub-Area B	8.2.1 **Secondary Uses**	8.2.~~1~~2 **Secondary Uses** h) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Renumber section and add short-term rental accommodation as a secondary use.
49.	CD26 – Capri Centre Comprehensive Development Zone 1.4 Principal Uses	(c) **apartment hotels**	~~(c) **apartment hotels**~~	Remove apartment hotels as a principal use.

No.	Section	Relevant Existing	Proposed	Explanation
50.	CD26 – Capri Centre Comprehensive Development Zone 1.5 Secondary Uses	n/a	(d) **short-term rental accommodation**, subject to section 9.17 of this Bylaw	Add short-term rental accommodation as a secondary use.

Part II – Table 8.1 – Parking Schedule

~~**Apartment Hotels**~~ **Short-Term Rental Accommodation** as a **Secondary Use**	1.0 medium space~~s~~ per two **sleeping units** Where **three dwelling housing**, **four dwelling housing**, or **multiple dwelling housing** is the **principal use**, the **dwelling** unit is exempt from the requirement in section 8.1.2 to have **parking spaces** for **secondary uses** in addition the required **parking spaces** for the **principal use**, provided the **dwelling** unit has a minimum of 2 **parking spaces**~~;~~ ~~1.0 spaces per 7 **dwelling** units which shall be designated as visitor~~
Short-Term Rental Accommodation as a **Principal Use**	Equivalent to **apartment housing** requirements for that **zone**

9.17 Short-Term Rental Accommodation

9.17.1 Where **short-term rental accommodation** is a **secondary use**, it must be secondary to a **dwelling** unit as a **principal use** and must be operated by a resident who resides for more than 240 days of the year at that **dwelling** unit.

9.17.2 **Short-term rental accommodation** is not permitted in a **secondary suite** or **carriage house**.

9.17.3 **Short-term rental accommodation** is not permitted in combination with a **bed and breakfast home**.

9.17.4 No more than one booking or reservation for **short-term rental accommodation** is permitted in each **dwelling** unit at one time.

9.17.5 No more than two adults may occupy a **sleeping unit** used for **short-term rental accommodation**.

9.17.6 The maximum number of **sleeping units** that may be used for **short-term rental accommodation** in each **dwelling** unit is specified in **Table 9.17.1**.

Table 9.17.1 Maximum Sleeping Units for Short-Term Rental Accommodation

Use	Maximum number of **sleeping units**
Single dwelling housing **Two dwelling housing** **Multiple dwelling housing** (including **apartment housing**) as a **principal use**	3
Three dwelling housing **Four dwelling housing** **Multiple dwelling housing** (including **apartment housing**) as a **secondary use**	2

9.17.7 Parking must be provided in accordance with the parking and loading regulations of Section 8. **Short-term rental accommodation** may not use required visitor **parking spaces**.

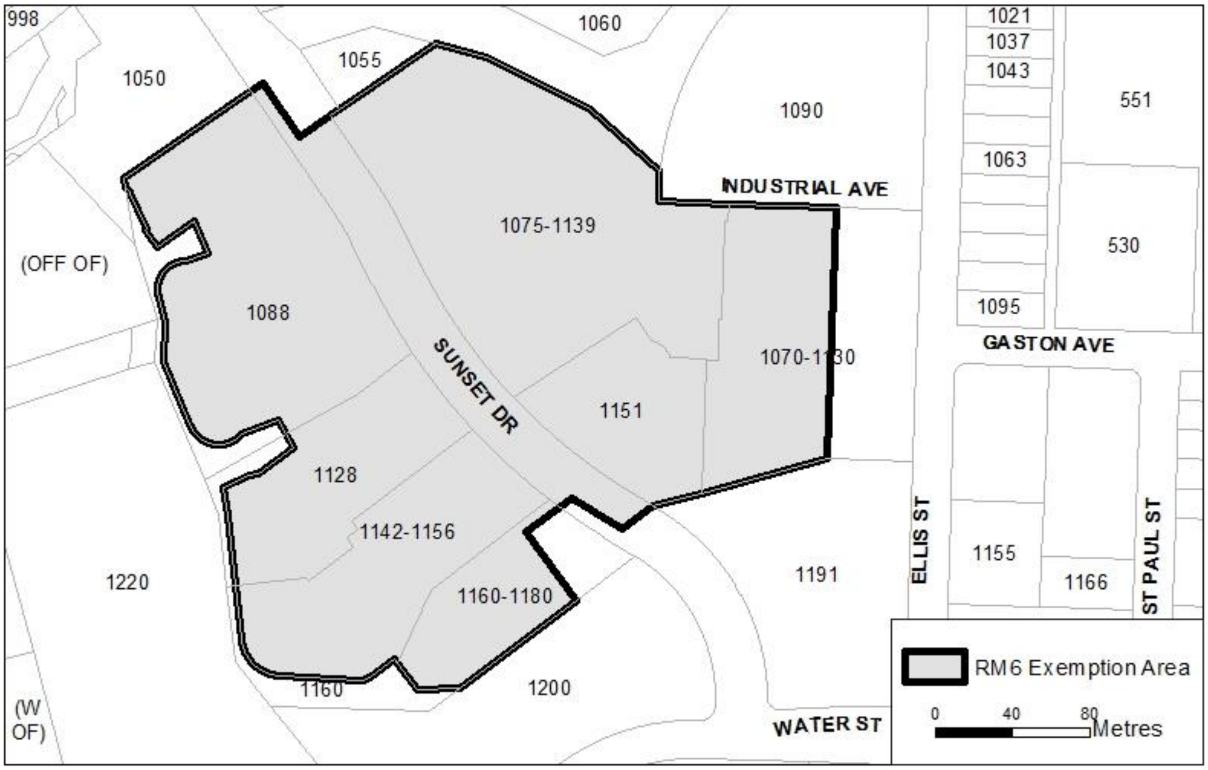
Part IV – Section 13.12.8: RM6 Site Specific Uses and Regulations

13.12.8 Site Specific Uses and Regulations

Uses and regulations apply to the RM6 – High Rise Apartment Housing **zone** on a site specific basis as follows:

	Legal Description	*Civic Address*	*Regulation*
1.	See Map A	1070-1130 Ellis Street 1075-1139 Sunset Drive 1088 Sunset Drive 1128 Sunset Drive 1142-1156 Sunset Drive 1151 Sunset Drive 1160 Sunset Drive	Notwithstanding section 9.17.1, the operator of **short-term rental accommodation** does not need to be a resident who resides for more than 240 days of the year at that **dwelling** unit.

Map A: Properties Zoned RM6 where Site Specific Use Regulation no. 1 Applies



TA19-0007 Short-Term Rental Accommodation

Zoning Bylaw Text Amendment

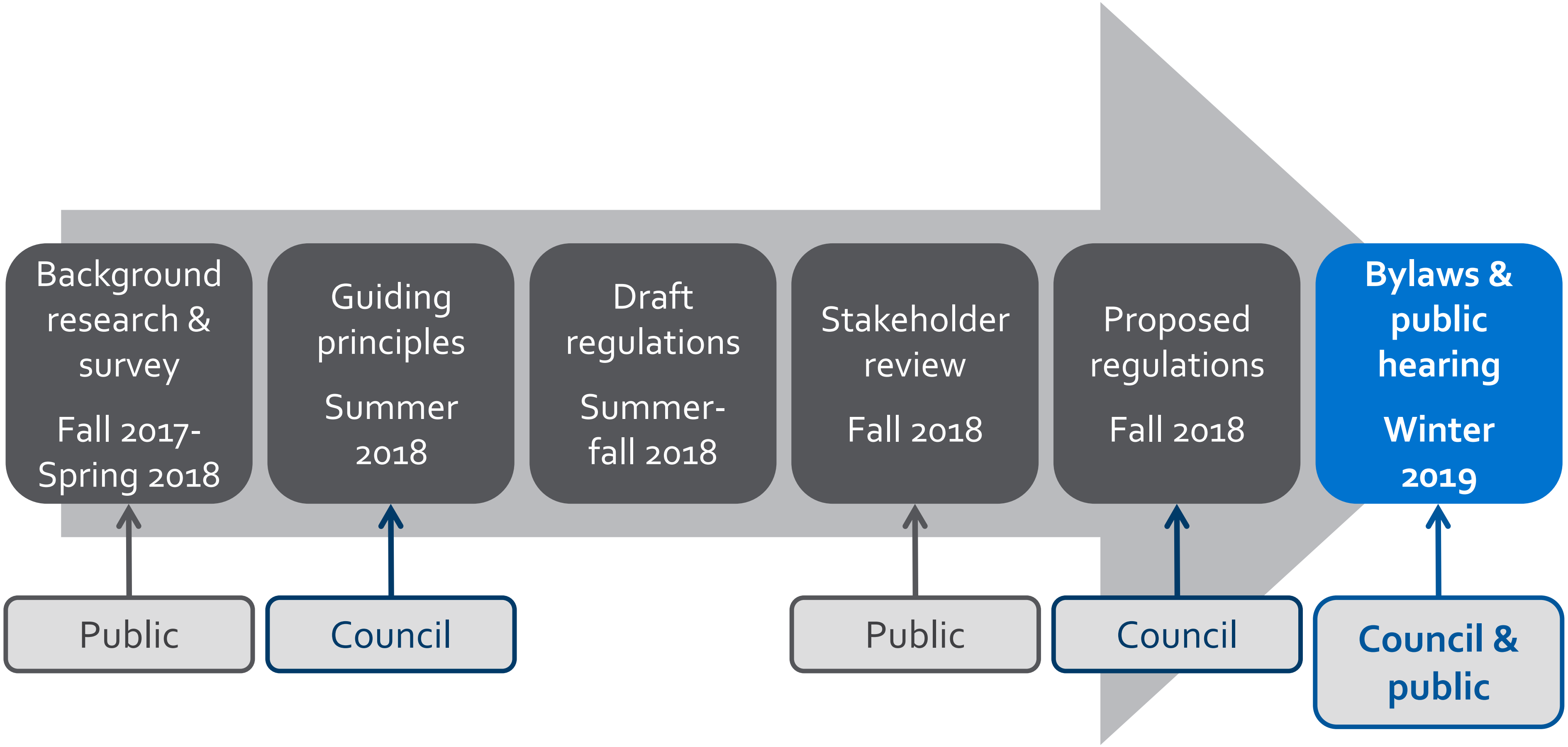
Purpose

- Introduce the new short-term rental accommodation use
- Define associated regulations
- Add the use to most residential & mixed-use commercial zones
- Remove the existing apartment hotels use

Overview

- Process
- Context
- Guiding principles & consultation
- Land use regulations
- Licencing & compliance strategy
- Non-conforming uses
- Next steps

Process



Background research & survey

Fall 2017-Spring 2018

Guiding principles

Summer 2018

Draft regulations

Summer-fall 2018

Stakeholder review

Fall 2018

Proposed regulations

Fall 2018

Bylaws & public hearing

Winter 2019

Public

Council

Public

Council

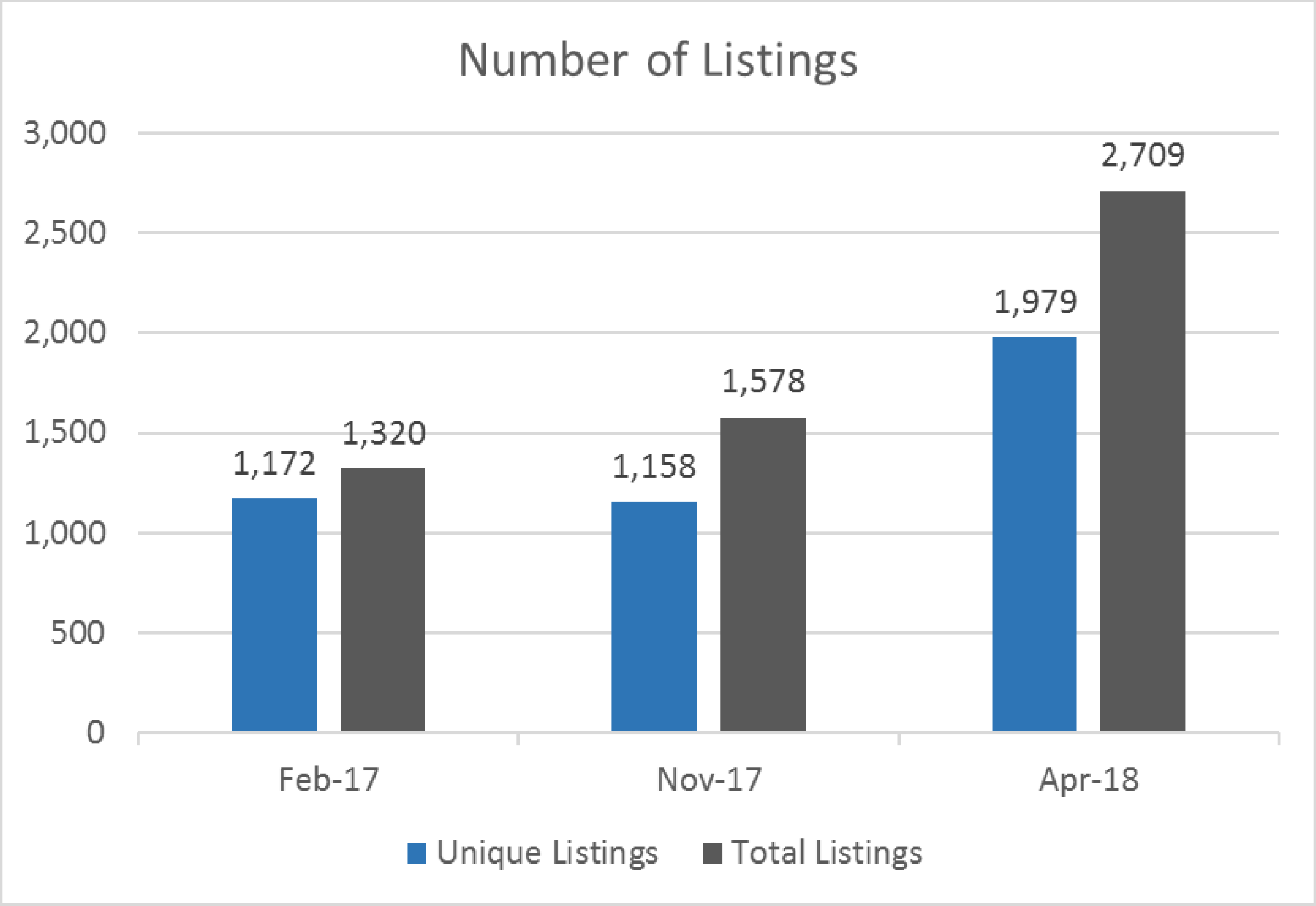
Council & public

Context

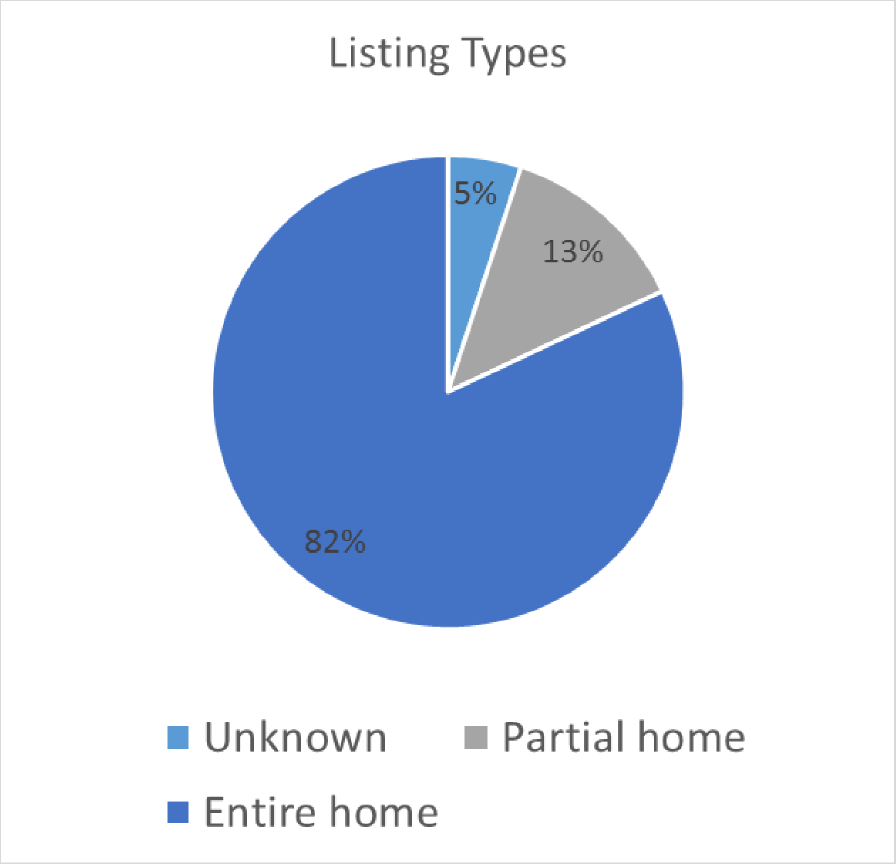
- Housing Needs Assessment
  - Security of tenure & short-term rentals
- Healthy Housing Strategy
  - Key direction: Promote & protect rental housing

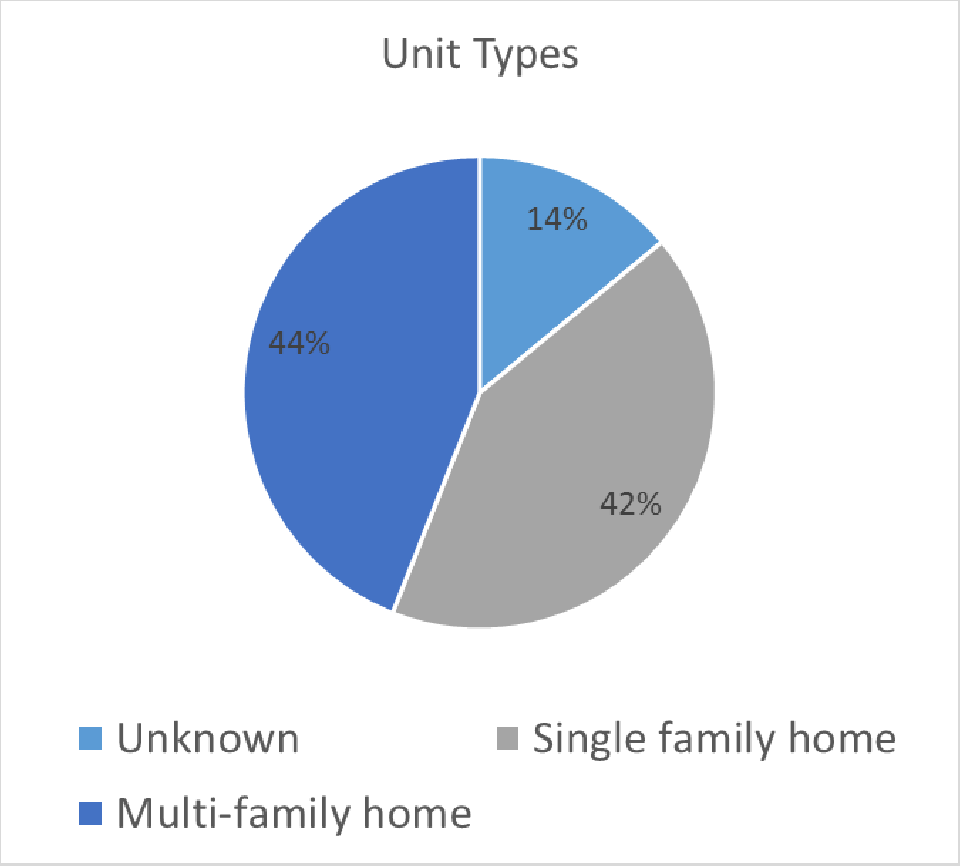
Action: Develop policy & regulations to protect the rental stock from the impacts of short-term rentals.

Short-Term Rental Listings



Short-Term Rental Listings





Median nightly rate: $220

Long-Term Rentals

Vacancy Rate	Secondary Rental Market	New Households Renting	New Rental Units Needed
1.9%	70% suites, carriage houses & entire homes	73%	550 annually

Guiding Principles

1. Ensure short-term rental accommodations **do not impact long-term rental housing supply** in negative way.
2. Ensure short-term rental accommodations are **good neighbours**.
3. Ensure **equity among** short-term **accommodation providers**.

Public & Stakeholder Consultation

- Public survey (fall 2017)
  - Over 2,600 responses
  - Initial input into developing regulations
- Stakeholder consultation (fall 2018)
  - Tourism & accommodation industry, business & neighbourhood associations, development industry, short-term rental platforms, Healthy Housing Advisory Committee, interested residents
  - Feedback on proposed regulations
- Responses reflect diverse community needs & interests

Short-Term Rental Accommodation

Short-term rental accommodation means the use of a dwelling unit or one or more sleeping units within a dwelling unit for **temporary overnight accommodation for a period of 29 days or less**. This use does not include bed and breakfast homes, hotels or motels.

Zones & Uses

	Current		Proposed	
Zone Category	**Principal Use**	**Secondary Use**	**Principal Use**	**Secondary Use**
Rural & single / two unit residential				✓[1]
Multi-unit residential		✓ (RM6)		✓
Mixed-use commercial	✓ (C4, C7)	✓ (C6, C8)		✓
Tourist commercial[2] & health district	✓	✓ (HD2)	✓	

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[1] Not allowed in secondary suites or carriage houses

[2] Tourist commercial: C9, parts of CD18 (McKinley Beach – Hilltown only) & CD24 (Hiawatha – Area A only)

Specific Use Regulations

Regulation	Rural & single / two unit residential	Multi-unit residential & commercial	Principal use (C9, HD2, parts of CD18 & CD24)
Maximum # of adults per bedroom	2	2	2
Maximum # of bedrooms	3	2	3
Maximum # of bookings at a time	1	1	1
Minimum # of parking spaces	1 per 2 bedrooms	1 per 2 bedrooms[1]	Same as apartment housing
Operator's principal residence	Yes	Yes[2]	No
Business license required	Yes	Yes	Yes

[1] Not in addition to principal dwelling unit if unit has two parking spaces

[2] RM6 properties along Sunset Dr are not restricted to the operator's principal residence

Refinements

- Principal residency: min. 8 months of year
- Multiple dwelling housing parking requirements
- RM6 properties on Sunset Drive listed & identified on a map
- Principal use in HD2 (health district)
- No longer a use in CD14 (Landmark)

Meeting the Principles

Requirement	Protect Long-Term Rentals	Good Neighbour	Short-Term Accommodation Equity
Operator's principal residence	X	X	
No suites or carriage houses	X		
Max. number of people, bedrooms & bookings		X	
Business license	X	X	X
Online accommodation platform taxes			X

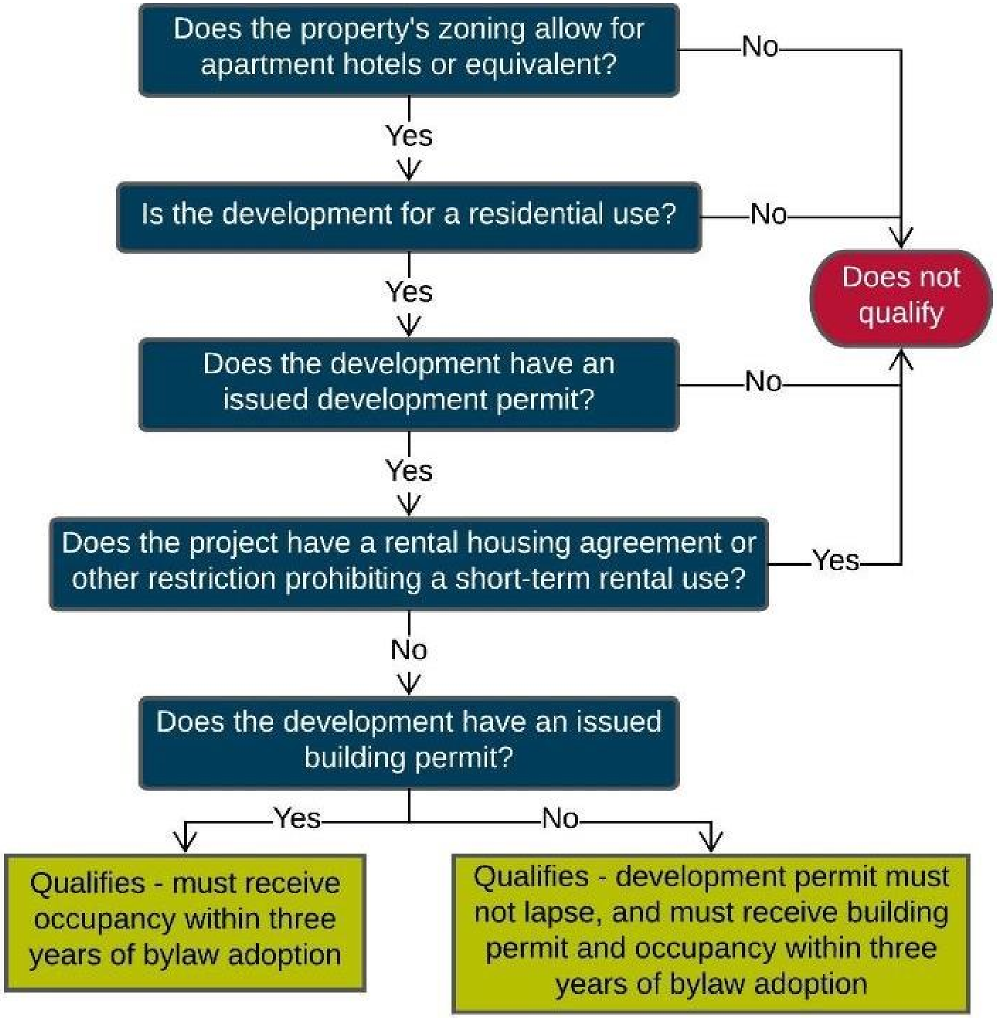
Licensing & Compliance

- Business licence will be required
  - Fees to support cost recovery
  - Documentation requirements
  - License conditions
- Third party monitoring & compliance
  - Proactive approach to enforcement
  - Provide additional tools
  - Limit impact on staff resources

Non-Conforming Uses

- *Local Government Act* provisions to protect property owners' rights when bylaws change
- Existing buildings with apartment hotel use
  - Operated lawfully in last year
  - Continue use under current regulations
  - Applies to all residential units in a building

Criteria for In-Stream Projects



Does the property's zoning allow for apartment hotels or equivalent?

Is the development for a residential use?

Does the development have an issued development permit?

Does the project have a rental housing agreement or other restriction prohibiting a short-term rental use?

Does the development have an issued building permit?

Does not qualify

Qualifies - must receive occupancy within three years of bylaw adoption

Qualifies - development permit must not lapse, and must receive building permit and occupancy within three years of bylaw adoption

In-Stream Projects

- Nearly 25 projects identified
- 7 do not qualify for non-conforming use provisions
  - Zone does not allow use
    - 1232 Ellis St (Ellis Parc)
  - DP application submitted, not yet approved
    - 105-115 Hwy 33 W, 165-179 Rutland Rd N, 430 Harvey Ave
  - Rental housing agreement
    - 1740 Richter St (Central Green Building B), 225 Rutland Rd S, 3477-3499 Lakeshore Rd (The Shore)
- Further due diligence

Next Steps

- Business License Bylaw
- Public Hearing
- Adoption & implementation
    - Education & application materials
    - Business license applications
    - Third party compliance company
- Ongoing monitoring & review

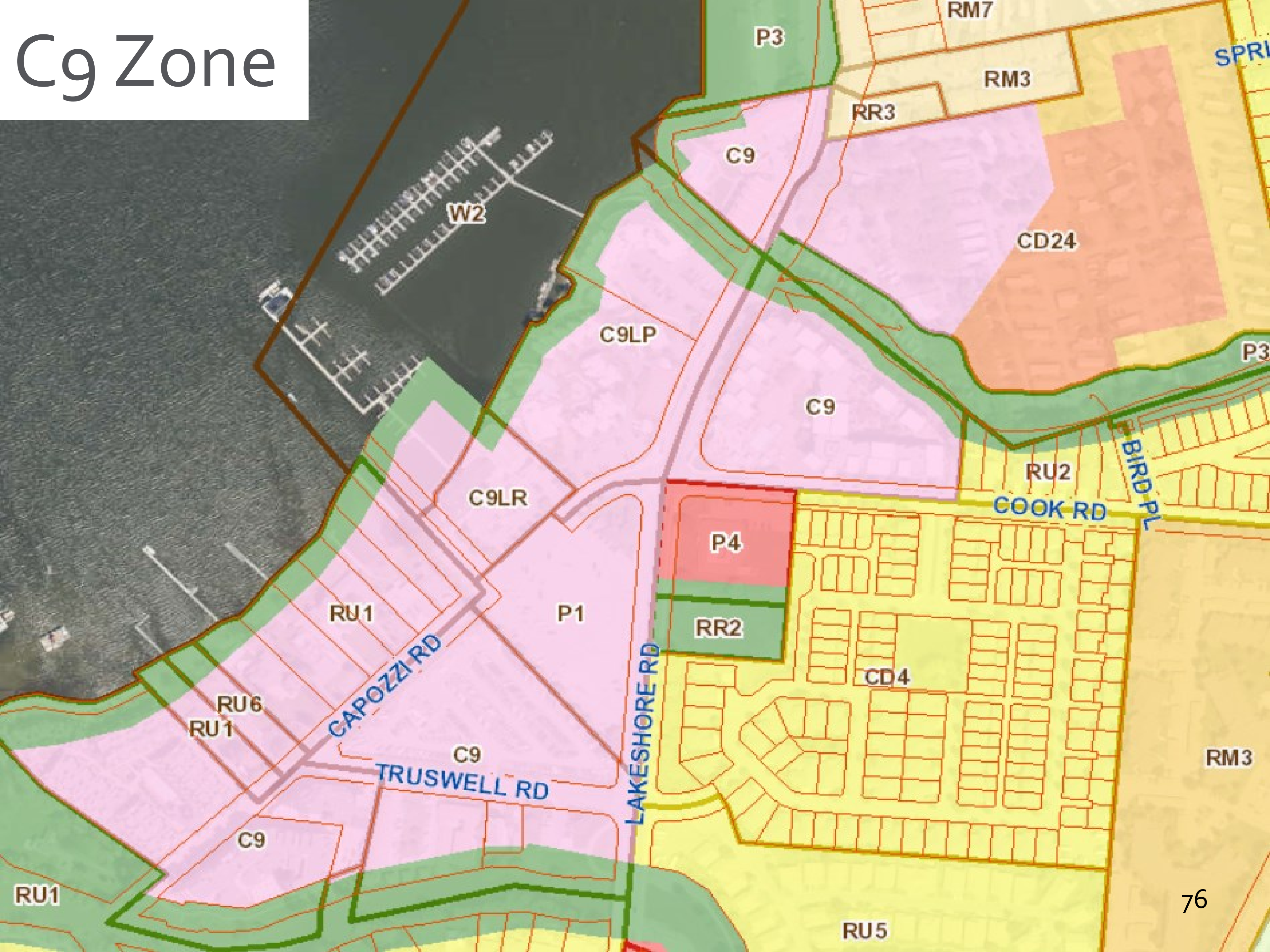
Staff Recommendation

- Recommend **support** for the Zoning Bylaw text amendment for short-term rental accommodation
  - Allows residents to operate short-term rentals
  - Aligns with previously endorsed guiding principles
  - Establishes clear regulations so the public understands the rules that apply to them
- Forward the text amendment bylaw to public hearing

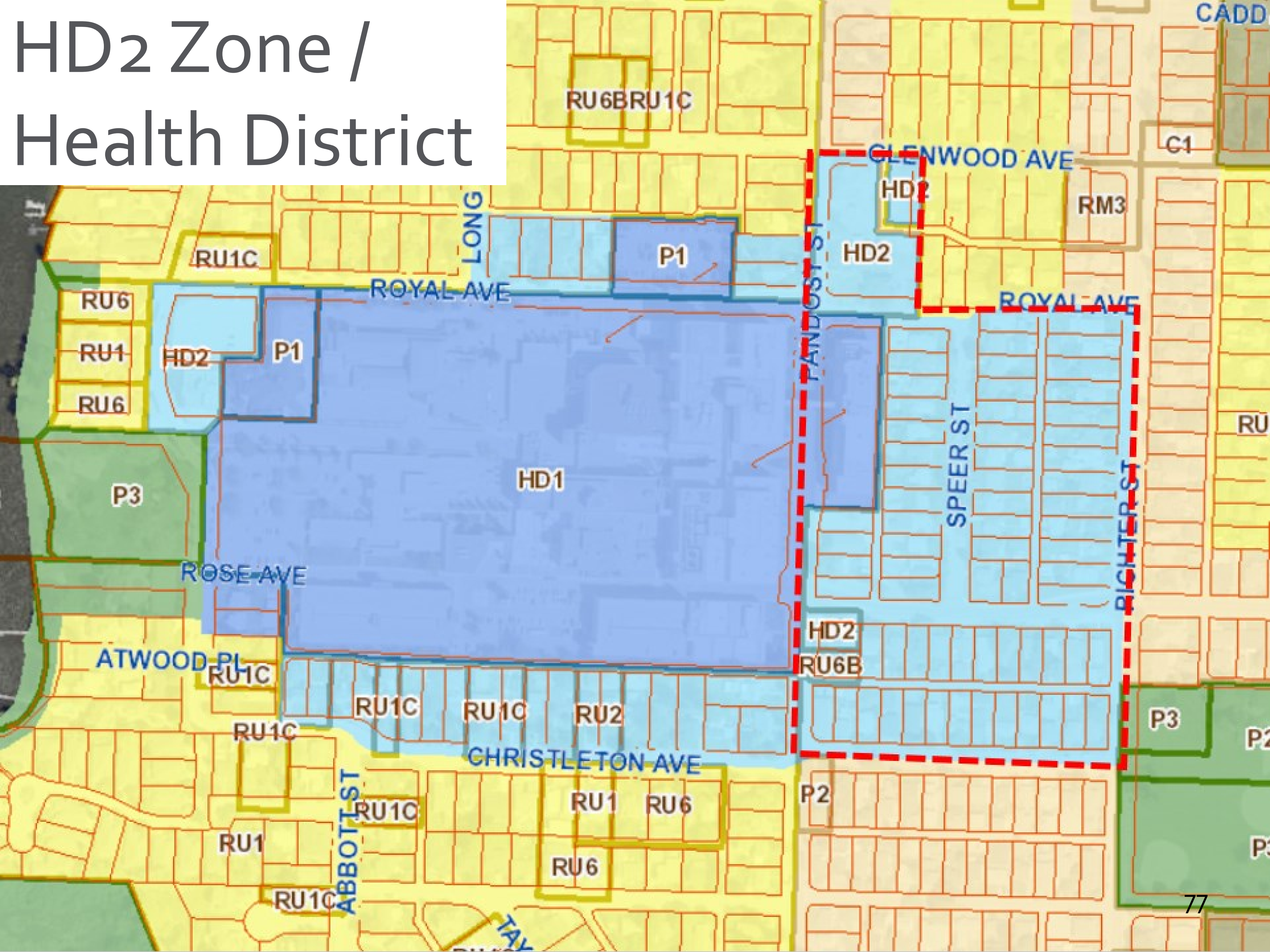
City of
Kelowna

Questions?

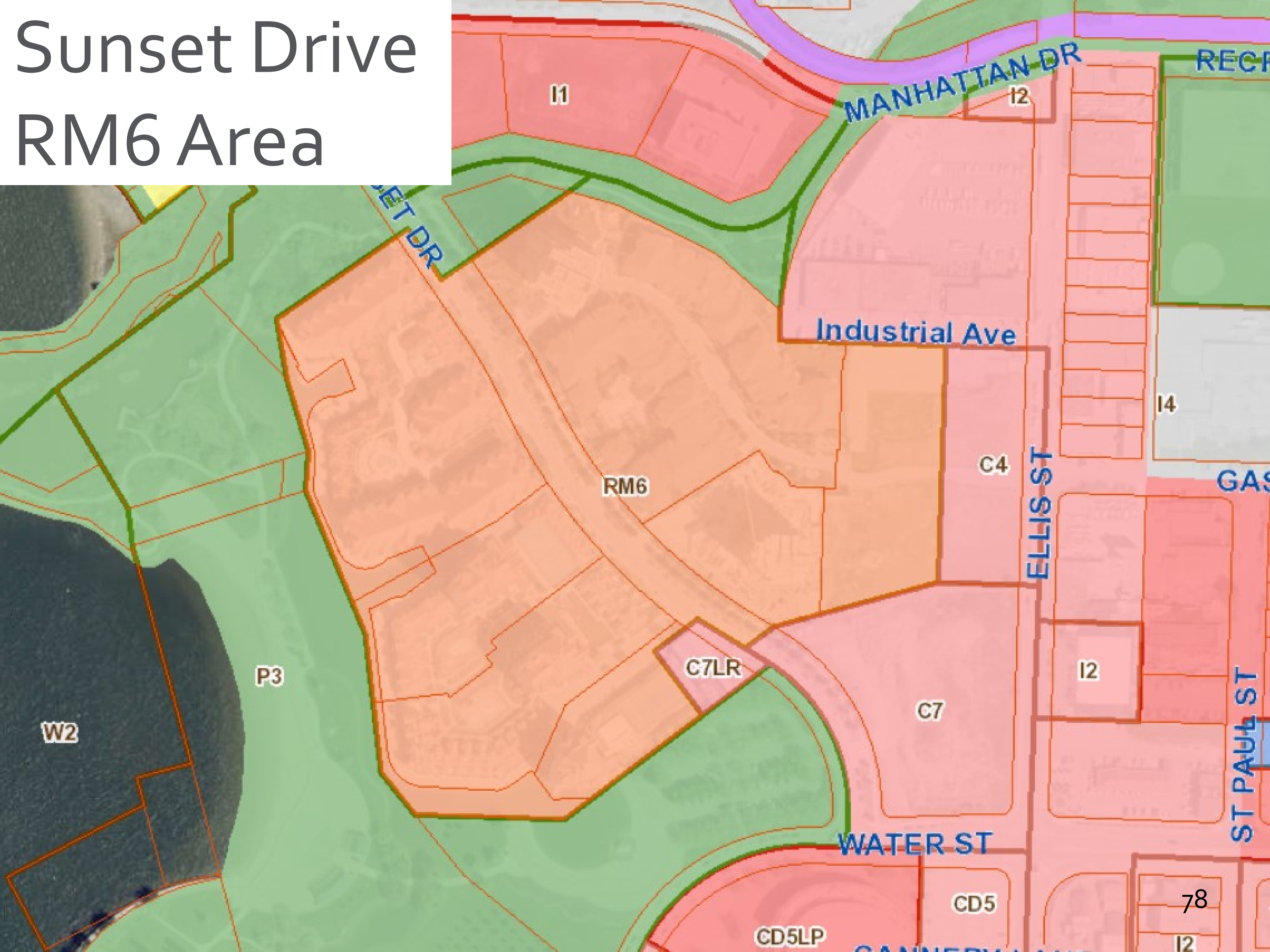
C9 Zone


RM7
P3
SPRI
RM3
RR3
C9
W2
CD24
C9LP
C9
P3
C9LR
RU2
BIRD PL
COOK RD
P4
RU1
P1
RR2
CAPOZZI RD
LAKESHORE RD
CD4
RU6
RU1
C9
TRUSWELL RD
RM3
C9
RU1
RU5

HD2 Zone / Health District



Sunset Drive RM6 Area



Case Studies

Municipality	Location of Short-Term Rentals	Licensing & Enforcement
Nelson	Most zones Operator's principal residence (some exceptions)	Municipal bylaw enforcement
Tofino	Limited locations Operator's principal residence (some exceptions)	Third party compliance
Vancouver	Most zones & locations Operator's principal residence only	Business license must be included in listing Agreement with Airbnb
Victoria	Most residential areas Operator's principal residence only	Business license must be included in listing Third party compliance

Short-Term Rental Listings

Report to Council

Date: February 25, 2019

File: 1200-40

To: City Manager

From: Laura Bentley, Community Planning Supervisor

Subject: Short-Term Rental Accommodation Non-Conforming Use Provisions

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Recommendation:

THAT Council receives, for information, the report from the Community Planning Department dated February 25, 2019, with respect to non-conforming use provisions for short-term rental accommodations.

Purpose:

To provide clarity on those properties that quality for non-conforming use provisions for short-term rental accommodation.

Background:

The *Local Government Act* outlines non-conforming use provisions that apply in cases where a land use regulation bylaw changes and a use no longer conforms to the new bylaw (see Legal/Statutory Authority below). In association with proposed regulations for short-term rental accommodations, staff have reviewed how the non-conforming use provisions would apply to those properties with zoning that currently allows for the 'apartment hotel' or similar use[1]. To provide clarity for Council, staff, property owners, developers, and the public, this report outlines how the provisions relate to existing buildings and those in the development process.

Existing Buildings

Units that are lawfully operating as apartment hotels, or have done so seasonally within the last year, may continue to operate under the existing regulations, provided they follow the non-conforming use provisions in section 528 of the *Local Government Act*. Notably, existing apartment hotels would not be restricted to the operator's principal residence. The *Local Government Act* also establishes that where a portion of a building has operated a use that becomes non-conforming, that use may continue in the

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[1] Applicable zones are: RM6, C4, C5, C7, C8, C9, HD2, CD14, CD17, CD18, CD22, CD24, and CD26. Specific regulations may apply in each zone, including whether the use is principal or secondary.

entire building. This means that if a unit in a condo building in the C7 zone, for example, has lawfully operated as an apartment hotel, all residential units in that building could operate that use and not be restricted to the new short-term rental regulations. This simplifies administration of non-conforming use provisions for staff and operators, where entire buildings that qualify for non-conforming use of apartment hotels can be identified rather than individual units in buildings.

Buildings Under Construction

Developments that are in-stream or under construction must follow somewhat different criteria than buildings that are occupied and operating apartment hotels. Based on the *Local Government Act* and examples from other communities, staff identified criteria against which to consider in-stream projects to determine if they qualify for non-conforming use provisions. These criteria are: zoning, building use, permit approvals, use restrictions, and timing.

As demonstrated in Figure 1, to qualify for non-conforming use for apartment hotels:

1. the property must be zoned for that use;
2. the development must be for a residential use, since that would allow for apartment hotels;
3. the project must have an approved development permit;
4. there may not be any restrictions on an apartment hotel or similar short-term rental use; and
5. the project must be issued a building permit and occupancy within three years of bylaw adoption.

To ensure the non-conforming use provisions only apply to the original project as approved, the relevant development permit must not lapse, and the development must receive a building permit and occupancy within three years of adoption of the new short-term rental accommodation bylaws.

It should be noted that rental housing agreements are intended to ensure buildings are used for long-term rentals and preclude short-term rental accommodation. As such, any projects that applied for rental housing grants or tax exemptions for rental housing and entered into a rental housing agreement would not qualify for non-conforming use provisions, since they are restricted from operating as apartment hotels under the existing regulations.

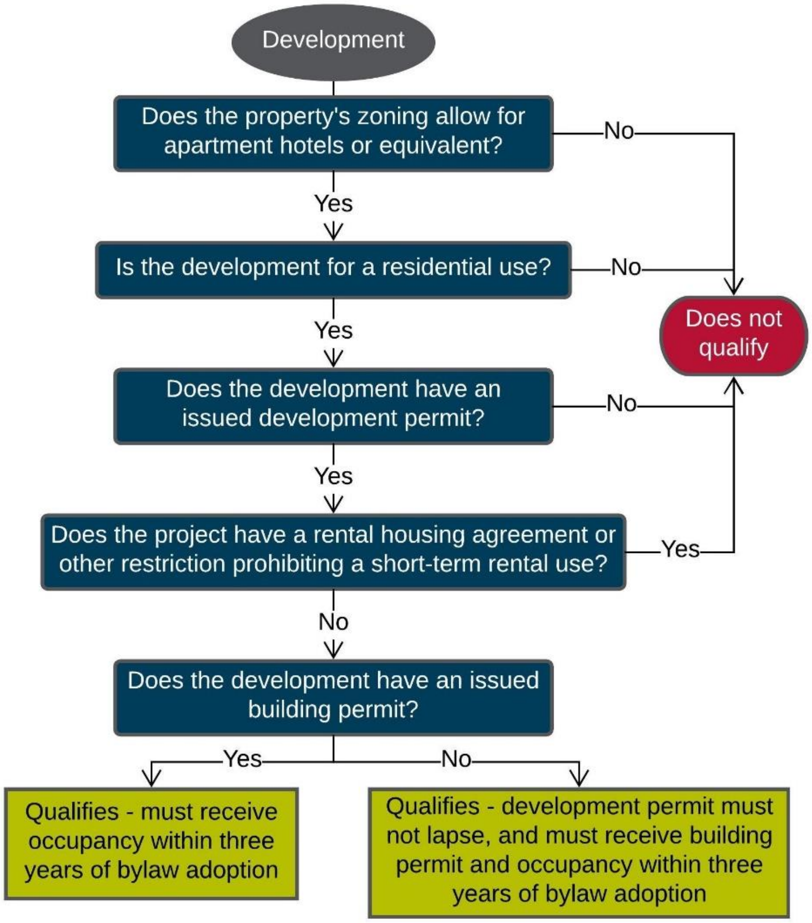


Figure 1: Criteria to Determine Non-Conforming Use on In-Stream Projects

Staff identified projects that are currently in-stream or under construction on properties with the applicable zoning in place and reviewed them against the above-listed criteria to determine if they qualify for non-conforming use provisions. The projects are listed in Table 1 below. While rental housing agreements were identified, full title searches to determine other use restrictions were not conducted, and strata bylaws or tenancy agreements may further restrict apartment hotel or short-term rental uses. Prospective property owners or residents are advised to conduct further due diligence. Should any projects have been missed from this list staff will consider them in the same way against the criteria.

Table 1: Non-Conforming Use Criteria for In-Stream Projects

Project Address	Zone	Zoning	Residential Use	Approved DP	Rental Housing Agreement	Issued BP	Non-Conforming Use
105-115 Hwy 33 W	C4	Yes	Yes	**No**	No	**No**	**No**
1151 Sunset Dr (1151 Sunset)	RM6	Yes	Yes	Yes	No	Yes	**Yes**
1164 Ellis St (One Water west)	C7	Yes	Yes	Yes	No	Yes	**Yes**
1191 Sunset Dr (One Water east)	C7	Yes	Yes	Yes	No	Yes	**Yes**
1205-1241 Richter	RM6	Yes	Yes	Yes	No	No	**Yes**
1215 St Paul St	C7	Yes	Yes	Yes	No	Yes	**Yes**
1232 Ellis St (Ellis Parc)	CD5	**No**	Yes	Yes	No	Yes	**No**
1471 St Paul St (Brooklyn)	C7	Yes	Yes	Yes	No	No	**Yes**
1580 Ellis St (Ella)	C7	Yes	Yes	Yes	No	Yes	**Yes**
165-179 Rutland Rd N	C4	Yes	Yes	**No**	No	**No**	**No**
1740 Richter St (Central Green Building B)	CD22	Yes	Yes	Yes	**Yes**	Yes	**No**
1800 Richter St (Urbana at Central Green)	CD22	Yes	Yes	Yes	No	Yes	**Yes**
1835 Gordon Dr (Capri Tower 1)	CD26	Yes	Yes	Yes	No	No	**Yes**
191 Hollywood Rd S	C4	Yes	Yes	Yes	No	No	**Yes**
1925 Enterprise Way	CD17	Yes	Yes	Yes	No	Yes	**Yes**
2169 Pandosy St (Collett Manor)	HD2	Yes	Yes	Yes	No	No	**Yes**
225 Rutland Rd S	C4	Yes	Yes	Yes	**Yes**	Yes	**No**
3475 Granite Close (Granite at McKinley Beach)	CD18	Yes	Yes	Yes	No	Yes	**Yes**
3477-3499 Lakeshore Rd (The Shore)	C4	Yes	Yes	Yes	**Yes**	Yes	**No**
430 Harvey Ave	C7	Yes	Yes	**No**	No	**No**	**No**
529 Truswell Rd	C9	Yes	Yes	Yes	No	Yes	**Yes**
529 Truswell Rd (Water's Edge North)	C9	Yes	Yes	Yes	No	Yes	**Yes**
955 Leon Ave	RM6	Yes	Yes	Yes	No	Yes	**Yes**

Legal/Statutory Authority:

Local Government Act Part 14 – Planning and Land Use Management

Non-conforming uses: authority to continue use

528 (1) Subject to this section, if, at the time a land use regulation bylaw is adopted,
  (a) land, or a building or other structure, to which that bylaw applies is lawfully used, and
  (b) the use does not conform to the bylaw,
 the use may be continued as a non-conforming use.
 (2) If a non-conforming use authorized under subsection (1) is discontinued for a continuous period of 6 months, any subsequent use of the land, building or other structure becomes subject to the land use regulation bylaw.
 (3) The use of land, a building or other structure, for seasonal uses or for agricultural purposes, is not discontinued as a result of normal seasonal or agricultural practices, including
  (a) seasonal, market or production cycles,
  (b) the control of disease or pests, or
  (c) the repair, replacement or installation of equipment to meet standards for the health or safety of people or animals.
 (4) A building or other structure that is lawfully under construction at the time of the adoption of a land use regulation bylaw is deemed, for the purpose of this section,
  (a) to be a building or other structure existing at that time, and
  (b) to be then in use for its intended purpose as determined from the building permit authorizing its construction.
 (5) If subsection (1) authorizes a non-conforming use of part of a building or other structure to continue, the whole of that building or other structure may be used for that non-conforming use.

Considerations not applicable to this report:
Internal Circulation:
Legal/Statutory Procedural Requirements:
Existing Policy:
Financial/Budgetary Considerations:
Personnel Implications:

Submitted by:

L. Bentley, Community Planning Supervisor

Approved for inclusion: R. Smith, Community Planning Department Manager

cc:
G. Wise, Business License Manager

CITY OF KELOWNA

BYLAW NO. 11766

TA19-0007 – Short Term Rental Accommodation

A bylaw to amend the "City of Kelowna Zoning Bylaw No. 8000".

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. THAT **Section 2 – Interpretation,** sub- section **2.3 General Definitions** be amended by:

   a) deleting the definition for **APARTMENT HOTELS** in its entirety that reads as follows:

   "**APARTMENT HOTELS** means **apartment housing** having a principal common entrance, cooking facilities and furnishings within each **dwelling**. This does not include any **commercial uses** except when specifically permitted in the **zone**."

   b) adding the following to the end of the sentence of the definition for **RESIDENTIAL ZONES** ", except for **short-term rental accommodation** as a **secondary use**." and

   c) adding a new definition for **SHORT-TERM RENTAL ACCOMMODATION** in its appropriate location that reads as follows:

   "**SHORT-TERM RENTAL ACCOMMODATION** means the **use** of a **dwelling** unit or one or more **sleeping units** within a **dwelling** unit for temporary overnight accommodation for a period of 29 days or less. This **use** does not include **bed and breakfast homes**, **hotels** or **motels**."

2. AND THAT **Section 6 – General Development Regulations,** sub- section **6.5 Accessory Development,** be amended by:

   a) by adding the words in sub-paragraph c "sleeping units" in the second sentence after the first word "**Bedrooms**" in sub- section **6.5.2 Accessory Building in Non-Residential Zones**; and

   b) by adding the words in sub-paragraph h "sleeping units" in the second sentence after the first word "**Bedrooms**" in sub- section **6.5.3 Accessory Building in Residential Zones**.

3. AND THAT **Section 8 – Parking and Loading, 8.1 Parking Schedule** be amended by:

   a) deleting in its entirety the section for **Apartment Hotels** that reads as follows:

Apartment Hotels	1.0 spaces per **sleeping unit**; 1.0 spaces per 7 **dwelling** units which shall be designated as visitor **parking spaces**

b) adding new sections for **Short-Term Rental Accommodation** as a **Secondary Use** and **Short-Term Rental Accommodation** as a **Principal Use** in their appropriate location that reads as follows:

Short-Term Rental Accommodation as a **Secondary Use**	1.0 medium space per two **sleeping units** Where **three dwelling housing**, **four dwelling housing**, or **multiple dwelling housing** is the **principal use**, the **dwelling** unit is exempt from the requirement in section 8.1.2 to have **parking spaces** for **secondary uses** in addition the required **parking spaces** for the **principal use**, provided the **dwelling** unit has a minimum of 2 **parking spaces**.
Short-Term Rental Accommodation as a **Principal Use**	Equivalent to **apartment housing** requirements for that **zone**

4. AND THAT **Section 9 – Specific Use Regulations,** sub- section **9.6 Bed and Breakfast Homes, 9** be amended by:

a) adding to the end of the sentence, in sub- section 9.6.1, sub-paragraph c the words "and be on site when the **bed and breakfast home** is operating."

b) deleting in sub-section 9.6.1, sub-paragraph c the word "or"

And replacing it with:

"of"

c) deleting sub- section 9.6.3 that reads:

"All **bed and breakfast homes** shall comply with the other provisions of this Bylaw, the BC **Building** Code, the **Agricultural Land Commission** General Order No. 1157/93 where applicable, and other fire and health regulations."

And replacing it with:

"All **bed and breakfast homes** shall comply with the other provisions of this Bylaw, the BC Building Code, the Agricultural Land Reserve Use, Subdivision and Procedure Regulation where applicable, and other fire and health regulations."

d) adding a new sub- section **9.17 Short-Term Rental Accommodation** in its appropriate location that reads:

"9.17 Short-Term Rental Accommodation

9.17.1 Where **short-term rental accommodation** is a **secondary use**, it must be secondary to a **dwelling** unit as a **principal use** and must be operated by a resident who resides for more than 240 days of the year at that **dwelling** unit.

9.17.2 **Short-term rental accommodation** is not permitted in a **secondary suite** or **carriage house**.

9.17.3 **Short-term rental accommodation** is not permitted in combination with a **bed and breakfast home**.

9.17.4 No more than one booking or reservation for **short-term rental accommodation** is permitted in each **dwelling** unit at one time.

9.17.5 No more than two adults may occupy a **sleeping unit** used for **short-term rental accommodation**.

9.17.6 The maximum number of **sleeping units** that may be used for **short-term rental accommodation** in each **dwelling** unit is specified in **Table 9.17.1**.

Table 9.17.1 Maximum Sleeping Units for Short-Term Rental Accommodation

Use	Maximum number of **sleeping units**
Single dwelling housing **Two dwelling housing** **Multiple dwelling housing** (including **apartment housing**) as a **principal use**	3
Three dwelling housing **Four dwelling housing** **Multiple dwelling housing** (including **apartment housing**) as a **secondary use**	2

9.17.7 Parking must be provided in accordance with the parking and loading regulations of Section 8. **Short-term rental accommodation** may not use required visitor **parking spaces**."

5. AND THAT **Section 12 – Rural Residential Zones,** be amended by:

   a) adding to Section **12.1 RR1 – Rural Residential 1 / RR1c – Rural Residential 1 with Carriage House,** sub- section **12.1.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw ";

   b) adding to Section **12.2 RR2 – Rural Residential 2 / RR2c – Rural Residential 2 with Carriage House,** sub- section **12.2.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw"; and

   c) adding to Section **12.3 RR3 – Rural Residential 3 / RR3c – Rural Residential 3 with Carriage House,** sub- section **12.3.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

6. AND THAT **Section 13 – Urban Residential Zones,** be amended by:

   a) adding to Section **13.1, RU1 – Large Lot Housing/Ru1c – Large Lot Housing with Carriage House/RU1h – Large Lot Housing (Hillside Area)/RU1hc – Large Lot Housing (Hillside Area) with Carriage House,** sub- section **13.1.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

   b) adding to Section **13.2, RU2 – Large Lot Housing/Ru2c – Large Lot Housing with Carriage House/RU2h – Large Lot Housing (Hillside Area)/RU2hc – Large Lot Housing (Hillside Area) with Carriage House,** sub- section **13.2.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

c) adding to Section **13.3 RU3 – Small Lot Housing/RU3h – Small Lot Housing (Hillside Area),** sub-section **13.3.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

d) adding to Section **13.4 RU4 – Low Density Cluster Housing/RU4h – Low Density Cluster Housing (Hillside Area),** sub- section **13.4.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

e) adding to Section **13.5 RU5 – Bareland Strata Housing,** sub- section **13.5.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

f) adding to Section **13.6 RU6 – Two Dwelling Housing / RU6 – Two Dwelling Housing with Boarding or Lodging House,** sub- section **13.6.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

g) adding to Section **13.7 RM1 – Four Dwelling Housing,** sub- section **13.7.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

h) adding to Section **13.8 RM2 – Low Density Row Housing / RM2h – Low Density Row Housing (Hillside Area),** sub- section **13.8.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

i) adding to Section **13.9 RM3 – Low Density Multiple Housing,** sub- section **13.9.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

j) adding to Section **13.10 RM4 – Transitional Low-Density Housing,** sub- section **13.10.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

k) adding to Section **13.11 RM5 – Medium Density Multiple Housing,** sub- section **13.11.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

l) deleting in Section **13.12 RM6 – High Rise Apartment Housing,** sub- section **13.12.3 Secondary Uses** sub-paragraph (e) that reads "**hotel/motel accommodation within a multiple residential unit"** and add in its appropriate location a new sub-paragraph that reads "**short-term rental accommodation** subject to Section 9.17 of this bylaw**";**

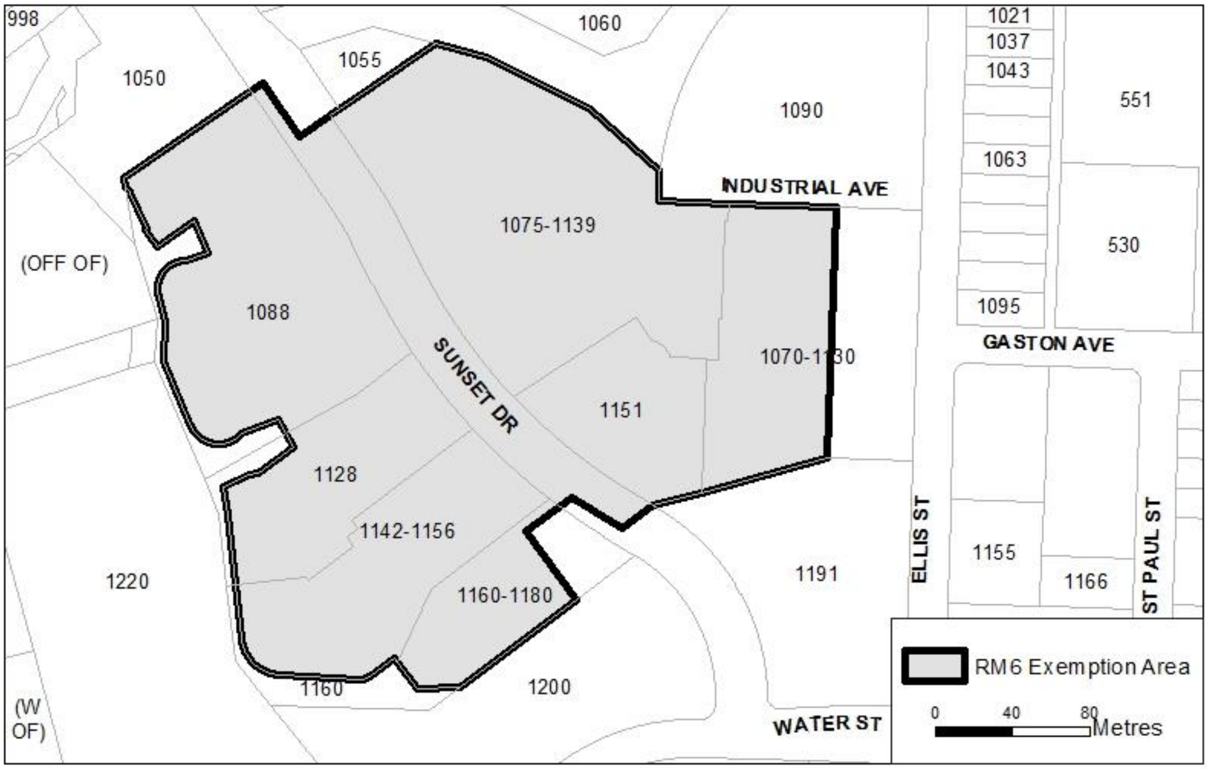
m) adding a new Section **13.12.8 Site Specific Uses and Regulations** in its appropriate location that reads:

"13.12.8 Site Specific Uses and Regulations

Uses and regulations apply to the RM6 – High Rise Apartment Housing **zone** on a site-specific basis as follows:

	Legal Description	*Civic Address*	*Regulation*
1.	See Map A	1070-1130 Ellis Street 1075-1139 Sunset Drive 1088 Sunset Drive 1128 Sunset Drive 1142-1156 Sunset Drive 1151 Sunset Drive 1160 Sunset Drive	Notwithstanding section 9.17.1, the operator of **short-term rental accommodation** does not need to be a resident who resides for more than 240 days of the year at that **dwelling** unit.

Map A: Properties Zoned RM6 where Site Specific Use Regulation No. 1 Applies



n) adding to Section **13.14 RH1 – Hillside Large Lot Residential,** sub- section **13.14.4 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

o) adding to Section **13.15 RH2 – Hillside Two Dwelling Housing,** sub- section **13.15.4 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw";

p) adding to Section **13.16 RH3 – Hillside Cluster Housing,** sub- section **13.16.4 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw"; and

q) adding to Section **13.17 RU7 – Infill Housing,** sub- section **13.17.3 Secondary Uses,** a new sub-paragraph in its appropriate location for "**short term rental accommodation** subject to Section 9.17 of this bylaw".

7. AND THAT **Section 14– Commercial Zones,** be amended by:

a) adding to Section **14.3 C3 – Community Commercial** in sub- section **14.3.3 Secondary Uses** in its appropriate location "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

b) deleting in Section **14.4 C4 –Urban Centre Commercial** in sub- section **14.4.2 Principal Uses** sub-paragraph (c) **apartment hotels**;

c) adding to Section **14.4 C4 –Urban Centre Commercial** in sub- section **14.4.3 Secondary Uses** in its appropriate location "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

d) deleting Section **14.4 C4 –Urban Centre Commercial,** sub- section **14.4.5 Development Regulations** sub-paragraph (c) that reads:

> "(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys** in the South Pandosy and Rutland Urban Centres. In the Springfield/Highway 97 Urban Centre, maximum **height** is the lesser of 15.0 m or 4 **storeys**, except that for **hotels**, **apartment hotels** and **apartment housing** it shall be the lesser of 37.0 m or 12 **storeys**. In all other areas, the maximum **height** shall be the lesser of 15.0 m or 4 **storeys.** For mixed-use developments located in Urban Centres, where parking is located entirely below natural grade and provides a co-op / car sharing program, and provides a **public courtyard** and **green roof**, the maximum building height shall be the lesser of 25.0 m or 7 **storeys**."

And replace it with:

> "(c) The maximum **height** is the lesser of 15.0 m or 4 **storeys** in the South Pandosy and Rutland Urban Centres. In the Midtown Urban Centre, maximum **height** is the lesser of 15.0 m or 4 **storeys**, except that for **hotels** and **apartment housing** it shall be the lesser of 37.0 m or 12 **storeys**. In all other areas, the maximum **height** shall be the lesser of 15.0 m or 4 **storeys.** For mixed-use developments located in Urban Centres, where parking is located entirely below natural grade and provides a co-op / car sharing program, and provides a **public courtyard** and **green roof**, the maximum building height shall be the lesser of 25.0 m or 7 **storeys**.";

e) adding to Section **14.5 C5 – Transition Commercial** in sub- section **14.5.3 Secondary Uses** in its appropriate location "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

f) deleting Section **14.6 C6 –Regional Commercial,** sub- section **14.6.3 Secondary Uses** sub-paragraph (c) **apartment hotels;**

g) adding to Section **14.6 C6 –Regional Commercial,** sub- section **14.6.3 Secondary Uses** a new sub-paragraph in its appropriate "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

h) deleting Section **14.6 C6 –Regional Commercial,** sub- section **14.6.5 Development Regulations** sub-paragraph (c) that reads:

"The maximum **height** is the lesser of 15.0 m or 4 **storeys** except for **hotels**, **apartment hotels** and **apartment housing**, shall be the lesser of 37.0 m or 12 **storeys**."

And replacing it with:

"The maximum **height** is the lesser of 15.0 m or 4 **storeys** except for **hotels** and **apartment housing**, it shall be the lesser of 37.0 m or 12 **storeys**."

i) deleting in Section **14.6 C6 –Regional Commercial,** sub- section **14.6.6 Other Regulations** sub-paragraph (a) the words "**apartment hotels**";

j) deleting in Section **14.7 C7 –Central Business Commercial,** sub- section **14.7.2 Principal Uses** sub-paragraph (c) the words "**apartment hotels**";

k) adding to Section **14.7 C7 –Central Business Commercial,** sub- section **14.7.3 Secondary Uses** a new sub-paragraph in its appropriate location "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

l) deleting Section **14.8 C8 –Convention Hotel Commercial,** sub- section **14.8.3 Secondary Uses** sub-paragraph "(c) **apartment hotel"**;

m) adding a new Section **14.8 C8 –Convention Hotel Commercial,** sub- section **14.8.3 Secondary Uses** in its appropriate location a new sub-paragraph that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

n) adding to Section **14.9 C9 – Tourist Commercial,** sub- section **14.9.2 Principal Uses** in its appropriate location a new sub-paragraph that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

o) deleting Section **14.9 C9 – Tourist Commercial,** sub- section **14.9.2 Principal Uses** sub-paragraph "(c) **apartment hotels"**;

p) deleting Section **14.9 C9 – Tourist Commercial,** sub- section **14.9.5 Secondary Uses** sub-paragraphs (a) and (b) that reads:

"(a) The maximum **floor area ratio** is 0.5 except it is 1.5 for **apartment hotels** and **hotels**.

(b) The maximum **height** is the lessor of 11.0 m or 2 **storeys** except 22.0 m or 6 **storeys** for **apartment hotels** and **hotels**."

And replace it with:

"(a) The maximum **floor area ratio** is 0.5 except it is 1.5 for **multiple dwelling housing**, **short-term rental accommodation** and **hotels**.

(b) The maximum **height** is the lesser of 11.0 m or 2 **storeys** except it is 22.0 m or 6 **storeys** for **multiple dwelling housing**, **short-term rental accommodation** and **hotels**."

q) deleting Section **14.9 C9 – Tourist Commercial,** sub- section **14.9.6 Other Regulations** sub-paragraph (e) that reads:

"(e) **Apartment hotels**, **hotels**, and **motels** are permitted only when connected to **urban services**.

And replace it with:

(e) **Multiple dwelling housing**, **short-term rental accommodation**, **hotels**, and **motels** are permitted only when connected to **urban services**."

8. AND THAT **Section 17– Health District Zone,** be amended by:

a) adding to Section **17.2 Health District Zone, 17.2 HD2 – Hospital and Health Support Services**, sub-section **17.2.2 Principal Uses**, 17.2.2.1 a new sub-paragraph that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

b) deleting Section **17.2 Health District Zone, 17.2 HD2 – Hospital and Health Support Services**, sub-section **17.2.3 Secondary Uses**, 17.2.3.1 sub-paragraph "(c) **apartment hotel**";

c) deleting from Section **17.2 Health District Zone, 17.2 HD2 – Hospital and Health Support Services**, sub-section **17.2.6 Parking Regulations specific to the HD2 zone**, sub-paragraph (a) & (b) the words "**apartment hotel**";

d) deleting from Section **17.2 Health District Zone, 17.2 HD2 – Hospital and Health Support Services**, sub-section **17.2.7 Other Regulations,** sub-paragraph (f) that reads:

"(f) **Apartment hotel** and **hotel** use shall only be permitted when secondary to **multiple dwelling housing** or **congregate housing**.";

e) deleting the title in Section **17.3 Health District Zone, 17.3 HD3 –Health Services Transitional**, sub-section "**17.3.2 Principal Uses"** and replace it with "**17.3.2 Uses**";

f) adding to Section **17.3 Health District Zone, 17.3 HD3 –Health Services Transitional**, sub-section **17.3.2 Principal Uses,** 17.3.2.2 a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

9. AND THAT **Section 18– Schedule 'B' – Comprehensive Development Zones,** be amended by:

a) adding to the **CD1 – Comprehensive Development One,** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

b) adding to the **CD2 – Kettle Valley Comprehensive Residential Development,** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

c) adding to the **CD3 –Comprehensive Development Three,** sub-section 1.2 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

d) adding to the **CD4 –Comprehensive Small Lot Residential,** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

e) adding to the **CD5–Multi-Purpose Facility/CD5lp – Multi-Purpose (Liquor Primary),** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

f) adding to the **CD10–Heritage Cultural,** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

g) deleting in **CD14–Comprehensive High-Tech Business Campus,** sub-section 1.3 **Secondary Uses** the sub-paragraph "(d) **apartment hotels**";

h) deleting in **CD14–Comprehensive High-Tech Business Campus,** sub-section 1.6 **Other Regulations** sub-paragraphs (e) and (f) that reads:

"(e) **Apartment Housing** is allowed only above the **first storey** and requires access to grade separate from the **commercial uses.**

(f) **Apartment Housing** and **apartment hotels** shall provide a minimum area of 6 m² of **private open space** per **bachelor dwelling**, 10 m² of **private open space** per **one bedroom dwelling**, and 15 m² of **private open space** per **dwelling** with more than **one bedroom**."

i) deleting in the CD**17–Mixed Use Commercial – High Density/CD17rcs – Mixed Use Commercial – High Density (Retail cannabis Sales),** sub-section 1.1 **Principal Uses** sub-paragraph (a) **apartment hotels**;

j) adding to the **CD17–Mixed Use Commercial – High Density/CD17rcs – Mixed Use Commercial – High Density (Retail cannabis Sales),** sub-section 1.1 **Principal Uses** a new sub-paragraph in its appropriate location that reads "**multiple dwelling housing";**

k) deleting in the **CD17–Mixed Use Commercial – High Density/CD17rcs – Mixed Use Commercial – High Density (Retail cannabis Sales),** sub-section 1.2 **Secondary Uses** sub-paragraph (a) **apartment housing**;

l) adding to the **CD17–Mixed Use Commercial – High Density/CD17rcs – Mixed Use Commercial – High Density (Retail cannabis Sales),** sub-section 1.2 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

m) deleting in the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (a) AREA 1 Village Centre, Principal Uses,** sub-paragraph (a) **apartment hotels**;

n) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (a) AREA 1 Village Centre, Principal Uses,** a new sub-paragraph in its appropriate location that reads "**multiple dwelling housing**";

o) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (a) AREA 1 Village Centre, Principal Uses,** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

p) deleting in the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (b) AREA 2 Winery and Resort Accommodation, Principal Uses,** sub-paragraph (a) **apartment hotels**;

q) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (b) AREA 2 Winery and Resort Accommodation, Principal Uses,** a new sub-paragraph in its appropriate location that reads "**multiple dwelling housing**";

r) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (b) AREA 2 Winery and Resort Accommodation, Secondary Uses,** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

s) deleting in the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (c) AREA III Hillside Resort Accommodation, Principal Uses,** sub-paragraph (a) **apartment hotels**;

t) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (c) AREA III Hillside Resort Accommodation, Secondary Uses,** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

u) deleting in the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (d) AREA IV Waterfront Resort Accommodation, Principal Uses,** sub-paragraph (a) **apartment hotels**;

v) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (d) AREA IV Waterfront Resort Accommodation, Principal Uses,** a new sub-paragraph in its appropriate location that reads "**multiple dwelling housing**";

w) adding to the **CD18–McKinley Beach Comprehensive Resort Development,** sub-section 1.2 **PRINCIPAL AND SECONDARY USES, 1.2 (d) AREA IV Waterfront Resort Accommodation, Secondary Uses,** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

x) deleting **CD18–McKinley Beach Comprehensive Resort Development,** sub-section **1.3 DEVELOPMENT REGULATIONS** sub-paragraph (g) that reads:

"(g) Resort accommodation which allows for short-term stays is made up of two types:

Type A:

Attached apartment hotel, hotel, congregate housing, motel units or row housing units (units in buildings exceeding 4 units with common amenities) – maximum area of 150m^2 per unit floor area net.

Type B:

Single detached housing with or without secondary suites, semi-detached housing, row housing with four units or less, with amenities that may be in separate buildings. The maximum gross floor area is 350m^2 per unit (excluding garages). The main floor footprint (excluding garage) may not exceed 175m^2 per unit (excluding garages). Type B units must be served by a common on-site or off-site reservation centre(s)."

And replacing it with:

"(g) Dwelling units or resort accommodation which allows for short-term stays is made up of two types:

Type A:

Attached apartment, hotel, congregate housing, motel units or row housing units (units in buildings exceeding 4 units with common amenities) – maximum area of 150m^2 per unit floor area net.

Type B:

Single detached housing with or without secondary suites, semi-detached housing, row housing with four units or less, with amenities that may be in separate buildings. The maximum gross floor area is 350m^2 per unit (excluding garages). The main floor footprint (excluding garage) may not exceed 175m^2 per unit (excluding garages)."

y) deleting Section **CD22 – Central Green Comprehensive Development Zone,** sub-section 1.4 **Central Green General Regulations** sub-paragraph (c) that reads:

"(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exceptions for:
Sub-Section **9.2 – Home Based Businesses, Minor**;
Sub-Section **9.3 – Home Based Businesses, Major**; and
Sub-Section **9.10 – Agriculture, Urban"**

And replace it with:

(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exceptions for:
Sub-Section **9.2 – Home Based Businesses, Minor**;
Sub-Section **9.3 – Home Based Businesses, Major**;

Sub-Section **9.10 – Agriculture, Urban**; and
Sub-Section **9.17 – Short-Term Rental Accommodation.”**

z) deleting Section **CD22 – Central Green Comprehensive Development Zone, Schedule 7 – CD22 Sub-Areas A & B Zoning, 7.2 Principal Uses** sub-paragraph (e) **apartment hotels**;

aa) adding to Section **CD22 – Central Green Comprehensive Development Zone, Schedule 7 – CD22 Sub-Areas A & B Zoning, 7.3 Secondary Uses** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

bb) adding to Section **CD22 – Central Green Comprehensive Development Zone, Schedule 8 – CD22 Sub-Areas C & G Zoning, 8.1 Permitted Uses, Secondary Uses** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

cc) adding to Section **CD22 – Central Green Comprehensive Development Zone, Schedule 9 – CD22 Sub-Area D Zoning, 9.1 Permitted Uses, Secondary Uses** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

dd) adding to Section **CD22 – Central Green Comprehensive Development Zone, Schedule 10 – CD22 Sub-Area E & F Zoning, 10.1 Permitted Uses, Secondary Uses** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

ee) adding to Section **CD22 – Central Green Comprehensive Development Zone, Schedule 11 – CD22 Sub-Area H Zoning, 11.1 Permitted Uses, Secondary Uses** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

ff) deleting Section **CD24 –Comprehensive Development Zone,** sub-section 1.4 **General Regulations of Comprehensive Site** sub-paragraph (c) that reads:

“c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exception of:
Sub-Section **9.2 – Home Based Business, Minor**;
Sub-Section **9.3 – Home Based Business, Major.**

And replace it with:

(c) **Section 9 – Specific Use Regulations** of this bylaw does not apply with the exception of:
Sub-Section **9.2 – Home Based Business, Minor**;
Sub-Section **9.3 – Home Based Business, Major**~~.~~; and
Sub-Section **9.17 – Short-Term Rental Accommodation.”**

gg) deleting in Section **CD24 –Comprehensive Development Zone, Schedule 1 – CD24 Sub-Area A Zoning, 7.2.1 Principal Uses** sub-paragraph (a) **apartment hotels**;

hh) adding to Section **CD24 –Comprehensive Development Zone, Schedule 1 – CD24 Sub-Area A Zoning, 7.2.1 Principal Uses,** a new sub-paragraph in its appropriate location that reads “**short-term rental accommodation**, subject to section 9.17 of this Bylaw”;

ii) deleting in Section **CD24 –Comprehensive Development Zone, Schedule 1 – CD24 Sub-Area A Zoning, 7.6 Private Open Space,** the words “‘**apartment hotel unit**” and replacing it with the words “**short-term rental accommodation**.”;

jj) deleting in Section **CD24 –Comprehensive Development Zone, Schedule 2 – CD24 Sub-Area B Zoning,** the title ”**8.2.1 Secondary Uses”** and replacing it with ”**8.2.2 Secondary Uses”**;

kk) adding to Section **CD24 –Comprehensive Development Zone, Schedule 2 – CD24 Sub-Area B Zoning, 8.2.1 Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw";

ll) deleting in Section **CD26 – Capri Centre Comprehensive Development Zone/CD26rcs – Capri Centre Comprehensive Development Zone (Retail Cannabis Sales), 1.4 Principal Uses** sub-paragraph (c) **apartment hotels**;

mm) adding to Section **CD26 – Capri Centre Comprehensive Development Zone/CD26rcs – Capri Centre Comprehensive Development Zone (Retail Cannabis Sales), 1.5 Secondary Uses** a new sub-paragraph that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw"; and

nn) adding to the **CD27 – Valley Land Subdivision,** sub-section 1.3 **Secondary Uses** a new sub-paragraph in its appropriate location that reads "**short-term rental accommodation**, subject to section 9.17 of this Bylaw".

10. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first time by the Municipal Council this

Considered at a Public Hearing on the

Read a second and third time by the Municipal Council this

Approved under the Transportation Act this

____
(Approving Officer-Ministry of Transportation)

Adopted by the Municipal Council of the City of Kelowna this

____
Mayor

____
City Clerk

REPORT TO COUNCIL

Date:	February 25, 2019		
RIM No.	1250-30		
To:	City Manager		
From:	Community Planning Department (KB)		
Application:	Z17-0113	**Owner:**	1018545 B.C. Ltd., Inc.No. BC1018545
Address:	2565-2575 Pandosy Street	**Applicant:**	Bear Land Development Services
Subject:	Rezoning Extension Application		

Existing OCP Designation:	MRL – Multiple Unit Residential (Low Density)
Existing Zone:	RU6 – Two Dwelling Housing
Proposed Zone:	RM3 – Low Density Multiple Housing

1.0 Recommendation

THAT in accordance with Development Application Procedures Bylaw No. 10540, the deadline for the adoption of Rezoning Bylaw No. 11562, be extended from March 20, 2019 to March 20, 2020.

AND THAT Council directs Staff to not accept any further extension requests.

2.0 Purpose

To extend the deadline for adoption of Rezoning Bylaw No. 11562 to March 20, 2020.

3.0 Community Planning

Rezoning Bylaw No. 11562 received second and third readings at a Regular meeting of Council held on Tuesday March 20, 2018. Final adoption of the zone amendment bylaw is subject to the applicant meeting the requirements of the Schedule "A": Development Engineering Memorandum, as well as Council consideration of a Development Permit and Development Variance Permit. The applicant has made progress towards meeting these requirements, including completing a lot consolidation and has been working to meet their Development Engineering requirements. They have requested additional time to do so. Staff are recommending that Council supports extending the deadline for adoption for the Rezoning Bylaw No. 11562 by one year to March 20, 2020.

Subject Property Map: 2565-2575 Pandosy Street

4.0 Application Chronology

Date of Application Received:	August 21, 2017
Date of Second and Third Readings:	March 20, 2018
Date of Extension Application Received:	February 13, 2019

Report prepared by:	Kimberly Brunet, Planner
Reviewed by:	Terry Barton, Urban Planning Manager
Approved for Inclusion:	Ryan Smith, Community Planning Department Manager

CITY OF KELOWNA

BYLAW NO. 11463
Z17-0054 – 4610 Darin Place

A bylaw to amend the "City of Kelowna Zoning Bylaw No. 8000".

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. THAT City of Kelowna Zoning Bylaw No. 8000 be amended by changing the zoning classification of Lot 5 District Lot 357 ODYD Plan KAP57058 located on Darin Place, Kelowna, B.C., from the RU1 – Large Lot Housing zone to the RU1c – Large Lot Housing with Carriage House zone.

2. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first time by the Municipal Council this 28th day of August, 2017.

Considered at a Public Hearing on the 12th day of September, 2017.

Read a second and third time by the Municipal Council this 12th day of September, 2017.

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

CITY OF KELOWNA

BYLAW NO. 11603

Z17-0083 – 1967, 1969 & 1973 Cross Road

A bylaw to amend the "City of Kelowna Zoning Bylaw No. 8000".

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. THAT City of Kelowna Zoning Bylaw No. 8000 be amended by changing the zoning classification of portions of:

    - Lot 2 Section 4 Township 23 ODYD Plan KAP84464, located at 1967 Cross Rd, Kelowna, BC, from the RU1 – Large Lot Housing zone to the RU2 Medium Lot Housing and RU2C Medium Lot Housing with Carriage House zones;
    - That Part of Lot 11 Block 6 Section 4 Township 23 ODYD Plan 986 Except Plan 10134 Shown Green on Plan H8323, located at 1969 Cross Rd, Kelowna, BC, from the A1 – Agricultural 1 zone to the RU2C Medium Lot Housing with Carriage House zone;
    - The portion of road between That Part of Lot 11 Block 6 Section 4 Township 23 ODYD Plan 986 Except Plan 10134 Shown Green on Plan H8323, located at 1969 Cross Rd, Kelowna, BC and Lot 39 Section 4 Township 23 ODYD Plan KAP48643, located at 1973 Cross Rd, Kelowna, BC, from the A1 – Agricultural 1 and RU1 – Large Lot Housing zones to the RU2 Medium Lot Housing and RU2C Medium Lot Housing with Carriage House zones; and
    - Lot 39 Section 4 Township 23 ODYD Plan KAP48643, located at 1973 Cross Rd, Kelowna, BC, from the RU1 – Large Lot Housing zone to the RU2 Medium Lot Housing, RU2C Medium Lot Housing with Carriage House and RU6 – Two Dwelling Housing zones;

    as per Map A attached to and forming part of this bylaw.

2. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first time by the Municipal Council this 23rd day of April, 2018.

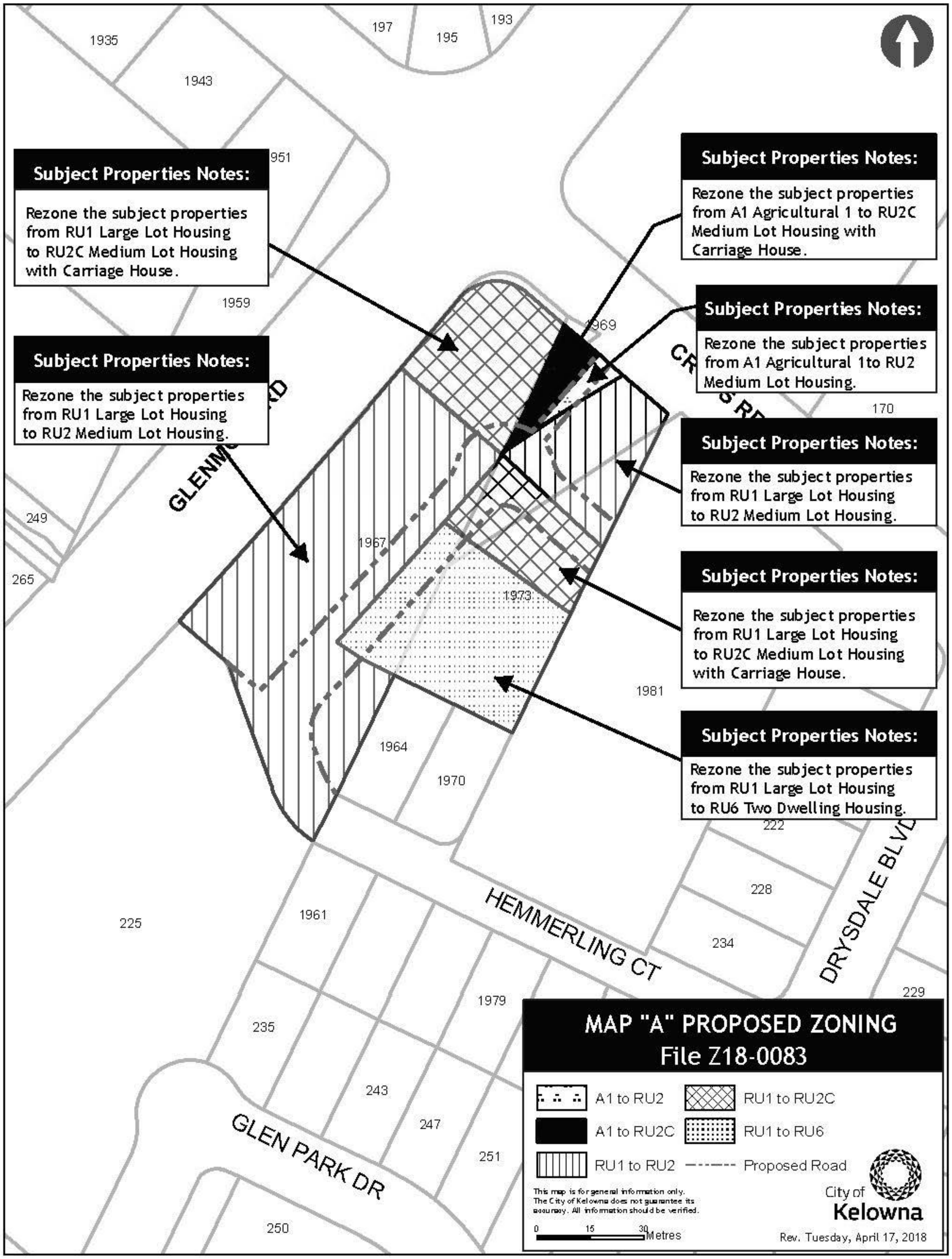
Considered at a Public Hearing on the 15th day of May, 2018.

Read a second and third time by the Municipal Council this 15th day of May, 2018.

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk



Subject Properties Notes:

Rezone the subject properties from RU1 Large Lot Housing to RU2C Medium Lot Housing with Carriage House.

Subject Properties Notes:

Rezone the subject properties from RU1 Large Lot Housing to RU2 Medium Lot Housing.

Subject Properties Notes:

Rezone the subject properties from A1 Agricultural 1 to RU2C Medium Lot Housing with Carriage House.

Subject Properties Notes:

Rezone the subject properties from A1 Agricultural 1to RU2 Medium Lot Housing.

Subject Properties Notes:

Rezone the subject properties from RU1 Large Lot Housing to RU2 Medium Lot Housing.

Subject Properties Notes:

Rezone the subject properties from RU1 Large Lot Housing to RU2C Medium Lot Housing with Carriage House.

Subject Properties Notes:

Rezone the subject properties from RU1 Large Lot Housing to RU6 Two Dwelling Housing.

MAP "A" PROPOSED ZONING
File Z18-0083

This map is for general information only. The City of Kelowna does not guarantee its accuracy. All information should be verified.

Rev. Tuesday, April 17, 2018

CITY OF KELOWNA

BYLAW NO. 11429

Z17-0039 – 200 Nickel Rd

A bylaw to amend the "City of Kelowna Zoning Bylaw No. 8000".

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. THAT City of Kelowna Zoning Bylaw No. 8000 be amended by changing the zoning classification of Lot 1, Section 27, Township 26, ODYD, Plan EPP73636 located on Nickel Road, Kelowna, B.C., from the RU1 – Large Lot Housing zone to the RM3 – Low Density Multiple housing zone.
2. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first time by the Municipal Council this 19th day of June, 2017.

Considered at a Public Hearing on the11th day of July 2017.

Read a second and third time by the Municipal Council this 11th day of July 2017.
.
Approved under the Transportation Act this 18th day of July, 2017.

___________Audrey Henry____
(Approving Officer – Ministry of Transportation)

Adopted by the Municipal Council of the City of Kelowna this

____
Mayor

____
City Clerk

Report to Council

Date:	February 25, 2019
File:	0920-20
To:	City Manager
From:	Lance Kayfish, Director of Community Safety
Subject:	2019-02-25 Remediation Order Re. Geotechnical Instability Loseth Rd.docx
	Report Prepared: James Kay, Manager, Development Engineering

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Recommendation:

WHEREAS the Council of the City of Kelowna has the authority under Section 72 (1) (a) and (b) of the Community Charter to impose a remedial action requirement in relation to hazardous/unsafe conditions or declared nuisances;

Council hereby considers that the fill slopes located at 2045 Loseth Road, Kelowna (the "Loseth Property") are in, and create, an unsafe condition, within the meaning of Section 73 (2)(a) of the Community Charter, as a result of the soil stability having an inadequate factor of safety and being susceptible to further destabilization from increased groundwater pressures.

Council hereby considers that the fill slopes located at 2001 Kloppenburg Court, Kelowna (the "Kloppenburg Ct. Property") are in, and create, an unsafe condition, within the meaning of Section 73 (2)(a) of the Community Charter, as a result of the soil stability having an inadequate factor of safety and being susceptible to further destabilization from increased groundwater pressures.

Council hereby declares the fill slopes at the Loseth Property to be a nuisance, within the meaning of Section 74 (2) of the Community Charter.

Council hereby declares the fill slopes at the Kloppenburg Ct. Property to be a nuisance, within the meaning of Section 74 (2) of the Community Charter.

Council considers that there is a significant risk to health and safety and that, pursuant to s. 79 of the Community Charter, the time limit set complying with any remedial action requirements should be shorter than the 30-day minimum period provided under section 76 and that the time limit for requesting reconsideration by Council of any remedial action requirement be 14 days.

Council hereby imposes on the registered owner of the Loseth Property the following remedial action requirement to address and remediate the unsafe condition and nuisance:

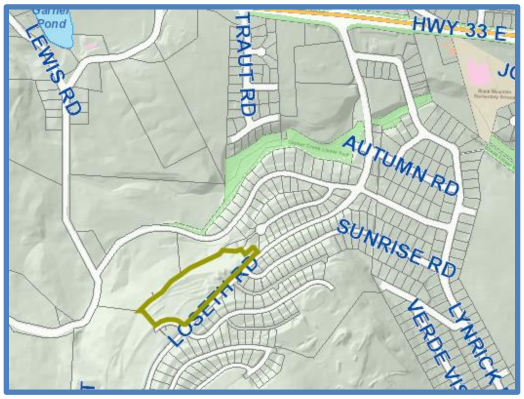
(a) prepare and present to the City's Manager, Development Engineering a remediation plan based on the January 24, 2019 Geotechnical Investigation Report of Westrek Geotechnical Services Ltd. (the "Westrek Report") that will achieve a factor of safety of 1.3 for the fill slopes;
(b) provide the remediation plan to the City's Manager, Development Engineering (the "Manager") no later than March 11, 2019;
(c) the remediation plan must be prepared or approved by a professional engineer or professional geoscientist with experience or training in geotechnical study and geohazard assessments (the "Qualified Professional");
(d) complete the work in accordance with the approved remediation plan by March 30, 2019;
(e) provide a report by the Qualified Professional to the Manager within two weeks of completion of the work, certifying the safe condition of the fill slopes.

Council hereby imposes on the registered owner of the Kloppenburg Ct. Property the following remedial action requirement to address and remediate the unsafe condition and nuisance:

(a) prepare and present to the City's Manager, Development Engineering a remediation plan based on the January 24, 2019 Geotechnical Investigation Report of Westrek Geotechnical Services Ltd. (the "Westrek Report") that will achieve a factor of safety of 1.3 for the fill slopes;
(b) provide the remediation plan to the City's Manager, Development Engineering (the "Manager") no later than March 11, 2019;
(c) the remediation plan must be prepared or approved by a professional engineer or professional geoscientist with experience or training in geotechnical study and geohazard assessments (the "Qualified Professional");
(d) complete the work in accordance with the approved remediation plan by March 30, 2019;
(e) provide a report by the Qualified Professional to the Manager within two weeks of completion of the work, certifying the condition of the fill slopes as having a factor of safety of 1.3.

Purpose:

Staff recommend Council impose Remedial Action Orders to rectify slope instability and unsafe condition at 2045 Loseth Road and 2001 Kloppenburg Court, which are both urgent and of high-consequence.



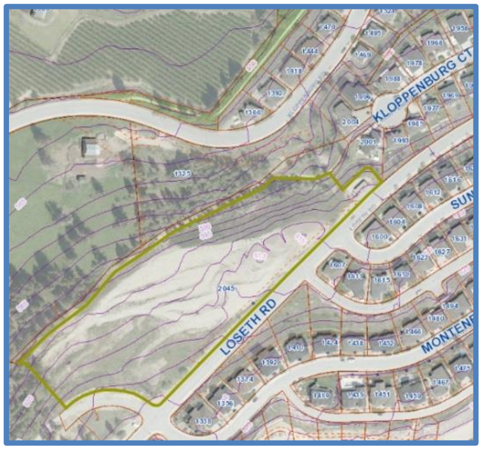
Background:

City of Kelowna Operations crews identified signs of slope instability at 2045 Loseth Road in Spring 2018. Tension cracks were evident both in the city-owned boulevard fronting the site, in the embankment on private property, as well as behind the BMID pump station on the property.

In Summer of 2018, Westrek Geotechnical Services Ltd. was retained to investigate and provide recommendations. Their preliminary investigation of June 3, 2018 and detailed geotechnical report of January 24, 2019 are attached. Key conclusions include:

- *The analysis concludes that the entire slope is just marginally stable under current conditions and can be destabilized by even a modest rise in groundwater pressures, which likely occurs each spring.*
- *The toe excavation along Cross-section C-C' in 2015 reduced the factor of safety by 9%, which would be enough to destabilize a marginally stable slope.*

As the tension cracks are evident in the slope, the geotechnical analysis evaluated the areas at risk downstream, which includes significant risk to residents and residence at 2001 Kloppenburg Court. It poses risk to 2004 Kloppenburg Court, as well as the City trail immediately below the slope, 1325 Kloppenburg Road, and Kloppenburg Road itself. The owners have been notified and are aware of the risks, but the situation requires resolution.



As the tension cracks are evident above the slope within Loseth Road, is it important to note that this section of Loseth is the only public access to approximately 90 homes up Kirschner Mountain and contains utility infrastructure under the surface. The BMID Booster Station supplies the reservoir. Of course any failure effecting a home or structure could result in injury or death of the occupants. For these reason staff assess that a failure in this area could have catastrophic consequences.

The instabilities originate on private property and the responsibility to remediate them should rest with the landowner. However, due to the scope and cost of the works, anticipated to be $750,000 - $1,200,000, the private owners have thus far not committed to remediate the slope instabilities or brought forward a plan of to make it safe.

Staff recommend Remedial Action Orders from Council requiring the owners to act and make the slope reasonably safe. It is understood that remediating the slope and area is a significant and costly undertaking. It will require coordination between the subject landowners, occupiers and others. The current land owners may ultimately be determined not be the persons responsible for the existing hazards arising from the fill materials but as owners they are responsible for ensuring the unsafe conditions do not damage homes, parkland and civic infrastructure. There will be an opportunity for the owner's and impacted parties to recover their losses through civil litigation or other means but those processes will take time and can be conducted after existing circumstance is made safe.
In the absence of owner action, staff will report back to council to seek authorization for the City to engage forces to remedy the situation and recover the costs accordingly. Staff and legal counsel are satisfied that the statutory prerequisites for imposing remedial action requirements are met in this case; specifically, that the slope instability risks are present in fill soils that were placed or dumped, the soils causing the hazards are not simply a natural condition and thus fall within the description of a "similar matter or thing" as that phrase is used in sections 73(1)(a) and 74(1)(a) of the Community Charter. With respect to the Kloppenburg Ct. Property, Westrek considers that the instability of the slope is related to an excavation for a small pond. The authority under section 73(1)(b) to impose a remedial action requirement in relation to an "artificial opening", "or a similar matter or thing" is also engaged.

The assessment and the amelioration of landslide risk is, according to a 2015 BC Supreme Court decision, an area of decision-making for which elected councils are well suited. It is for Council to determine whether the level of risk warrants intervention through a remedial action order so long as there is information from which Council could reasonably determine the risk from an unsafe condition should be remediated. Staff consider the January 24, 2019 Westrek Report and the further February 18, 2019 Technical Memorandum provide Council with the appropriate information to make the determination whether to impose remedial action requirements.

With respect to BMID's position, it is considered to be an occupier of that portion of the Loseth property statutory right of way area taken up by the pump station and surrounding concrete pad. For that area, there is no basis in the Westrek Report to indicate that the soils directly beneath the pump station are not properly compacted or contribute to the instability of the adjacent fill slopes. Further, the owner of the property retains the right to use the rest of statutory right of way area subject to the rights granted to BMID under the statutory right of way. BMID is therefore not considered to be an "occupier" of the problematic fill slopes for the purpose of the remedial action authority. Should new information arise during the course of remediation work, or otherwise, indicating that the soils directly below the BMID pump station are a source of instability, staff may, to the extent it is practical to do so, bring the matter back to Council to consider the appropriateness of a remedial action order directed to BMID.

Staff have met with the landowners directly effected, closed the trail at the bottom of the slope, and are formalizing an Emergency Response Plan that addresses communications and public notification, evacuations, restoration of an emergency access, stabilization of water, sewer, and shallow utilities, and emergency response if needed.

Staff are prepared to work with consultants and stakeholders to develop the technical details of the action plan to alleviate unsafe conditions, arrange for the contractors and site management, and intervene immediately upon either the dates outlined in the Remediation Order or written confirmation from each homeowner that they will not undertake the works themselves. Should the City undertake action, construction crews would remove the overburden, reduce the slopes, stabilize the instabilities at the bottom of the slope, and work to ensure the protection of the public, property and infrastructure in the area.

Financial/Budgetary Considerations:

If the landowners comply with the Remedial Action Orders, no exceptional budgetary requirements are anticipated. Staff would oversee and confirm completion of the works. The City may opt to seek recovery for costs to date, including the work undertaken by Westrek.

The remediation of this instability has been estimated at between $750k-$1.2m. The low range of this estimate assumes simple extension/buttressing of the bottom of the slope which would require additional land and significant impact to the adjacent landowners. The higher range of this estimate provides for stabilization of the slope in place, with more expensive technical solutions.

Should the City be required to undertake the works, staff will seek direction from Council to undertake the work and seek a budget amendment to fund this work.

Communications Comments:

A communications plan has been developed to inform the community regarding unsafe conditions.

Cost Recovery:

If a remedial action requirement is not satisfied by the date specified for compliance, the City may act in default, under section 17 of the Community Charter, and fulfill the requirements at the expense of the person in default. If the amount expended to effect compliance remains unpaid as of December 31 in the year the expense was incurred, it is deemed to be taxes in arrears.

Legal/Statutory Authority:

Council may impose remedial action requirements under the Community Charter, section 72(1)(a) in relation to hazardous/unsafe conditions referred to in s. 73 and section 72(1)(b) in relation to declared nuisances in respect of the subjects referred to in s. 74.

The remedial action requirement

(a) may be imposed on one or more of

  (ii) the owner or occupier of the land on which it is located, and

(b) may require the person to

  (i) remove or demolish the matter or thing,

  (iii) bring it up to a standard specified by bylaw, or

(iv) otherwise deal with it in accordance with the directions of council or a person authorized by council.

Legal/Statutory Procedural Requirements:

Notice of any remedial action requirement to be served on owner/person subject to requirement.
Time specified for carrying out remedial action must be no less than 30 days after notice provided unless pursuant to s. 79(1)(a) council considers that a shorter time limit should be set due to a significant risk to health or safety.

Right to request reconsideration under s. 78 Community Charter within 14 days of receiving notice unless pursuant to s. 79(1)(b) council sets a shorter time limit due to significant risk to health or safety.
Recovery of costs to achieve compliance in default under s. 17 and s. 258 Community Charter.

Submitted by: L. Kayfish, Director, Community Safety

Approved for inclusion: S. Leatherdale, Divisional Director, Human Resources and Community Safety

Internal Circulation:

Divisional Director, Infrastructure
Divisional Director, Human Resources & Community Safety
Divisional Director, Financial Services
Director, Development Services
City Clerk
Corporate Communications Manager

Considerations not applicable to this report:

Existing Policy:
Personnel Implications:
Alternate Recommendation:

Attachments: Geotechnical Investigation, 2045 Loseth Road, January 24, 2019;
Preliminary Slope Stability Assessment, June 3, 2018;
Technical Memorandum, lope Instability – 2045 Loseth Road, February 18, 2019,
Westrek Geotechnical Services Ltd

cc: J.Creron, Deputy City Manager
A.Newcombe, Divisional Director, Infrastructure
S. Leatherdale, Divisional Director, Human resources & Community Safety
D.Edstrom, Divisional Director, Community Planning & Strategic Investments
T.Whiting, Chief, Kelowna Fire Department
S. Fleming, City Clerk
M. Bayat, Director, Development Services
R.Smith, Manager, Community Planning
D. Noble-Brandt, Manager, Policy & Planning Department

I.Wilson, Manager, Infrastructure Operations Department
K.Van Vliet, Manager, Utility Services
T. Wilson, Manager, Corporate Communications
B. Williamson, Legal Counsel, Young Anderson

Geotechnical Investigation
2045 Loseth Road

Prepared for:

City of Kelowna
1435 Water Street
Kelowna, BC V1Y 1J4
Attention: Rod MacLean, P.Eng.
Manager – Utility Planning

Prepared by:

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Jan 24/19

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January 24, 2019
File No. 018-253

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List of Figures

Appendices

1 Introduction and Scope

Westrek Geotechnical Services Ltd. (Westrek) investigated several slope instabilities developing adjacent to the pump station along Loseth Road, near the corner with Sunrise Road, in Kelowna, BC. The purpose of the investigation was to assess slope stability, estimate the probability of a landslide and potential runout, and recommend methods to stabilize the slope.

The original scope of work was originally authorized by the Black Mountain Irrigation District (BMID) in a Client Service Agreement dated June 6, 2018. The City of Kelowna (the City) took over as lead authority for the project on December 3, 2018. The scope of consisted of:

- A review of available background information.
- A geotechnical subsurface investigation of the soils present on the slopes, in and around the observed movement.
- Installation and monitoring of slope inclinometers (SIs) and vibrating wire (VW) piezometers within several of the boreholes to measure slope displacement and groundwater pressure, respectively.
- A slope stability analysis to assess the mode and cause of the slope movement.
- Develop conceptual measures to stabilize the slope.

The services provided by Westrek are subject to the terms and conditions set out in the *Interpretation and Use of Study and Report and Limitations*, which is attached in Appendix A and incorporated herein by reference.

2 Investigation

2.1 Site Visit

Tim Smith, P.Geo., Eng.L., representing Westrek, conducted an initial site assessment on May 30, 2018, accompanied by Matt Cameron, P.Eng., with CTQ Consulting, and Kevin Burtsch and Toby Pike with BMID. A more thorough field assessment was conducted by Tim Smith and Eric McQuarrie, P.Eng., P.Geo., of Westrek on July 25, 2018. Visual observations and measurements were made of the terrain and drainage conditions, and the various areas of slope movement.

2.2 Background Documents

The following information was reviewed during this investigation:

- Environment Canada daily weather records for several weather stations in the Kelowna area.
- Environment Canada Climate Normals (1981 to 2010) for *Kelowna Airport*.
- *Surficial Geology of Kelowna.* Geological Survey of Canada. Open File 6146 (2009).
- *Geology of the Kelowna Tertiary Outlier.* BC Geological Survey. Preliminary Map 45. June 1981.
- Google Earth satellite imagery from 2002, 2004, 2005, 2006, 2009, 2012, 2015, 2016 & 2017.
- iKelowna Map Viewer [https://maps.kelowna.ca].
- *Kirschner Mountain Estates Loseth Road Plan/Profile – Sanitary and Storm. Dwg. No. PP001 Rev. No. 3.* As constructed January 5, 2005. City of Kelowna.

- *Geotechnical Investigation Proposed Subdivision, Garner Road Lot A, Section 13, Township 23, ODYD, Plan KAP48770 Kelowna, B*.C. Interior Testing Services Ltd. (ITSL) March 26, 2003.
- *Proposed Structural Fill Pumphouse, Kirschner Mountain Phase 1B*. Interior Testing Services Ltd. May 14, 2004.
- *Subdivision Development Kirschner Mountain Estates – Phase 1B and 2 Kelowna, B.C*. Interior Testing Services Ltd. May 18, 2004.
- *Daily Inspection Report No. 1 to 60. Kirschner Mt Estates Pump Station*. Agua Consulting Inc. (Agua) May 29, 2006 to October 19, 2006.
- *Proposed Pumphouse Kirschner Mountain Estates* – Phase 3. Interior Testing Services Ltd. June 6, 2006.
- *Proposed Multi-Family Development 2045 & 2062 Loseth Road, Kelowna, B.C*. Interior Testing Services Ltd. December 19, 2011.
- *Unnamed topographic plan showing pre-development contours reportedly from 2010.*

2.3 Drilling Investigation

Between August 3 and 19, 2018, thirteen bore holes were drilled using a track-mounted sonic drill rig supplied by Mud Bay Drilling. One bore hole was completed with a multidrill rig using ODEX methods.

- Bore holes BH18-01 and BH18-02 were drilled on the level area between the pump house and the slope.
- BH18-03 was drilled on the level paved area above the pump house.
- BH18-05, BH18-09, and BH18-10 were drilled along the northwest shoulder of Loseth Road;
- BH18-04, BH18-06, and BH18-08 were drilled within Loseth Road.
- BH18-11 and BH18-12 were drilled within the adjacent undeveloped lot at 2045 Loseth Road.
- BH18-13 and BH18-14 were drilled along the gravel trail midway along the slope.
- BH18-07 was eliminated because of the close proximity to underground services.

Twelve bore holes were terminated in bedrock, which ranged from 2.1 m depth in BH18-08, to 26.2 m depth in BH18-01. Two bore holes, BH18-13 and BH18-14, terminated in till at 10.7 and 8.5 m depth, respectively, without having encountered bedrock.

The sonic drill used 150 mm diameter casing to retrieve 100 mm diameter continuous core samples, logged in the field by Westrek. Selected samples were obtained for further testing, as described in Section 2.5. The soil consistency or density was determined in-situ by performing Dynamic Cone Penetration Tests (DCPTs) continuously through the fill in most of the boreholes. Standard Penetration Tests (SPTs) were conducted at 1.5 m intervals in BH18-13.

The drill rig was unable to access the base of the gully below the gravel trail; therefore, a test pit (TP18-15) was excavated instead. The test pit was dug with a Hitachi 210 excavator, provided and operated by BMID. The test pit advanced to practical refusal and terminated in till at 4.2 m depth.

The locations of the bore holes and test pit are shown on Drawing 01 in Appendix B, while the bore hole and test pit logs are included in Appendix C.

2.4 Instrumentation

Each bore hole was instrumented as summarized in Table 1 below.

Table 1: Summary of Borehole Instrumentation

Piezometer	Top of Hole Elev. (m)	Hole Depth (m)	Instrumentation
BH18-01	602.42	27.1	• Vibrating wire piezometer (#51703) • Slope inclinometer
BH18-02	602.14	18.0	• Vibrating wire piezometer (#51702) • Slope inclinometer
BH18-03	605.24	11.9	• Vibrating wire piezometer (#51704) • Slope inclinometer
BH18-04	606.29	5.8	• Vibrating wire piezometer (#51705) • Slope inclinometer
BH18-05	607.39	8.8	• Vibrating wire piezometer (#51711) • Slope inclinometer
BH18-06	607.99	5.8	• Vibrating wire piezometer (#51701) • Slope inclinometer
BH18-07	Not drilled due to underground utilities.		
BH18-08	609.4	2.1	• None
BH18-09	608.95	8.8	• Vibrating wire piezometer (#51708) • Slope inclinometer
BH18-10	611.7	5.8	• Slope inclinometer
BH18-11	610.15	14.0	• Vibrating wire piezometer (#51707) • Slope inclinometer
BH18-12	609.96	13.9	• Vibrating wire piezometer (#51709) • Slope inclinometer
BH18-13	588.96	10.7	• Vibrating wire piezometer (#51710) • Slope inclinometer
BH18-14	588.3	8.5	• None
TP18-15	573.1	4.4	• None

The piezometers are model VW2100 vibrating wire piezometers supplied by RST Instruments and all except BH18-09 are connected to a Model DT2011B single channel serial datalogger set to measure the piezometric pressure every 4 hours.

The slope inclinometers are 70 mm outside diameter PVC casing, also supplied by RST Instruments.

The initial reading of all instruments occurred on August 20, 2018 with subsequent measurements every week until October when the monitoring frequency was reduced to roughly every two weeks. The results to date are discussed in Section 6.

2.5 Laboratory Testing

A laboratory testing program was carried out to assist in characterizing the slope material and its engineering behaviour. Selected samples from the sonic bore holes and test pit were submitted for testing to Wood PLC's materials laboratory in Kamloops. The analyses carried out included fifty-six (56) moisture contents, seventeen (17) grain size distributions, including two (2) with hydrometer, and three (3) Atterberg limits.

The Atterberg limit testing yielded plasticity indices of 5.1 and 5.4 within the fill, indicating that the fines fraction (clay and silt) has low plasticity (CL-ML). The plasticity index in the colluvium in TP18-15 was 8.4%, which still classifies the soil as a CL.

The natural moisture contents of tested samples ranged from 4.2% in BH18-13 at 7.6 m depth to 21.2% in BH18-12 at 6.4 m depth.

The laboratory test results are provided in Appendix D and summarized on the bore hole logs.

3 Development History

The development history for the pump station site is summarized below based on information provided by BMID and the City; however, this information may not be complete.

- Loseth Road was constructed up to the intersection of Sunrise Court in 2004 (Loseth Road Plan Profile – as constructed).
- The pump station structural fill pad was placed and compacted up to the footing elevation from May 12 to May 21, 2004 (ITSL, May 14, 2004).
    - Specifications for the structural fill were maximum 300 mm lifts of silty sand and gravel, compacted to 95% modified Proctor dry density (ITSL, March 26, 2003).
    - A cursory review of the compaction testing results indicates the moisture content of the fill was well below optimum in several of the tests, despite having a modified Proctor result considerably higher than the target value. Given the moisture content results and variability of the fill, the validity of the Proctor Testing results are suspect and would need further review to confirm. Also, two separate Proctor values were used without explanation and the actual Proctor test results were unavailable for review.
    - It appears that compaction testing was only carried out on the structural fill beneath the building. No compaction test results were provided for the remainder of the fill pad.
    - The May 14, 2004 field memo states that "a 1H:1V splay for load spread is not practical. The existing stripped material has been stockpiled as a toe support for structural fill". It seems ITSL relied on a stockpile of stripped material to support the fillslope. The same memo states that "the slope will be graded to 1.5H:1V". Since this stockpile is no longer visible and the slope is much steeper than 1.5H:1V, either toe support was subsequently removed or it was buried within the fill as the fillslope was over-steepened.
    - Concerns regarding potential settlement of the fill, particularly if saturated, were noted in a memo from ITSL, dated May 18, 2004.

- The residence at 2001 Kloppenburg Court was constructed between 2003 and 2006. In 2006, an approximately 3 m high bench was present at the toe of the slope between the residence and the future location of the pump station (iKelowna Map Viewer).
- The pump station was constructed between June and October 2006 (Agua, 2006).
- During foundation preparation, the 2004 structural fill was exposed, and compaction testing was carried out at footing elevation. The foundation preparation was considered adequate for an allowable bearing pressure of 150 kPa (ITSL, June 6, 2006). Compaction testing results were not provided to us.
    - The field memo states that: "the existing fill slope appears well vegetated and stable at ± 1.5H:1V."
- The walking path extending from Kloppenburg Court appeared to be partially constructed in the 2009 City of Kelowna aerial photographs. No other information regarding construction of the walking trail was provided (iKelowna Map Viewer).
- Based on the City of Kelowna aerial photographs, the bench along the toe of the slope between the 2001 Kloppenburg Court residence and the pump station was removed and replaced with a stacked rock wall between 2012 and 2015 (iKelowna Map Viewer) (Figure 5). No additional information regarding this construction was provided to us.

The development history for the property at 2045 Loseth Road mainly involves placement of fill over various phases, as summarized below:

- The site was logged and much of the fill placed in summer of 2004 and November 2005. ITSL tested compaction of this material, although some of the fill placed in November 2005 was blasted rock (ITSL, December 19, 2011).
- The steep slope near the northeast end of the property was pushed out farther in 2006. The 2006 orthophoto or satellite image on iKelowna shows the slope formed by end-dumping waste soil (not rockfill) from the previous edge of slope. No compaction testing was reported during this phase of work.
    - ITSL's December 19, 2011 report post-dates this fill placements and states that the slope is stable at 1.25H:1V, but describes the slope as rockfill and does not provide any records showing that they inspected fill placement after November 2005.
- Additional filling began in 2009 closer to Loseth Road and working towards the southwest, continuing to 2017. No compaction testing was reported during this phase of work.
- The current stockpiles were placed in 2016 or 2017.

4 Site Conditions

4.1 Pump Station Area

Loseth Road climbs across the hill to the southwest while the hillslope has a northwesterly aspect. A pre-existing gully bisects the site and was completely filled in both at the pump station site and the upslope residential development. The pump station is constructed of reinforced concrete, built into a filled platform on the northwest side of the road. The asphalt paved access and the roof of the pump station are close to road grade while the filled platform steps 3 m down the slope to where the base of the pump station fully daylights (Photo 2).

The slope curves around the pump station, with both northwesterly and northerly aspects. The northwesterly slope (Figure 1, Cross-section A-A’) is more than 60 m long, with the upper 12 m sloping between 80 and 90% (39 and 42°) (Photo 1). The slope forms a 2 to 3 m wide bench as part of the back yard at 2001 Kloppenburg Court. The slope then descends another 1.5 m onto the municipal trail, which is about 3 m wide, and then descends 5 to 6 m into the remnant gully. The gully slopes at 40% for another 10 m and then flattens to 20% towards Kloppenburg Road.

Photos 1 & 2: Gravel area and slope behind the pump station.

Immediately southwest of the pump station, the crest of the slope is located at the shoulder of the road where more tension cracks were observed. The slope below is approximately 18 m high sloping at 60% (31°) down to the gravel trail (Figure 2, Cross-section B-B’).

The northerly slope (Figure 3, Cross-section C-C’) descends 13 m into the backyard of 2001 Kloppenburg Court with an overall slope of 80 to 90% (39 to 42°). The toe of the slope was excavated in 2015 to install a pond. The lower 5 m was excavated steeper than 50° and supported by a single row of stacked boulders that have since failed (Photos 3 & 4). The City did not issue a building permit for this boulder-stack wall, and the wall thickness indicates that it was not engineered.

Tension cracks have formed in the gravel-surfaced platform at the rear of the pump station (Photo 2). The tension cracks are 2 to 3 m from the slope crest and 15 cm wide, with 10 to 15 cm of vertical displacement. The slope movement is also evident by bending of the top pole in the chain-link fence around the pump house compound and displacement between fence posts.

Although the greatest movement was observed close to the slope crest, at least 3 cm of vertical displacement is evident in the ground beneath the steel stairs leading to the pump station entrance, the concrete slab near the base of the stairs is cracked, and minor settlement cracks were noted in the concrete footing for the pump station. The above-ground transformer box adjacent to the pump station is not level. More noticeably, wide tension cracks were noted along the shoulder of Loseth Road, indicating that the slope has moved more than 15 cm.

Photo 3: The toe of the slope at 2001 Kloppenburg Court.

Photo 4: Setback of the house from the slope and failure of the boulder-stack wall.

4.2 2045 Loseth Road

The slope pulls farther away from Loseth Road southwest of the pump station, where a large relatively level area has been prepared for development. The ground surface has been capped with a blanket of granular material and several stockpiles of granular fill cover the area.

Here, the ground area has been obviously filled out, creating an over-steepened slope more than 20 m high or 30 m long. The overall slope angle is 80 to 85% (39 to 40°) but the lower 20 m slopes at close to 100% (45°) (Figure 4, Cross-section D-D′). Several wide tension cracks are located at various elevations, and the lower half of the slope is bulged, indicating slope movement.

The toe of the slope flattens to between 30 and 50% leading down to Kloppenburg Road. The area is undeveloped at this time and sparsely forested with conifer trees. The trees along the toe of the slope are more densely spaced, with some fill partially burying the base of the trunks.

Photo 5: Slope at 2045 Loseth Road.

Photos 6 & 7: Open tension cracks on slope.

5 Subsurface Conditions

5.1 Loseth Road

Boreholes BH18-03 to BH18-06 are located within Loseth Road or the outside shoulder.

The subsurface conditions beneath Loseth Road generally consists of loose fill placed over bedrock. The fill is predominantly sandy silt with some clay, trace gravel, and occasional cobbles and organic debris. The SPT blow counts in BH18-03 ranged from less than 5 blows/ft to more than 20. The wide range suggests either the fill was compacted in roughly 1 m lifts or the higher blow counts may be caused by cobbles or rubble in the fill rather than by soil density. Most of the blow counts below the upper 1 m in BH18-05 were less than 10 blows/ft, indicating poor compaction. Overall, the drill results indicate that the fill beneath the road is not select granular material and was not placed in proper lifts or compacted to meet municipal specifications.

The fill was placed directly over the natural colluvium, comprised of sandy silt with some clay and gravel. The colluvium ranged from 0.6 to 1.1 m thick and overlies bedrock at depths of 3.7 to 5.5 m along the inside edge of the road, and 7.9 to 11.0 m below the outside shoulder.

5.2 Pump Station

The pump station is located over a former gully that was filled in as part of the residential development. The southwest bank seems to have been bedrock-controlled while the northeast bank was comprised of till. Topographic data indicates that up to 15 m if fill was placed within the middle of the gully. Boreholes BH18-01 to BH18-02 are located at the crest of the slope adjacent to the pump station, but straddle the middle of the gully. BH18-03 is located in the road shoulder on the southeast side of the pump station, also within the filled-in gully.

All three boreholes found a thick layer of fill predominantly comprised of silty sand to sandy silt with some clay and trace gravel. The upper 3 to 5 m is mostly loose with some compact layers below 3 to 5 m depth. The base of the fill ranges from 9.9 m deep in BH18-03 to 11.4 m in BH18-01. Essentially the entire slope is comprised of poorly compacted clay/silt/sand fill.

While BH18-03 found the fill overlying 1.1 m of colluvium and then bedrock, the fill in BH18-01 and BH18-02 overlies 1.1 to 1.6 m of weathered till and then unweathered till. The till is mostly silty sand with some clay and a trace of gravel. The till was more difficult to drill through and is, therefore, inferred to be hard/dense.

The till overlies bedrock but the bedrock surface is quite variable. While the bedrock is 11 m deep in BH18-03, it deepens to 16.2 m in BH18-02 and 26.2 m in BH18-01. Both BH18-01 and BH18-02 are approximately 3 m lower in elevation than BH18-03, further steepening the slope in the bedrock. BH18-01 and BH18-02 are just 10 m apart with a 10 m difference in the bedrock elevation, indicating a roughly 1:1 slope to the bedrock in the north to northeasterly direction.

5.3 Slope Below Pump Station

BH18-01 and BH18-02 are located at the crest of the slope, next to the pump station while BH18-13 is located at mid-slope along the trail off of Kloppenburg Court, and Test Pit TP18-15 is near the toe of the slope closer to Kloppenburg Road. All are located directly over the filled in gully.

The thick fill identified in BH18-01 and BH18-02 was also found in BH18-13. The trail is constructed over 6.2 m of loose silty sand fill. The fill becomes compact below 5 m depth and then overlies dense sandy silt till. No bedrock was found to 10.7 m depth.

TP18-15, excavated more than 65 m downslope of the pump station, found 2.5 m of fill comprised of mostly sandy silt but containing a wide range of materials including boulders and household refuse. The fill overlies a thin veneer of silt/clay colluvium and then till at 4.2 m depth. Bedrock was not encountered. Seepage entered the test pit from within the colluvium below 3.8 m depth.

5.4 Slope to Southwest of Pump Station

BH18-05 and BH18-09 were drilled along the shoulder of the road southwest of the pump station while BH18-14 is located near the toe of the steep section, adjacent to the trail off of Kloppenburg Court.

BH18-05 and BH18-09 both found 7.2 to 7.5 m of fill overlying bedrock or a thin veneer of colluvium and then bedrock. Most of the fill is the same uncompacted mixture of clay/silt/sand although BH18-09 found a layer of blasted rockfill at 3.2 m depth, within the middle of the sandy silty fill.

BH18-14, at the toe of the slope, found just 0.6 m of fill overlying till. The hole was drilled to 8.5 m depth without finding bedrock; therefore, the lower slope is not bedrock-controlled.

5.5 2045 Loseth Road

Farther southwest, BH18-11 and BH18-12 were drilled about 3 m from the edge of the over-steepened fillslope and found 11 to 12.5 m of fill directly overlying weathered bedrock. The fill in BH18-12, closer to the pump station, is the same mixture of poorly compacted (or uncompacted) clay/silt/sand, although some layers of more gravelly fill were found in the upper 5 m.

BH18-11 found a thick layer of blasted rockfill between 2.7 and 8.2 m depth, overlying loose clayey sand fill. The DCPT had some difficulty penetrating the upper 1 m of rockfill, indicating the probable presence of at least one boulder. However, the DCPT readily penetrated the coarse rockfill below 3.8 m depth, with blowcounts between 20 and 50 blows/ft. Such blowcounts in sand indicate dense soil, but in blasted rockfill, the high blowcounts are likely the result of cobble-size clasts. The DCPT should not have been able to penetrate through a well compacted rockfill, indicating that even the rockfill in this area is poorly compacted.

The lateral extent of the rockfill is not known. Construction reports by ITSL indicate that blast rockfill was placed throughout much of this area, but it was found in only one of three bore holes. Regardless, the slope is certainly not comprised of a 3 m wide rockfill blanket as identified on some past geotechnical reports.

6 Monitoring Results

6.1 Piezometers

The piezometers were installed in August, after groundwater levels had begun to subside. As a result, only two of the ten vibrating wire piezometers have measured any groundwater pressure.

The piezometric data is summarized on Table 2 below while graphs showing the piezometric pressure versus date for the two piezometers that measured water pressures are provided in Appendix E.

Table 2: Summary of Piezometric Data

Piezometer	Top of Hole Elev. (m)	Tip Depth (m)	Tip Elev. (m)	Head (m)		Piezometric Elevation (m)	
				Min. (Date)	Max. (Date)	Min.	Max.
BH18-01	602.42	13.4	589.02	0.30 (Nov 4)	0.55 (Nov 12)	589.32	589.57
BH18-02	602.14	9.4	592.74	-	-	-	-
BH18-03	605.24	9.4	595.84	-	-	-	-
BH18-04	606.29	5.2	601.09	-	-	-	-
BH18-05	607.39	5.2	602.19	-	-	-	-
BH18-06	607.99	3.5	604.49	0.29 (Sep 16)	1.41 (Nov 1)	604.78	605.90
BH18-09	608.95	6.1	602.85	-	-	-	-
BH18-11	610.15	11.9	598.25	-	-	-	-
BH18-12	609.96	10.1	599.86	-	-	-	-
BH18-13	588.96	5.5	583.46	-	-	-	-

The piezometer in BH18-06 is just 3.5 m deep and situated 0.2 m above the bedrock surface. The piezometric pressure has ranged 1.15 m, between 0.29 m and 1.41 m above the piezometer tip. The piezometer tip is shallow and location directly above the bedrock surface; as a result, the piezometer responded rapidly to precipitation. The piezometric elevation was relatively uniform while the weather was dry from mid-August to September 21, declining slightly from 605.0 m to 604.8 m. The Kelowna Airport measured 14.1 mm of rainfall on September 21 causing the piezometric pressure to rise 0.59 m in less than one day. After this initial rain, even 2 mm/day of rainfall caused groundwater pressures to increase at least 0.5 m in a single day and then drop again over about 3 days. The more frequent rainfall from October 28 to November 3 caused a total rise of more than 1.0 m in groundwater elevation to 605.9 m, dropping to 605.5 m in a single day after the rain passed.

The piezometer in BH18-01 is 10 m deeper, situated below the bottom of the thick fill. The piezometric pressure has ranged just 0.25 m, between approximately 0.30 m and 0.55 m above the piezometer tip. Some of the variability is due to rainfall but with more than 10 m of silty clayey fill, surface water infiltration into the groundwater is relatively slow, thereby muting the piezometric response. Comparing rainfall records for Kelowna Airport and the variations in piezometric pressures indicates a 5 to 10 day lag between rainfall and a rise in groundwater levels.

These two piezometers demonstrate the differences in response based on depth to bedrock and thickness of fill. The groundwater surface responds rapidly beneath Loseth Road where bedrock is shallow, while deeper bedrock and thicker silty soils downslope create a lag and dampens the magnitude of the response.

The rapid and exaggerated response in BH18-06 of roughly 0.5 m rise in groundwater pressure immediately following just a few millimetres of rainfall also suggests that shallow groundwater is concentrated in the infilled gully that crosses the site. Many of the houses upslope near the infilled gully are understood to be connected to in-ground stormwater disposal, which would also accelerate the groundwater response in the gully.

6.2 Slope Inclinometers

Noticeable slope movement occurred during the spring due to snowmelt and rainfall, but drilling did not occur until August. The base reading (to which all subsequent readings are compared) was made on August 20, during the dry season when groundwater levels had subsided. As a result, little movement has been detected by the slope inclinometers. Without definitive movement, the depth of the slip surface cannot be accurately located nor the magnitude of the landslide be determined.

Plots from the slope inclinometer (SI) measurements up to November 16, 2018 are included in Appendix E.

The SIs in BH18-01 and BH18-02 are both located in the fenced compound on the slope-side of the pump station, but they serve different purposes. BH18-02 is located on the slope-side of the tension crack, on the active landslide, where it can measure movement of the existing landslide mass. BH18-01 is located behind the tension crack, outside of the active landslide, in order to determine if the pump station is at risk.

BH18-01 has measured approximately 1 mm of movement extending down to 25 m depth but the movement is in the upslope direction, and there is equal movement across the slope (in the B-direction). The slope is only 13 m high and the base of the movement is slightly above the bedrock surface, well within the dense till. The movement cannot be caused by slope deformation and the fill has been in place too long for the movement to be caused by settlement. With just 1 mm of movement, it could be due to moisture variation in the clay till.

BH18-02 measured less than 2 mm of total movement in the downslope direction from August 20 to November 16. Up to 0.5 mm of movement occurred from 9 to 16 m depth. The base of the fill is at 10.8 m depth so most of this movement occurred within the till and is not related to slope movement. Another 1 mm of movement occurred within the fill above 9 m depth and half of that movement occurred within the upper 2 m. The movement to date is measurable but does not identify a definitive slip surface. The depth and magnitude of the landslide will likely not be measurable until spring 2019.

BH18-03 and BH18-04 measured less than 0.5 mm of movement and is more likely the result of moisture content variation in the soils.

BH18-05 measured less than 1 mm of horizontal movement down to 4 m depth, which is the base of the fill. The borehole is located in the shoulder of the road but behind the tension cracks in the fillslope below; therefore, the SI is not measuring the shallow surficial movement within the upper 2 m of the fillslope.

BH18-09 is similarly located as BH18-05 and measured less than 2 mm of horizontal movement to 8 m depth, which is the bottom of the fill. The SI is missing the surficial fillslope movement but still detecting creep extending the full depth of the fill.

BH18-11 and BH18-12 are located about 3 m back from the slope crest and, therefore, miss the surficial movement evident by the tension cracks. The SI in BH18-11 measures up to 2 mm of bending between 5 and 7.5 m depth, within the rockfill, but the movement resembles settlement rather than slope deformation. BH18-12 measures 2.5 mm of slope deformation down 5.5 m depth, combined with settlement between 3 and 5.5 m depth. The bore hole log shows loose fill at this depth.

BH18-13 is located in the trail at the base of the steep slope. It measured less than 1 mm of horizontal movement in the downslope direction with the base of the movement at 6 m depth, which is the base of the clayey sand fill. Although the movement is minor, it suggests that the landslide could extend downslope beyond BH18-13. The SI also measured 8 mm of lateral movement across the slope, peaking at 1.5 m depth, and with zero movement at the ground surface. The borehole encountered a boulder at 2 m depth and the inclinometer casing is being deformed by bending around the boulder.

Overall, the amount of landslide movement measured between August and November has been relatively minor. The landslide seems to have suspended movement seasonally, pending the next wet weather, particularly the spring snowmelt and rainfall.

7 Slope Stability Analyses

7.1 Methodology

2D limit equilibrium slope stability software (RocScience SLIDE 7.0) was used to estimate the stability of the slope under several conditions. Four cross-sections were created through the site, as shown in Figures 1 to 4. Subsurface conditions were interpolated between available borehole information and instrumentation readings.

The four cross-sections are shown on Drawing 01 and located as follows:

- Cross-section A-A′ runs northwest, directly down the former gully from the pump station.
- Cross-section B-B′ is located 21 m to the southeast of Cross-section A-A′, with a similar orientation.
- Cross-section C-C′ runs from the pump station directly northward down the slope to 2001 Kloppenburg Court.
- Cross-section D-D′ is located on the slope below BH18-12, at 2045 Loseth Road.

The soil strength properties were estimated based on the in-situ test results from the SPTs and DCPTs. The soil properties used in the analyses are summarized in Table 1:

Table 3: Summary of Estimated Soil Strength Parameters

Soil Unit	Bulk Density (kN/m^3)	Cohesion (kPa)	Friction Angle (°)
Fill (N<10)	18	3	27
Fill (N>10)	19	3	29
Weathered Till	20	0	35
Clay Till	21	20	35
Toe Buttress (Engineered)	21	0	38
Angular Rock Fill	21	0	39

The slopes were modeled under various conditions to assess the present stability, causes of the instability, and design of possible mitigation measures.

7.1.1 Existing Conditions

The existing slope configuration was modeled using the measured piezometric pressures to test the soil parameters. Conditions were adjusted slightly to ensure the factor of safety was greater than 1.0 to reflect the existing conditions where the slope is marginally stable. Groundwater pressures were then raised by 2 m to represent anticipated peak groundwater conditions.

7.1.2 Causal Analyses

Section C-C′ was first modeled with the apparent original slope configuration and then with the existing excavation at the toe, in order to assess the effects of the excavation on slope stability.

7.1.3 Mitigation

To assess various mitigation measures to improve slope stability, Cross-sections A-A′ and C-C′ were analyzed under the following scenarios:

a. Existing topography – as the base case.
b. Various configurations of toe buttresses and flattened slope angles.
c. With various spacings and types of soil nails.

Cross-section B-B′ was also analyzed under Scenario (a) and (b), but not (c) (the soil nails).

Cross-section D-D′ was analyzed under existing slope conditions and various flattened slopes.

All cases were analyzed with the piezometric level 2 m higher than measured to account for the estimated spring conditions.

The mitigation options using soil nails and Tecco mesh were also analyzed using Geobrugg’s Ruvolum design software; however, this software only considered surficial slope movement up to 2.5 m deep.

7.2 Results

The results of the slope stability analyses are summarized on Table 3. The calculated factor of safety and the relative change in factor of safety from the base condition are both given. A slight change in the soil strength parameters can affect the absolute factor of safety but should have little impact on the relative change in factor of safety; therefore, the relative change in factor of safety is the better measurement of the effectiveness of the various mitigation measures.

The analysis concludes that the entire slope is just marginally stable under current conditions and can be destabilized by even a modest rise in groundwater pressures, which likely occurs each spring.

The toe excavation along Cross-section C-C′ in 2015 reduced the factor of safety by 9%, which would be enough to destabilize a marginally stable slope. There is insufficient topographic data to determine the extent of the excavation along Cross-section A-A′ or to analyze the impact on slope stability.

With respect to mitigation, a minimum factor of safety of 1.3 should be the objective for long-term stability. Where this is difficult to achieve, the higher the relative increase in factor of safety should provide greater assurance. Even an increase in factor of safety of 0.1 (or 10%) should significantly reduce slope movement while an increase of 0.2 (or 20%) should halt movement under most circumstances.

The results of the stability analysis with respect to existing conditions are discussed further in Section 8 while the results with respect to mitigation options are discussed in Section 10.

Table 3: Summary of Slope Stability Results

	Condition	Factor-of-Safety	Increase
Cross-section A-A’	Existing Conditions	1.00	-
	Existing slope configuration - piezometric level +2 m (Base Case)	0.99	-
	Toe Berm - 1.5H:1V Rockfill slope 2H:1V upper slope	1.05	+0.05
	Toe Buttress - two-tiered GRS wall	1.20	+0.21
	Toe Buttress - GRS with 2H:1V Slope	1.13	+0.13
	Toe Buttress - GRS wall with 1.5H:1V engineered slope. Mid-slope bench with 2H:1V upper slope.	1.14	+0.15
	Soil Nails and Tecco Mesh	1.39	+0.40
	Trim upper slope to flatten to 33° slope	1.07	+0.08
	Trim + fill to flatten to 28° slope	1.02	+0.02
Cross-section B-B’	Existing Conditions	1.04	-
	Existing slope configuration - piezometric level +2 m (Base Case)	1.03	-
	2H:1V Slope	1.18	+0.15
	1.5H:1V Toe Berm with 2H:1V Slope Above	1.30	+0.27
Cross-section C-C’	Pre-2016 Slope	1.16	-
	Existing slope configuration	1.07	-
	Existing slope configuration - piezometric level +2 m (Base Case)	1.07	-
	Rockfill Toe Buttress	1.28	+0.21
	GRS Toe Buttress	1.48	+0.41
	Soil Nails and Tecco Mesh R51N hollow core soil nails 6 m long @3.6 m spacing	1.56	+0.49
Cross-section D-D’	Existing Conditions	0.88	-
	Existing slope configuration - piezometric level +2 m (Base Case)	0.88	-
	Pullback to 30° (1.75H:1V) slope	1.14	+0.26
	Pullback to 27° (2H:1V) slope	1.23	+0.35
	Pullback to 25° (to existing ditch)	1.24	+0.36
	Re-build fill with 27° (2H:1V) slope	1.36	+0.48

8 Discussion of Results

8.1 Original Construction

8.1.1 Pump Station

Understanding of the technical causes of the slope instability is necessary to analyze mitigation measures. This analysis does not attribute blame or responsibility for the slope failure but merely the apparent factors that destabilized the slope. To assess responsibility, further review of the development history of this site would be needed, with more thorough construction records.

The in-situ SPT and DCPT data indicates that the fill beneath the slope and the roadway was poorly compacted during site grading for the subdivision. Almost the entire 15 m high embankment is comprised of non-select fill that is poorly compacted. The fill is a mixture of clay, silt and sand, which drains poorly compared to clean granular soils, retains moisture, and softens when wet. The fill has a low shear strength and is prone to settlement under an increase in load, and susceptible to slope movement.

This loose fill was found in all bore holes, including those along the crest of the slope and within Loseth Road; however, no bore holes were drilled within or immediately adjacent to the pump station. ITSL claims the fill beneath the pump station was compacted in lifts; however, compaction test reports indicate that only the fill directly within the building footprint was tested. ITSL admitted that a 1:1 splay beneath the footings was not possible and the fillslope abutted a loose stockpile of soil stripped from the site. Whether this loose stockpile was later incorporated into the fillslope is unknown, but the records seem to confirm that the soil within the fillslope was not placed in lifts and properly compacted.

Significant settlement likely occurred during and immediately after construction, merely under the weight of the fill itself, but the settlement would have been fairly uniform. The embankment was constructed long before the pump station; therefore, the primary settlement occurred before the pump station was in place.

The existing slope angles below the pump station are close to 1.1H:1V, too steep for well compacted granular fill, and far too steep for poorly compacted clay/silt/sand fill. Even if the fill was well compacted, the slope angles should not have been any steeper than 2H:1V. These slopes were all constructed much too steep and without adequate compaction or engineering.

This combination of unfavourable conditions creates the potential for a landslide in the fill and, considering the thickness of the fill, such failures could be fairly deep. The slope was just marginally stable when originally constructed circa 2006.

8.1.2 Adjacent Slope to Southwest

The slope southwest of the pump station easement flattens slightly near BH18-05 and BH18-09. While this slope is also just marginally stable, as evident by the tension cracks in the shoulder of the road, and the slight movement in the slope inclinometers, the slope is not as steep as the others and the factor of safety is slightly above 1.0. This slope is less likely to fail than the others and is more readily stabilized.

8.1.3 2045 Loseth Road

The development history raises several discrepancies between the construction records and the bore hole results. Based on the number of compaction tests and the apparent frequency of testing, it seems the fill was placed in 0.5 to 1 m thick lefts, but was still compacted and partly tested; however, the area of fill placement was not well documented. Most of the fill placement occurred in July to August 2004, up to 2 m below what was assumed to be final grade, although there is no elevation given or confirmation that the final development grade is the same as the existing grade. Fill placement resumed in the summer of 2005 but only a few compaction test results from November 2005 were included in the ITSL summary report (December 19, 2011). Some of the fill was reportedly blasted rockfill, but records do not indicate the lift thickness or method of compaction. The final fill placed in 2005 is referred to as "sand and gravel" but the only compaction tests provided are on the "final grade".

Substantial fill was placed at the north end of the property in 2006, including the locations of both BH18-11 and BH18-12; the previous crest was roughly 7 m southwest of BH18-11 (Google Earth). Some fill had previously been placed in this area but the grade was raised significantly in 2006. No records of inspections or testing were provided for the fill placed in 2006; therefore, this fill does not seem to have been compacted or tested.

Discrepancies regarding the slope angle and composition are apparent in the ITSL documents. The slopes were initially designed or intended to be 1.5H:1V (67% or 34°), with the houses set back behind a 2H:1V projection up from the toe of the slope. Later documents acknowledge that the slope is actually 1.25H:1V (80% or 39°) but is said to be comprised of blast rock fill for the outer 3 m of the fillslope (ITSL, December 19, 2011). This fill is referred to as "structural fill" implying that it was compacted, despite the fact that the fill was placed after the compaction tests in 2004 and 2005.

The actual slope at the north end of the property (Cross-section D-D') is 1.25H:1V overall but the lower 15 to 20 m of the slope is close to 1:1. The bore hole logs show that only a portion of the slope is comprised of blasted rock fill, which was not well compacted. Most of the fill is gravelly sand with a relatively high silt and clay content. The open tension cracks on the slope expose this same material, indicating that the outer 3 m of fill was not constructed of blasted rock fill, as stated, as was not well compacted.

This filled slope near BH18-11 and BH18-12 is highly over-steepened with a factor of safety less than 1.0 under normal conditions. The number of tension cracks and their widths support a factor of safety less than 1.0 and the slope is considered to be unstable.

The slope was constructed in this manner in 2006 and likely showed signs of movement for several years. The weight of the stockpiles added in the past two years would have further reduced stability, but the slope is simply far too steep for the loose, poor quality fill. The cause of this slope movement is simply poor construction.

8.2 Groundwater

Shallow groundwater levels typically peak in the spring, shortly after snowmelt; therefore, the increased slope movement during spring 2018 suggests that the movement is related to groundwater pressures. Groundwater levels would have also risen during each preceding spring, so slope movement would have been expected during each spring and possibly even after heavy rainfall any time of the year.

The slope at the north end of 2045 Loseth Road has several, extensive tension cracks and a large toe bulge, indicating that movement has been occurring for several years. As such, the over-steepened slope, poor soil conditions, and seasonal rise in groundwater levels may fully account for the movement on this slope.

The wide tension crack in the gravel yard behind the pump station and the bending of the fence reportedly initiated within the last few years. Some movement may have occurred earlier but gone unnoticed, but the movement seems to have at least accelerated over the past few years, with the most movement occurring in spring 2018. Higher than normal snow levels on Kirschner Mountain or higher than normal rainfall during spring 2018 could account for higher than normal groundwater levels; however, Environment Canada’s weather data from the weather stations near Kelowna do not indicate such conditions. Therefore, with respect to the slope below the pump station, groundwater pressures seem to be a factor in stability of this slope, but the increased movement over the past few years must have another causal factor.

BMID reportedly pressure-tested the water mains and the City of Kelowna also checked their utilities in the vicinity of the site to confirm that they are not leaking, eliminating another potential source of additional groundwater.

8.3 Recent Changes to Slope

The toe of the slope at 2001 Kloppenburg Court was excavated in 2015 to install a small pond; a comparison of the 2012 and 2015 satellite images for the slope is provided in Figure 5. The excavation for the pond appears to have cut roughly 4 m into the toe of the bank, over-steepening the lower slope, removing toe support, and reducing the factor of safety by approximately 0.09. The timing of this excavation aligns with the reported initiation or acceleration of slope movement 2 to 3 years ago. This marginally stable slope became unstable and the movement in the northerly direction seems to have been directly caused by this toe excavation.

The base of the northwesterly slope was also altered in 2015 but it is less clear how much ground was excavated to create the landscaped panhandle between the toe of the steep slope and the trail. Prior to 2015, the slope between the pump station and the trail was fairly uniform. The landscaped panhandle is a level grassed area created by a combination of cut and fill. The amount of cut cannot be determined from the available information; therefore, the impact on slope stability is less certain.

9 Landslide Hazards & Risks

The probability of a landslide occurring has been rated based on both the slope stability analysis and the site observations. The criteria used for the probability ratings are provided in Table 4.

Table 4: Qualitative Landslide Probability Rating Criteria

Landslide Probability **P(H)** **Under Static Conditions**	**Rating**	**Criteria**
	Low	Factor of Safety > 1.3 under seasonal high groundwater conditions. No signs of slope movement or past landslides on the slopes below the property.
	Moderate	Factor of Safety between 1.1 and 1.3 under seasonal high groundwater conditions. Possibly signs of minor or small-scale slope movement but no signs of significant slope movement or past landslides.
	High	Factor of Safety < 1.1 under seasonal high groundwater conditions. Signs of significant slope movement or past landslides.
	Very High	Factor of Safety </= 1.0 under seasonal high groundwater conditions. Signs of significant slope movement or past landslides.
	Imminent	Factor of Safety < 1.0 under current groundwater conditions. Signs of significant active slope movement.

9.1 Pump Station

The soils directly beneath the pump station could not be investigated; however, compaction test results indicate that the fill beneath the pump station was compacted in lifts and, therefore, should be much denser than the loose fill found in BH18-01 and BH18-02. The slope stability model included better compaction of the fill beneath the pump station, which affects the results. Therefore, this analysis is predicated on compaction of the fill beneath the pump station. Still, the factor of safety with respect to a slope failure capable of directly reaching the pump station is less than 1.1, meaning the probability of a landslide affecting the pump station is high.

BH18-01 was located behind the tension crack to allow the slope inclinometer to measure any retrogression of the landslide that could pose a hazard to the pump station. It has not measured any movement since installation in August. BH18-02 is located on the slope-side of the tension crack, but has measured less than 1.5 mm of total movement, with less movement at depth. The SIs have not yet detected the actual slip surface; however, at this time, the slope movement does not appear to pose a direct hazard to the pump station. If the slope fails, the fence and part of the level platform behind the pump station would be lost, but the pump station should remain intact.

The pump station is at risk of settlement resulting from a slope failure. Significant settlement typically occurs behind the landslide headscarp, which could affect the concrete sidewalk at the entrance to the pump station, and possibly even the northwest wall of the building. Settlement resulting from a slope failure would be differential with greater movement along the northwest side of the building. The effects on the water infrastructure depend on the sensitivity of the pump facilities and are best analyzed by the City of Kelowna's or BMID's engineers.

9.2 Below the Pump Station

Both the north and northwest aspect slopes have a high to very high probability of failure. The thin rock wall at the toe has already failed but the greater hazard is a landslide extending from the crest of the fillslope near BH18-01 or BH18-02. Such a failure would likely be 10 to 12 m wide by 2 to 4 m thick, with a volume in the order of 500 m^3. The potential exists for deeper landslides, which would increase the volume. A longer landslide depletion zone is also possible in the northwest direction, creating a landslide volume exceeding 1,000 m^3.

The potential impacts of the landslide depend on the landslide runout, which can be influenced by several factors, most notably, the landslide volume and the fluidity or rheological properties of the slide debris. A simple means of estimating landslide runout is to predict the "angle of reach", measured from the crest of the slope to the toe of the runout. Based on the predicted landslide volume, the angle of reach could range from 17° to 27°. The gradation of the fill material and the fines content indicates that the fillslope is capable of static liquefaction and flow sliding, although most of the slope is above the groundwater table. A more likely range for the angle of reach is between 20° and 24°, which would yield the anticipated maximum and minimum landslide runout zones shown on Drawing 02.

With less than 7 m from the toe of the slope to the house at 2001 Kloppenburg Court, the predicted landslide runout would reach the middle of the house. Even a small slide on the north aspect slope would impact the house with sufficient force to cause both cosmetic and structural damage. Occupants of the adjacent rooms of the house would be at risk of serious harm.

A slide on the northwest aspect slope would overwhelm the gravel trail and possibly reach Kloppenburg Road. Based on the predicted angle of reach, the minimum runout distance would be within 10 m of the road while the maximum predicted runout could reach the far side of the road, where some mud could even enter the driveways on the opposite side and reach the houses. The main element at risk would be users on the trail at the time of the slide.

The probability of a landslide occurring is very high, but with little movement measured since August, the potential landslide is not considered to be imminent (as defined on Table 4). A rise in groundwater pressures in the spring could destabilize the slope fairly quickly, increasing the hazard rating from very high to imminent. The only noticeable signs of a pending landslide may be widening of the tension crack and movement measured in the slope inclinometers; however, there could be no warning if the movement occurs between readings.

Once the hazard is deemed imminent, the house at 2001 Kloppenburg Court should be evacuated and the adjacent trail closed. An evacuation order would restrict the mitigation options due to worker safety; therefore, delaying mitigation until the landslide becomes imminent can be problematic.

9.3 Adjacent Slope to Southwest

The slope on this adjacent property is steeper and has more tension cracks indicating greater movement to date and a very high probability of a landslide. The current rate measured in BH18-12 is approximately 1 mm/month, which does not suggest an imminent hazard at this time.

However, a rapid slope failure must be considered imminent each spring and possibly whenever heavy rainfall occurs.

The tension cracks are currently limited to the slope, although there are signs of settlement behind the slope crest. The most likely scenario would be a landslide 12 to 15 m wide by 2 to 3 m deep, with a volume in the order of 1,000 m^3; however, the potential exists for a much larger landslide.

The potential landslide would easily reach the gravel trail below; at present there are no houses between the trail and Kloppenburg Road. Using an angle of reach between 20 and 24°, the potential landslide would easily reach Kloppenburg Road and could directly impact on the houses opposite.

10 Mitigation Measures

The main mitigation measures considered for this project are:

i. Flattening the slope by pulling back or excavating the upper slope. This reduces the weight of soil in the upper part of the slope, thereby reducing the driving forces causing landslide movement.
ii. Constructing a toe buttress near the base of the slope, and flattening the slope above. This option increases the resisting forces supporting the slope.
iii. Reinforcing the unstable soil mass using soil nails and Tecco mesh.

Drainage measures were not considered at this stage because piezometric pressures are not high enough to achieve sufficient benefit from drainage and the groundwater table is expected to rise only 1 to 2 m over the till surface. Intercepting groundwater using horizontal drains would be challenging. Also, the benefits of drainage would be minor because the slope is over-steepened and just marginally stable without the seasonal rise in groundwater.

10.1 North Slope Below Pump Station

10.1.1 Toe Buttress

The most cost-effective means of stabilizing the north aspect slope would be to construct a toe buttress to replace the material excavated from the toe of the slope in 2015. The original fill slope was already too steep prior to excavation; therefore, the buttressed slope should be flattened to 2H:1V (27°). With between 5.3 and 7 m between the house and the toe of slope, the toe buttress must be constructed of either coarse blast rock or a geosynthetic reinforced soil (GRS) wall. Both options will reduce the distance between the toe of slope and the house.

A rockfill buttress, shown on Figure 6, would increase the factor of safety to 1.3, which should be considered the minimum tolerable factor of safety. The toe buttress base should be roughly 5 m wide, leaving less than 2 m between the toe of the buttress and the house. Since the lower 4 m of the buttress would be steepened to 1H:1V, rolling boulders could still pose a hazard. This hazard could be reduced by ensuring each surface boulder is well interlocked or by grouting or concreting the surface layer of rock.

A 3 m high GRS toe buttress wall, shown on Figure 7, should improve the factor of safety to almost 1.5 simply because of the geotextile reinforcement layers. A GRS wall would increase the setback from the house to 3 m and would eliminate the hazard of loose boulders rolling down the slope.

10.1.2 Soil Nail & Mesh

A third option is to heavily reinforce the slope using soil nails and steel mesh, as shown on Figure 8. The analysis indicates that the following conceptual design should provide a factor of safety greater than 1.4.

- IBO R51N soil nails 8 m long, installed at an angle of 20° below horizontal, in a diamond pattern at a spacing of 2.5 m.
- Tecco Mesh G65/4, galvanized, with P66 plates.

The soil nail and mesh option will be much more costly than either buttress option but would preserve most of the slope in its current configuration. The failed toe would have to be reconstructed but should have just a minor impact on the spacing from the house to the slope.

10.2 Northwest Slope Below Pump Station

The same two options are also available for the northwest slope below the pump station; however, the thick fill within this former gully creates the potential for deeper and longer landslides, which affects the design of both the buttress and soil nails.

10.2.1 Toe Buttress

With 6 m of poorly compacted clay/silt/sand fill beneath the trail, a buttress constructed on the trail bench would increase the factor of safety just marginally because the slip surface can extend beneath the trail and into the gully below. The buttress must extend more than 20 m downslope of the trail, requiring significant earthworks. The buttress would also have to be excavated through the existing fill, which is 2.5 m thick in TP18-15, to bear directly on till.

A simple rockfill buttress constructed with a slope of 1.5H:1V (34°) is not thick enough and would only improve the factor of safety to 1.05 (from 1.00).

Constructing a 5.1 m high GRS buttress wall at the bottom of the slope and a 2H:1V slope for the full height up to the pump station would increase the factor of safety to 1.13. Steepening the lower slope above the GRS wall in order to allow the trail to be reconstructed at mid-slope results in a factor of safety of 1.14 and is shown on Figure 9.

The costs of fill placement across the upper slope could be reduced by constructing a shorter GRS wall at the crest, just outside of the current fence line surrounding the pump station. This option increases the factor of safety to 1.20 and is shown on Figure 10. This upper GRS wall would be founded on loose fill and, therefore, prone to future settlement. However, GRS walls with a flexible welded-wire facing are able to accommodate greater settlement than structural walls.

While none of the buttress options are able to reach a factor of safety greater than 1.2, they should be adequate to significantly reduce, if not halt, the slope movement. The factor of safety would not reach acceptable standards of stability for new construction, but may be acceptable for stabilization of an existing landslide.

10.2.2 Soil Nail & Mesh

Reinforcing the slope with soil nails and mesh requires longer soil nails and a tighter spacing than on the north-facing slope because of the length of slope and thickness of fill. The analysis indicates that the following conceptual design, shown on Figure 11, should provide a factor of safety greater than 1.3.

- IBO R51N soil nails 14 to 16 m long, installed at an angle of 20° below horizontal, in a diamond pattern at a spacing of 2.3 m.
- Tecco Mesh G65/4, galvanized, with P66 plates.

A factor of safety of 1.3 for the soil nail and mesh option does not imply that it is more stable than the factor of safety of 1.2 for the toe buttress option. The soil nail design carries greater uncertainties, particularly with respect to the grout penetration and bond within the fill, which could significantly affect stability. Therefore, the soil nail and mesh option warrants a higher factor of safety than the toe buttress option.

10.2.3 Pullback Options

Another option to flatten the slope would be to trim or pullback the upper slope 4 to 5 m from the existing crest to the edge of the concrete sidewalk at the entrance to the pump station. The slope could be flattened from its current 39° to 42° to approximately 33° or 1.5H:1V. This pullback would remove the fill that is currently failing, thereby preventing the development of an imminent hazard. The factor of safety with respect to deep-seated failure capable of impacting on the pump station, would increase 8% to 1.07, as shown on Figure 12.

The pullback is suitable for mitigating the imminent and short-term stability because it would be the quickest and least costly mitigation measure. The pullback also allows greater flexibility with respect to construction of a toe buttress without destabilizing the upper slope. The disadvantage of the pullback option is that the vehicular access to the back door of the pump station would be lost, although pedestrian access via the metal stairway would be maintained.

A work procedure and logistics, such as excavator access, truck access, whether the excavator bails material to the bottom of the slope or benches down from the top, must still be resolved.

The long-term objective should be a higher factor of safety closer to 1.2 plus equipment access to the back of the pump station. This pullback would be a necessary step in constructing the upper GRS wall and, therefore, could be used as a short-term solution prior to constructing the GRS buttress and upper wall option in Figure 10.

10.3 Adjacent Slope to Southwest

10.3.1 Toe Buttress

The slight draw in the slope immediately south of the pump station is not as steep as the adjacent slopes and can be readily stabilized by supporting the lower slope, just upslope of the trail. This draw will be partially filled as part of the mitigation along Cross-section A-A’, flattening the slope to 2H:V. Placing fill upslope of the trail would increase the factor of safety to 1.18, as shown on Figure 13. Adding a larger toe buttress near the trail alignment, as shown on Figure 14, would increase the factor of safety to 1.30, but the grades will depend on the final grades along Cross-section A-A′ .

Mitigating the hazard along Cross-section B-B′ should be relatively easy. By comparison, the large fill area to the southwest (Cross-section D-D′) will require much greater effort to stabilize.

A toe buttress at Cross-section D-D′ is not viable because the toe of the slope is right along property line and the slope is already over-steepened and unstable. The height and width of the toe buttress wall would require significant excavation into the slope, which would pose serious short-term hazards during construction. Essentially, the slope would have to be deconstructed from the top prior to constructing the toe buttress, which would result in almost complete reconstruction of the slope.

10.3.2 Soil Nails & Mesh

The large fillslope on the development site can be mitigated using soil nails and mesh, but the costs would be prohibitive considering that the land above is currently undeveloped.

10.3.3 Flatten the Slope

Since the property is still vacant, the easiest means of mitigating the slope hazard is to flatten it by excavating the crest back. Given the height of the slope, this requires more than a simple pullback or trimming; excavators will have to work the crest of the slope down in benches.

Flattening the slope to 1.75H:1V (30°) by trimming the crest of the slope back 9 m at Cross-section D-D′, would increase the factor of safety to approximately 1.14 as shown on Figure 15. This level of stability would not be adequate for future residential development but should be adequate to prevent an imminent hazard from developing. This work should not be delayed until an imminent hazard develops because, at that time, the slope will be too unstable to safely allow equipment and trucks to operate.

Flattening the slope to an overall 2H:1V would trim the crest back 15 m but still only achieve a factor of safety of 1.23. If the property is to be developed for residential use, the poorly compacted fill should be completely removed and replaced in maximum 300 mm thick lifts, compacted to a minimum 95% standard Proctor density. The extent of the excavation will depend on if or where the structural fill that was reportedly placed and compacted in lifts is encountered. Encountering the blast rockfill would be even better, provided it was properly placed and compacted.

If the existing fill with a high fines content is to be used as an engineered fill, a drainage layer should be placed near the bottom of the fill and then at least every 5 m of fill height. This drainage layer should be comprised of free-draining granular material to prevent the build-up of groundwater pressures in the fill. Even if properly compacted and drained, the existing clay/silt/sand fill should be sloped no steeper than 2H:1V. Any steeper of a slope will require additional stabilization measures, such as GRS walls.

11 Recommendations

A detailed site survey is required prior to preliminary design of the mitigation measures and cost estimations. This survey should proceed immediately.

Preliminary cost estimates will depend on the preliminary designs; however, the soil nail option will invariably be the most expensive. This option is attractive if the land required to flatten the slope and construct the toe buttresses is unavailable or if the property owners are willing to pay the cost premium associated with the soil nail option. Otherwise, the recommended mitigation works include the following:

i. Construct a 3 m high GRS toe buttress wall at the base of the slope on 2001 Kloppenburg Court and then flatten the slope above to 2H:1V (see Figure 7). This work should proceed immediately due to the risks to the occupants of the house below.

ii. Flatten the northwest aspect slope at the rear of the pump house by pulling back the upper slope to 1.5H:1V as a temporary measure. This work should proceed before spring to mitigate the imminent hazard that is expected to develop.

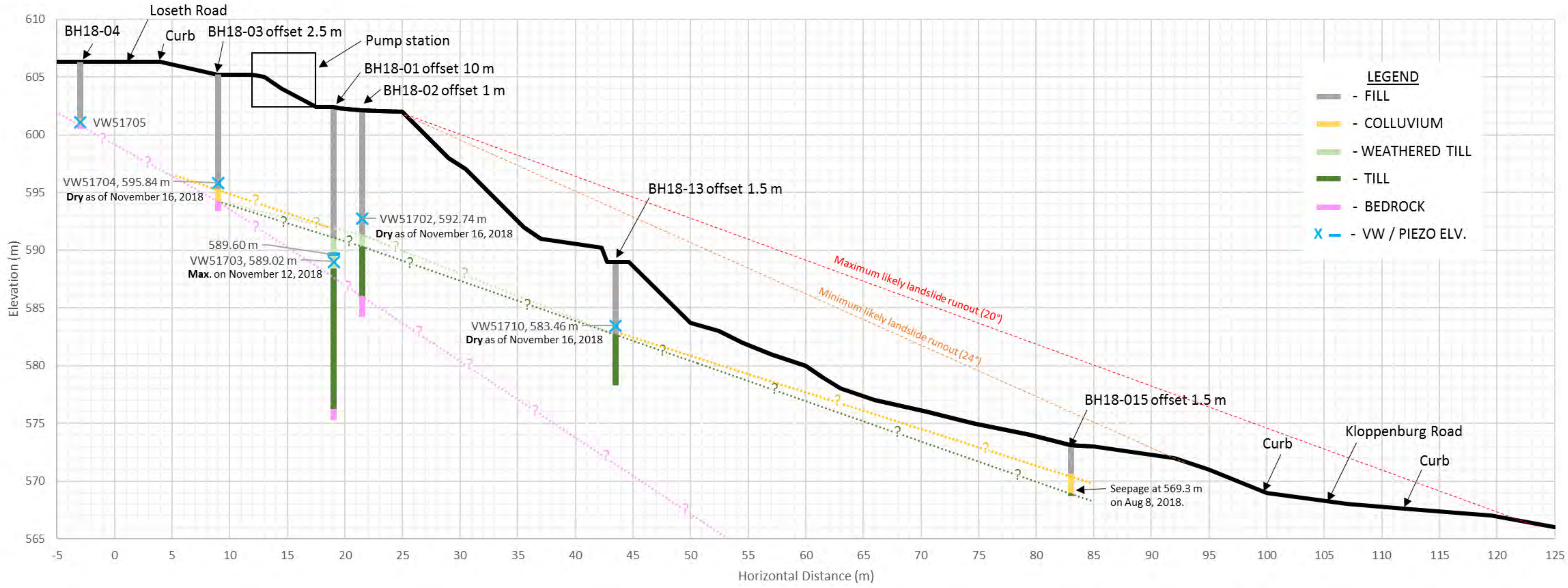
iii. A large GRS toe buttress wall should be constructed at the base of the slope, below the trail, and the slope flattened as shown on Figure 10.

iv. The upper slope at the rear of the pump house can then be reconstructed by supporting the upper slope behind a second GRS wall, also shown on Figure 10.

v. The large fillslope at 2045 Loseth Road should be flattened to no steeper than 1.75H:1V as part of the short-term mitigation measures. Considering the magnitude and effort of the earthworks required to flatten the slope, the property owners may choose to flatten the slope even farther to 2H:1V for long-term stability, depending on their development plans. However, a 1.75H:1V slope is considered the maximum slope angle that should be permitted by the City for the safety of those downslope.

12 Limitations

All of the analysis is based on preliminary cross-sections created using the available topographic data. The recommended slope angles, setbacks, wall heights, etc. are all dependent on these cross-sections and topographic data. A more accurate survey of the topography is needed prior to final design, which could affect the final wall heights, setbacks, and slope angles.



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Scale 1:350

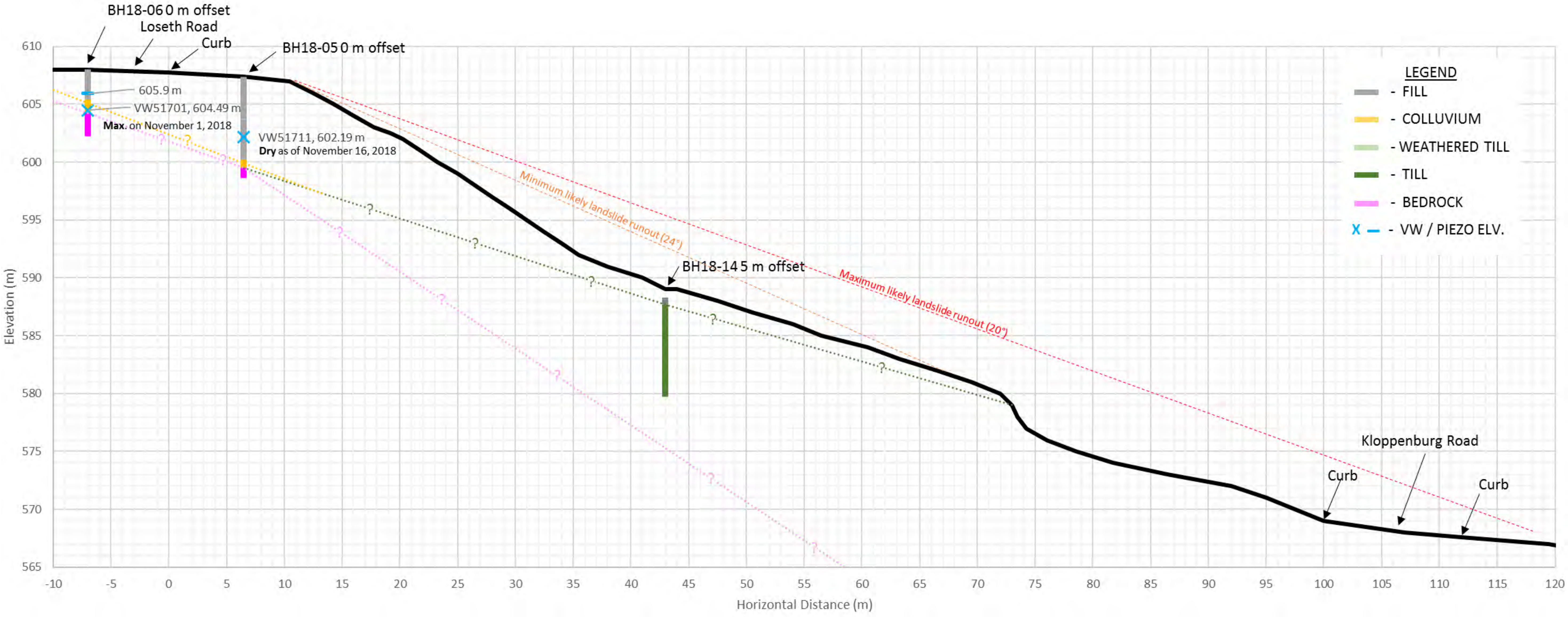
December 19, 2018

Project: 018-253

2045 LOSETH ROAD PUMP STATION

CROSS-SECTION A-A'

FIGURE 1



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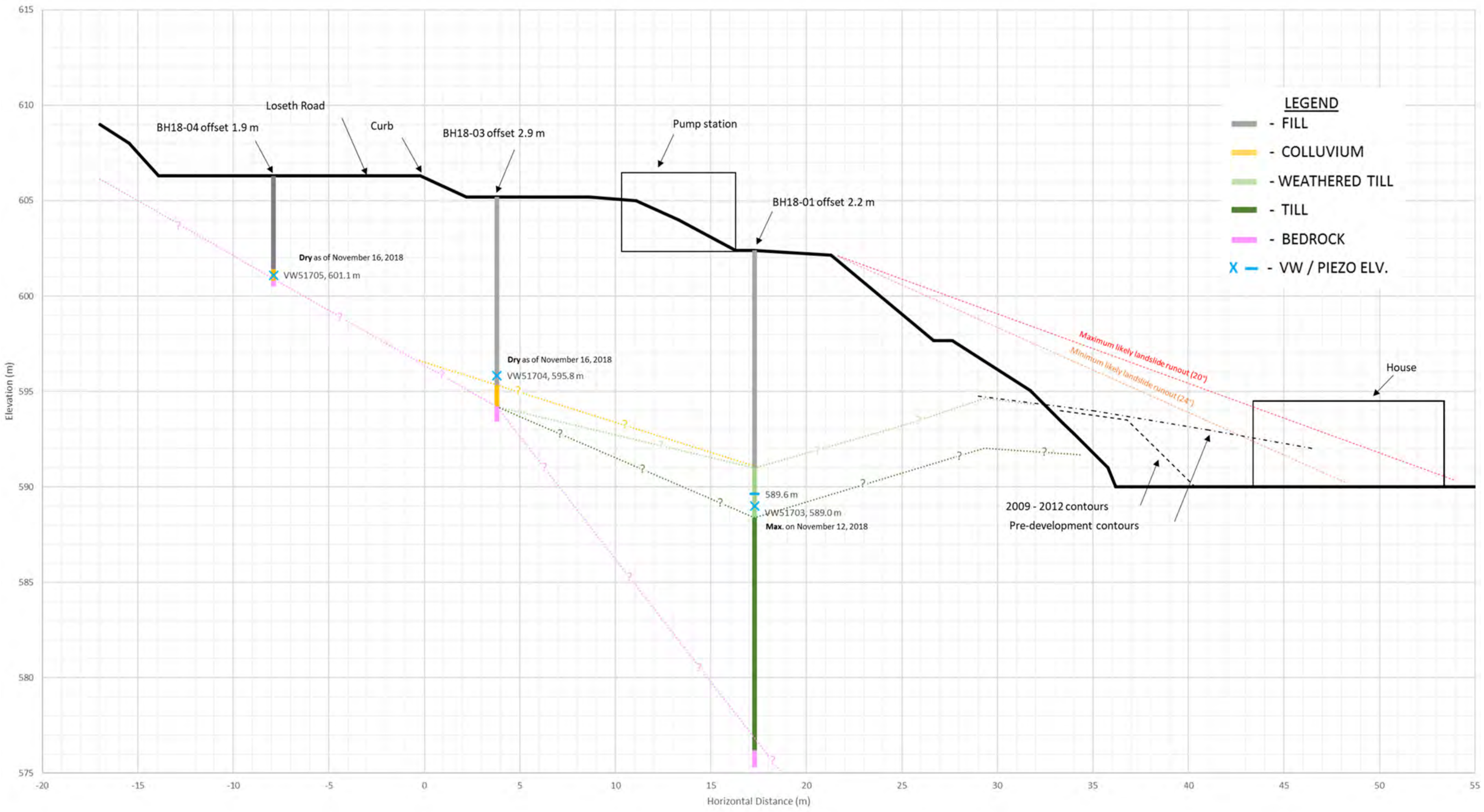
2045 LOSETH ROAD PUMP STATION

CROSS-SECTION B-B'

FIGURE 2



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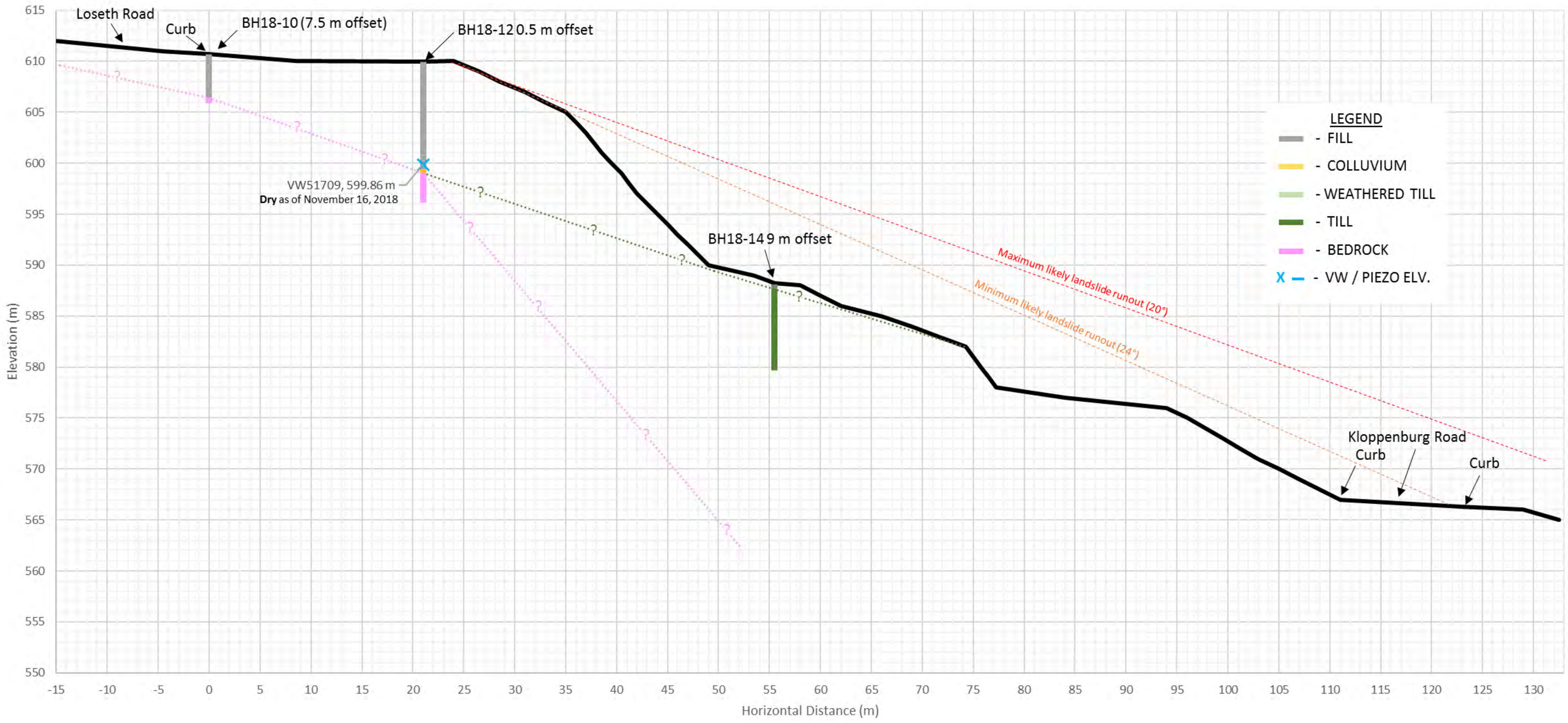
2045 LOSETH ROAD PUMP STATION

CROSS-SECTION C-C'

FIGURE 3



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2045 LOSETH ROAD PUMP STATION
CROSS-SECTION D-D’

FIGURE 4

2012 satellite image of slope below the pump station.

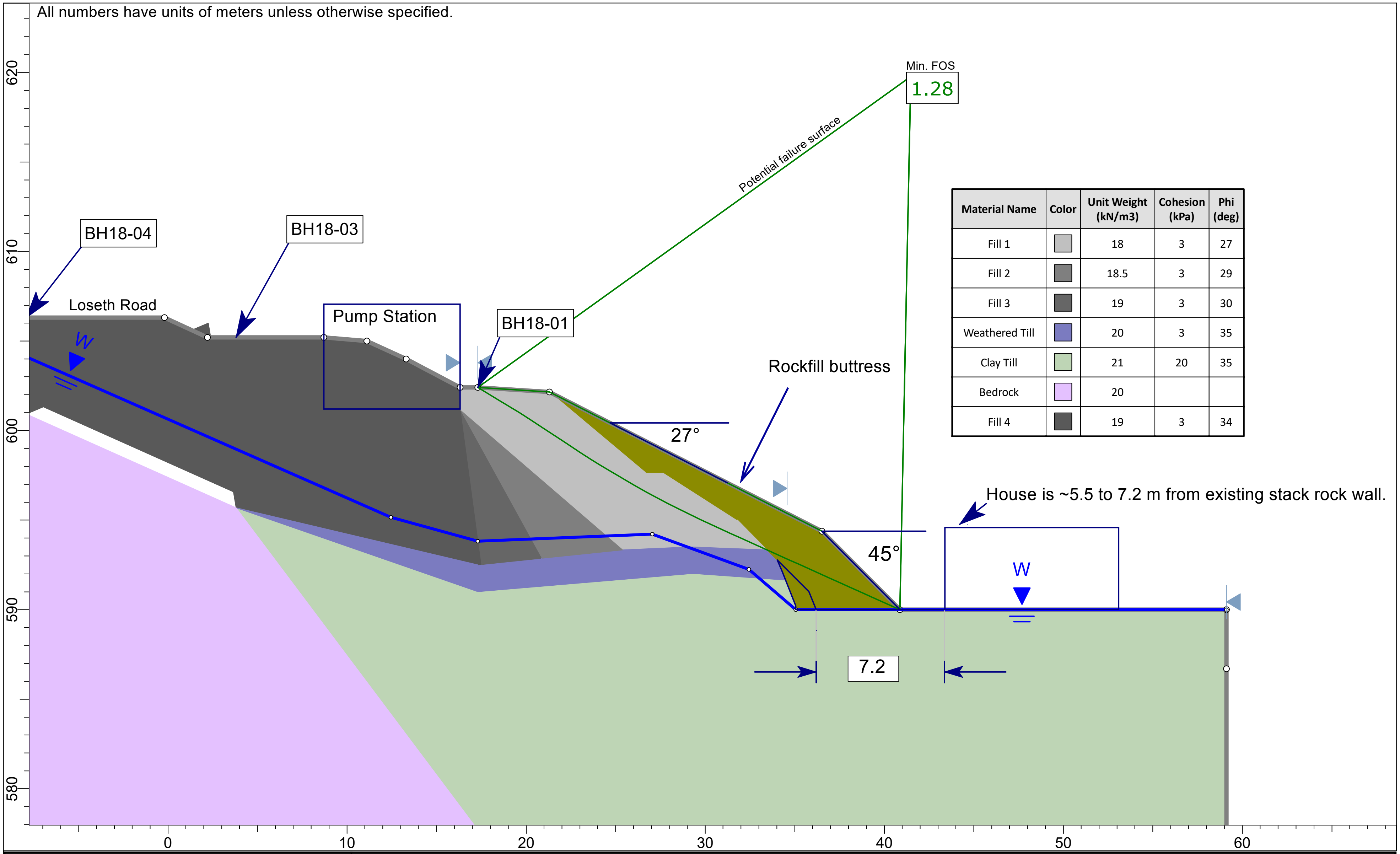
2015 satellite image of slope below the pump station.

N

Satellite images from iKelowna map website.

westrek geotechnical services ltd.	**Comparison of the Slope in 2012 and 2015 2045 Loseth Road Pump Station**	City of Kelowna December 14, 2018 Project: 018-253	**FIGURE 5**

All numbers have units of meters unless otherwise specified.



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	⬜	18	3	27
Fill 2	▨	18.5	3	29
Fill 3	⬛	19	3	30
Weathered Till	🟦	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	⬛	19	3	34

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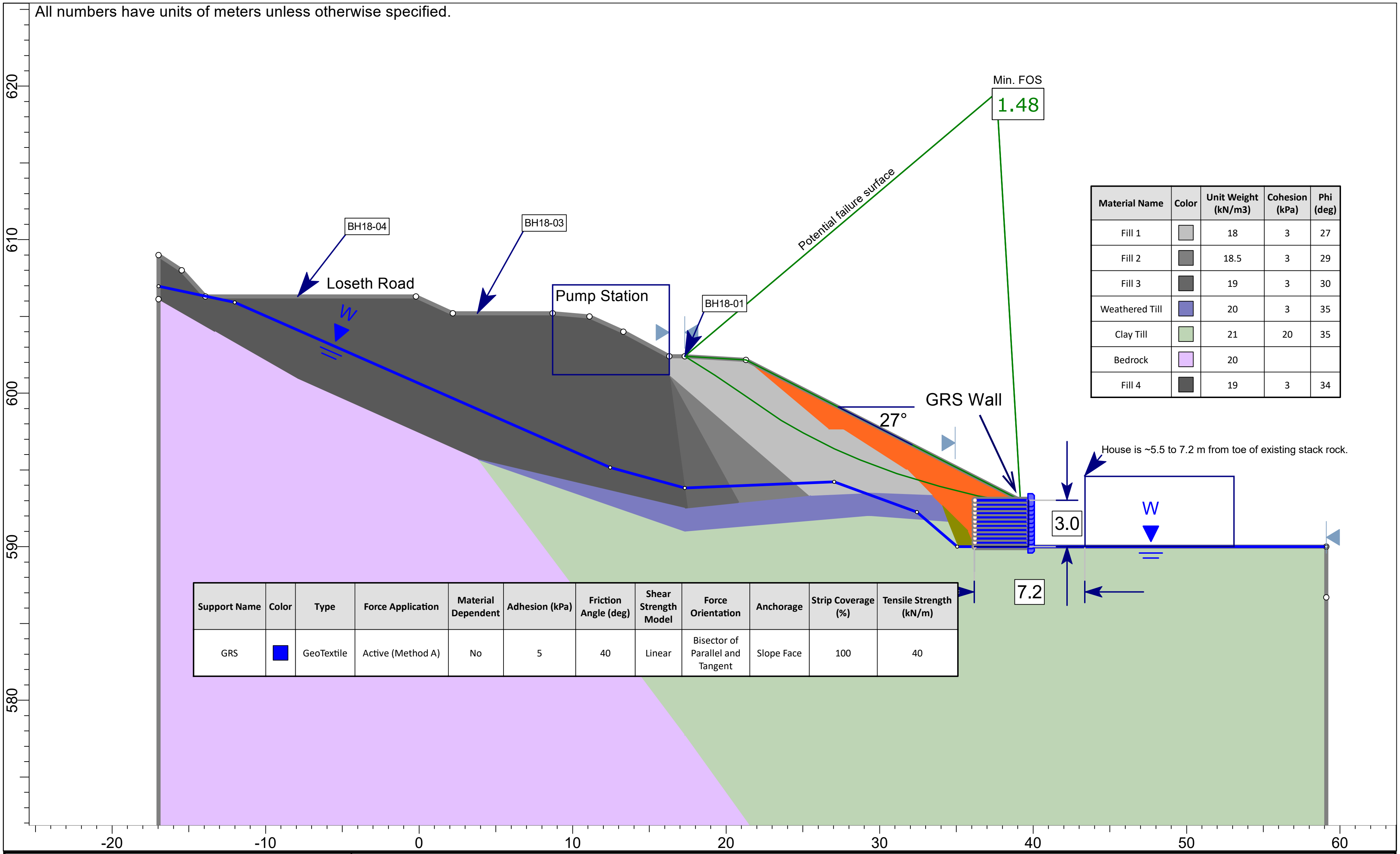
SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section C-C' - Rockfill Buttress
Drawn By	JP
Scale	1:300
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 6



All numbers have units of meters unless otherwise specified.

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	⬜	18	3	27
Fill 2	■	18.5	3	29
Fill 3	■	19	3	30
Weathered Till	🟦	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	■	19	3	34

Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (kN/m)
GRS	🟦	GeoTextile	Active (Method A)	No	5	40	Linear	Bisector of Parallel and Tangent	Slope Face	100	40

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SLIDEINTERPRET 7.037

Project
2045 Loseth Road Pump Station

Analysis Description
Section C-C' - GRS Toe Buttress Wall

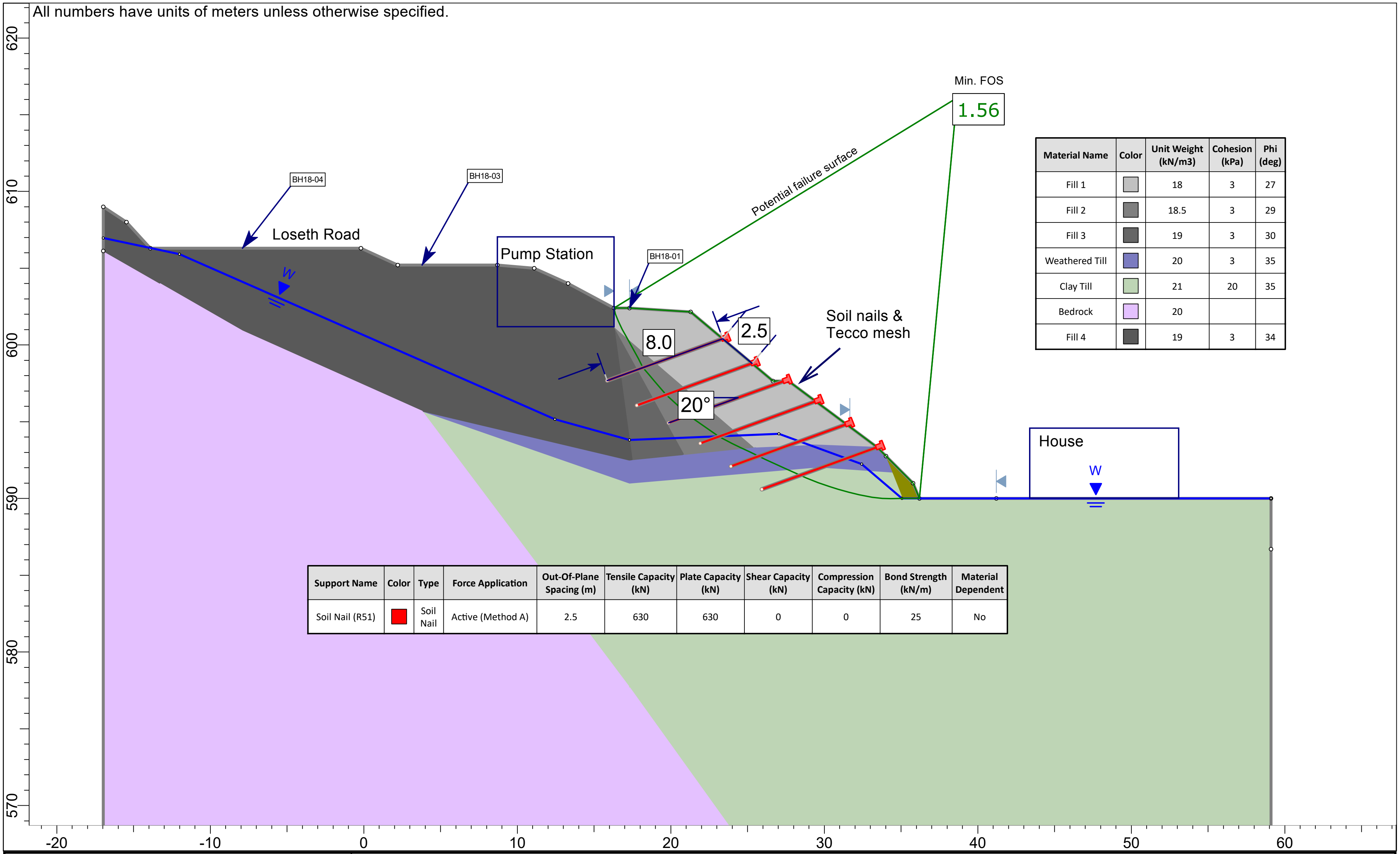
Drawn By JP

Scale 1:350

Company Westrek Geotechnical Services Ltd.

Date 2018-12-19

FIGURE 7



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▒	18	3	27
Fill 2	▓	18.5	3	29
Fill 3	■	19	3	30
Weathered Till	🟦	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	■	19	3	34

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (m)	Tensile Capacity (kN)	Plate Capacity (kN)	Shear Capacity (kN)	Compression Capacity (kN)	Bond Strength (kN/m)	Material Dependent
Soil Nail (R51)	🟥	Soil Nail	Active (Method A)	2.5	630	630	0	0	25	No

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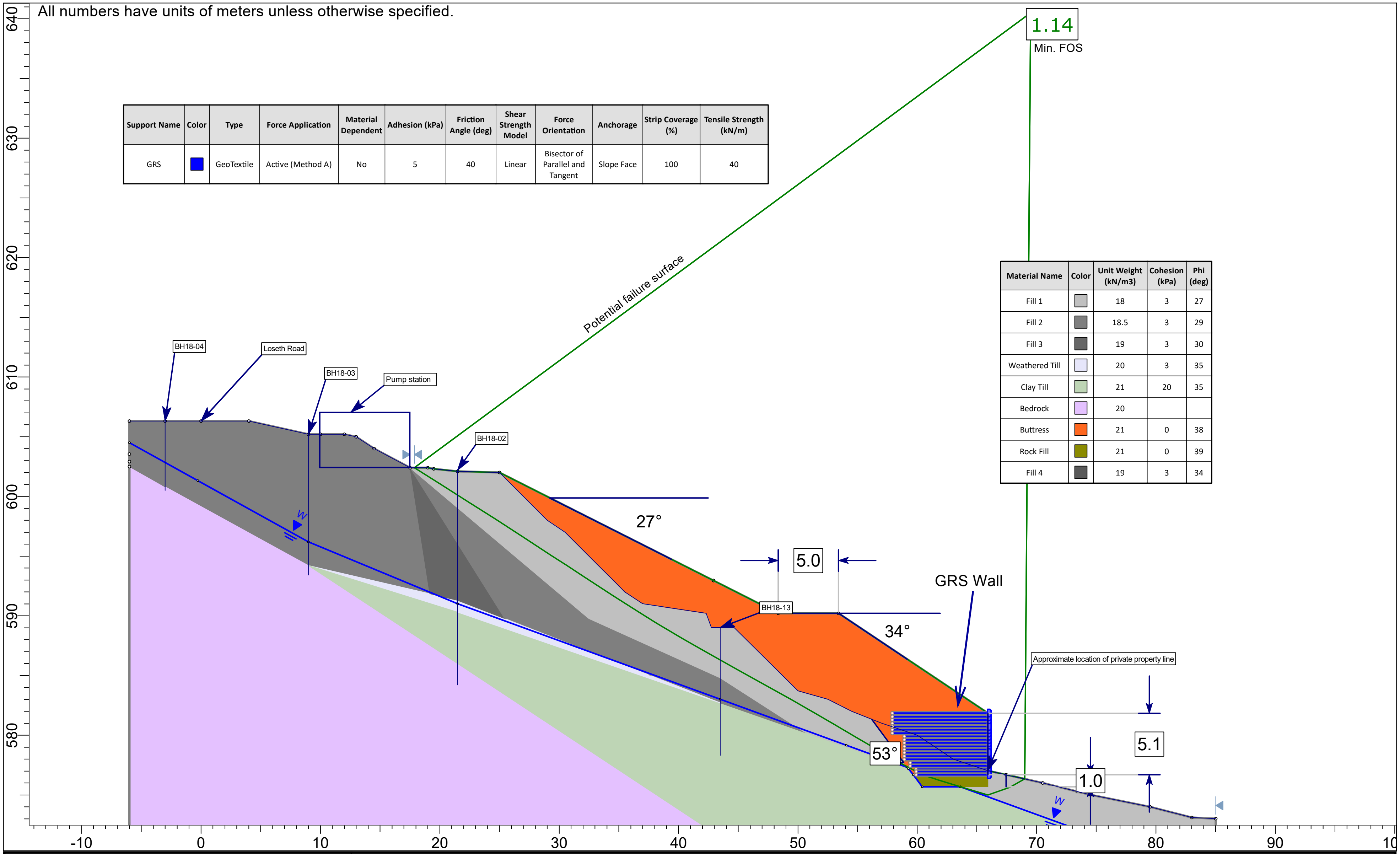
SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section C-C' - Soil Nails and Tecco Mesh
Drawn By	JP
Scale	1:350
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 8

All numbers have units of meters unless otherwise specified.



Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (kN/m)
GRS	🟦	GeoTextile	Active (Method A)	No	5	40	Linear	Bisector of Parallel and Tangent	Slope Face	100	40

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	■	18	3	27
Fill 2	■	18.5	3	29
Fill 3	■	19	3	30
Weathered Till	■	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Buttress	🟧	21	0	38
Rock Fill	■	21	0	39
Fill 4	■	19	3	34

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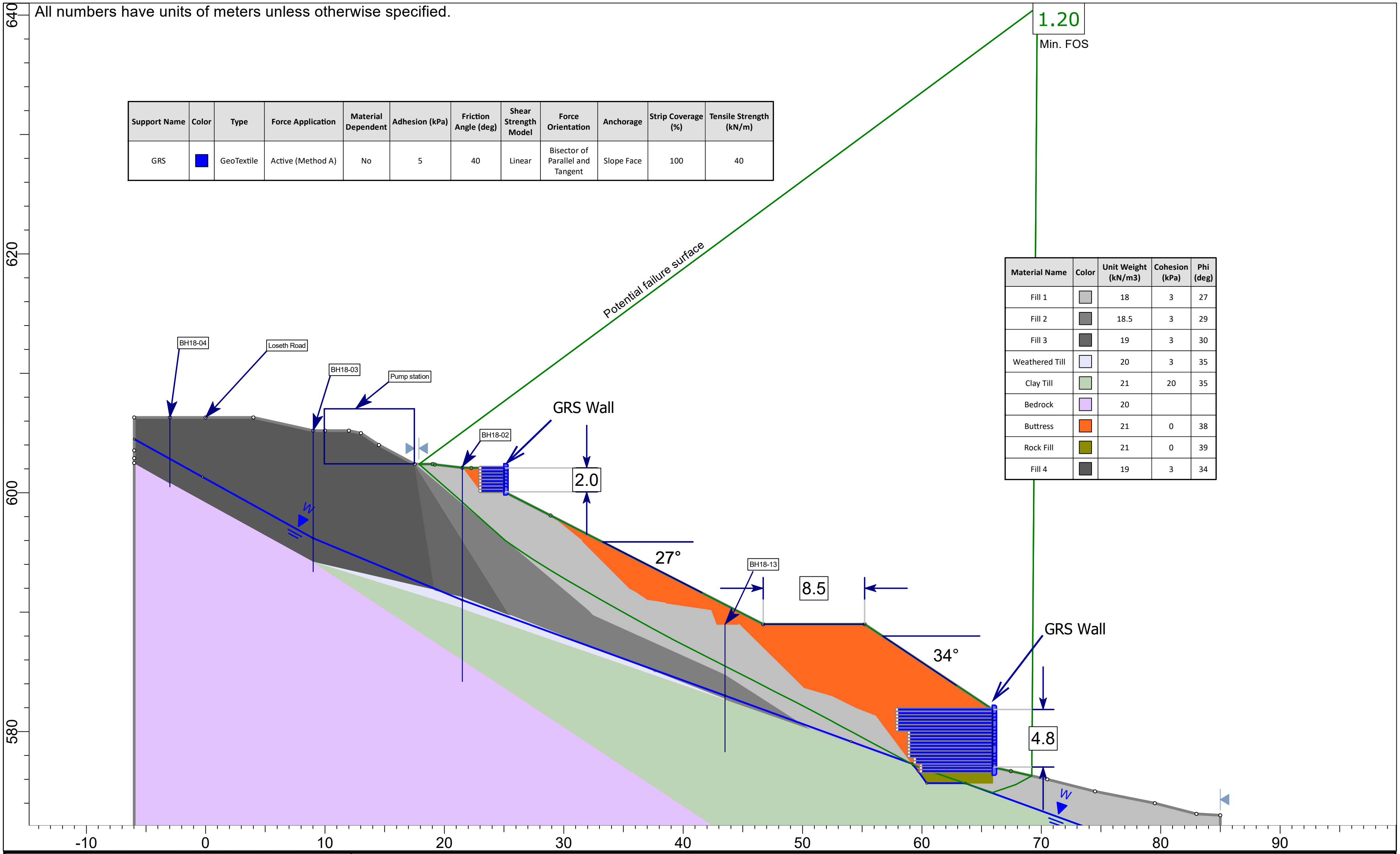
SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section A-A' - GRS Toe Buttress with Benched Slope
Drawn By	JP
Scale	1:450
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 9



Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (kN/m)
GRS	🟦	GeoTextile	Active (Method A)	No	5	40	Linear	Bisector of Parallel and Tangent	Slope Face	100	40

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	⬜	18	3	27
Fill 2	⬛	18.5	3	29
Fill 3	⬛	19	3	30
Weathered Till	⬜	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Buttress	🟧	21	0	38
Rock Fill	🟫	21	0	39
Fill 4	⬛	19	3	34

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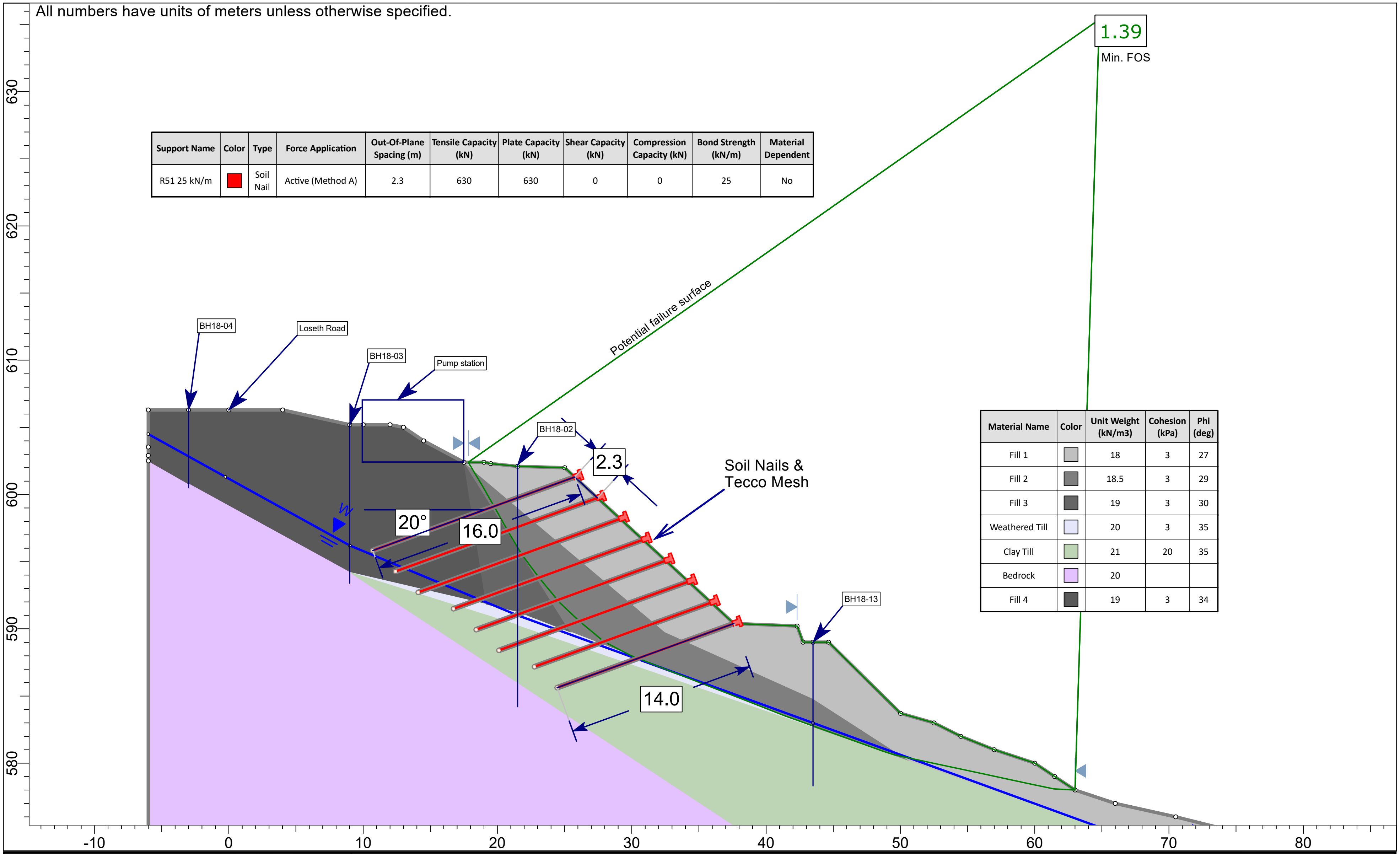
Project	2045 Loseth Road Pump Station
Analysis Description	Section A-A' - GRS Toe Buttress + GRS Wall at Crest
Drawn By JP	*Scale* 1:450
Company	Westrek Geotechnical Services Ltd.
Date 2018-12-19	**FIGURE 10**



All numbers have units of meters unless otherwise specified.

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (m)	Tensile Capacity (kN)	Plate Capacity (kN)	Shear Capacity (kN)	Compression Capacity (kN)	Bond Strength (kN/m)	Material Dependent
R51 25 kN/m	🟥	Soil Nail	Active (Method A)	2.3	630	630	0	0	25	No

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▨	18	3	27
Fill 2	▨	18.5	3	29
Fill 3	▨	19	3	30
Weathered Till	⬜	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	▨	19	3	34

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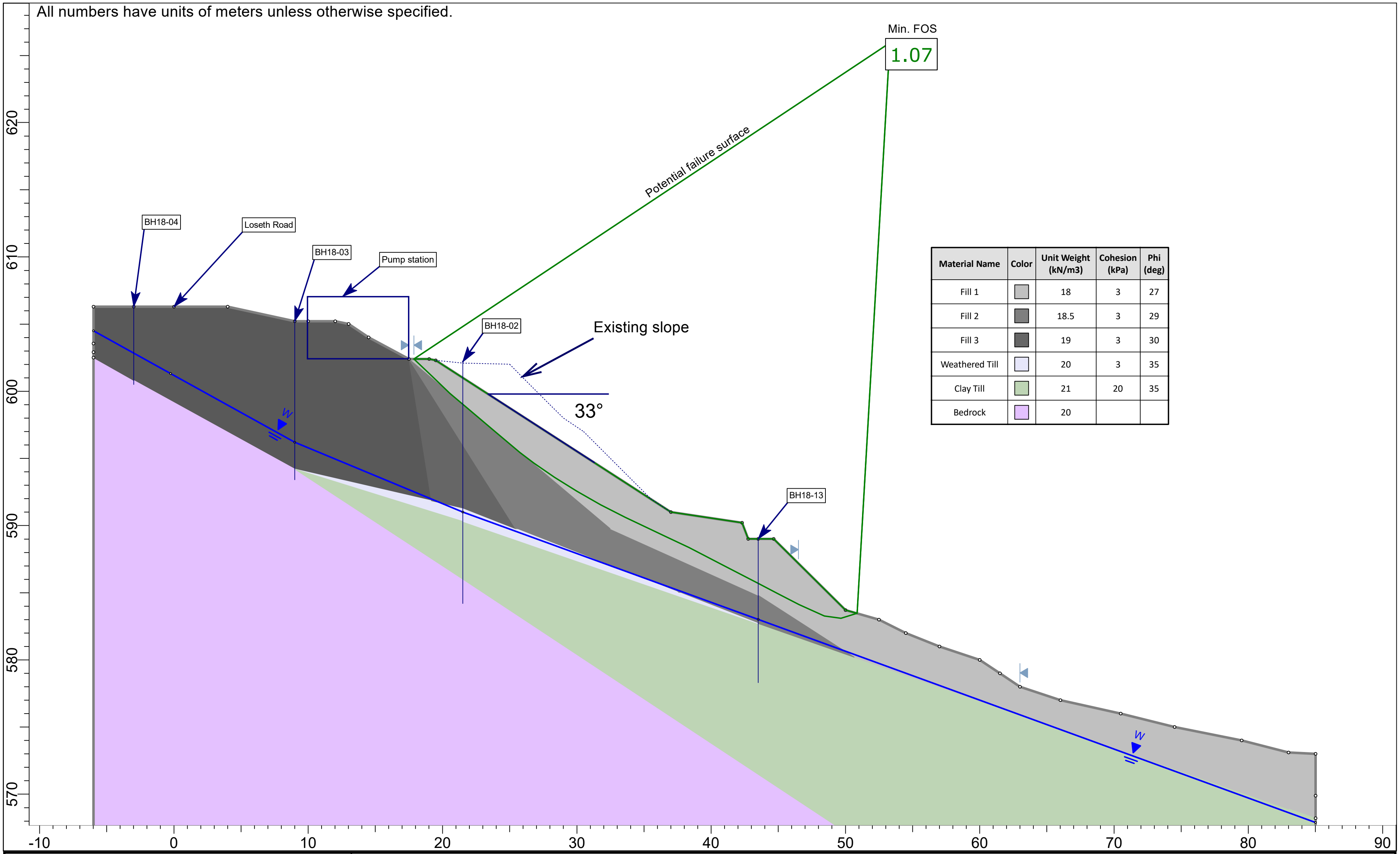
Project	2045 Loseth Road Pump Station		
Analysis Description	Section A-A' - Soil Nails and Tecco Mesh		
Drawn By JP	*Scale* 1:400	*Company*	Westrek Geotechnical Services Ltd.
Date	2018-12-19		**FIGURE 11**



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▨	18	3	27
Fill 2	▩	18.5	3	29
Fill 3	■	19	3	30
Weathered Till	⬜	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		

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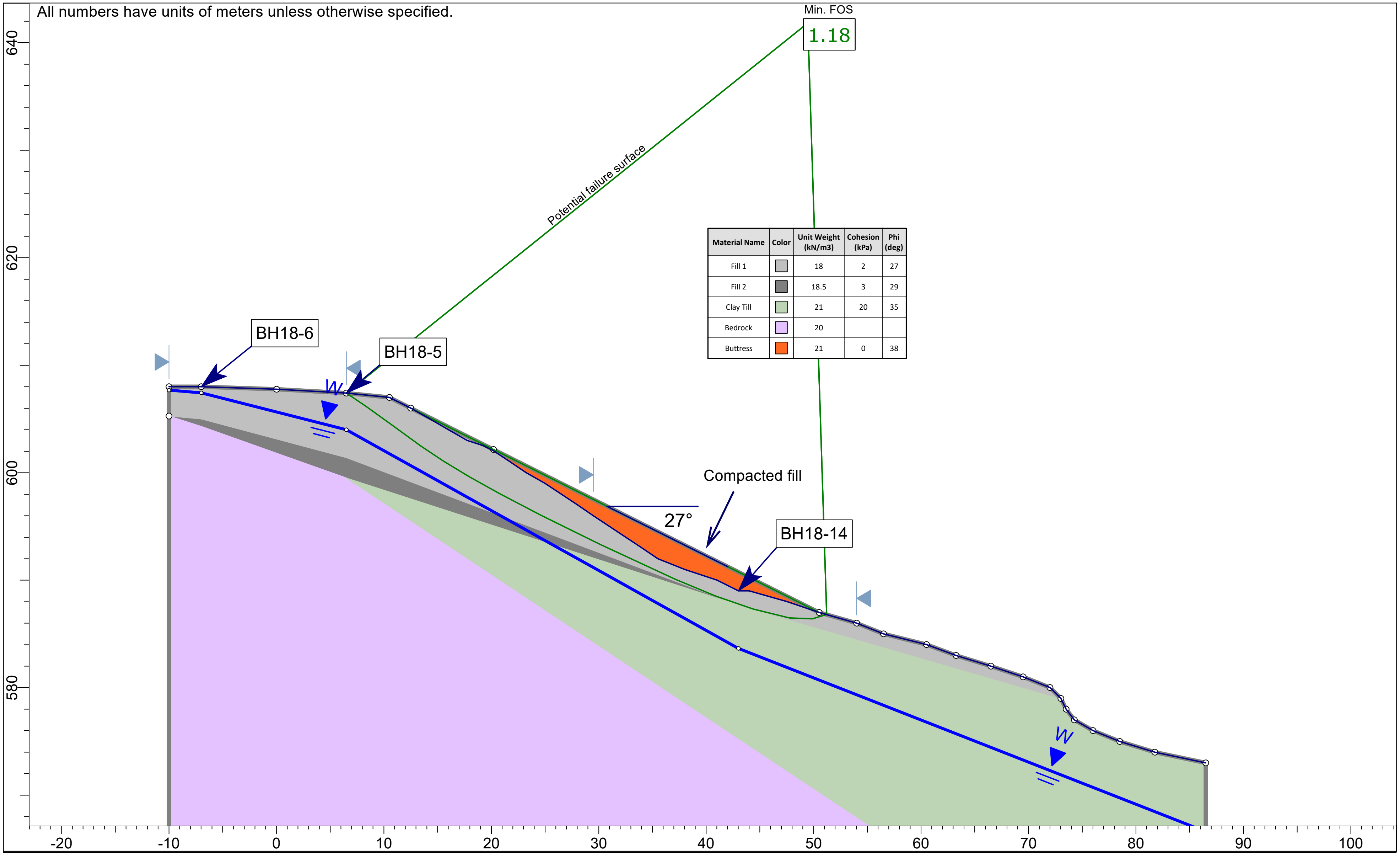
SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section A-A' Trim Slope to 33°
Drawn By	JP
Scale	1:400
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 12



All numbers have units of meters unless otherwise specified.

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▨	18	2	27
Fill 2	■	18.5	3	29
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Buttress	🟧	21	0	38

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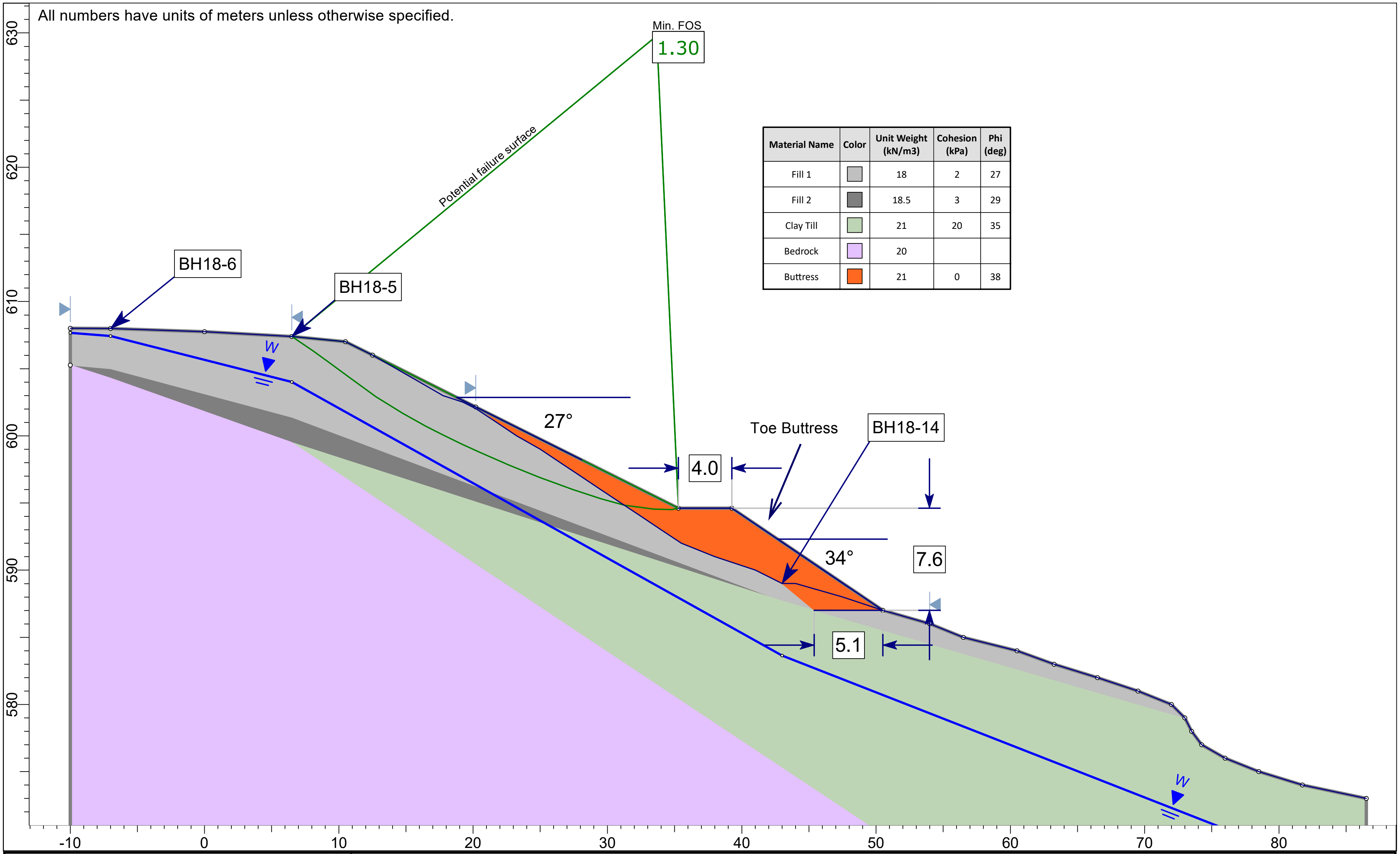
Project	2045 Loseth Road Pump Station
Analysis Description	Section B-B - Fill Lower Slope at 2H:1V
Drawn By	JP
Scale	1:500
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 13



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▨	18	2	27
Fill 2	▨	18.5	3	29
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Buttress	🟧	21	0	38

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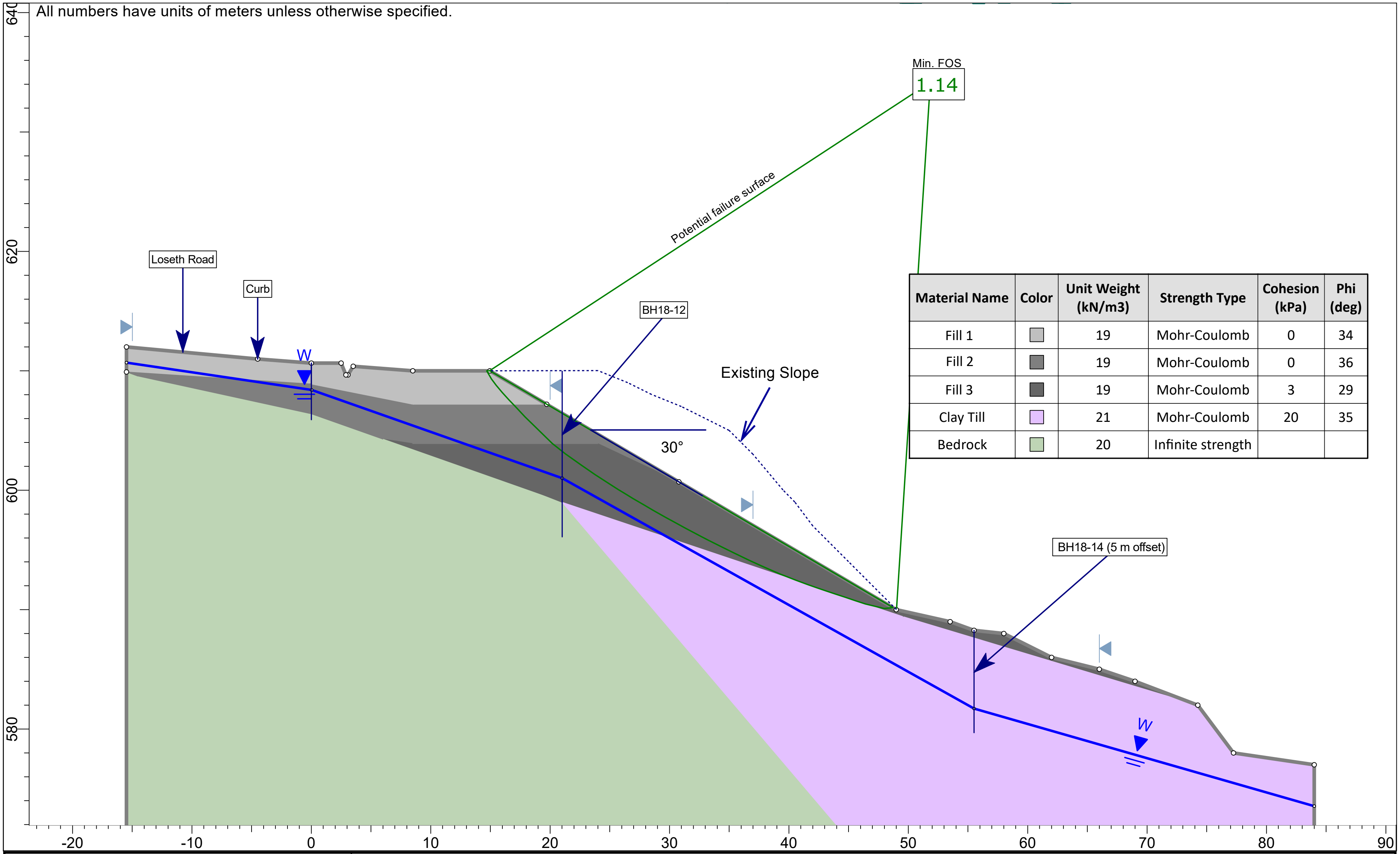
Project	2045 Loseth Road Pump Station		
Analysis Description	Section B-B' - Toe Buttress		
Drawn By JP	*Scale* 1:400	*Company*	Westrek Geotechnical Services Ltd.
Date	2018-12-19		**FIGURE 14**


All numbers have units of meters unless otherwise specified.

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Fill 1	⬜	19	Mohr-Coulomb	0	34
Fill 2	▩	19	Mohr-Coulomb	0	36
Fill 3	⬛	19	Mohr-Coulomb	3	29
Clay Till	🟪	21	Mohr-Coulomb	20	35
Bedrock	🟩	20	Infinite strength		

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SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section D-D' - 1.75H:1V Pullback
Drawn By	MS
Scale	1:450
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 15

APPENDIX A

INTERPRETATION AND USE OF STUDY AND REPORT AND LIMITATIONS

1. STANDARD OF CARE.

This study and Report have been prepared in accordance with generally accepted engineering and geoscience practices. No other warranty, express or implied, is made. Geological and geotechnical studies and reports do not include environmental consulting unless specifically stated in the report.

2. COMPLETE REPORT.

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT.

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT.

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report or any portion thereof, available to any party without our written permission. Any uses, which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. Westrek accepts no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT.

(i) Nature and Exactness of Soil and Description: Classification and identification of soils, rocks, geological units, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilising the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

(ii) Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations or fraudulent acts of any persons providing representations, information and instructions.

(iii) To avoid misunderstandings, Westrek should be retained to work with the other design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to engineering issues. Further, Westrek should be retained to provide field reviews during the construction, consistent with generally accepted practices.

6. LIMITATIONS OF LIABILITY.

Westrek's liability will be limited as follows:

(a) In recognition of the relative risks and benefits of the Services to be provided to the Client by Westrek, the risks have been allocated such that the Client agrees, to the fullest extent permitted by law, to limit the liability of Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, whether arising in contract or tort including negligence, including legal fees and costs and disbursements (the "Claim"), so that the total aggregate liability of Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals:

   i. if the Claim is satisfied by the re-performance of the Services proven to be in error, shall not exceed and shall be limited to the cost to Westrek in re-performing such Services; or

   ii. if the Claim cannot be satisfied by the re-performance of the Services and:

      1. if Westrek's professional liability insurance does not apply to the Claim, shall not exceed and shall be limited to Westrek's total fee for services rendered for this matter, whichever is the lesser amount. The Client will indemnify and hold harmless Westrek from third party Claims that exceed such amount; or

      2. if Westrek's professional liability insurance applies to the Claim, shall be limited to the coverage amount available under Westrek's professional liability insurance at the time of the Claim. The Client will indemnify and hold harmless Westrek from third party Claims that exceed such coverage amount. Westrek shall maintain professional liability insurance in the amount of $2,000,000 per occurrence, $2,000,000 in the aggregate, for a period of two (2) years from the date of substantial performance of the Services or earlier termination of this Agreement. If the Client wishes to increase the amount of such insurance coverage or duration of such policy or obtain other special or increased insurance coverage, Westrek will cooperate with the Client to obtain such coverage at the Client's expense.

      It is intended that this limitation will apply to any and all liability or cause of action however alleged or arising, including negligence, unless otherwise prohibited by law. Notwithstanding the foregoing, it is expressly agreed that there shall be no claim whatsoever against Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals for loss of income, profit or other consequential damages howsoever arising, including negligence, liability being limited to direct damages.

(b) Westrek is not responsible for any errors, omissions, mistakes or inaccuracies contained in information provided by the Client, including but not limited to the location of underground or buried services, and with respect to such information, Westrek may rely on it without having to verify or test that information. Further, Westrek is not responsible for any errors or omissions committed by persons, consultants or specialists retained directly by the Client and with respect to any information, documents or opinions provided by such persons, consultants or specialists, Westrek may rely on such information, documents or opinions without having to verify or test the same.

(c) Notwithstanding the provisions of the Limitation Act, R.S.B.C. 2012 c. 13, amendments thereto, or new legislation enacted in its place, Westrek's liability for any and all claims, including a Claim as defined herein, of the Client or any third party shall absolutely cease to exist after a period of two (2) years following the date of:

   i. Substantial performance of the Services,

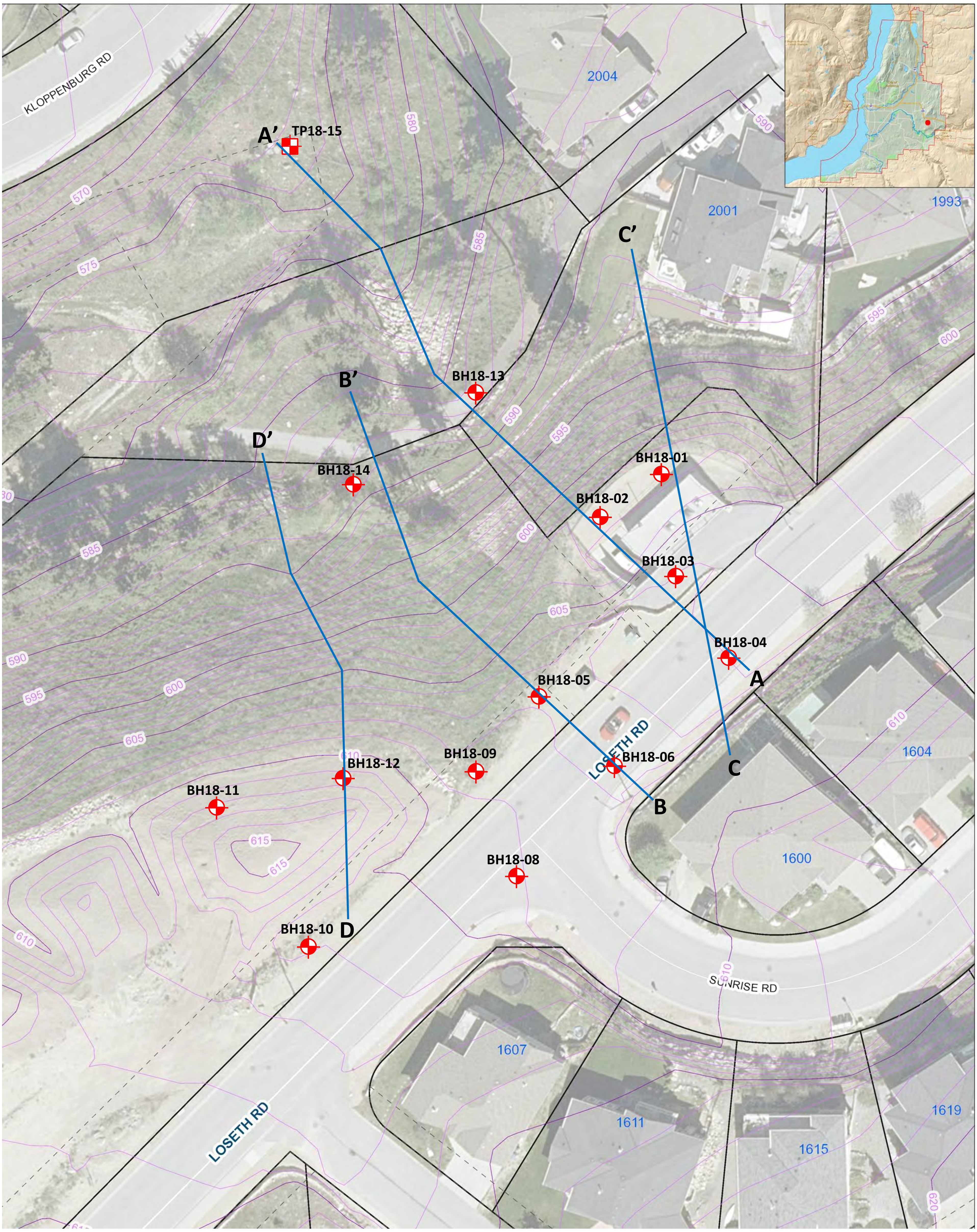
   ii. Suspension or abandonment of the Services provided under this agreement, or

   iii. Termination of Westrek's Services under the agreement,

whichever shall occur first, and following such period, the Client shall have no claim, including a Claim as defined herein, whatsoever against Westrek.

APPENDIX B

Drawing 01, Bore Hole Location Plan
Drawing 02, Potential Landslide Runout



LEGEND

⊕ - Borehole location

▣ - Test-pit location

D — D' - Cross-section profile

Map Source: City of Kelowna online mapping application

westrek geotechnical services ltd.

100 -1383 McGill Road, Kamloops, BC V2C 6K7

SCALE 1:500

December 7, 2018

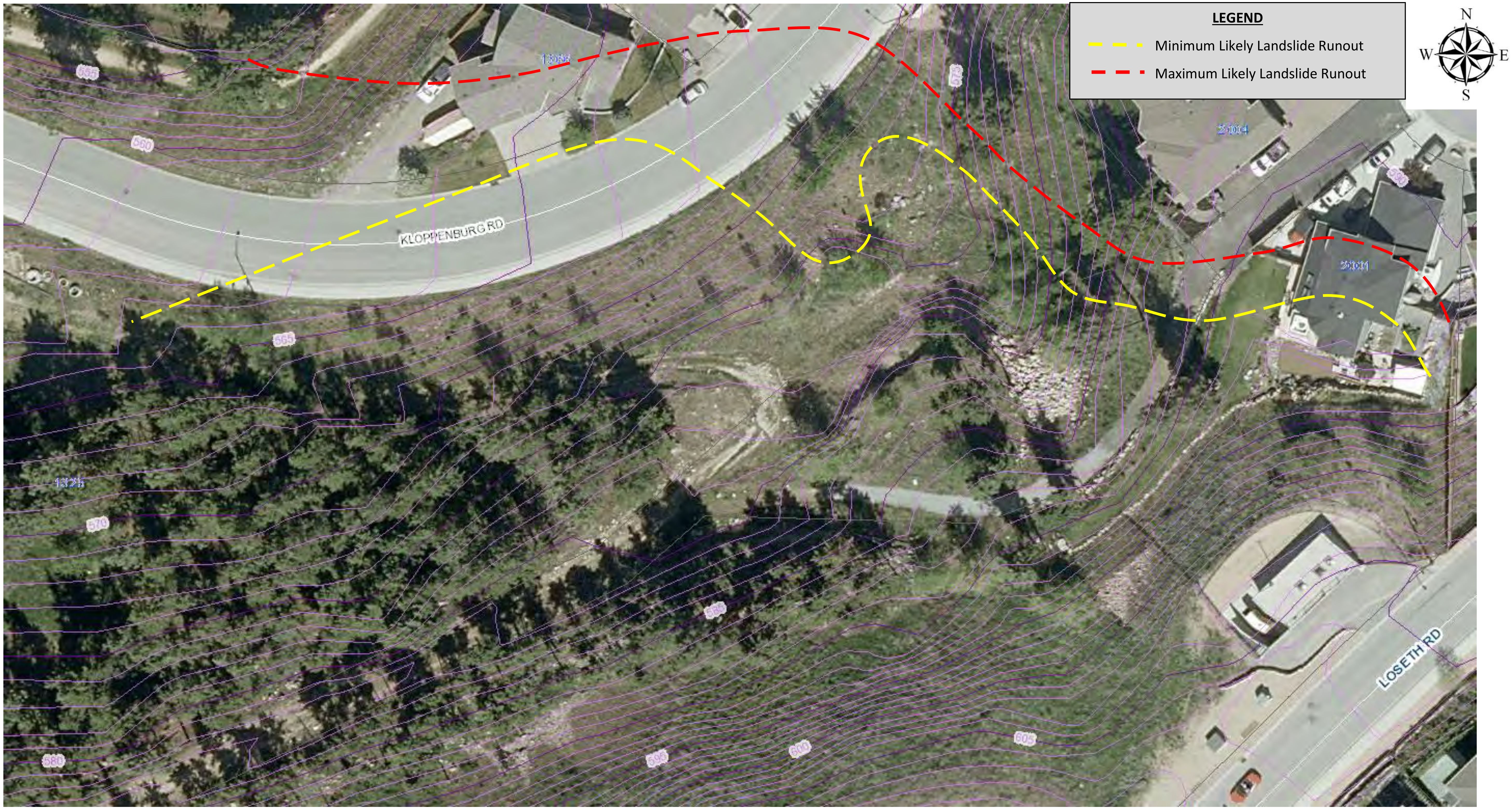
Project: 018-253

City of Kelowna

2045 Loseth Road Pump Station

Bore Hole Location Plan

DRAWING 01



Map Source: City of Kelowna online mapping application

20th ANNIVERSARY

westrek
geotechnical services ltd.
100 -1383 McGill Road, Kamloops, BC V2C 6K7

SCALE 1:500

December 18, 2018

Project: 018-253

City of Kelowna
2045 Loseth Road Pump Station
Potential Landslide Runout

DRAWING 02

APPENDIX C

Bore Hole Logs & Test Pit Log

RECORD OF BOREHOLE BH18-01
2045 Loseth Road Pump Station
City of Kelowna

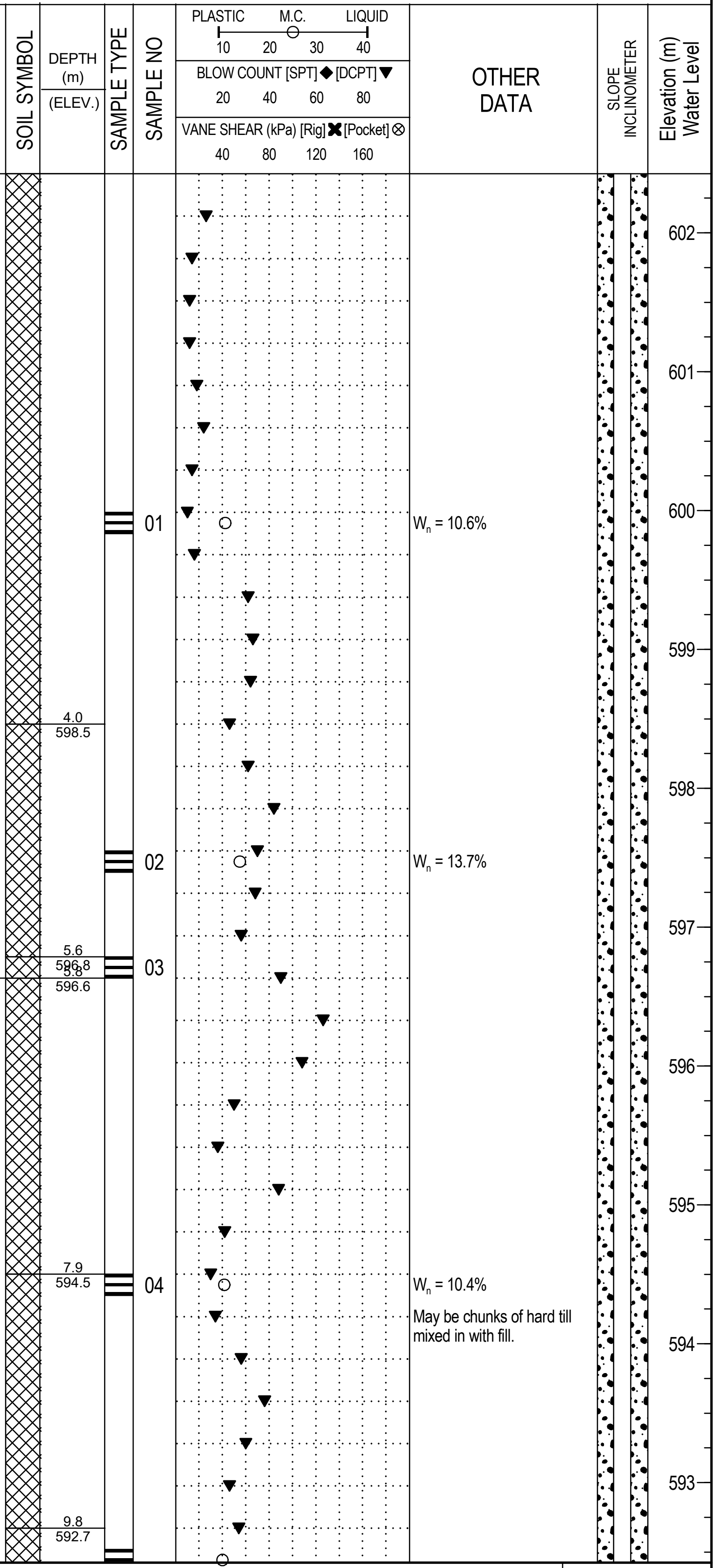
westrek
geotechnical services ltd.

Project No.: 018-253	Co-ordinate: 11 330515.64E 5526037.92N
Date Drilled: Aug 07-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 602.4 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE; ☰ GRAB SAMPLE; ▥ SHELBY TUBE; ▮ CORE SAMPLE; ■ NO RECOVERY

INSTALLATION: ⁘ GROUT; ■ BENTONITE; ⁘ SAND; ▨ DRILL CUTTINGS; ⊟ SCREEN

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
0	Sonic	(SM-SC) fine SANDY SILT some clay, trace gravel; loose, dry; brown-grey [FILL].				
2.5				☰	01	W_n = 10.6%
4		...becomes trace cobbles, dry to moist, compact.	4.0 598.5			
5				☰	02	W_n = 13.7%
5.6		...becomes dark grey with organics; moist to wet.	5.6 596.8	☰	03	
5.8		(SM-SC) SILTY SAND some clay, trace gravel, trace organics; loose/soft to compact/stiff, dry; brown-grey [FILL].	5.8 596.6			
8		...highly variable density; discontinuous pods of hard soil.	7.9 594.5	☰	04	W_n = 10.4% May be chunks of hard till mixed in with fill.
10		...becomes loose to compact.	9.8 592.7	☰		



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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 1 of 3

WESTREK SOIL BOREHOLE LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - NO PPEN.GPJ WGS SOIL LOG.GDT 18-12-20

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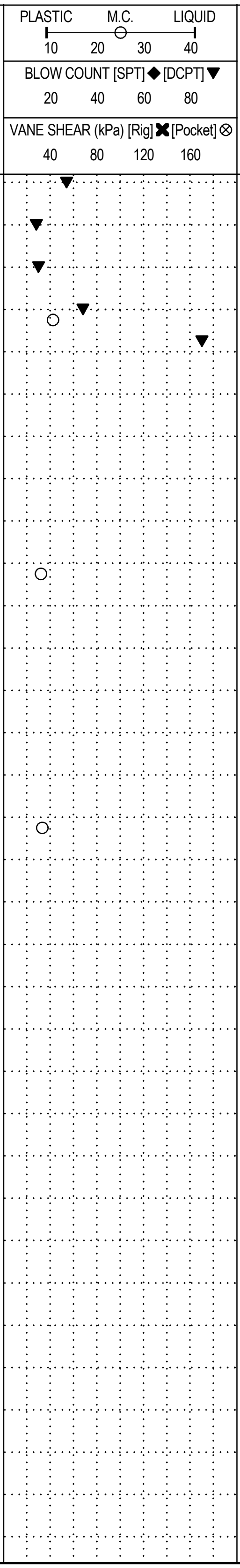
RECORD OF BOREHOLE BH18-01
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330515.64E 5526037.92N
Date Drilled: Aug 07-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 602.4 m [Survey]

SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	▨ GROUT	■ BENTONITE	▨ SAND	▨ DRILL CUTTINGS	⊟ SCREEN

Drilling method: Sonic

Depth (m)	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
10			☰	05	W_n = 10.0% Sieve Analysis (10.0 m): Gravel = 13% Sand = 42% Fines = 45%
	(SP/GP) SAND and GRAVEL sub-angular to sub-rounded, some silt; dry to moist, compact; brown-grey [FILL].	10.4 592.1			
11	(ML) fine SANDY SILT some clay, trace gravel, sub-rounded to sub-angular, occasional cobbles; inferred compact, moist; brown-grey [FILL].	10.8 591.6	☰	06	W_n = 10.6%
12	(SM) SILTY SAND some gravel, sub-rounded to sub-angular, trace clay, occasional cobbles; inferred compact, moist; medium brown [WEATHERED TILL].	11.4 591.0			
13			☰	07	W_n = 8.0% Sieve Analysis (12.9 m): Gravel = 21% Sand = 42% Fines = 37% VW piezometer installed at ~13.4 m depth.
14	(SM) SILTY SAND some gravel, sub-rounded to sub-angular, trace clay, occasional cobbles; dense, moist; grey-brown [TILL].	14.0 588.4			Difficult drilling and high core expansion below.
15			☰	08	W_n = 8.3%
16					
17					
18					
19					
20					



SLOPE INCLINOMETER

Elevation (m) Water Level: 592, 591, 590, 589, 588, 587, 586, 585, 584, 583

WESTREK SOIL BOREHOLE LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - NO PPEN.GPJ WGS SOIL LOG.GDT 18-12-20

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
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RECORD OF BOREHOLE BH18-01
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330515.64E 5526037.92N
Date Drilled: Aug 07-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 602.4 m [Survey]

SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	▨ GROUT	■ BENTONITE	▨ SAND	▨ DRILL CUTTINGS	⊟ SCREEN

PLASTIC — M.C. — LIQUID: 10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼: 20 40 60 80
VANE SHEAR (kPa) [Rig] ✖ [Pocket] ⊗: 40 80 120 160

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
20	Sonic					
20.5				☰	09	W$_n$ = 10.0% Sieve Analysis (20.5 m): Gravel = 10% Sand = 51% Fines = 40%
21		...gravel and cobble content decreases slightly, below.	21.0 581.4			
26.2		**BEDROCK** Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	26.2 576.2			
27.1		End of hole at 27.1 m (575.3 m) Notes: Piezometer max head elevation 589.6 m (November 12, 2018). Ground surface is 0.18 m above top of slope inclinometer casing.	27.1 575.3			

Depth scale (m): 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
Elevation (m): 582, 581, 580, 579, 578, 577, 576, 575, 574, 573

SLOPE INCLINOMETER

Elevation (m) Water Level

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

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Page 3 of 3

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RECORD OF BOREHOLE BH18-02
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330507.6E 5526032.91N
Date Drilled: Aug 09-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 602.1 m [Survey]

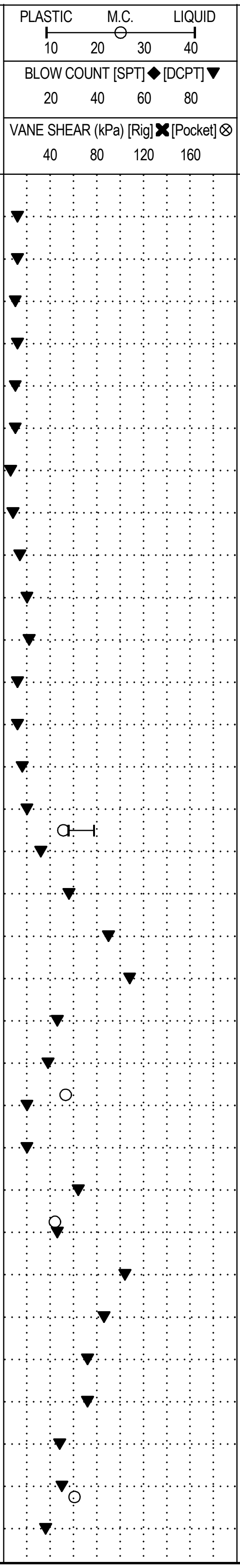
SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	⁘ GROUT	■ BENTONITE	⁘ SAND	▨ DRILL CUTTINGS	⊟ SCREEN

Drilling method: Sonic

Depth (m)	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
0	(ML) SILT some gravel, fine to coarse, angular, occasional cobbles and boulders; loose, moist; dark brown [FILL].	0.2 602.0			
	(SM) fine SANDY SILT trace to some clay, trace gravel, rounded to sub-angular; loose, moist; medium brown-grey, blocky [FILL].				
			☰	01	W_n = 12.8% PL = 13.9% LL = 19.3% Sieve Analysis (4.7 m): Gravel = 8% Sand = 31% Silt = 51% Clay = 9%
	...becomes occasional hard chunk, occasional cobble; very stiff/compact, moist; medium grey with light to medium brown mottling.	5.6 596.5			
	...becomes soft/loose, moist to wet; brown-grey.	6.6 595.6	☰	02	W_n = 13.3%
	...becomes trace sand and occasional cobbles; dense, moist; medium grey.	7.5 594.7	☰	03	W_n = 11.0%
	...becomes fewer cobbles and trace organics (bark); very dense, moist; dark blue-grey.	7.8 594.4	☰	04	
	...increased sand and gravel content, occasional cobbles.	8.2 593.9	☰	05	
	(SM) SILTY SAND some clay, trace fine gravel; variable loose to compact (firm to stiff), wet; medium grey [FILL].	9.3 592.8	☰	06	VW piezometer installed at 9.4 m depth. W_n = 15.2% Sieve Analysis (9.5 m):
10					

Depth (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Elevation (m): 602, 601, 600, 599, 598, 597, 596, 595, 594, 593

SLOPE INCLINOMETER



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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

westrek geotechnical services ltd.

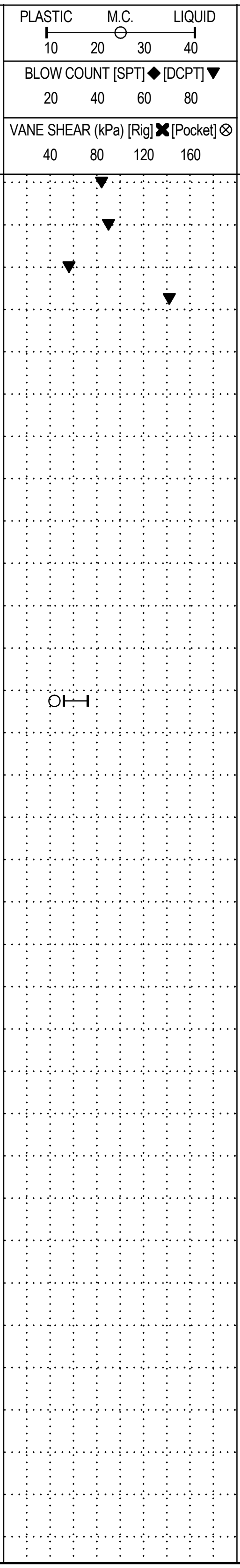
RECORD OF BOREHOLE BH18-02
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330507.6E 5526032.91N
Date Drilled: Aug 09-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 602.1 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE · ☰ GRAB SAMPLE · ▥ SHELBY TUBE · ▮ CORE SAMPLE · ■ NO RECOVERY

INSTALLATION: ⁘ GROUT · ■ BENTONITE · ⁘ SAND · ▨ DRILL CUTTINGS · ⊟ SCREEN

Depth (m)	Drilling Method	Soil Description	Depth (m) (Elev.)	Sample Type	Sample No	Other Data	Elevation (m)
10	Sonic	...becomes trace to some gravel, occasional cobbles; dense, dry to moist (variable); dark grey with brown mottling.	10.4 591.8			Gravel = 7% Sand = 49% Fines = 44%	592
11		(SM) SILTY SAND some clay, trace to some gravel, rounded to sub-angular, some cobbles; inferred very dense, dry; light brown to off-white [WEATHERED TILL].	10.8 591.3			Very difficult to drill below.	591
12		(SM) SILTY SAND trace to some clay, trace gravel, rounded to sub-angular, trace cobbles; inferred dense, dry to moist (variable); medium grey-brown [TILL].	11.9 590.3				590
13							589
14				☰	07	W_n = 10.9% PL = 12.9% LL = 18.0% Sieve Analysis (13.8 m): Gravel = 9% Sand = 47% Silt = 35% Clay = 9%	588
15							587
16		BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	16.2 586.0				586
17							585
18		End of hole at 18.0 m (584.2 m) Notes: Piezometer was dry (August 27, 2018). Ground surface is 0.12m above top of slope inclinometer casing.	18.0 584.2				584
19							583
20							



SLOPE INCLINOMETER

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

RECORD OF BOREHOLE BH18-03

2045 Loseth Road Pump Station

City of Kelowna

westrek geotechnical services ltd.

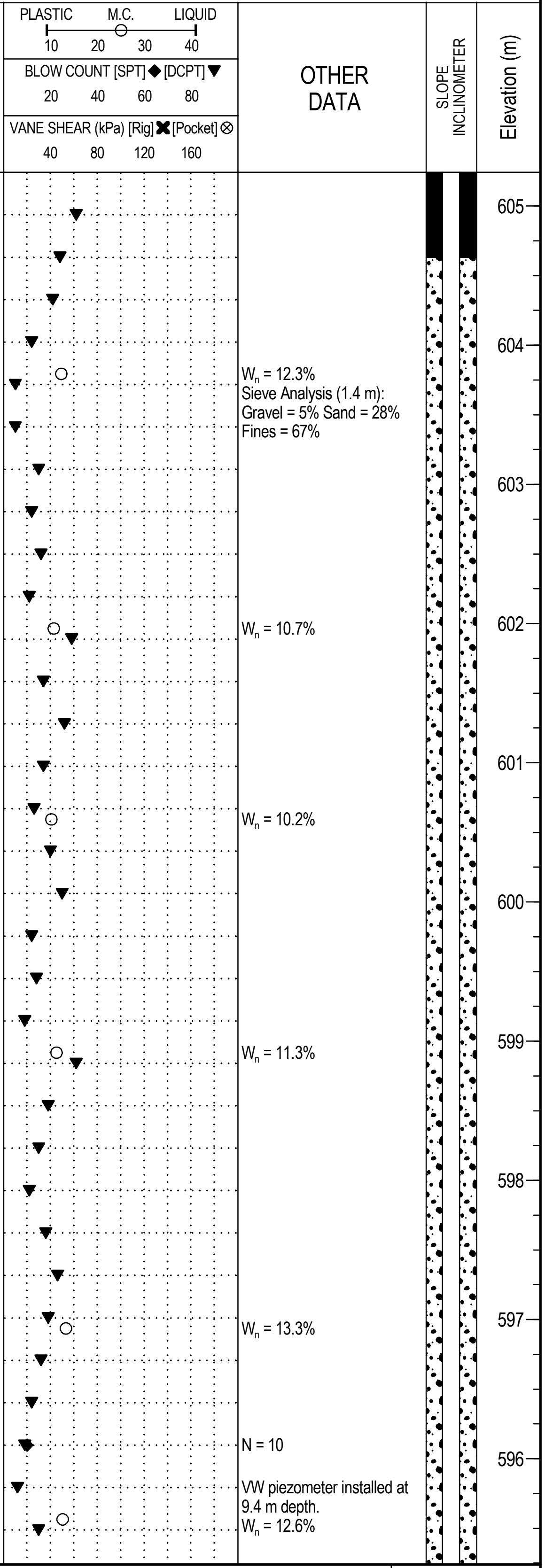
Project No.: 018-253	Co-ordinate: 11 330517.38E 5526025.15N
Date Drilled: Aug 07-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 605.2 m [Survey]

SAMPLE TYPE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY

INSTALLATION ⁙ GROUT ■ BENTONITE ⁙ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

Drilling method: Sonic

Depth (m)	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
0	ASPHALT	0.2 605.0			
	(GP) GRAVEL 3-inch minus granular [ROAD BASE].	0.6 604.6			
	...becomes cobbly with sand and fines, wet.	0.8 604.4			
1	(SM-SC) sandy SILT fine-grained, some clay, trace gravel, sub-rounded; loose to compact, moist; medium brown to grey-brown [FILL].		☰	01	Wₙ = 12.3% Sieve Analysis (1.4 m): Gravel = 5% Sand = 28% Fines = 67%
2			☰	02	
3			☰	03	Wₙ = 10.7%
	... becomes trace to some gravel, sub-rounded to sub-angular, trace cobbles, trace organics (roots); dense; brown-grey.	3.4 601.9			
4			☰	04	Wₙ = 10.2%
5					
6	... slight medium brown mottling.	5.9 599.3	☰	05	Wₙ = 11.3%
7			☰	06	
8			☰	07	Wₙ = 13.3%
9	... becomes some gravel, trace cobbles, trace organics; loose, wet; dark grey with yellow-brown mottling.	8.8 596.4	☒	01	N = 10 VW piezometer installed at 9.4 m depth.
10		9.9	☰	08	Wₙ = 12.6%



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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

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DRAWN: ms/hkw
Page 1 of 2

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RECORD OF BOREHOLE BH18-03

2045 Loseth Road Pump Station

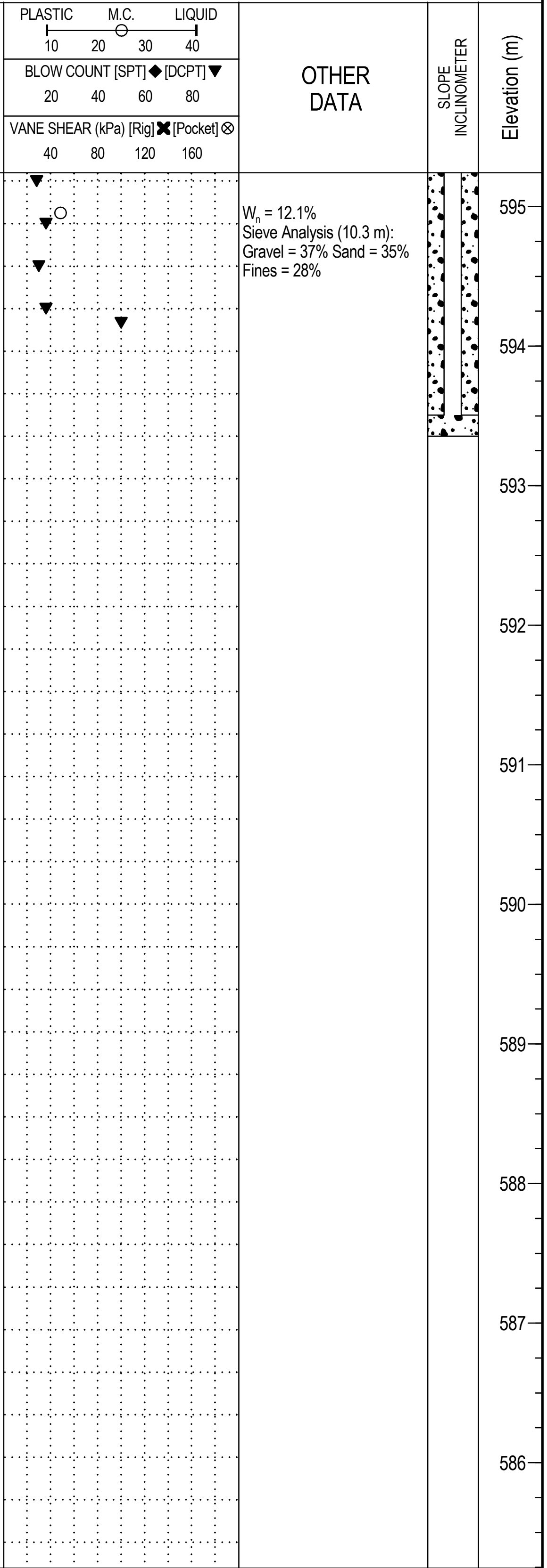
City of Kelowna

Project No.: 018-253	Co-ordinate: 11 330517.38E 5526025.15N
Date Drilled: Aug 07-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 605.2 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE, ☰ GRAB SAMPLE, ▥ SHELBY TUBE, ▮ CORE SAMPLE, ■ NO RECOVERY

INSTALLATION: ▨ GROUT, ■ BENTONITE, ▨ SAND, ▨ DRILL CUTTINGS, ⊟ SCREEN

Depth (m)	Drilling Method	Soil Description	Depth (m) (Elev.)	Sample Type	Sample No	Other Data
10	Sonic	(GM) sandy GRAVEL some silt, trace clay, trace cobbles; compact, moist to wet; medium brown with dark grey silty clay pods [COLLUVIUM].	595.3	☰	09	W_n = 12.1% Sieve Analysis (10.3 m): Gravel = 37% Sand = 35% Fines = 28%
11		BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	11.0 594.2			
12		End of hole at 11.9 m (593.4 m) Notes: Piezometer was dry (August 27, 2018). Ground surface is 0.07m above top of slope inclinometer casing.	11.9 593.4			



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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

westrek geotechnical services ltd.

RECORD OF BOREHOLE BH18-04

2045 Loseth Road Pump Station

City of Kelowna

Project No.: 018-253

Co-ordinate: 11 330524.3E 5526014.39N

Date Drilled: Aug 03-2018

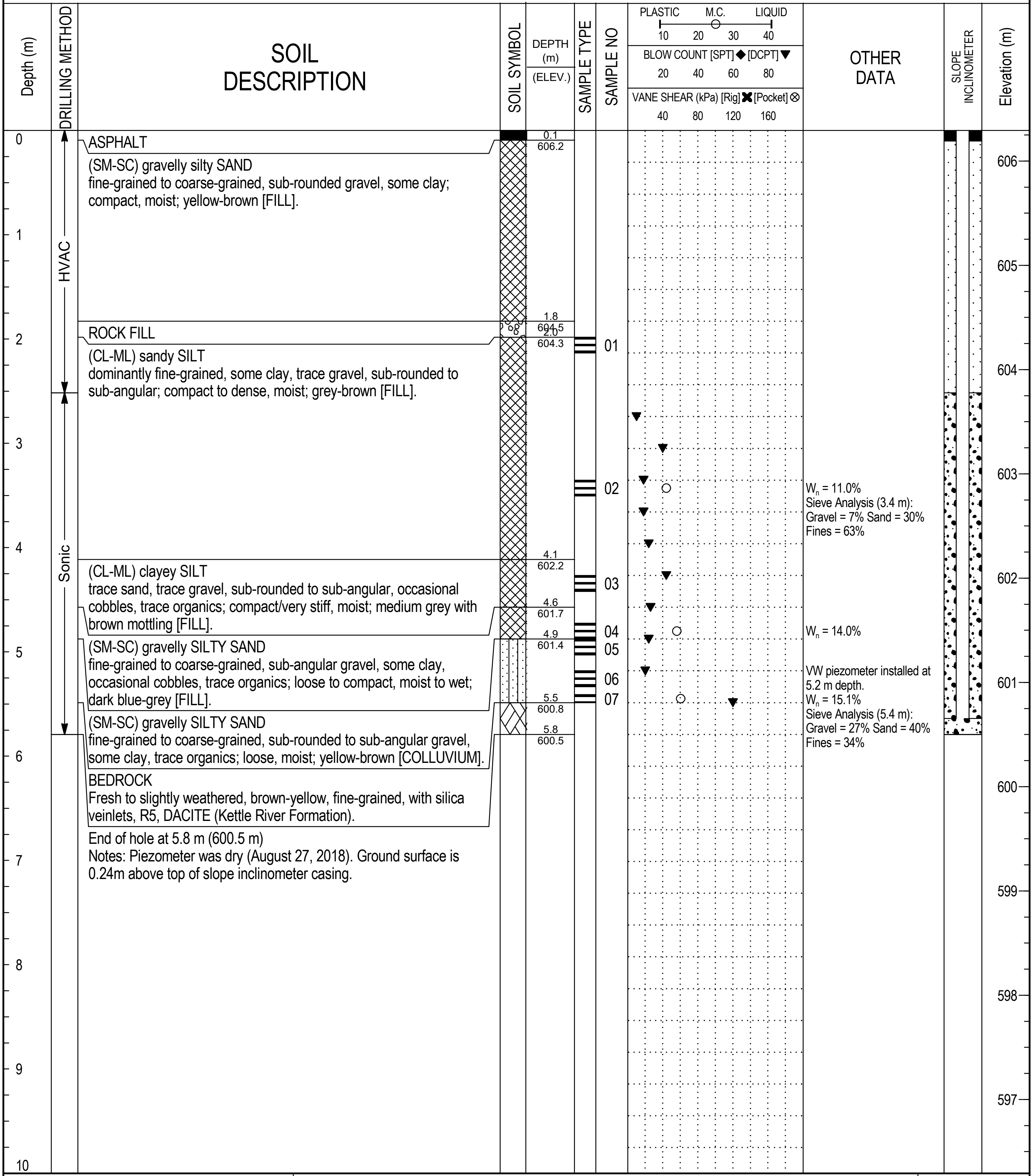
Drill Type: Sonic

Driller: Mud Bay Drilling

Elevation: 606.3 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE; ☰ GRAB SAMPLE; ▥ SHELBY TUBE; ▮ CORE SAMPLE; ■ NO RECOVERY

INSTALLATION: ⁘ GROUT; ■ BENTONITE; ⁘ SAND; ▨ DRILL CUTTINGS; ⊟ SCREEN



Depth (m) (Elev.)	Soil Description	Sample No	Other Data
0.1 606.2	ASPHALT		
	(SM-SC) gravelly silty SAND fine-grained to coarse-grained, sub-rounded gravel, some clay; compact, moist; yellow-brown [FILL].		
1.8 604.5	ROCK FILL		
2.0 604.3	(CL-ML) sandy SILT dominantly fine-grained, some clay, trace gravel, sub-rounded to sub-angular; compact to dense, moist; grey-brown [FILL].	01 02	W_n = 11.0% Sieve Analysis (3.4 m): Gravel = 7% Sand = 30% Fines = 63%
4.1 602.2	(CL-ML) clayey SILT trace sand, trace gravel, sub-rounded to sub-angular, occasional cobbles, trace organics; compact/very stiff, moist; medium grey with brown mottling [FILL].	03	
4.6 601.7	(SM-SC) gravelly SILTY SAND fine-grained to coarse-grained, sub-angular gravel, some clay, occasional cobbles, trace organics; loose to compact, moist to wet; dark blue-grey [FILL].	04 05 06	W_n = 14.0% VW piezometer installed at 5.2 m depth.
4.9 601.4	(SM-SC) gravelly SILTY SAND fine-grained to coarse-grained, sub-rounded to sub-angular gravel, some clay, trace organics; loose, moist; yellow-brown [COLLUVIUM].	07	W_n = 15.1% Sieve Analysis (5.4 m): Gravel = 27% Sand = 40% Fines = 34%
5.5 600.8	BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).		
5.8 600.5	End of hole at 5.8 m (600.5 m)		

Notes: Piezometer was dry (August 27, 2018). Ground surface is 0.24m above top of slope inclinometer casing.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

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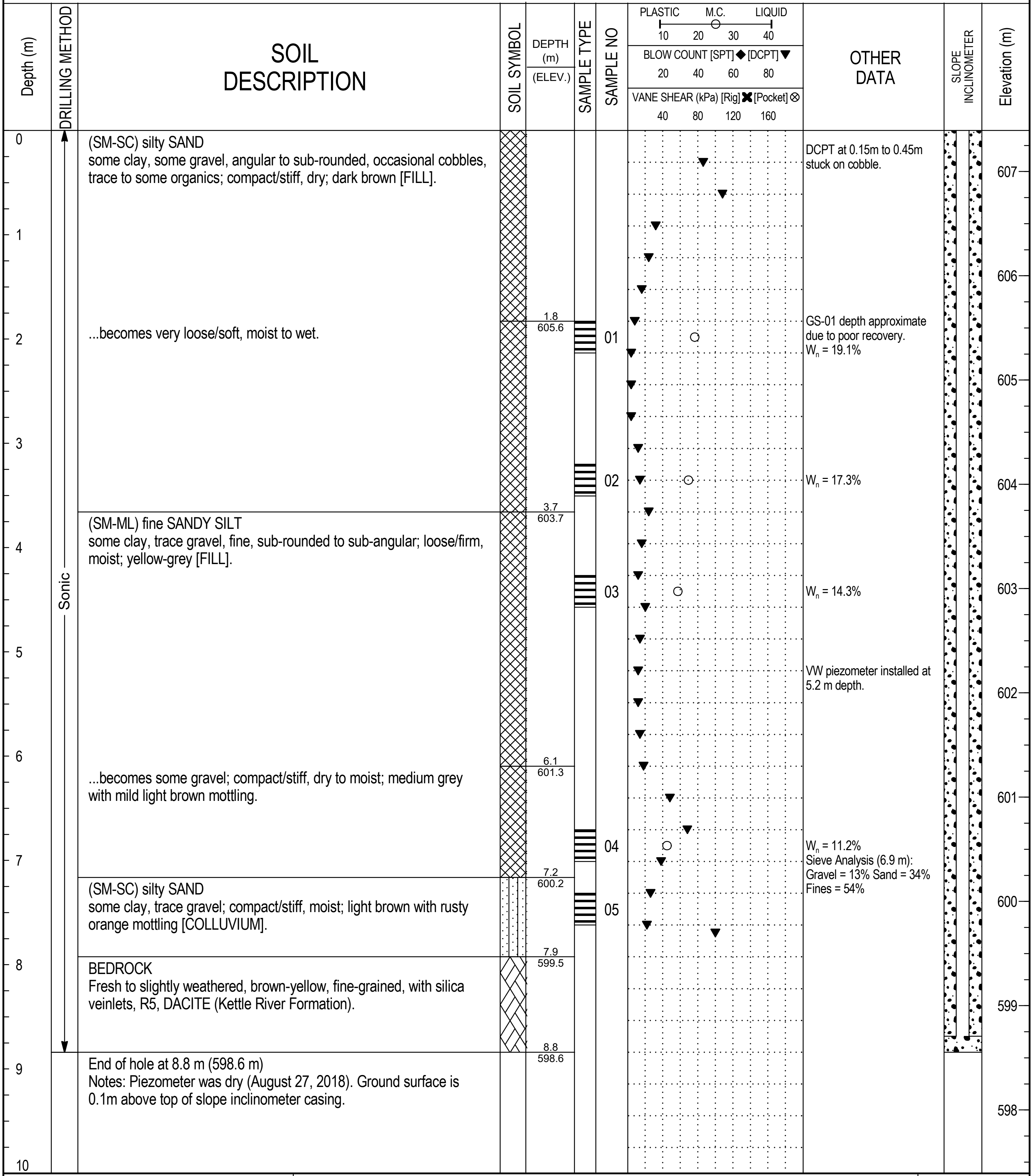
RECORD OF BOREHOLE BH18-05
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253	Co-ordinate: 11 330499.59E 5526009.41N
Date Drilled: Aug 10-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 607.4 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY

INSTALLATION: ⁙ GROUT ■ BENTONITE ⁙ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

Depth (m)	Drilling Method	Soil Description	Depth (m) (Elev.)	Sample Type	Sample No	Other Data
0	Sonic	(SM-SC) silty SAND some clay, some gravel, angular to sub-rounded, occasional cobbles, trace to some organics; compact/stiff, dry; dark brown [FILL].				DCPT at 0.15m to 0.45m stuck on cobble.
2		...becomes very loose/soft, moist to wet.	1.8 605.6	☰	01	GS-01 depth approximate due to poor recovery. W_n = 19.1%
3.5				☰	02	W_n = 17.3%
4		(SM-ML) fine SANDY SILT some clay, trace gravel, fine, sub-rounded to sub-angular; loose/firm, moist; yellow-grey [FILL].	3.7 603.7			
4.5				☰	03	W_n = 14.3%
5						VW piezometer installed at 5.2 m depth.
6.5		...becomes some gravel; compact/stiff, dry to moist; medium grey with mild light brown mottling.	6.1 601.3			
7				☰	04	W_n = 11.2% Sieve Analysis (6.9 m): Gravel = 13% Sand = 34% Fines = 54%
7.5		(SM-SC) silty SAND some clay, trace gravel; compact/stiff, moist; light brown with rusty orange mottling [COLLUVIUM].	7.2 600.2	☰	05	
8		BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	7.9 599.5			
9		End of hole at 8.8 m (598.6 m) Notes: Piezometer was dry (August 27, 2018). Ground surface is 0.1m above top of slope inclinometer casing.	8.8 598.6			



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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 1 of 1

RECORD OF BOREHOLE BH18-06

2045 Loseth Road Pump Station
City of Kelowna

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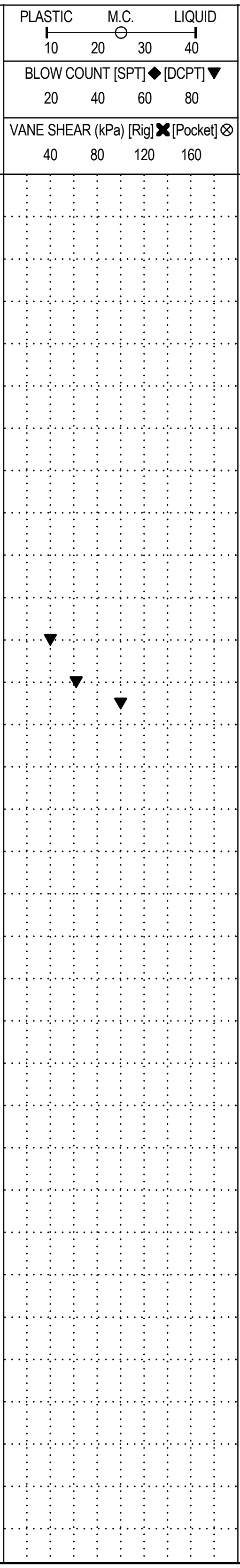
Date Drilled:	Aug 03-2018
Drill Type:	Sonic
Driller:	Mud Bay Drilling
Elevation:	608.0 m [Survey]
Project No.:	018-253
Co-ordinate:	11 330509.53E 5526000.32N

SAMPLE TYPE: ☒ SPT SAMPLE; ☰ GRAB SAMPLE; ▥ SHELBY TUBE; ▮ CORE SAMPLE; ■ NO RECOVERY

INSTALLATION: ⁘ GROUT; ■ BENTONITE; ⁘ SAND; ▨ DRILL CUTTINGS; ⊟ SCREEN

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	OTHER DATA
0	Hydrovac	ASPHALT	0.1 607.9	
		(SM) gravelly silty SAND fine-grained to coarse-grained sand, fine to coarse gravel, sub-rounded; compact, moist; yellow-brown [FILL].	2.4 605.6	
	Sonic	ROCK FILL	2.6 605.4	
3		(SM-GM) gravelly silty SAND fine-grained to coarse-grained sand, fine to coarse sub-rounded gravel; compact, moist; yellow-brown [COLLUVIUM].	3.7 604.3	VW piezometer installed at 3.5 m depth.
4		BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	5.8 602.2	
6		End of hole at 5.8 m (602.2 m) Notes: Piezometer max head elevation 605.9 m (November 1, 2018). Ground surface is 0.18 m above top of slope inclinometer casing.		

Columns: SOIL SYMBOL; SAMPLE TYPE; SAMPLE NO; SLOPE INCLINOMETER; Elevation (m) Water Level



Depth (m): 0 1 2 3 4 5 6 7 8 9 10

Elevation (m): 607 606 605 604 603 602 601 600 599

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 1 of 1

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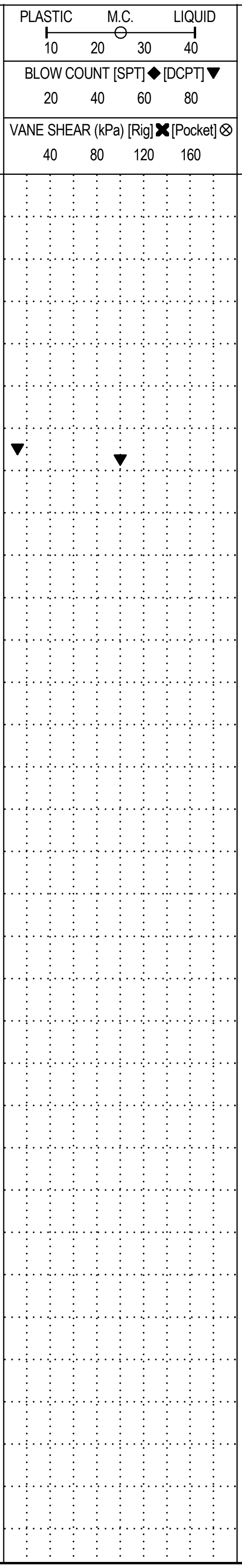
RECORD OF BOREHOLE BH18-08
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253	Co-ordinate: 11 330496.57E 5525986.05N
Date Drilled: Aug 03-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 609.4 m [Survey]

SAMPLE TYPE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY

INSTALLATION ⁘ GROUT ■ BENTONITE ⁘ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO
0	Hydrovac	ASPHALT	0.1 609.3		
		(SP/GP) SAND and GRAVEL fine-grained tocoarse-grained sand, sub-rounded gravel, trace to some fines, occasional cobbles; compact, moist; medium to dark brown [FILL].	1.2 608.2	☰	01
1		ROCK FILL	1.4 608.0		
	DCPT	(SM-ML) sandy SILT some clay, trace gravel, sub-angular to angular; loose to compact, moist; grey brown [FILL].	2.1 607.4	☰	02
2		BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	2.1 607.3		
		End of hole at 2.1 m (607.4 m)			



OTHER DATA

Elevation (m): 609, 608, 607, 606, 605, 604, 603, 602, 601, 600

Depth (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

RECORD OF BOREHOLE BH18-09

2045 Loseth Road Pump Station

City of Kelowna

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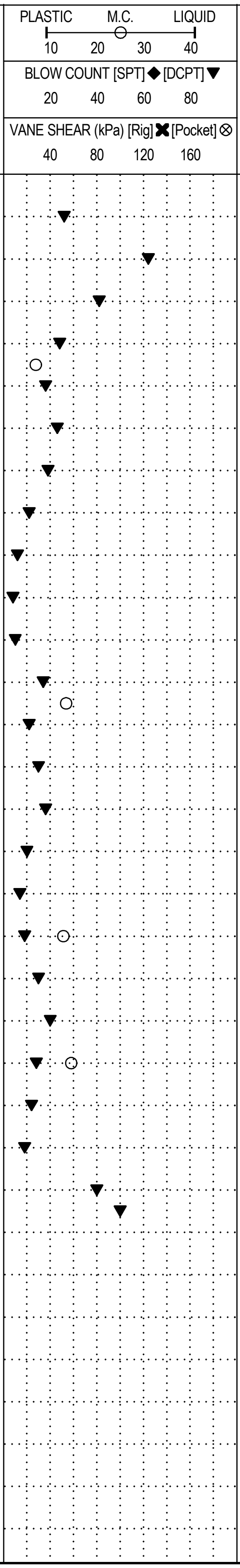
Project No.: 018-253
Co-ordinate: 11 330491.27E 5525999.77N

Date Drilled: Aug 09-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 609.0 m [Survey]

SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	▨ GROUT	■ BENTONITE	▨ SAND	▨ DRILL CUTTINGS	⊟ SCREEN

Drilling method: Sonic (0 to 8.8 m)

SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
ROCK FILL angular rock from pad building.	0.3 608.6			DCPT results skewed from surface to about 1 m depth due to rocks.
(SM-GM) silty SAND some gravel, fine to coarse, angular to sub-rounded, trace to some clay, inferred occasional cobbles and boulders; inferred compact, dry; light brown [FILL].	2.4 606.5	☰	01	W_n = 6.9%
(SM-SC) fine sandy SILT some clay, trace gravel, sub-angular to sub-rounded, trace cobbles; loose to compact (variable density), moist; brown-grey [FILL].	3.2 605.8			
ROCK FILL angular	3.5 605.4			
(SM-SC) fine sandy SILT trace to some clay, trace gravel, sub-angular to sub-rounded, trace cobbles; loose to compact / stiff to very stiff (variable density), moist; brown-grey [FILL].	6.9 602.1	☰ ☰ ☰	02 03 04	W_n = 13.4% W_n = 12.8% VW piezometer installed at 6.1 m depth. W_n = 14.5% Variable density between 5.8 m and 6.9 m.
(SM-GM) silty SAND some clay, some gravel, angular to sub-rounded, some organics (roots); compact, moist to wet; dark black-grey [FILL].	7.5 601.5	☰	05	Spongey.
BEDROCK Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).	8.8 600.1			
End of hole at 8.8 m (600.1 m) Notes: Ground surface is 0.95 m below top of slope inclinometer casing.				



Depth (m): 0 – 10; Elevation (m): 608 – 600; SLOPE INCLINOMETER

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 1 of 1

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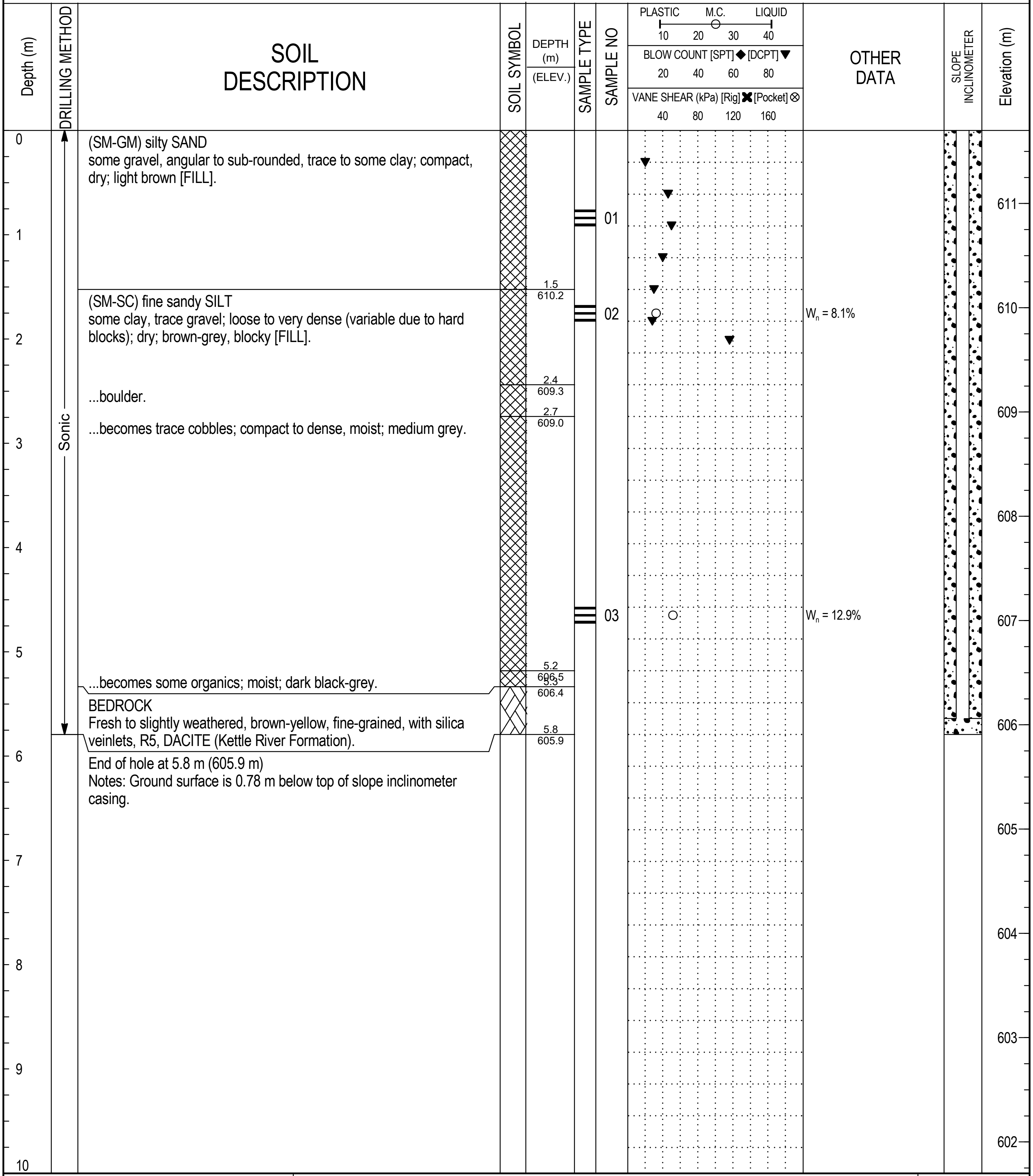
RECORD OF BOREHOLE BH18-10
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253	Co-ordinate: 11 330469.61E 5525977.12N
Date Drilled: Aug 10-2018	
Drill Type: Sonic	
Driller: Mud Bay Drilling	
Elevation: 611.7 m [Survey]	

SAMPLE TYPE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY
INSTALLATION ⁘ GROUT ■ BENTONITE ⁘ SAND ▨ DRILL CUTTINGS ⊟ SCREEN



SOIL DESCRIPTION

(SM-GM) silty SAND
some gravel, angular to sub-rounded, trace to some clay; compact, dry; light brown [FILL].

(SM-SC) fine sandy SILT
some clay, trace gravel; loose to very dense (variable due to hard blocks); dry; brown-grey, blocky [FILL].

...boulder.

...becomes trace cobbles; compact to dense, moist; medium grey.

...becomes some organics; moist; dark black-grey.

BEDROCK
Fresh to slightly weathered, brown-yellow, fine-grained, with silica veinlets, R5, DACITE (Kettle River Formation).

End of hole at 5.8 m (605.9 m)
Notes: Ground surface is 0.78 m below top of slope inclinometer casing.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw

RECORD OF BOREHOLE BH18-11

2045 Loseth Road Pump Station

City of Kelowna

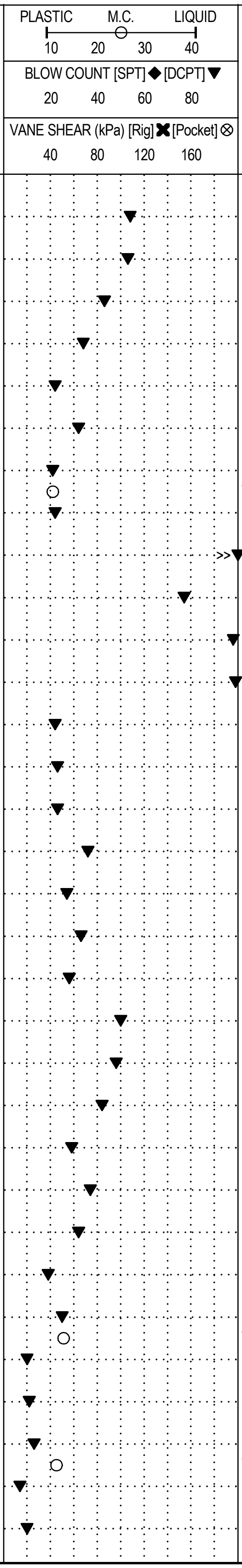
Date Drilled: Aug 19-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 610.1 m [Survey]
Project No.: 018-253	Co-ordinate: 11 330457.98E 5525995.02N

SAMPLE TYPE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY

INSTALLATION ⁘ GROUT ■ BENTONITE ⁘ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

DRILLING METHOD: Sonic (0 – 10 m)

Depth (m)	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE NO	OTHER DATA
0	(SM-GM) gravelly SAND sub-rounded to sub-angular, some silt, trace clay; dense; brown [FILL].			
1.5	...becomes compact.	1.5 608.6		
2.1	(SM-SC) SILT and SAND some clay, some gravel; sub-angular to angular; compact, moist; brown [FILL].	2.1 608.0	01	W_n = 10.5%
2.7	ROCK FILL angular fragments up to 15 cm, local dacite lithology; light grey-orange.	2.7 607.4		
4				Poor sample recovery.
5.3			02	
8.0			03	
8.2	(SM-SC) fine sandy SILT some clay, trace gravel, sub-rounded to sub-angular; loose to compact, wet; brown [FILL].	8.2 601.9	04	W_n = 12.8%
8.8	...becomes trace cobbles, sub-rounded to sub-angular; loose / firm.	8.8 601.3	05	W_n = 11.3%



Elevation (m): 610, 609, 608, 607, 606, 605, 604, 603, 602, 601

SLOPE INCLINOMETER

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: jp
DRAWN: ms/hkw

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RECORD OF BOREHOLE BH18-11

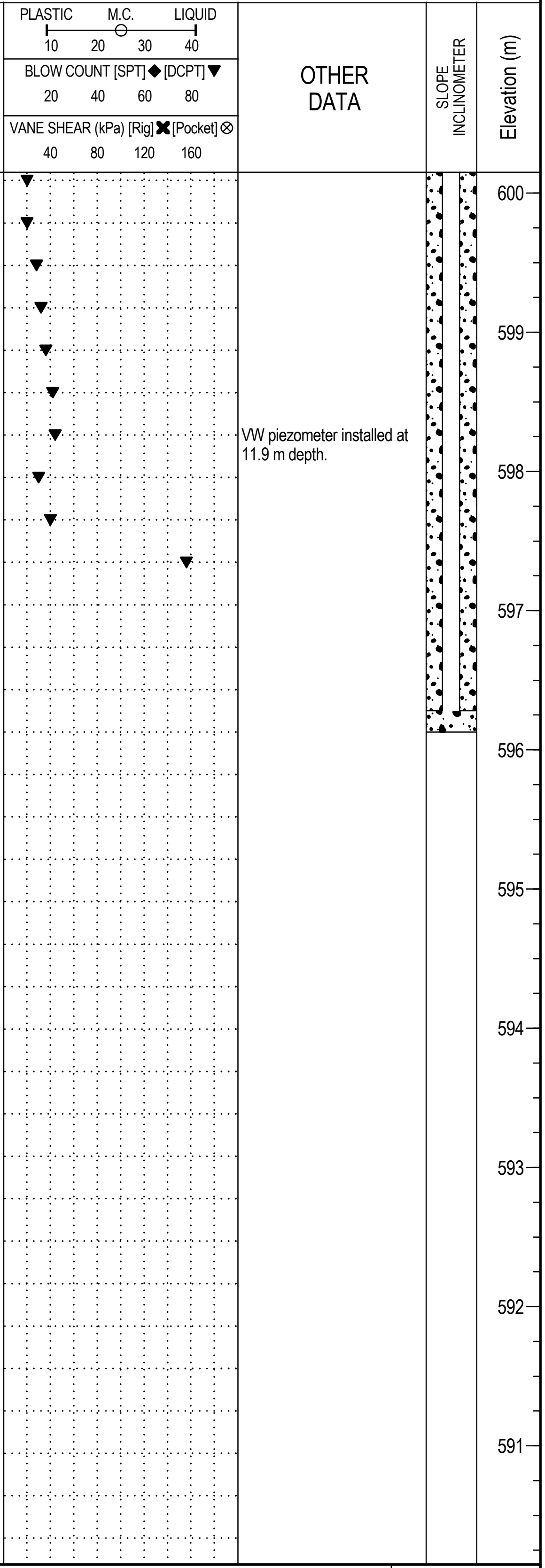
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330457.98E 5525995.02N
Date Drilled: Aug 19-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 610.1 m [Survey]

SAMPLE TYPE: ☒ SPT SAMPLE; ☰ GRAB SAMPLE; ▥ SHELBY TUBE; ▮ CORE SAMPLE; ■ NO RECOVERY

INSTALLATION: ⁘ GROUT; ■ BENTONITE; ⁘ SAND; ▨ DRILL CUTTINGS; ⊟ SCREEN

Depth (m)	Drilling Method	Soil Description	Depth (m) (Elev.)	Sample Type	Sample No	Other Data
10	Sonic					
11		...becomes loose to compact / firm to stiff.	11.0 599.2			
		...becomes with angular fragments; wet; orange to light grey.	11.6 598.6			
12				☰	06	VW piezometer installed at 11.9 m depth.
		WEATHERED BEDROCK Highly weathered, orange to light grey, fine-grained, clayey, dry, R1, DACITE (Kettle River Formation).	12.5 597.7			
13		**BEDROCK** Fresh to slightly weathered, light orange-grey, fine-grained, with silica veinlets, dry, R5, DACITE (Kettle River Formation).	12.8 597.3	☰	07	
14				☰	087	
		End of hole at 14.0 m (596.1 m) Notes: Ground surface is 0.1 m above top of slope inclinometer casing.	14.0 596.1			



Depth (m): 10 11 12 13 14 15 16 17 18 19 20

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: jp
DRAWN: ms/hkw

RECORD OF BOREHOLE BH18-12

2045 Loseth Road Pump Station

City of Kelowna

westrek geotechnical services ltd.

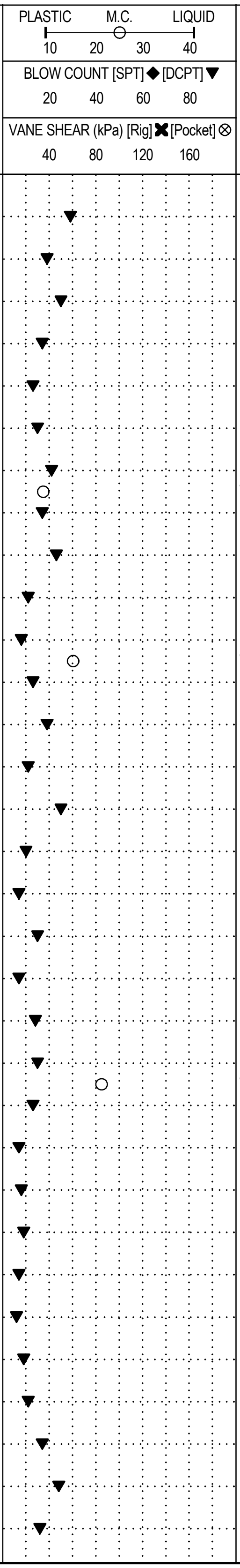
Project No.: 018-253	Co-ordinate: 11 330474.1E 5525998.84N
Date Drilled: Aug 19-2018	Drill Type: Sonic
Driller: Mud Bay Drilling	Elevation: 610.0 m [Survey]

SAMPLE TYPE ☒ SPT SAMPLE ☰ GRAB SAMPLE ▥ SHELBY TUBE ▮ CORE SAMPLE ■ NO RECOVERY

INSTALLATION ▨ GROUT ■ BENTONITE ▨ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

Drilling method: Sonic (0–10 m)

Depth (m)	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	OTHER DATA
0	(GM-GC) gravelly SAND to SAND and GRAVEL sub-rounded to angular, some silt, some clay; loose to compact, moist; brown [FILL].				
2.3			☰	01	W_n = 8.7% Sieve Analysis (2.3 m): Gravel = 47% Sand = 32% Fines = 21%
2.7	...becomes some angular to sub-angular blocks (max 6 cm); moist to wet.	2.7 607.2			
3.5			☰	02	W_n = 15.1%
5.0	...becomes loose.	5.0 605.0			
6.1	(SM) silty SAND some gravel, fine, sub-rounded to sub-angular, some clay, trace organics (rootlets, pieces of wood, charcoal); loose, wet; dark brown, likely poorly stripped topsoil mixed with fill [FILL].	6.1 603.9			
6.6			☰	03	W_n = 21.2%
9.1	...becomes some organics (woody fragments up to 5 cm, roots, charcoal); loose, wet; dark brown-black.	9.1 600.8			



Elevation (m): 609, 608, 607, 606, 605, 604, 603, 602, 601

SLOPE INCLINOMETER

WESTREK SOIL BOREHOLE LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - NO PPEN.GPJ WGS SOIL LOG.GDT 18-12-20

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: jp
DRAWN: ms/hkw

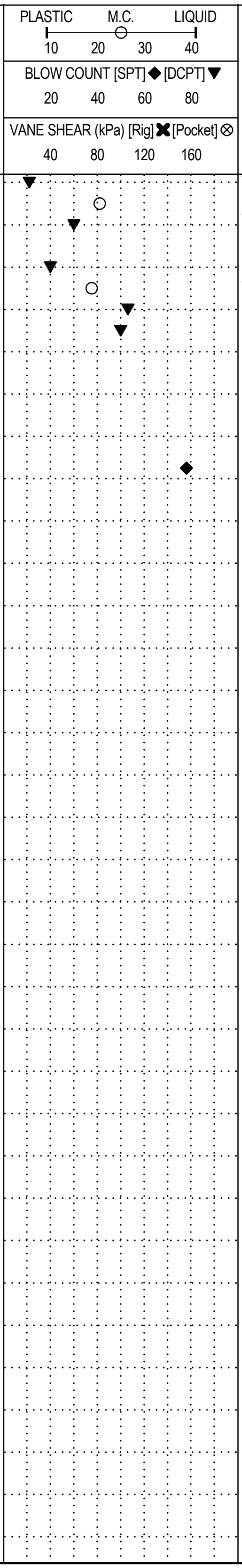
westrek geotechnical services ltd.

RECORD OF BOREHOLE BH18-12

2045 Loseth Road Pump Station
City of Kelowna

Date Drilled:	Aug 19-2018
Drill Type:	Sonic
Driller:	Mud Bay Drilling
Project No.:	018-253
Co-ordinate:	11 330474.1E 5525998.84N
Elevation:	610.0 m [Survey]

SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	⁘ GROUT	■ BENTONITE	⁘ SAND	▨ DRILL CUTTINGS	⊟ SCREEN



Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	DEPTH (m) (ELEV.)	SAMPLE NO	OTHER DATA	Elevation (m)
10	Sonic	...becomes gravelly, sub-rounded to sub-angular, trace organics.	10.5 599.4	04 05	VW piezometer installed at 10.1 m depth. W_n = 20.5% W_n = 18.8%	
11		WEATHERED BEDROCK Highly weathered, brown-yellow, fine-grained, with silica veinlets, dry, R1, DACITE (Kettle River Formation).	11.0 599.0	06 01	N = 78	599
12		BEDROCK Moderately weathered, orange to light grey, fine-grained, with silica veinlets, dry, R2, DACITE (Kettle River Formation).	12.2 597.8	07 08		598 597
13		...becomes fresh, R5.	13.4 596.5	09		
14		End of hole at 13.9 m (596.1 m) Notes: Ground surface is 0.09 m above top of slope inclinometer casing.	13.9 596.1			596
15						595
16						594
17						593
18						592
19						591
20						

WESTREK SOIL BOREHOLE LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - NO PPEN.GPJ WGS SOIL LOG.GDT 18-12-20

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: jp
DRAWN: ms/hkw

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RECORD OF BOREHOLE BH18-13

2045 Loseth Road Pump Station

City of Kelowna

Project No.: 018-253	Co-ordinate: 11 330491.59E 5526048.48N
Date Drilled: Aug 16-2018	Drill Type: ODEX
Driller: Mud Bay Drilling	Elevation: 589.0 m [Survey]

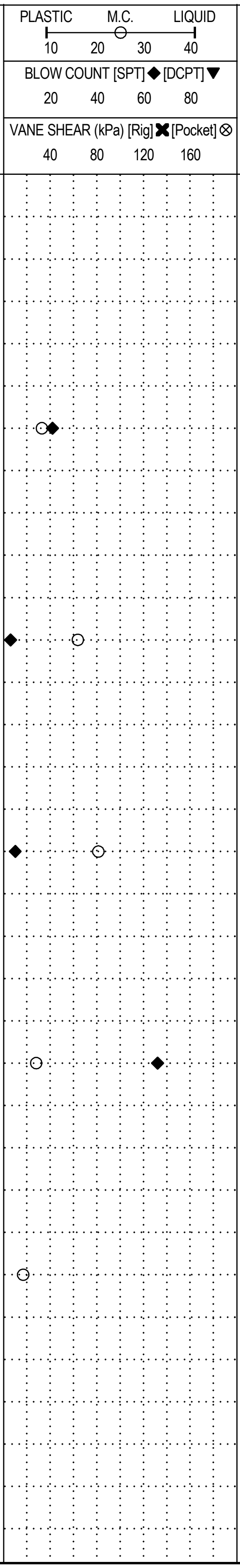
SAMPLE TYPE: ☒ SPT SAMPLE · ☰ GRAB SAMPLE · ▥ SHELBY TUBE · ▮ CORE SAMPLE · ■ NO RECOVERY

INSTALLATION: ⁘ GROUT · ■ BENTONITE · ⁘ SAND · ▨ DRILL CUTTINGS · ⊟ SCREEN

Columns: Depth (m) · DRILLING METHOD · SOIL DESCRIPTION · SOIL SYMBOL · DEPTH (m) (ELEV.) · SAMPLE TYPE · SAMPLE NO · PLASTIC / M.C. / LIQUID (10 20 30 40) · BLOW COUNT [SPT] ◆ [DCPT] ▼ (20 40 60 80) · VANE SHEAR (kPa) [Rig] ✖ [Pocket] ⊗ (40 80 120 160) · OTHER DATA · SLOPE INCLINOMETER · Elevation (m)

Drilling method: ODEX

Depth (m) (Elev.)	Soil Description
0	**(SC-SM) SILTY SAND** fine-grained to medium-grained, some clay, trace gravel, angular; loose to compact, moist; medium to dark brown [FILL].
2.1 (586.9)	...boulder.
2.4 (586.5)	...inferred occasional cobbles, trace organics; loose, moist; brown-grey [FILL].
4.9 (584.1)	...encountered cobble or small boulder midway into SPT.
6.2 (582.7)	**(SM-GM) silty SAND** some gravel, sub-rounded to sub-angular, trace to some clay, inferred occasional cobbles; dense, dry; medium brown [TILL].
8.5 (580.4)	...becomes trace gravel.



Sample No	Sample Type	Other Data
01	SPT	N = 21 W_n = 8.2% REC = 42% SPT for SS-01 had rock in shoe. Rock in bit from 2.1 m to 2.4 m but soil is soft.
02	SPT	N = 3 W_n = 15.9% Sieve Analysis (3.4 m): Gravel = 11% Sand = 41% Fines = 48% REC = 58%
03	SPT	N = 5 W_n = 20.3% REC = 50% VW piezometer installed at 5.5 m depth.
04	SPT	N = 66 W_n = 7.0% Sieve Analysis (6.4 m): Gravel = 16% Sand = 47% Fines = 37% REC = 100%
05	SPT	W_n = 4.2% REC = 67%
06	SPT	REC = 88%

Depth (m)	Elevation (m)
0	
1	588
2	587
3	586
4	585
5	584
6	583
7	582
8	581
9	580
10	

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: m[illegible]/hkw

RECORD OF BOREHOLE BH18-13
2045 Loseth Road Pump Station
City of Kelowna

Date Drilled:	Aug 16-2018
Drill Type:	ODEX
Driller:	Mud Bay Drilling
Project No.:	018-253
Co-ordinate:	11 330491.59E 5526048.48N
Elevation:	589.0 m [Survey]

SAMPLE TYPE ☒ SPT SAMPLE ▤ GRAB SAMPLE ▥ SHELBY TUBE ◧ CORE SAMPLE ■ NO RECOVERY
INSTALLATION ⁘ GROUT ■ BENTONITE ⁘ SAND ▨ DRILL CUTTINGS ⊟ SCREEN

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	SOIL SYMBOL	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	PLASTIC M.C. LIQUID 10 20 30 40 BLOW COUNT [SPT]◆ [DCPT]▼ 20 40 60 80 VANE SHEAR (kPa) [Rig]✖ [Pocket]⊗ 40 80 120 160	OTHER DATA	SLOPE INCLINOMETER	Elevation (m)
10	ODEX									
		End of hole at 10.7 m (578.3 m) Notes: Ground surface is 0.14 m above top of slope inclinometer casing.								
11										578
12										577
13										576
14										575
15										574
16										573
17										572
18										571
19										570
20										

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 2 of 2

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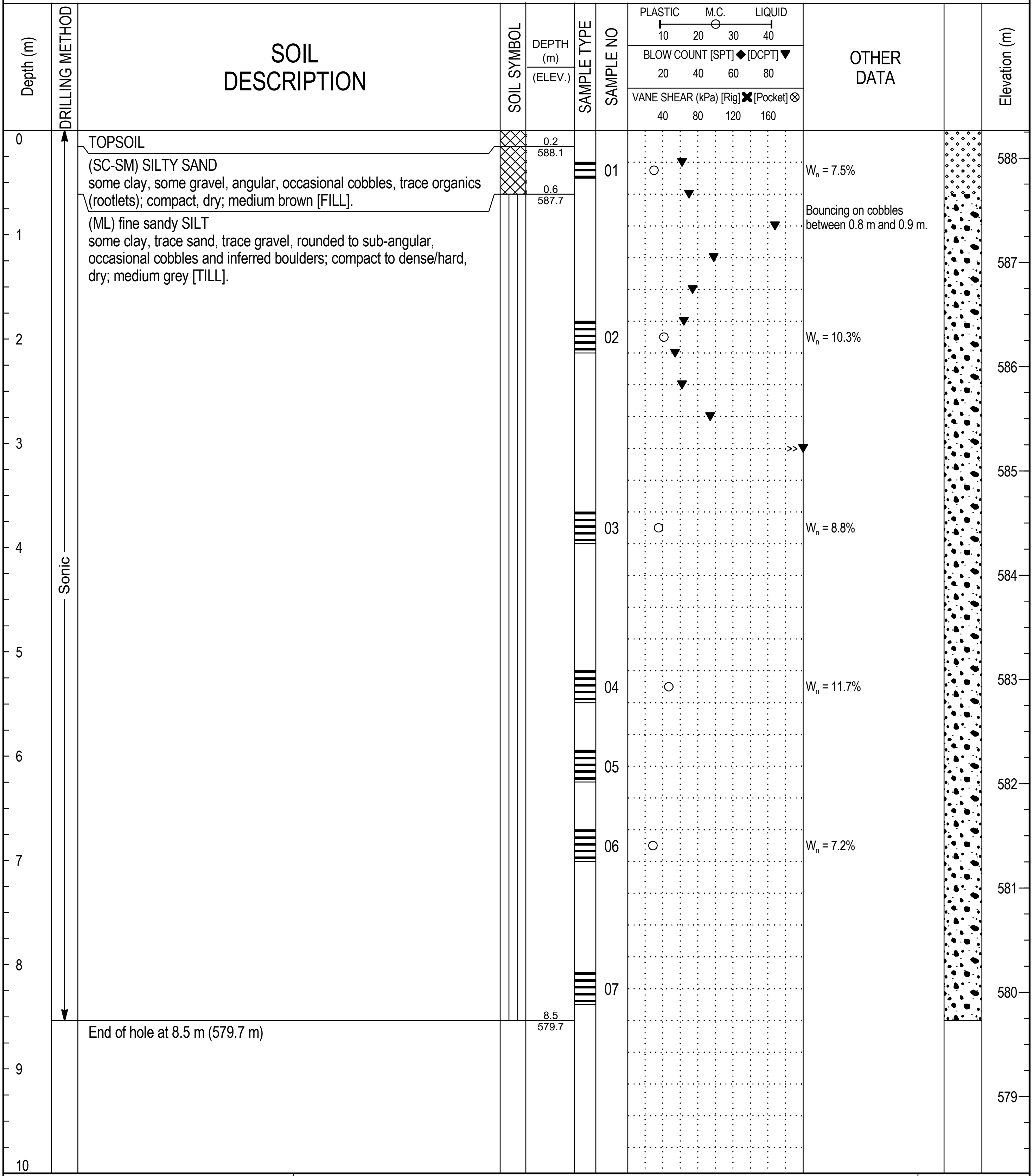
RECORD OF BOREHOLE BH18-14
2045 Loseth Road Pump Station
City of Kelowna

Project No.: 018-253
Co-ordinate: 11 330475.43E 5526037.09N

Date Drilled: Aug 11-2018
Drill Type: Sonic
Driller: Mud Bay Drilling
Elevation: 588.3 m [Survey]

SAMPLE TYPE	☒ SPT SAMPLE	☰ GRAB SAMPLE	▥ SHELBY TUBE	▮ CORE SAMPLE	■ NO RECOVERY
INSTALLATION	⁘ GROUT	■ BENTONITE	⁘ SAND	▨ DRILL CUTTINGS	⊟ SCREEN



TOPSOIL

(SC-SM) SILTY SAND
some clay, some gravel, angular, occasional cobbles, trace organics (rootlets); compact, dry; medium brown [FILL].

(ML) fine sandy SILT
some clay, trace sand, trace gravel, rounded to sub-angular, occasional cobbles and inferred boulders; compact to dense/hard, dry; medium grey [TILL].

End of hole at 8.5 m (579.7 m)

DEPTH (m)	(ELEV.)
0.2	588.1
0.6	587.7
8.5	579.7

SAMPLE NO	OTHER DATA
01	W_n = 7.5%
	Bouncing on cobbles between 0.8 m and 0.9 m.
02	W_n = 10.3%
03	W_n = 8.8%
04	W_n = 11.7%
05	
06	W_n = 7.2%
07	

WESTREK SOIL BOREHOLE LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - NO PPEN.GPJ WGS SOIL LOG.GDT 18-12-20

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: ms/hkw
Page 1 of 1

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RECORD OF TEST PIT TP18-15

2045 Loseth Road Pump Station
City of Kelowna

Site Conditions:

Date Excavated: 2018-Aug-08
Equipment: Hitachi 210 excavator
Project No.: 018-253
Coordinates: 11 330467.35E 5526080.96N
Elevation: 1880.35 m [Survey]

PLASTIC M.C. LIQUID (20 40 60 80)
■ DCPT RESISTANCE [PORTABLE] ■ (20 40 60 80)
◆ POCKET PEN. UCS (kPa) ◆
⊗ TORVANE UCS (kPa) ⊗ (50 100 150 200)

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SAMPLE NO	OTHER DATA	Elevation (m)
0		TOPSOIL grass and roots			
	0.2 572.9	(SM-SC) fine sandy SILT some clay, some gravel, sub-rounded, trace rootlet or small piece of wood; compact, dry; light brown [FILL].			573
	0.5 572.6	... becomes dense.			
	0.7 572.4	... becomes occasional cobbles; medium brown, with rare charcoal.			
1					572
	1.6 571.5	... becomes some organics (roots); loose, moist; dark brown, spongey.			
	1.7 571.4	... garbage (household refuse) encountered.	1	W_n = 11.3%	
	1.8 571.3	... large boulders (up to 1.5 m) encountered during excavation.			
2					571
	2.5 570.6	(SM-SC) SILT and SAND some clay, trace gravel, trace organics; loose/firm, moist to wet; dark brown [COLLUVIUM].	2	W_n = 15.3% PL = 14.5% LL = 22.9% Sieve Analysis : Gravel = 8% Sand = 37% Fines = 54%	
3					570
	3.8 569.3	... seepage.			▼
4					569
	4.2 568.9	(SM-SC) SILT and SAND some clay, trace gravel, occasional cobbles and boulders; very dense, moist; grey [TILL].	3 4	W_n = 9.3% W_n = 8.1% Sieve Analysis : Gravel = 3% Sand = 40% Fines = 57%	
	4.4 (568.7)	End of hole at 4.4 m (568.7 m)			
5					

DCP Resistance
Number of blows of a 15 lb (6.8 kg) hammer dropped 10 inches (254 mm) to produce 1-3/4 inches (44 mm) of penetration of a 1.5 inch (38.1 mm) diameter, 45 degree cone.

LOGGED: hkw
DRAWN: hkw
Page 1 of 1

WESTREK TEST PIT LOG 018-098 BMID KIRSCHNER MOUNTAIN PUMP STATION SLIDE - TP15.GPJ WGS SOIL LOG.GDT 18-12-20

APPENDIX D

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 1

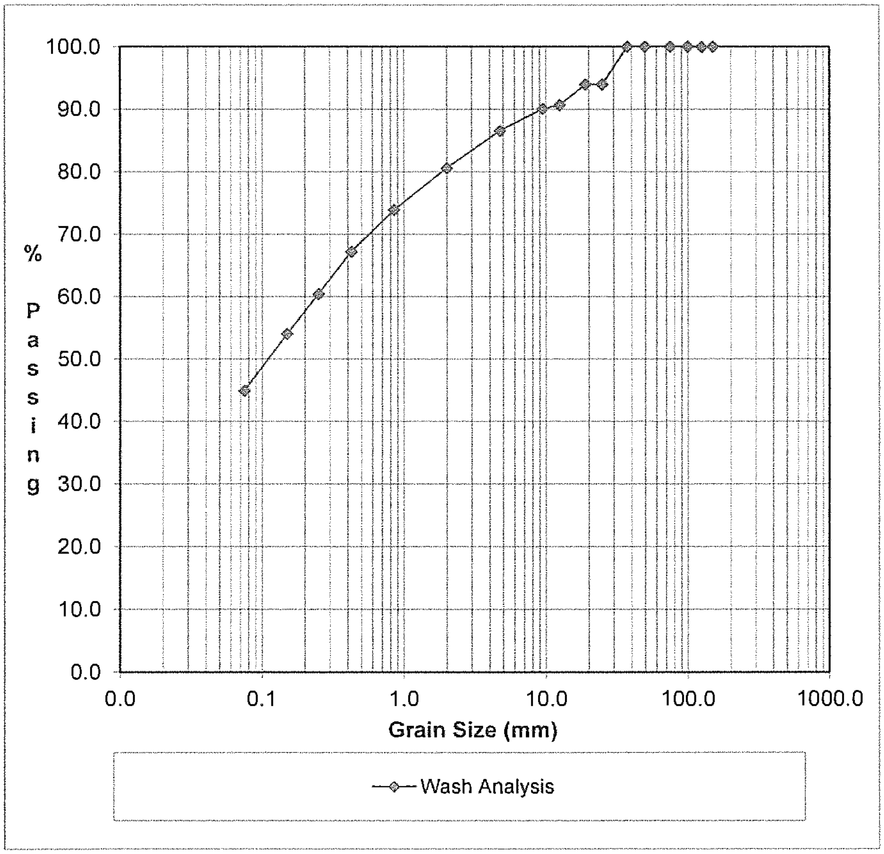
Source: BH 01 @ 32.5' - 33'
Grab Sample # 05

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	6.0	94.0		
19.0	0.0	94.0		
12.5	3.3	90.7		
9.5	0.6	90.1		
4.75	3.5	86.6		
2.000	5.9	80.6		
0.850	6.7	73.9		
0.425	6.7	67.2		
0.250	6.8	60.5		
0.150	6.5	54.0		
0.075	9.1	44.9		
PAN	44.9			

Sieve Mass (g): 949.5

Gravel	13.4 %
Sand	41.6 %
Fines	44.9 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 2

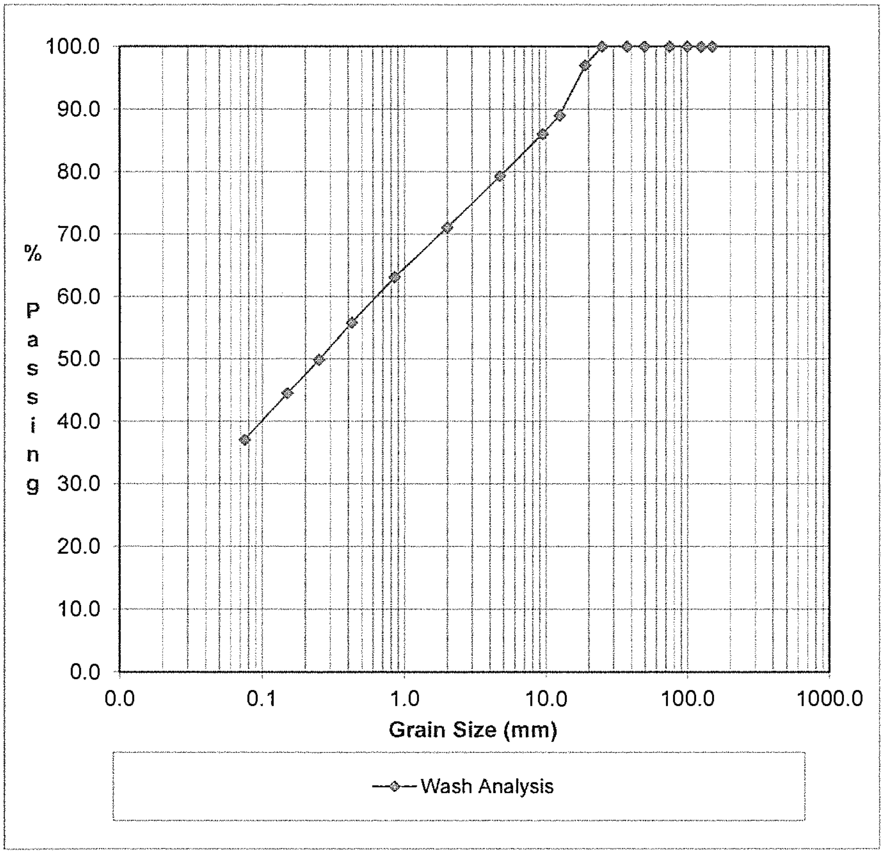
Source: BH 01 @ 42 - 42.5'
Grab Sample # 07

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	3.0	97.0		
12.5	8.0	89.0		
9.5	3.0	86.0		
4.75	6.7	79.3		
2.000	8.2	71.1		
0.850	8.0	63.1		
0.425	7.2	55.9		
0.250	6.0	49.8		
0.150	5.3	44.5		
0.075	7.5	37.0		
PAN	37.0			

Sieve Mass (g): 1030.9

Gravel	20.7 %
Sand	42.3 %
Fines	37.0 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

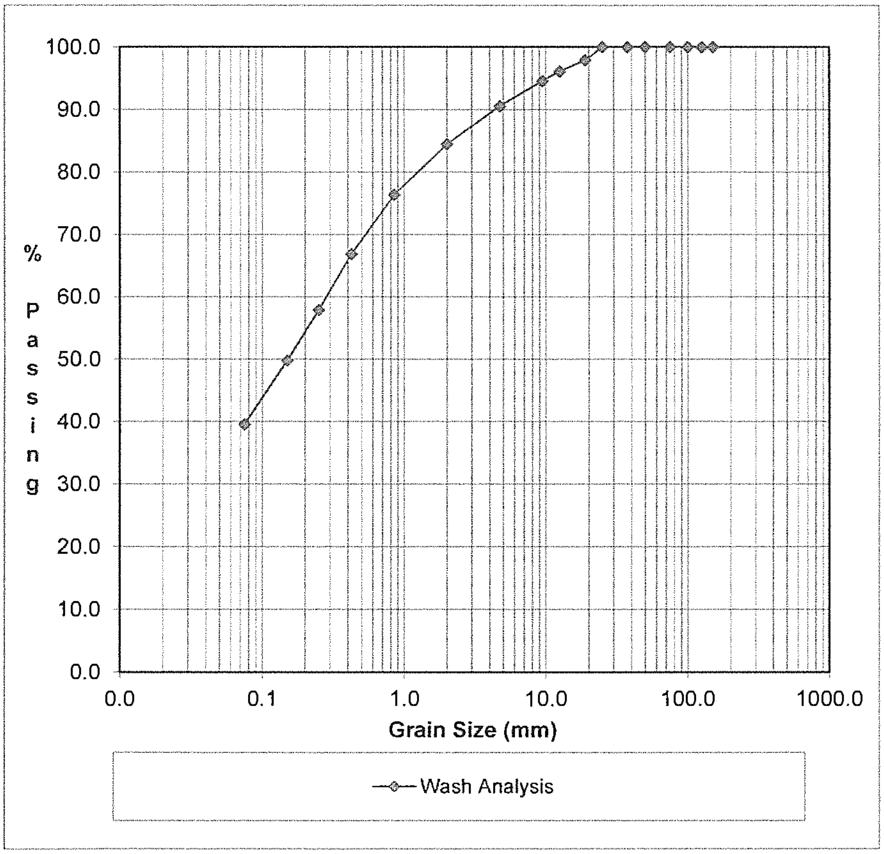
Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 3
Source: BH 01 @ 67 - 67.5'
Grab Sample # 08
Sample Type: Grab sample
Date Rec'd: Aug 27, 2018
By: Client
Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	2.1	97.9		
12.5	1.8	96.1		
9.5	1.6	94.6		
4.75	4.0	90.5		
2.000	6.1	84.5		
0.850	8.1	76.4		
0.425	9.5	66.9		
0.250	9.0	57.9		
0.150	8.1	49.8		
0.075	10.3	39.5		
PAN	39.5			

Sieve Mass (g): 967.1

Gravel	9.5 %
Sand	51.0 %
Fines	39.5 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 4

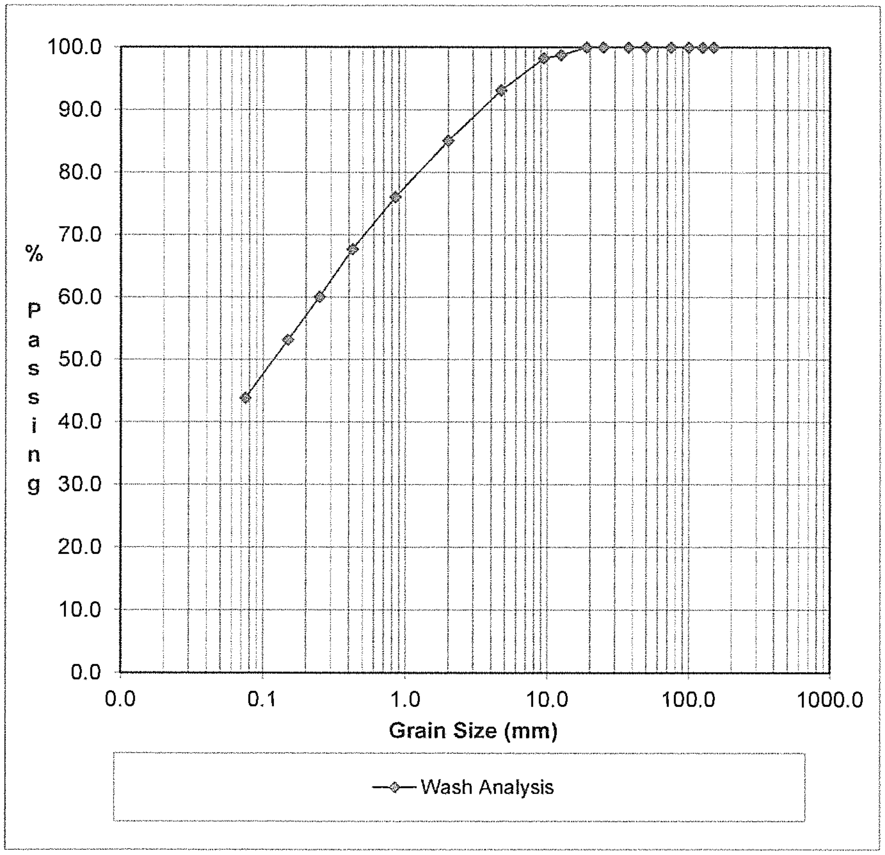
Date Rec'd: Aug 27, 2018

Source: BH 02 @ 31 - 31.5'
Grab Sample # 06

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	0.0	100.0		
12.5	1.3	98.7		
9.5	0.5	98.3		
4.75	5.2	93.1		
2.000	8.1	85.0		
0.850	9.0	76.1		
0.425	8.4	67.7		
0.250	7.6	60.1		
0.150	6.9	53.2		
0.075	9.4	43.8		
PAN	43.8			

Sieve Mass (g): 834.5

Gravel	6.9 %
Sand	49.3 %
Fines	43.8 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 5

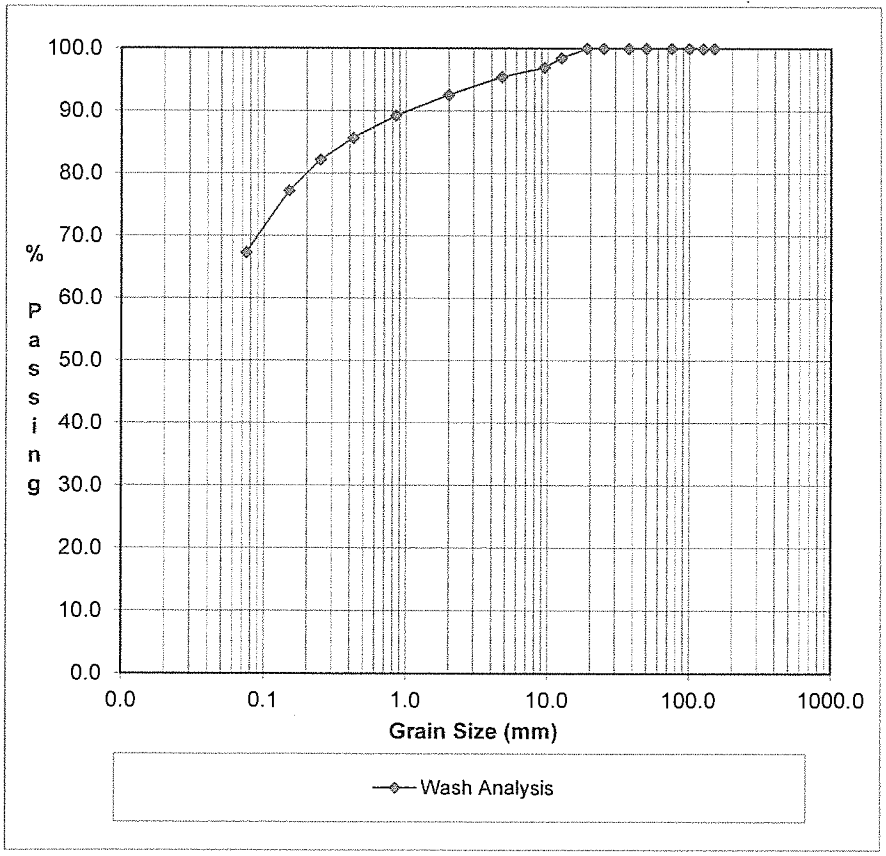
Date Rec'd: Aug 27, 2018

Source: BH 03 @ 4.5 - 5.0'
Grab Sample # 01

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	0.0	100.0		
12.5	1.5	98.5		
9.5	1.5	96.9		
4.75	1.5	95.4		
2.000	2.9	92.6		
0.850	3.4	89.2		
0.425	3.5	85.7		
0.250	3.6	82.1		
0.150	4.9	77.2		
0.075	9.9	67.3		
PAN	67.3			

Sieve Mass (g): 1440.9

Gravel	4.6 %
Sand	28.1 %
Fines	67.3 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 6

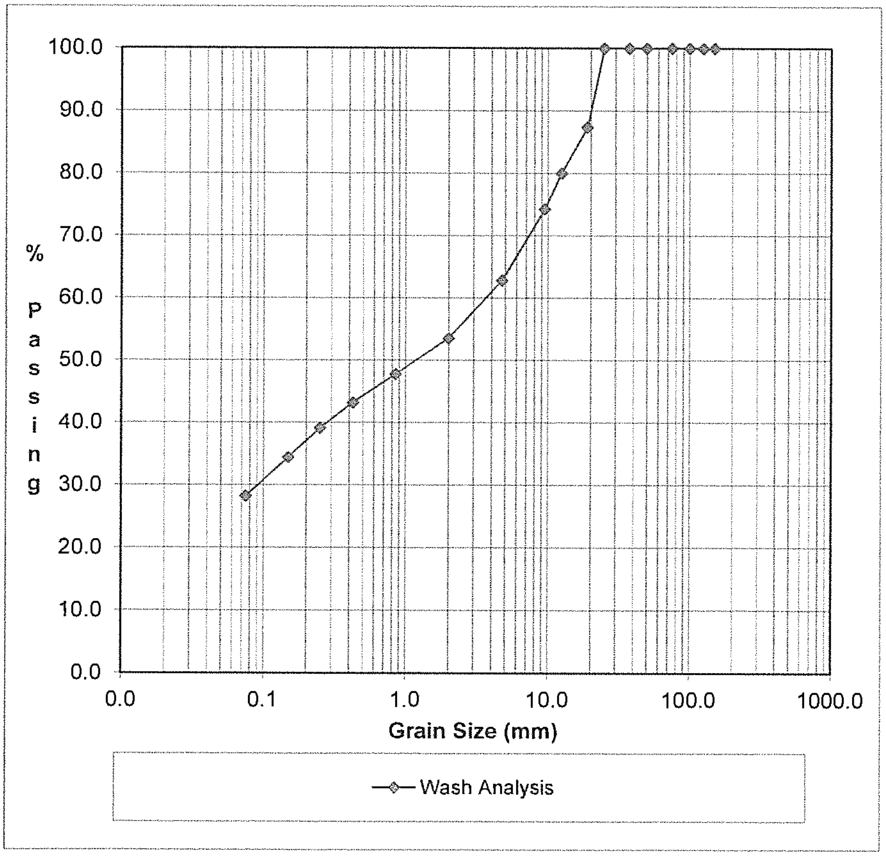
Date Rec'd: Aug 27, 2018

Source: BH 03 @ 33.5 - 34'
Grab Sample # 09

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	12.7	87.3		
12.5	7.4	80.0		
9.5	5.7	74.3		
4.75	11.4	62.8		
2.000	9.3	53.5		
0.850	5.8	47.7		
0.425	4.6	43.2		
0.250	4.1	39.1		
0.150	4.7	34.4		
0.075	6.2	28.2		
PAN	28.2			

Sieve Mass (g): 1199.6

Gravel	37.2 %
Sand	34.6 %
Fines	28.2 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 7

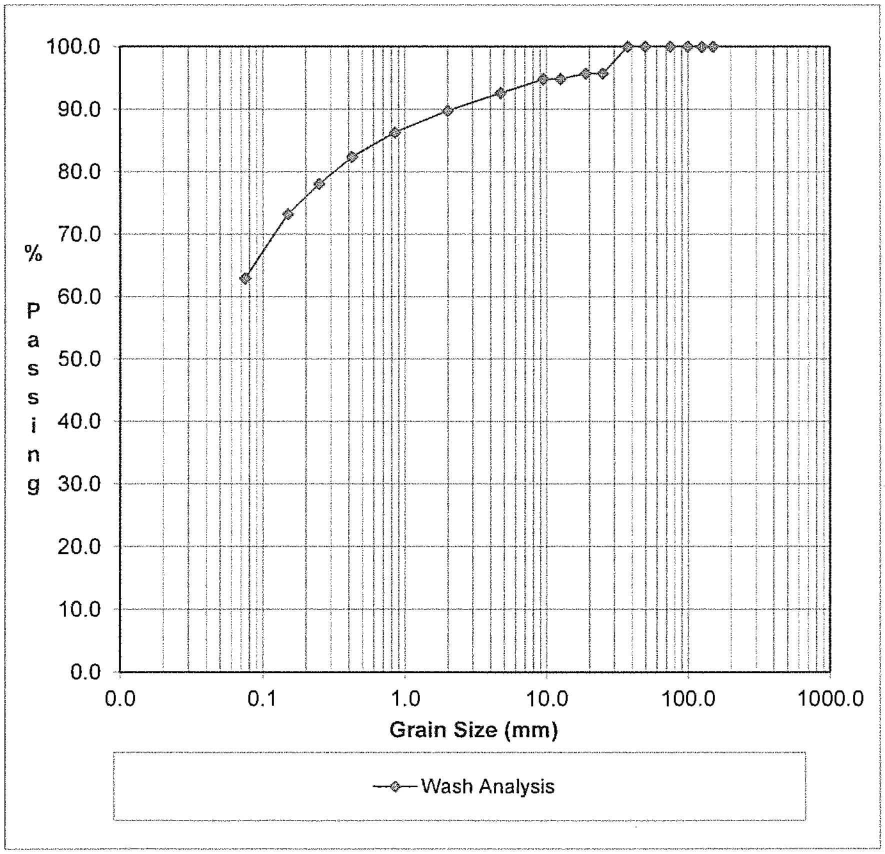
Source: BH 04 @ 11 - 11.5'
Grab Sample # 02

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	4.3	95.7		
19.0	0.0	95.7		
12.5	0.8	94.9		
9.5	0.1	94.8		
4.75	2.2	92.6		
2.000	2.8	89.8		
0.850	3.5	86.3		
0.425	3.9	82.4		
0.250	4.3	78.1		
0.150	4.9	73.2		
0.075	10.3	62.9		
PAN	62.9			

Sieve Mass (g): 1717.8

Gravel	7.4 %
Sand	29.7 %
Fines	62.9 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

Reporting of these test results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 8

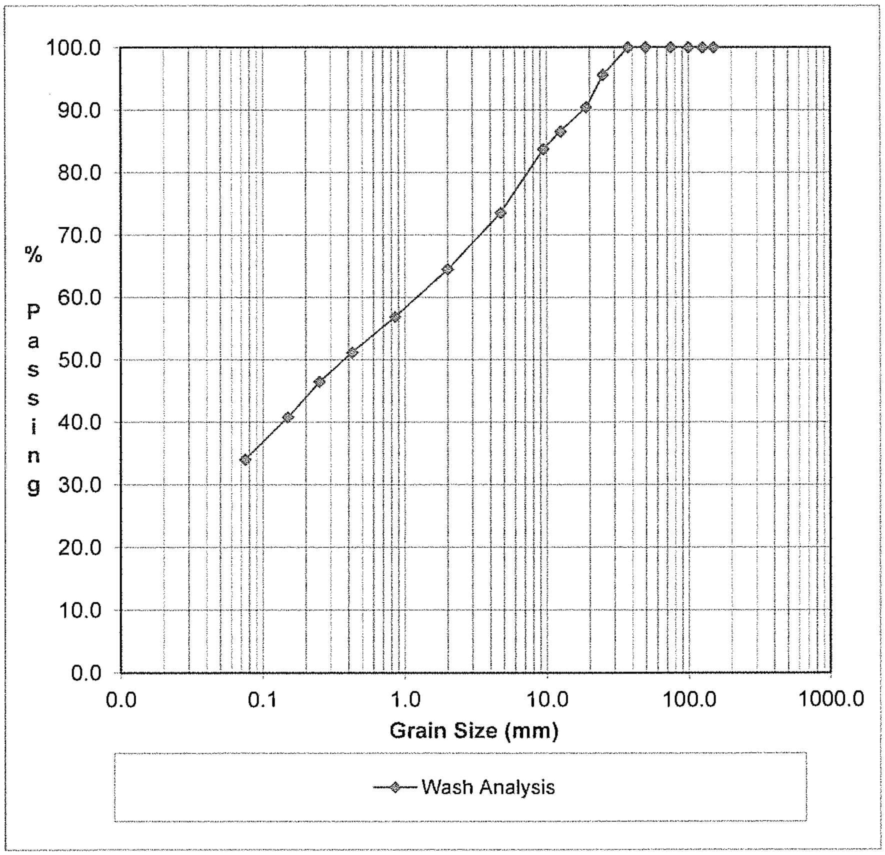
Source: BH 04 @ 17' 8" - 18'
Grab Sample # 07

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	4.4	95.6		
19.0	5.2	90.4		
12.5	3.8	86.6		
9.5	2.9	83.7		
4.75	10.2	73.5		
2.000	9.0	64.5		
0.850	7.6	56.9		
0.425	5.7	51.2		
0.250	4.7	46.4		
0.150	5.6	40.8		
0.075	6.8	34.0		
PAN	34.0			

Sieve Mass (g): 699.7

Gravel	26.5 %
Sand	39.5 %
Fines	34.0 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 9

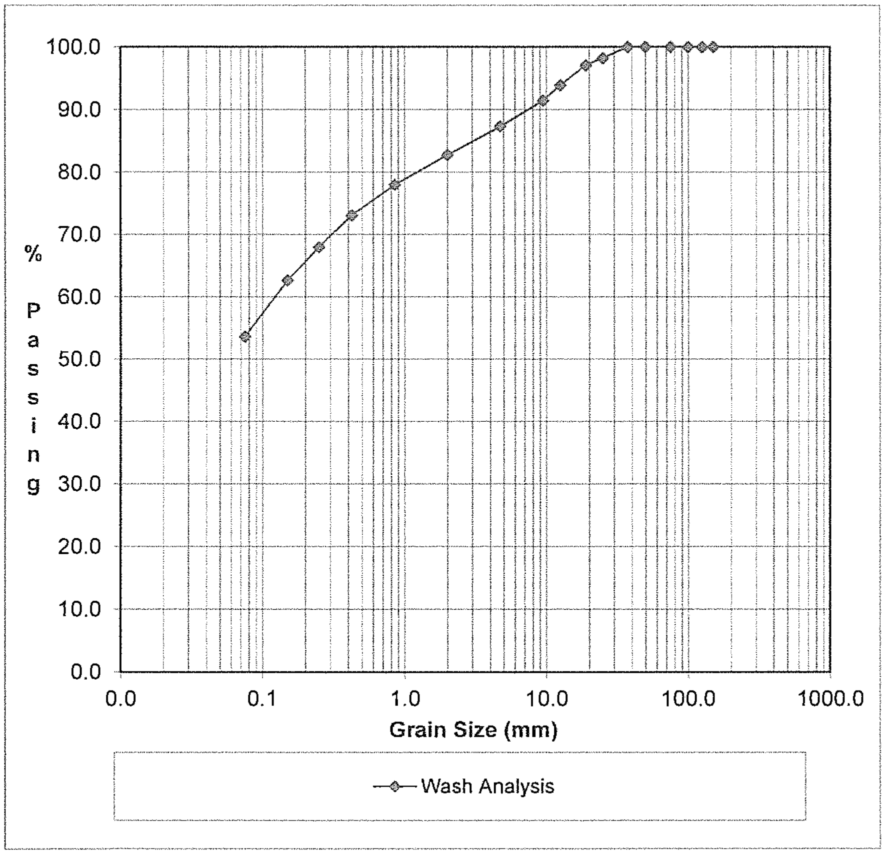
Date Rec'd: Aug 27, 2018

Source: BH 05 @ 22 - 23'
Grab Sample # 04

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	1.8	98.2		
19.0	1.1	97.1		
12.5	3.3	93.8		
9.5	2.4	91.4		
4.75	4.1	87.3		
2.000	4.6	82.7		
0.850	4.8	78.0		
0.425	4.9	73.1		
0.250	5.1	68.0		
0.150	5.3	62.6		
0.075	9.0	53.6		
PAN	53.6			

Sieve Mass (g): 1346.9

Gravel	12.7 %
Sand	33.7 %
Fines	53.6 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 10

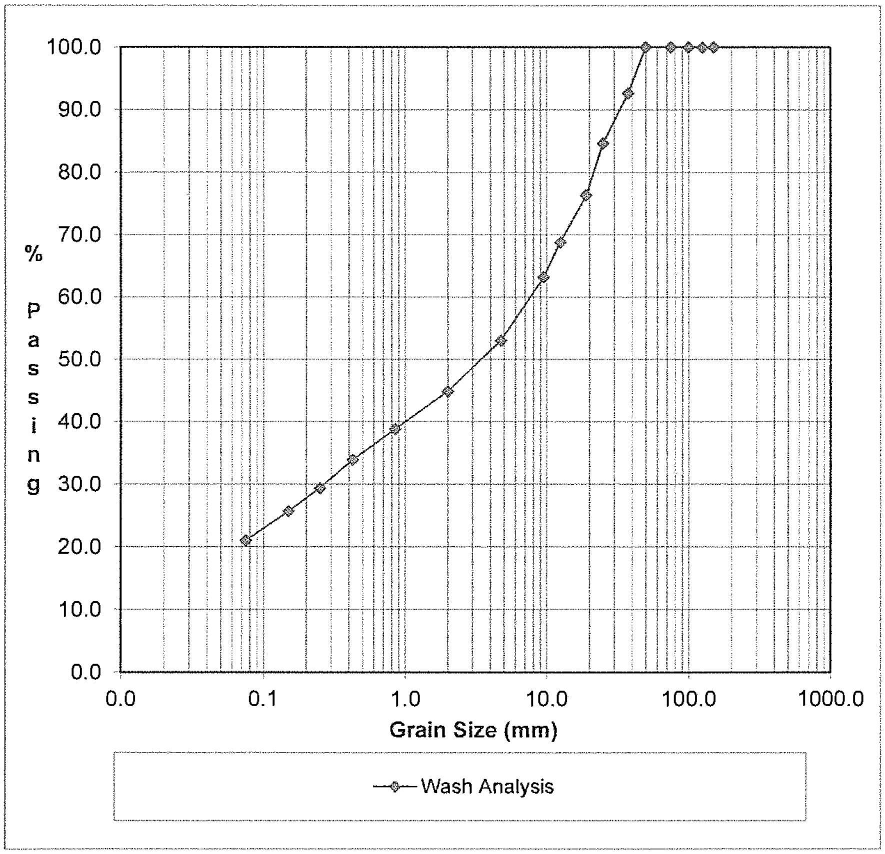
Source: BH 12 @ 7 - 8'
Grab Sample # 01

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	7.4	92.6		
25.0	8.0	84.6		
19.0	8.3	76.3		
12.5	7.5	68.8		
9.5	5.6	63.2		
4.75	10.2	53.0		
2.000	8.1	44.9		
0.850	6.0	38.9		
0.425	5.0	33.9		
0.250	4.5	29.4		
0.150	3.7	25.7		
0.075	4.7	21.0		
PAN	21.0			

Sieve Mass (g): 2362.1

Gravel	47.0 %
Sand	32.0 %
Fines	21.0 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 11

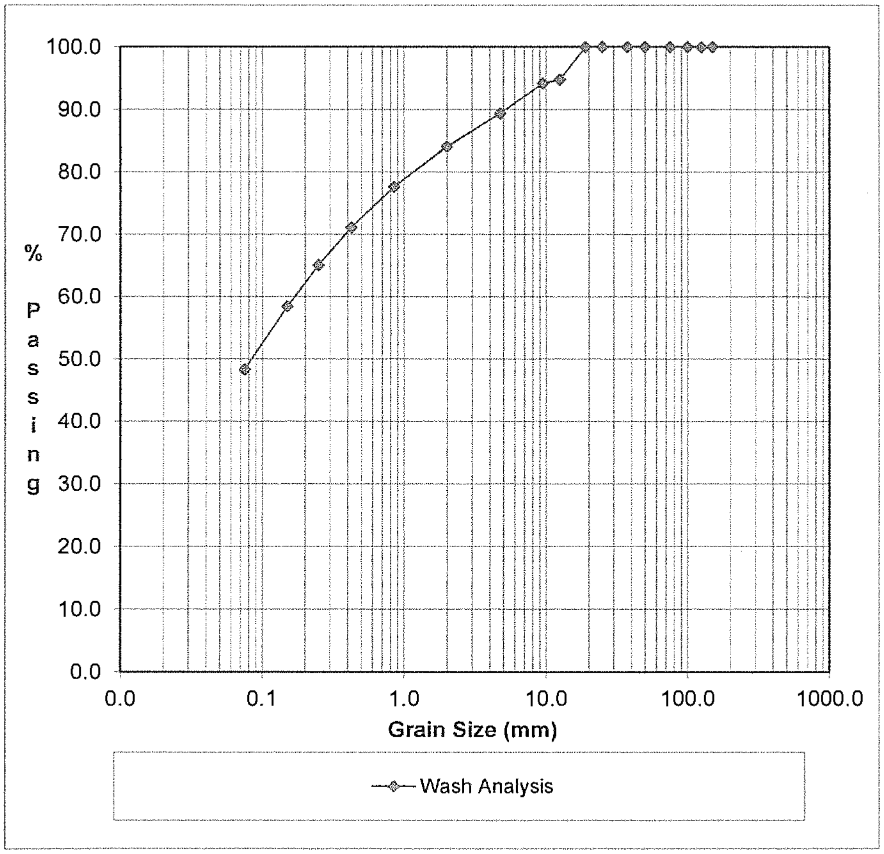
Source: BH 13 @ 10 - 12'
Split Spoon # 02

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	0.0	100.0		
12.5	5.3	94.7		
9.5	0.6	94.1		
4.75	4.8	89.4		
2.000	5.3	84.1		
0.850	6.4	77.7		
0.425	6.6	71.1		
0.250	6.0	65.1		
0.150	6.6	58.5		
0.075	10.1	48.3		
PAN	48.3			

Sieve Mass (g): 338.4

Gravel	10.6 %
Sand	41.0 %
Fines	48.3 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 12

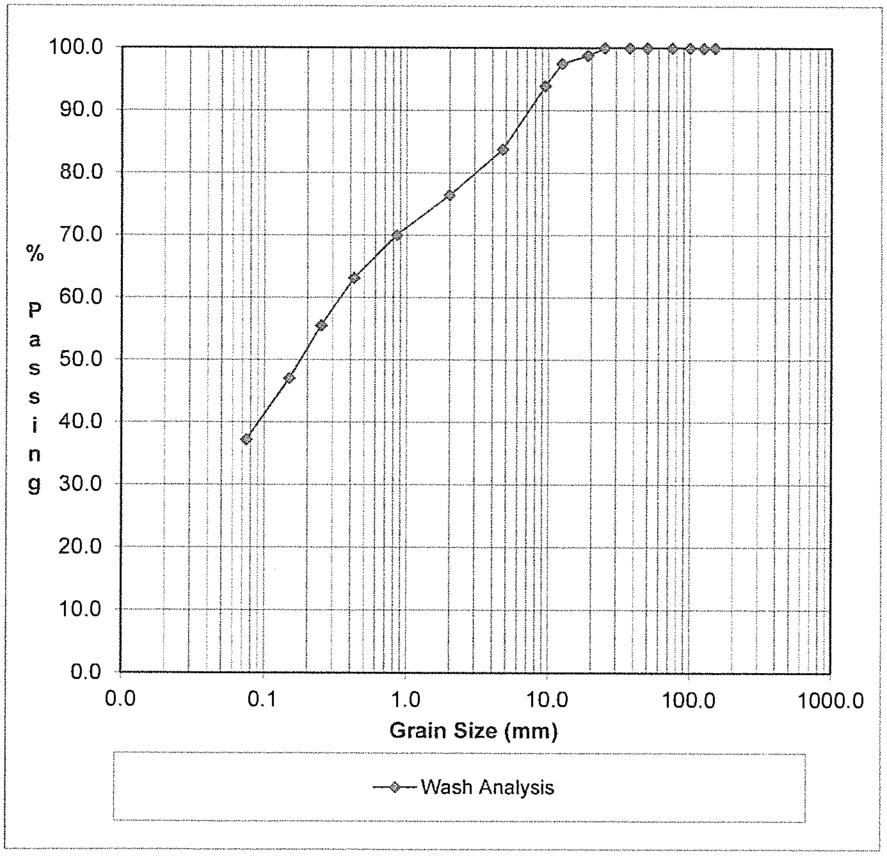
Date Rec'd: Aug 27, 2018

Source: BH 13 @ 20 - 22'
Split Spoon # 04

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	1.2	98.8		
12.5	1.3	97.5		
9.5	3.6	93.9		
4.75	10.1	83.8		
2.000	7.4	76.4		
0.850	6.4	70.0		
0.425	6.9	63.1		
0.250	7.6	55.5		
0.150	8.5	47.0		
0.075	9.8	37.2		
PAN	37.2			

Sieve Mass (g): 1139.4

Gravel	16.2 %
Sand	46.5 %
Fines	37.2 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 13

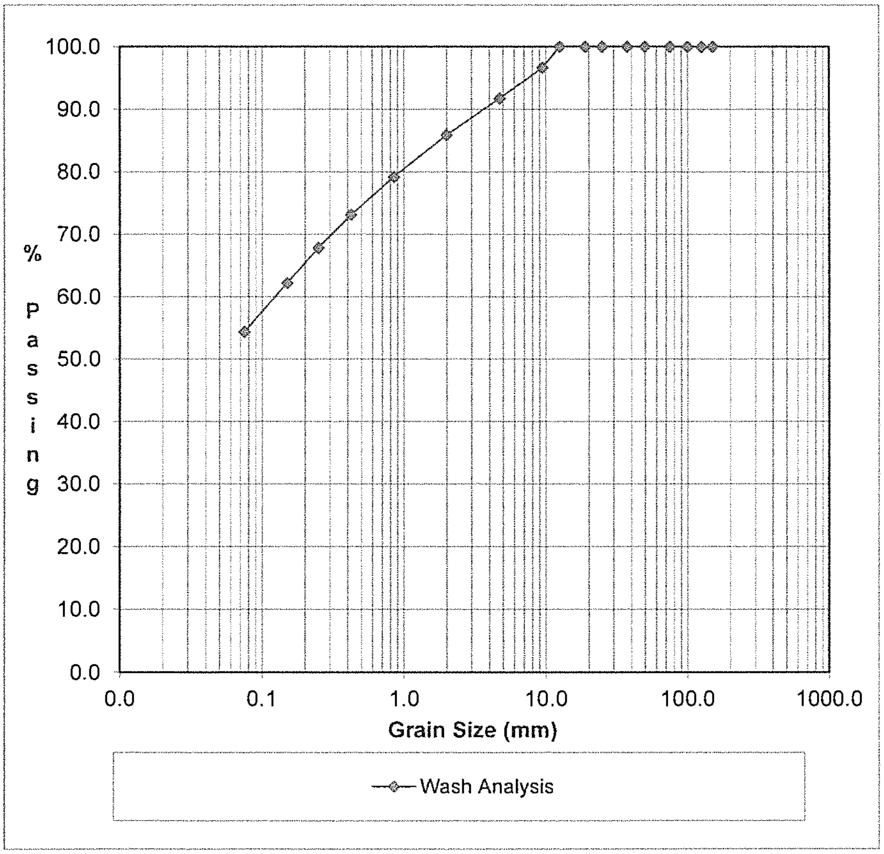
Date Rec'd: Aug 27, 2018

Source: TP 15 @ 2.6 - 2.7m
Grab Sample # 02

By: Client

Sample Type: Grab sample

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	0.0	100.0		
12.5	0.0	100.0		
9.5	3.3	96.7		
4.75	4.9	91.7		
2.000	5.8	85.9		
0.850	6.7	79.2		
0.425	6.1	73.1		
0.250	5.3	67.9		
0.150	5.7	62.2		
0.075	7.8	54.4		
PAN	54.4			

Sieve Mass (g): 428.4

Gravel	8.3 %
Sand	37.3 %
Fines	54.4 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

GRAIN SIZE DISTRIBUTION

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No:KX13690
Date: September 9, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump Station

Test No.: 18 - 107 - 13

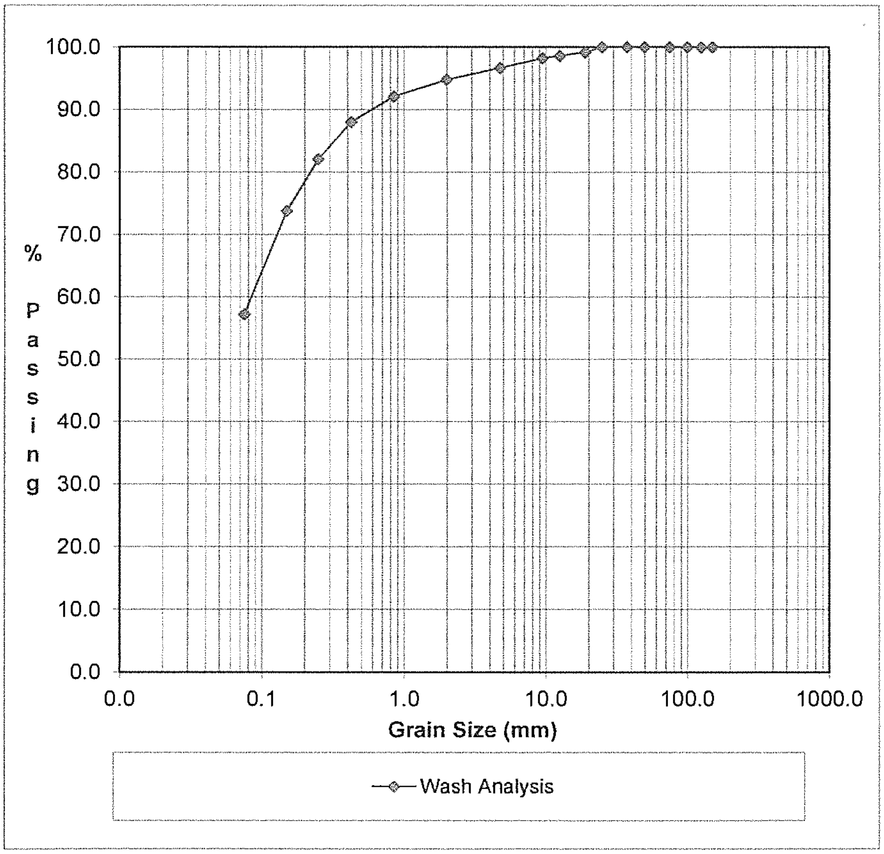
Source: TP 15 @ 4.3m
Grab Sample # 04

Sample Type: Grab sample

Date Rec'd: Aug 27, 2018

By: Client

Date Tested: Sept 1, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	0.0	100.0		
19.0	0.8	99.2		
12.5	0.5	98.6		
9.5	0.4	98.2		
4.75	1.5	96.7		
2.000	1.9	94.8		
0.850	2.7	92.1		
0.425	4.1	88.0		
0.250	5.9	82.1		
0.150	8.3	73.8		
0.075	16.6	57.2		
PAN	57.2			

Sieve Mass (g): 1545.2

Gravel	3.3 %
Sand	39.5 %
Fines	57.2 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

MOISTURE CONTENT WORKSHEET

Project: KX13690
Lab 18- 107 - 1
Technician: B.Shearer
Date: Aug 30, 2018
Kirschner Mountain Pump Station

Hole No.	BH01 GS-01	BH01 GS-02	BH01 GS-04	BH01 GS-05	BH01 GS-06
Depth(Ft)	8-8.5'	16-16.5'	26-26.5'	32.5-33'	36-36.5'
Tare No.	1	2	3	4	5
Wt. Sple. Wet + Tare	575.6	752.4	712.1	1546.6	519.0
Wt. Sple. Dry + Tare	521.8	663.5	646.5	1451.4	470.8
Wt. Water	53.8	88.9	65.6	95.2	48.2
Tare Container	13.6	14.7	14.8	502.2	14.7
Wt. Dry Sample	508.2	648.8	631.7	949.2	456.1
Moist. Cont. %	10.6%	13.7%	10.4%	10.0%	10.6%

Hole No.	BH01 GS-07	BH01 GS-08	BH01 GS-09	BH02 GS-01	BH02 GS-02
Depth(Ft)	42-42.5'	48-48.5'	67-67.5'	15-16'	21.5-22'
Tare No.	6	7	8	9	10
Wt. Sple. Wet + Tare	1614.4	1548.6	531.5	635.6	734.8
Wt. Sple. Dry + Tare	1532.2	1468.3	484.5	565.3	650.1
Wt. Water	82.2	80.3	47.0	70.3	84.7
Tare Container	501.3	501.3	14.1	14.5	14.3
Wt. Dry Sample	1030.9	967.0	470.4	550.8	635.8
Moist. Cont. %	8.0%	8.3%	10.0%	12.8%	13.3%

Hole No.	BH02 GS-03	BH02 GS-06	BH02 GS-07	BH03 GS-01	BH03 GS-03
Depth(Ft)	24.5-25.5'	31-31.5'	45-45.5'	4.5-5.0'	4.5-5'
Tare No.	11	12	13	14	15
Wt. Sple. Wet + Tare	582.6	1461.2	197.1	2159.6	695.6
Wt. Sple. Dry + Tare	526.4	1334.3	179.1	1983.0	629.9
Wt. Water	56.2	126.9	18.0	176.6	65.7
Tare Container	14.6	499.7	14.3	542.0	15.2
Wt. Dry Sample	511.8	834.6	164.8	1441.0	614.7
Moist. Cont. %	11.0%	15.2%	10.9%	12.3%	10.7%

Hole No.	BH03 GS-04	BH03 GS-05	BH03 GS-07	BH03 GS-08	BH03 GS-09
Depth(Ft)	15-15.5'	20.5-21'	27-27.5'	31.5-32'	33.5-34'
Tare No.	16	17	18	19	20
Wt. Sple. Wet + Tare	495.0	697.6	540.0	758.9	1747.7
Wt. Sple. Dry + Tare	450.7	628.1	478.2	675.7	1603.0
Wt. Water	44.3	69.5	61.8	83.2	144.7
Tare Container	14.6	14.5	14.8	14.6	403.2
Wt. Dry Sample	436.1	613.6	463.4	661.1	1199.8
Moist. Cont. %	10.2%	11.3%	13.3%	12.6%	12.1%

Hole No.	BH04 GS-02	BH04 GS-04	BH04 GS-07		
Depth(Ft)	11-11.5'	15.5-16'	17.8-18'		
Tare No.	21	22	23		
Wt. Sple. Wet + Tare	2346.8	477.9	1214.8		
Wt. Sple. Dry + Tare	2157.3	420.9	1109.2		
Wt. Water	189.5	57.0	105.6		
Tare Container	439.5	14.7	409.2		
Wt. Dry Sample	1717.8	406.2	700.0		
Moist. Cont. %	11.0%	14.0%	15.1%		

MOISTURE CONTENT WORKSHEET

Project: KX13690
Lab 18- 107 - 1
Technician: B.Shearer
Date: Aug 30, 2018
Kirschner Mountain Pump Station

Hole No.	**BH05 GS-01**	**BH05 GS-02**	**BH05 GS-03**	**BH05 GS-04**	**BH09 GS-01**
Depth(Ft)	**6-7'**	**9.5-10.5'**	**14-15'**	**22-23'**	**4-5'**
Tare No.	24	25	26	27	28
Wt. Sple. Wet + Tare	376.8	495.6	694.7	1910.8	453.7
Wt. Sple. Dry + Tare	318.7	424.7	609.8	1759.6	425.5
Wt. Water	58.1	70.9	84.9	151.2	28.2
Tare Container	14.6	14.4	15.2	412.6	14.8
Wt. Dry Sample	304.1	410.3	594.6	1347.0	410.7
Moist. Cont. %	19.1%	17.3%	14.3%	11.2%	6.9%
Hole No.	**BH09 GS-02**	**BH09 GS-03**	**BH09 GS-04**	**BH10 GS-02**	**BH10 GS-03**
Depth(Ft)	**12-13'**	**17.5-18.5'**	**20.5-21.5'**	**5.5-6'**	**15-15.5'**
Tare No.	29	30	31	32	33
Wt. Sple. Wet + Tare	633.1	678.3	675.0	514.6	707.4
Wt. Sple. Dry + Tare	560.1	602.9	591.6	477.3	628.4
Wt. Water	73.0	75.4	83.4	37.3	79.0
Tare Container	14.6	14.6	14.7	14.6	14.8
Wt. Dry Sample	545.5	588.3	576.9	462.7	613.6
Moist. Cont. %	13.4%	12.8%	14.5%	8.1%	12.9%
Hole No.	**BH11 GS-01**	**BH11 GS-04**	**BH11 GS-05**	**BH12 GS-01**	**BH12 GS-02**
Depth(Ft)	**7-8'**	**27-28'**	**30-31'**	**7-8'**	**11-12'**
Tare No.	34	35	36	37	38
Wt. Sple. Wet + Tare	683.7	778.7	721.4	2988.8	663.9
Wt. Sple. Dry + Tare	620.4	692.1	649.5	2782.6	578.9
Wt. Water	63.3	86.6	71.9	206.2	85.0
Tare Container	14.7	14.8	14.7	420.4	14.8
Wt. Dry Sample	605.7	677.3	634.8	2362.2	564.1
Moist. Cont. %	10.5%	12.8%	11.3%	8.7%	15.1%
Hole No.	**BH12 GS-3**	**BH12 GS-04**	**BH12 GS-05**	**BH13 SS-01**	**BH13 SS-02**
Depth(Ft)	**21-22'**	**33-34'**	**35-36'**	**5-7'**	**10-12'**
Tare No.	39	40	41	42	43
Wt. Sple. Wet + Tare	604.1	635.5	685.4	251.0	806.8
Wt. Sple. Dry + Tare	501.0	529.8	579.2	233.0	753.1
Wt. Water	103.1	105.7	106.2	18.0	53.7
Tare Container	15.0	14.6	15.3	14.8	414.7
Wt. Dry Sample	486.0	515.2	563.9	218.2	338.4
Moist. Cont. %	21.2%	20.5%	18.8%	8.2%	15.9%
Hole No.	**BH13 SS-03**	**BH13 SS-04**	**BH13 SS-05**		
Depth(Ft)	**15-17'**	**20-22'**	**25-27'**		
Tare No.	44	45	46		
Wt. Sple. Wet + Tare	347.1	1757.1	603.5		
Wt. Sple. Dry + Tare	291.0	1677.3	579.7		
Wt. Water	56.1	79.8	23.8		
Tare Container	14.4	537.8	14.5		
Wt. Dry Sample	276.6	1139.5	565.2		
Moist. Cont. %	20.3%	7.0%	4.2%		

MOISTURE CONTENT WORKSHEET

Project: KX13690
Lab 18- 107 - 1
Technician: B.Shearer
Date: Aug 30, 2018
Kirschner Mountain Pump Station

Hole No.	**BH14 GS-01**	**BH14 GS-02**	**BH14 GS-03**	**BH14 GS-04**	**BH14 GS-06**
Depth(Ft)	**1-1.5'**	**6-7'**	**12-13'**	**17-18'**	**22-23'**
Tare No.	47	48	49	50	51
Wt. Sple. Wet + Tare	670.1	478.7	597.2	1209.0	657.4
Wt. Sple. Dry + Tare	624.2	435.3	549.9	1083.7	614.3
Wt. Water	45.9	43.4	47.3	125.3	43.1
Tare Container	14.7	15.5	14.6	14.3	14.6
Wt. Dry Sample	609.5	419.8	535.3	1069.4	599.7
Moist. Cont. %	7.5%	10.3%	8.8%	11.7%	7.2%
Hole No.	**TP15 GS-01**	**TP15 GS-02**	**TP15 GS-03**	**TP15 GS-04**	
Depth(**M**)	**1.7-1.8m**	**2.6-2.7m**	**4.2-4.3m**	**4.3m**	
Tare No.	52	53	54	55	
Wt. Sple. Wet + Tare	237.6	1029.8	544.8	2217.8	
Wt. Sple. Dry + Tare	215.0	964.3	499.5	2092.2	
Wt. Water	22.6	65.5	45.3	125.6	
Tare Container	14.8	536.2	14.3	546.9	
Wt. Dry Sample	200.2	428.1	485.2	1545.3	
Moist. Cont. %	11.3%	15.3%	9.3%	8.1%	
Hole No.					
Depth(Ft)					
Tare No.					
Wt. Sple. Wet + Tare					
Wt. Sple. Dry + Tare					
Wt. Water					
Tare Container					
Wt. Dry Sample					
Moist. Cont. %					
Hole No.					
Depth(Ft)					
Tare No.					
Wt. Sple. Wet + Tare					
Wt. Sple. Dry + Tare					
Wt. Water					
Tare Container					
Wt. Dry Sample					
Moist. Cont. %					
Hole No.					
Depth(Ft)					
Tare No.					
Wt. Sple. Wet + Tare					
Wt. Sple. Dry + Tare					
Wt. Water					
Tare Container					
Wt. Dry Sample					
Moist. Cont. %					

ATTERBERG LIMITS

wood.

PROJECT : Westrek Geotechnical Services Ltd.
Project Number: KX13690
Lab : 18- 107- 1
Date: September 11, 2018

Sample ID: Kirschner Mountain Pump Station; BH18-02 @ 15-16'- GS 01
Technician: B. Shearer

Liquid Limit

Trial No.	1	2	3	
No. of Blows	33	24	20	
Tare ID:	1	2	3	
Mass Wet + Tare	101.04	92.71	95.62	
Mass Dry + Tare	93.53	86.44	88.83	
Mass Tare:	53.67	54.15	54.28	
Mass of Water:	7.51	6.27	6.79	
Dry Soil Mass:	39.86	32.29	34.55	
Moisture Content:	18.8%	19.4%	19.7%	
Liquid Limit:	19.6%	19.3%	19.1%	

Average Liquid Limit: 19.3%

Plastic Limit

Trial No.	4	5	6	
Tare ID:	1	2	3	
Mass Wet + Tare	62.97	62.78	61.67	
Mass Dry + Tare	61.83	61.71	60.73	
Mass Tare:	53.74	53.97	53.93	
Mass of Water:	1.14	1.07	0.94	
Dry Soil Mass:	8.09	7.74	6.80	
Moisture Content:	14.1%	13.8%	13.8%	

Average Plastic Limit: 13.9%

Plasticity Index: 5.4

ATTERBERG LIMITS

PROJECT : Westrek Geotechnical Services Ltd.
Project Number: KX13690
Lab : 18- 107- 2
Date: September 11, 2018

Sample ID: Kirschner Mountain Pump Station; BH18-02 @ 45-45.5'- GS 07
Technician: B. Shearer

Liquid Limit

Trial No.	1	2	3	
No. of Blows	30	27	21	
Tare ID:	1	2	3	
Mass Wet + Tare	99.48	95.65	93.33	
Mass Dry + Tare	92.70	89.16	87.35	
Mass Tare:	54.25	52.83	54.38	
Mass of Water:	6.78	6.49	5.98	
Dry Soil Mass:	38.45	36.33	32.97	
Moisture Content:	17.6%	17.9%	18.1%	
Liquid Limit:	18.1%	18.1%	17.7%	

Average Liquid Limit: 18.0%

Plastic Limit

Trial No.	4	5	6	
Tare ID:	1	2	3	
Mass Wet + Tare	62.70	62.80	63.58	
Mass Dry + Tare	61.69	61.79	62.50	
Mass Tare:	53.80	53.88	54.20	
Mass of Water:	1.01	1.01	1.08	
Dry Soil Mass:	7.89	7.91	8.30	
Moisture Content:	12.8%	12.8%	13.0%	

Average Plastic Limit: 12.9%

Plasticity Index: 5.1

ATTERBERG LIMITS

PROJECT : Westrek Geotechnical Services Ltd.
Project Number: KX13690
Lab : 18- 107-3
Date: September 11, 2018

Sample ID: Kirschner Mountain Pump Station; TP18-15 @ 2.6-2.7m - GS 02
Technician: B. Shearer

Liquid Limit

Trial No.	1	2	3	
No. of Blows	28	25	21	
Tare ID:	1	2	3	
Mass Wet + Tare	85.63	91.03	88.89	
Mass Dry + Tare	79.75	84.16	82.33	
Mass Tare:	53.55	54.24	54.24	
Mass of Water:	5.88	6.87	6.56	
Dry Soil Mass:	26.20	29.92	28.09	
Moisture Content:	22.4%	23.0%	23.4%	
Liquid Limit:	22.8%	23.0%	22.8%	

Average Liquid Limit: 22.9%

Plastic Limit

Trial No.	4	5	6	
Tare ID:	1	2	3	
Mass Wet + Tare	61.18	61.79	62.37	
Mass Dry + Tare	60.06	60.77	61.30	
Mass Tare:	52.40	53.69	53.93	
Mass of Water:	1.12	1.02	1.07	
Dry Soil Mass:	7.66	7.08	7.37	
Moisture Content:	14.6%	14.4%	14.5%	

Average Plastic Limit: 14.5%

Plasticity Index: 8.4

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

OFFICE: Kamloops, BC
PROJECT: KX13690
DATE: September 11, 2018

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump House

TEST NO: 18-107-1

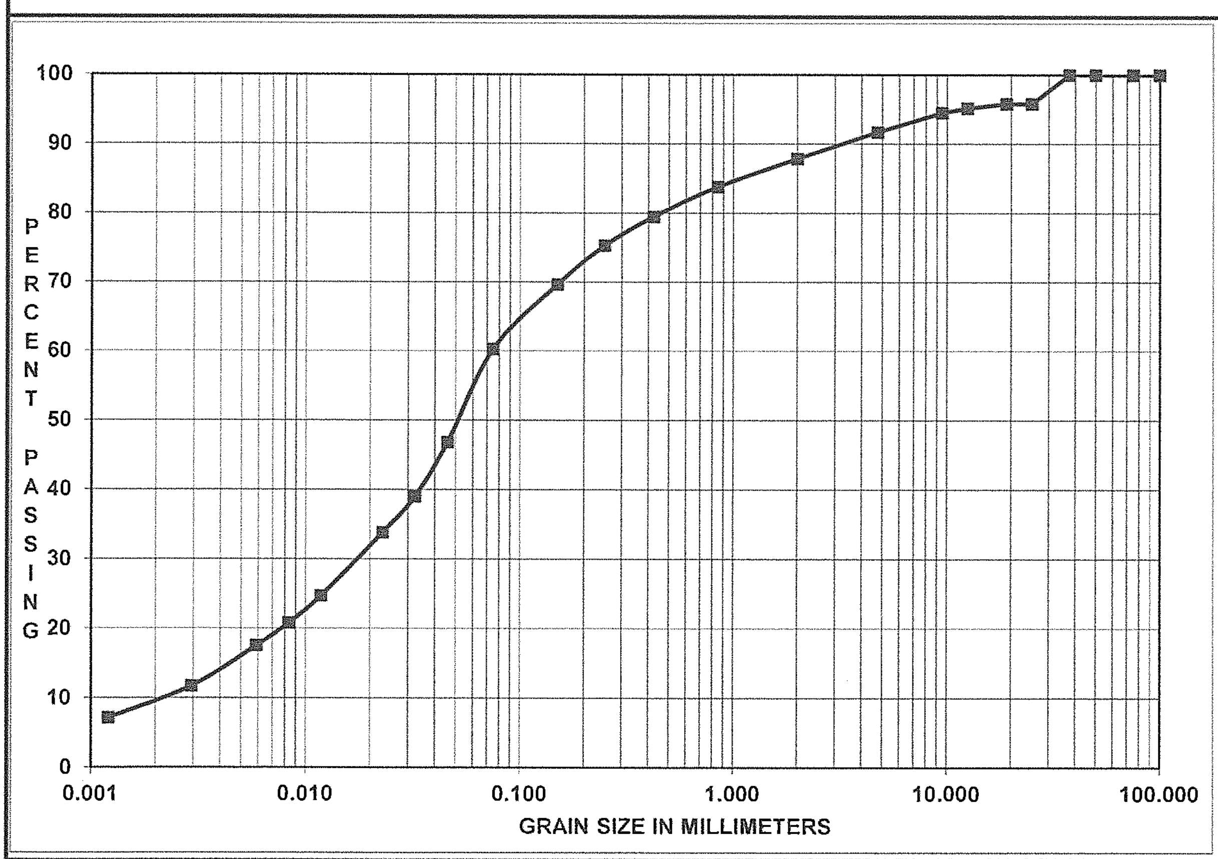
SAMPLED BY: Client

DATE Rec'd: August 27, 2018

SOURCE: BH18-02 @ 15 - 16' - GS01

DATE TESTED: Sept 9, 2018

SAMPLE TYPE: Grab Sample



SUMMARY

Grain size (mm)	Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	95.8
19.0	95.8
12.5	95.2
9.5	94.5
4.75	91.7
2.00	87.9
0.850	83.8
0.425	79.5
0.250	75.3
0.150	69.6
0.075	60.3
0.0459	46.8
0.0324	39.0
0.0229	33.8
0.0118	24.7
0.0084	20.8
0.0059	17.6
0.0030	11.7
0.0012	7.2

REMARKS:

GRAVEL	8.3%
SAND	31.4%
SILT	51.1%
CLAY	9.2%

TECHNICIAN: B. Shearer

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Attn: Jeffrey Pisio / Kevin Turner

Project Name: Kirschner Mountain Pump House

OFFICE: Kamloops, BC
PROJECT: KX13690
DATE: September 11, 2018

TEST NO: 18-107-2

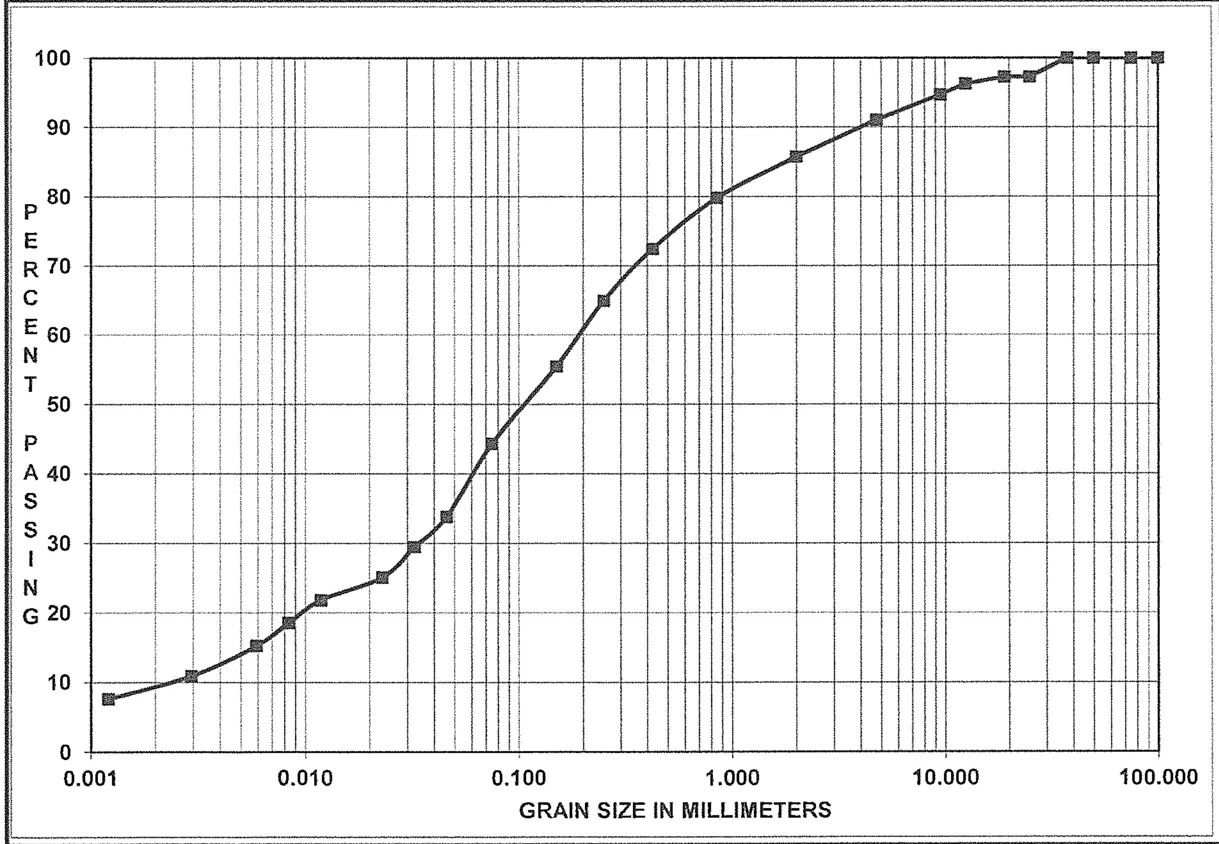
DATE Rec'd: August 27, 2018

DATE TESTED: Sept 9, 2018

SAMPLED BY: Client

SOURCE: BH18-02 @ 45 - 45.5' - GS07

SAMPLE TYPE: Grab Sample



SUMMARY

Grain size (mm)	Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	97.3
19.0	97.3
12.5	96.3
9.5	94.7
4.75	91.1
2.00	85.7
0.850	79.8
0.425	72.4
0.250	64.9
0.150	55.4
0.075	44.3
0.0459	33.8
0.0324	29.5
0.0229	25.1
0.0118	21.8
0.0084	18.5
0.0059	15.3
0.0030	10.9
0.0012	7.6

REMARKS:

GRAVEL	8.9%
SAND	46.8%
SILT	35.2%
CLAY	9.1%

TECHNICIAN: B. Shearer

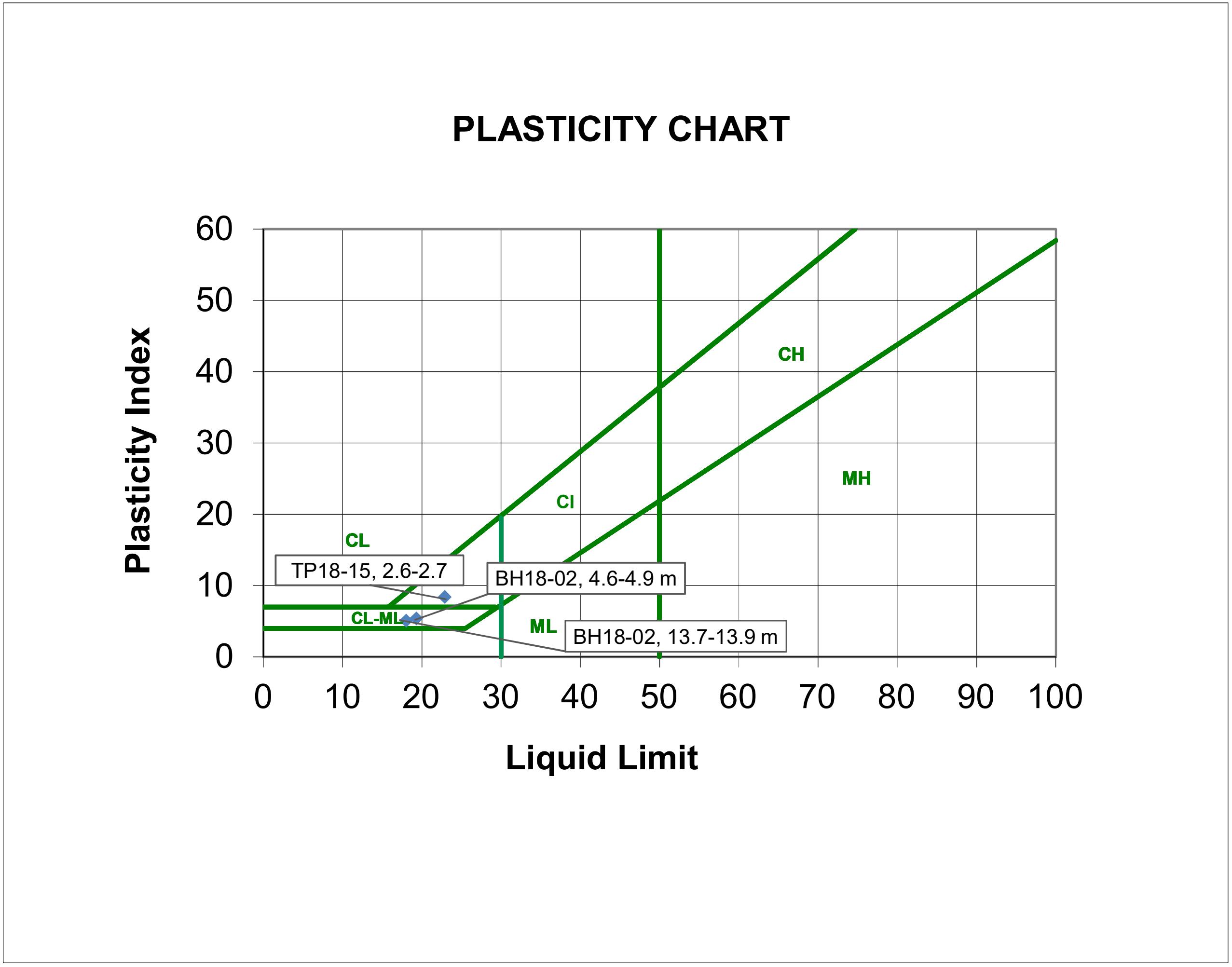
APPENDIX C

Atterberg Limits Testing Results

Project: City of Kelowna - 2045 Loseth Road Pump Station **Project:** 018-253

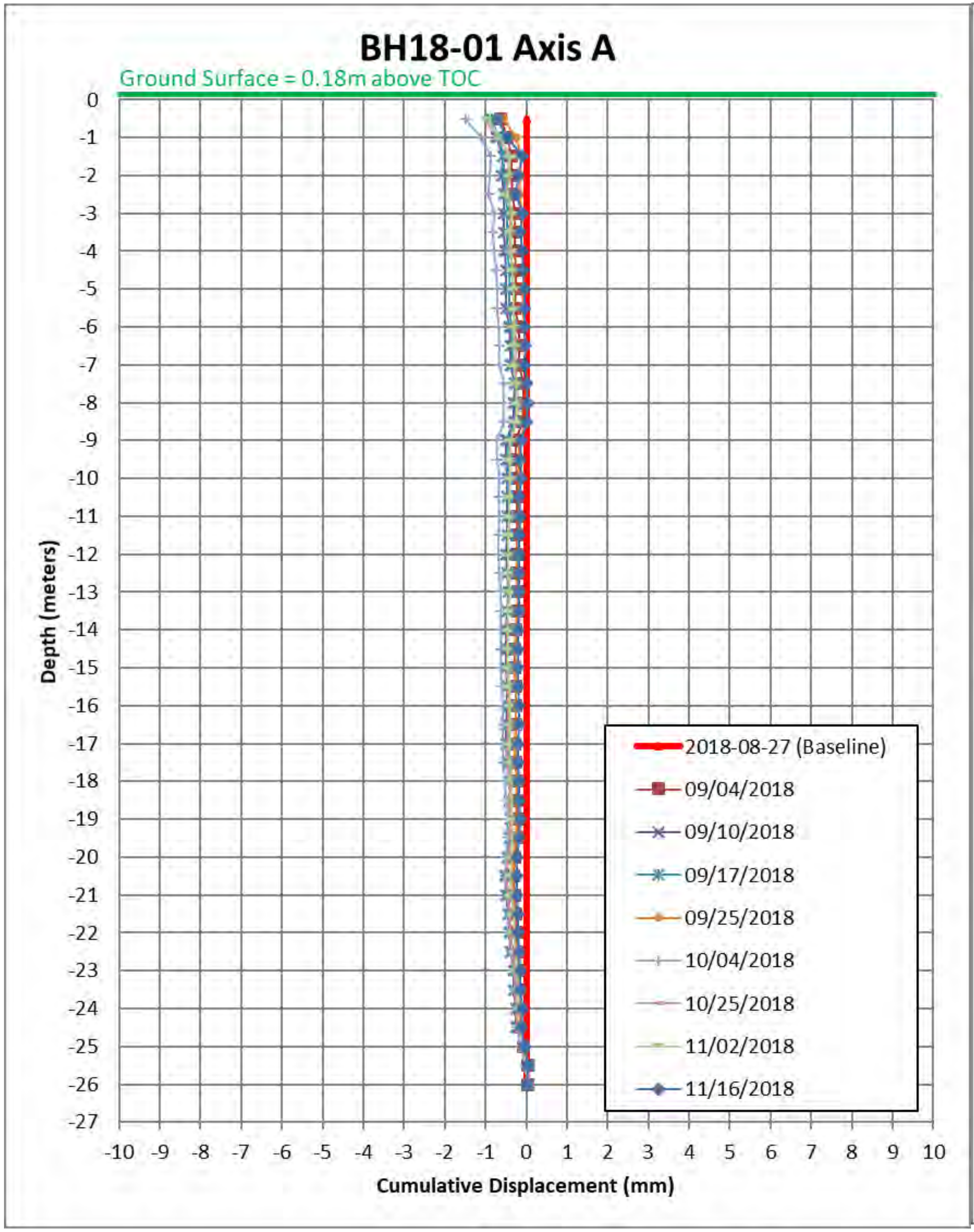
Sample Location					Particle Size Distribution										Index Parameters (%)						
Borehole	Sample	Top depth (ft)	Bottom depth (ft)	Depth (m)	Gravel	Sand	Silt	Clay	Fines	D10	D30	D60	CU	CC	W_N	LL	PL	PI	LI	Act.	USCS
BH18-02	GS-01	15	16	4.6-4.9 m											12.8	19.3	13.9	5.4	-0.20		CL-ML
BH18-02	GS-07	45	45.5	13.7-13.9 m											10.9	18.0	12.9	5.1	-0.39		CL-ML
TP18-15	GS-02	8.5	8.9	2.6-2.7 m											15.3	22.9	14.5	8.4	0.10		CL

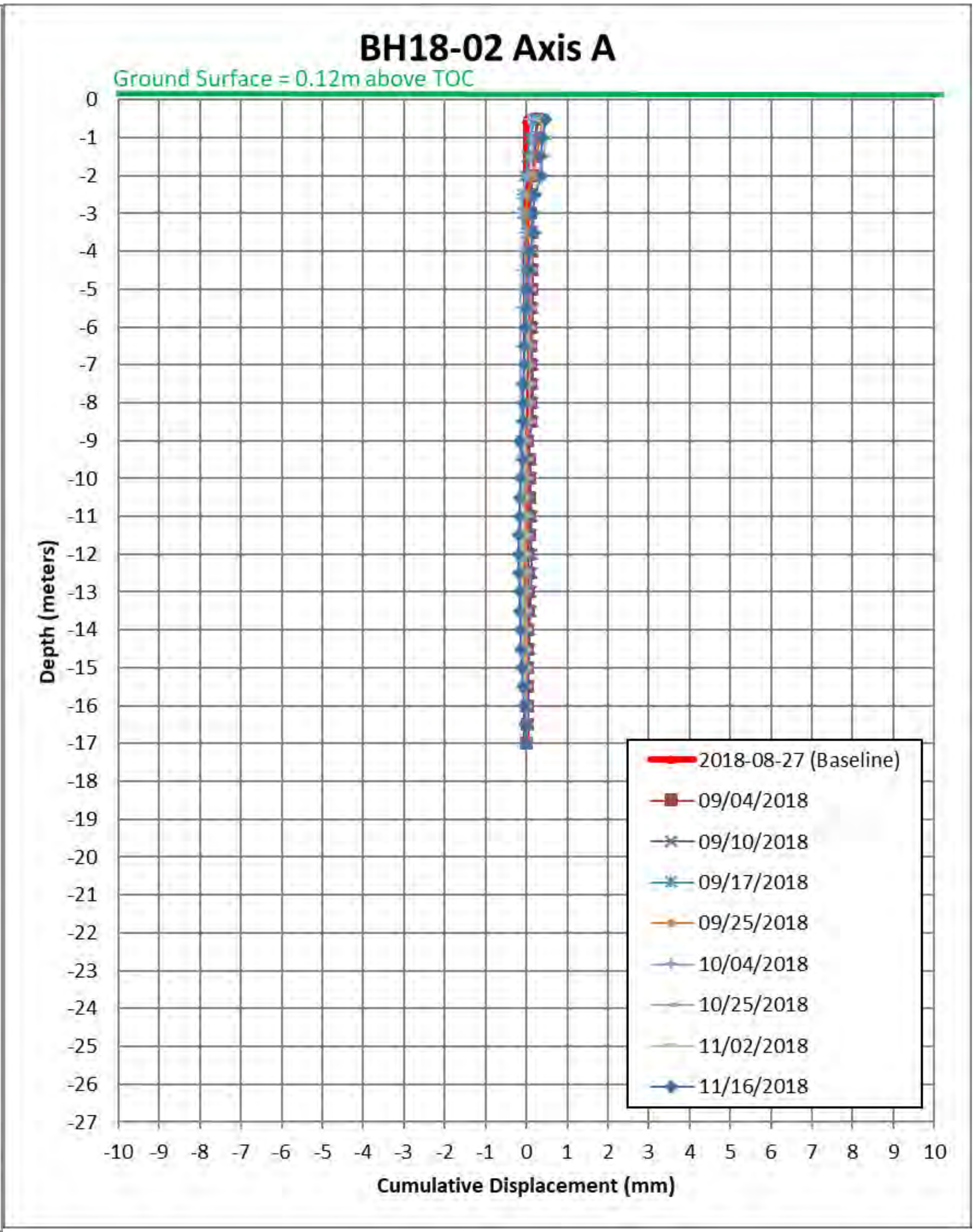
Remarks / Notes:



APPENDIX E

Slope Inclinometer and Piezometer Monitoring





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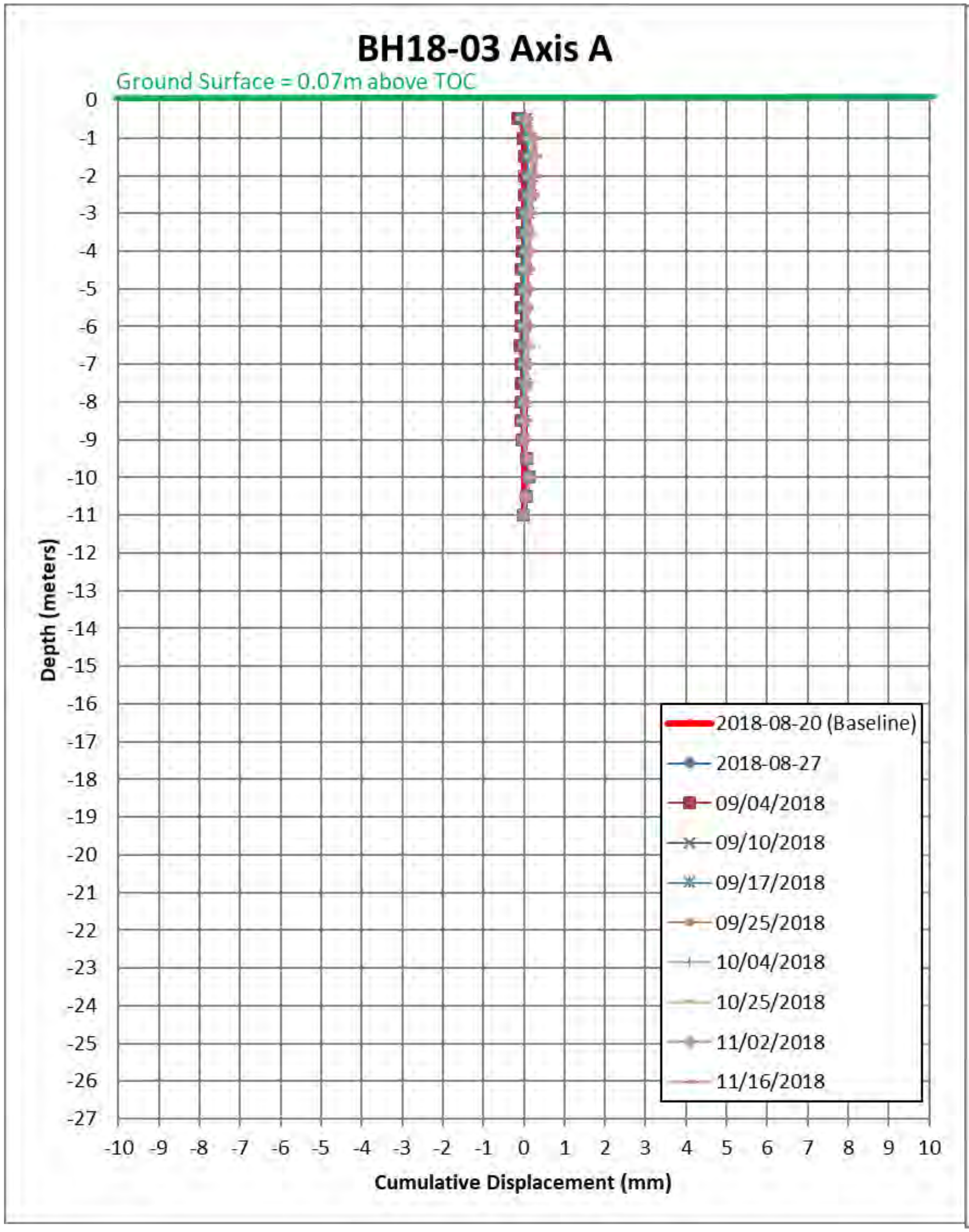
BH18-01 and BH18-02 Slope Inclinometer Readings
2045 Loseth Road Pump Station

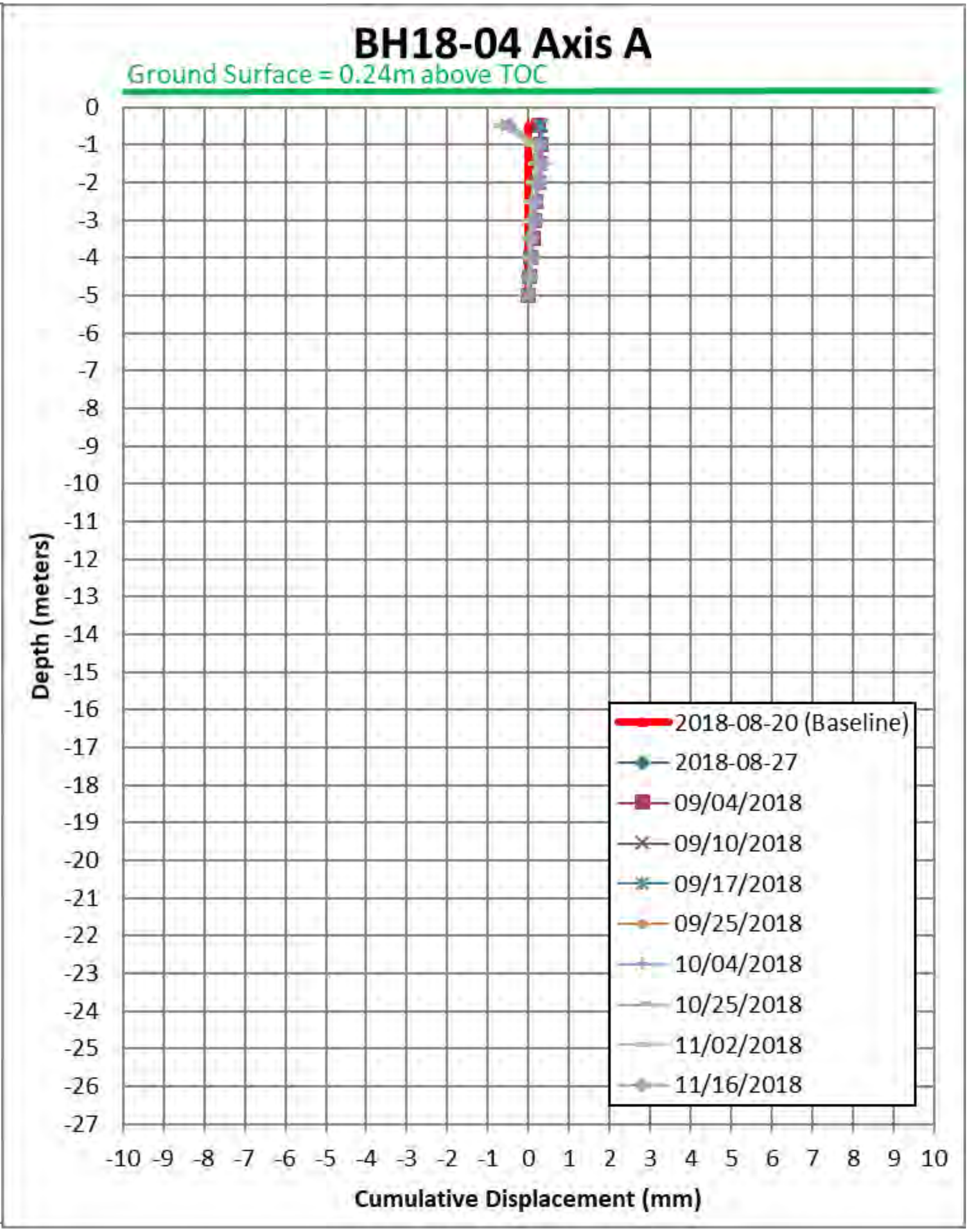
City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 1





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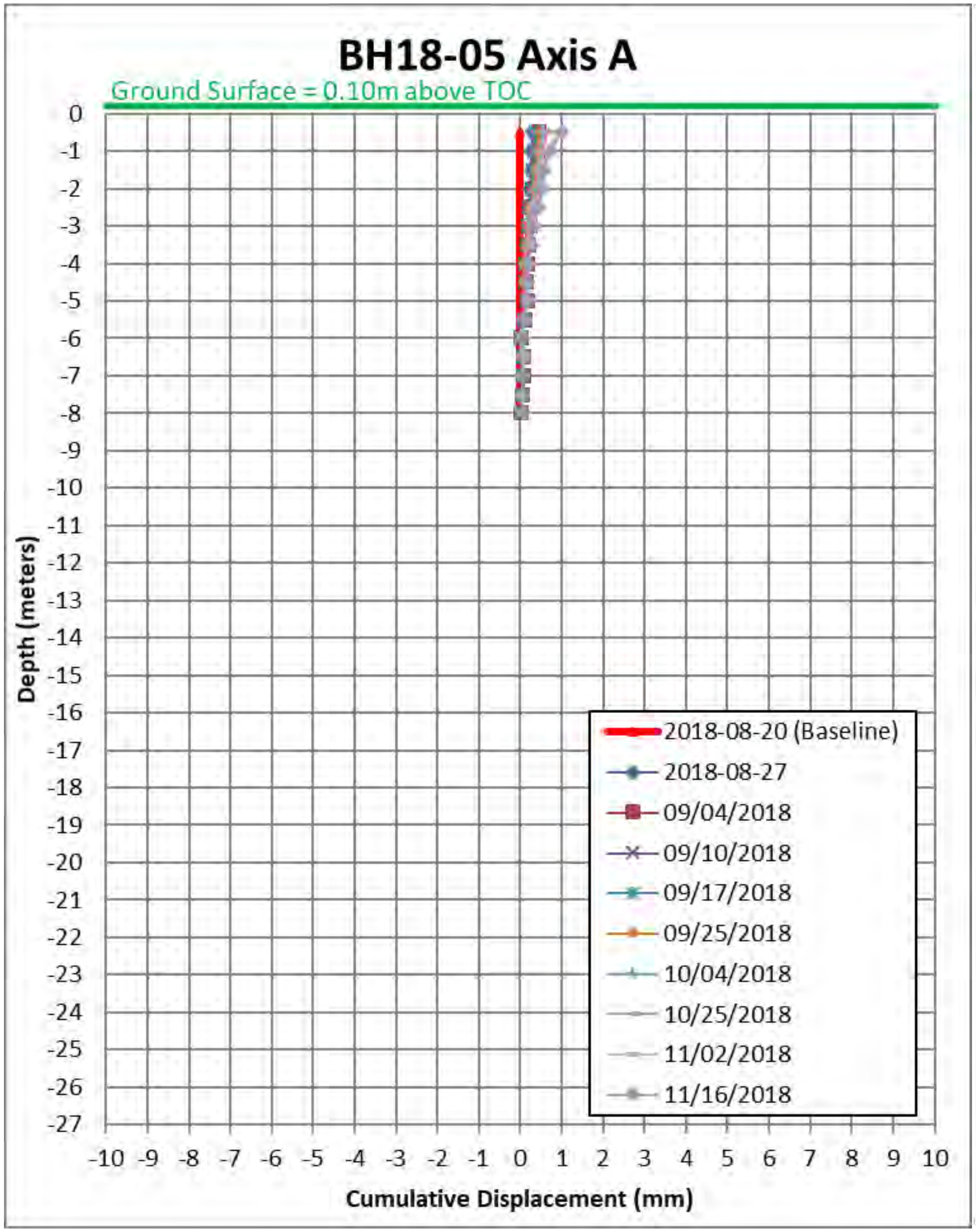
BH18-03 and BH18-04 Slope Inclinometer Readings 2045 Loseth Road Pump Station

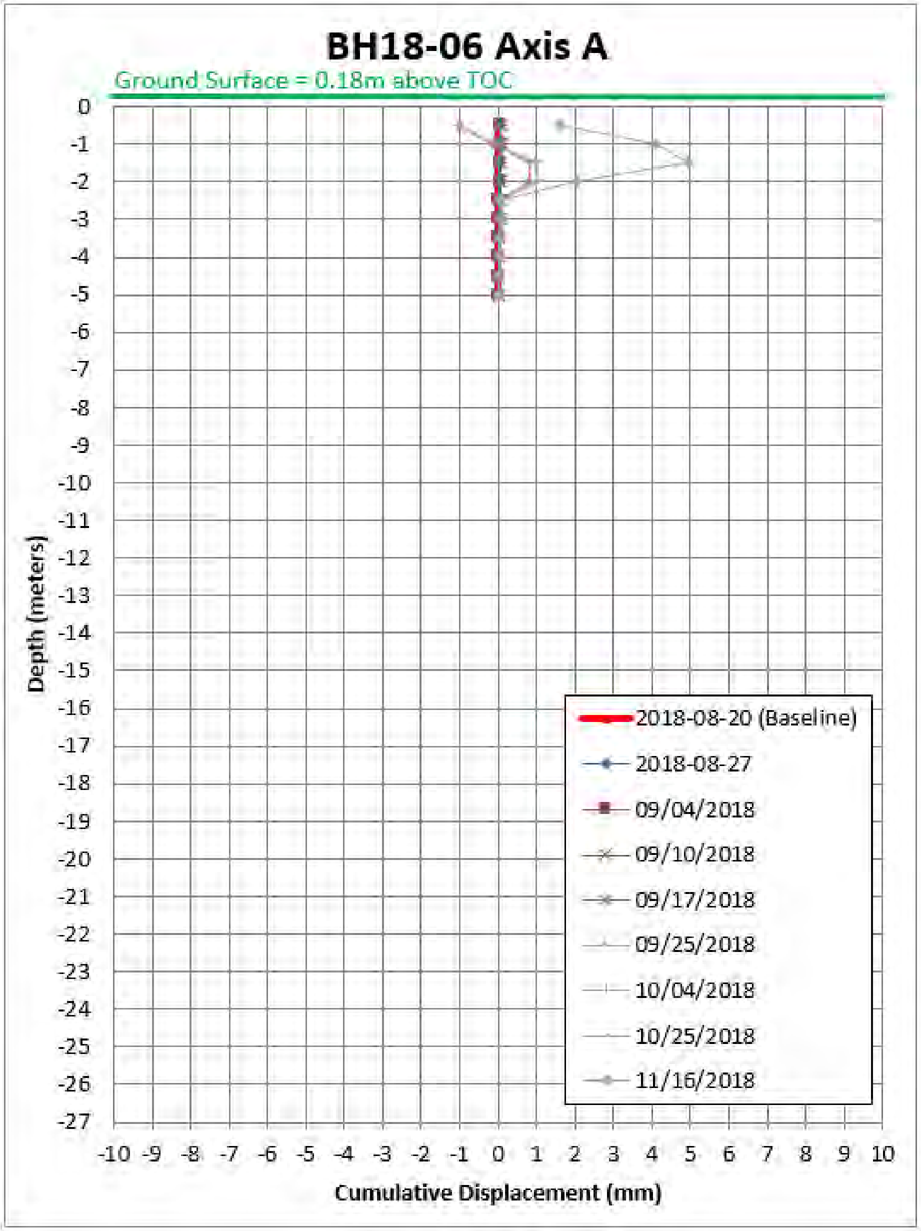
City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 2





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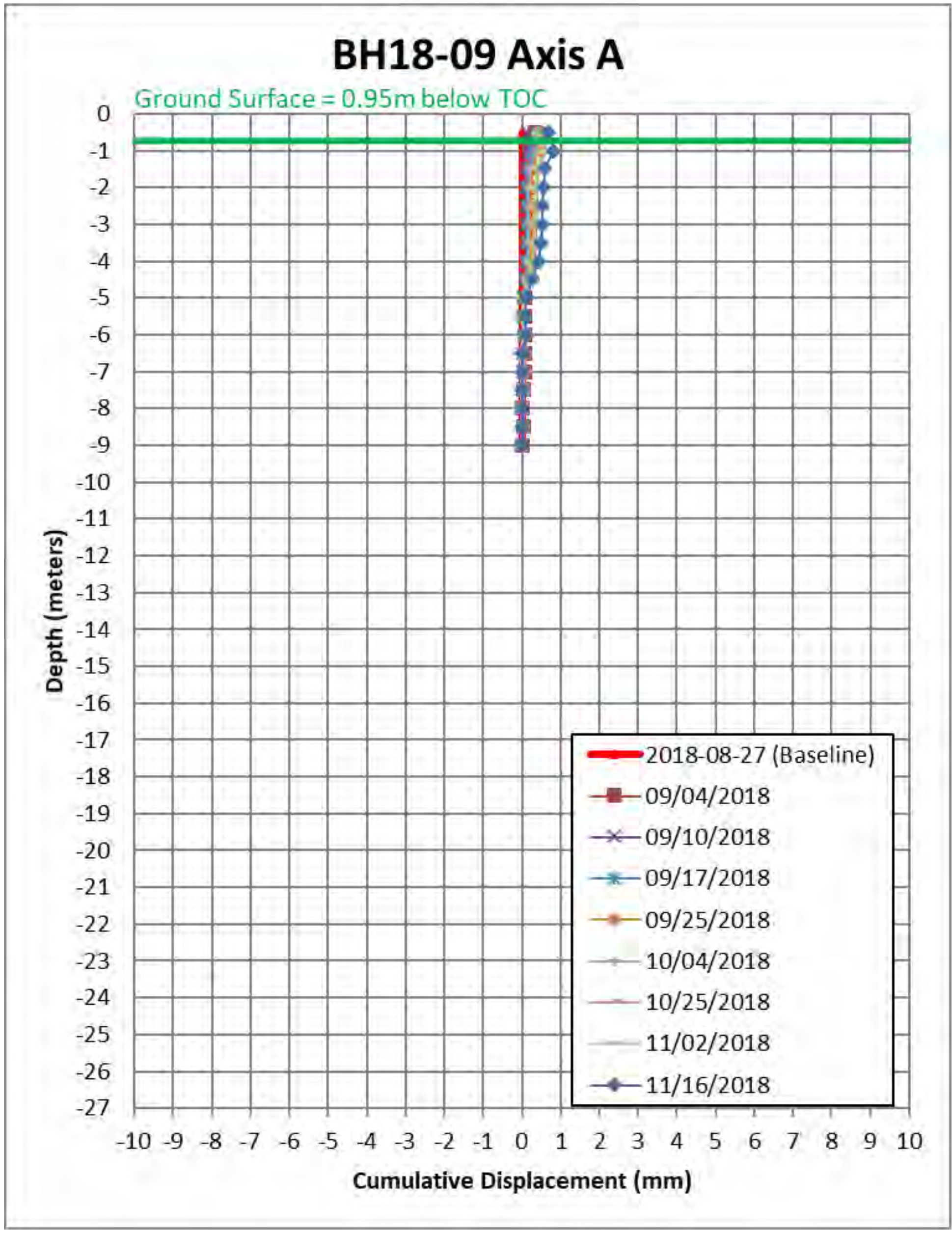
BH18-05 and BH18-06 Slope Inclinometer Readings
2045 Loseth Road Pump Station

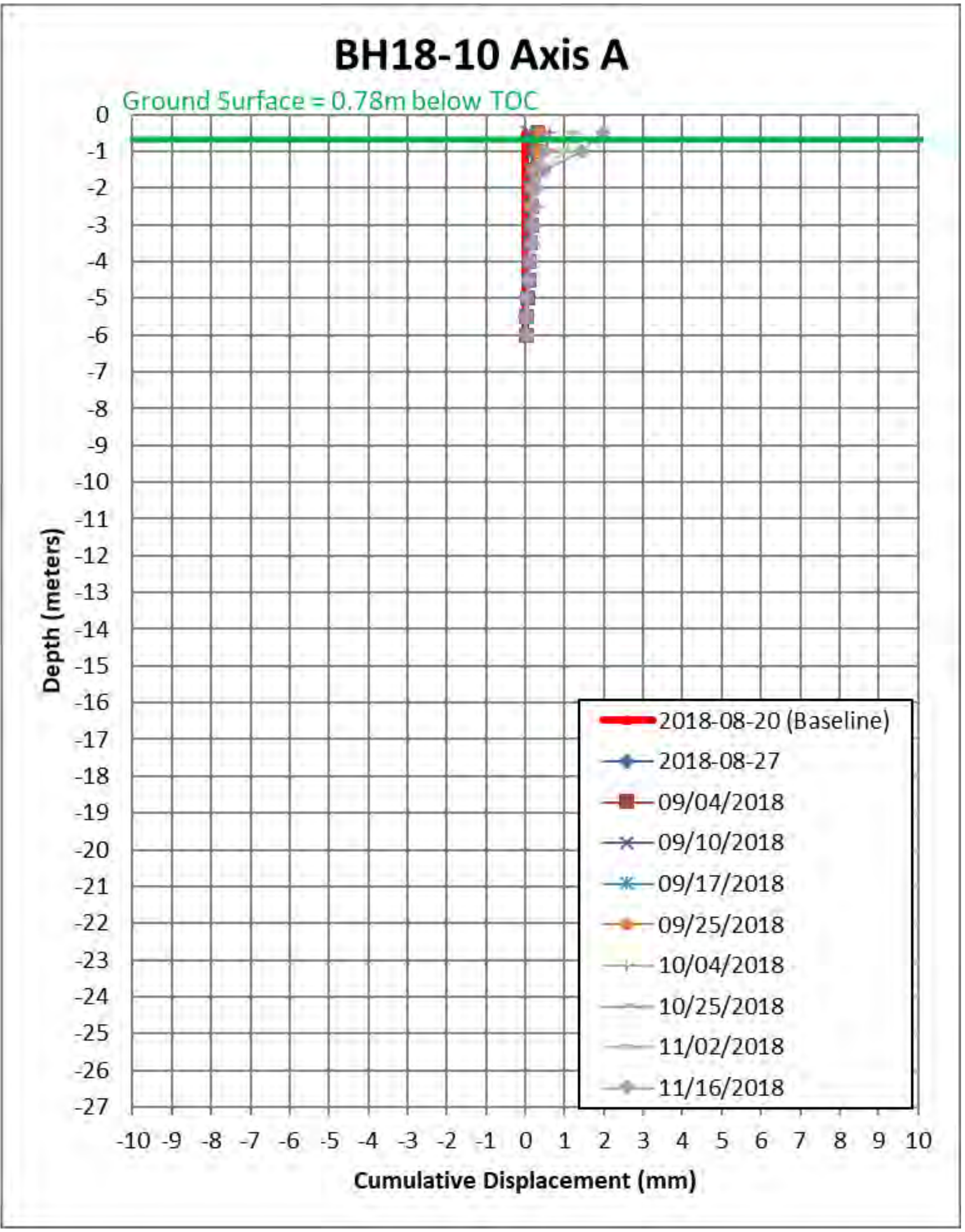
City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 3





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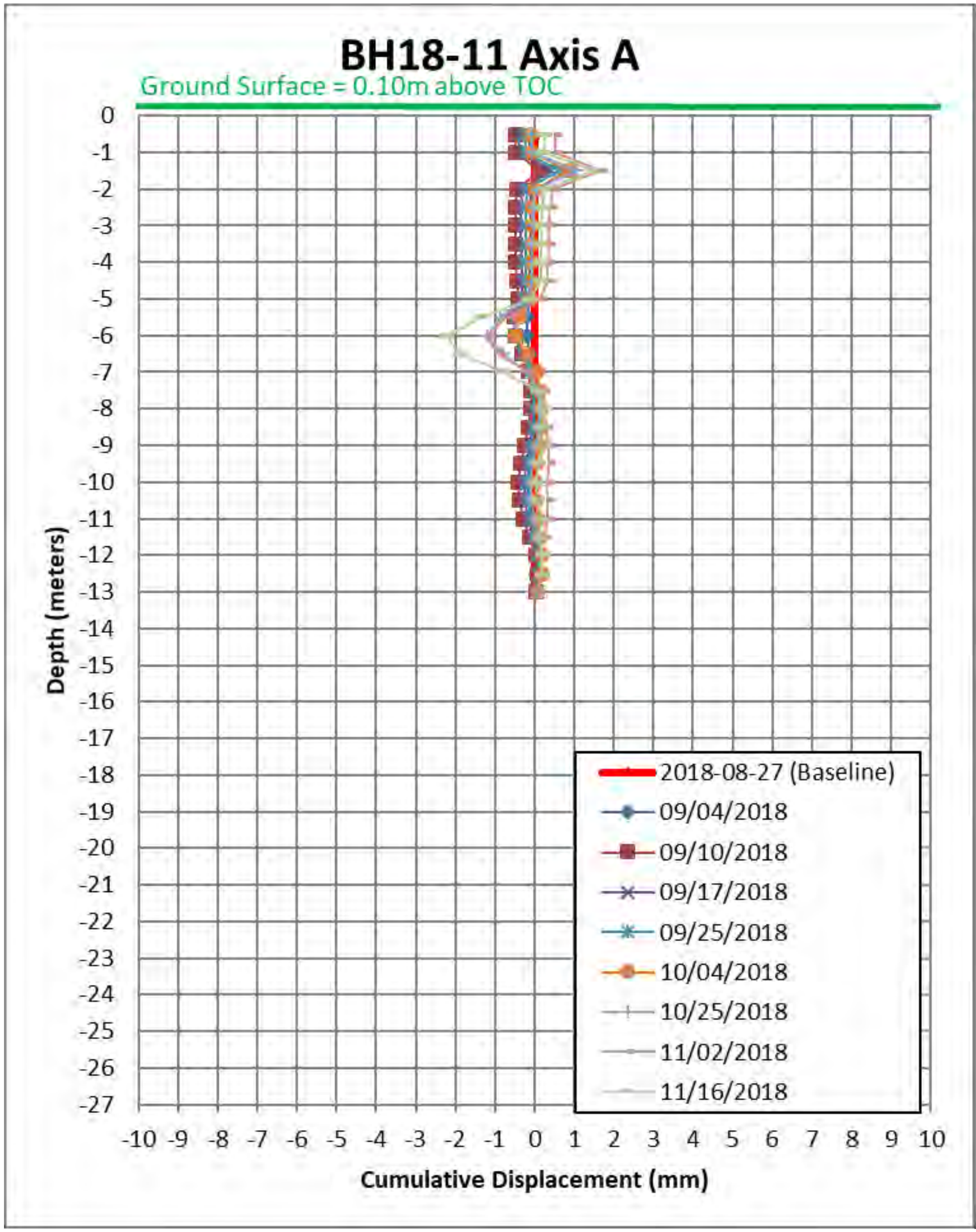
BH18-09 and BH18-10 Slope Inclinometer Readings
2045 Loseth Road Pump Station

City of Kelowna

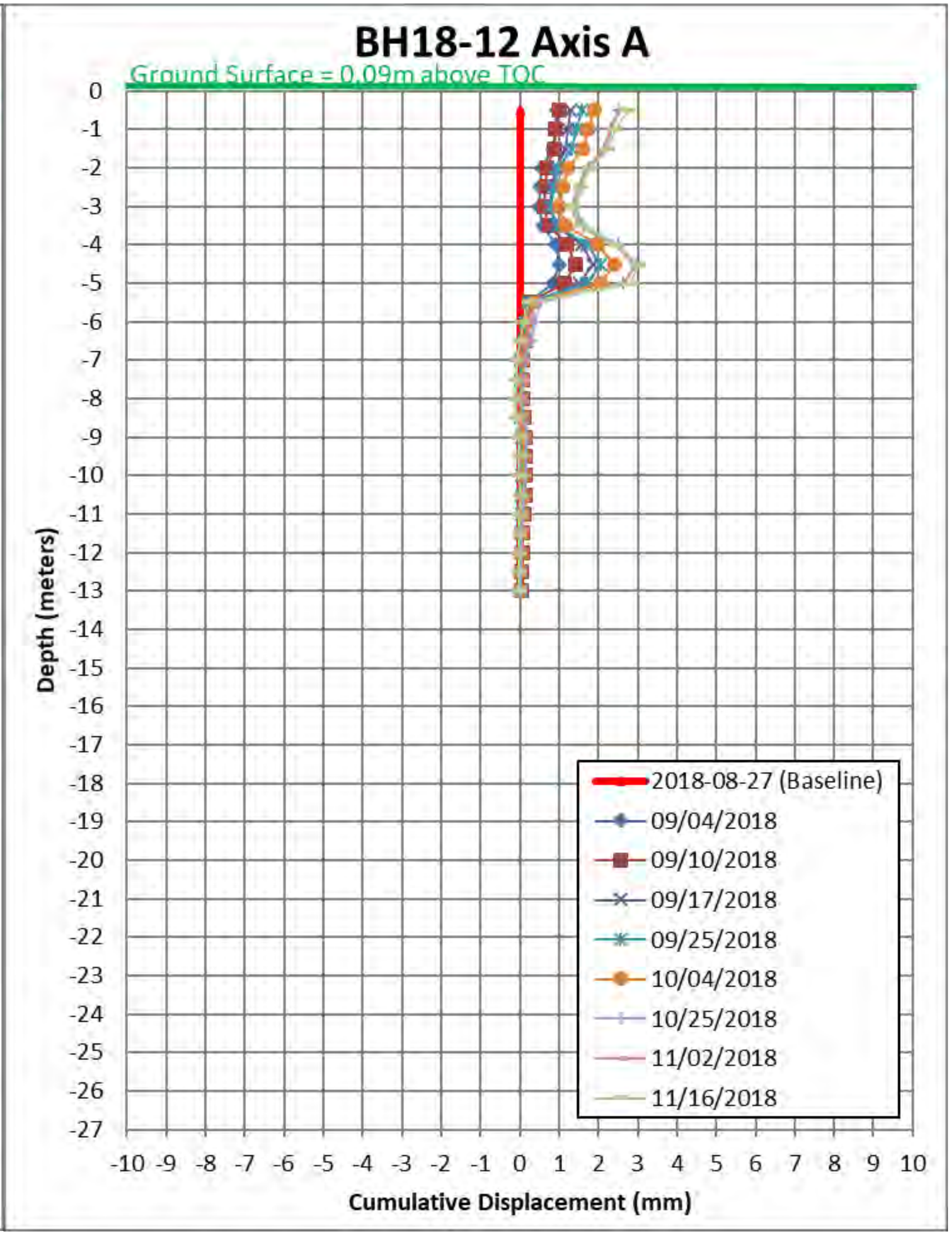
December 7, 2018

Project: 018-253

APPENDIX E - 4


BH18-11 Axis A

Ground Surface = 0.10m above TOC


BH18-12 Axis A

Ground Surface = 0.09m above TOC

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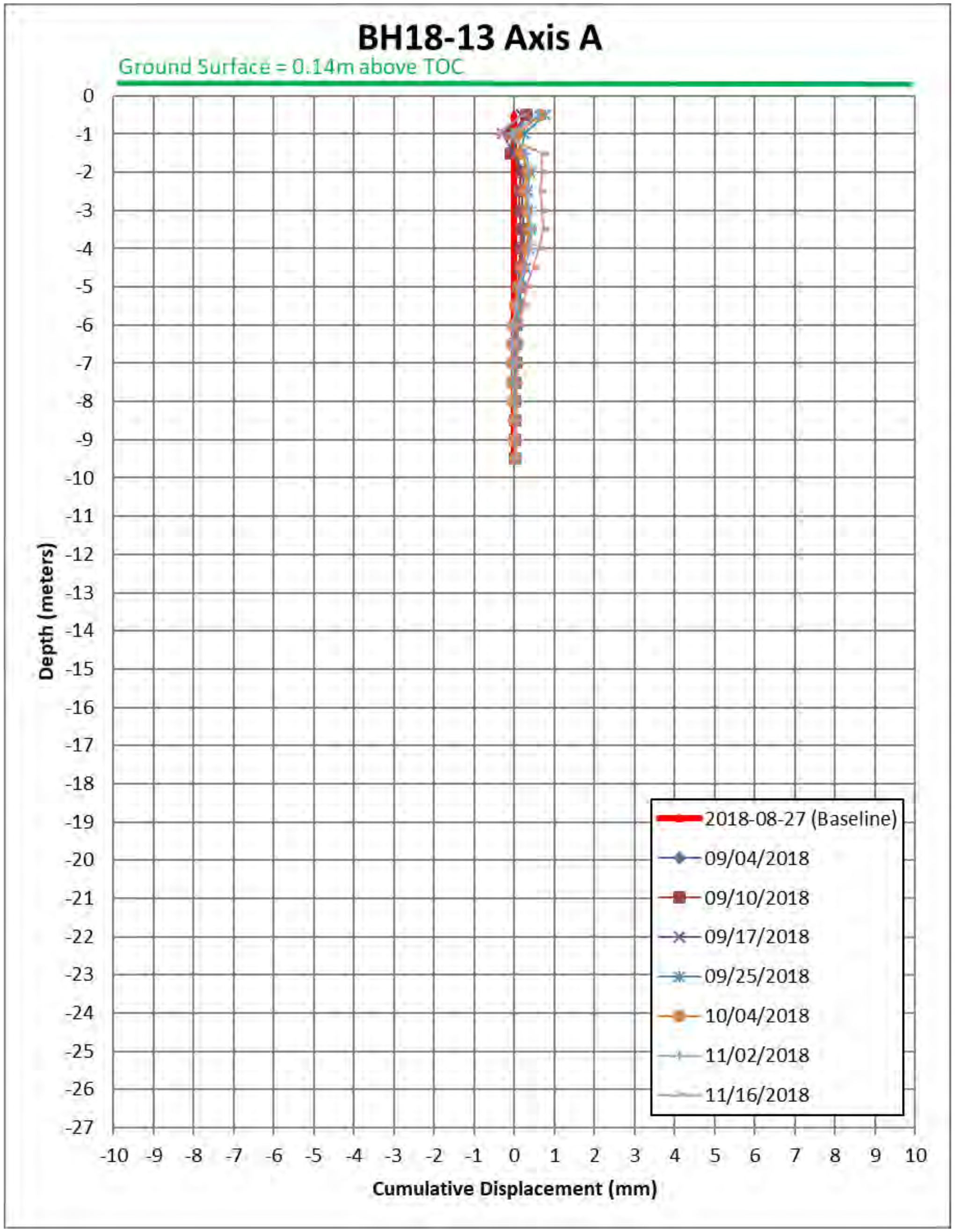
BH18-11 and BH18-12 Slope Inclinometer Readings
2045 Loseth Road Pump Station

City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 5



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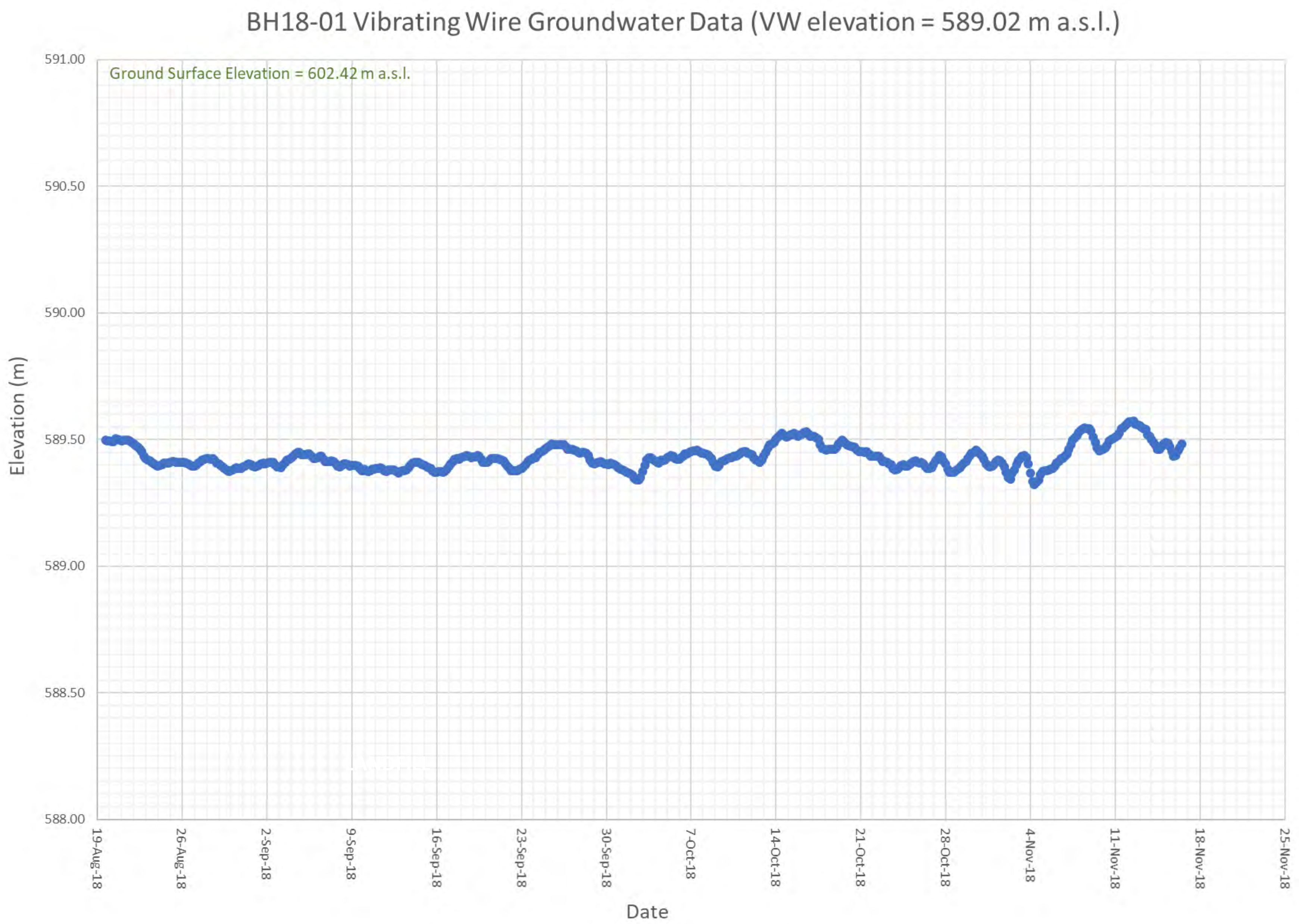
BH18-13 Slope Inclinometer Readings
2045 Loseth Road Pump Station

City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 6



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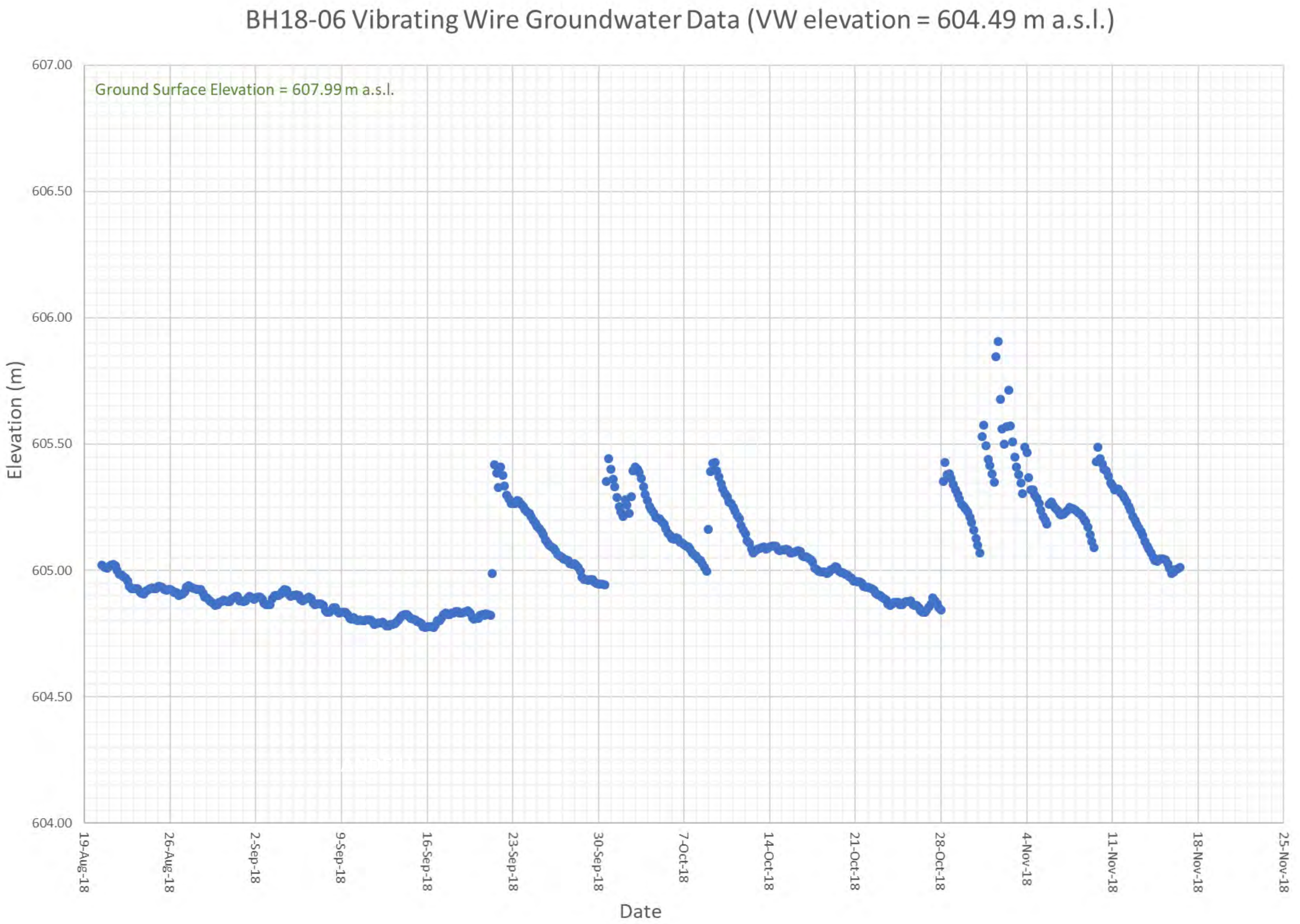
BH18-01 Water Level Readings
2045 Loseth Road Pump Station

City of Kelowna

December 7, 2018

Project: 018-253

APPENDIX E - 7



westrek geotechnical services ltd.

BH18-06 Water Level Readings
2045 Loseth Road Pump Station

City of Kelowna
December 7, 2018
Project: 018-253

APPENDIX E - 8

20th ANNIVERSARY
westrek
geotechnical services ltd.
100 - 1383 McGill Road, Kamloops, BC V2C 6K7
www.westrekgeotech.com

TECHNICAL MEMORANDUM

Date:	June 3, 2018
To:	Toby Pike, Black Mountain Irrigation District
Cc:	Matt Cameron PEng, CTQ Consultants Ltd. Kevin Burtsch, Black Mountain Irrigation District
Re:	**Preliminary Slope Stability Assessment** **Kirschner Mountain Pump Station** **Loseth Road, Kelowna BC**

---

1 Introduction

At the request of Matt Cameron PEng representing CTQ Consultants Ltd. (CTQ) on behalf of Black Mountain Irrigation District (BMID), Westrek Geotechnical Services Ltd. (Westrek) was asked to conduct a preliminary assessment of the stability of the slopes on and adjacent to the Kirschner Mountain Pump Station (the Pump Station) in Kelowna, BC.

This assessment was completed on May 30, 2018. Present were Timothy Smith PGeo, EngL representing Westrek, Matt Cameron, and Kevin Burtsch and Toby Pike representing the BMID. It was clear and sunny at the time.

2 Observations

The Pump Station is located next to the crest of steep fill slopes on the northwest side of Loseth Road, to the immediate north of the junction of Loseth and Sunrise Roads (Photo 1). We understand that the fill was placed at this site to infill a convergent-concave shaped landform (i.e. a broad gully) to create a site for the Pump Station and several lots to the southwest. No information on either the amount and type of fill, the fill placement or the level of compaction was available at the time of our assessment. The fill slope ranges from 75 to 80% and is about 25 m long next to the Pump Station. These slopes lengthen to about 30 m on the lots to the southwest, and bulging was observed in this area.

A trail is located at the toe of the fill slope, and riprap armour has been placed in the base of the unfilled gully beyond it. This generally extends downslope to Kloppenburg Road. Several houses are constructed on the low (or northwest) side of this road (Photo 1). A house is located next to the north side of the fill slope on the cul-de-sac on Kloppenburg Court.

We understand that the fill was placed in this area about 6 years ago and the Pump Station was built about 5 years ago (pers. Comm. Matt Cameron). BMID has indicated that tension cracks in the fill slopes adjacent to the pump station were first noted in October 2017; they since become progressively worse during the 2018 freshet.

Photo 1: An overview of the approximate location of known and possible tension cracks at the site.

Several, large tension cracks were observed near the crest of the fill slopes in this area (Photo1). They show both vertical and horizontal separation (Photos 2 and 3). These features are located on the Pump Station property, the adjacent lots to the southwest, and the Loseth Road shoulder where buried services are located (i.e. Fortis gas and electricity). The City of Kelowna's (the City) storm and sanitary sewer lines are buried in the adjacent road subgrade; the depth of burial is not known by Westrek at this time. A linear crack was observed in the road surface that could be related to the adjacent slope movement, although this has not been confirmed.

A crack was also observed in the concrete slab for the Pump Station that generally parallels the tension cracks in the fill, supporting this structure. It is not known if this is related to the adjacent slope movement.

BMID has indicated that the Pump Station is connected to a reservoir that is located upslope on Kirschner Mountain.

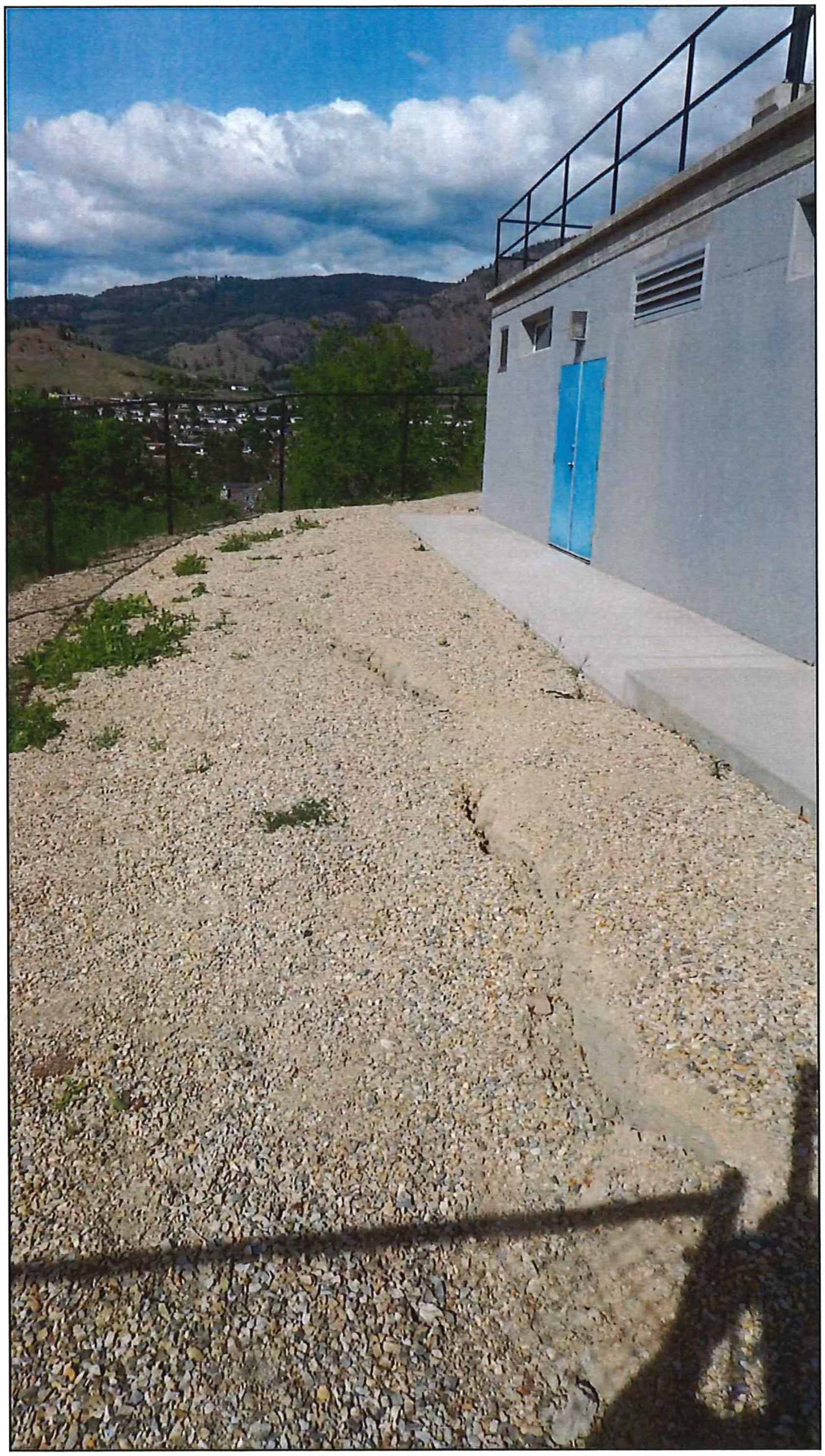


Photo 2: Looking at the tension crack on the northwest side of the Pump Station. Note the vertical and horizontal separation.

Photo 3: Looking at the tension crack in the fill slope at the rear of one of the un-developed lots to the southwest of the pump station.

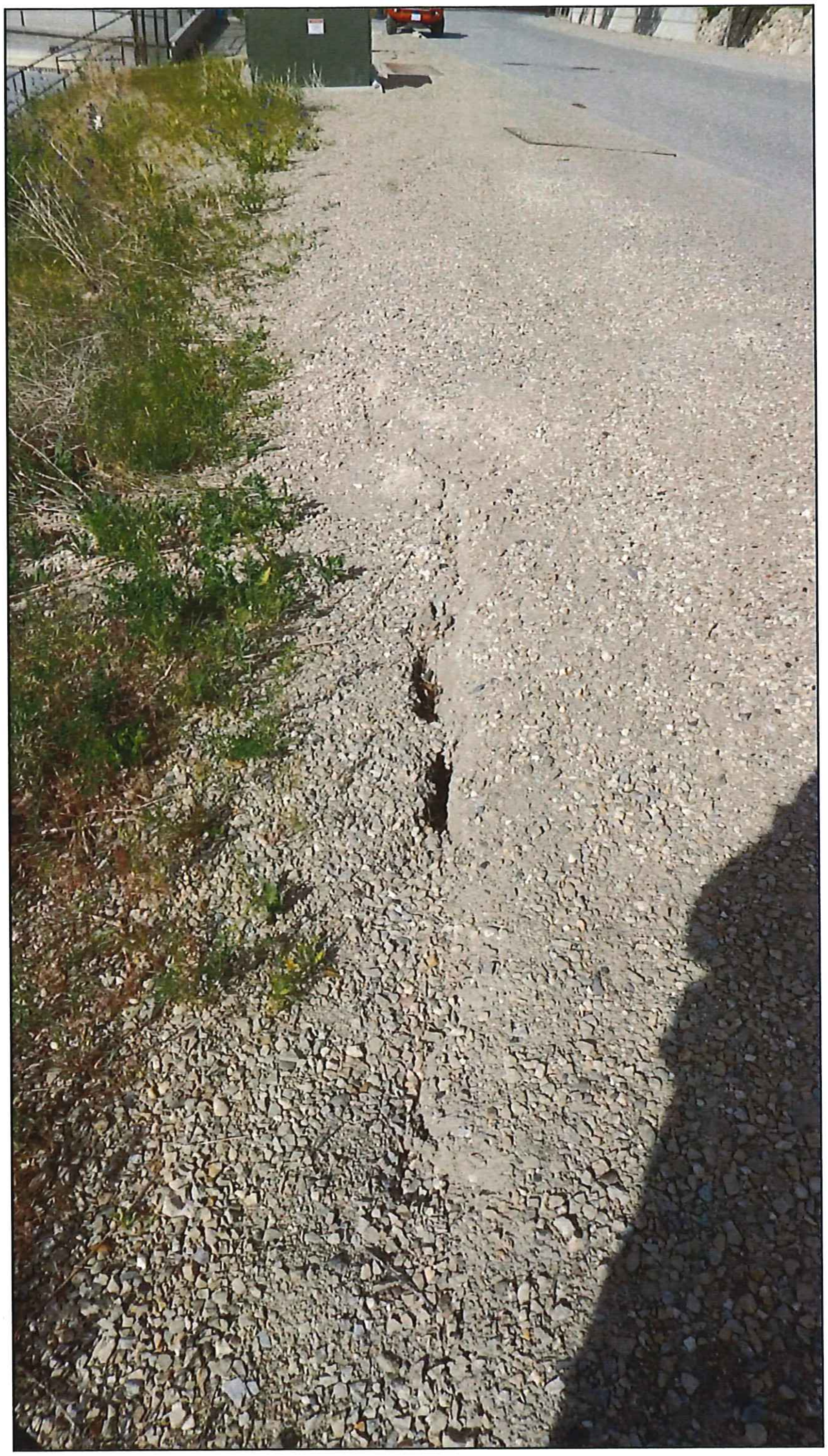


Photo 4: Looking at the tension crack in the shoulder of Loseth Road. The kiosk in the background belongs to Fortis.

3 Analysis

The slopes on and adjacent to the Pump Station site are unstable, and could fail catastrophically. The failure could be triggered by:

- Moderate to heavy rainfall.
- Prolonged rainfall.
- Snowmelt.
- Ongoing slope movement that causes either the pipes or pipe connections at the Pump Station to break or separate creating uncontrolled flow (from the reservoir).
- Ongoing slope movement that causes the City's pipes to break or separate creating uncontrolled flow.

If the slopes fail, and the failure is either triggered or perpetuated by uncontrolled flow from the reservoir (as it drains), there a very high likelihood that the debris will reach the houses downslope, i.e. those on the northwest side of Kloppenberg Road. This creates a very high partial risk to these structures.

If these structures are occupied at the time, it could create a significant risk to the occupants.

In addition, the supply of drinking water (derived from the upslope reservoir) will be affected.

4 Recommendations

We recommend the following:

- All stakeholders affected by these unstable slopes should be made aware the hazard and risk. At a minimum this should include, but not be limited to, the City, BMID, Fortis, and the adjacent property owners to the southwest. It is suggested that a site meeting be held with the affected stakeholders and Westrek to discuss the gravity of the situation and the necessary steps moving forward.
- The City and BMID should develop a management strategy in advance of a slope failure at this site. At the minimum, this should include (i) consultation with adjacent property owners to advise them of the situation, (ii) consideration of issuing evacuation orders to the affected property owners downslope, and (iii) developing a contingency plan for the supply of drinking water to the Kirschner Mountain area.
- The City and BMID should thoroughly check all infrastructure in the area to determine if there are any leaks. All leaks should be fixed as soon as possible.
- A detailed investigation of the landslide should be undertaken to characterize it and determine possible causes. This should include surface monitoring, advancing boreholes and installing instrumentation on all affected properties.
- Once the site geology and possible causes have been determined, conceptual measures to stabilize the site should be developed.

5 Closure

This memorandum contains information relating to our preliminary stability assessment of the slopes on and adjacent to the Pump Station, and must be read in conjunction with the attached Appendices A and B.

Yours truly,

Westrek Geotechnical Services Ltd.

18/06/03
PGeo EngL

T. SMITH
20639

Timothy Smith, PGeo, EngL
Senior Engineering Geologist

Attached: Appendix A *Interpretation and Use of Study and Report and Limitations*
Appendix B *Terminology and Methodology*

APPENDIX A
INTERPRETATION AND USE OF STUDY AND REPORT AND LIMITATIONS

1. STANDARD OF CARE.

This study and Report have been prepared in accordance with generally accepted engineering and geoscience practices. No other warranty, express or implied, is made. Geological and geotechnical studies and reports do not include environmental consulting unless specifically stated in the report.

2. COMPLETE REPORT.

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT.

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT.

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report or any portion thereof, available to any party without our written permission. Any uses, which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. Westrek accepts no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT.

(i) Nature and Exactness of Soil and Description: Classification and identification of soils, rocks, geological units, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilising the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

(ii) Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations or fraudulent acts of any persons providing representations, information and instructions.

(iii) To avoid misunderstandings, Westrek should be retained to work with the other design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to engineering issues. Further, Westrek should be retained to provide field reviews during the construction, consistent with generally accepted practices.

6. LIMITATIONS OF LIABILITY.

Westrek's liability will be limited as follows:

(a) In recognition of the relative risks and benefits of the Services to be provided to the Client by Westrek, the risks have been allocated such that the Client agrees, to the fullest extent permitted by law, to limit the liability of Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, whether arising in contract or tort including negligence, including legal fees and costs and disbursements (the "Claim"), so that the total aggregate liability of Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals:

   i. if the Claim is satisfied by the re-performance of the Services proven to be in error, shall not exceed and shall be limited to the cost to Westrek in re-performing such Services; or

   ii. if the Claim cannot be satisfied by the re-performance of the Services and:

      1. if Westrek's professional liability insurance does not apply to the Claim, shall not exceed and shall be limited to Westrek's total fee for services rendered for this matter, whichever is the lesser amount. The Client will indemnify and hold harmless Westrek from third party Claims that exceed such amount; or

      2. if Westrek's professional liability insurance applies to the Claim, shall be limited to the coverage amount available under Westrek's professional liability insurance at the time of the Claim. The Client will indemnify and hold harmless Westrek from third party Claims that exceed such coverage amount. Westrek shall maintain professional liability insurance in the amount of $2,000,000 per occurrence, $2,000,000 in the aggregate, for a period of two (2) years from the date of substantial performance of the Services or earlier termination of this Agreement. If the Client wishes to increase the amount of such insurance coverage or duration of such policy or obtain other special or increased insurance coverage, Westrek will cooperate with the Client to obtain such coverage at the Client's expense.

      It is intended that this limitation will apply to any and all liability or cause of action however alleged or arising, including negligence, unless otherwise prohibited by law. Notwithstanding the foregoing, it is expressly agreed that there shall be no claim whatsoever against Westrek, its officers, directors, partners, employees, shareholders, owners, subconsultants and principals for loss of income, profit or other consequential damages howsoever arising, including negligence, liability being limited to direct damages.

(b) Westrek is not responsible for any errors, omissions, mistakes or inaccuracies contained in information provided by the Client, including but not limited to the location of underground or buried services, and with respect to such information, Westrek may rely on it without having to verify or test that information. Further, Westrek is not responsible for any errors or omissions committed by persons, consultants or specialists retained directly by the Client and with respect to any information, documents or opinions provided by such persons, consultants or specialists, Westrek may rely on such information, documents or opinions without having to verify or test the same.

(c) Notwithstanding the provisions of the Limitation Act, R.S.B.C. 2012 c. 13, amendments thereto, or new legislation enacted in its place, Westrek's liability for any and all claims, including a Claim as defined herein, of the Client or any third party shall absolutely cease to exist after a period of two (2) years following the date of:

   i. Substantial performance of the Services,

   ii. Suspension or abandonment of the Services provided under this agreement, or

   iii. Termination of Westrek's Services under the agreement,

whichever shall occur first, and following such period, the Client shall have no claim, including a Claim as defined herein, whatsoever against Westrek.

APPENDIX B
TERMINOLOGY AND METHODOLOGY

SCOPE

The TSA was done in general accordance with the *Guidelines for Terrain Stability Assessments in the Forest Sector* (APEGBC / ABCFP, 2010). No other warranty is expressed or implied.

Information on the shallow subsurface conditions are gathered from exposures, trail or road cuts, shallow hand-dug pits, and root wads of fallen trees. No test pits are typically advanced using machinery to investigate the subsurface conditions.

Surficial deposits can be highly variable, even over short distances, and consequently there is a degree of uncertainty with TSAs. Westrek does not represent or warrant that the conditions described in the report are consistent throughout the site and the user should recognise that variations will exist. Where subsequent field review indicates the terrain is different than described, the person taking responsibility for the project should contact Westrek to review the conclusions and recommendations, and this may require additional investigation or engineering to meet the project objectives.

In most cases, a "comparative-observational" approach has been used to provide the rationale for the findings. This approach relies on the examination of historical air photographs, field review of past forestry practices, and professional judgement to assess the potential response of the terrain to the proposed development.

TERMINOLOGY

Terminology used to describe the terrain, are based on the BC Terrain Classification System (Howes and Kenk, 1997).

SLOPES		
Slope Type	**Description**	
Plain	0 - 3°	(0 - 5%)
Gentle	4 - 15°	(6 - 26%)
Moderate	16 - 26°	(27 - 49%)
Moderately steep	27 - 35°	(50 - 70%)
Steep	36- 42°	(71 - 90%)
Very steep	> 42°	(> 90%)

Surface expression (slope shape, profile and surface expression) are described using the terms in the following table, as adapted from the BC Ministry of Forests Land Management Handbook 18.

SURFACE EXPRESSION	
Thickness	**Description**
Blanket	Deposits mask bedrock, >1 m thick
Veneer	Deposits reflect bedrock, <1 m thick
Thin Veneer	Deposits are 10 to 25 cm thick
Variable	Deposits vary, 0 to >1 m thick
Shape	**Description**
Concave	Slope aspect converges along contour
Convex	Slopes aspect diverges along contour
Uniform	Slope aspect is consistent along contour
Irregular	Slope aspect has no pattern
Undulating	Slope aspect varies regularly
Terraced	Distinct flat surface and steep frontal slope formed by a fluvial process.
Profile	**Description**
Concave	Slope angle decreases downhill
Convex	Slopes angle increases downhill
Uniform	Slope angle is consistent
Irregular	Slope angle varies with no pattern
Benched	Slope is interrupted by narrow distinctly flatter slope gradients.

Draws	Description
Gully	Linear erosion feature >3m deep; sidewalls near angle-of-repose (usually >50%); channel gradients typically >20% (may be less for some reaches); may or may not contain an active stream channel.
Swale	Broad V or U-shaped linear feature aligned down the slope fall-line, usually <1 m deep, usually does not contain an active stream channel.
Draw	A feature not meeting the above or otherwise undifferentiated.

Texture is described using the BC Terrain Classification System. Where mixed materials are described, descriptors are based on the Canadian Foundation Engineering Manual (CGS, 2006).

SURFICIAL MATERIAL TEXTURE	
Angular / Sub-angular Particles	
Blocks (a)	> 256 mm
Rubble (r)	2 to 256 mm
Angular fragments (x)	> 2 mm
Rounded / Sub-rounded Particles	
Boulders (b)	> 256 mm
Cobbles (k)	64 to 256 mm
Pebbles (p)	2 to 64 mm
Gravel (g)	> 2 mm
Sand (s)	0.62 to 2 mm
Silt (z)	0.002 to 0.062 mm
Clay (c)	< 0.002 mm
Other	
Mixed angular to rounded fragments (d)	> 2 mm
Mixtures	
Main component	> 50% by weight
"and"	35 to 50% by weight
Suffix "y" i.e. silty	20 to 35% by weight
"some"	10 to 20% by weight
"trace"	0 to 10% by weight

Soil drainage is described using the Canadian Soil Classification terminology (AAFC, 1998).

SOIL DRAINAGE	
Slopes	**Description**
Rapidly drained	Water is removed from the soil rapidly in relation to supply.
Well drained	Water is removed from the soil readily but not rapidly.
Moderately Well drained	Water is removed from the soil somewhat slowly in relation to supply.
Imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Some mottling is common.
Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Soils are generally mottled and/or gleyed.
Very Poorly drained	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen (i.e. wetlands).

APPENDIX B
TERMINOLOGY AND METHODOLOGY

Landslides

Landslide classification uses terminology developed by Cruden and Varnes (1996) and Hungr *et al.* (2001).

Landslide magnitude of a landslide is expressed in qualitative terms using the ranges shown below.

LANDSLIDE MAGNITUDE		
Size Rating	**Typical Area (ha)**	**Typical Volume (m^3)**
Very Large	>5	>50,000
Large	0.5 - 5	5,000 – 50,000
Medium	0.05 – 0.5	500 – 5,000
Small	0.005 – 0.05	50 – 500
Very Small	<0.005	<50

RISK ANALYSIS

Risk analysis is a process that examines the chance of an injury or loss as a result of a harmful event occurring and its effect on the identified elements at risk. Hazard and risk ratings are based on the definitions and terminology in Land Management Handbook (LMH) 56 (Wise *et al*, 2006). **Unless otherwise stated a "partial risk analysis" approach, as described in LMH 56, has been used.**

In "partial risk analysis", no interpretation of the vulnerability or the degree of loss to the element at risk is considered. Risk is rated for an estimated landslide that may initiate and affect the element at risk, and it considers that an impact is negative (undesirable), even though it may not be destructive or dangerous. Therefore "partial risk" is actually an "encounter probability". Furthermore, since many risk analyses are done on a specific unmoving object or linear feature, the probability of a temporal impact is often ignored. This is a conservative approach but it is generally appropriate for TSAs for forest development. For the analysis of risk to a specific element or an analysis of total risk, an examination of other risk components and a more detailed analysis may be required.

In summary, "partial risk" is defined as: mathematically as P(HA) = P(H) × P(S:H), where:

(P:H) = the likelihood of a landslide occurring that may affect an identified element at risk;

(S:H) = the likelihood of a spatial impact given a landslide occurrence.

Qualitative relationships are used in the determination of these components, as defined below.

Likelihood of Landslide Initiation - P(H)

The likelihood of landslide initiation (or landslide hazard) is the probability that a described landslide will occur, given the proposed development or the proposed road construction method. The following table gives the probability range for each rating.

RELATIVE HAZARD PROBABILITIES P(H)		
Rating	**Alternate**	**Annual Probability**
Very Low	Remote	P_A = less than 1/10,000 (i.e. < 1% in 20 years)
Low	Unlikely	P_A = 1/10,000 to 1/500 (i.e. 1% to 4% in 20 years)
Moderate	Possible	P_A = 1/500 to 1/100 (i.e. 4% to 18% in 20 years)
High	Likely	P_A = 1/100 to 1/20 (i.e. 18% to 64% in 20 years)
Very High	Certain	P_A = > 1/20 (i.e. >64% in 20 years)

Likelihood of a Spatial Impact - P(S:H)

This defines the likelihood that a certain landslide will impact the element at risk. Travel distance estimation is difficult without topographic modelling and simulation using 3-dimensional computer modelling. Studies such as Fannin and Rollerson (1993), Fannin and Wise (2001), Millard (1999) and VanDine (1985, 1996) are useful for predicting where debris flows may begin to deposit but these models are based on data obtained in coastal settings.

Unless noted otherwise, spatial probability is determined from estimates of landslide travel distance using simple geometric models by Corominas (1996) and/or Hunter and Fell (2003). These models estimate angle-of-reach, which is the angle measured below the horizontal from the landslide initiation point to the distal edge of its debris. Input slope profiles for the analysis were generated using GeoBC data. For the Corominas model, landslide volume is estimated from site observations or local data. Areas that lie between the average and upper angle-of-reach are assigned a high likelihood of spatial impact. Areas that lie between the average and lower bound angle-of-reach are assigned a moderate likelihood of spatial impact. Areas beyond the lowest angle-of-reach are assigned a low likelihood of spatial impact. For simplicity, no account is made for the lateral spatial probability of a landslide impact, which is defined largely by topographic constraints; consequently, this approach is expected to be conservative.

Estimates of hazard and spatial probability are combined in a matrix to yield the "partial risk" estimate. Note that this approach does not estimate the degree of damage to an element, but it simply means it may reach the element. Expressed qualitatively, estimated spatial probability relationships are shown in the following table.

SPATIAL PROBABLITY RATINGS		
Rating	**Alternative Rating**	**Chance**
High	Likely	>30%
Moderate	Possible	10 – 30%
Low	Unlikely	4 – 10%
Very Low	Remote	<4%

Partial Risk Analysis P(HA)

Using the estimates for likelihood of landslides (the hazard) and the spatial probability of impact, the following matrix is used to determine the partial risk to an element at risk from a described landslide.

PARTIAL RISK ANALYSIS MATRIX				
Hazard	**Spatial Probability**			
	H	**M**	**L**	**VL**
H	VH	H	M	L
M	H	M	L	L
L	M	L	VL	VL
VL	L	L	VL	VL

where VH = very high, H = high, M = moderate, L = low, and VL = very low

Partial risk analysis does not estimate if a landslide impact would constitute a "material adverse effect", which is a societal judgement parameter. Management implications for the partial risk ratings are provided in Appendix B.

APPENDIX B
TERMINOLOGY AND METHODOLOGY

Risk Assessment and Management Implications

Risk management is a decision-making process that considers the mitigation strategy or strategies necessary to guide the owner or person responsible for the development to accept or mitigate the potential for loss or damage to an element at risk. The acceptance of these definitions by the client / owner indicates a willingness to take responsibility for the risks to the identified elements at risk. The following table is intended to provide guidance to the decision maker, but it would have to be tailored to the risk acceptability of the owner or decision maker.

RISK ASSESSMENT AND RISK MANAGEMENT CONSIDERATIONS		
Rating	**Description**	**Example of management implication**
VH	Very high risk	The risk is usually unacceptable and would require extensive detailed investigation, research, planning engineering and implementation of treatment options essential to reduce risk to acceptable levels: may be too expensive and not practical to implement.
H	High risk	The risk is probably not tolerable as is, and treatment options are likely required to reduce risk to acceptable levels. Detailed investigation, planning, engineering, and construction supervision during the implementation of risk reduction measures will be necessary. On-going risk control is likely needed.
M	Moderate risk	The risk may or may not be tolerable, depending on the risk acceptability criteria of the resource manager or approval agency. • The risk may be tolerable as is, with or without further consideration, or with the understanding that the results will be monitored. • It may be tolerable provided a treatment plan is implemented to minimize the influence of certain factors that contribute to the hazard. • It may also require additional investigation prior to making a decision, to define the risk and / or assumptions used to define the risk, in more certainty. • It may involve consideration of additional or alternate treatment options, which may require more assessment and engineering. It will likely require consideration of risk from other activities (i.e. other than landslide risk) to be weighed in terms of overall risk from the proposed activity.
L	Low risk	Usually acceptable. Treatment requirements and responsibility may be defined to maintain or reduce risk.
VL	Very low risk	Acceptable. Manage by normal operational and maintenance procedures in the development area.

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20th ANNIVERSARY
westrek
geotechnical services ltd.
100 – 1383 McGill Road, Kamloops, BC V2C 6K7
www.westrekgeotech.com

TECHNICAL MEMORANDUM

Date:	February 18, 2019
To:	James Kay City of Kelowna
Re:	**Slope Instability - 2045 Loseth Road** **Questions for Discussion with Westrek**

1 Introduction

This memo answers questions raised in the teleconference on February 15, 2019 regarding the slope instability below the pump station at 2045 Loseth Road. The questions pertain to issues raised in the report by Westrek Geotechnical Services Ltd. (Westrek) titled "*Geotechnical Investigation – 2045 Loseth Road*", dated January 24, 2019.

This memo is subject to the terms and conditions set out in the *Interpretation and Use of Study and Report and Limitations*, which is attached in Appendix A of the referenced report.

2 Answers to Questions Raised Prior to Meeting

Question 1: Can you provide a drawing showing an aerial view of the fill areas?

Answer 1: The approximate area of fill delineated by drilling and site observations is shown on the attached map.

Question 2: Further clarification on the risk to BMID Pump Station – At page 20 of the report there are statements that "the probability of a landslide affecting the pump station is high" and "[t]he pump station is at risk of settlement resulting from a slope failure". Is the risk to the pump station from a failure of the slope(s) below a matter of settlement at worst, or is there a potential for a loss of the pump station?

Answer 2: The factor of safety of a slope failure capable of reaching the pump station is very close to 1.0, meaning a failure directly impacting on the pump station is likely. However, a more likely scenario is that the slope fails back to roughly the existing tension cracks, 2 to 2.5 m from the building, creating a near-vertical headscarp. Significant settlement and subsequent retrogressive failures would severely impact on the pump station shortly after the initial slope failure.

Question 3: With respect to the imminent hazard that is referenced as expected to develop [page 26, point ii], is it possible that the hazard will not increase to imminent probability but that there is no way of knowing at this time whether that will be the case?

Answer 3: The slope may continue to simply creep downslope, which would eventually result in an over-steepened headscarp as discussed in Answer 2. However, given the amount of movement during spring 2018, a sudden and catastrophic failure is the more likely outcome.

Question 4: Taking into account the conditions in the intervening 3 weeks since the report, can you say anything as to the timing in progression from high/very high probability to imminent risk of a landslide? In other words, is Westrek's recommendation that mitigation steps should be commenced as soon as possible, or is there an interim period where no action is required?

Answer 4: Slope stability is expected to deteriorate quickly once snow melt begins and groundwater pressures rise. Once significant movement is observed, there will likely not be sufficient time to mitigate the risks, other than evacuating the residences below and shutting down the pump station. Failure could also occur catastrophically, and without significant warning to the City of Kelowna (the City) or Black Mountain Irrigation District (the BMID).

Question 5: Is there any basis for distinguishing between the timing for initiating mitigation works on the slope above 2001 Kloppenburg Ct and the slope below the pump station on 2045 Loseth?

Answer 5: No. The slope on 2045 Loseth poses a greater hazard (i.e. failure is more likely), but the consequences of a failure above 2001 Kloppenburg Ct is greater due to the house at the toe.

Question 6: Following on the above, can the slopes be mitigated separately? Or must the mitigation work be co-ordinated?

Answer 6: No. It is better to mitigate the slopes together. Separate mitigation works could cost more and limit access to the other site.

Question 7: Given the tension cracks immediately north of the pump station and (apparently) within the statutory right of way area, does the mitigation work plan include work within the SRW area itself (and which perhaps should be directed to BMID)?

Answer 7: Yes, the toe buttress option includes either flattening the upper slope within the SRW or construction of a short GRS wall to stabilize the upper slope.

Question 8: Is there a benefit in attempting to cut off groundwater before it enters the unstable slope material? Any ideas how this might be done?

Answer 8: Yes, there would be some benefit; however, see the answer to Question 9. Source control likely requires eliminating in-ground stormwater disposal upslope. A deep drain would be very challenging because of the concentration of underground services beneath Loseth Road. Gravity drainage would be needed and the original gully is 11 m deep, requiring a very deep drain. However, this could be explored further, if required.

Question 9: What is the difference in the safety factors between the saturated and unsaturated slope?

Answer 9: The fill slope is just marginally stable when dry, and does not meet any standards for slope stability. We have not monitored the piezometers through a spring yet, so we do not know how high groundwater levels rise, but they do not have to rise much to trigger slope movement.

Question 10: BH18-06 showed quite a bit of variation in groundwater elevation and was very responsive to precipitation events. Was this observed in other boreholes as well?

Answer 10: We have not monitored through spring yet. To date, the only piezometers to measure any groundwater pressures are in BH18-01 and BH18-06. As noted, BH18-06 measured much greater fluctuations in water level than BH18-01. Some of the other piezometers may measure similar variations in the spring.

Question 11: Were groundwater levels ever shown to be higher than the potential failure surface in any of the boreholes?

Answer 11: Not to date. However, none of the instrumentation has been monitored through spring. Not only are groundwater levels expected to rise, the SI's have not all definitively measured the depth to the slip surface.

3 Additional Items Raised During Meeting

Monitoring Frequency

The monitoring frequency has been monthly over the winter but will increase gradually into spring. Weekly readings are expected by the end of April; twice weekly readings, if movement is detected, or even daily if movement is significant.

Consideration by the City could be given to establishing real-time monitoring of the vibrating wire piezometers to establish when the SI reading frequency should increase. This could be achieved by connecting the existing dataloggers to a wireless system. Westrek can assess the costs for the additional equipment.

Next Step

Pending the City's approval, Westrek will work with the City's engineers to develop a grading plan for the proposed slope buttress option. We will assess options to refine the buttress, including extending the fillslope farther downslope to eliminate the GRS wall along Cross-section A-A' and reducing the size of the level area at the crest of the slope.

4 Closure

We trust these answers will assist the City staff in their presentation to council. Please contact us if there are any other questions raised during the council meeting.

Westrek Geotechnical Services Ltd.

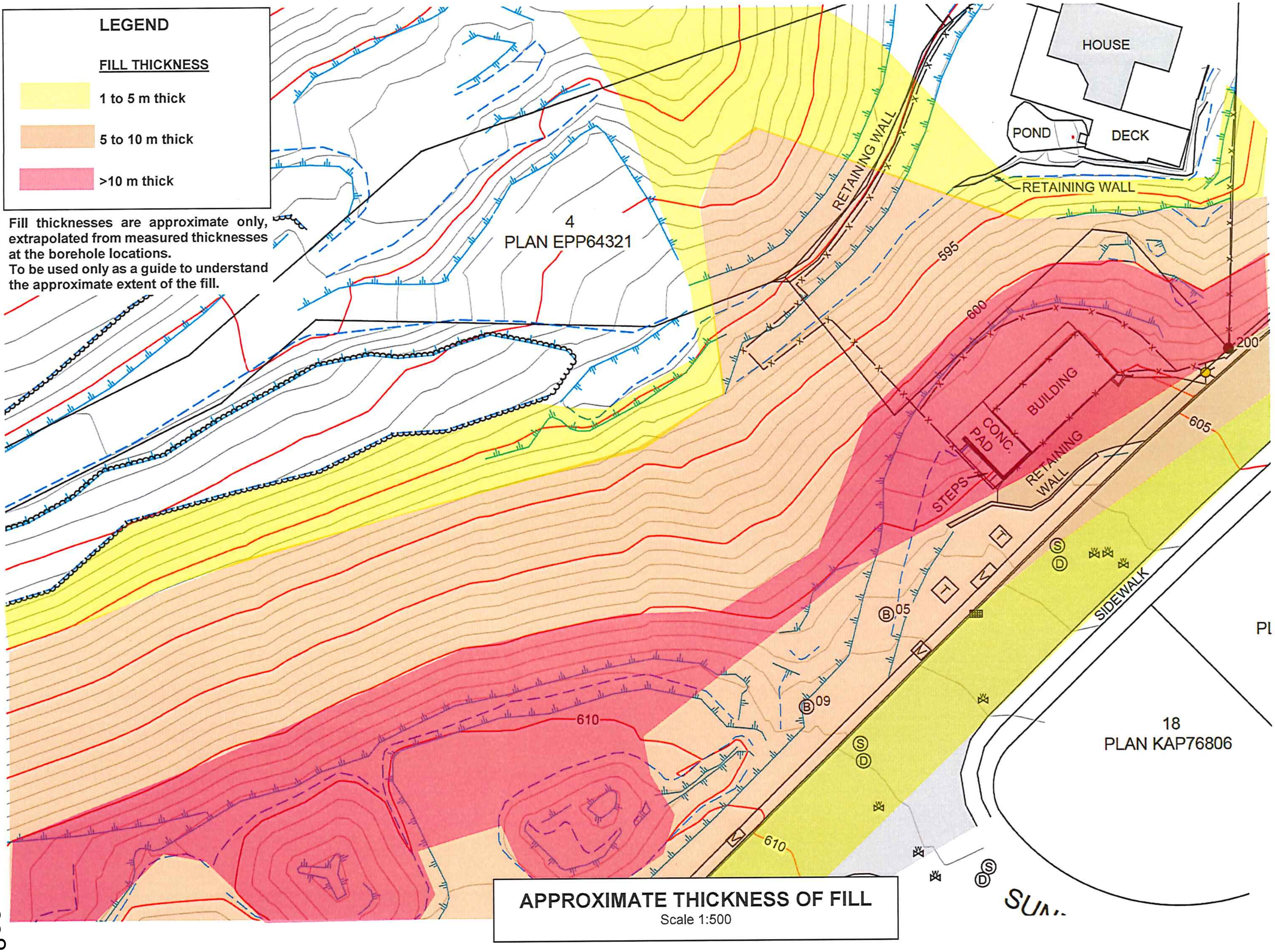
E. J. McQUARRIE
E. J. McQUARRIE
16420
February 18, 2019

EJ McQuarrie

Eric McQuarrie PEng, PGeo
Senior Geotechnical Engineer

Tim Smith, PGeo, EngL
Principal and Senior Engineering Geologist

Attachment: Map of Fill Area



Fill thicknesses are approximate only, extrapolated from measured thicknesses at the borehole locations.
To be used only as a guide to understand the approximate extent of the fill.

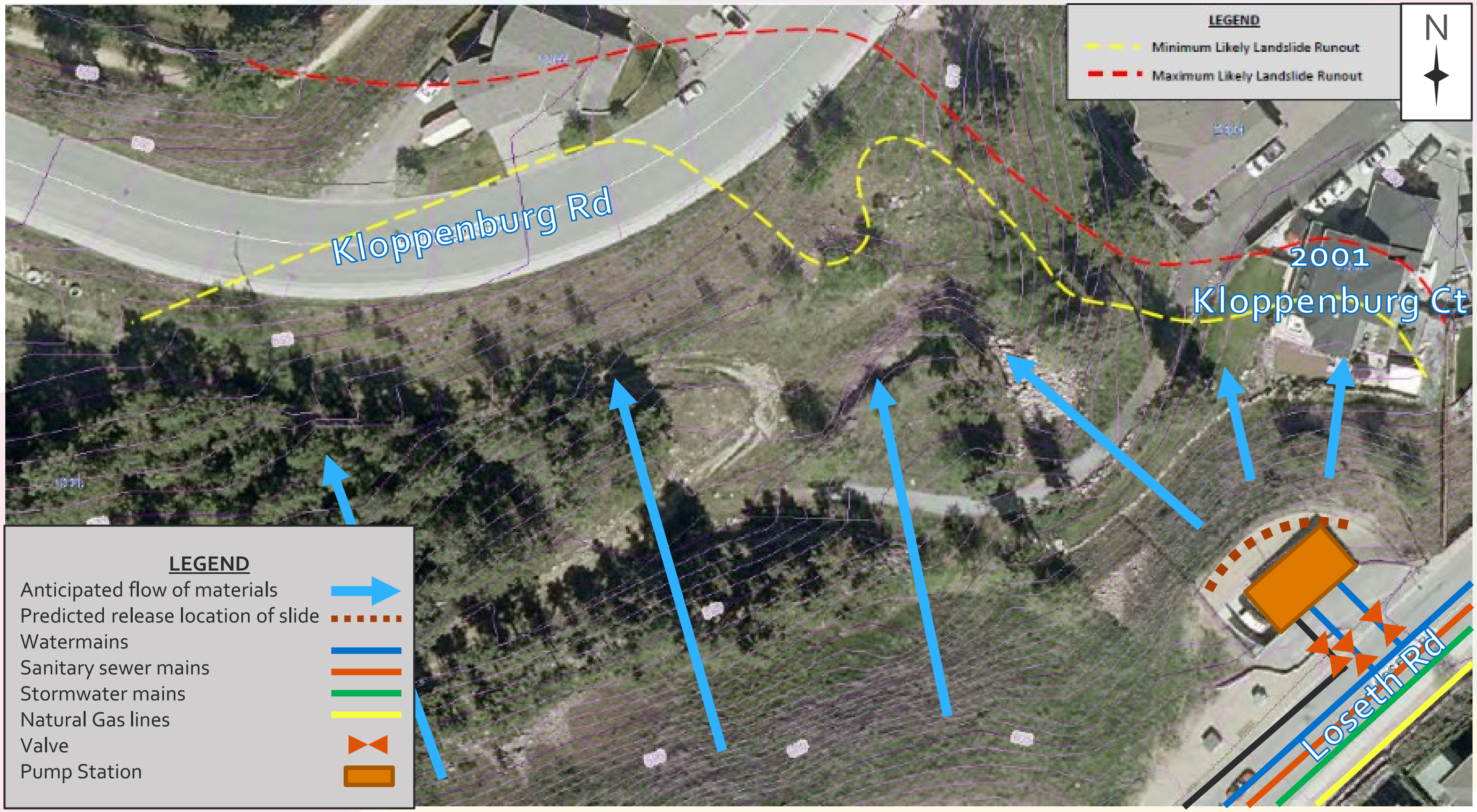
APPROXIMATE THICKNESS OF FILL

Scale 1:500

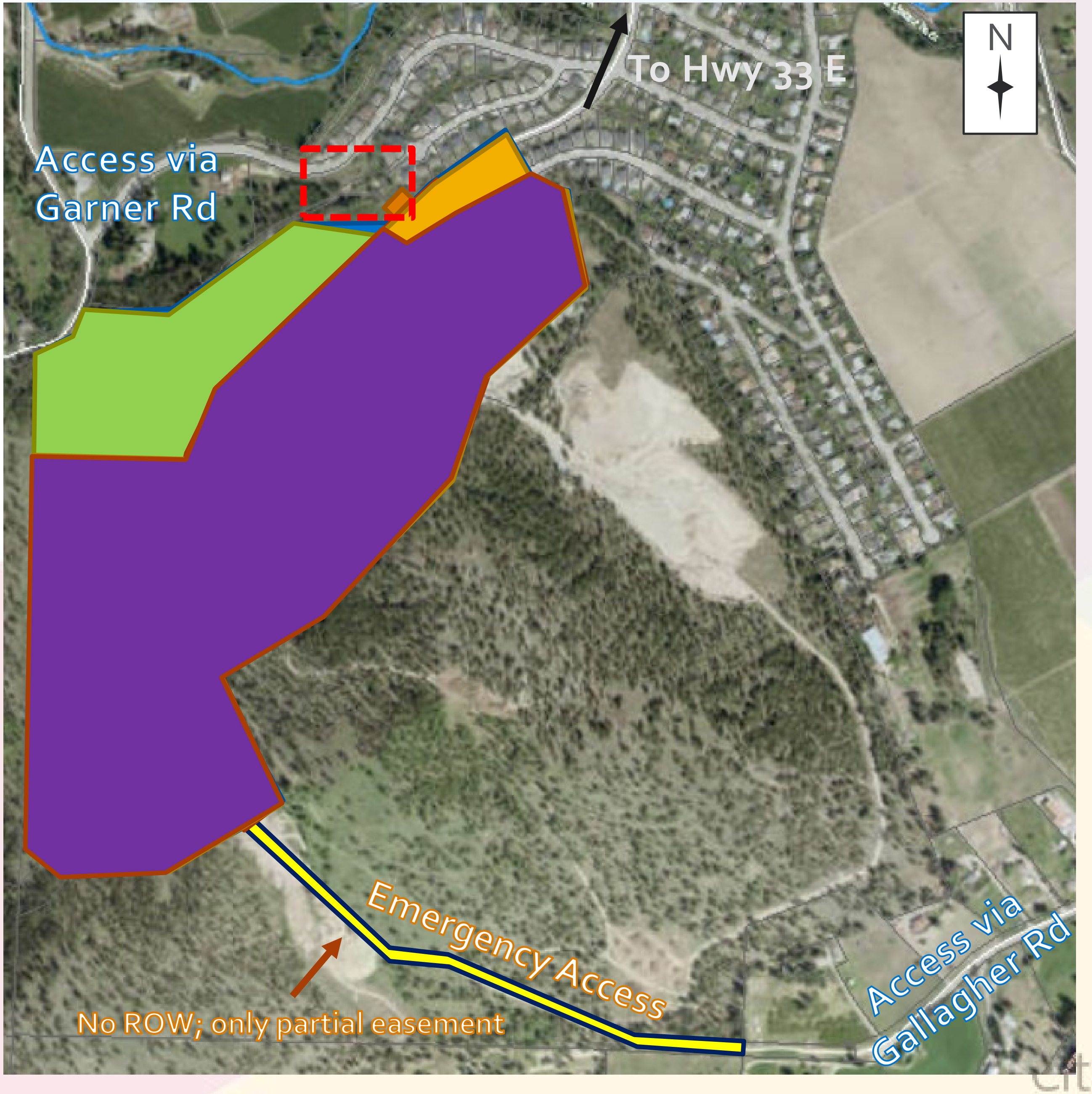
Loseth Rd Pump Station

Risks and mitigation

Immediate Area



Local Area



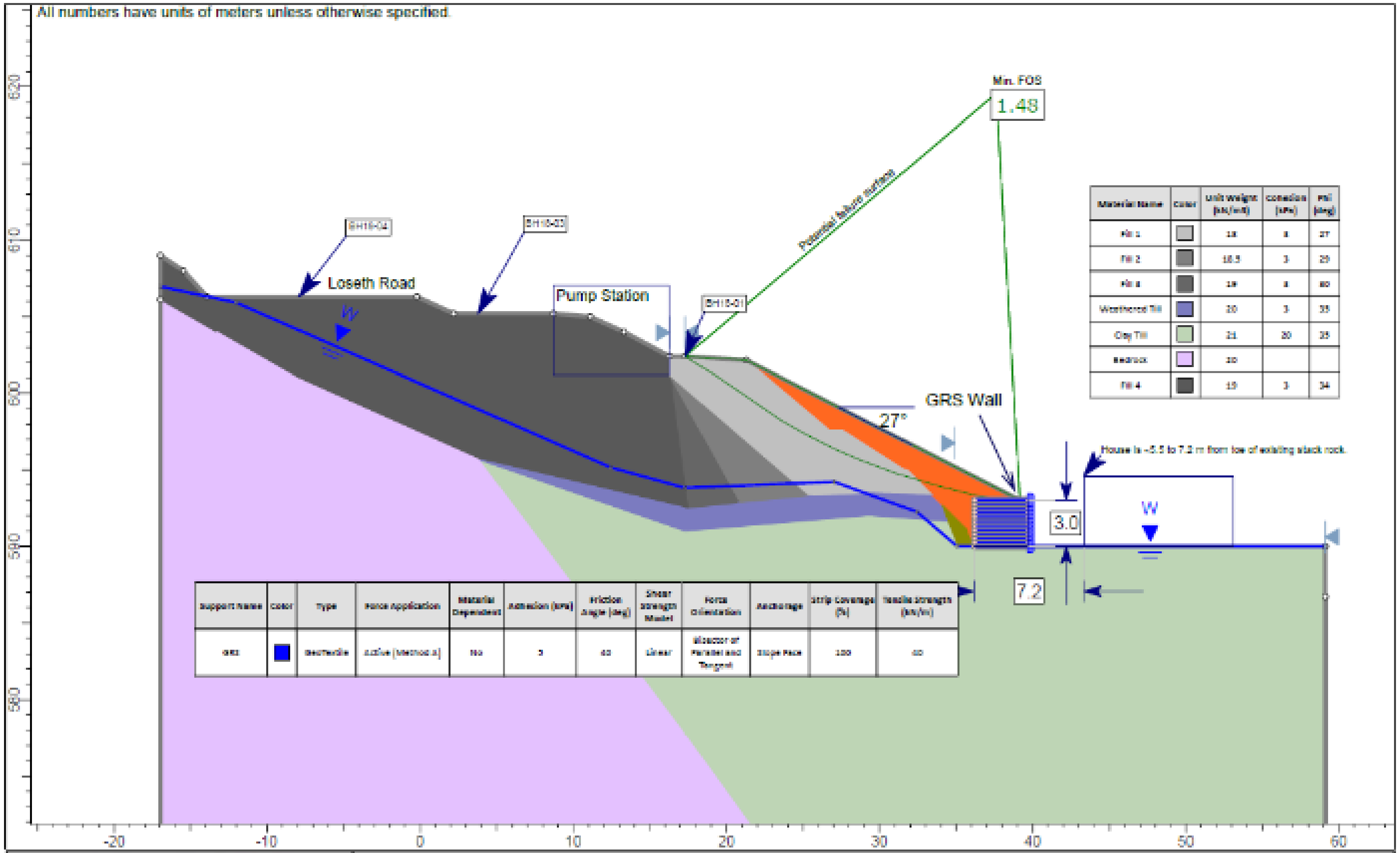
Service disruption areas

Water	🟦
Transportation	🟩
Sanitary service	🟧
Electric + Comm’n	🟨
Natural gas	🟪
Immediate Area	⬚

Site overview

GRS wall + flattening

$100,000 - $125,000 @ 2001 Kloppenburg Ct



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	▨	18	8	27
Fill 2	▨	18.5	3	29
Fill 3	▨	18	8	30
Weathered Till	🟦	20	3	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	▨	19	3	34

Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (kN/m)
GRS	🟦	Geotextile	Active (Method A)	No	5	40	Linear	Bisector of Parallel and Tangent	Slope Face	100	40

Project	2045 Loseth Road Pump Station	
Analysis Description	Section C-C' - GRS Toe Buttress Wall	
Drawn By JP	*Scale* 1:350	*Company* Westrek Geotechnical Services Ltd.
Date 2018-12-19		FIGURE 7

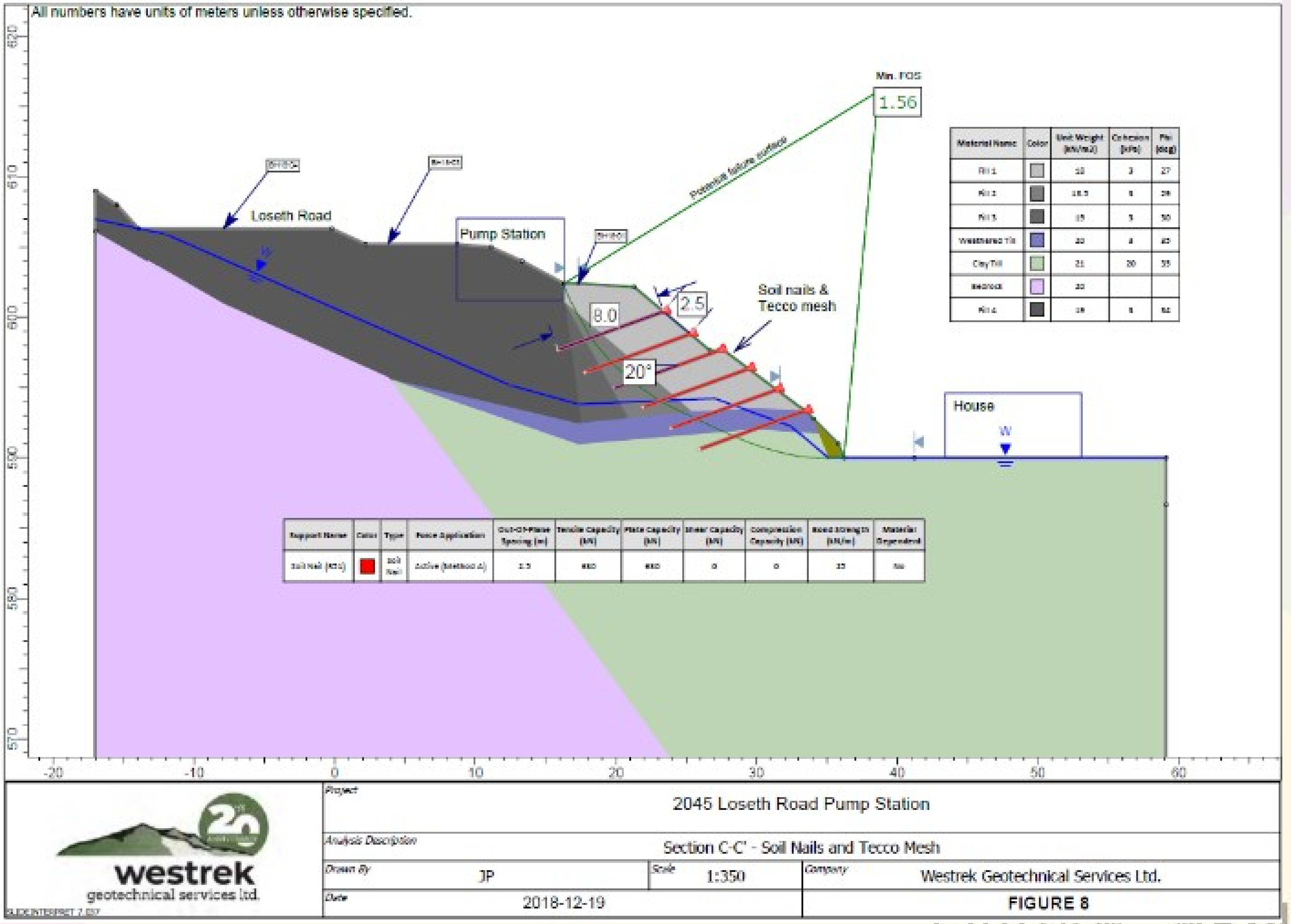
westrek geotechnical services ltd

SLIDEINTERPRET 7.037

City of Kelowna

Soil nails + Tecco mesh

$300,000 - $350,000 @ 2001 Kloppenburg Ct



Project: 2045 Loseth Road Pump Station

Analysis Description: Section C-C' - Soil Nails and Tecco Mesh

Drawn By: JP

Scale: 1:350

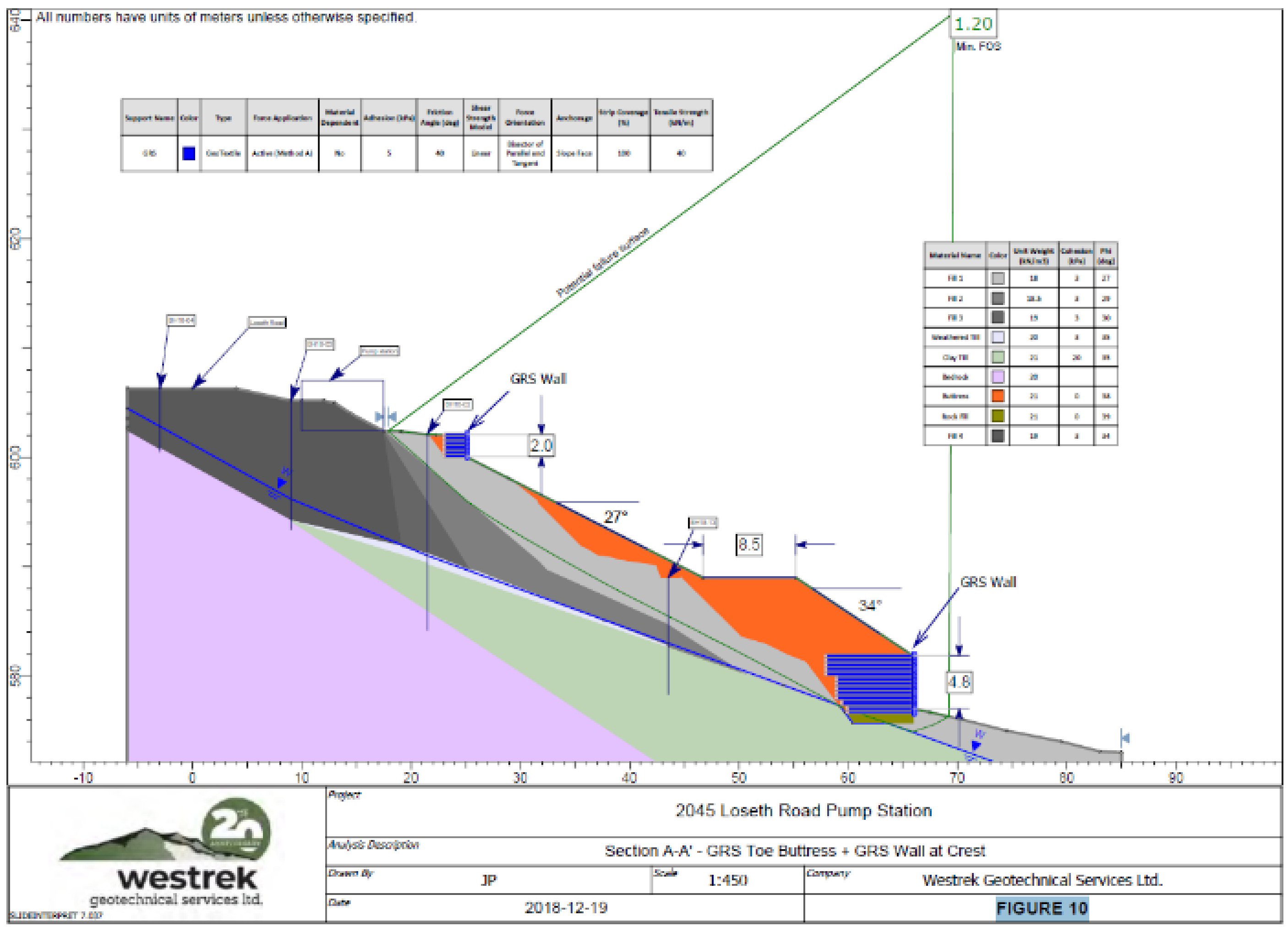
Company: Westrek Geotechnical Services Ltd.

Date: 2018-12-19

FIGURE 8

GRS wall + flattening

$350,000 - $400,000 @ 2045 Loseth Rd



Project 2045 Loseth Road Pump Station

Analysis Description Section A-A' - GRS Toe Buttress + GRS Wall at Crest

Drawn By JP

Scale 1:450

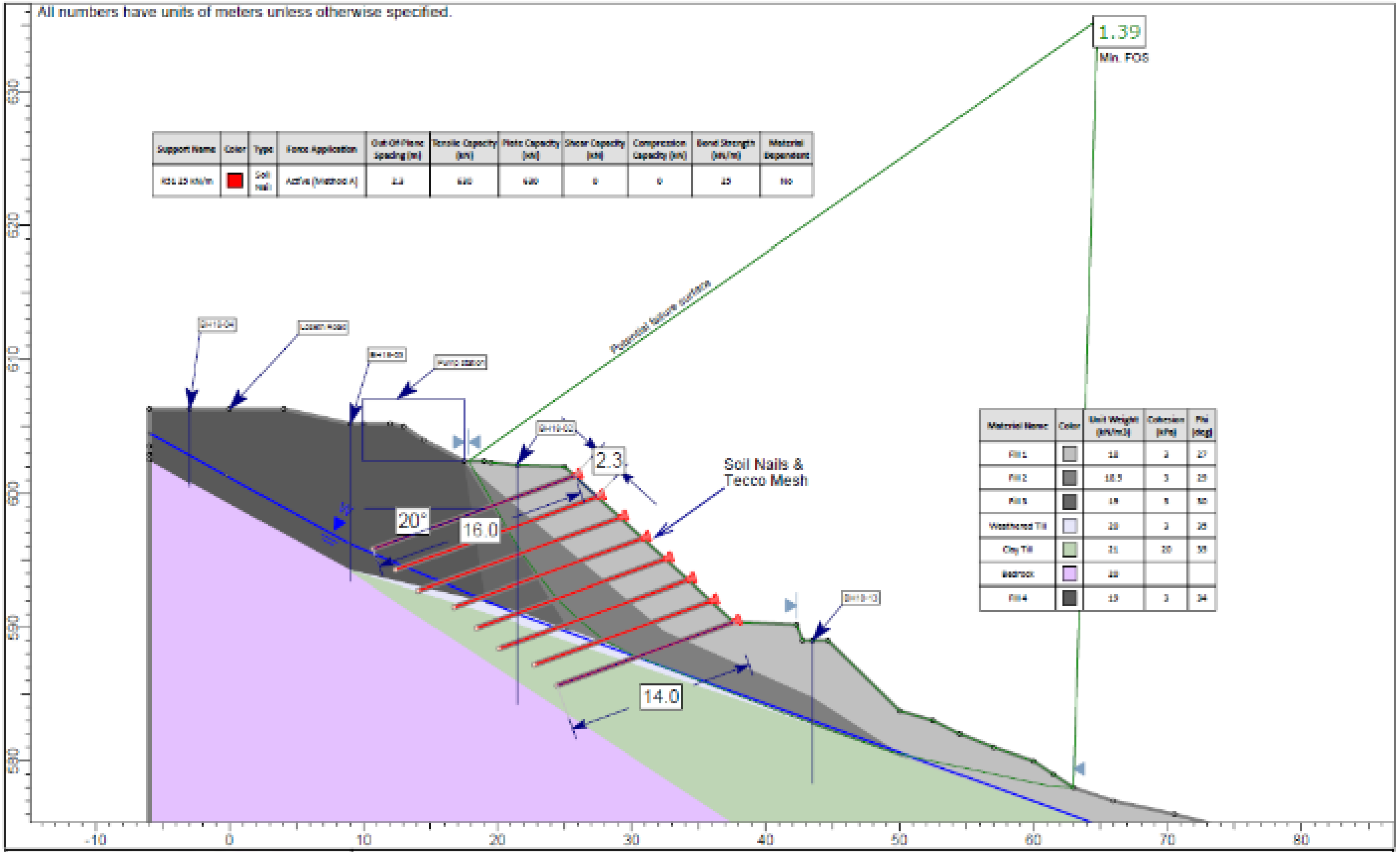
Company Westrek Geotechnical Services Ltd.

Date 2018-12-19

FIGURE 10

Soil nails + Tecco mesh

$600,000 - $700,000 @ 2045 Loseth Rd



westrek geotechnical services ltd.

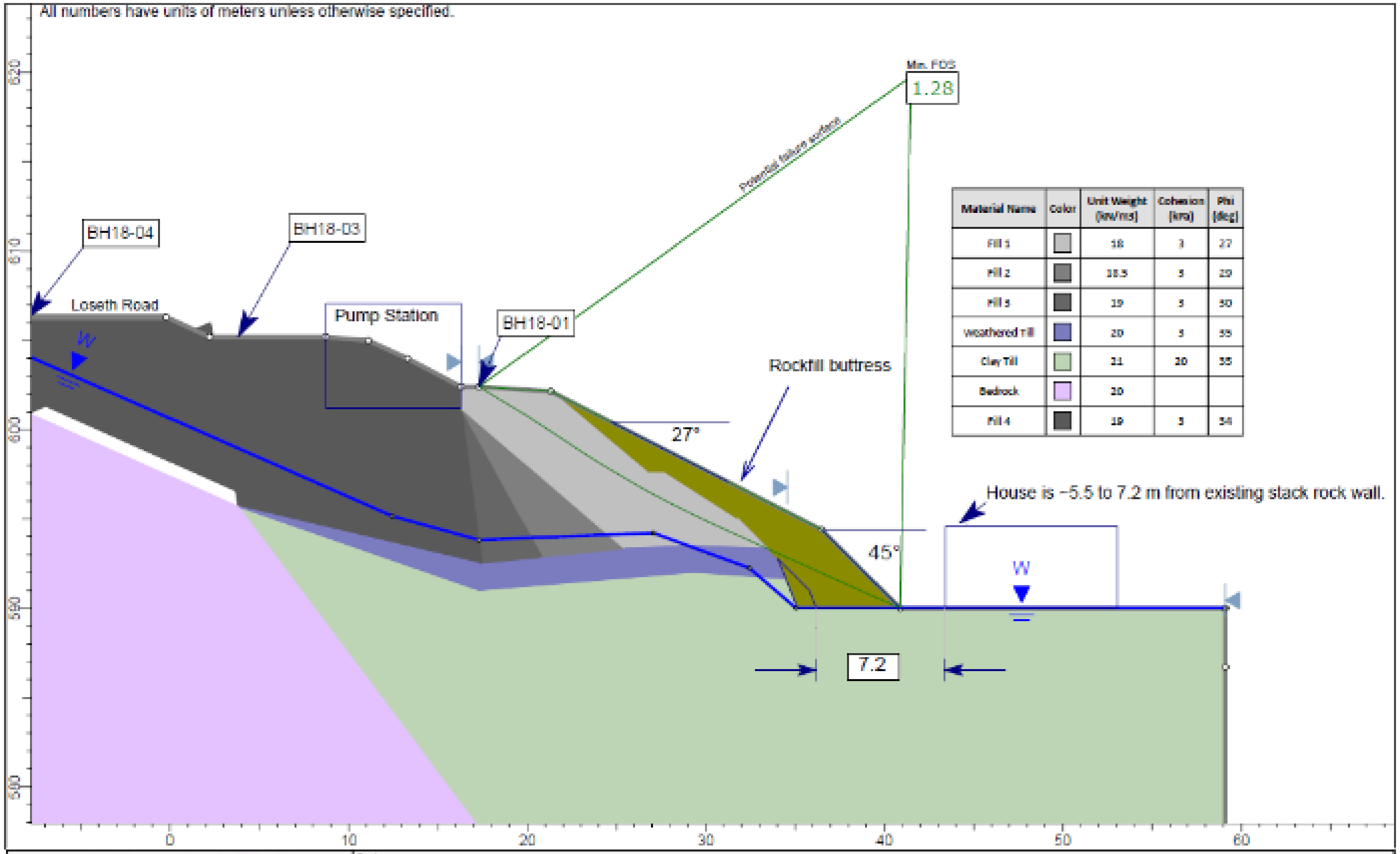
SLIDEINTERPRET 7.037

Project	2045 Loseth Road Pump Station
Analysis Description	Section A-A' - Soil Nails and Tecco Mesh
Drawn By	JP
Scale	1:400
Company	Westrek Geotechnical Services Ltd.
Date	2018-12-19
	FIGURE 11

City of Kelowna

Rockfill buttress

No quote provided for 2001 Kloppenburg Ct



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Fill 1	⬜	18	3	27
Fill 2	⬛	18.5	5	29
Fill 3	⬛	19	5	30
Weathered Till	🟦	20	5	35
Clay Till	🟩	21	20	35
Bedrock	🟪	20		
Fill 4	⬛	19	5	34

westrek geotechnical services ltd.

SLIDEINTERPRET 7.027

Project	2045 Loseth Road Pump Station		
Analysis Description	Section C-C' - Rockfill Buttress		
Drawn By JP	*Scale* 1:300	*Company*	Westrek Geotechnical Services Ltd.
Date 2018-12-19			FIGURE 6

Report to Council

Date: February 25, 2019

File: 0610-50

To: Doug Gilchrist, City Manager

From: Shayne Dyrdal, Senior Airport Finance & Corporate Services Manager

Subject: Kelowna International Airport Airport Improvement Fee Memorandum of Agreement Amendment

---

Recommendation:

THAT Council receive for information the report of the Senior Airport Finance and Corporate Services Manager dated February 25, 2019 with respect to the amendment of the Airport Improvement Fee Memorandum of Agreement;

AND THAT the Airport Director be authorized to execute all documents necessary to complete this amendment.

Purpose:

To obtain Council's approval to amend the Airport Improvement Fee Memorandum of Agreement (the AIF MOA).

Background:

In 1999, Kelowna International Airport (the Airport) entered into a Memorandum of Agreement with the Air Transport Association of Canada (ATAC), certain Canadian airports and certain air carriers operating in Canada with regards to the collection of the Airport Improvement Fee (AIF). The term of the AIF MOA was for 20 years commencing on May 31, 1999. The AIF MOA does not include an option to extend or an over holding clause and will expire on May 30, 2019.

In 2018, the airports and air carriers developed negotiation teams in order to discuss the terms and conditions of a new airport improvement fee agreement that would replace the AIF MOA. There has been significant progress in finalizing the commercial terms of the new agreement but the drafting of the agreement is anticipated to take several months. As a result, both of the negotiation teams recommend a short extension of the AIF MOA be implemented to ensure that there is sufficient time to draft the new agreement before the AIF MOA expires.

The proposed amendment to the AIF MOA has been included as Appendix A (the Amendment). The Amendment would amend Section 17.1 of the AIF MOA to change the term from 20 years to 20 years and three months. The Amendment would also include a further option to extend for three months beyond the 20 years and three months (the Second Extension) with the Winnipeg Airports Authority designated as the airports irrevocable representative for the execution of the Second Extension. Under the AIF MOA, an amendment to the term requires approval by the majority of the airports. The designation of the Winnipeg Airports Authority as the irrevocable representative of the airports would streamline the approval process for the Second Extension, if required.

Internal Circulation:

Jessica Hewitt, Communications Advisor

Considerations not applicable to this report:
Financial/Budgetary Considerations: N/A
Legal/Statutory Authority: N/A
Legal/Statutory Procedural Requirements: N/A
Existing Policy: N/A
Personnel Implications: N/A
External Agency/Public Comments: N/A
Communications Comments: N/A
Alternate Recommendation: N/A

Submitted by:

Shayne Dyrdal, Senior Airport Finance & Corporate Services Manager

Approved for inclusion:
Doug Gilchrist, City Manager
Sam Samaddar, Airport Director

cc: Genelle Davidson, Divisional Director, Financial Services
Jackie Dueck, Controller
Kari O'Rourke, Corporate Communications Manager

Air Transport Association of Canada
Association du transport aérien du Canada

CONSENT TO AMENDMENT TO MEMORANDUM OF AGREEMENT AS AMENDED EFFECTIVE JANUARY 20, 2004 AMONG THE AIR TRANSPORT ASSOCIATION OF CANADA AND SIGNATORY AIR CARRIERS AND CERTAIN AIRPORTS REGARDING AIRPORT IMPROVEMENT FEES ("MOA")

TO: AIR TRANSPORT ASSOCIATION OF CANADA

FAX # 613-230-8648

RE: Consent to MOA Amendment dated February 12, 2019

The Kelowna International Airport hereby consents to the amendment to the MOA attached as Schedule "A" to this consent form.

DATE: ______________________

The Kelowna International Airport

____

Authorized Signatory

____

Title

SCHEDULE "A"

AMENDMENT TO MEMORANDUM OF AGREEMENT AS AMENDED EFFECTIVE JANUARY 20, 2004 AMONG THE AIR TRANSPORT ASSOCIATION OF CANADA AND SIGNATORY AIR CARRIERS AND CERTAIN AIRPORTS REGARDING AIRPORT IMPROVEMENT FEES ("MOA")

Dated February 12, 2019

1. All references to the "MOA" in the MOA shall mean the MOA as amended below.

2. The MOA is amended in Section 17.1 by adding the phrase "and three (3) months" after the phrase "20 years" and by deleting the last sentence of Section 17.1 in its entirety and replacing it with the following:

> "The Parties agree this MOA may be extended beyond the initial term stated above for a period not to exceed three (3) months subject to the agreement of the Airports and the Signatory Air Carriers to such extension at least thirty (30) days prior to expiry of this MOA (the "Second Extension") in accordance with the process set forth herein.
>
> The Airports hereby jointly and severally designate the Winnipeg Airports Authority as their irrevocable representative solely for the limited purpose of effecting such agreement related to the Second Extension on each of their individual behalf and for all of the Airports collectively.
>
> The Signatory Air Carriers hereby jointly and severally designate Air Canada as their irrevocable representative solely for the limited purpose of effecting such agreement to effect such agreement related to the Second Extension on each of their individual behalf and for all of the Signatory Air Carriers collectively.

Where such agreement related to the Second Extension has been reached by the Parties (through their respective representative), no further consent of the Signatory Air Carriers or Airports will be required to give effect to the Second Extension and the notice provisions contained in Section 34.0 of the MOA shall not apply to the MOA extension process set forth herein. Upon the representatives named above reaching such agreement related to the Second Extension, they shall promptly advise ATAC, and ATAC shall provide notice of the effectiveness of the Second Extension to the Signatory Air Carriers."

3. Any notice for the purposes of administering the Second Extension, including notice to the respective representatives as described above, shall be sent to the following:

	Individual Contact	**E-mail address**
Winnipeg Airports Authority on behalf of the Airports	Catherine Kloepfer	ckloepfer@waa.ca
Air Canada on behalf of the Signatory Air Carriers	Josephine Pietracupa	josephine.pietracupa@aircanada.ca
ATAC	Wayne Gouveia	wgouveia@atac.ca

Report to Council

Date: February 25, 2019

File: 0610-50

To: Doug Gilchrist, City Manager

From: Shayne Dyrdal, Senior Airport Finance & Corporate Services Manager

Subject: Kelowna International Airport Bylaw Amendment

Recommendation:

THAT Council receive for information the report of the Senior Airport Finance and Corporate Services Manager dated February 25, 2019 with respect to amending City of Kelowna Airport Fees Bylaw No. 7982;

AND THAT Bylaw No. 11763 being Amendment No. 34 to the City of Kelowna Airport Fees Bylaw No. 7982 be advanced for reading consideration.

Purpose:

To obtain Council's approval to amend City of Kelowna Airport Fees Bylaw 7982.

Background:

To facilitate additional air service development, the Airport Director is currently able to approve a 50 percent reduction in landing and terminal fees for a maximum of six months after inauguration of a new air service for the new service. New air service includes service from new airlines and new routes from existing airlines. The ability to apply this fee reduction has been in place since 2000. In order to help stimulate air service development at Kelowna International Airport (the Airport) even further, the Airport is requesting that the amount of time that the Airport Director is able to approve a 50 percent reduction in landing and terminal fees be increased from six months to twelve months.

In 2018, the number of passengers travelling through the Airport increased by 10 percent. Ensuring the continued development of air service is essential to ensuring the Airport remains competitive with other similar-sized airports and continues to provide the service its growing number of passengers would like to see.

Upon detailed review of Bylaw 7982, minor edits related to wording and/or formatting are being recommended for Sections 3.2(ii), 14.1(c) and 22.1. Edits to Section 18 and the removal of Section 20 are also being recommended to simplify the licensing of shuttles at Kelowna International Airport.

Internal Circulation:

Stephen Fleming, City Clerk
Jackie Dueck, Controller
Jessica Hewitt, Communications Advisor

Considerations not applicable to this report:
Financial/Budgetary Considerations: N/A
Legal/Statutory Authority: N/A
Legal/Statutory Procedural Requirements: N/A
Existing Policy: N/A
Personnel Implications: N/A
External Agency/Public Comments: N/A
Communications Comments: N/A
Alternate Recommendation: N/A

Submitted by:

Shayne Dyrdal, Senior Airport Finance & Corporate Services Manager

Approved for inclusion: ☐ Doug Gilchrist, City Manager
Sam Samaddar, Airport Director

cc: Genelle Davidson, Divisional Director, Financial Services
Kari O'Rourke, Corporate Communications Manager

CITY OF KELOWNA

BYLAW NO. 11763

Amendment No. 34 to Airport Fees Bylaw No. 7982

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts that the City of Kelowna Airport Fees Bylaw No. 7982 be amended as follows:

1. THAT **Schedule A,** 1. **AIRCRAFT LANDING FEES**, 1.4 be amended by replacing the word "*six*" after "and terminal fees for a maximum of" with the word "*twelve*".

2. THAT **Schedule A,** 3. **AIRCRAFT PARKING FEE**, 3.2(ii) be amended by adding the words "*per annum*" after $500.

3. THAT **Schedule A,** 18. **COURTESY SHUTTLE BUS & BAGGAGE DELIVERY SERVICES**, be amended by deleting the title that reads:

   a. **COURTESY SHUTTLE BUS & BAGGAGE DELIVERY SERVICES**

   And replacing it with:

   SHUTTLE BUS & BAGGAGE DELIVERY SERVICES

   And deleting subsection 18.1 that reads:

   b. Courtesy Shuttle Bus services will be licensed at a rate of $200.00 per month over the period operated. (Example: Big White Shuttle Bus Service during the winter months for ski season).

   And replacing it with:

   Shuttle Bus services will be licensed at a rate of $200.00 per month over the period operated.

4. THAT **Schedule A,** 20. **AIRPORT BUS SERVICE**, be amended by deleting in its entirety:

   "A percentage rate of the gross revenue will be charged for the licence agreement to transfer passengers to and/or from the Kelowna Airport as follows:

Effective Date	**Percentage of Gross Revenue to be Charged**
July 1, 2005	2%
July 1, 2006	2.5%
July 1, 2007	3%
July 1, 2008	3.5%
July 1, 2009	4%

"

5. THAT **Schedule A,** 22. **AIRPORT IMPROVEMENT FEES**, 22.1 be amended by replacing "AIR TRANSPORT ASSOCIATION (ATAC)" with "AIRPORT IMPROVEMENT FEE (AIF)".

6. This bylaw may be cited for all purposes as "Bylaw No. 11763, being Amendment No. 34 to Airport Fees Bylaw No. 7982."

7. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first, second and third time by the Municipal Council this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Report to Council

City of
Kelowna

Date:	February 25, 2019
File:	0705-61
To:	City Manager
From:	Christine McWillis, Cultural Services Manager
Subject:	Kelowna-Kasugai Sister City Association Sponsor Agreement

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Recommendation:

THAT Council authorizes the City to enter into a Sister City Sponsor Agreement with the Kelowna-Kasugai Sister City Association, in the form attached to the Report from the Cultural Services Manager dated February 25, 2019;

AND THAT Council authorizes the Mayor and City Clerk to execute all documents associated with this Agreement.

Purpose:

To consider executing a Sponsor Agreement with the Kelowna-Kasugai Sister City Association to establish the roles and objectives of the Sister City sponsor organization's relationship with Kasugai, Japan (the Sister City).

Background:

The City of Kelowna recognizes the cultural, educational, recreational and economic benefits that Sister City relationships foster. In pursuit of attaining these benefits, Kelowna and Kasugai became sister cities in 1981.

For over thirty years, the Kelowna-Kasugai Sister City Association has fostered the relationship with Kasugai. They facilitate communications, visits and student exchange programs with the goal of learning more about the areas of culture, education, commerce, athletics, civic affairs and our two environments.

In addition to delegations and school exchanges with the Sister City, the Association supports local, community events such as Culture Days, hosts Japanese language, cooking and crafting classes and annual fundraisers, such as Taste of Japan.

The most recent Sponsor Agreement expired in December 2017. Through 2018, Cultural Services staff worked with the Association as they developed a workplan for the upcoming three years.

The plan highlights key tasks for their Board of Directors, membership, community involvement and fundraising. These include:

- redefining roles and responsibilities of key positions
- the development of a policy and procedures manual
- review of membership and membership recruitment
- enhance the Taste of Japan event and new fundraising opportunities
- continue to participate in culture days as well as offering Japanese language, craft and cooking classes
- enhance collaborations with similar interest groups.

With a workplan in place, the 2019-2021 Sponsor Agreement (attached) itemizes roles and responsibilities of both the Kelowna-Kasugai Sister City Association and the City of Kelowna in fulfilling the objectives of the Sister City Policy and the Sister City relationship with Kasugai, Japan.

The term of this Agreement is for three years with the possibility of renewal for an additional period of up to five years, pursuant to the Sister Cities Policy.

Existing Policy:

Policy 355 - Sister Cities Policy

Considerations not applicable to this report:
Alternate Recommendation
Internal Circulation
Legal/Statutory Authority
Legal/Statutory Procedural Requirements
Financial/Budgetary Considerations
Personnel Implications
External Agency/Public Comments
Communications Comments

Submitted by: C.McWillis, Cultural Services Manager

Approved for inclusion: J. Gabriel, Divisional Director Active Living and Culture

Attachments:
Sponsor Agreement (2019-2021)

cc:
Stephen Fleming, Chief Clerk
Carson Chan, Payroll & Internal Controls
Amanda Lamberti, Communication Coordinator
Arlene Henderson, President – Kelowna-Kasugai Sister City Association

Kelowna-Kasugai Sister City Association Sponsor Agreement

February 25, 2019

Sister City Relationship

- Established in 1981
- Cultural, educational, recreational, economic benefits

Kelowna-Kasugai Sister City Association

- fosters the relationship with Kasugai, Japan
- organizes delegations and school exchanges
- supports and hosts local events
- delivers Japanese language, cooking and crafting classes

Workplan Highlights

- define roles and responsibilities
- develop a policy and procedures manual
- enhance membership recruitment
- Progress the Taste of Japan event and new fundraising opportunities
- continue to participate in culture days as well as offering Japanese language, craft and cooking classes
- enrich collaborations with similar interest groups.

City of
Kelowna

Questions?

For more information, visit **kelowna.ca**.

This agreement dated February 19, 2019

Sponsor Agreement

between

City of Kelowna (The City)

1435 Water Street, Kelowna, BC V1Y 1J4

and

Kelowna-Kasugai Sister City Association (The Sponsor)

(P.O. Box 30088, RPO Kelowna, BC V1V 2M4)

Attention: President

Whereas:

The City has, by Council resolution R550/14/07/28 approved the revised Council Policy 355 (Sister City Policy); and

The Sister City Policy provides that a Sponsor Agreement should be established between The City and the Kelowna-Kasugai Sister City Association as The Sponsor of the Sister City relationship between the City of Kelowna and the City of Kasugai, Japan;

This agreement sets out the roles and responsibilities of the City and the Sponsor in fulfilling the objectives of the Sister City Policy and the Sister City relationship with Kasugai, Japan (the Sister City).

1. The term of this agreement will be three (3) years commencing January 1, 2019 and ending December 31, 2021.

2. This Agreement may be renewed for an additional period of up to five (5) years, pursuant to the Sister City Policy.

3. This Agreement can be amended at any time by written agreement of the City and the Sponsor.

4. The Sponsor, as the lead organization responsible for the Sister City relationship, will fulfill the role of ambassador of international goodwill for the benefit of the City by:
    a) creating cultural, educational, recreational and economic programs and activities which develop and promote interest in the Sister City and benefit the City of Kelowna;
    b) assisting City officials when meeting with their counterparts from the Sister City and organizing local cross-cultural events;
    c) providing representation at official and community events and celebrations;
    d) facilitating and fundraising for exchange visits between the City and the Sister City at least once every three (3) years;
    e) providing volunteer and financial resources to support and fund the Sister City relationship;
    f) responding to requests for information regarding the Sister City and the activities within the Sister City relationship; and
    g) establishing an active working Committee which is inclusive and reflective of the City of Kelowna and which has provided for ongoing recruitment.

5. The Sponsor will, in administering the Sister City relationship:
    a) provide documentation to the City verifying that the Sponsor is a registered British Columbia Society in good financial standing and that it has the authority, by resolution of its directors, to enter into this agreement;
    b) demonstrate proof of insurance, satisfactory to the City;
    c) abide by all applicable by-laws, statutes, ordinances, and regulations of any governmental agency having jurisdiction over the activities of the Sponsor;
    d) not assign or transfer any interest in this agreement or the Sister City relationship without the prior written consent of the City;

e) indemnify and hold harmless the City and its personnel from all actions, proceedings, losses, expenses, and costs arising out of, or in any way connected with the Sponsor's activities, any breach or default by the Sponsor under this agreement, or any wrongful act, omission, or negligence of the Sponsor;

f) seek approval from the City prior to issuing any communication with the public, including any media organization, with regard to the Sister City relationship;

g) acknowledge the financial assistance of the City of Kelowna on all communications and promotional materials relating to the Sister City relationship, such as programmes, brochures, posters, advertisements, websites, news releases and signs; and

h) provide regular reports and requested information to the City of Kelowna in a prescribed format including Committee meeting minutes and annual work plans, budgets and reports to City of Kelowna.

6. The City will:
   a) receive an annual report from the Sponsor in a format acceptable to the City of Kelowna;
   b) in discussion with the Sponsor, complete an annual review of the Sponsor's annual work plans, budgets, reports and information to identify achievements and possible areas for improvement in the fulfillment of the Sponsor Agreement;
   c) provide annual matching funding to the Sponsor in accordance with Council Policy 355 (attached); and
   d) in accordance with Council Policy 355, the City may consider an annual grant application from the Sponsor such application(s) to be adjudicated in accordance with the program guidelines. Grants are awarded on an annual basis, based on the merits of the application and the program criteria. Applicants must re-apply each year. Continued funding is not guaranteed. Depending on the nature of the application and the program guidelines, application-based grant funding may be in addition to, or an alternative to, the annual matching funding specified above in section 6(c).

7. If the Sponsor violates or fails to comply with any provisions of this agreement, the City may provide fair notice to the Sponsor of default. If the default is not rectified to the City's satisfaction within the time specified in the City's notice, city staff will recommend to City Council that this agreement be terminated.

8. In the event that this agreement expires at the end of the term and is not renewed, or is terminated by the City prior to the end of the term, the City may:
   a) Seek a new Sponsor to support the Sister City relationship; or
   b) Terminate the Sister City Relationship with Kasugai, Japan.

We agree to the terms and conditions outlined in this Agreement.

aHenderson — 19 Feb 2019.

On behalf of the Sponsor Organization — Date

Print Name: Arlene Henderson

________________ — __________

On behalf of the Sponsor Organization — Date

Print Name:

________________ — __________

On behalf of the City of Kelowna — Date

Print Name:

________________ — __________

On behalf of the City of Kelowna — Date

Print Name:

Report to Council

Date: February 25, 2019

File: 0710-20

To: City Manager

From: Christine McWillis, Cultural Services Manager

Subject: 2019 Heritage Grants Program Agreement

Recommendation:

THAT Council authorizes the City to enter into a Grant Administration Agreement for the Heritage Grants Program with the Central Okanagan Heritage Society in the form attached to the Report from the Cultural Services Manager dated February 25, 2019;

AND THAT Council authorizes the Mayor and City Clerk to execute all documents associated with this Agreement.

Purpose:

To consider executing a Grant Administration Agreement with the Central Okanagan Heritage Society to administer and adjudicate the Heritage Grants Program on behalf of the City of Kelowna.

Background:

The City of Kelowna recognizes the importance of protecting the community's heritage resources. The City is also aware that the cost to maintain and restore heritage properties (both publicly and under private ownership) can be significant. In recognition of these costs, the City of Kelowna Heritage Grants Program (CoKHGP) was created in 1991 to support heritage conservation efforts.

The program promotes the conservation of residential, commercial, industrial, institutional and agricultural heritage buildings by assisting owners with grants for a portion of the costs incurred in conservation work. Any property listed on the Kelowna Heritage Register is eligible for this grant program. Heritage Designated properties are given priority followed by residential homes on the Heritage Register.

Since 2008, the CoKHGP has been administered by the Central Okanagan Heritage Society (COHS). The annual funds available for the CoKHGP is $35,000. The maximum grant per property is $7,500 for properties on the Heritage Register (per three year period) and $12,500 for Heritage Designated properties (per three year period), to be allocated to a maximum of 50% of the project cost (exclusive of all taxes). The contract to administer the program is $9,500.

COHS prepares an annual report summarizing the program activities over the past year. Staff reviewed the 2018 City of Kelowna Heritage Grants Program Annual Report and recommend continuing the partnership with COHS to administer the CoKHGP. The knowledge and skills offered by COHS staff add value to the program administration.

In addition to working closely with COHS through 2018 on this program, the Cultural Services Manager attended all CoKHGP Committee Meetings and the annual information session to ensure the process was consistent with other grant administration practices utilized in other City programs.

The attached 2019-2020 Grant Administration Agreement itemizes roles and responsibilities of both the COHS and the City of Kelowna to ensure the highest value is delivered back to the community with the grant funding of the CoKHGP.

The term of this Agreement is for two years with the possibility of two additional one year extensions. Moving to a multi-year agreement has been a recommendation of the COHS for the last several years which is supported by staff. This allows COHS to plan for the staff requirements of program over a multi-year period, get information out to the public early in the new year, host an information session with ample time for property owners to prepare their application prior to the first intake.

Existing Policy:

Official Community Plan – 2030

> **Objective 9.2, Policy 3 Financial Support.** Continue to support the conservation, rehabilitation, interpretation, operation and maintenance of heritage assets through grants, incentives and other means.

Heritage Strategy 2007, Updated July 2015

> **Policy 1.3.** Continue to develop revenue sources to assist with funding the conservation of heritage resources.

Financial/Budgetary Considerations:
$35,000 plus $9,500 for grant administration (within an existing approved budget).

Considerations not applicable to this report:

Internal Circulation
Legal/Statutory Authority
Legal/Statutory Procedural Requirements
Personnel Implications

External Agency/Public Comments

Communications Comments
Alternate Recommendation

Submitted by: C. McWillis, Cultural Services Manager

Approved for inclusion: J. Gabriel, Divisional Director Active Living & Culture

Attachments:
Heritage Grants Program Administration Agreement (2019/2020
Heritage Grants Program Terms of Reference (Updated February 2019)

cc:
Carson Chan, Payroll & Internal Controls
James Moore, Long Range Policy Planning Manager
Lauren Sanbrooks, Planner II
Amanda Lamberti, Communications Coordinator

Heritage Grants Program

February 25, 2019

Heritage Grants Program

- Established in 1991
- Heritage Registered & Designated Properties
- Recognizes cost of maintenance / upgrading
- Incentives for heritage conservation

Heritage Grant Program

- $35,000 Annually
- $7,500 Registered / $12,500 Designated (50%)
- $9,500 Administration to COHS annually

Policy

- OCP 2030
  - 9.3.3 Financial Support
    - Support conservation of heritage assets through grants and incentives
- Heritage Strategy 2007
  - Policy 1.3
    - Develop revenue sources to assist with funding conservation of heritage resources

Upcoming in 2019

- Information Session on March 7th
- Planning Support

City of Kelowna

Questions?

For more information, visit **kelowna.ca**.

City of Kelowna

c/o Central Okanagan Heritage
Society
3-537 Bernard Avenue,
Kelowna, B.C. V1Y 6N9
Tel (250) 861-7188

Terms of Reference

Heritage Grants Program

Updated February 2019

1.0 INTRODUCTION

The Heritage Grants Program was established in 1991 and was administered by City staff with applications reviewed by a volunteer board. In 2008, the Central Okanagan Heritage Society (COHS) was awarded the contract to administer the grants program.

The intent of the program is to recognize the value of Kelowna's built heritage. Through the granting process, financial support is extended to assist with the upkeep of properties listed on the City of Kelowna's Heritage Register.

2.0 PURPOSE

The City of Kelowna's Heritage Grants Program promotes the conservation of residential, commercial, industrial, institutional and agricultural heritage buildings by assisting owners with grants for a portion of the costs incurred in conservation work.

3.0 AMOUNT OF MONEY AVAILABLE

Approximately $35,000 in total is available for distribution annually from the City.

4.0 ELIGIBLE APPLICANTS

Any property listed on the Kelowna Heritage Register is eligible for this grants program. This program is limited to exterior and building foundation (stabilization) work.

The conservation work should recognize the importance of "Character-defining Elements" as documented in the Heritage Register Record for the property. This Record can be accessed at https://www.kelowna.ca/our-community/arts-culture-heritage/heritage

- Heritage Designated properties will be given first priority in the granting program. Followed by Residential properties listed on the Kelowna Heritage Register.
- Grants will not be given for work undertaken prior to a successful grant application.
- Municipal property taxes must be fully paid (if applicable).

5.0 APPLICATION DEADLINE

Application deadlines are established at the start of each year. Check the City of Kelowna website or consult with the COHS to determine the next available intake . Please note: there is limited funding and an application does not guarantee support in whole or in part.

Grants applied for may be moved to the next funding intake.

6.0 GRANTS

Buildings “Designated” heritage are eligible for grants to a maximum of $12,500/ 3 year period.

Buildings listed on the Kelowna Heritage Register are eligible for grants to a maximum of $7,500/ 3 year period.

Grants for Exterior Conservation Work including: reroofing; prep & new paint*; window, door, siding and porch conservation, will not exceed 50% of the cost of the work to be done (exclusive of applicable taxes), to a maximum of $7,500 (Heritage Register) or $12,500 (Designated) per 3 year period.

*Heritage paint colour schemes using the Historical True Colours palette are required. Exceptions MAY be considered on a case by case basis and as approved by the Committee.

Grants for Foundation Work will not exceed 50% of the cost of work to be done (exclusive of applicable taxes), to a maximum of $7,500 (Heritage Register) or $12,500 (Designated) per 3 year period.

Except for special circumstances, original materials are to be used. Compatible adaptation of modern materials may be considered on a case by case basis.

7.0 DOCUMENTATION

For All Applications:
1. All applicants need to complete the application form and provide current photographs of the heritage property, and specifically of the area where the work is to be done.

Grants for Exterior Painting:
As well as the required documents for all applications (listed above), applicants applying for a grant for exterior painting of a heritage property need to include in their application:

- Colour scheme and paint colour samples. Benjamin Moore Historical True Colour Palette is highly recommended.
- Estimate for cost of work is to be done by the owner (up to 100% for materials only).
- Two estimates if work is to be done by a contractor.

Grants for Reroofing:
As well as the required documents for all applications (listed above), applicants applying for a grant for reroofing of a heritage property need to include in their application:

- Proposed colour and roofing material
- Estimates for cost from two contractors
- One year guarantee for labour and materials; a written copy needs to be provided with the “Declaration of Project Completion.” A roof inspection is required for all reroofing projects.

Grants for Exterior & Foundation Work:

As well as the required documents for all applications (listed above), applicants applying for a grant for exterior and foundation work of a heritage property need to include in their application:

- Estimates for cost from two contractors
- One year guarantee for labour and materials MAY be required; a written copy may need to be provided with the "Declaration of Project Completion." If a guarantee for labour and/or materials is needed, this will be stipulated in the grant approval letter.

8.0 TIMELINE & PROCEDURES

1. Once an application has been received, it will be screened by the City of Kelowna Heritage Grant Program manager (COHS) to ensure the application is complete.

2. The application will be reviewed by the City of Kelowna Heritage Grants Committee using a established set of criteria and evaluation tool.

3. When an application is approved or declined by the Committee, the applicant will be advised in writing.

4. Prior to the commencement of work, any required municipal building permits must be applied for.

5. The successful applicant must have the work completed within one year of the grant being awarded. An applicant can ask for an extension in the case of unforeseen circumstances and this requires approval by the Committee.

6. Upon the completion of the heritage building conservation project, the following must be submitted to the committee before the grant will be paid out:

a) Photographs showing the completed project.
b) Submission of all bills showing 'paid in full' with an authorized signature or showing a $0 balance. Costs of plans and related expenses may be included.
c) The attached "Declaration of Project Completion" form must be submitted to the Committee.
d) Site Inspection by Committee member or as required by the City of Kelowna.
e) Written warrantees or inspections as required for reroofing, foundation and exterior restoration work.
f) demonstration that any other requirements, as described in the approval letter was met.

****Completion documentation must be received by the Application Deadline to be approved and paid in that cycle.***

7. No application may, in any manner, be considered to form a contractual or other obligation on the part of the Committee.

9.0 PROGRAM CLAUSES

9.1 CONFIDENTIALITY OF INFORMATION

The COHS shall keep, strictly confidential, all information which in any way reveals the City's confidential business, financial or investment details, programs, strategies or plans, learned through the term of the Agreement. Information pertaining to the City obtained by the COHS as a result of participation in this Agreement is confidential and must not be disclosed without written authorization from the City.

9.2 CONFLICT OF INTEREST

As per the Central Okanagan Heritage Society Policy Statement, and as noted in the COHS Heritage Grants Program Administration Agreement for 2018.

9.3 OWNERSHIP OF DOCUMENTS AND FREEDOM OF INFORMATION

All documents, submitted to the City become the property of the City. They will be received by the City and are subject to the provisions of the Freedom of Information and Protection of Privacy Act. For additional information, please go to:
http://www.cio.gov.bc.ca/cio/priv_leg/foippa/contracting/ppsindex.page

9.4 COHS PERFORMANCE RECORD

The City conducts a mid-point check-in and a year-end Performance Record for COHS which are part of the contract administration.

The Application form, Terms of Reference for the Heritage Grants Program, and other grant-related documents may be obtained online at www.okheritagesociety.com or contact Lorri Dauncey, Central Okanagan Heritage Society at 250-861-7188 or ldauncey.cohs@telus.net

Heritage Grants Program Administration Agreement

This Agreement dated for reference February 25, 2019, is

BETWEEN:

City of Kelowna, a municipality incorporated under the Local Government Act, R.S.B.C. 1979, c. 290 and having its municipal office at 1435 Water Street, Kelowna, British Columbia V1Y 1J4

(the "City")

AND:

Central Okanagan Heritage Society a registered charity, incorporated in 1982 in the Province of British Columbia, and having its office located at 3-537 Bernard Avenue, Kelowna, British Columbia, V1Y 6N9. Note: mailing address is *1060 Cameron Avenue, Kelowna BC V1Y 8V3.*

(the "COHS")

To adjudicate and administer the:

City of Kelowna 2019 and 2020 Heritage Grants Program - $35, 000;

The City of Kelowna (hereafter referred to as the City) will provide financial assistance to non-profit and community organizations to provide programs of benefit to the community in accordance with the City of Kelowna Official Community Plan Objective 9.2 Policy 3 – Financial Support. Continue to support the conservation, rehabilitation, interpretation, operation and maintenance of heritage assets through grants, incentives and other means.

This Agreement will be governed by and will be construed and interpreted in accordance with the laws of the Province of British Columbia.

To ensure the successful administration of the Heritage Grants Program grants, this agreement is hereby established between the City and the Central Okanagan Heritage Society (hereafter referred to as COHS) as follows:

1. The term of this agreement will be for two years, commencing January 1, 2019 and ending December 31, 2020. However, the continuation of the program will be determined on an annual basis through the City of Kelowna budget process. The City, at its sole discretion, may cancel or modify the program prior to the commencement of a new grant year.
2. The City of Kelowna Heritage Grants Program Committee (hereafter referred to as the Committee) will evaluate requests for heritage grants from property owners with properties listed on the Kelowna Heritage Register. The program will be administered by COHS as per the City of Kelowna's guidelines (Appendix A). In particular, COHS will:
    a) Be the primary point of contact for inquiries from grant applicants for the Heritage Grants Program.
    b) Distribute grant application forms to eligible property owners.
    c) After the grant application deadlines, review submitted grant applications to determine eligibility and comprehensiveness of the application to ensure the Committee can make an informed and responsible decision. If minor gaps are identified, COHS will contact applicant to offer them an opportunity to fill in the gaps / answer questions.

d) Support requests, advise the Committee and make recommendations. COHS agrees that it will ensure all criteria set out in the Terms of Reference (Appendix A) for the approval and distribution of grants is being followed.

e) Convene and facilitate a meeting of the Committee to review each grant application as a group and to formulate recommendations for grant awards. Costs and expenses associated with the committee meetings are to be paid by the COHS.

f) Ensure that comprehensive minutes are recorded at the Committee meeting, documenting the discussion and rationale for recommendations. Any costs associated with recording of minutes are to be paid by the COHS.

g) Prepare minutes from the Committee meetings for distribution to and approval by the Committee members. Upon approval by the Committee, the minutes will be provided to the City.

h) Facilitate payment of grant awards to successful applicants.

i) Provide the City with an annual report by January 31 of each calendar year.

j) Provide a mid- year summary report to the City by August of each year including information about grant distribution to date, challenges and recommendations. The report shall be reviewed by both parties at a mid-year update meeting.

k) Upon request, provide the City with all the property owner's information including, but not limited to application forms, supplementary materials, and final reports on the use of grant funds.

3. The annual report shall include:

   a) the Committees' decisions for awarding grants with an overview of the tool used to determine the successful recipients.

   b) the summary information about each of the successful applicants / projects that were selected.

   c) the summary information about projects that were rescinded, incomplete or delayed

   d) a breakdown of the administration fees (report only), in addition to the breakdown of the grant money.

   e) other relevant information.

4. COHS may be required to deliver a presentation to Council regarding the Heritage Grants Program in a format determined at the time of the request.

5. The administration costs for COHS may include:

   a) Staffing costs related to administration of the Heritage Grants Program.

   b) Office supplies and photocopying related to administration of the grant program

   c) On-going file management of all inquiries to the COHS to the program.

   d) A portion of overhead.

   e) Volunteer recognition including refreshments for meetings.

   For the sake of clarity, administration costs do <u>NOT</u> include:

   f) Membership with any heritage organization such as Heritage BC or Heritage Canada.

   g) Website costs (the application form will be hosted on the City of Kelowna's website).

  h) A plaque recognition program.

  i) The organization of any workshops or public education programs, except for a Heritage Grants Information Session for heritage building owners.

6. The City will:

  a) Disburse $9,500 annually, inclusive of any applicable taxes, to COHS upon invoice by the COHS.

  b) Advertise the City's Heritage Grants Program.

  c) Print the mail out letters for the Heritage Grants Program and provide the corresponding envelopes.

7. All communication for the City of Kelowna's Heritage Grants Program will recognize that the City provides the funding for the program. City recognition requires that all communication with the public be on City of Kelowna letterhead & envelopes. Approval of content is required by City of Kelowna before such communication is distributed.

8. Communications between the COHS and the City of Kelowna will, in most instances be between the COHS CoKHGP Manager, and the City of Kelowna Cultural Services Manager.

9. No COHS documentation will be attached to any mail outs regarding the program.

10. COHS will:
  a) Deliver demonstrable public benefit;
  b) Use sound governance and management practices;
  c) Maintain financial sustainability;
  d) Ensure transparency in operations and reporting; and
  e) Commit to a public service mindset.

11. Upon request COHS will provide the City with all the Organization's information with regards to administering the Heritage Grants Program.

12. Both parties agree that it is their intention to receive, review and adjudicate applications and disburse the Heritage Grants Program and will cooperate to this end.

13. COHS and the City of Kelowna agree that should the COHS Board of Director wish to apply for the Heritage Grants Program for a property owned or managed by the organization that the City of Kelowna shall be notified prior to the application being made, shall be present at the adjudication of the application and that no COHS Board or staff will be present while discussion or the decision is being made.

14. If COHS has not been in default under this agreement and the City of Kelowna wishes to continue its commitment to the Heritage Grants Program without modification, as determined by a commitment in the annual budgeting process, COHS may have (2) consecutive options to renew this agreement, each option being for a further one (1) year term. This option may be exercised by COHS giving written notice for a further one (1) year term not less than 2 months and not more than 3 months before the expiry of the Term or the renewal term as the case may be. In the event the option or options are exercised, all other terms and conditions shall remain binding.

IN WITNESS WHEREOF, THE City and COHS have executed this Agreement on the date first above written.

On behalf of THE CITY OF KELOWNA

____
Mayor

____
City Clerk

On behalf of THE CENTRAL OKANAGAN HERITAGE SOCIETY

____
Authorized Signatory

Lynda M. Dorman
Authorized Signatory

Report to Council

City of Kelowna

Date: February 25, 2019

File: 1840-10

To: City Manager

From: Divisional Director, Infrastructure

Subject: Budget Amendment for the Rehabilitation of City Park Water Park

Report Prepared by Scott Bushell, Design Technician

Recommendation:

THAT Council receives for information, the report from the Divisional Director, Infrastructure dated February 25, 2019, with respect to the Budget Amendment for the Rehabilitation of City Park Water Park;

AND THAT the 2019 Financial Plan be amended to include the initial use of up to $410,000 funded from the Insurance Deductible reserve for the restoration of the City Park Water Park;

AND THAT the 2019 Financial Plan be amended to include receipt from the City's Insurance Provider estimated at $410,000 for the insurance claim proceeds to the Insurance Deductible reserve.

Purpose:

To amend the 2019 Financial Plan to support the restoration of City Park Water Park to an operational condition for the 2019 season.

Background:

In 2017, the widespread flooding in the Okanagan region caused high groundwater and record high Okanagan Lake levels, resulting in the partial flooding of City Park, including the popular water park facility. The water park was closed during the 2017 season due to the high water and damage to underground equipment. The water park closure was extended through the 2018 season as the insurance claim was pursued for repair cost recovery.

The underground equipment room containing the pumps and the treatment system for the park was completely flooded and remained under water for a prolonged period of time, rendering the equipment damaged beyond repair. The flooding brought silt, sand and debris into the water lines to the spray park features, which trapped water during the winter of 2018 and compromised approximately 40% of the lines due to freezing.

The City's insurance representatives retained a Building Consultant and Appraiser, to comment on the extent of damage. The valuation of the claim has been estimated at $410,000 and is pending submission of supplemental cost estimates from Building Consultant to restore the park to the pre-flood conditions with like materials. Approval of the insurance claim is expected soon.

The need to repair the water park has provided the City with the opportunity to reconsider the configuration and operation of the facility to reduce the potential for future flood damage, optimize net operational costs and reduce health risks. The project team collectively reviewed three (3) options to rehabilitate the facility:

1. Reestablish the existing circulation and treatment system below ground.
2. Install a new standalone circulation and treatment system above ground.
3. Flow-Through System – direct City water connection flowing through to City sanitary system.

The option selected is the Flow-Through System. The direct potable City water source to the features is safe, simple and does not require on-site treatment (filtration and chlorination). The Flow-Through system is the preferred option of Interior Health and will limit the risk of the City as it pertains to water quality and on-site treatment procedures. Ongoing operational costs will include both sewerage and water utility charges, but a net saving could be realized through reduced staffing and on-site treatment cost. Water conservation will be achieved through low flow nozzles, activation buttons and time of day sequencing. Lastly, a conversion of the park to a Flow-Through System will reduce flood risk by eliminating process equipment and relocating remaining critical infrastructure above grade. This rehabilitation option can be completed in time for regular operation this 2019 summer season.

Financial/Budgetary Considerations:
The costs associated with the restoration of City Park Water Park are not included in the City's current financial plan. The 2019 Financial Plan will require the addition of up to $410,000 funded from the Insurance Deductible reserve for the restration of the City Park Water Park and the subsequent reimbursement estimated at $410,000 for the insurance claim proceeds to the Insurance Deductible reserve.

Internal Circulation:
Divisional Director, Infrastructure Delivery – A.Newcombe
Divisional Director, Community Safety – L.Kayfish
Risk Manager – J.Hemmett
Budget Supervisor – M.Antunes
Financial Planning Manager – G.King
Infrastructure Delivery Manager – B.Beach
Senior Project Manager – A.Gibbs

Considerations not applicable to this report:
Legal/Statutory Authority:
Legal/Statutory Procedural Requirements:
Existing Policy:
Personnel Implications:
External Agency/Public Comments:
Communications Comments:

Alternate Recommendation:

Submitted by:

A. Newcombe, Divisional Director, Infrastructure

Approved for inclusion: ☐ D. Gilchrist, City Manager

cc: City Clerk
Deputy City Manager
Divisional Director, Community Planning and Strategic Investments
Divisional Director, Community Safety
Divisional Director, Financial Services
Divisional Director, Infrastructure

Report to Council

Date: February 11, 2019

File: 0605-20

To: City Manager

From: Kevin Van Vliet, Utility Services Manager

Subject: Update on Kelowna Joint Water Committee

Recommendation:

THAT Council support dissolution of the Kelowna Joint Water Committee and direct staff to continue to work together with Improvement District staff to improve overall efficiencies, reduce risks and form partnerships for shared services in an effort to best serve all of the citizens of Kelowna.

Purpose:

To update Council on the status and activities of the Kelowna Joint Water Committee

Background:

Kelowna has four major water purveyors that provide drinking and irrigation water to Kelowna residents: City of Kelowna Water utility, Black Mountain Irrigation District (BMID), Rutland Waterworks (RWW) and Glenmore Ellison Improvement District (GEID); in addition to two dozen small independent water systems. In June 2018, the South East Kelowna Irrigation District (SEKID) was integrated into the City's Water Utility.

These major water providers have many common interests that drive a good working relationship. In the past, it was felt beneficial to formalize this relationship through the Kelowna Joint Water Committee (KJWC). Founded in 1991, the KJWC acted as an umbrella organization to promote standardization of methods and materials, improve communications, and to provide an integrated approach to water supply within the City boundaries. Since its creation, the committee has implemented a few successful technical programs including a common "approved products list" for new development, a city-wide cross connection control program, the 2012 Integrated Water Supply Plan and an independent website to provide information about water suppliers in Kelowna. The KJWC operates a bank account to fund some common projects and initiatives. Funds are collected from each partner annually. The City of Kelowna administers the cross-connection control program under the KJWC name.

The KJWC structure currently exists as a political partnership in the form of a Board of the Whole that includes a member appointed from each elected Board of Trustees and a member of Council. The KJWC is not a Committee of Council, but Council does appoint a member to the KJWC Board of the Whole. The Board of the Whole is supported by a Technical Committee consisting of the managers from each water provider.

The KJWC is not a legal entity or society, and as such lacks transparency and accountability. Decisions made by the Board of the Whole are not binding on any member, but are recommendations to each respective water provider's decision-making bodies or approvals for expenditure of KJWC funds.

The last official Board of the Whole meeting was held on September 10, 2015. The main topic of discussion was an attempt to develop a Terms of Reference for a Value Planning consultant to review the 2012 Integrated Water Supply Plan. This issue was never resolved to the satisfaction of all of the water providers.

Staff from each of the water providers have continued to meet as the Technical Committee of the KJWC. Three meetings were held in 2016, two in 2017 and three meetings in 2018 to deal with common interests and ongoing management of existing KJWC programs.

It has become apparent that a working relationship with the Improvement Districts is sufficient to continue to build on the work of the KJWC and move towards an integrated water system over time. Staff from each of the providers feel that it is in the best interest of our respective utilities, as well as the citizens of Kelowna, to continue to work together on common interests and partner where practical. Some Improvement District staff have informed the City that their respective Boards of Trustees support the dissolution of the KJWC Board of the Whole and continuing to work together regularly at a staff level. Meetings at the political level can be held informally as and when required.

Upon dissolution of the Kelowna Joint Water Committee (including all subcommittees), the KJWC bank account will be closed and funds returned to each provider based on the ratio of contributions made. The **kjwc.org** website will be removed including the automated centralized water quality notification system. In place of this, each district has already implemented their own water quality notification system with messaging in line with Interior Health Authority requirements. The City of Kelowna will continue to provide information on "who is my water provider" for all Kelowna citizens and will continue to manage the cross-connection control program on behalf of the partners.

City staff will continue to maintain and build operating and planning relationships with all Kelowna water providers to optimize operational and capital efficiencies as well as inter-agency operational support including, but not limited to the following areas:

1. Improvement of overall water supply reliability across the City of Kelowna,
2. Continued operation of successful inter-agency programs such as Cross Connection Control, drought response and others through a partnership model,
3. Development of operational programs to improve water supply and water system management consistency across the City,
4. Emergency preparedness and response,

5. Development of a consistent approach for setting agricultural water rates across the City,
6. Development and implementation of a consistent approach to water use restrictions and conservation efforts,
7. Implementation of universal domestic and agricultural metering,
8. Streamlining water system design and pricing for development,
9. Facilitating future water system consolidation consistent with City of Kelowna and Provincial policies.

Internal Circulation:
Divisional Director, Infrastructure
Utility Planning Manager
Senior Engineer, Infrastructure
Communications Consultant

Considerations not applicable to this report:
Legal/Statutory Authority:
Legal/Statutory Procedural Requirements:
Existing Policy:
Financial/Budgetary Considerations:
Personnel Implications:
Communications Comments:
External Agency/Public Comments:
Alternate Recommendation:

Submitted by:

Kevin Van Vliet, Utility Services Manager

Approved for inclusion: J Creron, Deputy City Manager

Report to Council

Date:	February 25, 2019
File:	1890-20
To:	City Manager
From:	Senior Engineer - Infrastructure
Subject:	Water System Integration Policy

Recommendation:

THAT Council receives, for information, the report from the Senior Engineer – Infrastructure dated February 25, 2019, with respect to the Water System Integration Policy;

AND THAT Council endorse the vision for City-wide integrated water supply and distribution as per the '2017 Kelowna Integrated Water Supply Plan – Value Planning Study' dated February 2017;

AND THAT Council approve Policy No.378 titled 'Water Systems Integration Policy' as attached to the report of the Senior Engineer – Infrastructure dated February 25, 2018;

AND FURTHER THAT Council rescind Council Policy No.31, 'Municipal Water Supply Within City Boundaries'.

Purpose:

To formalize the vision and policy for city-wide integrated water distribution systems for domestic and agricultural users and to enable actions leading to development of a city-wide water system for the City of Kelowna.

Background:

Vision of a City-Wide Water System Integration

In February, 2017, City Council received a report by a Value Planning consultant titled '2017 Kelowna Integrated Water Supply Plan'. The report outlined the findings of a team of senior engineers and planners who had assessed engineering studies that were completed over the prior ten years by the City of Kelowna and Kelowna's large irrigation and improvement districts. The objective of this consultant's work was to determine the best-lowest cost long-term technical solution for achieving public health objectives, simplifying system administration, maintaining agricultural interests and achieving an efficient and resilient system, without regard to how the system would be governed.

Including the larger Improvement Districts, there are more than 25 different independent water systems operating within the City. These organizations provide water service to their customers with only limited interconnectivity between providers. The water supply for these utilities comes from a variety of water sources including Okanagan Lake, Mission Creek, Mill Creek, Scotty Creek and Hydraulic Creek, as well as from groundwater aquifers. These sources vary in water quality; some that have not met drinking water quality guidelines in addition to other significant aesthetic issues related to taste, odour and colour.

The Value Planning consultant noted that, while technically these water quality issues can be solved independently by each provider, these independent solutions will be very costly, creating substantial rate inequity for Kelowna's citizens. In addition, independent systems with fewer water source options, are less resilient and costlier to operate. The most sustainable solution is to integrate the water systems over time to better meet the customers' water service expectations relative to serving the demand, protecting public health, improving the aesthetic qualities of the water, providing redundancy of supply, ensuring resiliency, addressing impacts of climate change and having equity in both services and costs.

The 2017 Kelowna Integrated Water Supply Plan presented a vision of a city-wide integrated water system. The vision includes separation of domestic and agricultural irrigation systems in rural areas and using the most appropriate water sources for each. The best quality water sources would be preserved and consolidated for potable (drinking) water use and the lower quality water supplies would be preserved for irrigation use.

Water Integration Policy

Several independent water purveyors continue to supply domestic and/or irrigation water within the City boundary. These purveyors have struggled to provide potable water that consistently meets Canadian Drinking Water Quality Guidelines. To date, the City has incorporated several of these private or public water systems, and is in the process of integrating the South Okanagan Mission Irrigation District (SOMID). Our vision now, for the reasons stated above, is to work towards a fully integrated city-wide water system. To facilitate and clearly communicate this, a new Council policy is recommended.

Policy No.378, Water Systems Integration Policy is recommended to define the criteria and process by which the City integrates private and public water systems into its Water Utility. At present, the City does not have jurisdiction to unilaterally do this and must rely on either the independent utility or the Province to initiate the process. One incentive for an independent system is the ability of the City to access senior government grants. The proposed City Policy supports Provincial Policy that funding will only be made available through amalgamation with the City. However, in some cases the subject water system is not able to continue operating for various reasons and/or senior government grants aren't available. Where there are insufficient senior government grants to cover the full cost of integration, the City will consider establishing a Local Area Service and recover the net cost of the integration from the benefiting properties.

Provincial guidelines note that independent water systems may only apply through the City to access senior government funding. Through enactment of this policy, Council is requiring that, prior to any applications for senior government funding, proposed capital improvements will include physical integration with the City Utility.

In the interest of achieving its goal of a city-wide integrated water system, the City will establish detailed integration plans. These plans are to ensure the reliable and sustainable provision of clean, safe drinking water for public health and reliable water supply for agriculture and fire protection in the most affordable and efficient manner for all citizens of Kelowna irrespective of current water system boundaries or service area.

This policy identifies the guiding principles, criteria and process required for a water system to integrate with the City water utility and for Council to support senior government funding for water system improvements.

Policy No.31, Municipal Water Supply Within City Boundaries (1976), is now inconsistent with the City's vision of a city-wide water system. It is therefore recommended to be rescinded.

Internal Circulation:
Division Director, Infrastructure
Division Director, Corporate Strategic Services
Utility Planning Manager
Utility Services Manager
Deputy City Clerk
Communications Consultant

Existing Policy:
Existing policy concerning the major water Improvement Districts operating within the City has been in place since 1976. It is now inconsistent with the City's plans for city-wide water service subject to Council's approval of the recommendations within this report.

Considerations not applicable to this report:
Financial/Budgetary Considerations
Legal/Statutory Authority
Legal/Statutory Procedural Requirements
Personnel Implications
External Agency/Public Comments
Communications Comments
Alternate Recommendation

Submitted by:

R. Westlake, P.Eng.
Senior Engineer

Approved for inclusion: A. Newcombe, Division Director, Infrastructure

Attachment 1 - Council Policy No.378 (new) 'Water System Integration Policy'
Attachment 2 - Council Policy No. 31, (rescind) "Municipal Water Supply within City Boundaries'

cc: Deputy City Manager
Division Director, Infrastructure
Division Director, Corporate Strategic Services
Deputy City Clerk

POLICY 378

City of Kelowna
1435 Water Street
Kelowna, BC V1Y 1J4
250 469-8500
kelowna.ca

Council Policy

Water Systems Integration Policy

ESTABLISHED: February 25, 2019

Contact Department: Infrastructure

Guiding Principle

The City envisions, over time, a city-wide integrated water system that delivers clean, safe, reliable drinking water to all of its citizens at equitable rates, and offers an affordable, reliable and sustainable water supply for agricultural users.

Objective

To combine potable water systems within the City boundary into an integrated water system. The system integration will be seamless, sustainable, and include interconnectivity and source protection to a consistent clean water quality standard.

Policy Statements

- A Purveyor or Water System must apply to the City for integration into the City Water Utility; and must apply to the Province for dissolution. In a situation where the Purveyor or Water System cannot continue to operate for any reason, they will dissolve at the direction of the Province in accordance with provincial policy or direction.
- There must be minimal capital or operational impacts, or risk to the existing City Utility and its users.
- The City will not take on undue risk.
- The City will seek to recover the costs of the integration from incoming ratepayers of the applicant water utility.
- Any proposed improvements or upgrades to the water system must be consistent with the Kelowna Integrated Water Supply Plan and City standards as amended from time to time.
- The governing body of the water system must agree to transfer all water system assets, administration functions, reserves and water rights to the City. Depending on the circumstances, a transition agreement or a transfer agreement may be required. The cost of transferring assets to the City will be one dollar ($1).
- The City will require a detailed Integration Review report as part of the application to address all of the items above. Prior to the City assuming operations and control of a water system, the City will require the applicant water users and/or the Province to upgrade the existing system to City standards or a minimum acceptable standard approved by Council.

Application Process

- A water system wishing to be considered to be integrated into the City water system must indicate its desire to Council. This can be a simple resolution from its Board of Directors, governing body or through Provincial directive.
- Council will respond to the application after considering the effort and costs based on the ***integration review***. The following information will be required and considered by the City as part of the integration review and approval:
    - A report evaluating the current state of the water system;
    - An assessment of present and future water requirements: for potable and agricultural use;
    - Evaluation of improvements/costs required to ensure the water system meets City standards;
    - Upgrades required to meet regulatory requirements;
    - An asset management plan that details the current condition of assets, service levels and inherent system risks which includes a 20-year forecast of costs for O&M;

  - Financial assessment of assets (infrastructure, reserves, water licenses and lands), and liabilities (debt and legal risk); &
  - A financial strategy to cover debts, liabilities and upgrades. The financial strategy will include impacts of a successful grant application, if applicable.
- Upon confirmation of approval from the Province and Council to integrate the water system into the City Water Utility, a transition plan or Transfer Agreement may be developed by staff for Council's consideration and include:
- consideration for existing staff positions,
- an orderly and logical transfer of buildings and assets,
- an orderly transition of administration and governance, and
- a timeline for the transition, which may occur quickly, or over a longer period.
- In all cases, consultation with the Purveyor or Water System Board of Directors and the Province on the Transition Plan or Transfer Agreement will be required. Financial terms related to the integration may require Provincial funding and/or grants to mitigate all impacts to the City and other resources or activities.

POLICY 31

City of Kelowna
1435 Water Street
Kelowna, BC V1Y 1J4
250 469-8500
kelowna.ca

Council Policy

Municipal Water Supply Within City Boundaries

APPROVED December 7, 1976

RESOLUTION: R375/10/04/26
REPLACING: R892/99/11/01; R728/99/08/23; R-76/1976/12/07
DATE OF LAST REVIEW: April 2010

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1. The City of Kelowna should continue to be served by the Kelowna Water Utility, Rutland Waterworks District, South East Kelowna Irrigation District, Glenmore Irrigation District, Black Mountain Irrigation District. No steps shall be taken at this time to amalgamate one or more of the systems with the Kelowna Water Utility.
2. Future developments within the existing boundaries of the foregoing systems shall be serviced by those systems.
3. The Kelowna Water Utility shall be operated as a self-liquidating utility.

REASON FOR POLICY

To identify the water purveyors within the City of Kelowna and the City’s intent not to amalgamate.

LEGISLATIVE AUTHORITY

Council Resolution.

PROCEDURE FOR IMPLEMENTATION

NA

Report to Council

Date: February 25, 2019

File: 0600-10

To: City Manager

From: City Clerk

Subject: South Okanagan Mission Agricultural Users Local Area Service – Certificate of Sufficiency

Report Prepared by: R. Westlake, Senior Engineer and C. Boback, Legislative Coordinator

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Recommendation:

THAT Council receives for information, the report from the City Clerk, dated February 25, 2019 regarding South Okanagan Mission Irrigation Water Integration Local Service Area;

AND THAT Council receive the Certificate of Sufficiency dated February 13, 2019 pertaining to the South Okanagan Mission Agricultural Local Area Service;

AND THAT Bylaw No.11745 being South Okanagan Mission Agricultural Users Local Area Service Establishment Bylaw be forwarded for Council consideration;

AND FURTHER THAT Bylaw No.11746 South Okanagan Mission Agricultural Users Loan Authorization Bylaw be forwarded for Council consideration.

Purpose:

To receive the Certificate of Sufficiency for the South Okanagan Mission Agricultural Users Local Area Service from the customers involved in the South Okanagan Mission Irrigation Distribution Water Integration Project and to forward the Establishment and Loan Authorization Bylaws for reading consideration.

Background:

In July 2016, the Board of the SOMID passed a resolution indicating their intent to dissolve and be integrated into the City's Water Utility. In August 2016, the City commissioned an engineering assignment to undertake preliminary engineering to determine the costs to integrate the SOMID system with the City's system. This work was broadened to include integration of the South-East Kelowna Irrigation District. The engineering work was substantially completed in the fall of 2016.

The federal/provincial Clean Water and Wastewater Fund program came available for local government applications in the fall of 2016. The City made application for water infrastructure upgrades to SOMID, SEKID and City systems to complete the integration of these systems. Senior government funding was announced in March 2017.

The senior government grants will cover the costs of the City's supply integration infrastructure. The remaining costs will need to be recovered through a Local Service Area process as per the Community Charter. These remaining costs and the apportionment of them, have been explained to the affected property owners.

As of January 2019, owners of the affected properties signed in favor a Local Area Service petition for the construction of the water upgrades. For a petition to be sufficient under the Community Charter, at least 50% of affected owners **and** at least 50% of the total assessed values must approve the local service area. As of January 30th, 2019, the Office of the City Clerk received valid signatures representing 7 of the 7 affected properties.

With the Community Charter conditions achieved, Council may consider construction of the requested improvements.

Subject to Council's approval of initial readings of the Loan Authorization bylaw, City staff will forward the bylaw to the Ministry of Municipal Affairs for their approval. Once we receive the Ministry's approval of the Loan Authorization Bylaw, staff will bring a report to Council for final reading of the establishment and loan authorization bylaws.

The dissolution of SOMID will take place on January 1, 2020. Once the bylaws are approved, the infrastructure improvements will be scheduled for construction.

Internal Circulation:
Accounting Operations Manager
Budget Supervisor
Division Director, Financial Services
Financial Planning Manager
Infrastructure Delivery Department Manager
Utilities Operations Manager
Utility Planning Manager

Legal/Statutory Authority:
Community Charter - Section 179 – Borrowing
Community Charter -Section 210 & 216 – Authority for Local Service Areas
Community Charter -Section 211 – Requirements for establishing a Local Service Area

Legal/Statutory Procedural Requirements:
Community Charter – Section 212 – Requirements for the Owner initiated Local Area Service.
Community Charter – Section 212(2) to (6) – Petitioning requirements and Corporate Officer sufficiency determination.

Existing Policy:
The City's policy regarding financial participation of benefiting property owners as set out in the existing policy.

Financial/Budgetary Considerations:

Considerations not applicable to this report:

Personnel Implications:
External Agency/Public Comments:
Communications Comments:
Alternate Recommendation:

Submitted by:

S. Fleming, City Clerk

Approved for inclusion:

cc:

City Manager
Divisional Director, Financial Services
Infrastructure Delivery Department Manager
Infrastructure Engineering Manager
Infrastructure Operations Department Manager

CITY OF KELOWNA

OFFICE OF THE CITY CLERK

CORPORATE OFFICER CERTIFICATE OF SUFFICIENCY

I hereby certify that the Office of the City Clerk received **sufficient** signatures and assessed values in relation to the Owner Initiated Local Area Service opportunity for the South Okanagan Mission Improvement District (SOMID) Agricultural Customers Project. The Local Area Service for South Okanagan Mission Improvement District (SOMID) Agricultural Customers Project is for installing new water mains, redirecting existing water mains, installing new PRV, seven new Water Meter Pits and Chambers with Backflow Prevention, disconnect old services where required and tie-in to distribution of watermains.

Dated this 13th day of February 2019.

S. Fleming, City Clerk

South Okanagan Mission Improvement District (SOMID) Agricultural Customers Project Local Area Service						
Total No. Of Affected Parcels	**No. of Required Valid Petitions to Create the LAS for** South Okanagan Mission Improvement District (SOMID) Agricultural Customers Project **(More than 50% of Total Parcels Affected)**	**Total No. of Valid Petitions Received**		**Total Assessed Value of Land and Improvements for the Affected Parcels**	**Total Assessed Value Required to Create the LAS for** South Okanagan Mission Improvement District (SOMID) Agricultural Customers Project **(More than 50% of Total)**	**Total Petitioners' Assessment**
7	4	7		$10, 301,022.00	$5, 150, 011.00 (more than 50%)	$10, 301,022.00

CITY OF KELOWNA

BYLAW NO. 11745

South Okanagan Mission Agricultural Water Establishment Bylaw

A bylaw of the City of Kelowna to establish the Local Area Service for upgrading of a local irrigation watering system servicing the South Okanagan Mission agricultural customers

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WHEREAS pursuant to the provisions of Section 210 of the Community Charter, and amendments thereto, empowers the Council of the City of Kelowna with the authority to adopt a local area service bylaw to recover costs from property owner's pursuant to Section 216 of the Community Charter and amendments thereto, who derive a benefit from the service provided from local improvement works;

AND WHEREAS pursuant to the provisions of Section 211 of the *Community Charter*, and amendments thereto, states that the Council of the City of Kelowna must adopt a bylaw to establish a local area service;

AND WHEREAS pursuant to the provisions of Section 211 of the *Community Charter*, and amendments thereto, the local area service works proposed by this bylaw include all things necessary in providing the upgrading of a local irrigation watering system servicing South Okanagan Mission agricultural customers;

AND WHEREAS pursuant to the provisions of Section 148 and 212 of the Community Charter, and amendments thereto, the Corporate Officer assigned responsibility has certified the sufficiency of the petition and the petitions received in favor of the proposed work was sufficient therefore unable to prevent Council from proceeding with the work within the LAS;

AND WHEREAS the Council of the City of Kelowna has been advised through a report prepared by the Corporate Officer that the elector responses submitted by the affected property owners of the LAS, requesting that Council to proceed with upgrading of a local irrigation watering system servicing South Okanagan Mission agricultural customers project, are sufficient;

NOW THEREFORE the Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. There shall be and is hereby established a Local Area Service (LAS) under the provision of the Community Charter, and amendments thereto, to be known as the "South Okanagan Mission Agricultural Customer User Local Are Service";

2. The boundaries of the City of Kelowna South Okanagan Mission Agricultural Customer User Local Area Service project is outlined in Schedule "A" attached to and forming part of this bylaw;

3. The City of Kelowna is hereby authorized to provide, operate, maintain and to undertake and carry out, or cause to be carried out, the construction upgrading of a local distribution system servicing existing South Okanagan Mission agricultural customers consisting of installing new water mains, redirecting existing water mains, installing new PRV, seven new Water Meter Pits and Chambers with Backflow Prevention, disconnect old services where required and tie-in to distribution of watermains in the LAS as outline in Schedule "A" attached to and forming part of this bylaw;

4. The entire capital costs of the work shall be borne by the benefiting area, as identified in Schedule A, and shall be raised by way of a local service parcel tax under Section 216 of the Community Charter, levied in 20 annual instalments commencing after completion of construction;

5. Upon completion of the local area service works, the actual construction cost will be specially charged against the parcels benefiting from, being the parcels shown on Schedule A as attached to and forming part of this bylaw;

6. Should the sums recovered through the levy of the local service parcel tax at any time be insufficient to meet the costs of repayment of the debt, the Council may levy and impose within the benefiting area an additional rate on land and improvements over and above all other rates sufficient to meet such deficit in the same manner and time as other general municipal levies.

7. Any person whose parcel is subject to being specially charged under Section 4 of this bylaw, may elect to make a one-time payment of the portion of the cost of construction assessed upon their parcel within sixty days of receipt of written instructions from the Collector.

8. This bylaw may be cited for all purposes as being "South Okanagan Mission Agricultural Water Establishment Bylaw No. 11745."

9. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

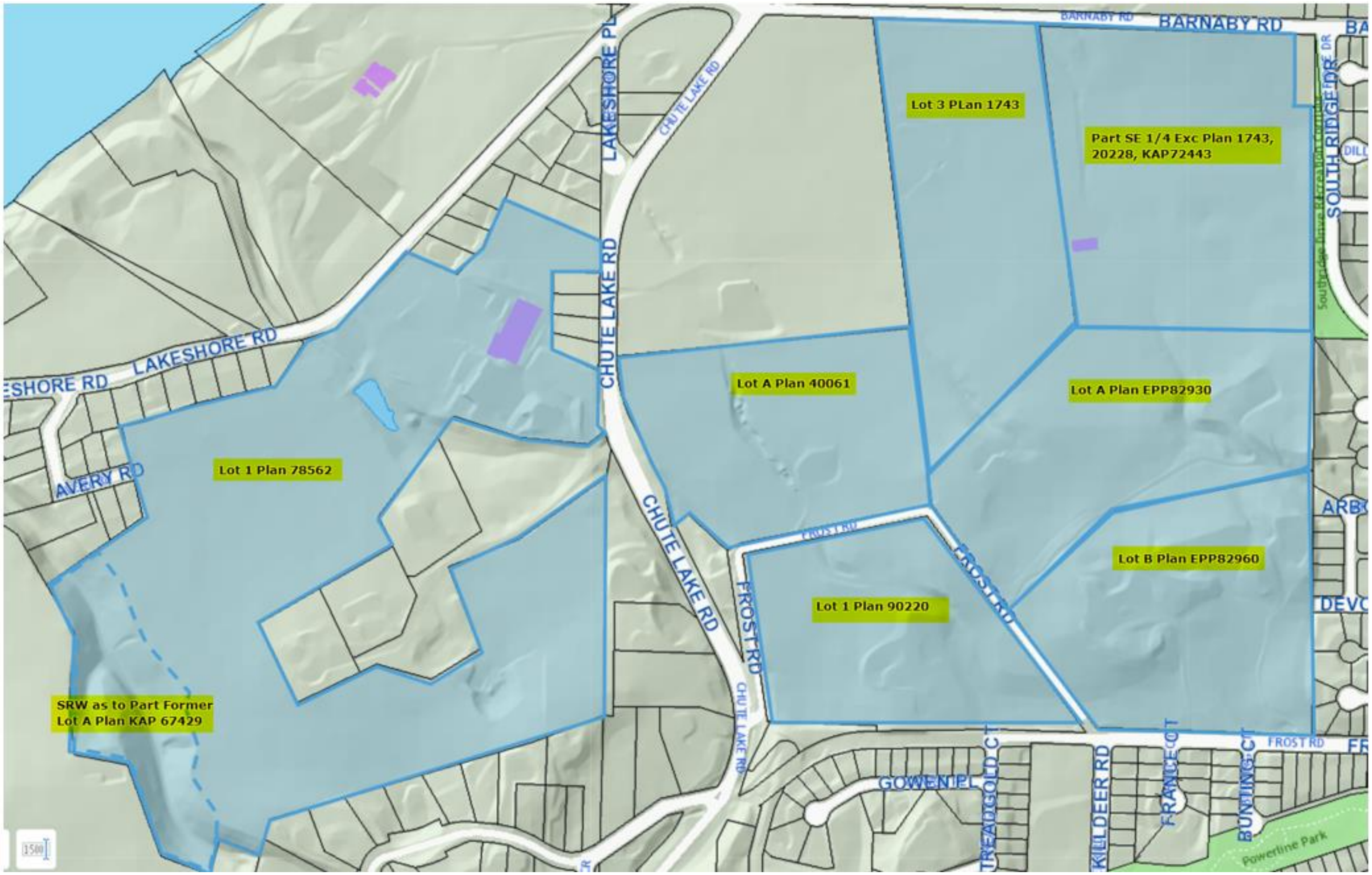
Read a first, second and third time by the Municipal Council this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Schedule A


Lot 3 PLan 1743
Part SE 1/4 Exc Plan 1743, 20228, KAP72443
Lot A Plan 40061
Lot A Plan EPP82930
Lot 1 Plan 78562
Lot B Plan EPP82960
Lot 1 Plan 90220
SRW as to Part Former Lot A Plan KAP 67429
BARNABY RD
BARNABY RD
LAKESHORE PL
CHUTE LAKE RD
CHUTE LAKE RD
CHUTE LAKE RD
CHUTE LAKE RD
LAKESHORE RD
ESHORE RD
AVERY RD
FROST RD
FROST RD
FROST RD
FROST RD
SOUTH RIDGE DR
Southridge Drive Recreation Centre
GOWEN PL
TREADGOLD CT
KILLDEER RD
FRANCE CT
BUNTING CT
Powerline Park
ARB
DEV
DILL
1500

CITY OF KELOWNA

BYLAW NO. 11746

South Okanagan Mission Agricultural Users Local Area Service Loan Authorization Bylaw

A bylaw of the City of Kelowna to authorize the borrowing of funds for the Local Area Service for upgrading of a local water irrigation system servicing South Okanagan Mission Agricultural Local Area Service

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WHEREAS Section 179 of the Community Charter authorizes the Council of the City of Kelowna to borrow for a local area service by means of a loan authorization bylaw adopted with the approval of the Inspector of Municipalities;

AND WHEREAS pursuant to the provisions of Section 210 of the Community Charter, and amendments thereto, empowers the Council of the City of Kelowna with the authority to adopt a local area service bylaw to recover costs from property owner's pursuant to Section 216 of the Community Charter and amendments thereto, who derive a benefit from the service provided from local improvement works;

AND WHEREAS pursuant to the provisions of Section 212 of the Community Charter, and amendments thereto, the Council of the City of Kelowna has been advised through a report prepared by the Corporate Officer that the elector responses submitted by the affected property owners of the Local Area Service, requesting that Council to proceed with the borrowing to undertake the upgrading of a local water irrigation system servicing South Okanagan Mission Agricultural Users, are sufficient;

AND WHEREAS the Council of the City of Kelowna may borrow sums of money, not exceeding the total cost of the work that may be necessary, pursuant to Section 217 of the Community Charter and amendments thereto;

AND WHEREAS the estimated cost of the Local Area Service for upgrading of a local water irrigation system servicing South Okanagan Mission Agricultural Users is in the sum of Four Hundred and Forty-One Thousand Dollars ($441, 000.00) and is the amount of debt intended to be borrowed under this bylaw;

AND WHEREAS the maximum term for the debentures to be issued to secure the monies authorized to be borrowed hereunder is twenty (20) years;

AND WHEREAS Council has established, by the "South Okanagan Mission Agricultural Users Local Area Service Establishment Bylaw No. 11745" a local area service for the upgrading of a water irrigation system servicing the South Okanagan Mission Agricultural Users;

NOW THEREFORE the Municipal Council of the City of Kelowna, in open meeting assembled, enacts as follows:

1. The City of Kelowna is hereby authorized to provide, operate, maintain and to undertake and carry out, or cause to be carried out, the construction for the upgrading of a water irrigation system servicing South Okanagan Mission Improvement Agricultural User Local Area Service, established under the "South Okanagan Mission Agricultural Users Local Area Service Establishment Bylaw No. 11745", generally in accordance with plans on file in the municipal office and to do all things necessary in connection therewith and without limiting the generality of the foregoing:

   a. The City of Kelowna is hereby authorized to borrow, upon the credit of the City of Kelowna, a sum not exceeding Four Hundred and Forty-One Thousand Dollars ($441, 000.00) for constructing the works more particularly described in Section 1.

   b. To acquire all such real property, easements, rights-of-way, licenses, rights or authorities as may be requisite or desirable for or in connection with the construction of the South Okanagan Mission Agricultural User local water irrigation system.

2. The entire capital costs of the work paid for out of money borrowed, pursuant to the authorization of this bylaw shall be borne by borne by the South Okanagan Mission Agricultural Users local service area.

3. The maximum term for which debentures may be issued to secure the debt created by this bylaw is 20 years.

4. This bylaw may be cited for all purposes as " South Okanagan Mission Agricultural User Loan Authorization Bylaw No. 11746."

5. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first, second and third time by the Municipal Council this

Approved by the Inspector of Municipalities this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Report to Council

Date:	February 25, 2019
File:	0245-20
To:	City Manager
From:	J. Shaw Manager, Infrastructure Engineering Manager
Subject:	Development Cost Charges Bylaw No. 11755 Amendment No.4 to Development Cost Charge Bylaw No.10515

Recommendation:

THAT Council receives, for information, the report from the Infrastructure Engineering Manager dated February 25, 2019, with respect to amending the Development Cost Charge Bylaw No.10515.

AND THAT Bylaw No. 11755 being Amendment No.4 to Development Cost Charge Bylaw No.10515 be forwarded for reading consideration;

AND THAT Council direct staff to submit DCC Bylaw and supporting documentation to Ministry of Community Services for their review and approval prior to fourth reading and adoption of the DCC Bylaw by Council.

Purpose:

To inform Council about the proposed changes to the Development Cost Charge Bylaw and receive direction from Council to submit the bylaw for Ministry approval prior to returning to Council for adoption.

Background:

The Development Cost Charge (DCC) Bylaw sets out the charges imposed on developers to offset some of the infrastructure expenditures incurred to service the needs for new development. DCCs are intended to facilitate development by providing a method to finance capital projects related to public roads, water, sanitary sewer, drainage and parkland. The current DCC Bylaw 10515 was adopted by Council June 13, 2011 in conjunction with the OCP review.

The City's 20 Year Serving Plan and Financial Strategy forms the basis of the DCC program and provides detailed analysis of the major serving needs required to service growth as projected in the 2030 Official Community Plan. The City has recently updated project costs in the 20 Year Serving Plan and Financial Strategy based on current construction and land costs. These costs have been used to revise the Development Cost Charges (DCC) which were last updated in July 2016. This review updates construction and land costs only and there were no changes made to the projects or type and quantity of developable units in the program.

Project Cost Estimating

Urban Systems Limited (USL) was retained by the City to review construction costs and update the project costs in the 20-Year Servicing Plan. Where possible, unit rates were derived from City of Kelowna tendered projects from 2016, 2017 and 2018. Construction costs from other projects tendered in the region were used where local costs were not available. USL reviewed each unit cost, and using engineering judgment, selected the appropriate unit cost to use in the 20-Yr Servicing Plan. The selected unit cost was typically on the lower end of low-average. This is meant to be conservative in order to recognize the possible inaccuracies in relying on an average approach.

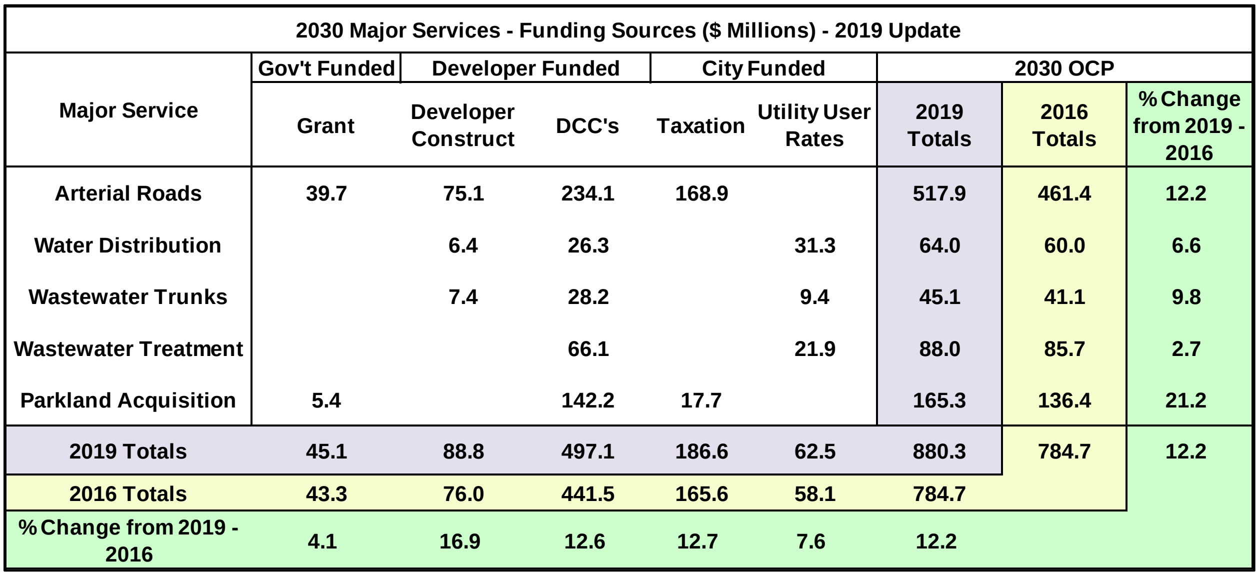
Where unit costs were not available, a 7% construction escalation factor was used, based upon the Engineering News Record Construction Cost Index. The value used was an average increase between the years of 2015 and 2017.

The City's Real Estate Department updated the land and parkland costs in the 20-Yr Servicing Plan. The real estate market conditions have significantly increased since 2015 with general land and parkland increasing by 25%.

Table 1 summarizes the updated (2018) costs of major servicing in comparison to the costs in the current 20-Year Servicing Plan. The total program cost increased from $784.7 to $880.3 million (12.2%) since the last update in 2016. The portion of the program funded from DCCs and the City funded portion increased as follows:

DCCs increased from $441.5 to $497.1 million (12.6%)
City Funded- Taxation share increased from $165.6 to $186.6 million (12.7%)
City Funded - Utility user rates share increased from $58.1 million to $62.5 million (7.6%)

Table 1 - Funding sources for the 20-Yr Servicing Plan and Financial Strategy based on the 2018 construction and land cost update.



2030 Major Services - Funding Sources ($ Millions) - 2019 Update

	Gov't Funded	Developer Funded		City Funded		2030 OCP		
Major Service	**Grant**	**Developer Construct**	**DCC's**	**Taxation**	**Utility User Rates**	**2019 Totals**	**2016 Totals**	**% Change from 2019 - 2016**
Arterial Roads	39.7	75.1	234.1	168.9		517.9	461.4	12.2
Water Distribution		6.4	26.3		31.3	64.0	60.0	6.6
Wastewater Trunks		7.4	28.2		9.4	45.1	41.1	9.8
Wastewater Treatment			66.1		21.9	88.0	85.7	2.7
Parkland Acquisition	5.4		142.2	17.7		165.3	136.4	21.2
2019 Totals	45.1	88.8	497.1	186.6	62.5	880.3	784.7	12.2
2016 Totals	43.3	76.0	441.5	165.6	58.1	784.7		
% Change from 2019 - 2016	4.1	16.9	12.6	12.7	7.6	12.2		

The Arterial Roads Program (both Roads and Active Transportation) costs increased from $461.4 to $517.9 million (12.2%) since the last update in 2016. The primary cost increases were attributable to concrete curb and gutter (+47%), concrete sidewalk (27%), granular subbase (+35%) and asphalt (+25%).

Costs for the Water Distribution program increased from $60 to $64 million (6.6%) since the last update.

Costs for the Wastewater Trunks program increased from $41.1 million to $45.1 million (9.8%).

Costs for the Wastewater Treatment program increased from $85.7 to $88.0 million (2.7%).

Parkland Acquisition costs increased from $136.4 to $165.3 million (21.2%) since the last update. Assisting in the keeping the parkland acquisition cost increase manageable a conservative estimate was used. This estimate did not incorporate a justifiable premium for the high proportion of 'unique' properties (i.e. waterfront properties or properties with prime development potential) on the parkland acquisition list.

Development Cost Update

Stemming from the land and construction cost increases, the DCC rates in all areas of the City have increased since the last update. The table on the next page summarizes the DCC rates by service area and sector for Residential 1 – Single Family.

When all services are combined the DCC rate increase ranges from 10.5% in Sector C to 21.1% in Sector A (Table 2).

As a result of this update, the City will be able to maintain DCC reserves at a level that reflects construction costs of the current economic environment in order to allow appropriate levels of growth related infrastructure investment.

Table 2 - Proposed DCC rates by service area and sector based on 2018 construction and land cost update

2019 VERSUS 2016 DCC RATES ($'s per Residential 1 Unit)

	S.E. Kelowna	South Mission	NE of Inner City	North of Hwy 33	North of Inner City	Inner City
Arterial Roads	A	B	C	D	E	I
2016 Update	9,243	26,118	15,513	13,321	11,000	8,338
2019 Update	11,068	27,666	16,758	15,054	13,244	9,583
$ Difference	1,825	1,549	1,245	1,733	2,244	1,245
% Change	19.7	5.9	8.0	13.0	20.4	14.9
Parkland Acquisition	A					
2016 Update	5,795					
2019 Update	7,142					
$ Difference	1,347					
% Change	23.2					
Wastewater Treatment	A					
2016 Update	3,645					
2019 Update	3,691					
$ Difference	46					
% Change	1					
Wastewater Trunks	A	B				
2016 Update	1,541	1,379				
2019 Update	1,687	1,631				
$ Difference	146	252				
% Change	9.5	18.3				
Water Distribution	A	B	D			
2016 Update	1,282	833	3,584			
2019 Update	1,503	995	3,729			
$ Difference	221	162	145			
% Change	17.2	19.4	4.0			
Total All Services	S.E. Kelowna (A)	South Mission (B)	N.E. of Inner City	N. Hwy 33 (D)	N. of Inner City (E)	Inner City (I)
2016 Update	15,038	37,769	26,494	24,302	21,981	20,601
2019 Update	18,209	41,125	29,278	27,574	25,764	23,606
$ Difference	3,172	3,355	2,784	3,272	3,783	3,005
% change	21.1	8.9	10.5	13.5	17.2	14.6

Internal Circulation:
Divisional Director, Infrastructure
Divisional Director, Community Planning & Strategic Investment

Divisional Director, Corporate Strategic Services
Legislative Coordinator
Director, Financial Services
Financial Analyst, Infrastructure Planning

Legal/Statutory Authority:
The Development Cost Charge (DCC) Bylaw sets out the charges collected from Developers for public roads, water, sanitary sewer infrastructure and public parkland acquisition when subdividing or constructing, altering or extending a building, pursuant the Local Government Act.

Legal/Statutory Procedural Requirements:
The Local Government Act requires the Inspector of Municipalities to approve local government DCC bylaws. The following process, which is recommend by DCC Best Practices Guide, is being followed by staff for amending the DCC Bylaw.

- Staff calculate DCC rates and amend DCC Bylaw for review,
- Letter with amended rates submitted to stakeholder groups for input (UDI and Canadian Home Builders' Associate November 9, 2018)
- Rates adjusted based on stakeholder input (UDI December 21, 2018)
- Council readings (1st, 2nd and 3rd) of proposed DCC Bylaw by Council (February 25, 2019),
- Bylaw revisions by staff (if any) considering Council input from February 25, 2019 meeting,
- Submission of DCC Bylaw and Supporting Documentation to Ministry of Community Services,
- Statutory approval from Inspector of Municipalities
- Fourth Reading and adoption of DCC Bylaw by Council,
- Bylaw adoption.

Existing Policy:
Development Cost Charge Bylaw 10515

Financial/Budgetary Considerations:
The City's 10-Year Capital Plan will be updated to reflect the revised project costs once the DCC Bylaw has been adopted by Council.

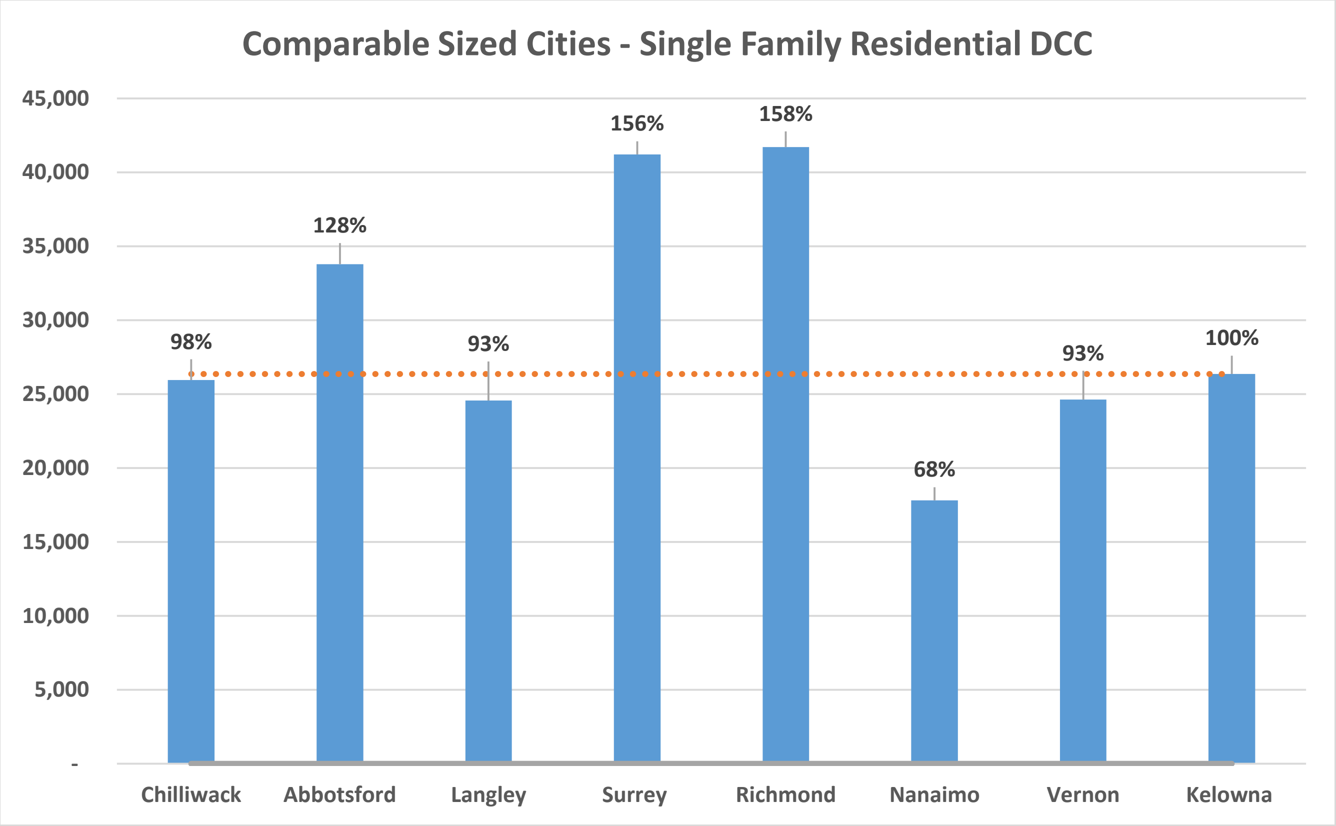
DCCs contribute to the initial capital cost of growth-related infrastructure, along with taxpayer and utility contributions that account for the benefit of the new infrastructure to the existing community. The subsequent operation, maintenance, capital renewal and the eventual replacement of all infrastructures accrues to general taxation or utility rates

External Agency/Public Comments:
Staff met with the Urban Development Institute on November 16, 2018 and have responded to their questions. UDI expressed general concern over project cost increases and inquired whether cost savings strategies were considered. UDI also provided comment on issues to address in the upcoming 20-Yr Servicing Plan update in conjunction with the OCP update. With respect to project costs the City is continually looking for ways to deliver infrastructure projects in a cost effective way. All major construction projects are procured through a competitive public procurement process. Where possible

the City reduces cost by combining projects for economy of scale, providing contractors with longer construction schedules and tendering early in the year before the construction market is busy.

The increased rates are still comparable to like size communities in B.C. as shown in the figure below.

Figure 1. Single Family Residential Average DCC Rate based on updated DCC rates



Considerations not applicable to this report:
Alternate Recommendation: N/A
Communications Comments: N/A
Personnel Implications: N/A

Submitted by:

J. Shaw, Manager, Infrastructure Engineering Manager

Approved for inclusion: ☐ A. Newcombe, Division Director, Infrastructure

Attachment 1 - DCC Cost Update Presentation

cc: City Clerk
Divisional Director, Community Planning & Strategic Investment
Divisional Director, Corporate Strategic Services
Divisional Director, Financial Services
Divisional Director, Infrastructure

DCC Cost Update

February 25th, 2019

Development Cost Charges (DCCs)

- DCCs are collected from land developers to pay for infrastructure to service new development.
- DCCs are imposed by Bylaw pursuant to the Local Government Act.
- DCCs facilitate development by providing a method to finance capital projects related to growth.
- Payable at subdivision or building permit.
- DCC Bylaw requires Provincial approval.

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Eligible Infrastructure

- Transportation – not off street parking
- Sewage
- Water
- Drainage
- Parkland Acquisition and Improvement

Ineligible Infrastructure

- Fire Halls, Police Buildings
- Recreation and Cultural Centers
- City Halls
- Works Yards
- Arenas
- Affordable housing
- Child care facilities

Process for DCC Update

- Notified UDI of forthcoming DCC update (Feb 2018)
- Urban Systems retained to update construction cost estimates (Apr 2018)
- Real Estate Department updated land costs.
- Actual cost used for completed projects and confirmed grants.
- Construction and land costs were updated for all 150
- Sent revised rates to UDI and CHBA (Nov, 2018)
- Consulted with UDI and provided feedback (Nov – Dec 2018)
- Notified UDI that City would be taking proposed changed to Council (Dec 2018)

Funding for DCC Services

2030 Major Services - Funding Sources ($ Millions) - 2019 Update								
	Gov't Funded	Developer Funded		City Funded		2030 OCP		
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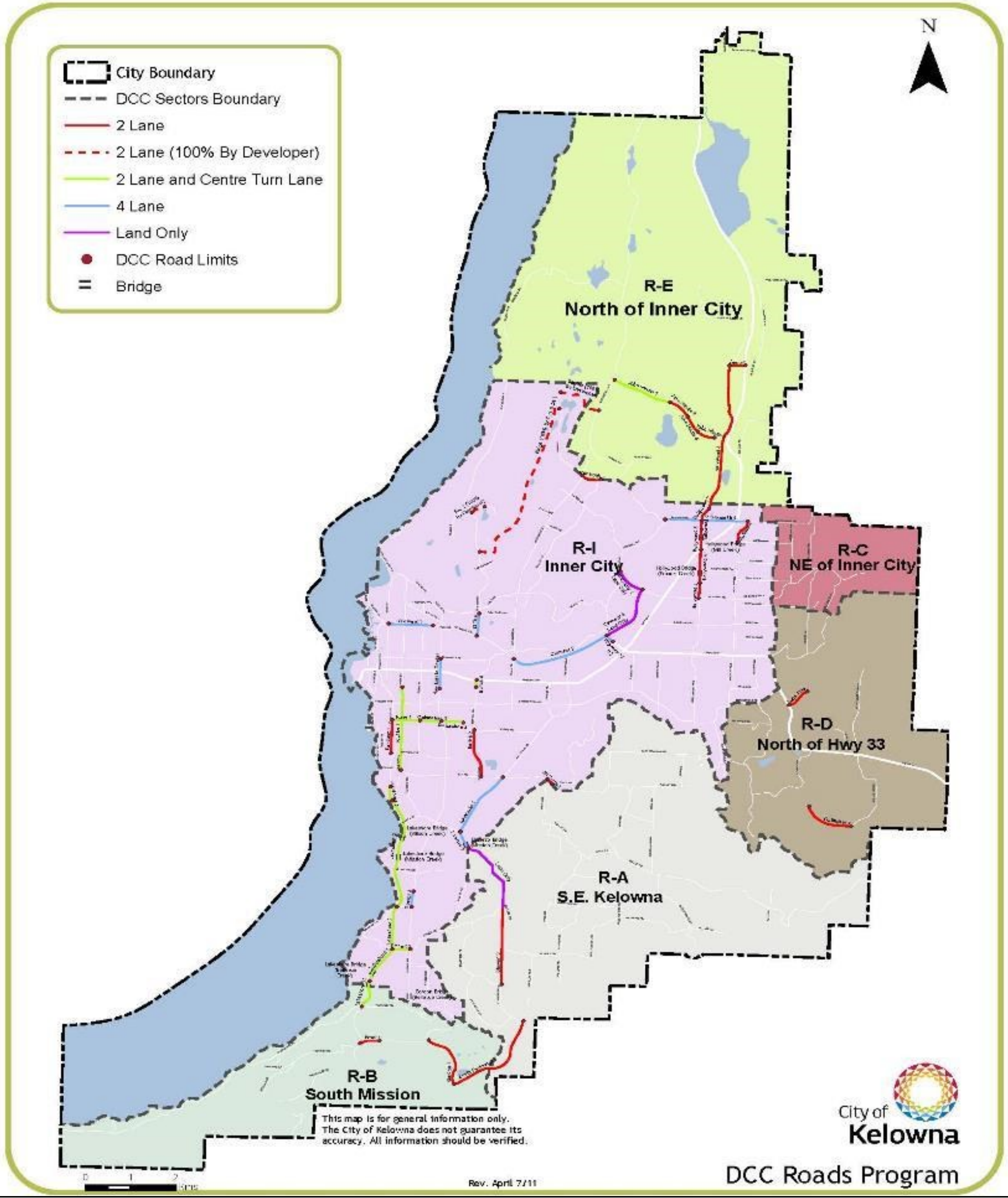

Total All Services	S.E. Kelowna (A)	South Mission (B)	N.E. of Inner City	N. Hwy 33 (D)	N. of Inner City (E)	Inner City (I)
2016 Update	**15,038**	**37,769**	**26,494**	**24,302**	**21,981**	**20,601**
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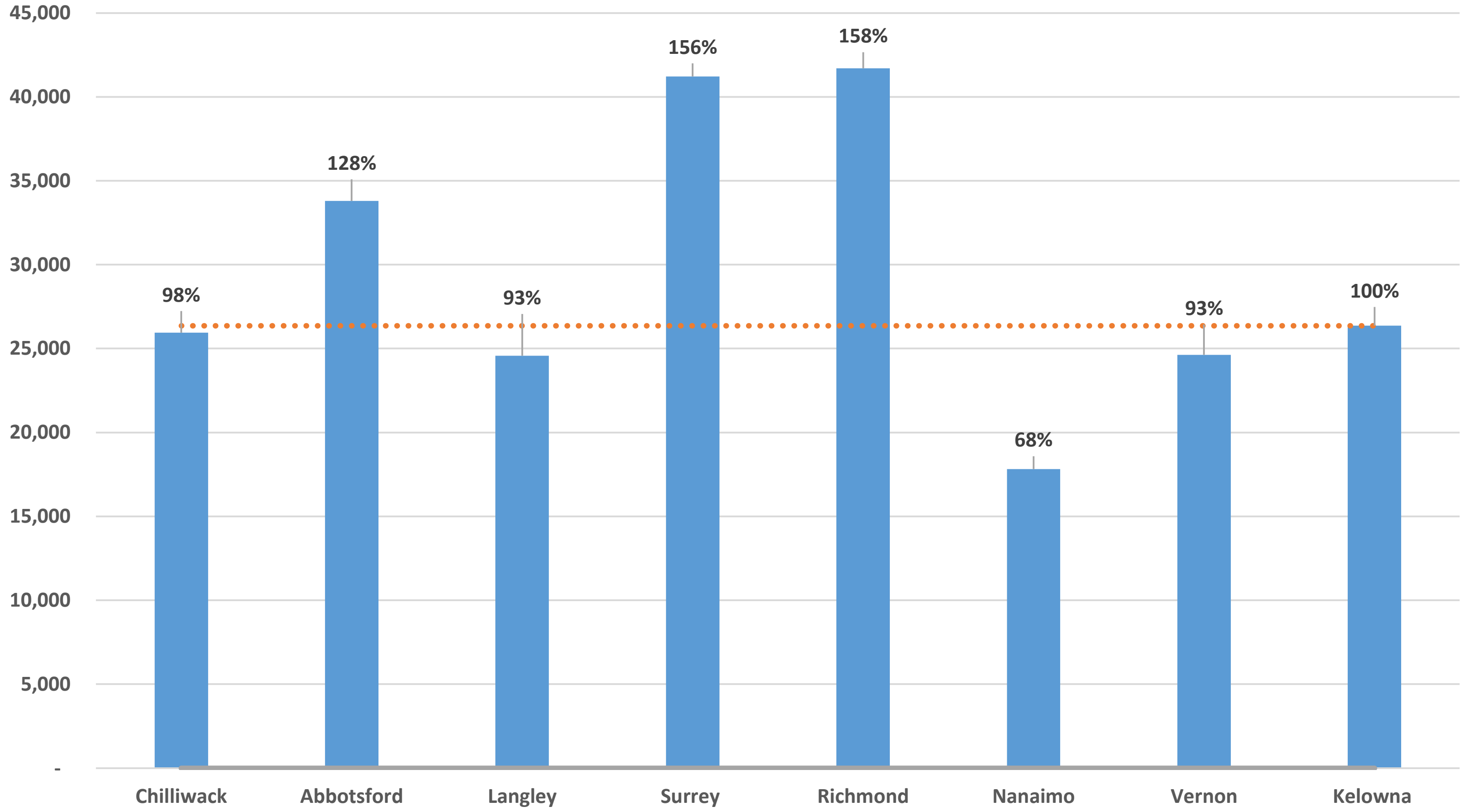
$ Difference	**3,172**	**3,355**	**2,784**	**3,272**	**3,783**	**3,005**
% change	**21.1**	**8.9**	**10.5**	**13.5**	**17.2**	**14.6**

Comparable Sized Cities - Single Family Residential DCC



City of **Kelowna**

Next Steps

- Council readings (1st, 2nd and 3rd) of proposed DCC Bylaw (Feb 25th 2019),
- Submission of DCC Bylaw and Supporting Documentation to Ministry of Community Services,
- Statutory approval from Inspector of Municipalities
- Fourth Reading and adoption of DCC Bylaw by Council,
- Bylaw implementation.

Questions?

For more information, visit **kelowna.ca**.

CITY OF KELOWNA

BYLAW NO. 11755

Amendment No. 4 to Development Cost Charge Bylaw No. 10515

The Municipal Council of the City of Kelowna, in open meeting assembled, enacts that the City of Kelowna Development Cost Charge Bylaw No. 10515 be amended as follows:

1. THAT Schedule A be deleted in its entirety and replaced with a new Schedule A as attached to and forming part of this bylaw.

2. This bylaw may be cited for all purposes as "Bylaw No. 11755, being Amendment No. 4 to Development Cost Charge Bylaw No. 10515."

3. This bylaw shall come into full force and effect and is binding on all persons as and from the date of adoption.

Read a first, second and third time by the Municipal Council this

Approved by the Inspector of Municipalities this

Adopted by the Municipal Council this

Mayor

City Clerk

Schedule 'A'

SERVICE AREA	Sector	Residential 1 To 15 Units/Hectare (Each Lot or Unit)	Residential 2 >15-35 Units/Hectare (Each Lot or Unit)	Residential 3 >35-85 Units/Hectare (Each Lot or Unit)	Residential 4 Greater Than 85 Units/Hectare (Each Lot or Unit)	Residential 5 Maximum applied to 56 sq. mtrs. unit	Residential 5 Per Square Meter of habitable floor space applied to units 56 sq. mtrs. or less	Secondary Suites Per Unit	Commercial For 1st 93 sq. mtrs. of floor area or portion; 1/93rd the rate for per sq. mtr over 93	Commercial Per Square Meter	Seasonal Agricultural Commercial (See Commercial)	Institutional "A" For 1st 93 sq. mtrs. of floor area or portion; 1/93rd the rate for per sq. mtr over 93	Institutional "B" For 1st 93 sq. mtrs. of floor area or portion; 1/93rd the rate for per sq. mtr over 93	Industrial/ Campground Minimums	Industrial/ Campground Per Hectare over minimum Developable Land	Seasonal Agricult. Industrial See Industrial Minimums	Seasonal Agricult. Industrial Per Hectare over minimum
ALL SERVICES								2,500									
ROADS																	
SE Kelowna	R-A	11,068	10,404	7,415	6,973	5,423	97.3		3,405	36.6	1,702	3,405		11,068 - 1st .405 hctr/prtn	27,338	5,534	13,669
South Mission	R-B	27,666	26,006	18,536	17,430	13,556	243.3		8,511	91.6	4,255	8,511		27,666 - 1st .405 hctr/prtn	68,337	13,833	34,168
NE of Inner City	R-C	16,758	15,753	11,228	10,558	8,211	147.4		5,155	55.5	2,578	5,155		16,758 - 1st .405 hctr/prtn	41,393	8,379	20,697
North of Hwy 33	R-D	15,054	14,151	10,086	9,484	7,377	132.4		4,631	49.8	2,315	4,631		15,054 - 1st .405 hctr/prtn	37,184	7,527	18,592
North of Inner City	R-E	13,244	12,449	8,873	8,344	6,489	116.5		4,074	43.9	2,037	4,074		13,244 - 1st .405 hctr/prtn	32,713	6,622	16,356
Inner City	R-I	9,583	9,008	6,421	6,037	4,696	84.3		2,948	31.7	1,474	2,948		9,583 - 1st .405 hctr/prtn	23,671	4,792	11,835
WATER																	
Inner City	W-A	1,503	1,007	721	511	421	7.6		577	6.2	288	577	577	1,503 -1st .15 hctr/prtn	10,398	751	5,199
South Mission	W-B	995	666	477	338	279	5.0		382	4.1	191	382	382	995 -1st .15 hctr/prtn	6,883	497	3,442
Clifton/Glenmore	W-D	3,729	2,498	1,790	1,268	1,045	18.7		1,432	15.4	716	1,432	1,432	3,729 -1st .15 hctr/prtn	25,805	1,865	12,902
TRUNKS																	
Inner City	S-A	1,687	1,401	945	911	743	13.3		648	7.0	324	648	648	1,687 -1st .15 hctr/prtn	11,677	844	5,838
South Mission	S-B	1,631	1,354	914	881	719	12.9		626	6.7	313	626	626	1,631 -1st .15 hctr/prtn	11,289	816	5,644
TREATMENT																	
Inner City & South Mission	T-A	3,691	3,063	2,067	1,993	1,626	29.2		1,417	15.3	708	1,417	1,417	3,691 -1st .15 hctr/prtn	25,540	1,845	12,770
PARKS	P-A	7,142	7,142	7,142	7,142	7,142	128.2		Exempt	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt	Exempt

NOTES

- Roads - Charges are Net of "Assist Factor" of 15%

- Wastewater Trunks/Treatment - Charges are Net of "Assist Factor" of 1%

- Water - Charges are Net of "Assist Factor" of 1%
    - Areas not noted above are provided water by suppliers other than the City

- Parks - Charges are Net of "Assist Factor" of 8%

- General - 1,000 square feet is considered to be the equivalent of 92.9 meters
    - sector designations denote geographical areas as designated on attached Sector maps A1 to A5

- Commercial or Institutional Calculation

The measurement unit for Commercial and Institutional development is square meters of floor area. The calculation of floor area of a commercial or institutional building is based on the gross floor area which is measured from the outside edge of all exterior walls, less the area used for parking of motor vehicles and bicycles in the building permit application.

- Industrial Calculation

The measurement unit for Industrial development is hectares of site area. The calculation of industrial site area is based on the gross area of the site that is proposed for development in a building permit application, including access, parking and loading and excludes landscaped areas and the undeveloped portion of the site that is being held in it's pre-developed state for future additional development (0.405 hectares minimum).

Report to Council

City of
Kelowna

Date: February 25, 2019

File: 1845-05

To: City Manager

From: Rod MacLean, Utility Planning Manager

Subject: Landfill Design Operations and Closure Plan (DOCP)

Recommendation:

THAT Council receives for information, the report from the Utility Planning Manager dated February 25, 2019, regarding the Landfill Design Operations and Closure Plan;

AND THAT Council adopt the Landfill Design Operations and Closure Plan provided by GHD Consultants Ltd as summarized in, and attached to, the report from the Utility Planning Manager, dated February 25, 2019;

AND THAT Council direct staff to submit the Landfill Design Operations and Closure Plan to the Province as required to maintain the Glenmore Landfill Operational Certificate 12218.

Purpose:

The purpose of this report is to present Council with the new Landfill Design Operations and Closure Plan report, and request approval to submit this report to the Province to meet the conditions in Operational Certificate 12218.

Background:

The Glenmore Landfill is owned by the City of Kelowna and is authorized to landfill 170,000 tonnes of waste per year. The Glenmore Landfill is the only solid waste disposal facility serving the Regional District of Central Okanagan (RDCO) and the Big White area.

Landfills of this size are a significant asset, and form an integral part of the economy for both the City of Kelowna and the other municipalities in the RDCO. The Landfill operation manages excess material from a variety of activities and systems, including disposal from development activities, commercial operations, industrial practice, residential systems, natural wastes, emergency waste and helps coordinate recycling opportunities. Sustainably operated landfill practices reduce the threat of illegal dumping and ensure safe waste management.

The Landfill operates pursuant to the RDCO Solid Waste Management Plan and Operational Certificate 12218 issued by the Province of British Columbia. The Province requires, as part of this permit, to complete, submit, maintain and regularly update a Design, Operation and Closure Plan (DOCP).

The City engaged a consultant, GHD Ltd., to compile, coordinate and complete the plan. The DOCP Final Report was submitted on November 30, 2018, following a significant review by City staff, and is submitted to Council for final approval. Once approved by Council, the Plan will be submitted to the Province for approval.

What is a Design, Operations and Closure Plan?

The DOCP is a comprehensive look at the planned life of the Glenmore Landfill in compliance with the Ministry Operational Certificate. The Plan presents the current status, regulatory framework, infrastructure needs, environmental practices, monitoring needs, design concepts, and operational practices, as well as a long-term plan to progressively and ultimately close the landfill.

Rationale for Closure

The purpose of closing a landfill or landfill cell properly is to minimize the potential for contamination, leachate generation, fire, or environmental release of landfill gas. In the long term, the closed area will cease to produce leachate and landfill gas, becoming effectively inert, and the cell or landfill would no longer require any further monitoring or post-closure care. Ultimately, the area can be naturalized as it will no longer generate any contamination from snow, rain or other temporal events.

Instead of closing the entire facility at once when full, the DOCP strategy follows the Provincial guidance of "Progressive Closure" for the landfill. Once a Fill Area within the landfill footprint has achieved capacity, that Area shall be "closed" within 365 days. Such closure activities will include the construction of a final cover, extending surface water ditches and access roads, planting vegetation, erecting or relocating signage. The actual timing of the progressive closure activities will be based on the filling plan. The goal of Progressive Closure is to reduce any environmental liability of allowing contamination to continue unmitigated.

The Province requires the City to monitor and control all activities within and around a "closed" landfill for a contaminating lifespan, also known as the "Post-Closure" period. Post-Closure operation and maintenance (O&M), as well as an environmental monitoring program, is currently estimated at 80 years and shall be done in accordance with the Closure Plan.

Report Scope

In June 2016, the Province updated the *Landfill Criteria for Municipal Solid Waste (*Guidelines*)*. In 2017, GHD Limited of Richmond BC was retained to perform a Gap Analysis, to assess what additional information was required to meet the updated Guidelines. City personnel presented an updated Fill Plan to Council in October of 2017 and the updated DOCP was then completed in late 2018.

The scope of the work and final report includes:

- A description of the facility and the physical setting of the Site.
- The latest 10-year conceptual design of the Landfill including the base liner system, leachate collection system, and final cover.

- A Surface Water Management Plan and Leachate Management Plan for the Site.
- Identification of the major capital components and costs required to implement the Landfill Development Plan and a more detailed 10-year capital plan.
- Demonstrating that the Landfill Criteria design objectives and minimal requirements for the Landfill and environmental control systems are met.
- Operational procedures for waste acceptance and landfilling.
- Environmental monitoring and Landfill monitoring plans.
- The closure and post-closure requirements for the Landfill.

Report Recommendations

Much of the DOCP produced is consistent with the historical 2008 Comprehensive Site Development Plan, with some updates in design to reflect the current requirements of the Guidelines. The following are some key recommendations from the planning effort and report:

1. <u>Develop a long term Nuisance monitoring and mitigation program.</u> – The landfill currently receives few complaints about common nuisances such as noise, odour, dust or litter. This is largely due to the efforts of Landfill operations as well as the location and setback from potentially impacted groups. In the early development stages of the DOCP, the nuisance criteria were brought into question, resulting in a study being conducted by GHD on behalf of the City. In 2018, a Council Report was presented on the topic, with recommendations for a more detailed Nuisance Study and analysis (Council Resolution R266/18/03/19) to be completed. Further to this, it is recommended that the Official Community Plan be updated to reflect the zoning limitations near the landfill and the future operational plan.

2. <u>Surface Water Management</u> – Historically, storm water management at the landfill has been handled internally. This includes the collection and storage of rain, runoff, snowmelt and groundwater during the winter and spring, and applying it as irrigation on the neighboring farms, or allowing it to evaporate during the dry summer months. The flooding events of 2017 and 2018 and the observed rise in valley groundwater levels over the last five years have identified concerns that additional measures are required to increase the resiliency of the landfill against the impacts of Climate Change on the storm water system. As such, the DOCP includes a conceptual storm system design to capture more surface water north of the site, and diverting this uncontaminated water past the landfill and beyond Robert Lake to the south. This plan will require integrating the Surface Water Management Plan into the Glenmore Master Drainage Plans and requires a Downstream Impact Assessment as part of the planning.

3. <u>A revised 10-year Capital Plan for the Landfill</u> – The existing 10-year Capital Plan will be updated to include the revised capital program in the DOCP. The new Fill Plan stages the sequence and timing of Capital Costs over the life of the landfill (Note that the DOCP does not include long term work required for the compost site, and that this will be coordinated at a later time). The infrastructure required includes liners, leachate systems, landfill gas systems, roads, civil works, pump stations and the storm water diversion system. As the DOCP is required to be updated every five years, better forecasting should be available in future 10-year Capital Plans.

4. Financial Security – A requirement of the Landfill Operational Certificate and the Guidelines is a landfill Post Closure Financial Security Plan. This Plan allows for ongoing Operations and Maintenance of the Landfill for a defined period of time (80 years) after the landfill is closed. This Financial Security Plan calculation uses the methodology provided by the Guidelines, and conservatively considers both planned and emergency closure of the Landfill and includes a 20% contingency allowance. This fund is currently calculated at $81,080,000. Utility Services will work with the Financial Services Group to ensure that this fund is reflected in City accounting as per the requirements of Section PS 3270 of the Public Sector Accounting Board's (PSAB) financial reporting model for annual financial reporting purposes.

Next Steps

- Submit the final DOCP report to the Province.
- Staff will review and update operational, capital and financial plans to implement the recommendations in the DOCP Report.
- Complete the detailed design and construction process for projects.
- Apply for two minor Operational Certificate Amendments. The new plan identifies minor variations in annual volumes, and secondly may require a clarification in contaminated soil acceptance levels and definitions to better align operations with the BC Contaminated Sites Regulations. The City may present an update to the Province in the coming year.

Internal Circulation:
Development Engineering Manager
Infrastructure Engineering Manager
Utility Services Manager
Financial Planning Manager
Planning and Development Manager
Communications Manager
Solid Waste Supervisor
Divisional Director, Financial Services

Considerations not applicable to this report:
Legal/Statutory Authority:
Legal/Statutory Procedural Requirements:
Existing Policy:
Financial/Budgetary Considerations:
Personnel Implications:
External Agency/Public Comments:
Communications Comments:
Alternate Recommendation:

Submitted by:

Rod MacLean, P. Eng., Utilities Planning Manager

Approved for inclusion: A. Newcombe, P. Eng., Divisional Director, Infrastructure

Attachment 1 - Landfill Design Operations and Closure Plan Presentation
Attachment 2 – Landfill Design Operations and Closure Plan

cc: Deputy City Manager
Divisional Director, Corporate Strategic Services
Divisional Director, Financial Services
Divisional Director, Infrastructure

Design, Operations and Closure Plan
Glenmore Landfill

Rod MacLean, P. Eng. & Scott Hoekstra | February 25, 2019

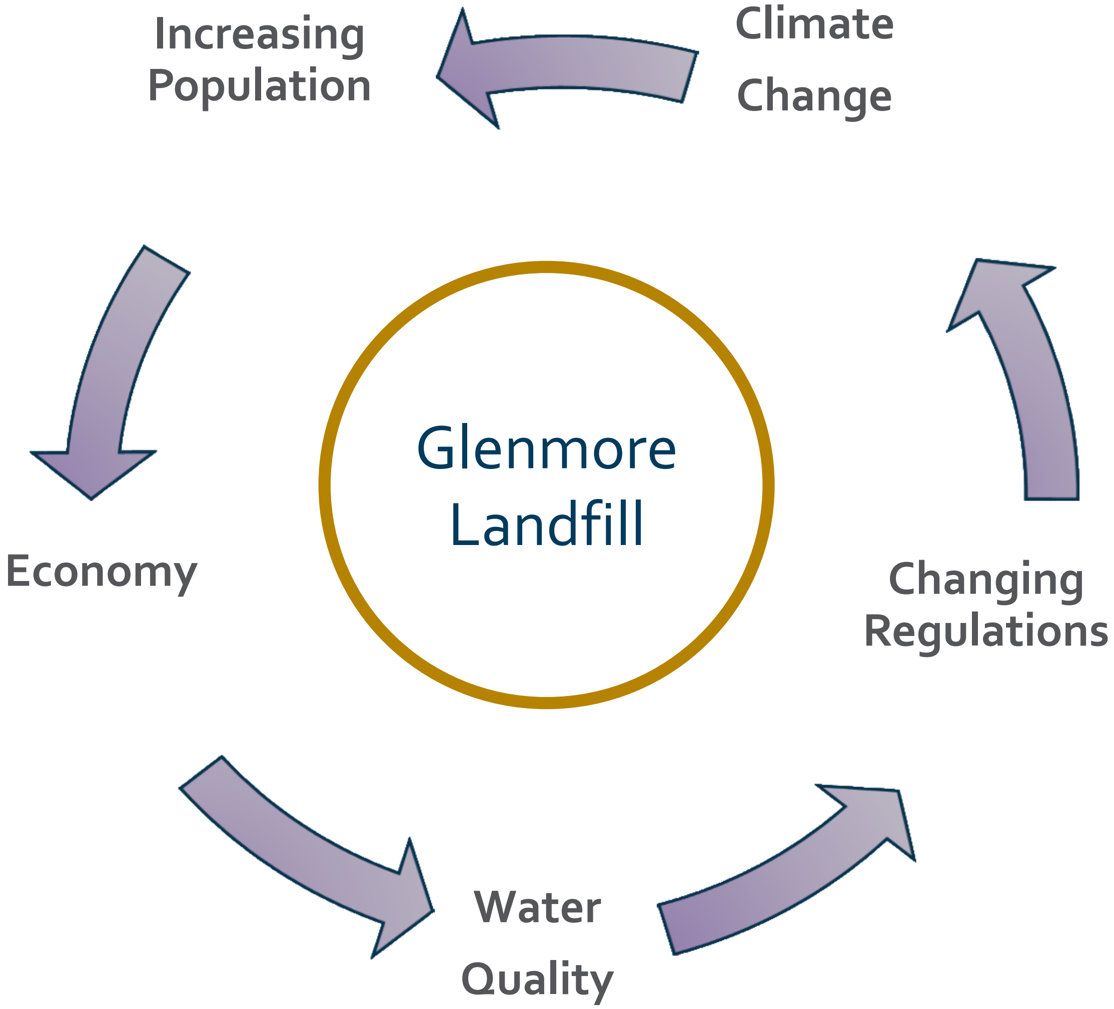
Agenda

- Introduction
- Design, Operation and Closure Plan
  - Principles
  - Requirements
  - Report
- DOCP Highlights
- Wrap-up

Glenmore Landfill

- Landfill and waste management facility for RDCO and Big White
- Operates under RDCO SWMP and OC
- Services population of ~ 200,000
- 170,000 tonnes of waste per year permitted
- Landfill capacity ~39,800,000 m^3
- 90 years site life

sustainability



Glenmore Landfill

Climate Change

Increasing Population

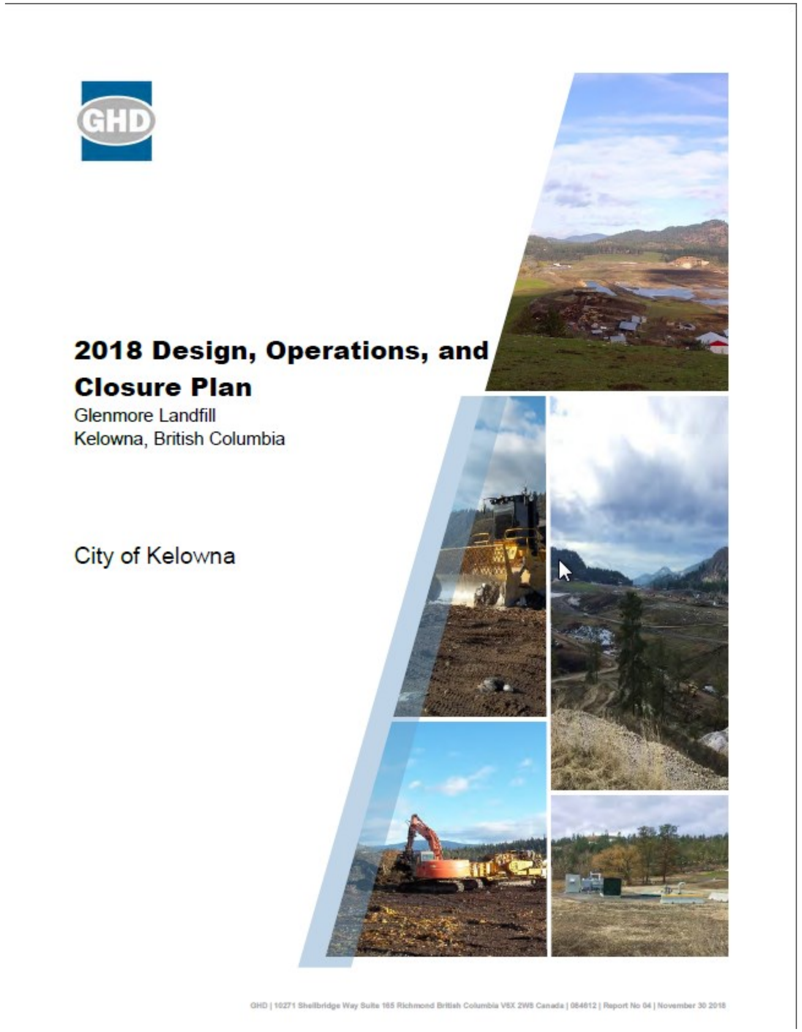
Economy

Water Quality

Changing Regulations

Design, Operations and Closure Plan

- Updates/modernizes the 2008 Comprehensive Site Development Plan.
- Wording and content has now been standardized by the Province to be called DOCP,
- Landfill will be planned, designed, constructed, operated, monitored and closed in accordance with the Landfill Criteria (BC ENV, 2016)
- Now to be updated every 5 years



GHD

2018 Design, Operations, and Closure Plan

Glenmore Landfill
Kelowna, British Columbia

City of Kelowna

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DOCP Report

- Description of the facility and the physical setting
- 10-year conceptual design of the Landfill
  - Base liner system,
  - Leachate collection system,
  - Final cover
- Surface Water Management Plan
  - Minimizing Leachate

DOCP Report (Cont'd)

- Leachate Management Plan
- Site Development Plan
  - Filling plan,
  - Major capital components
- Operational procedures - waste acceptance and landfilling

DOCP Report (Cont'd)

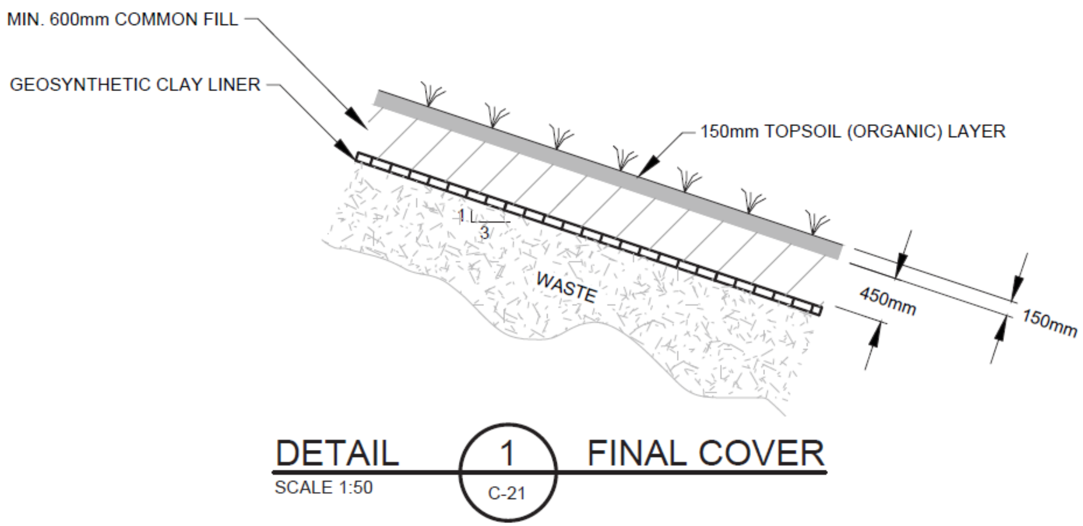
- Environmental Monitoring Plan
  - Groundwater Impact Assessment
- Closure and post-closure requirements
- Demonstrate Landfill Criteria design objectives, minimal requirements for the Landfill and environmental control systems are met
- Financial Security Plan

Highlights

- Progressive closure
- Nuisance monitoring and mitigation
- Surface water management plan
- Updated 10-year Capital Plan
- Financial Security

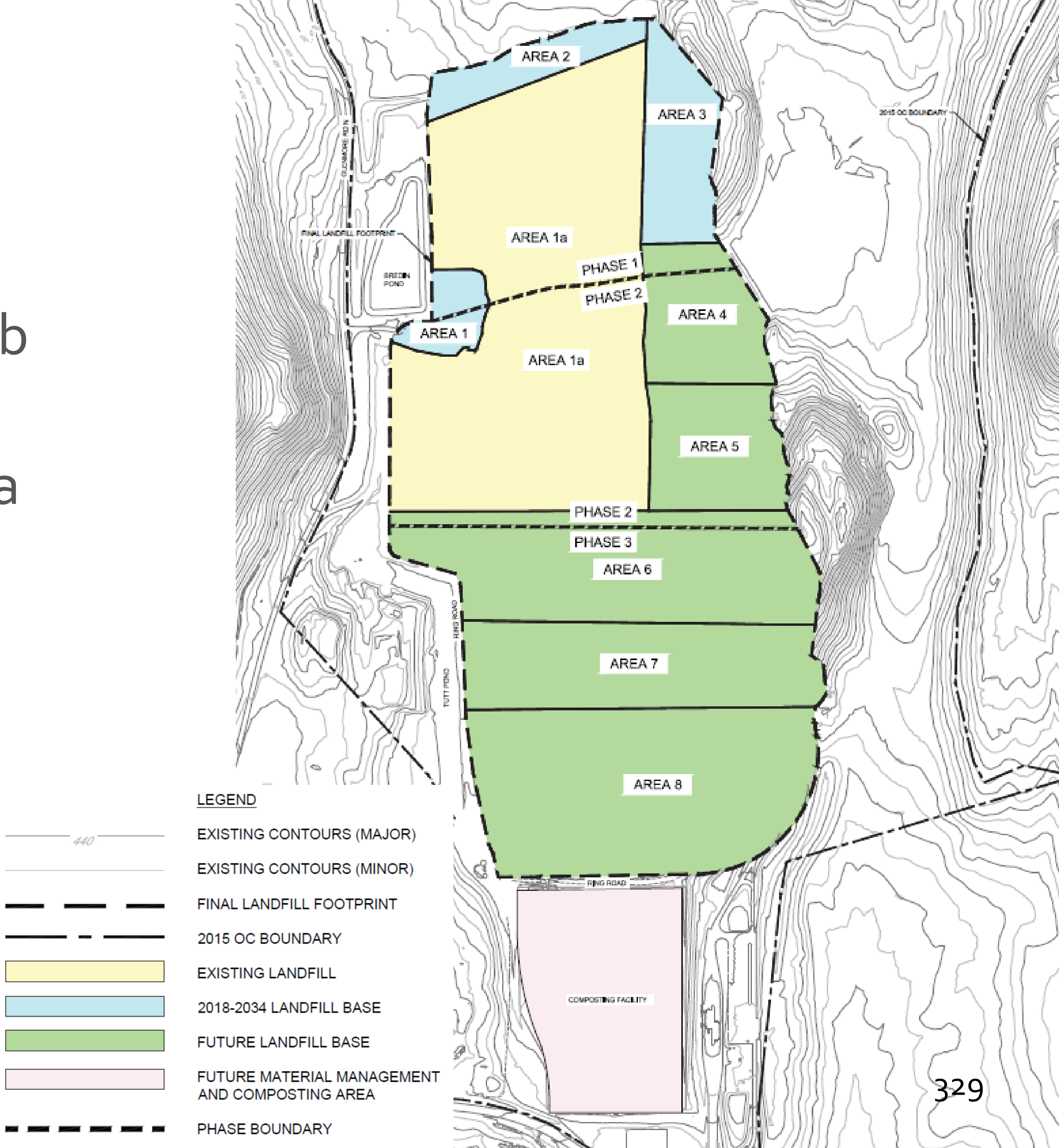
Closure

- Minimize potential for contamination, leachate or gas generation.
  - Inert 80 years after closure,
  - No more monitoring or care.
  - Areas to be naturalized.
- Final closure plans must be approved by the Province.
  - Must be consistent with current zoning at the time of closure.



Revised Landfill Layout

- **Next 10-years:**
  - Landfilling plateau - Areas 1a and 1b (existing unlined/lined)
  - Area 1 – former public drop-off area (lined)
  - Area 2 – northern extension (lined)
  - Area 3 – Bredin Hill (lined)
- **Long-term (~90 years):**
  - Extend Phase 2 to Tutt Mountain
  - Develop Phase 3 (Slough)

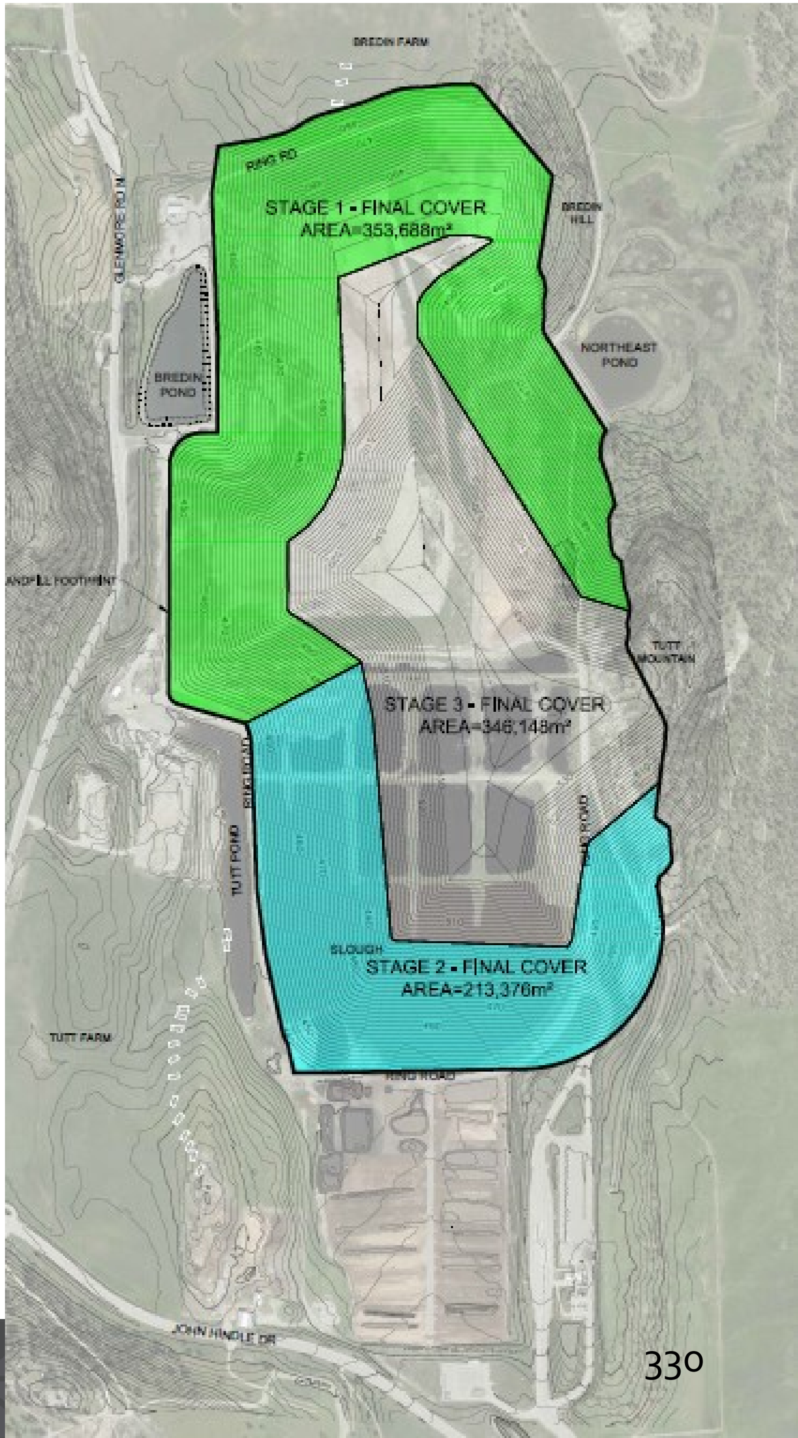


LEGEND

440	EXISTING CONTOURS (MAJOR)
	EXISTING CONTOURS (MINOR)
— — —	FINAL LANDFILL FOOTPRINT
—— - ——	2015 OC BOUNDARY
🟨	EXISTING LANDFILL
🟦	2018-2034 LANDFILL BASE
🟩	FUTURE LANDFILL BASE
🟪	FUTURE MATERIAL MANAGEMENT AND COMPOSTING AREA
- - - - -	PHASE BOUNDARY

Progressive Closure

- Legally required (MOE).
- Allows cost recovery of closure while generating revenue.
- Areas that reach final waste contours will be closed once the area is sufficient to warrant construction of final cover.
- Over 913,000 m² to be closed in three stages
  - 2053 - Phase 1 and 2 side slopes
  - 2099 - Phase 3 side slopes
  - 2108 - Final closure (plateau)



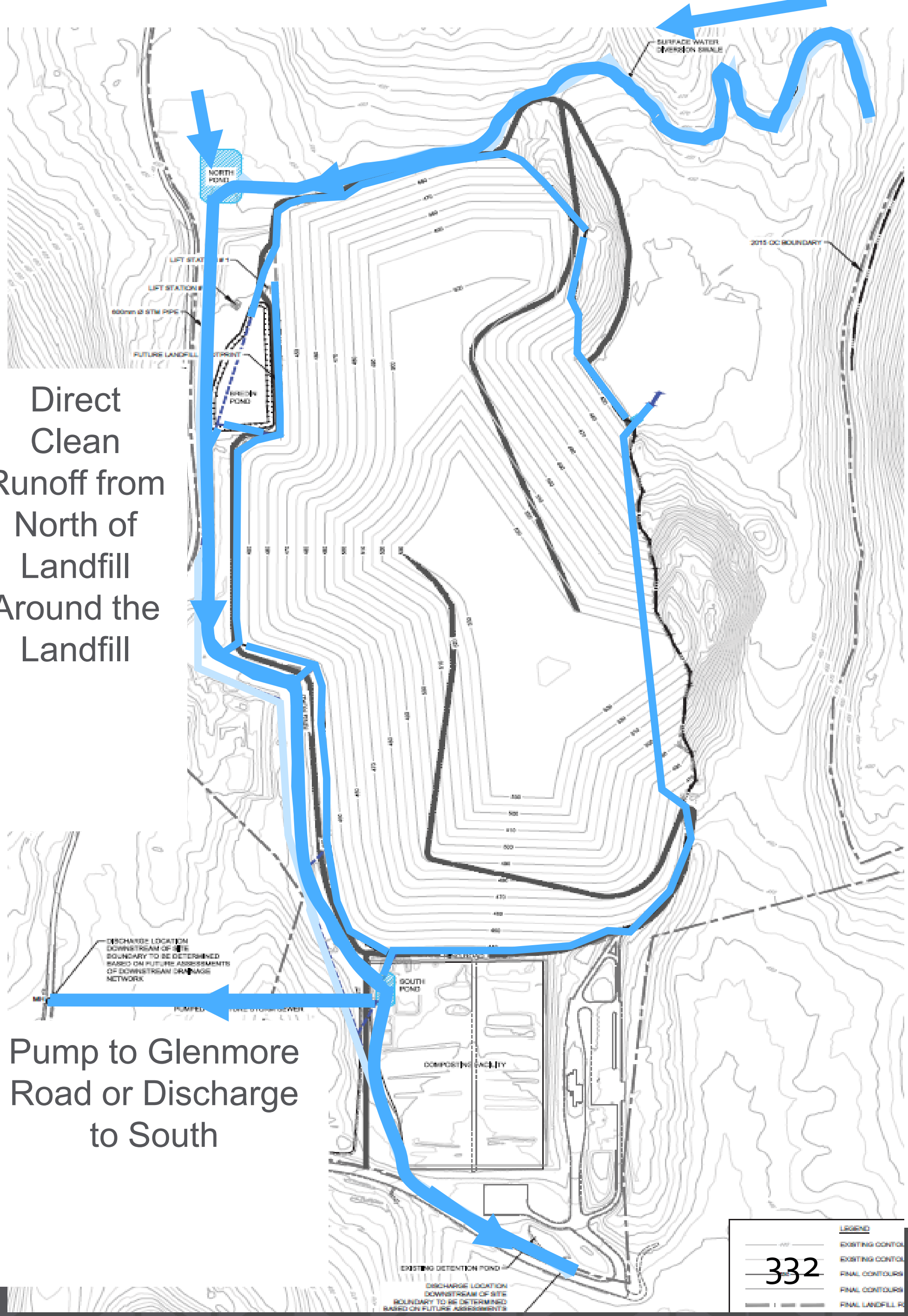
Detailed Nuisance Study

- Detailed Modeling Process
- Dust and Odour Measurement
- Recommend long term BMP’s

Courtesy London Free Press, 2017

Surface Water Master Plan

- Phase 3 cell development requires new surface water storage
- Manage future runoff from final cover:
  - Increased runoff.
  - Perimeter ditch/pipe and pond system.
  - Divert clean water from north of the landfill to Brandts Creek



Direct Clean Runoff from North of Landfill Around the Landfill

Pump to Glenmore Road or Discharge to South

Capital Plan Update

- Proposed 10 Year Capital Plan Update
  - $42.15M over 10 years (2019-2028)
    - Areas 1, 2 and 3 - Membranes and Construction
    - Northeast Dam Decommissioning
    - Surface Water Management System.
- Long Term Costs (2029-2108)
  - $114.81M over remaining 80 years.
    - Areas 4 – 8 – Membranes and Construction
    - Progressive Closure Stages 1, 2 and 3.

Post-Closure Contaminating Life Span & Financial Security

- Modelled contaminating life span (CLS) of 80 years
- Financial security
  - Fund an emergency closure of the landfill in that year and fund post-closure operations, monitoring, and maintenance for 79 years.
  - Currently - $81M:
    - Capital & Emergency Closure costs – $50M
    - Post closure O&M costs (79 years) – $31M
- Progressive closure allows the Emergency Closure costs to decrease over time.

Next Steps

- Submit the final DOCP report to the Province.
- Staff will review and update operational, capital and financial plans.
- Complete the detailed design and construction projects.
- Apply for two minor Operational Certificate Amendments.
  - Minor variations in annual volumes,
  - A clarification in contaminated soil acceptance levels and definitions to better align operations with the BC Contaminated Sites Regulations.

Discussion & Questions

Landfill Design Operations and Closure Plan (DOCP)*

This document is being provided to Council and the members of the public electronically, through the Council meeting agenda package as published on the City of Kelowna website.

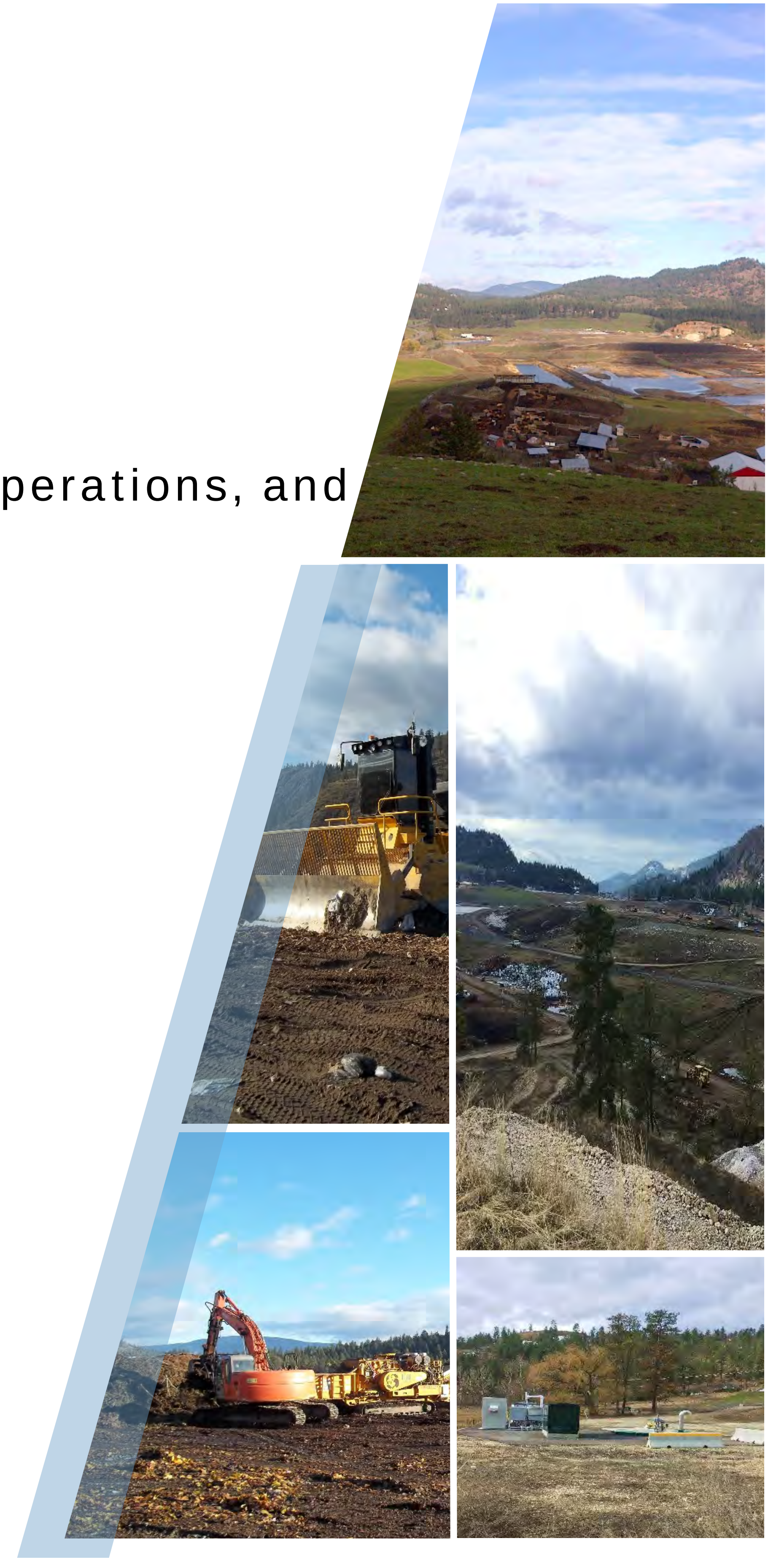
A hard copy is available at City Hall, 1435 Water Street at the Office of the Mayor and the Office of the City Clerk on request.

*as referenced and summarized in the Report to Council from the Utility Planning Manager dated February 25, 2019, item 5.15

2018 Design, Operations, and Closure Plan

Glenmore Landfill
Kelowna, British Columbia

City of Kelowna



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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:

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

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

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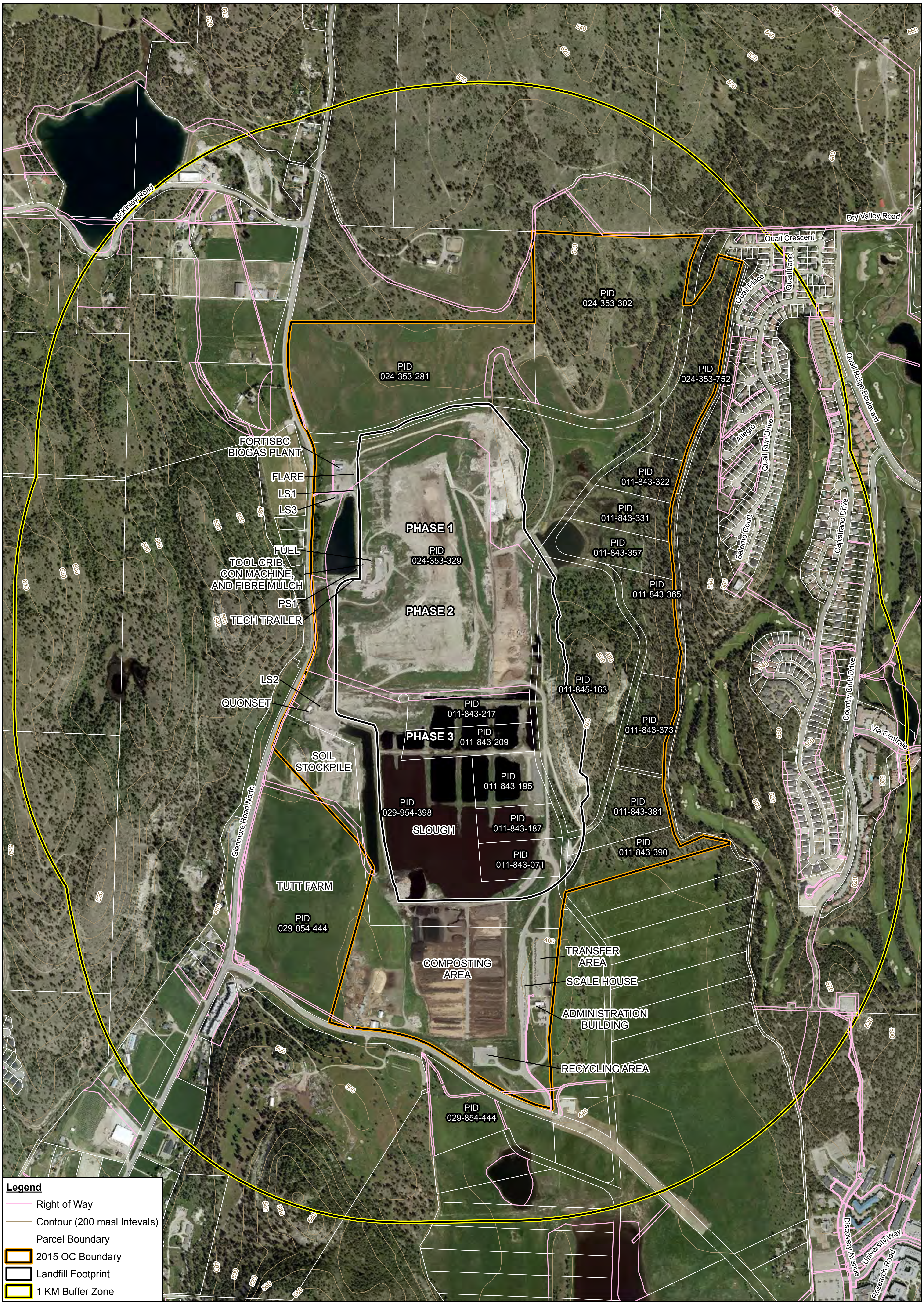


Source: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation. B.C. Ministry of Environment, and B.C. Ministry of Forests, Lands and Natural Resource Operations (2016-17).
Aerial: City of Kelowna Orthophotos, May 21, 2017

0 110 220 330
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

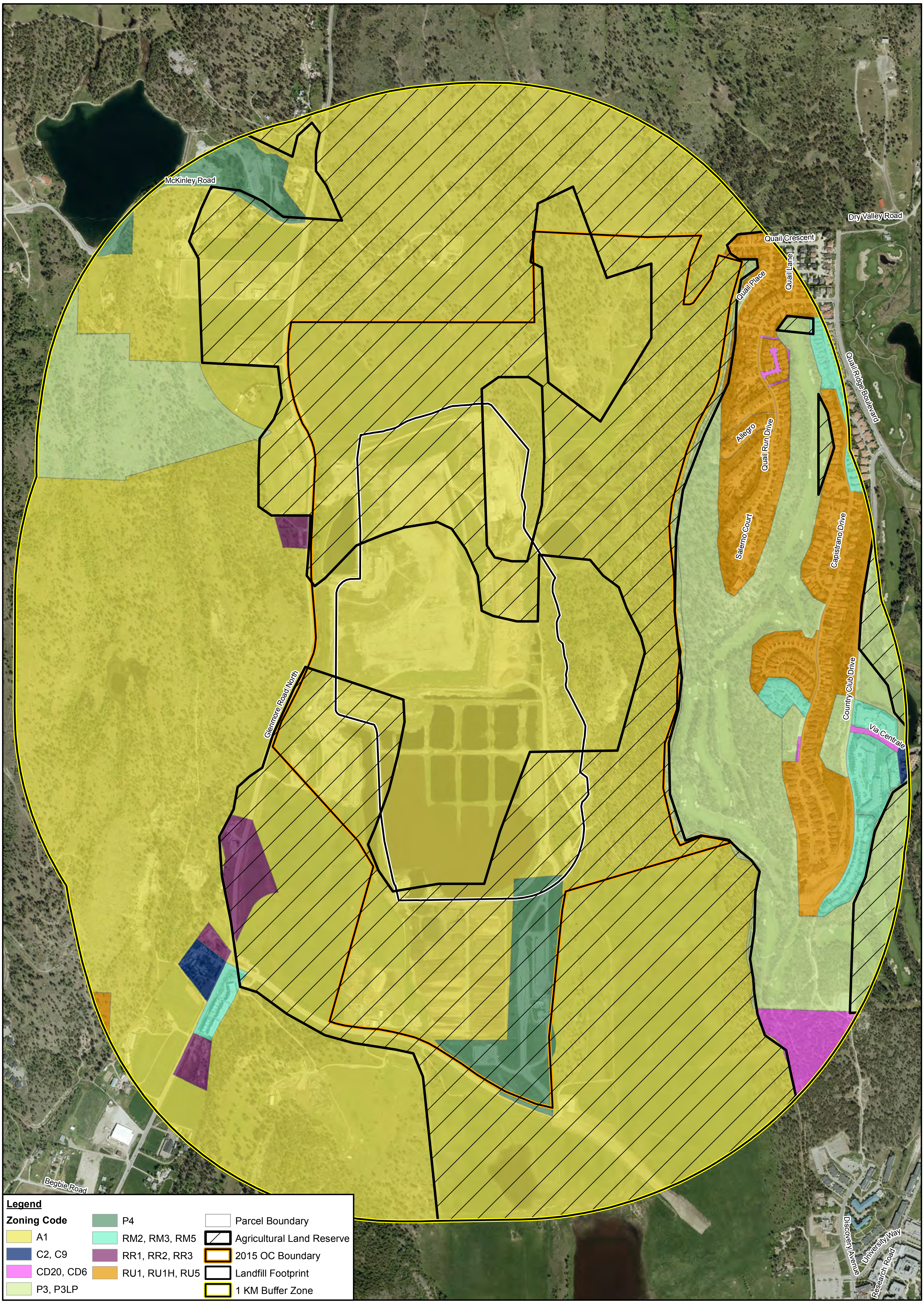
N

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

084612-22
Jul 11, 2018

SITE PLAN

FIGURE 4.1



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Aerial: City of Kelowna Orthophotos, May 21, 2017

0 110 220 330
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

N

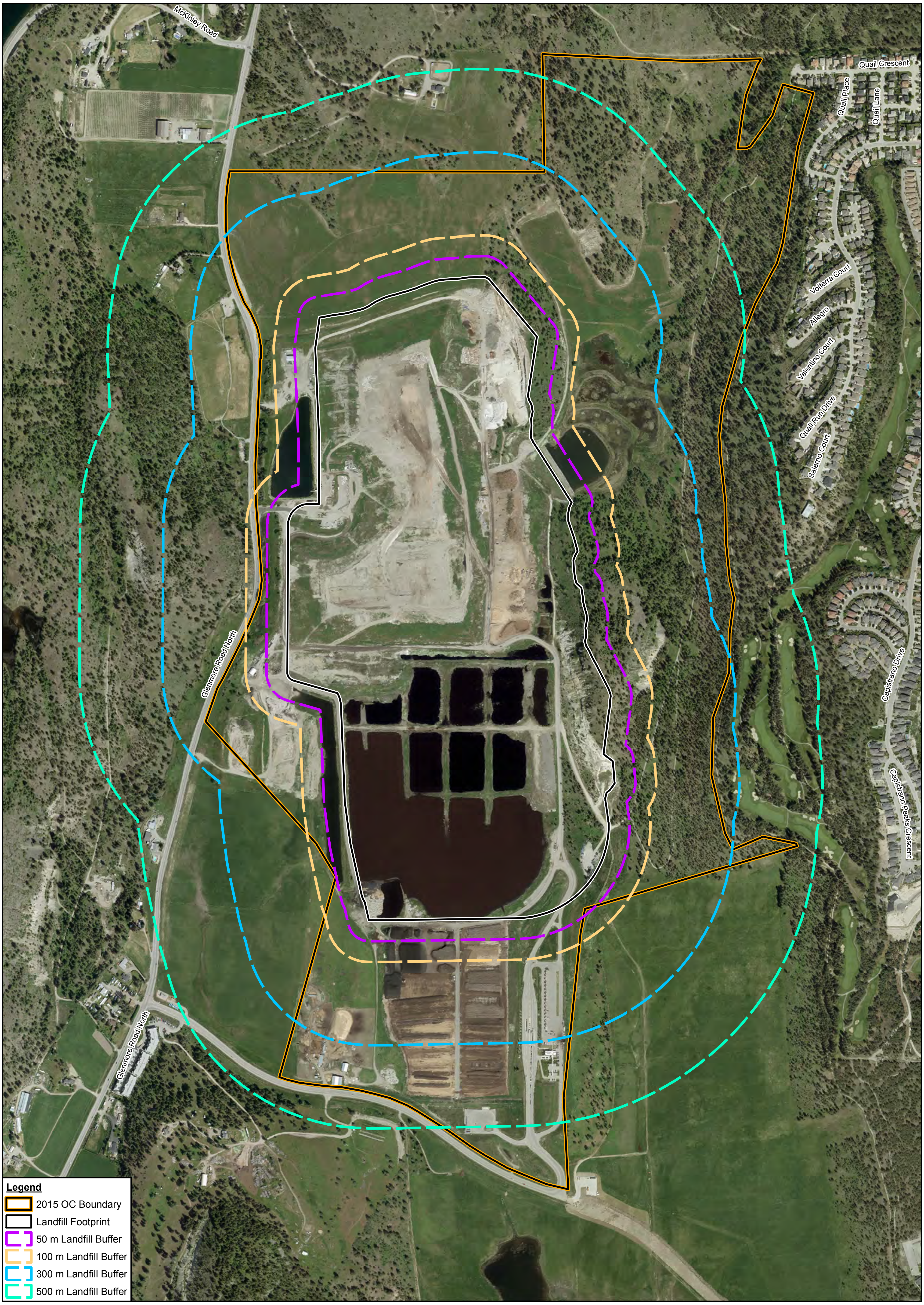
2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

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



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0 85 170 255
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

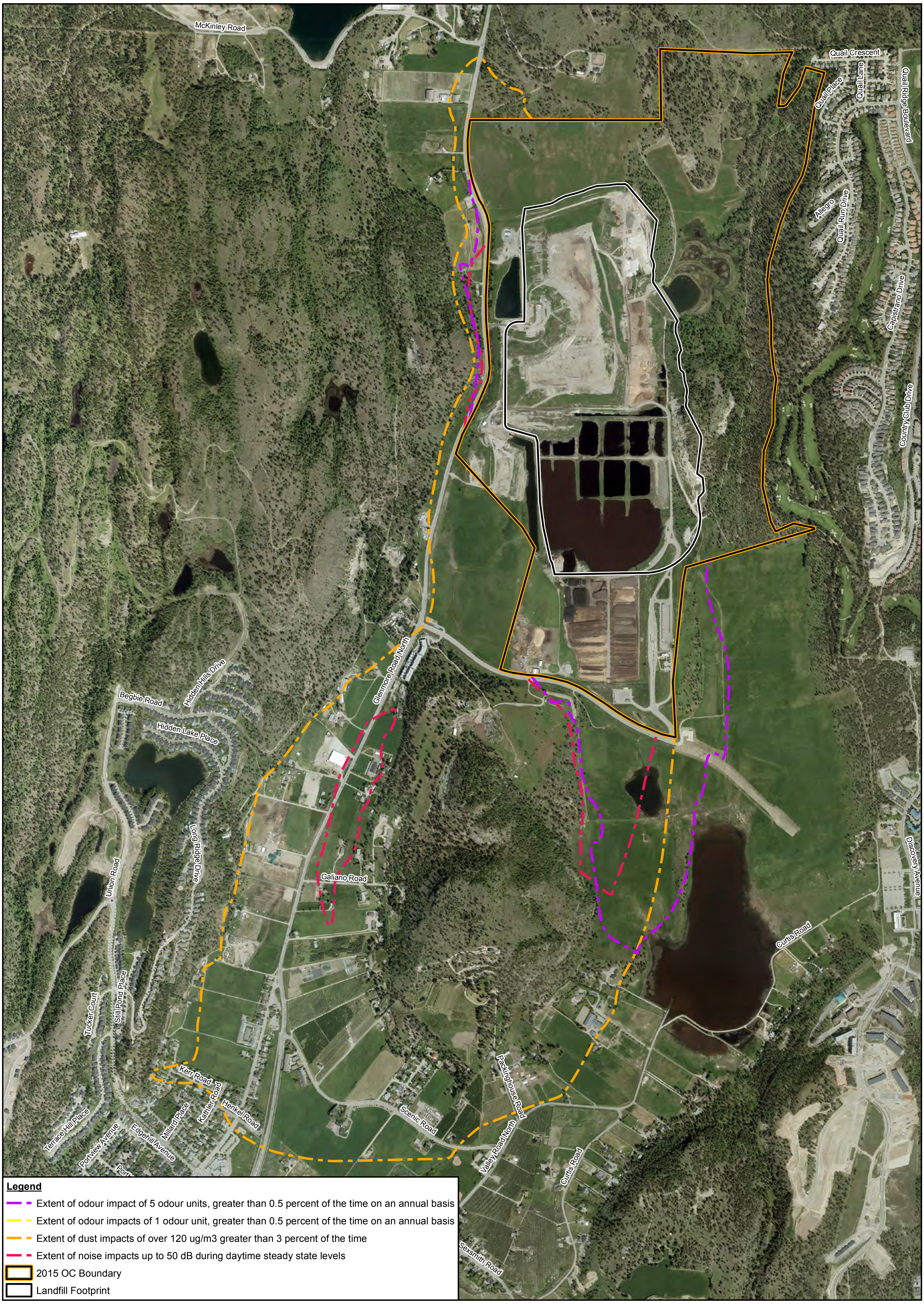
DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

084612-22
Sep 7, 2018

BUFFER ZONES

FIGURE4.3

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

0 140 280 420
Meters

Coordinate System:
NAD 1983 UTM Zone 11N

N

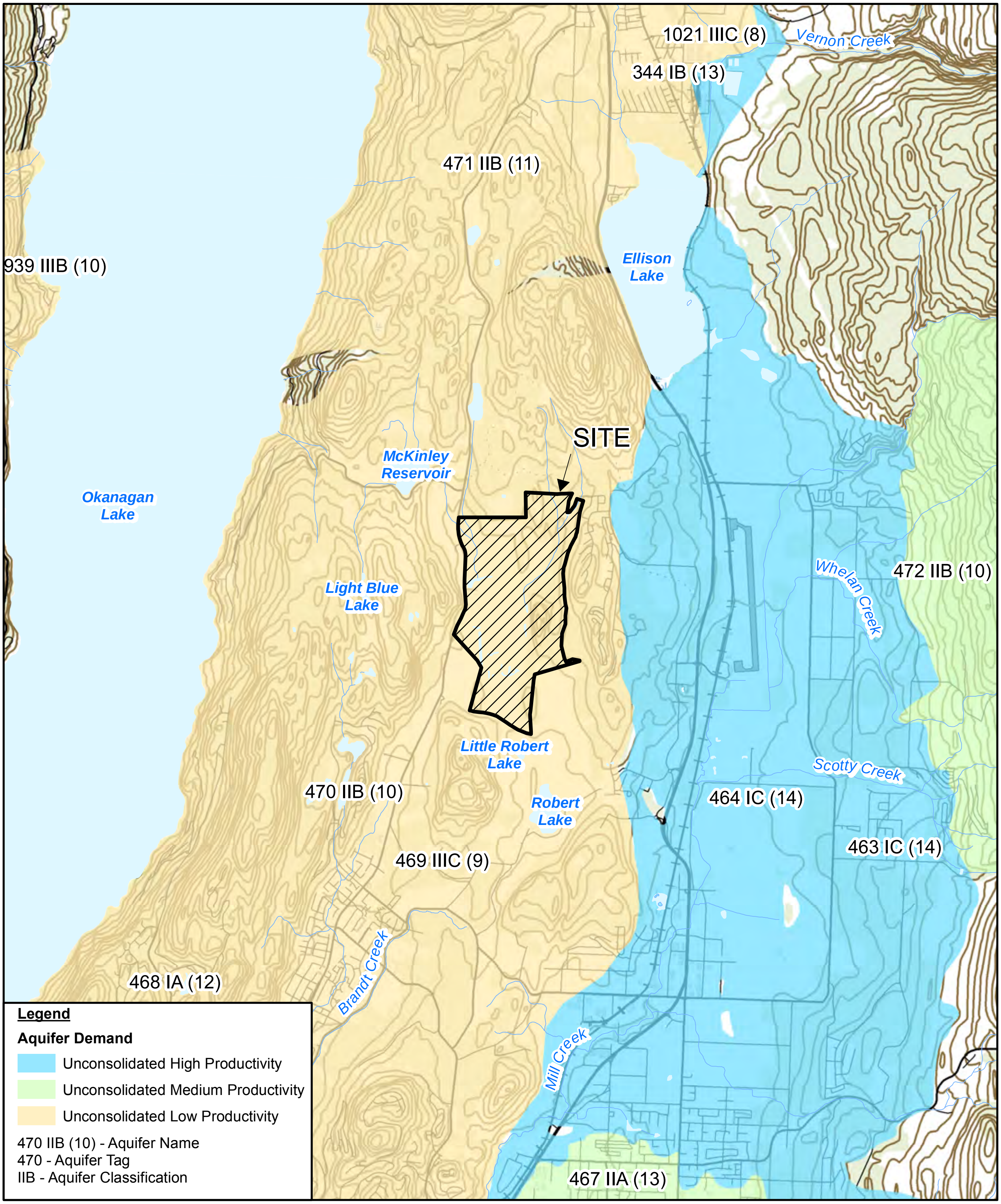
DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

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

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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

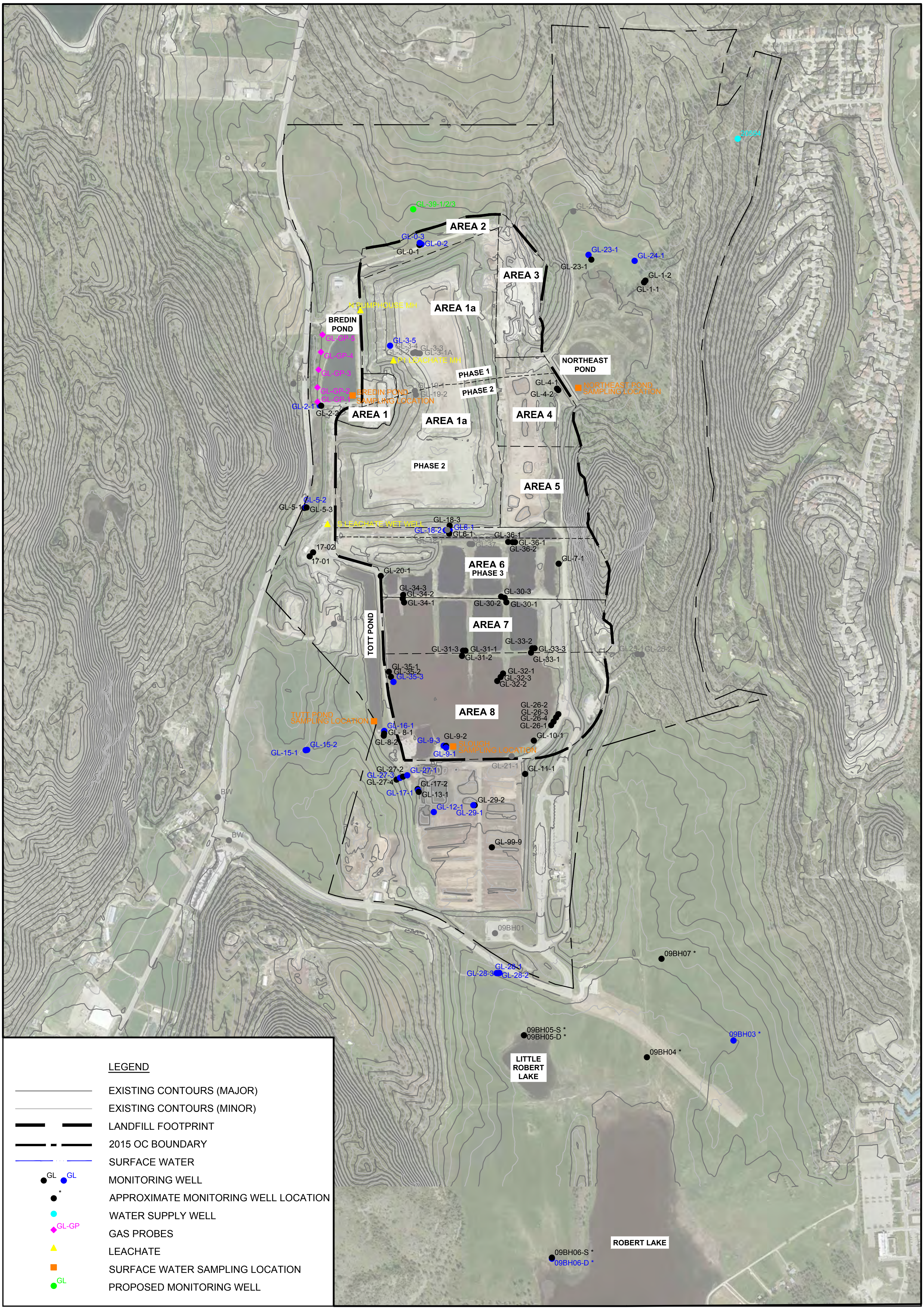
2018 DESIGN, OPERATIONS AND CLOSURE PLAN
GLENMORE LANDFILL
CITY OF KELOWNA

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



0 100 200 300m

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

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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

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Original Size
ANSI D

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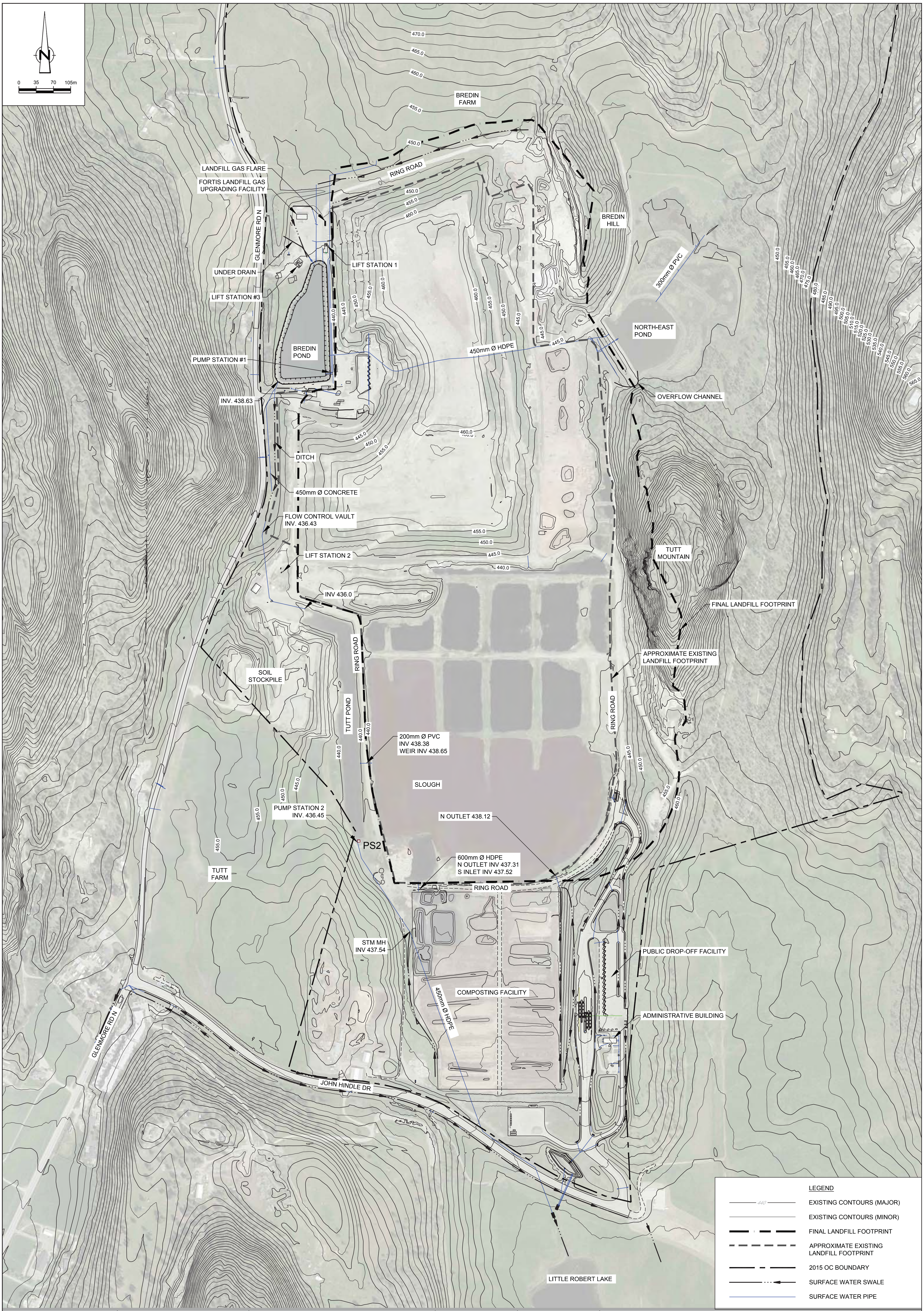
Project No. 84612-22

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



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Project Manager	D.LIDDY	Date	2018-10-25
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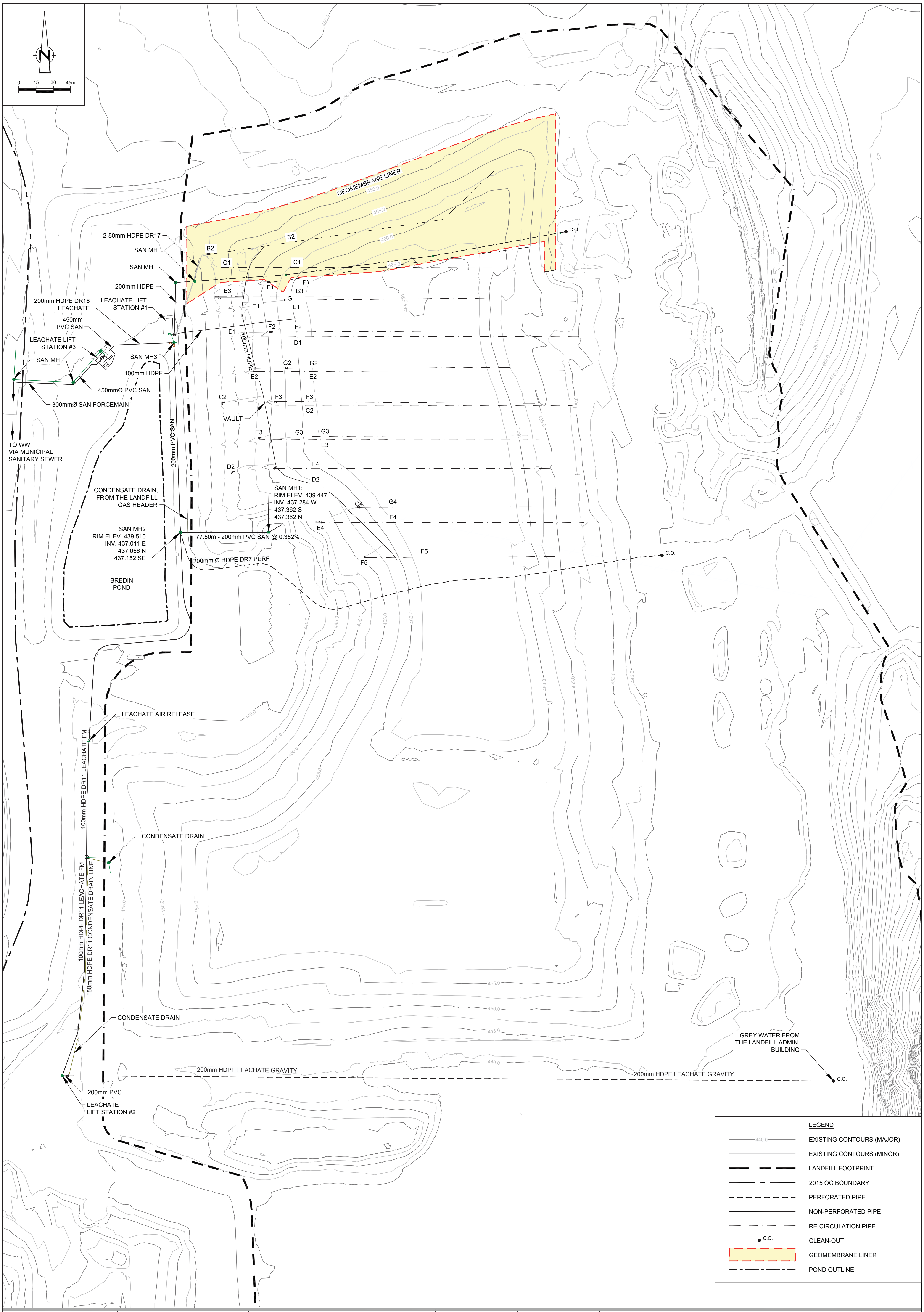
Project CITY OF KELOWNA - GLENMORE LANDFILL DESIGN, OPERATIONS AND CLOSURE PLAN
Title SITE PLAN

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



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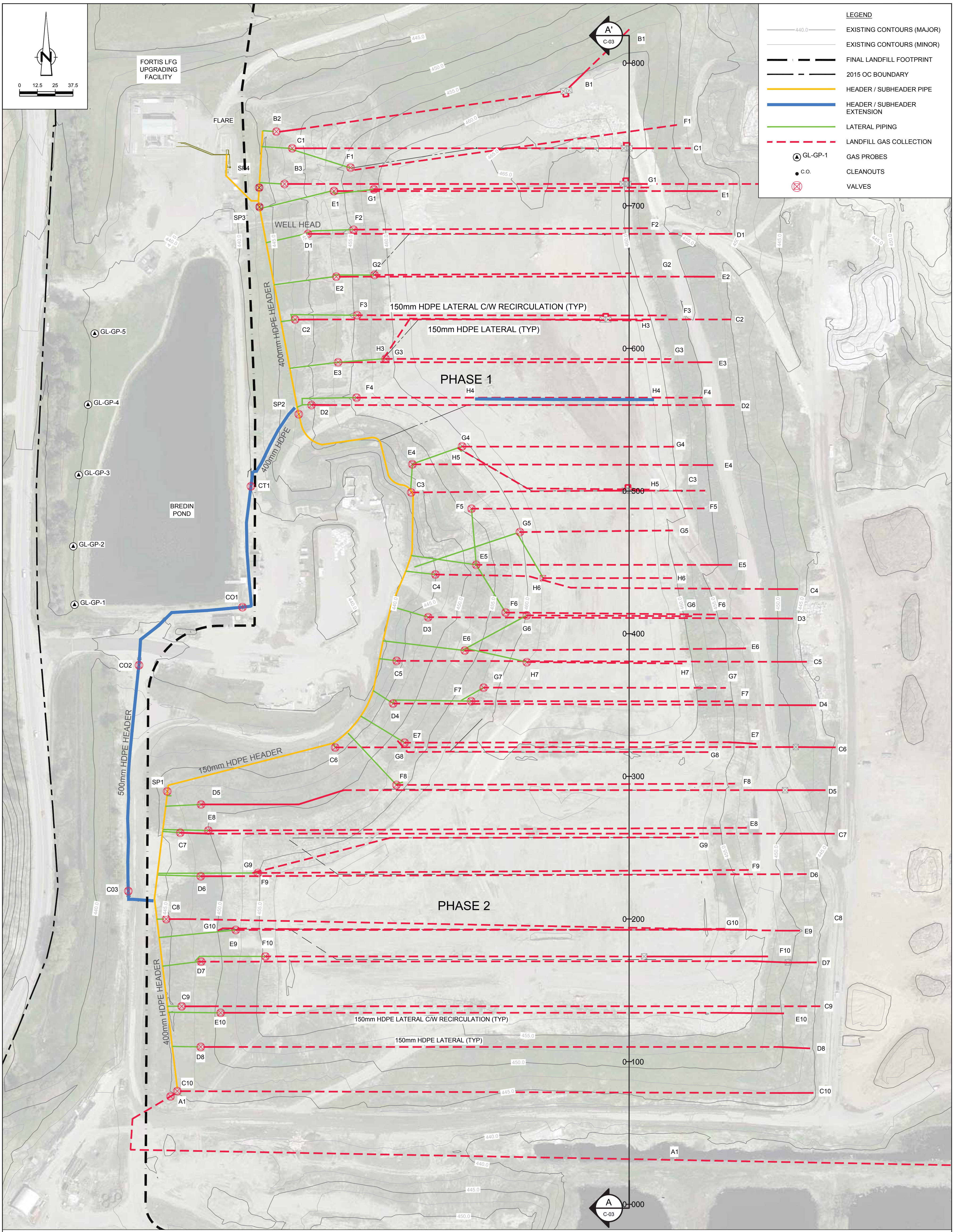
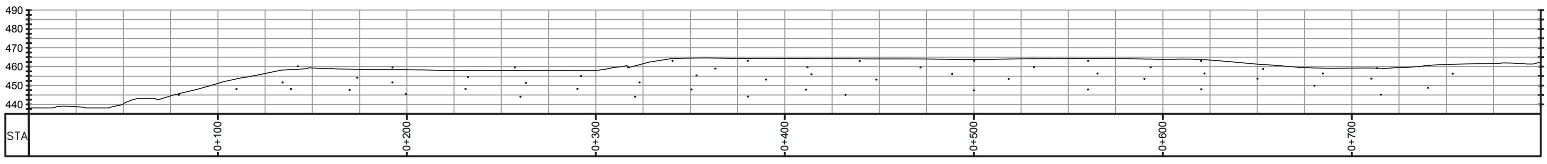
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title EXISTING CONDITIONS - BASE LINER AND LEACHATE COLLECTION AND RECIRCULATION SYSTEMS
Project No. 084612-22
Original Size ANSI D
Sheet No. C-02
Sheet [illegible] of 24





SECTION A-A'
C-03
HOR. SCALE 1:1000

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Project 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 [illegible] of 24

Plot Date: 31 October 2018 - 4:02 PM
Plotted By: Tyler Wagstaff
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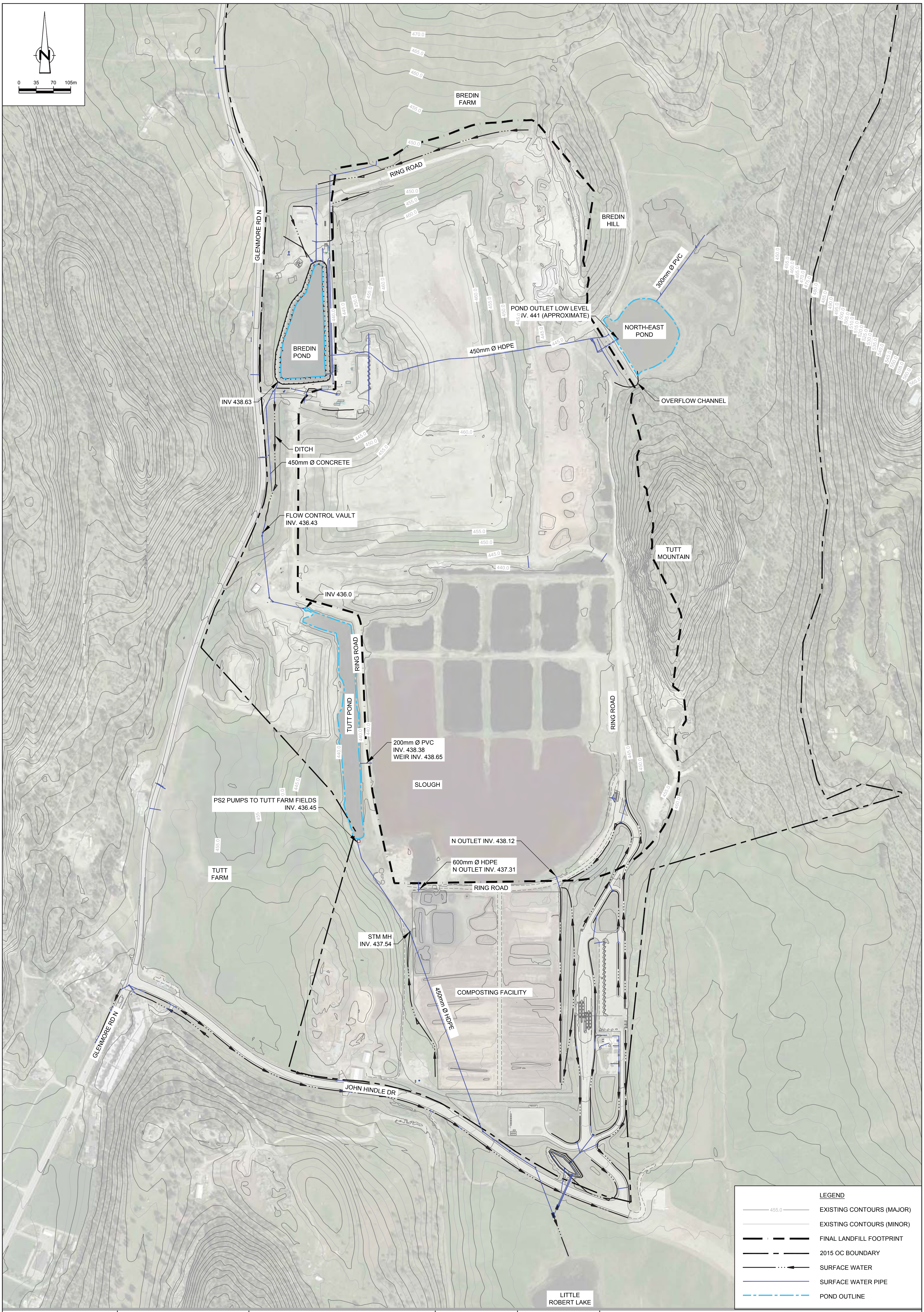

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CITY OF KELOWNA - GLENMORE LANDFILL DESIGN, OPERATIONS AND CLOSURE PLAN

Title

EXISTING CONDITIONS SURFACE WATER WORKS

Project No. 084612-22

Original Size ANSI D

Sheet No. C-04

Sheet 6 of 24

Plot Date: 30 October 2018 - 9:32 AM

Plotted By: Tyler Wagstaff

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Project 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
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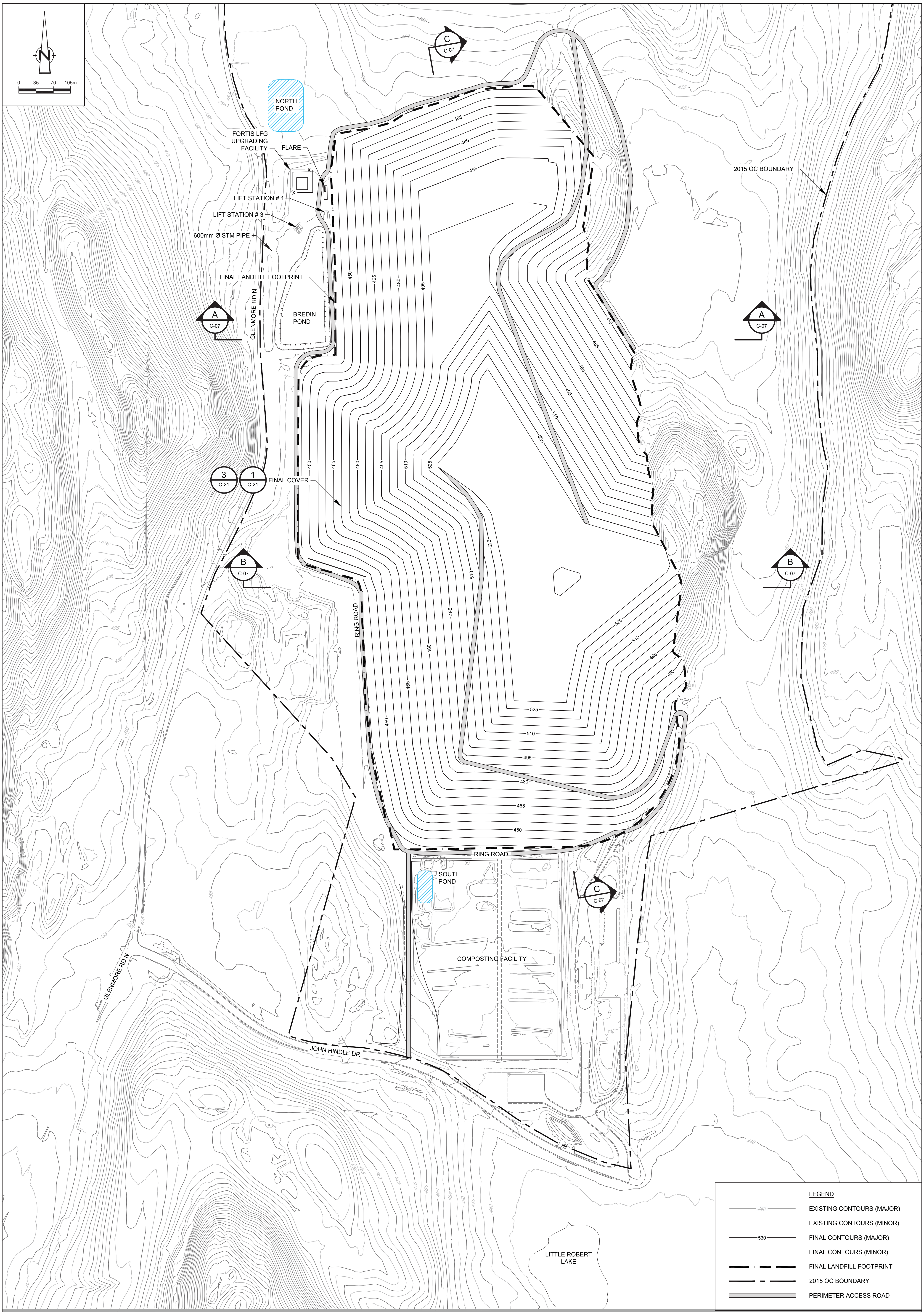

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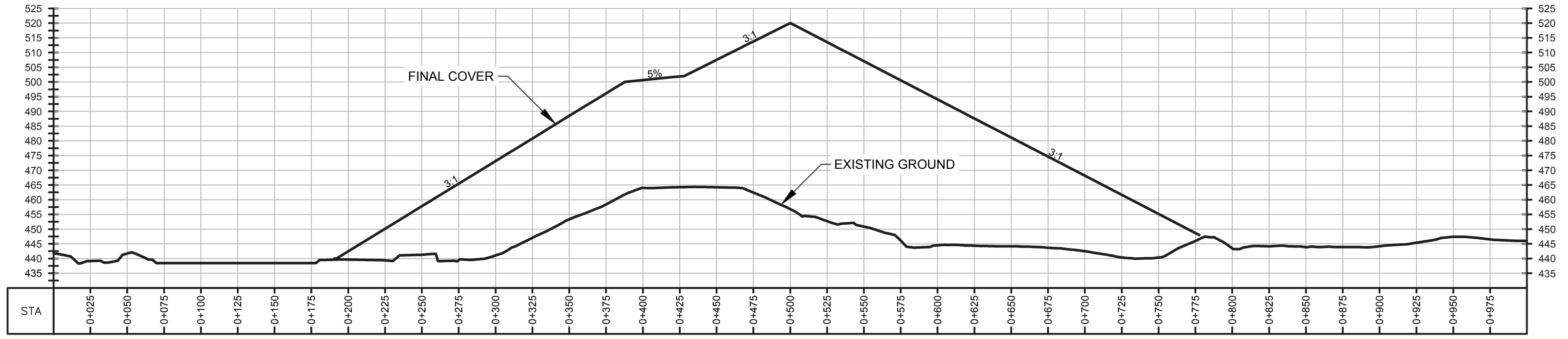
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

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



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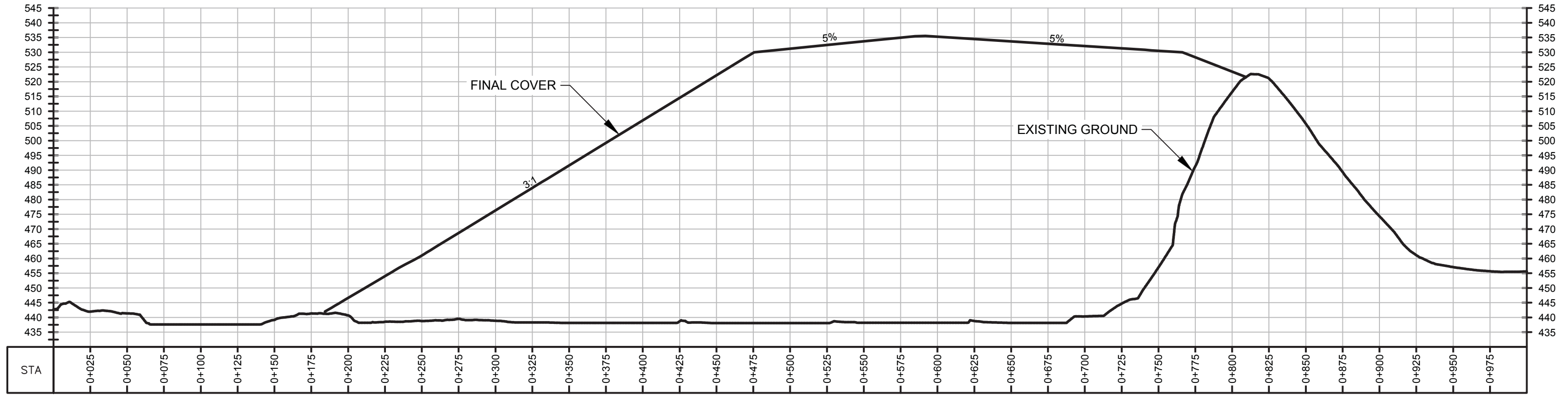
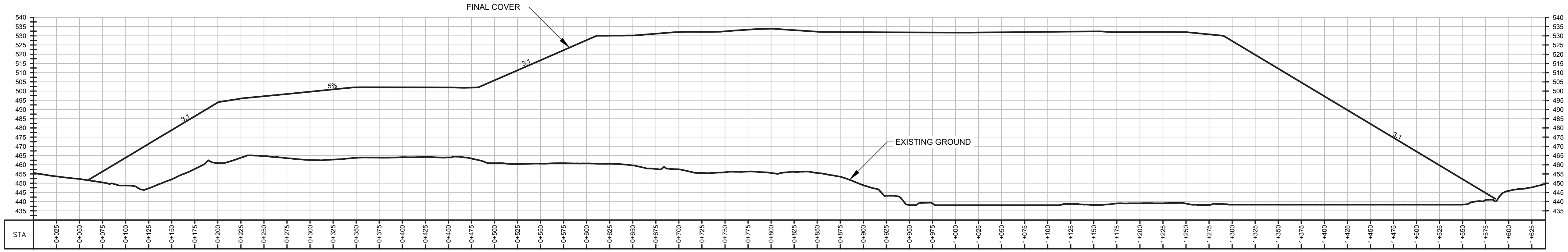
HOR. 1:2500
VER. 1:1250
C-06



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



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

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CITY OF KELOWNA -
GLENMORE LANDFILL

Project
DESIGN, OPERATIONS
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1	FINAL	TW	DL	10/11/2018
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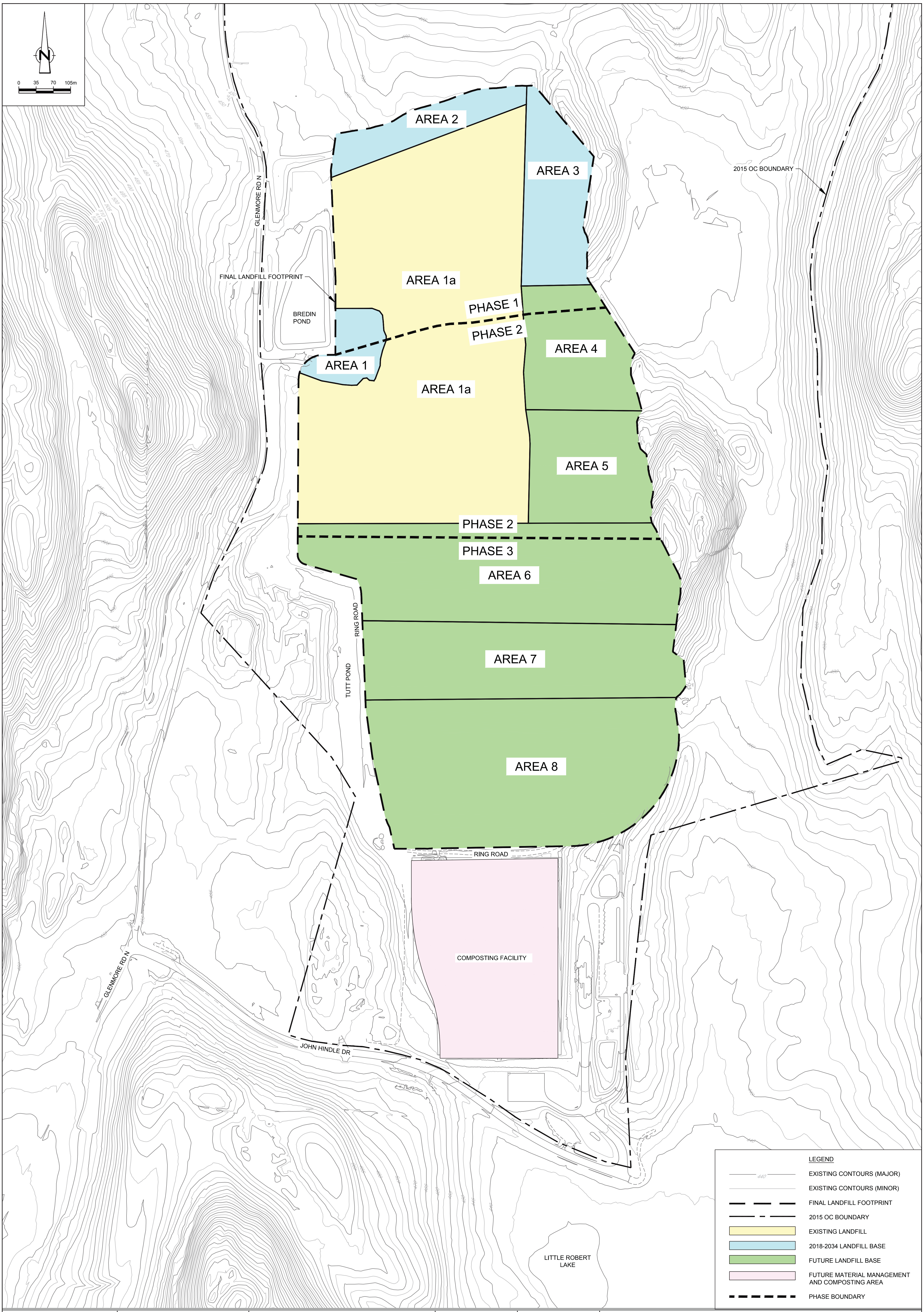
Project No. 084612-22

Title
FINAL CONDITIONS
CROSS SECTIONS

Sheet No.
C-07

Sheet 8 of 24



LEGEND

440	EXISTING CONTOURS (MAJOR)
	EXISTING CONTOURS (MINOR)
— — —	FINAL LANDFILL FOOTPRINT
— - —	2015 OC BOUNDARY
🟨	EXISTING LANDFILL
🟦	2018-2034 LANDFILL BASE
🟩	FUTURE LANDFILL BASE
🟪	FUTURE MATERIAL MANAGEMENT AND COMPOSTING AREA
■ ■ ■ ■	PHASE BOUNDARY

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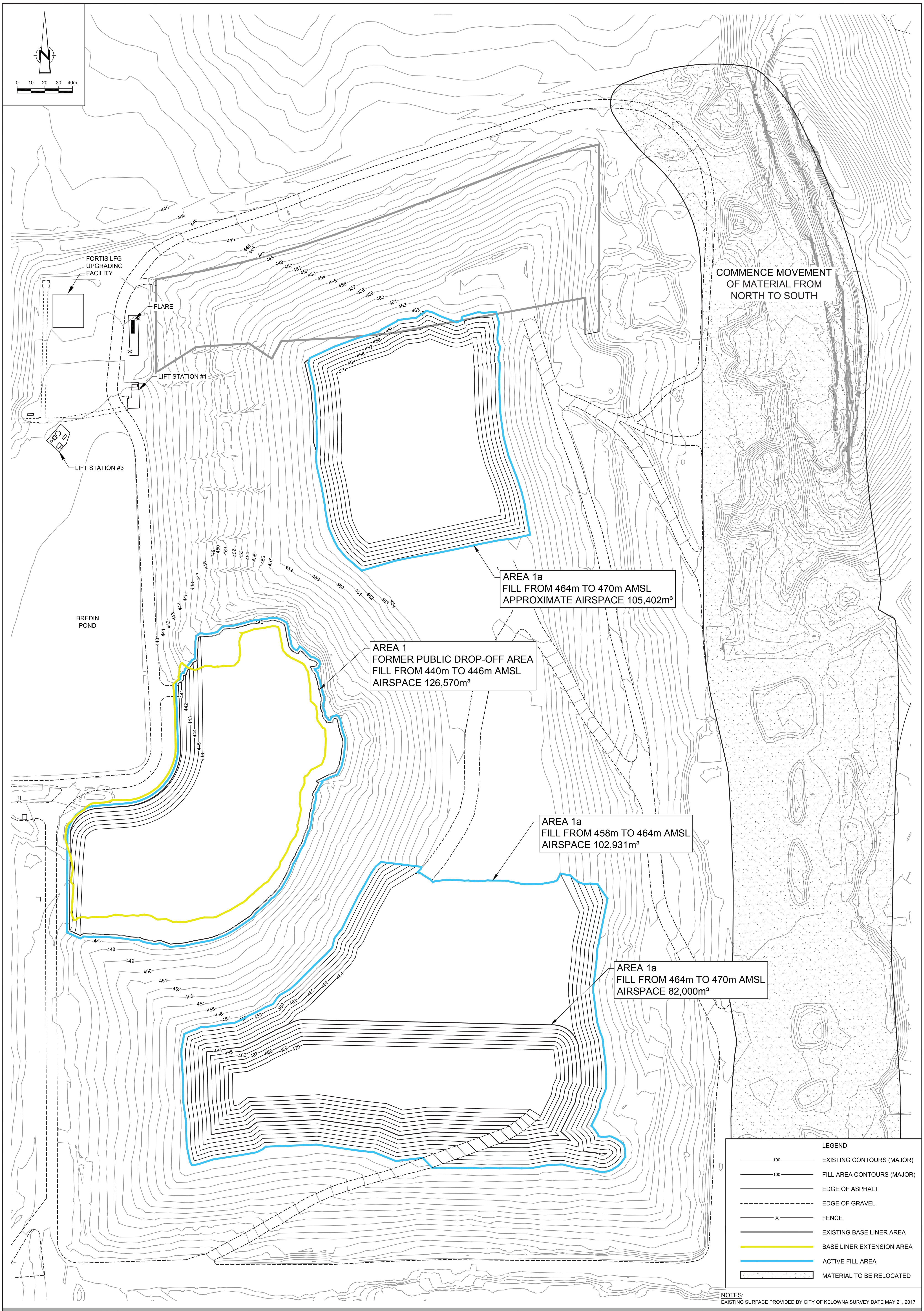
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title LANDFILL BASE AREAS

Project No. 084612-22

Original Size ANSI D
Sheet No. C-08
Sheet 8 of 24



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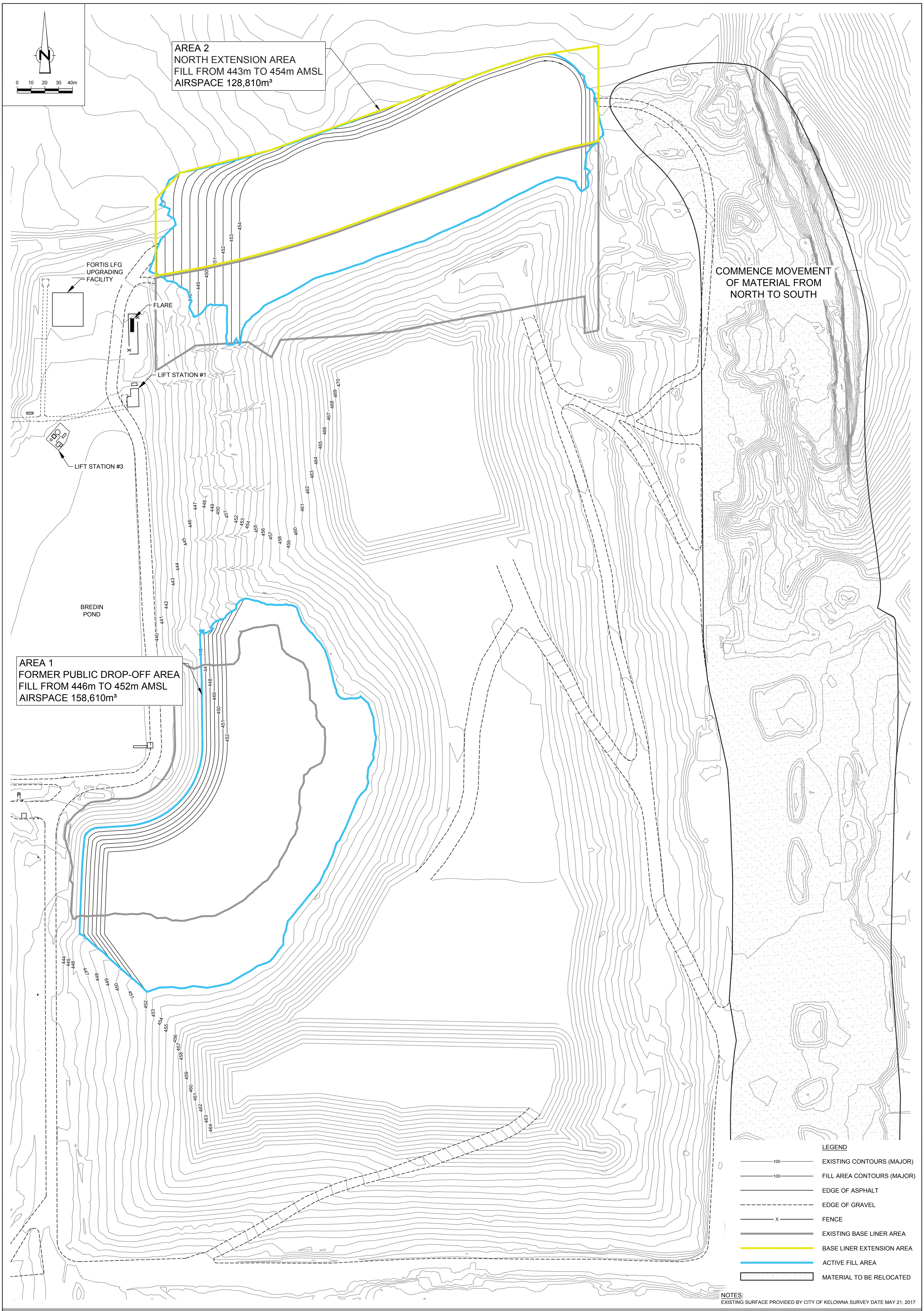
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

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



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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
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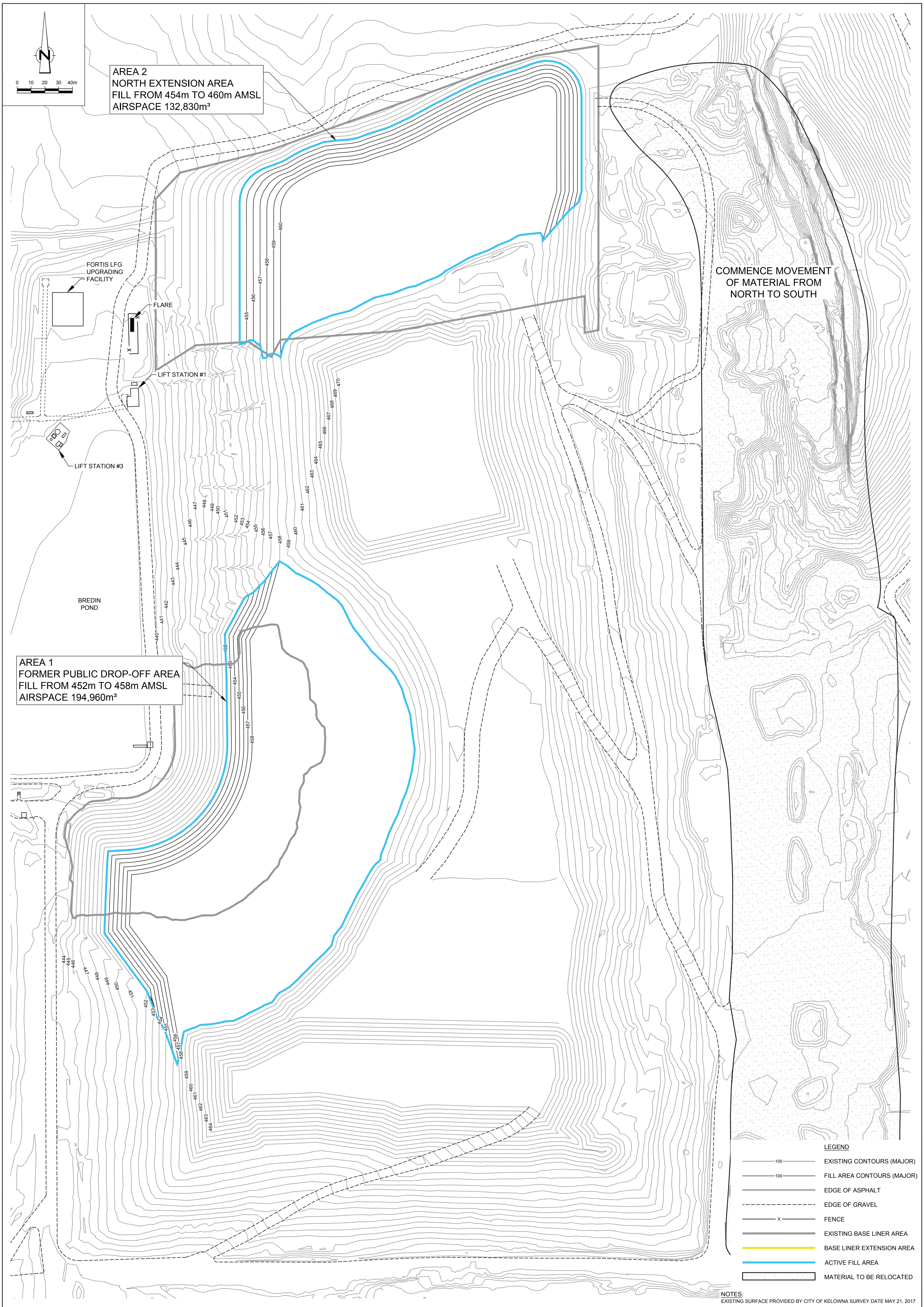

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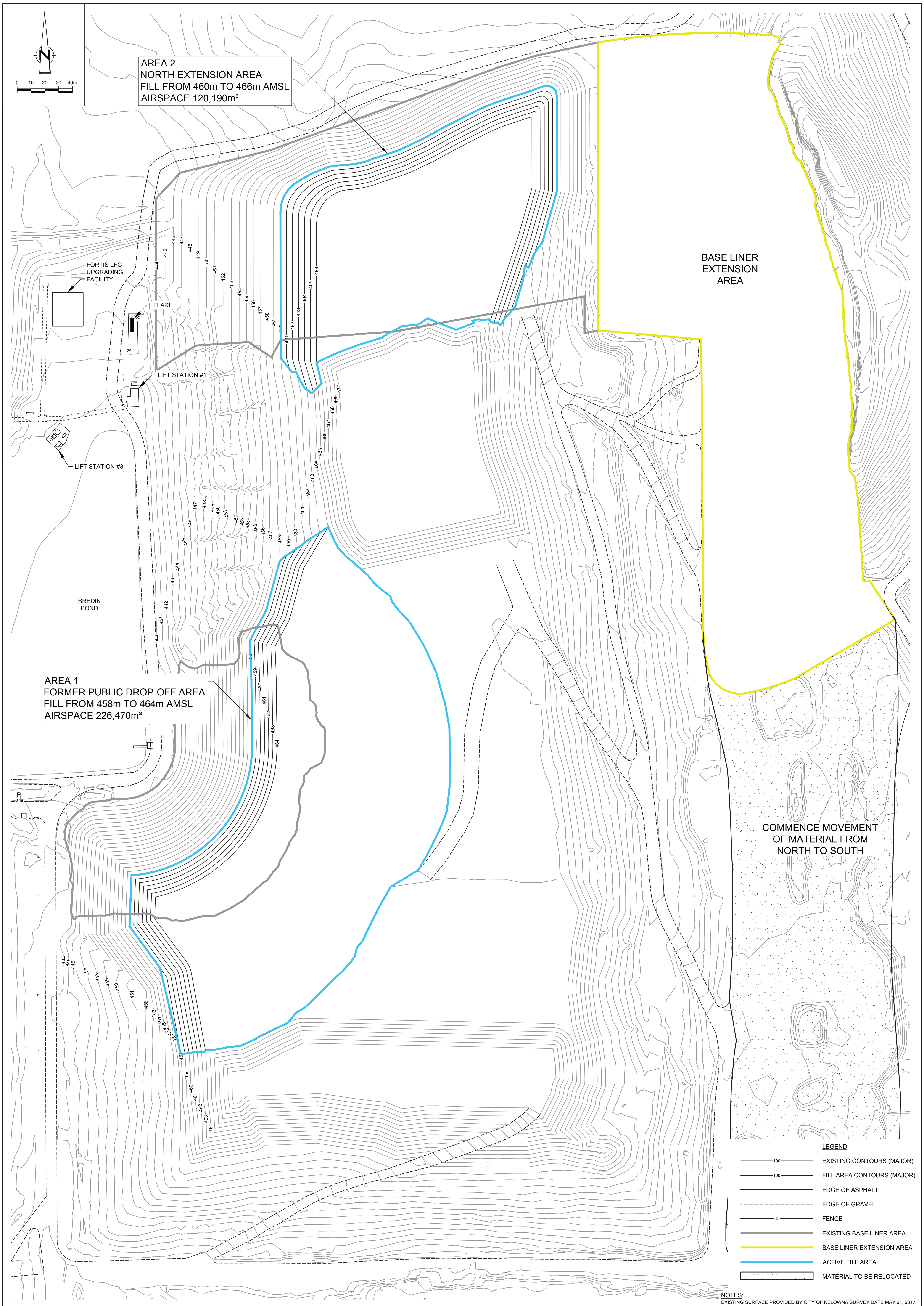
Client
Project
CITY OF KELOWNA - GLENMORE LANDFILL
DESIGN, OPERATIONS AND CLOSURE PLAN

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



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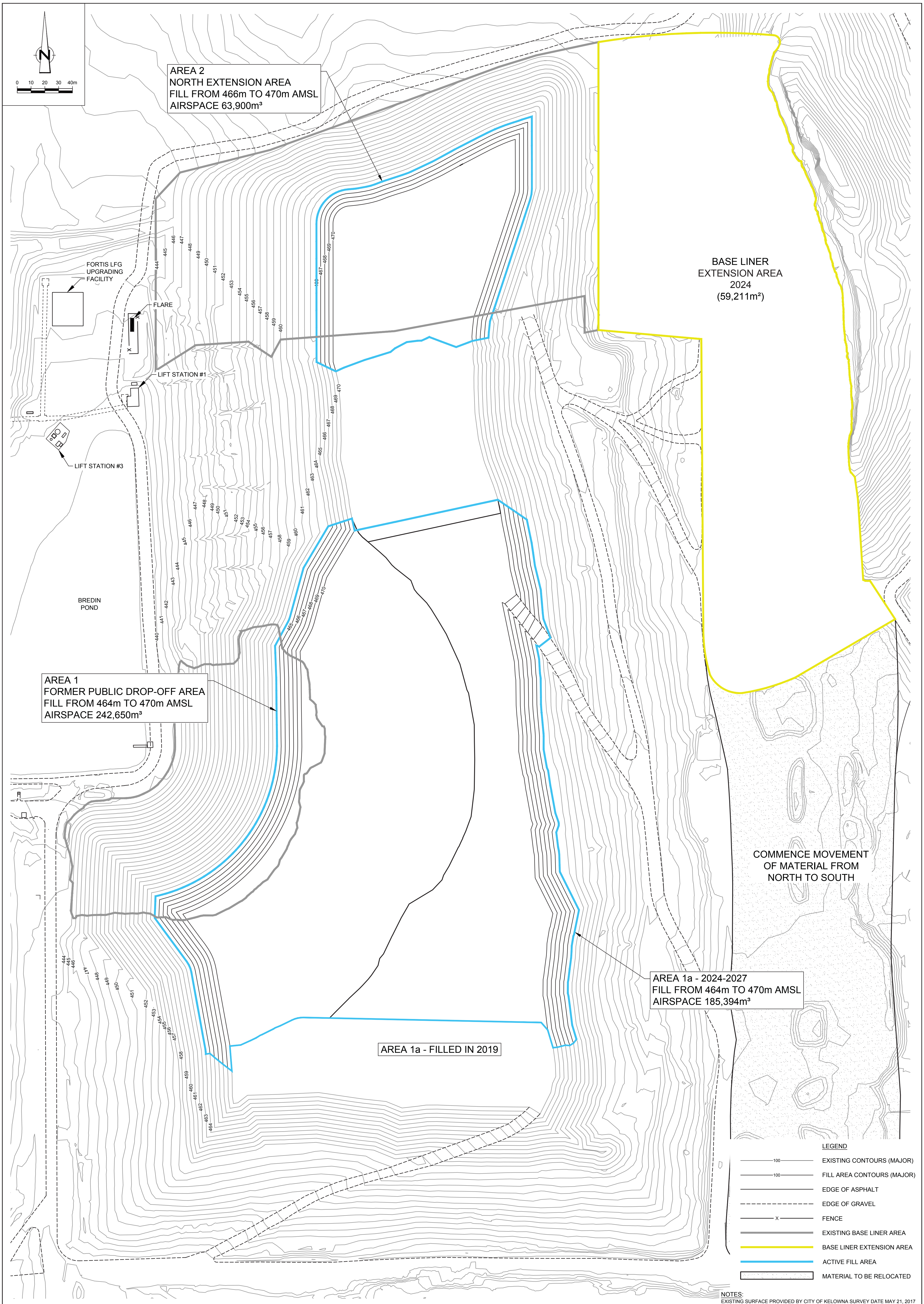
Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2023 - 2024 FILL AREAS

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



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Project
CITY OF KELOWNA - GLENMORE LANDFILL
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
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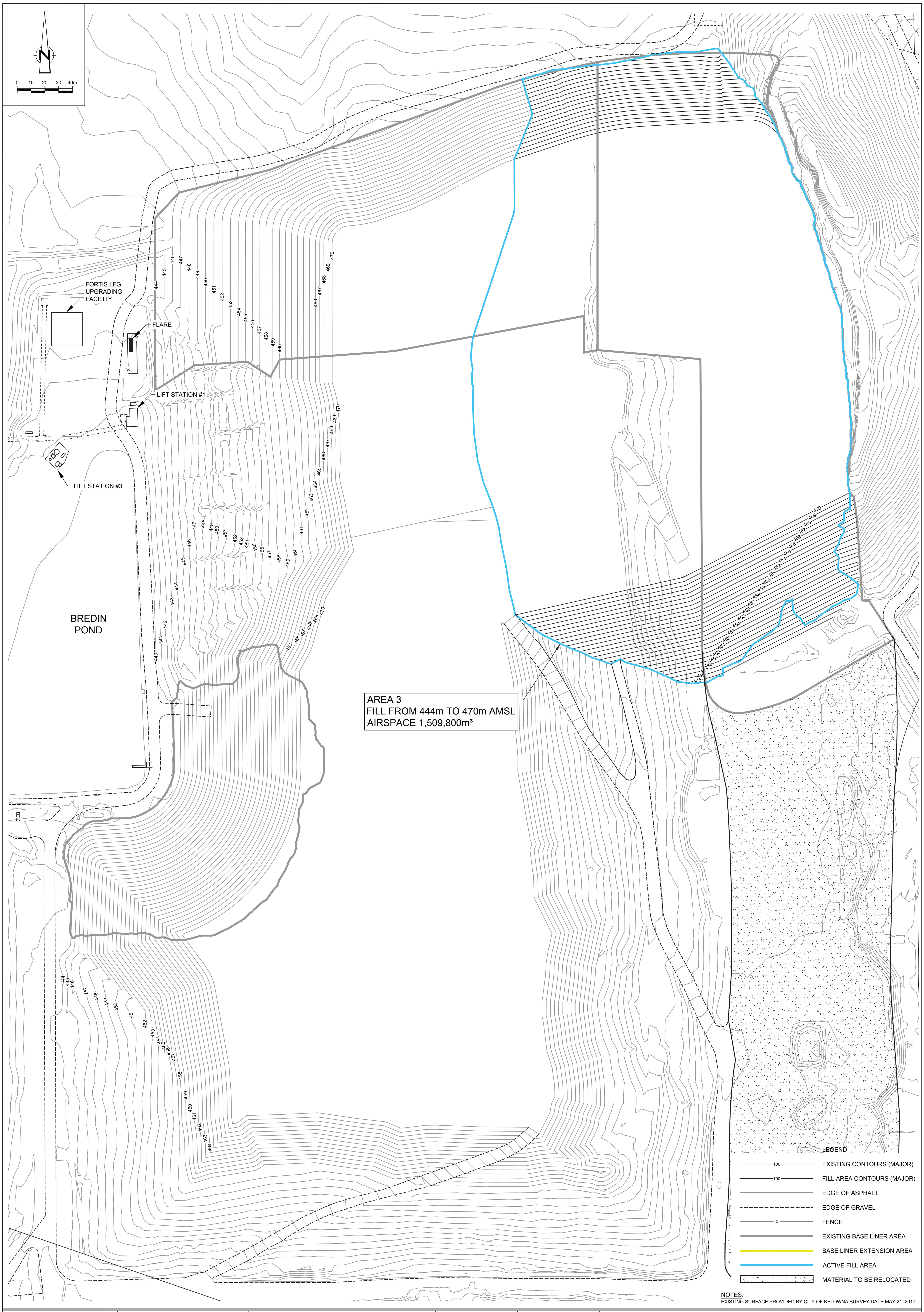

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Project DESIGN, OPERATIONS AND CLOSURE PLAN
Title 2027 - 2034 FILL AREAS: AREA 3

Project No. 084612-22
Original Size ANSI D
Sheet No. C-14
Sheet 16 of 24

Plot Date: 31 October 2018 - 2:38 PM
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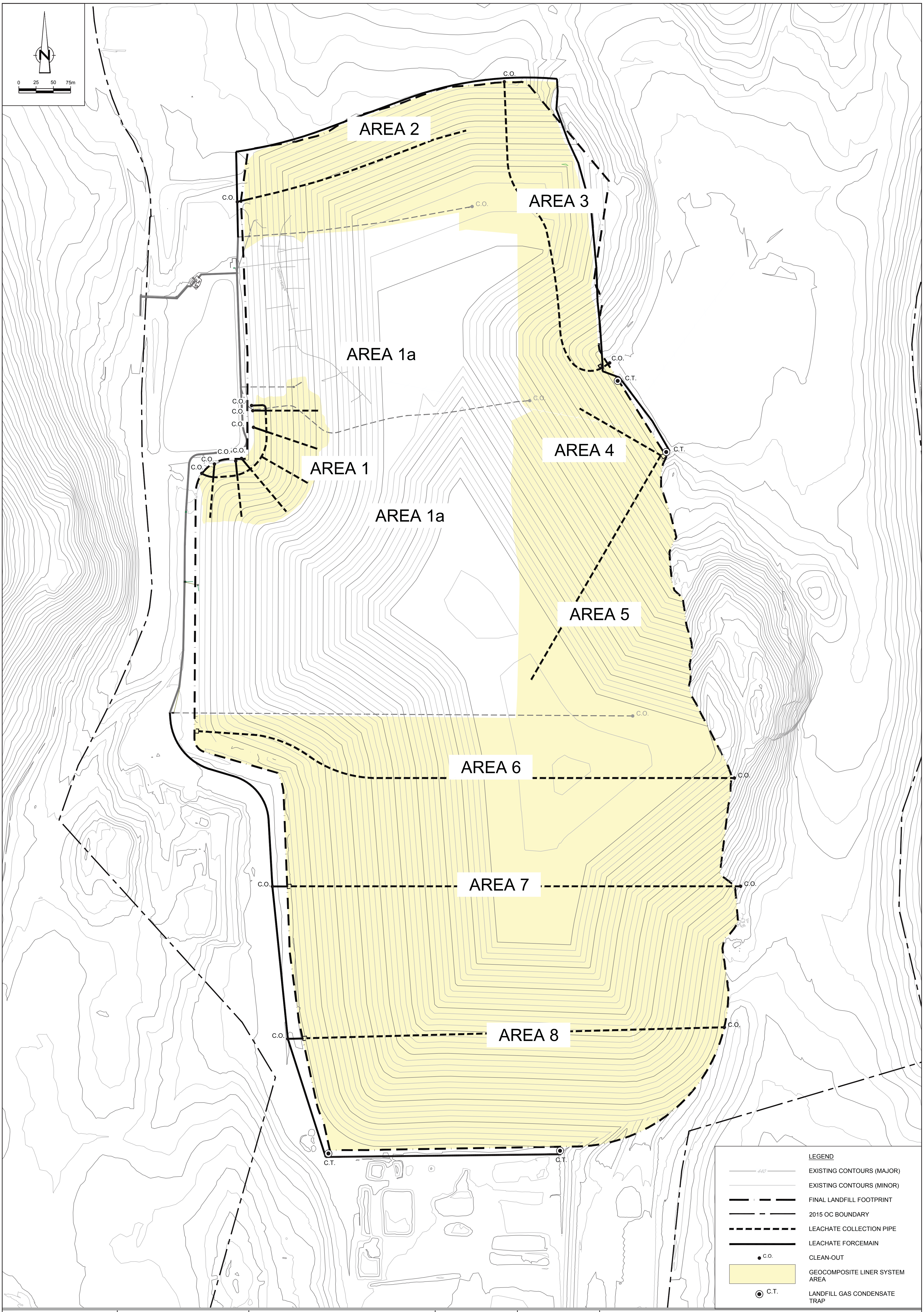

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Title LEACHATE COLLECTION SYSTEM

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

Plot Date: 31 October 2018 - 2:59 PM
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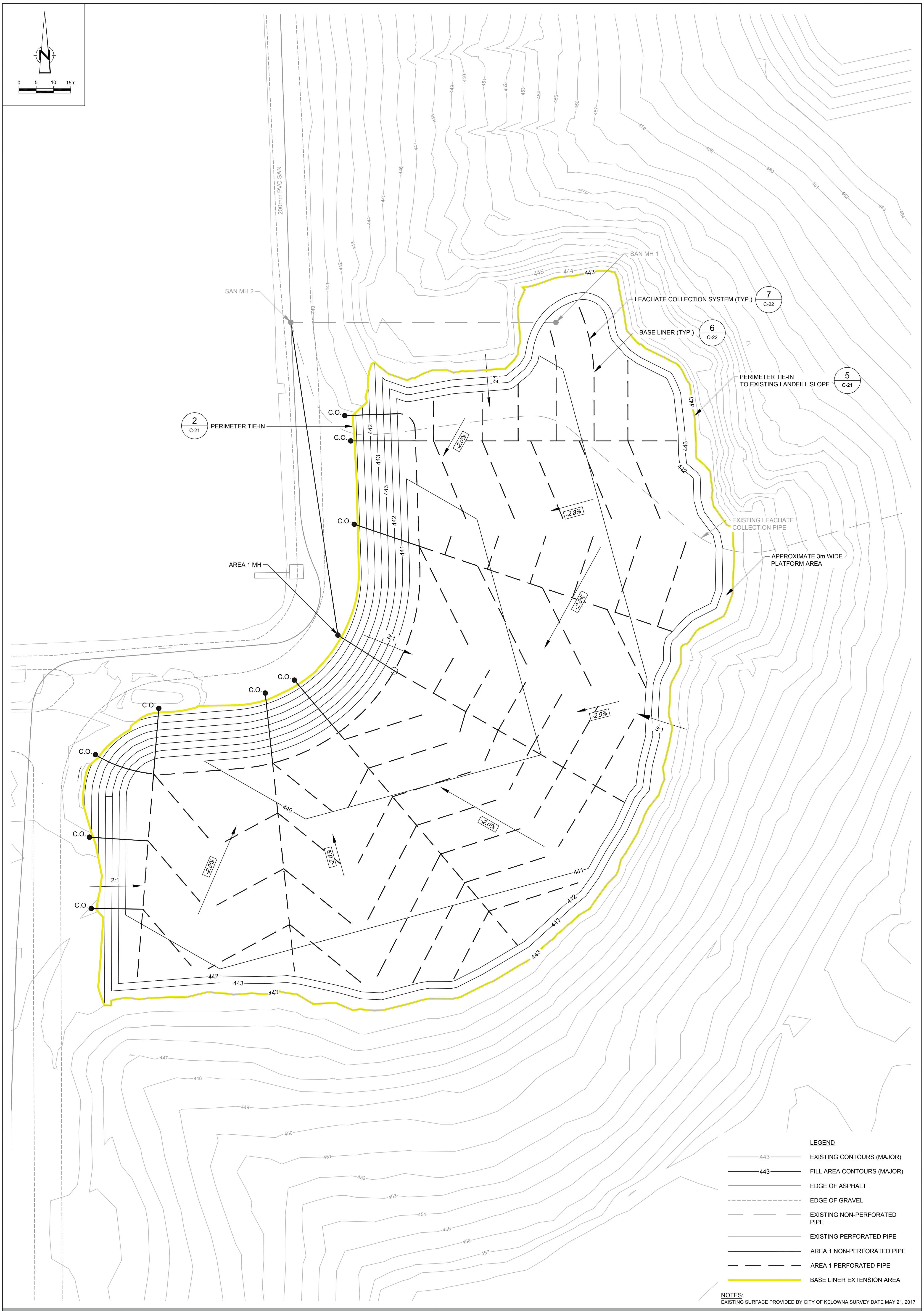

LEGEND

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

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Title AREA 1 LEACHATE COLLECTION SYSTEM

Project No. 084612-22
Original Size ANSI D
Sheet No. C-16
Sheet [illegible] of 24

Plot Date: 31 October 2018 - 3:17 PM
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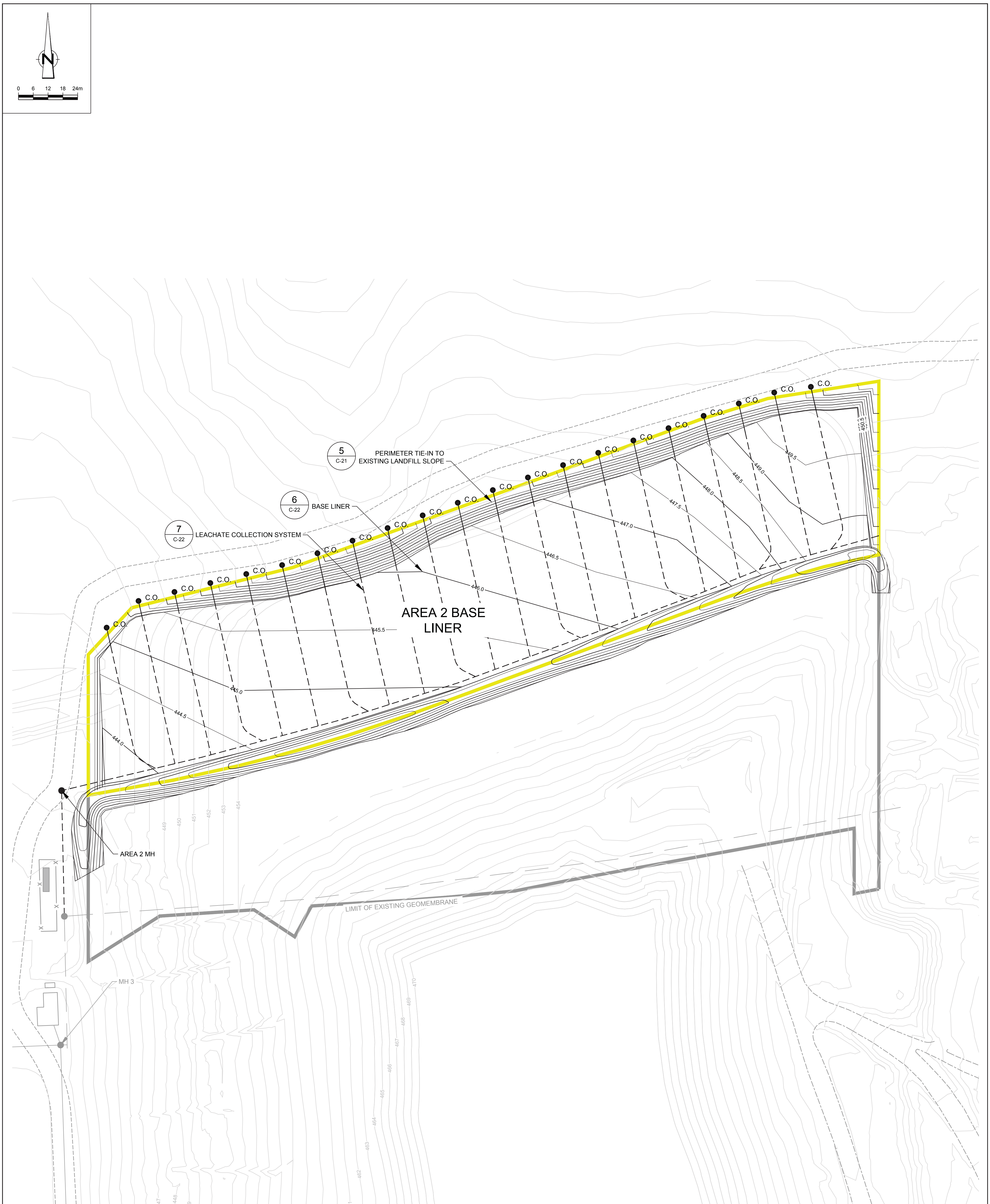

LEGEND

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:
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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
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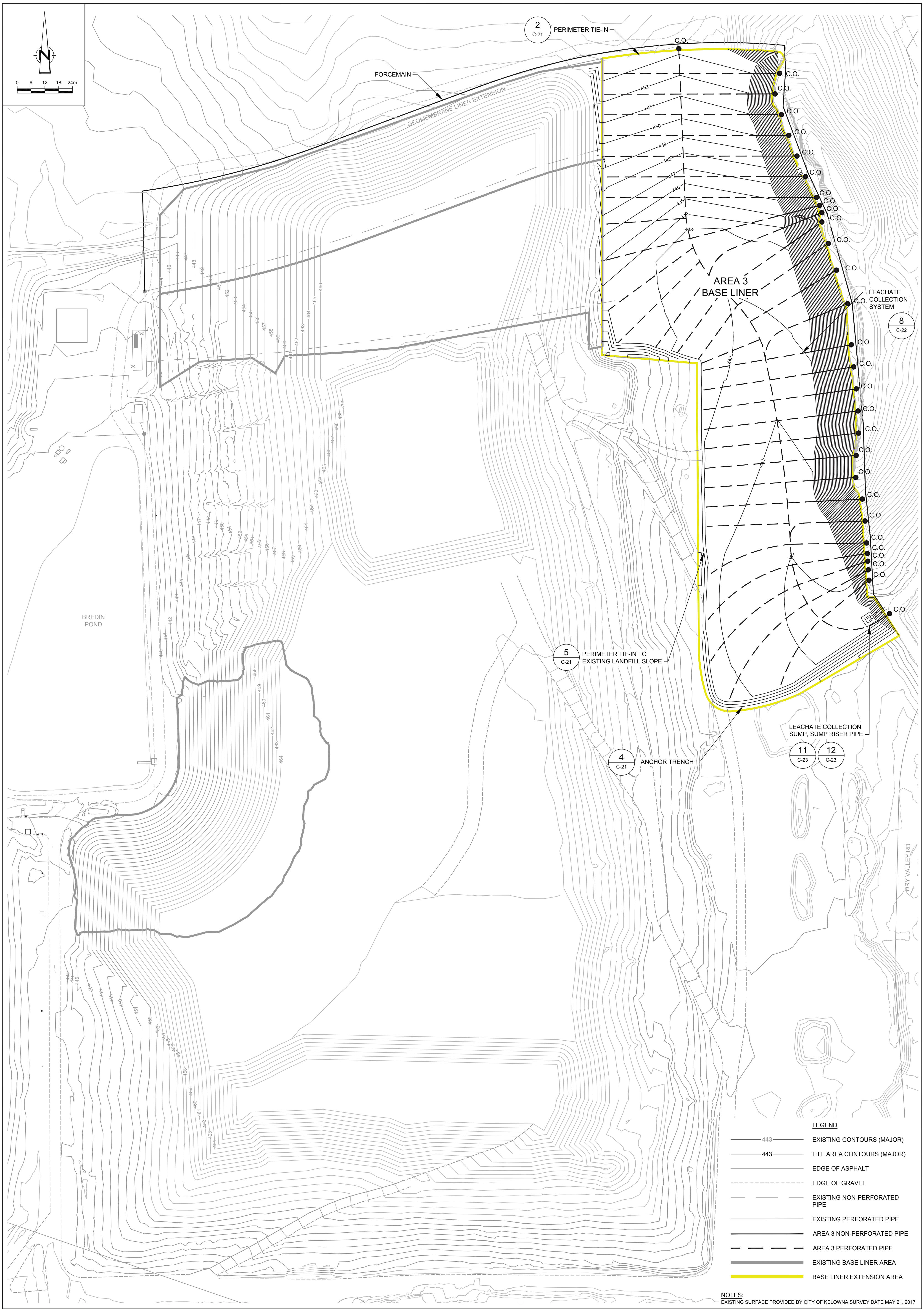

LEGEND

—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:
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CITY OF KELOWNA - GLENMORE LANDFILL

Project
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

Plot Date: 2 November 2018 - 12:02 PM
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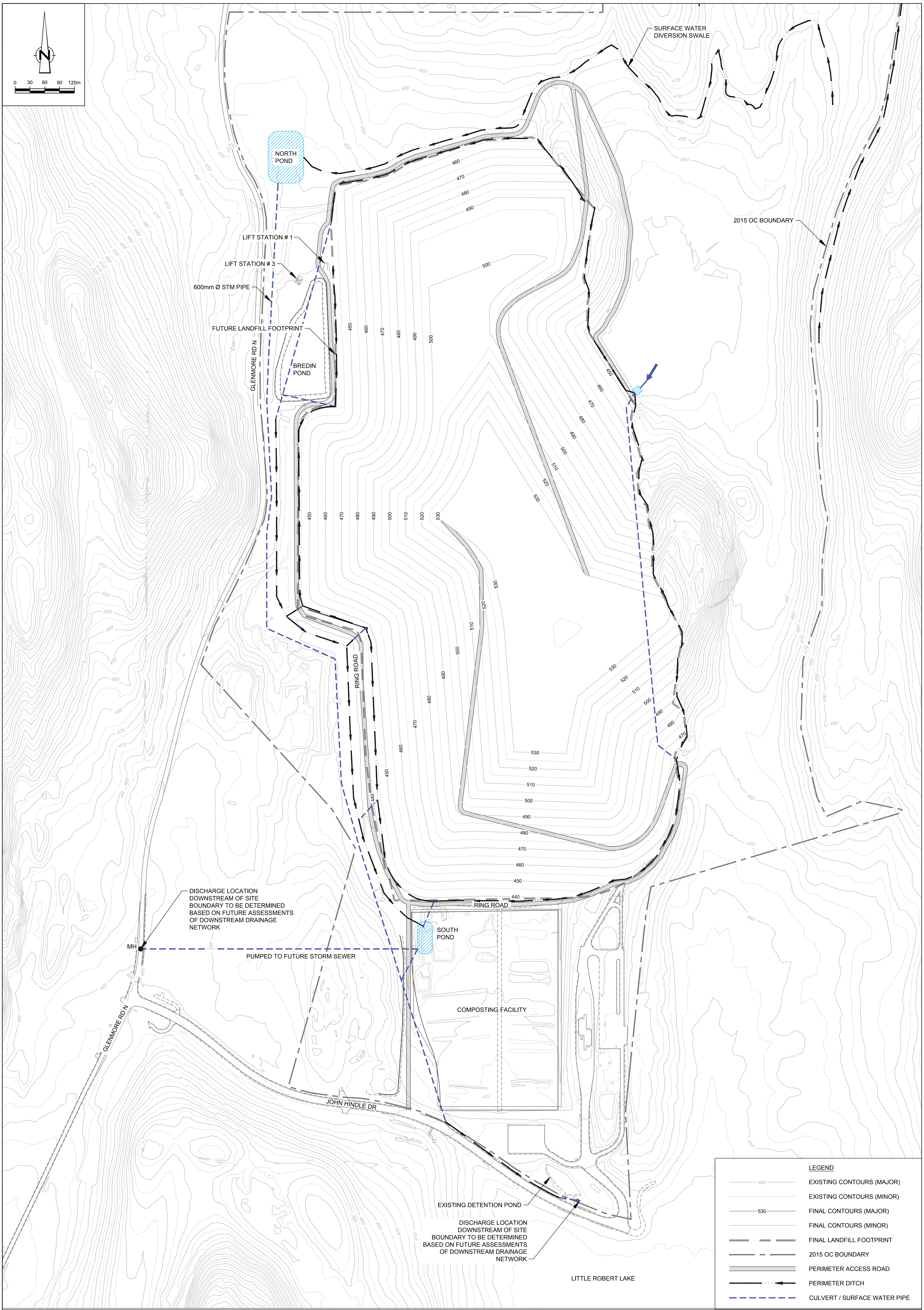

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Title SURFACE WATER MANAGEMENT PLAN

Project No. 084612-22
Original Size ANSI D
Sheet No. C-19
Sheet 20 of 24

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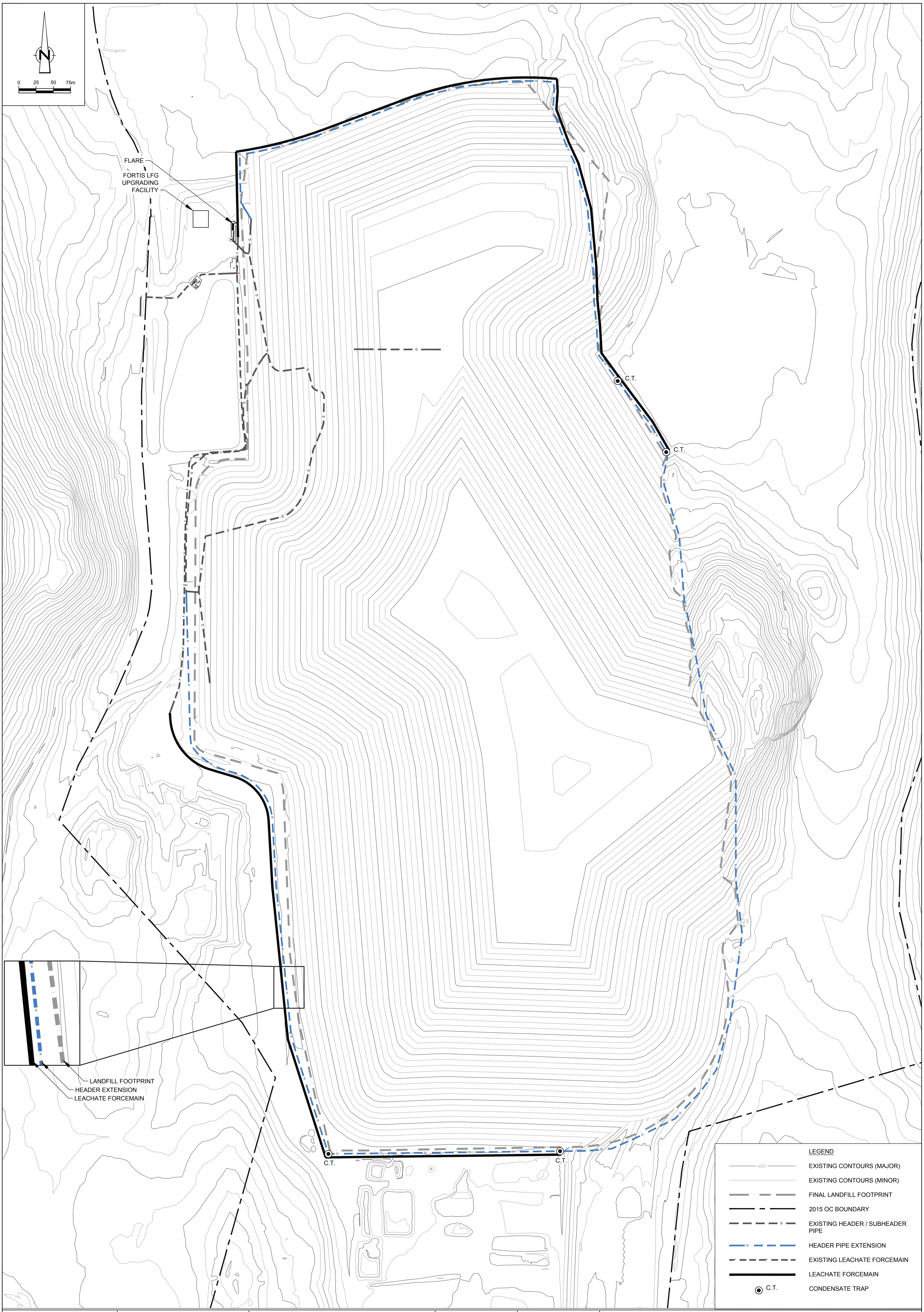

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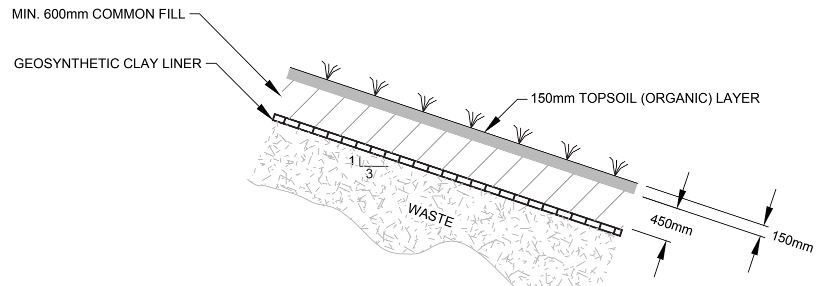
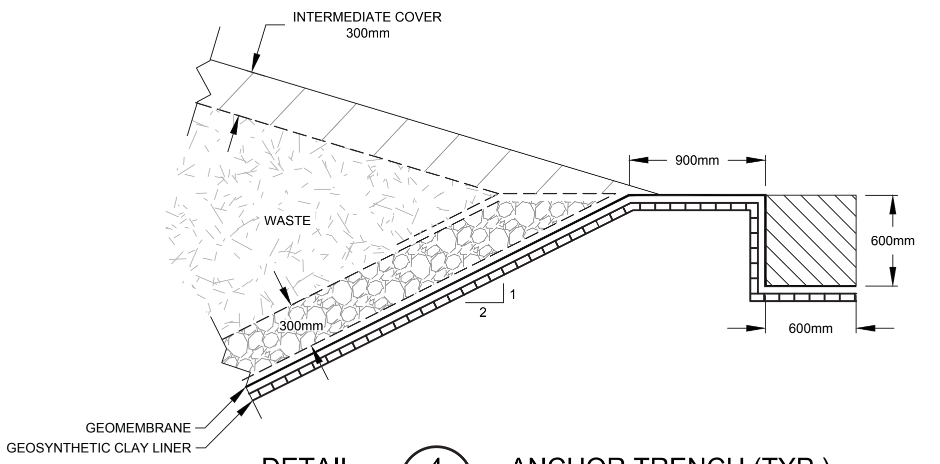
Title LANDFILL GAS HEADER EXTENSION

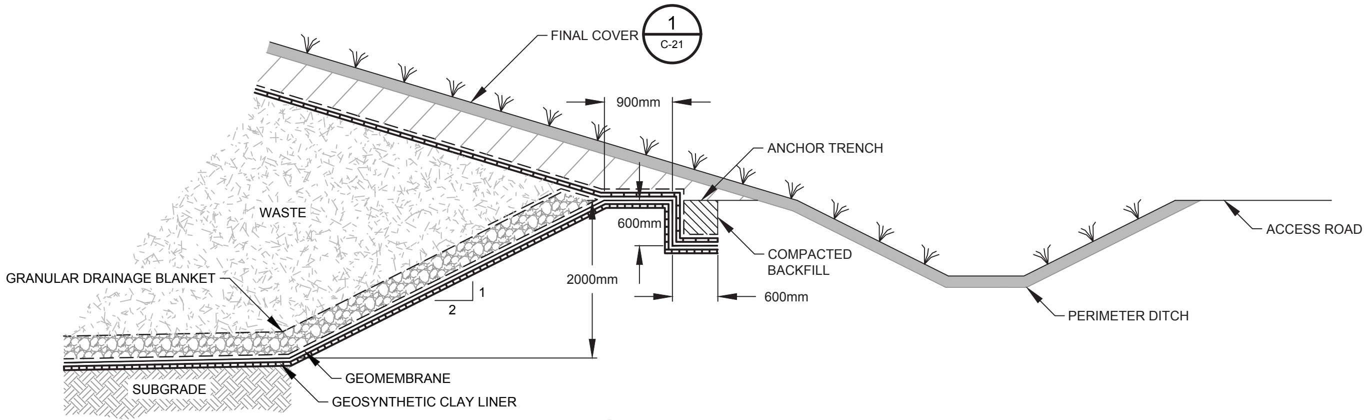
Project No. 084612-22
Original Size ANSI D
Sheet No. C-20
Sheet 21 of 24



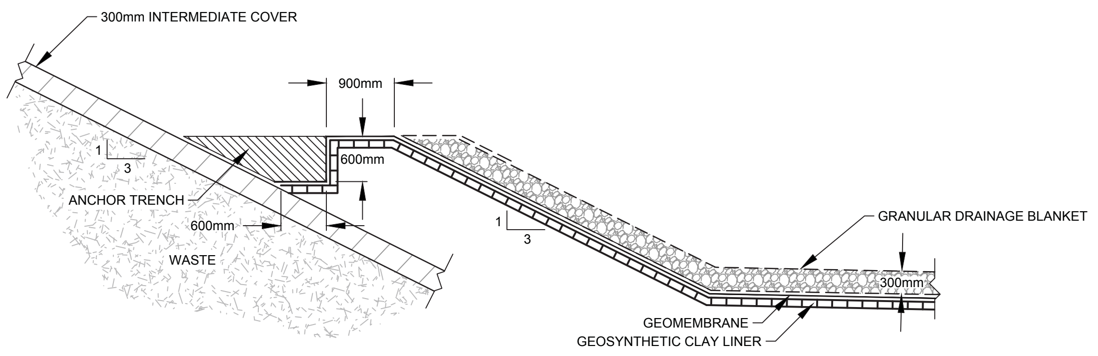
DETAIL 1 C-21 **FINAL COVER**
SCALE 1:50



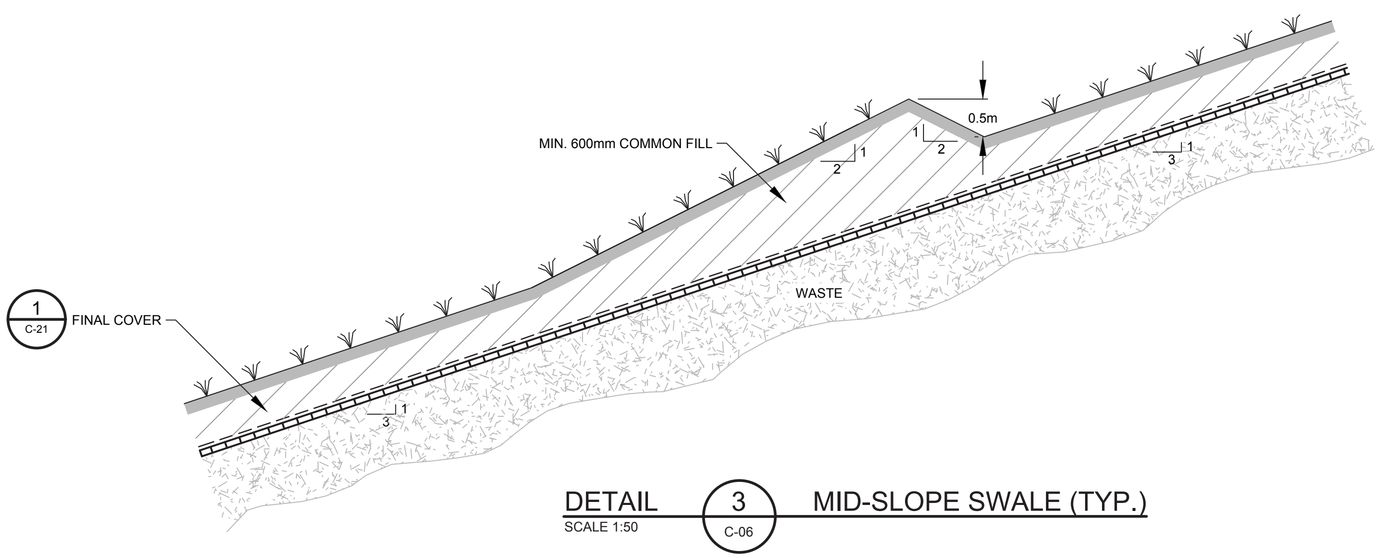
DETAIL 4 C-18 **ANCHOR TRENCH (TYP.)**
AREA 3
SCALE 1:25



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



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



DETAIL 3 C-06 **MID-SLOPE SWALE (TYP.)**
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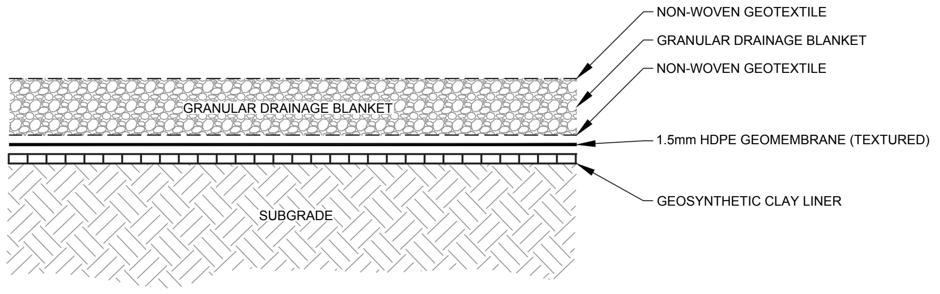
Title
FINAL COVER AND PERIMETER
TIE-IN DETAILS

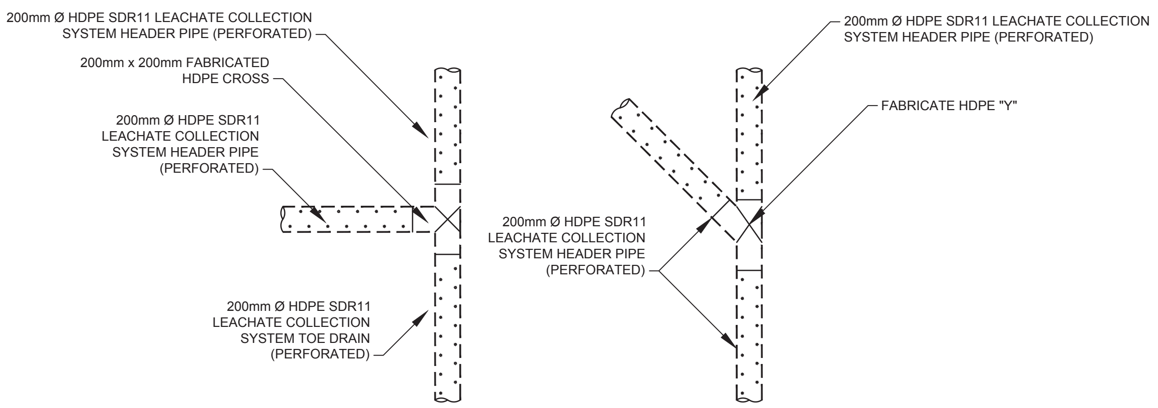
Sheet No.
C-21

Sheet 22 of 24

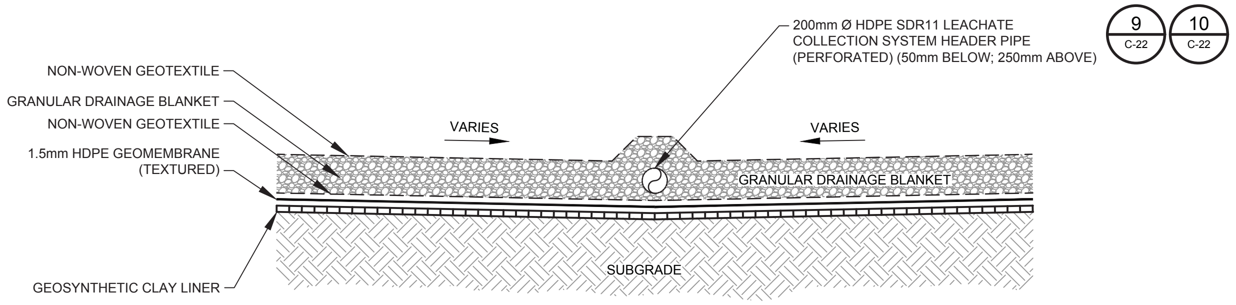
Plot Date: 31 October 2018 - 12:43 PM Plotted By: Tyler Wagstaff CAD File: P:\drawings\84000s\84612\84612-report\84612-22(004)\84612-22(004)CI\084612-22(004)CI-WA026.dwg



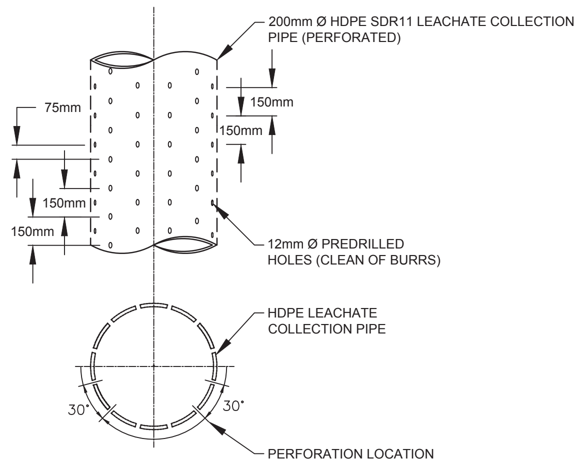
DETAIL 6 BASE LINER (TYP.) AREA 2 & 3
SCALE 1:20
C-16



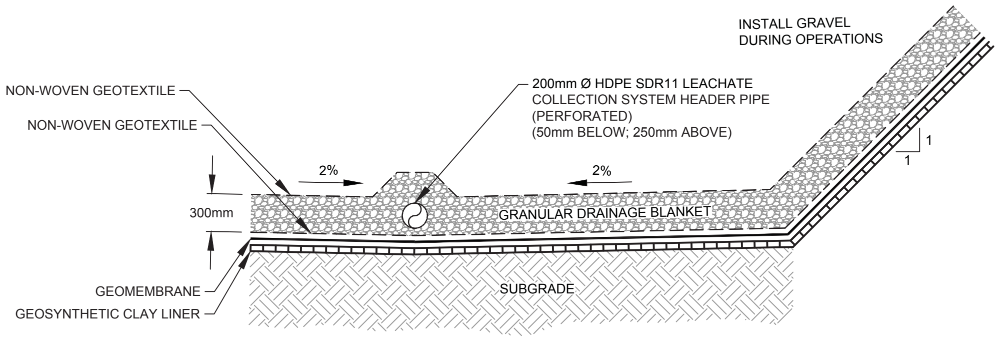
DETAIL 9 LEACHATE COLLECTION SYSTEM PIPE CONNECTIONS
SCALE 1:30
C-22



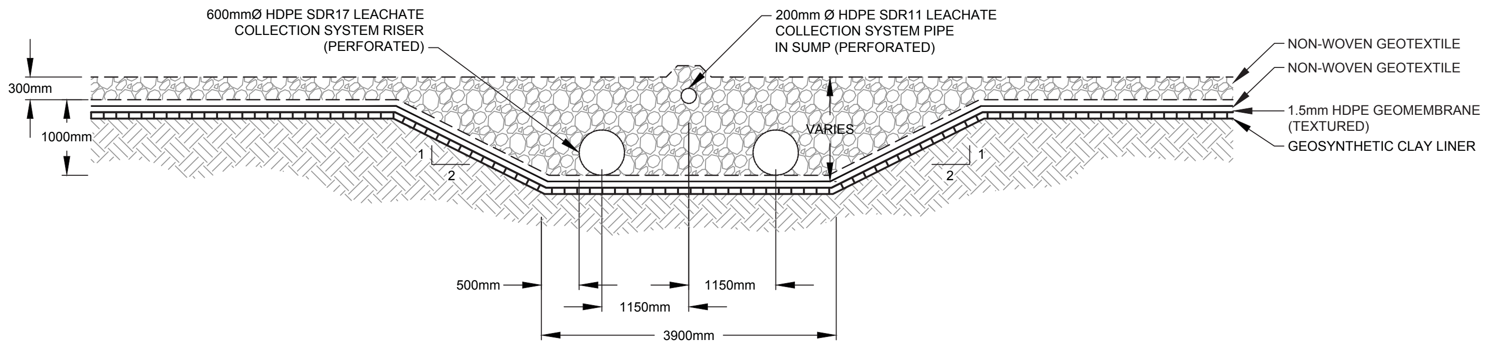
DETAIL 7 LEACHATE COLLECTION SYSTEM (TYP.)
SCALE 1:30
C-16



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

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Project No. 084612-22

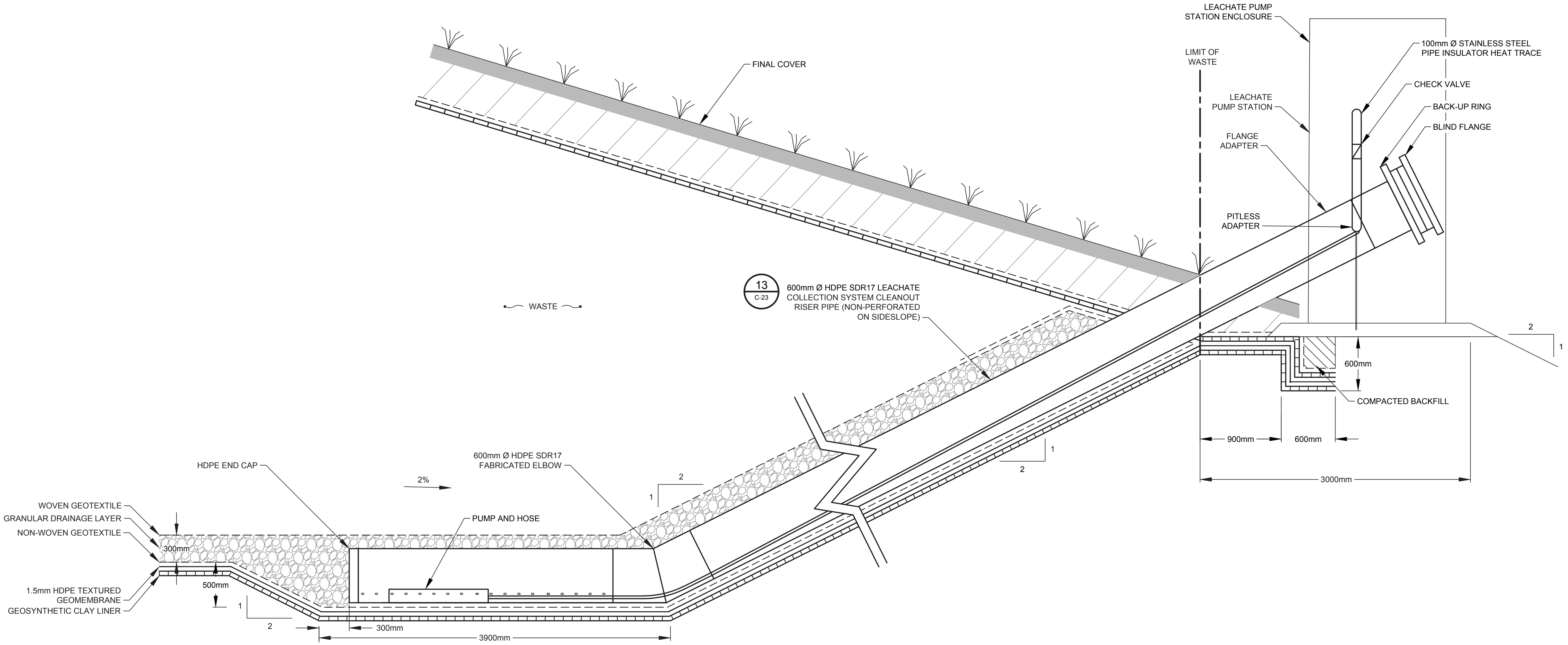
Title
BASE LINER AND LEACHATE
COLLECTION SYSTEM
DETAILS

Sheet No.
C-22

Sheet 23 of 24

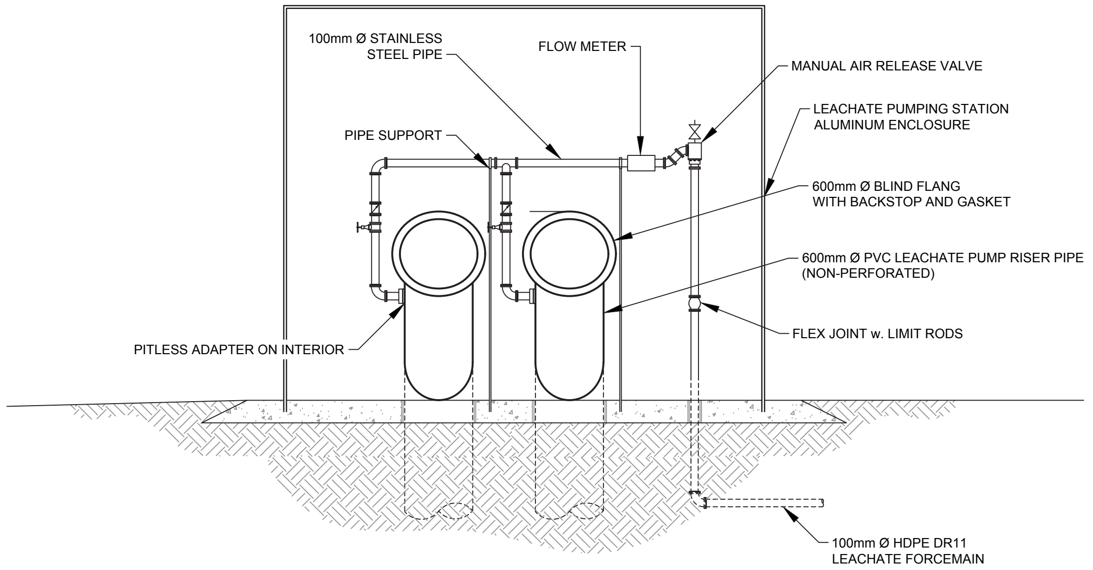
440

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 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.

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Project No. 084612-22

Title

LEACHATE COLLECTION SUMP
& SUMP RISER
AREA 3 - DETAILS

Sheet No.

C-23

Sheet 24 of 24

441

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

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

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

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

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: June 29, 2015
(most recent)

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:

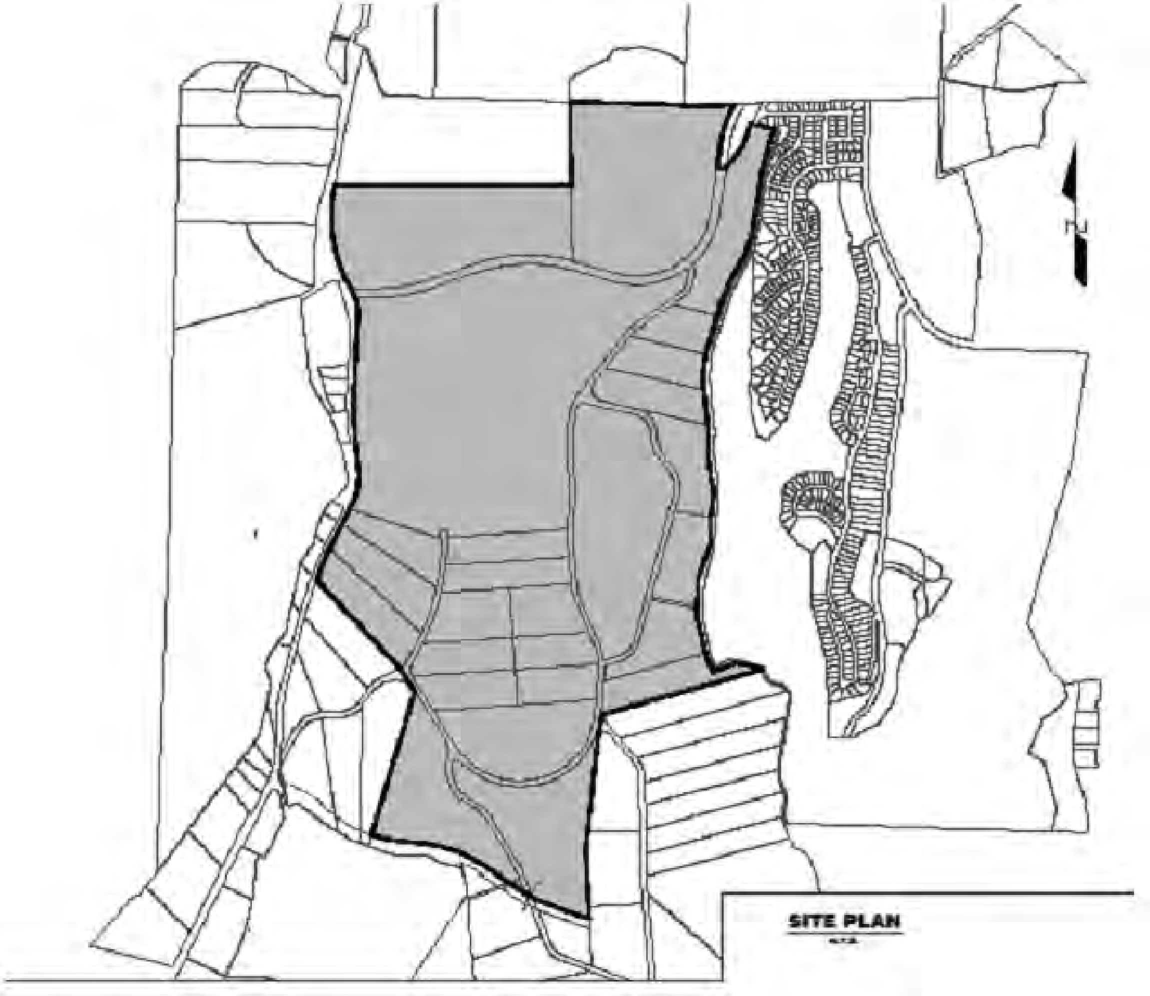
- Results of the environmental monitoring program.
- Data tabulation, comparison to performance criteria, interpretation, trend analysis, graphs, etc.
- Identification of any current or predicted future non-compliance with performance criteria.
- Conclusions, recommendation and proposed changes to the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



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

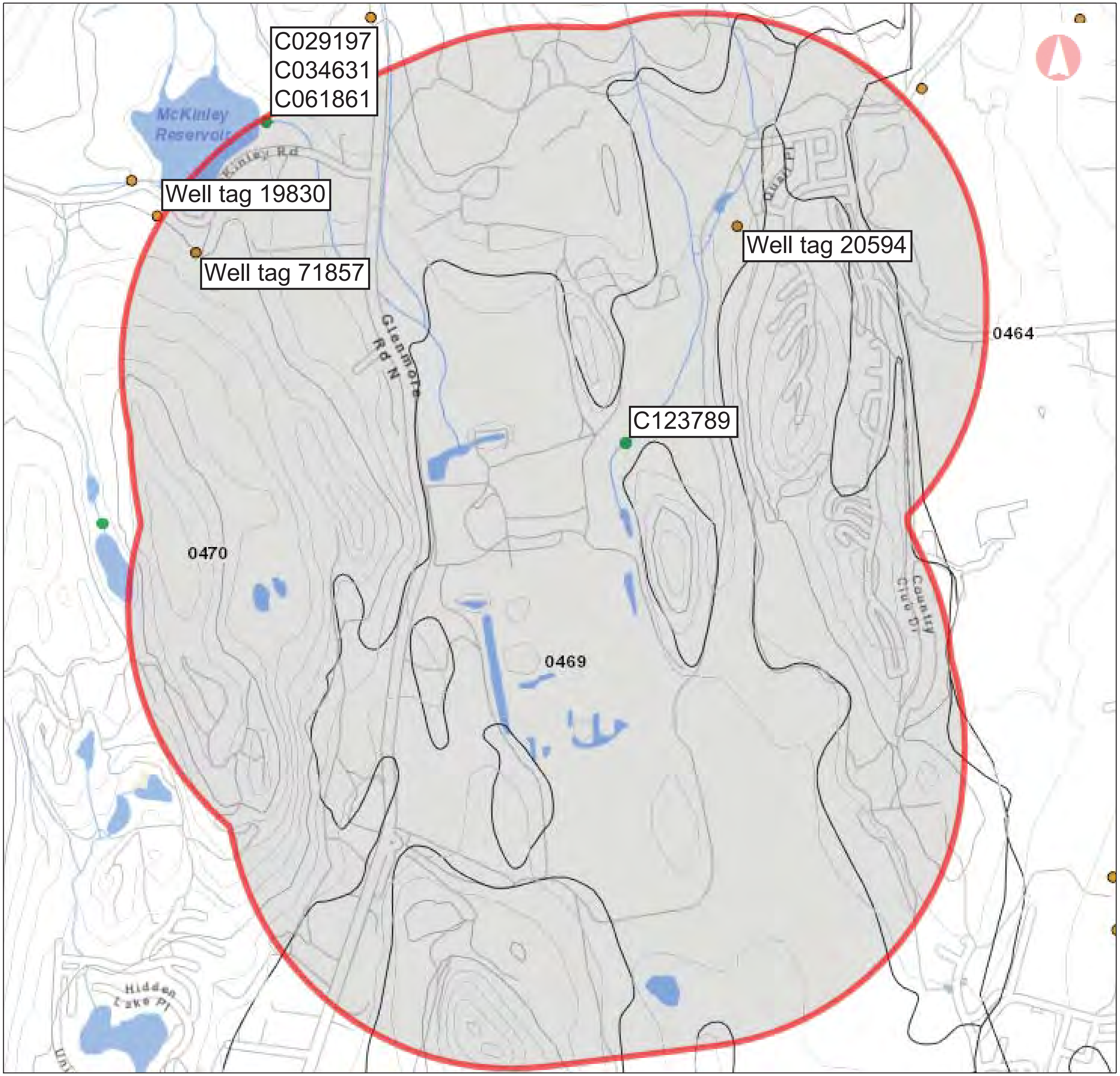
Carol Danyluk, P.Eng.
for Director, *Environmental Management Act*
Southern Interior Region - Okanagan

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 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

Information Disclaimer

082E.093.4.2.3.

82 E.093
4.2.3

E/14-S½

1

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

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.G.P.M. through an open hole.

North of OS 1
82E/14 49S

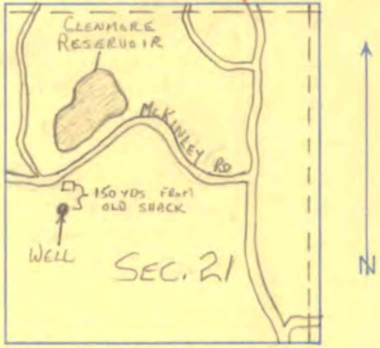
MAX. RATE WITHDRAWAL ☐ ESTIMATED ☐ MEASURED ______

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.

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

CHARACTER OF SUPPLY AQUIFER: SAND, GRAVEL, TILL

WATER USE: DOMESTIC, GARDEN, STOCK, COOLING, IRRIGATION, INDUSTRIAL, WATERWORKS

RELIABILITY OF DATA: GOOD, FAIR, POOR

SUPPLY AQUIFER: UNITS 1 2 4 7, TENS 1 2 4 7
OTHER AQUIFER PRESENT: UNITS 1 2 4 7, TENS 1 2 4 7
OTHER AQUIFER PRESENT: UNITS 1 2 4 7, TENS 1 2 4 7

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

1008

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

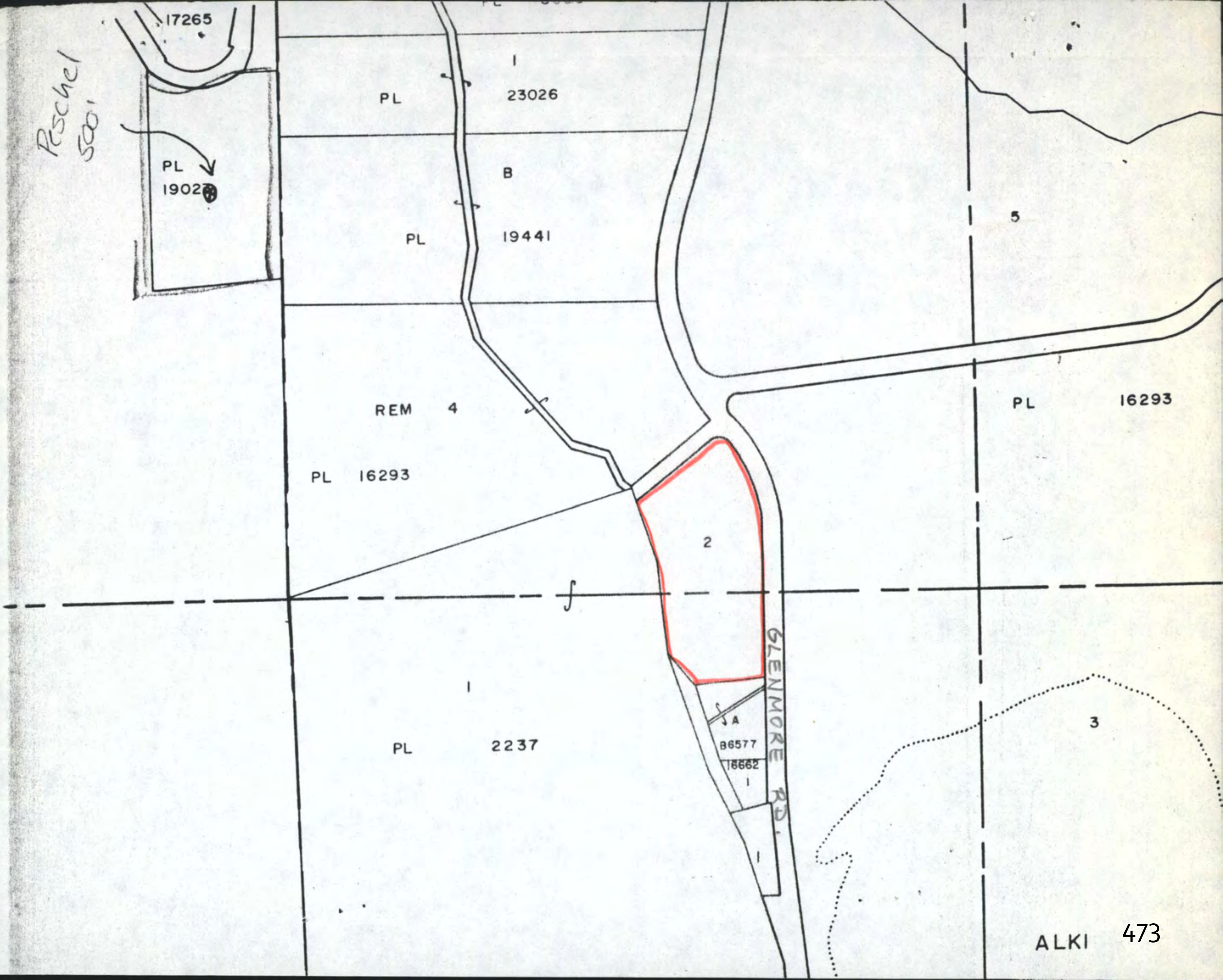
Casing from	to feet	Diameter	Material	Drive Shoe

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
Pischel
500'
PL
19027
PL
1
23026
B
PL
19441
5
PL
16293
REM
4
PL
16293
2
1
PL
2237
GLENMORE RD.
A
B6577
16662
1
1
3
ALKI

82E·093·4·2·4

1

7 4 2 1 7 4 2 1 6 5 4 C E
RIDIAN

2 1 | 7 4 2 1 | 2 1 | 7 4 2 1 | NE SE SW NW | 4 2 1 | 7 4 2 1
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 ____

TEMPERATURE ____ PUMPS SAND ☐ ____

CLOGS SCREEN ☐ TYPE DEPOSIT ____ AQUIFER DATA ____

LICENSE No. ____ DATE LICENSE ____ AMOUNT ____

DATE APPLICATION ____ USE ____

west of os2

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 — 30, 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

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

992

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 ______

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 bailed 5 g.p.m.

thick black water - never cleared

OTHER DATA

SIZE ANALYSIS, ETC. ______

CARD BY AA. DATE Dec 68

SOURCES INFORMATION Okanagan Rotary Water Wells

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

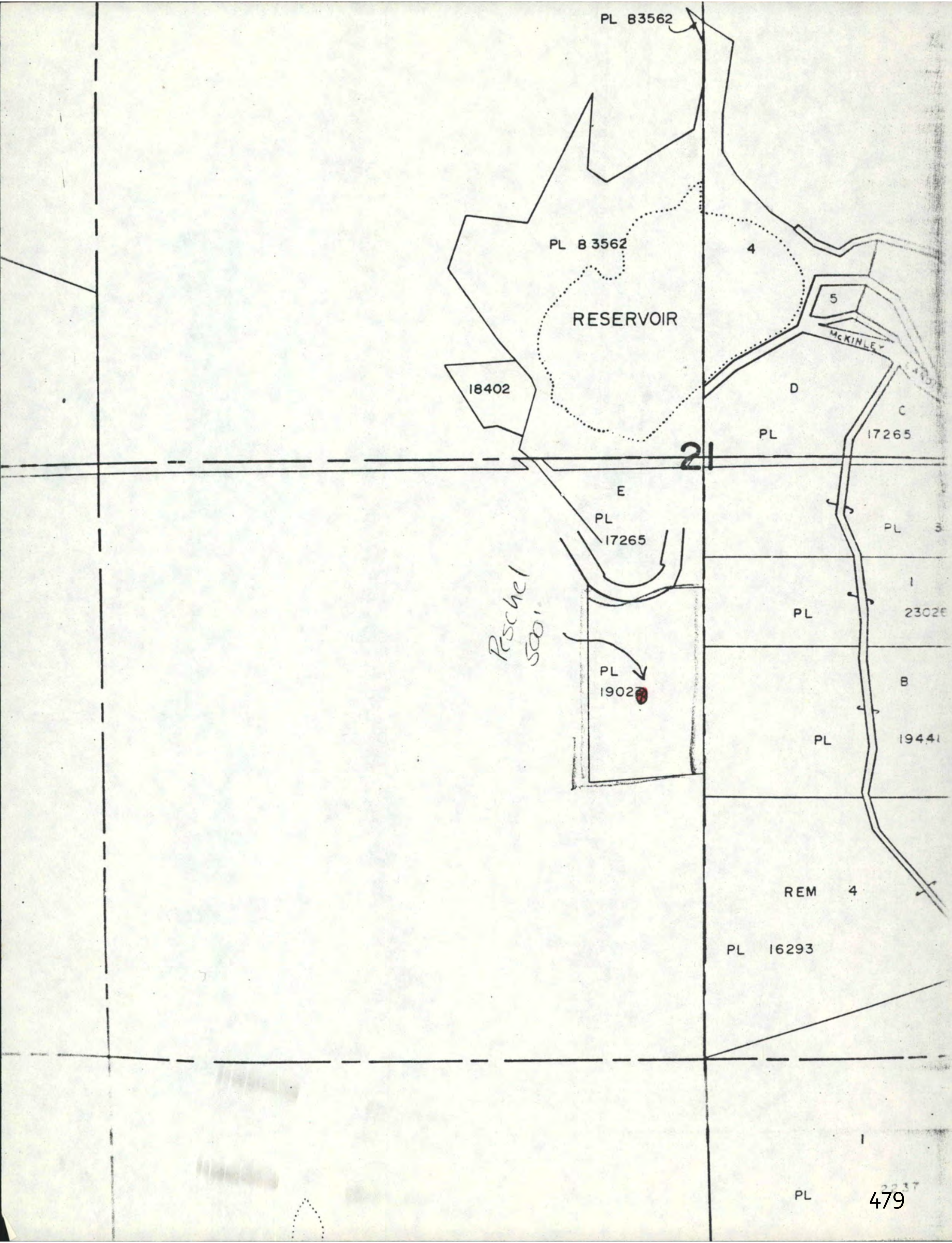
RESS P.O.B. 1114 Kelowna

Lot 11 B Sec 21 Twp 23
Plan 19233 L. 41 ODYD

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

ER NO. | CASH | CHEQUE

TERMS: DEPOSIT OR 25% ON COMPLETION


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

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

NO_2 = NITRITE NO_3 = NITRATE

CHEMISTRY SITE NO. ____

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 ☐ PUMP TEST DATA ☐ CHEMICAL ANALYSIS

☐ SIEVE ANALYSIS ☐ GEOPHYSICAL LOGS ☐ 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!

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.

.../2

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
8426 8A
Map No. 8427 A
By G.P.E.S.A.

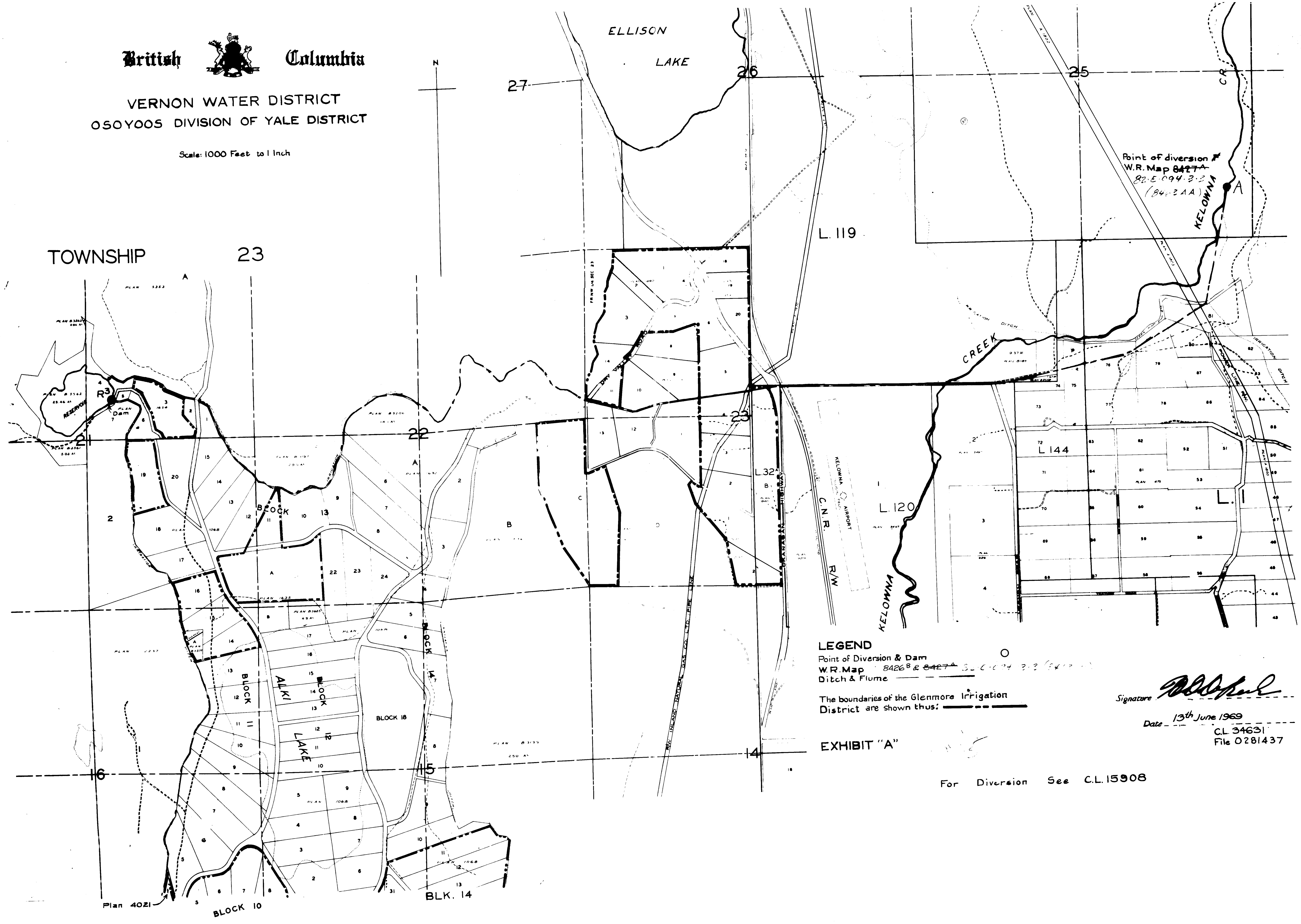
H. D. DeBeck,
Comptroller of Water Rights.

File No. 0281437 Date issued: 13 June 1969 Conditional Licence No. 34631

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 (84.3 [illegible])

Ditch & Flume

The boundaries of the Glenmore Irrigation District are shown thus:

Signature

Date 13th June 1969

C.L. 34631
File 0281437

EXHIBIT "A"

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.

.../2

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.

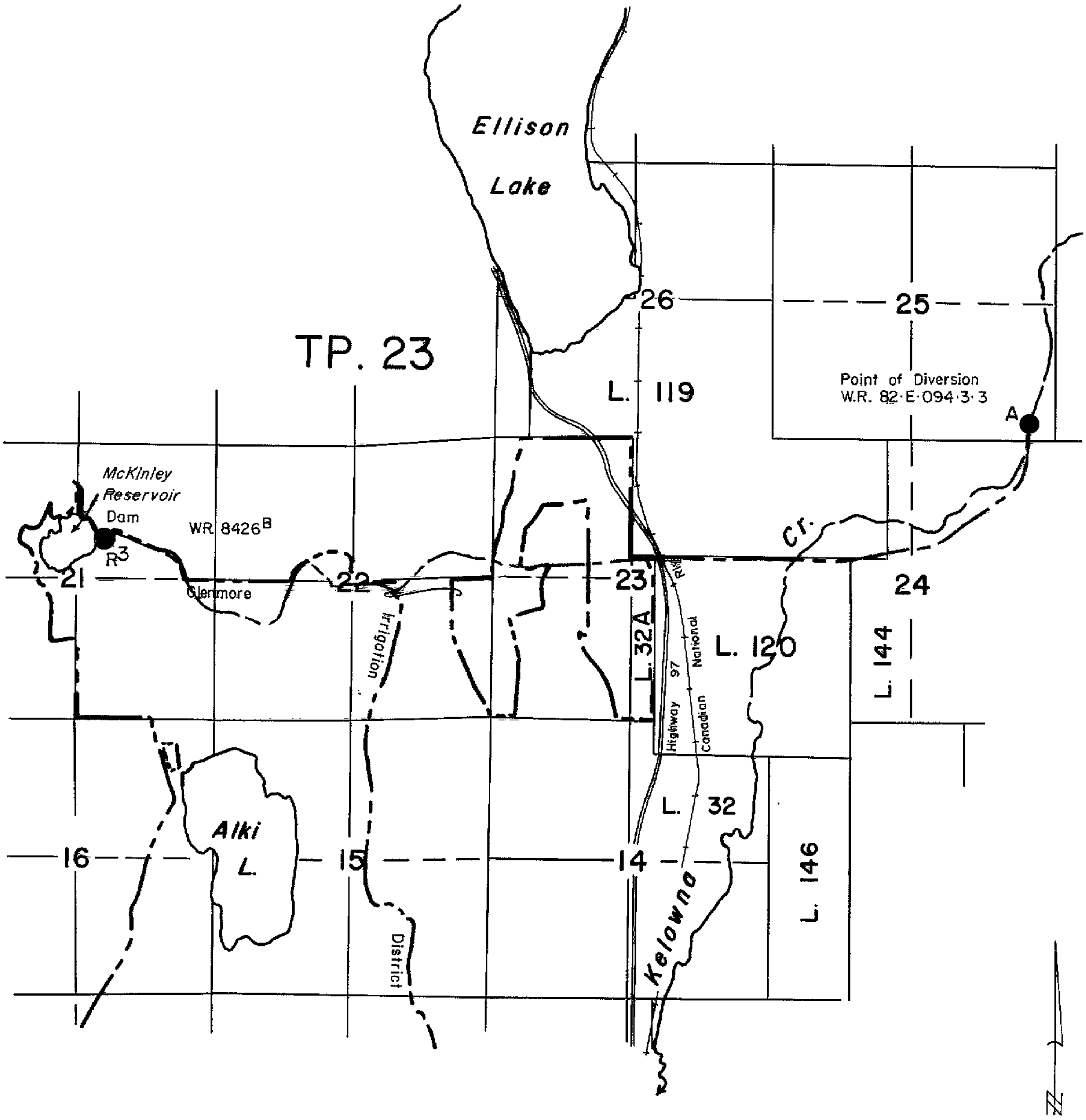
(k) The reservoir area shall be cleared and the debris disposed of in such a manner and extent as directed by the Comptroller of Water Rights.

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

LEGEND

Scale : 40 Chains to 1 Inch
Point of Diversion, Dam : ●
Map Number : WR 82·E·094·3·3, WR. 8426B
Pipe : ——— — ———

Signature Paul Gavell
Date January 30, 1987

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

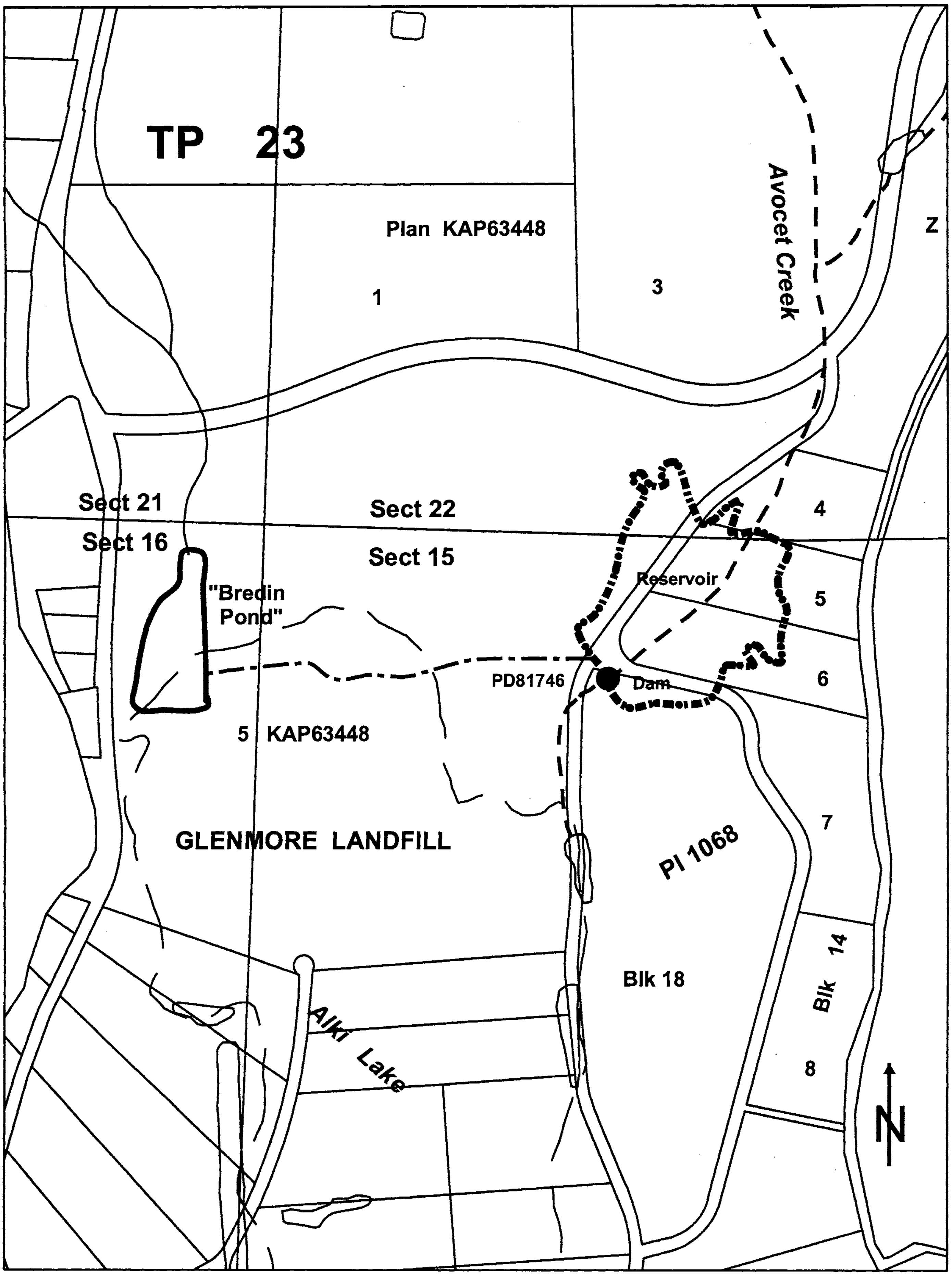
Date Issued: February 4, 2010

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

TECHNICAL MEMORANDUM

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.

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[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

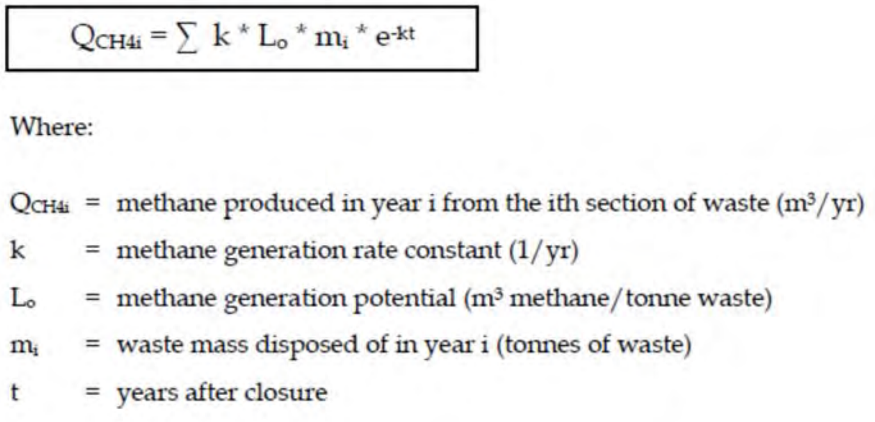
Year	Population	Projected Waste Disposed(tonnes)	Cumulative Waste Disposed (tonnes)	Cumulative Waste Disposal Volume (cubic metre)
2090	512,821	299,146	17,879,820	25,542,600
2091	519,534	303,061	18,182,881	25,975,545
2092	526,334	189,319	18,372,200	26,246,000

(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

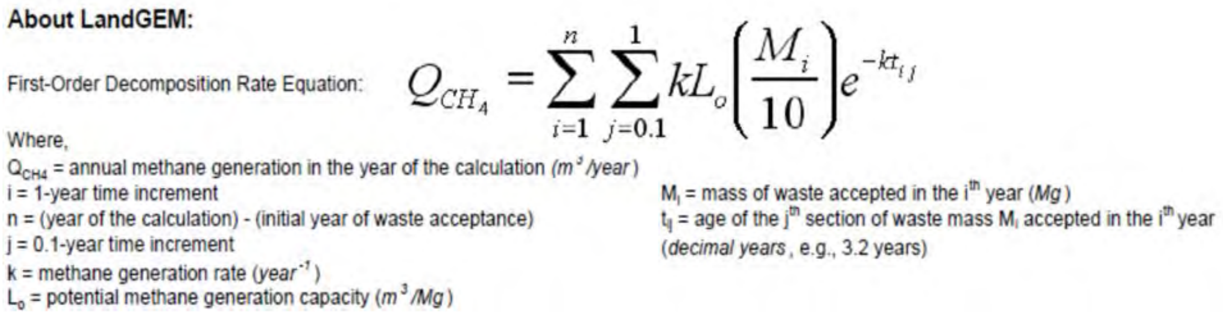
TABLE 2

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.

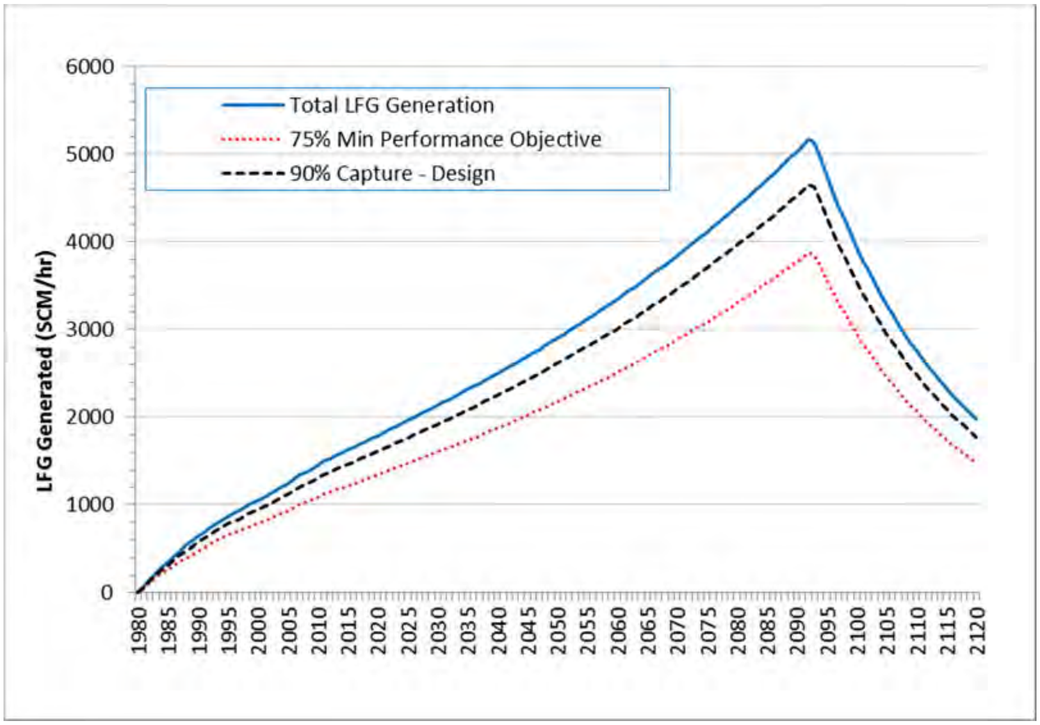


FIGURE 1. LANDFILL GAS GENERATION ESTIMATE (EPA LANDGEM)

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.

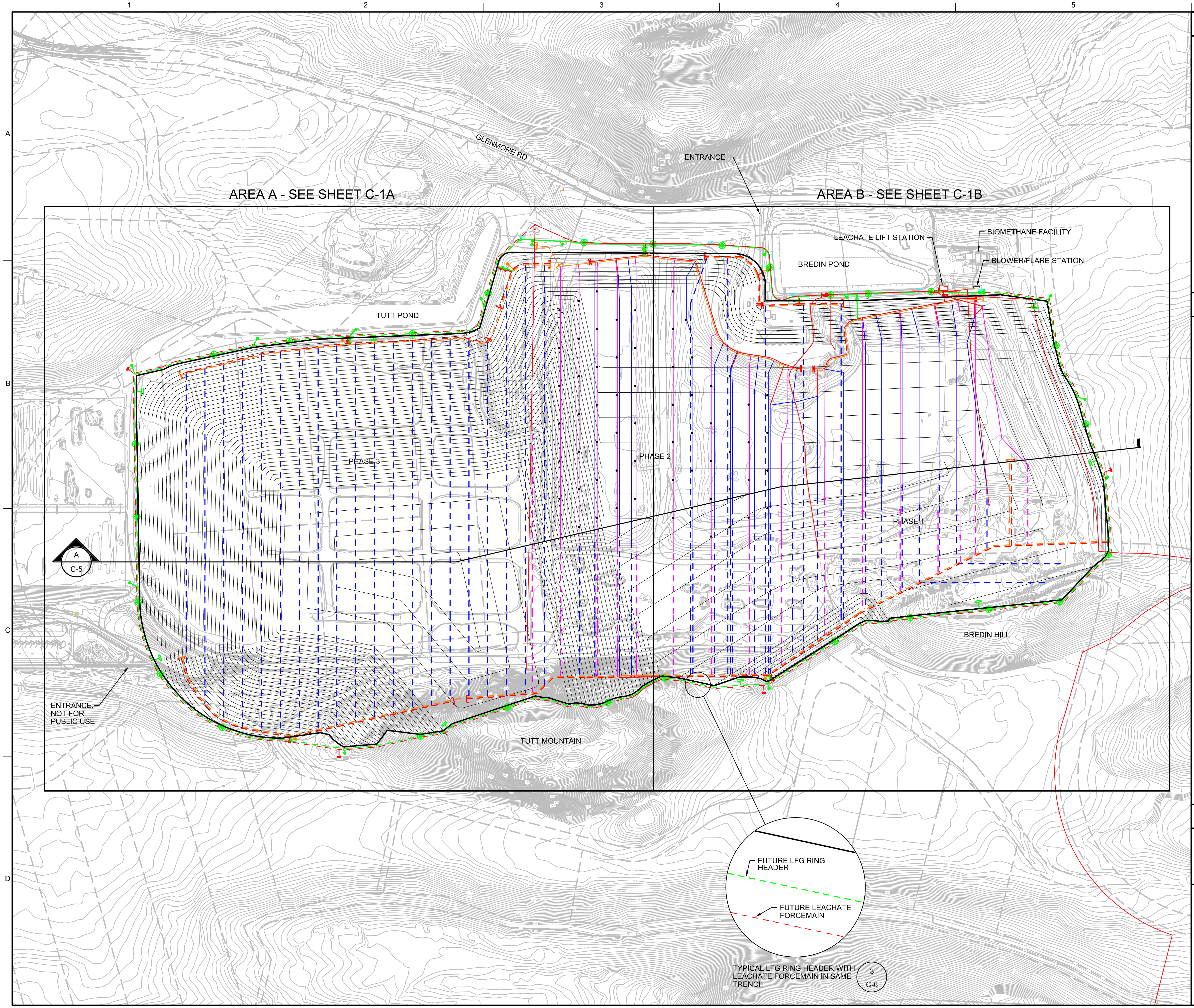
The estimated unit cost for installation of future infrastructure is presented Table 6.

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



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

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CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

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OVERALL SITE PLAN

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DWG	C-1
SHEET	1 OF 8

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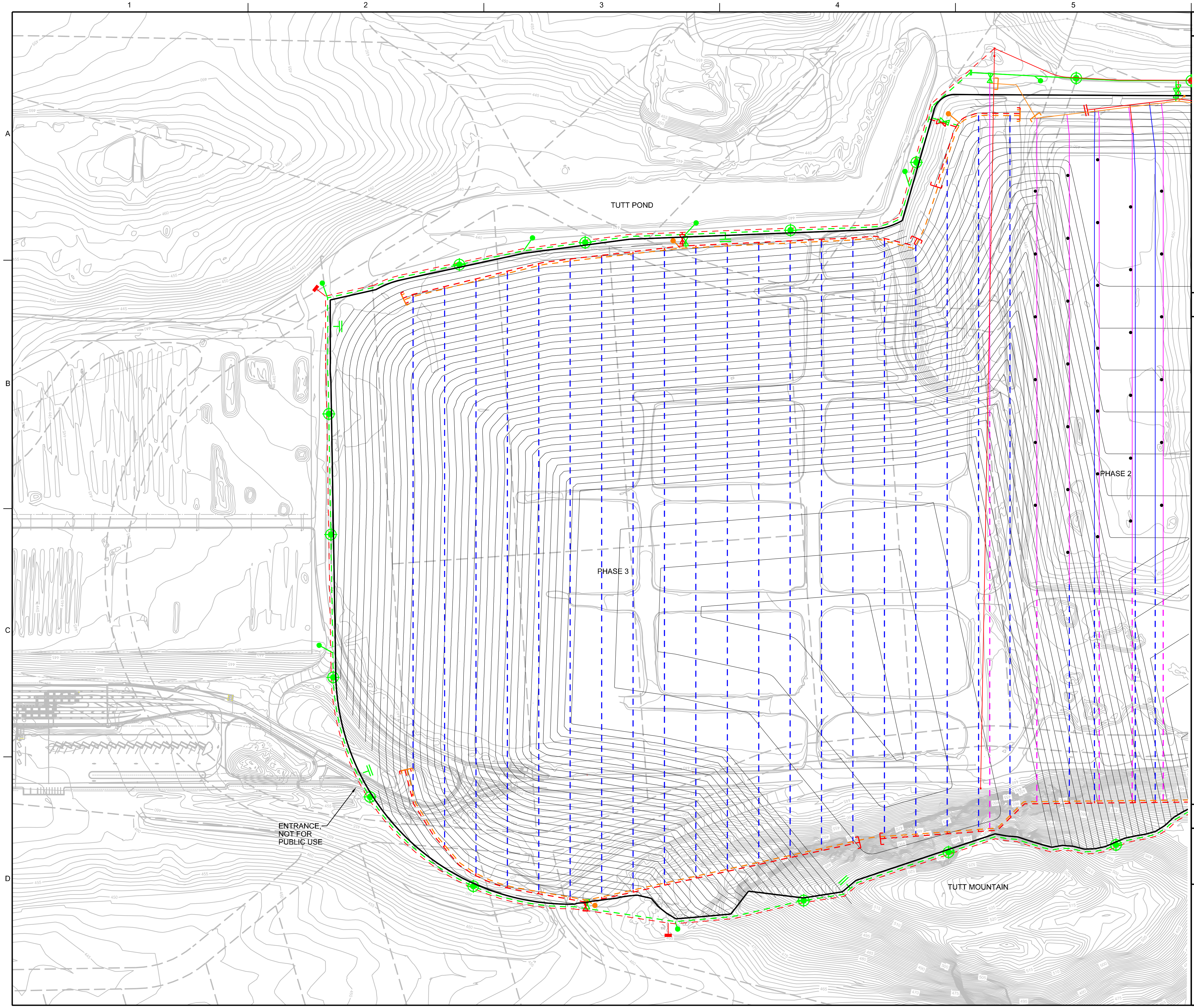

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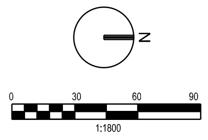

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Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

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AREA A

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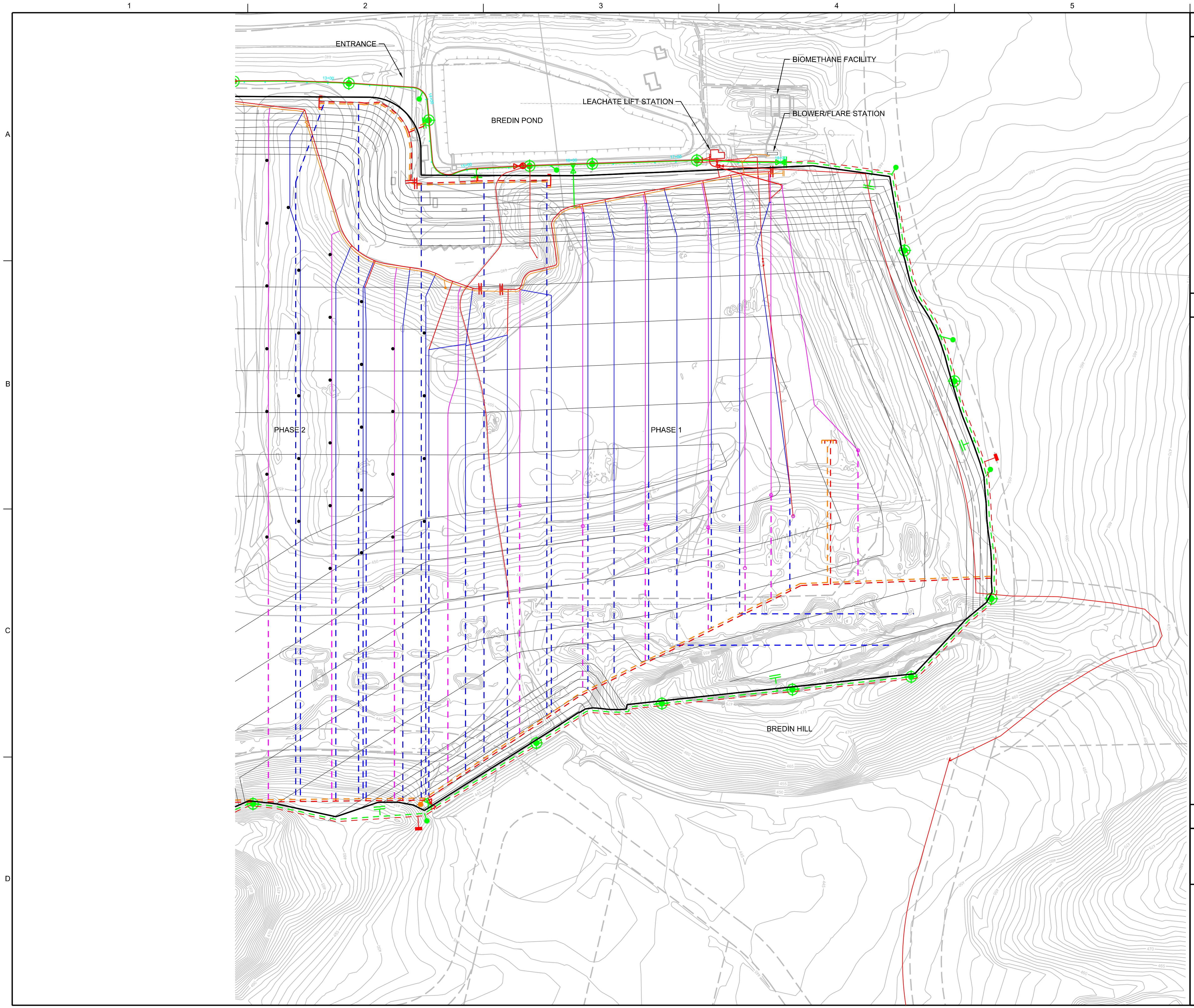
SHEET	533



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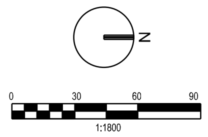

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Kelowna, British Columbia

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AREA B

DATE DEC 2014
PROJ 653224
DWG C-1B
SHEET

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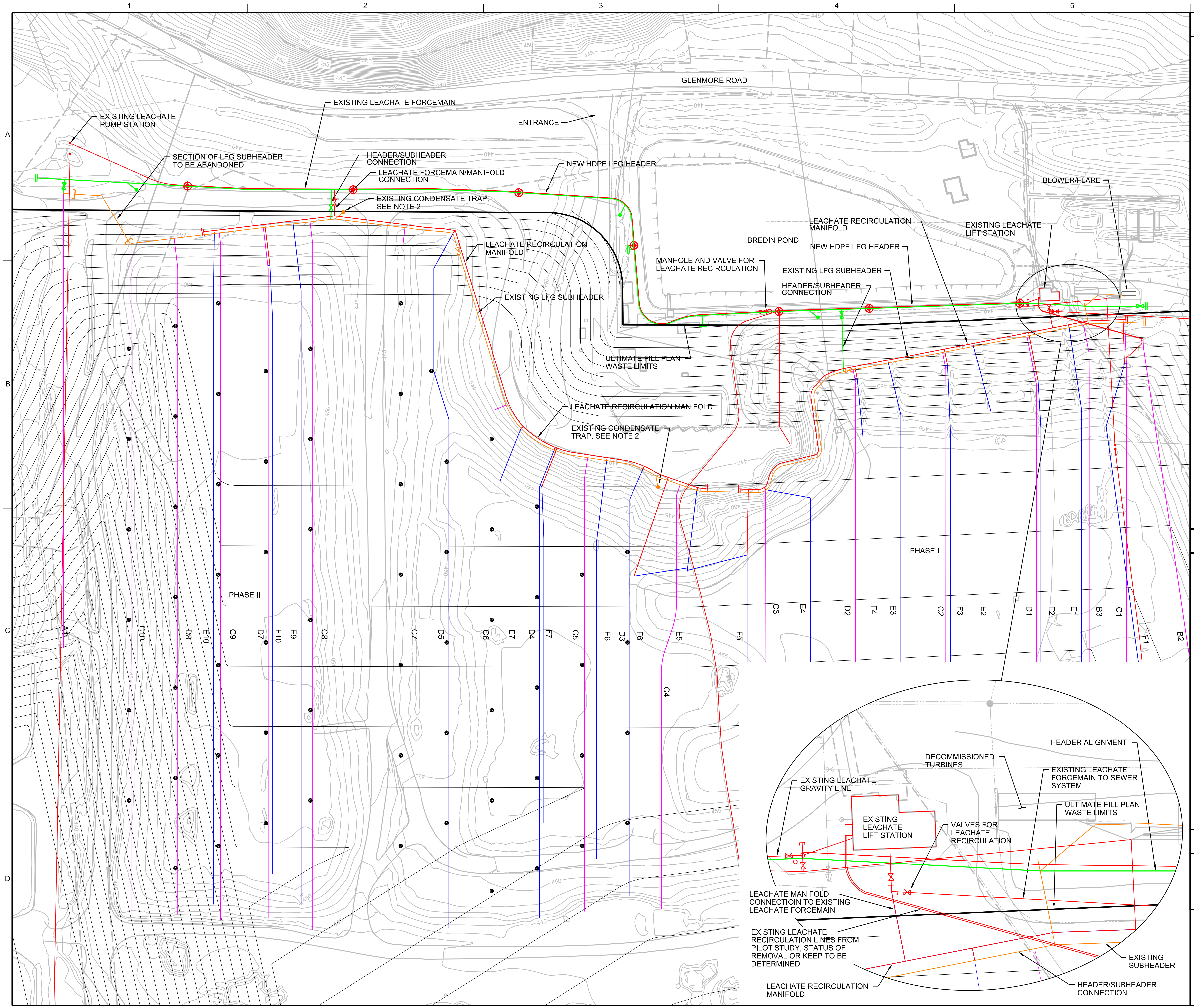

SHEET NOTES

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
450	CONTOUR FROM 2012 AERIAL TOPO
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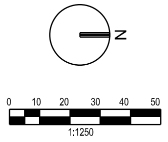


NO.	DATE	REVISION	BY	APVD
1	03/2015	FINAL PRELIMINARY DESIGN DRAWINGS	EB	RL
0	12/2014	DRAFT PRELIMINARY DESIGN DRAWINGS	EB	RL

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

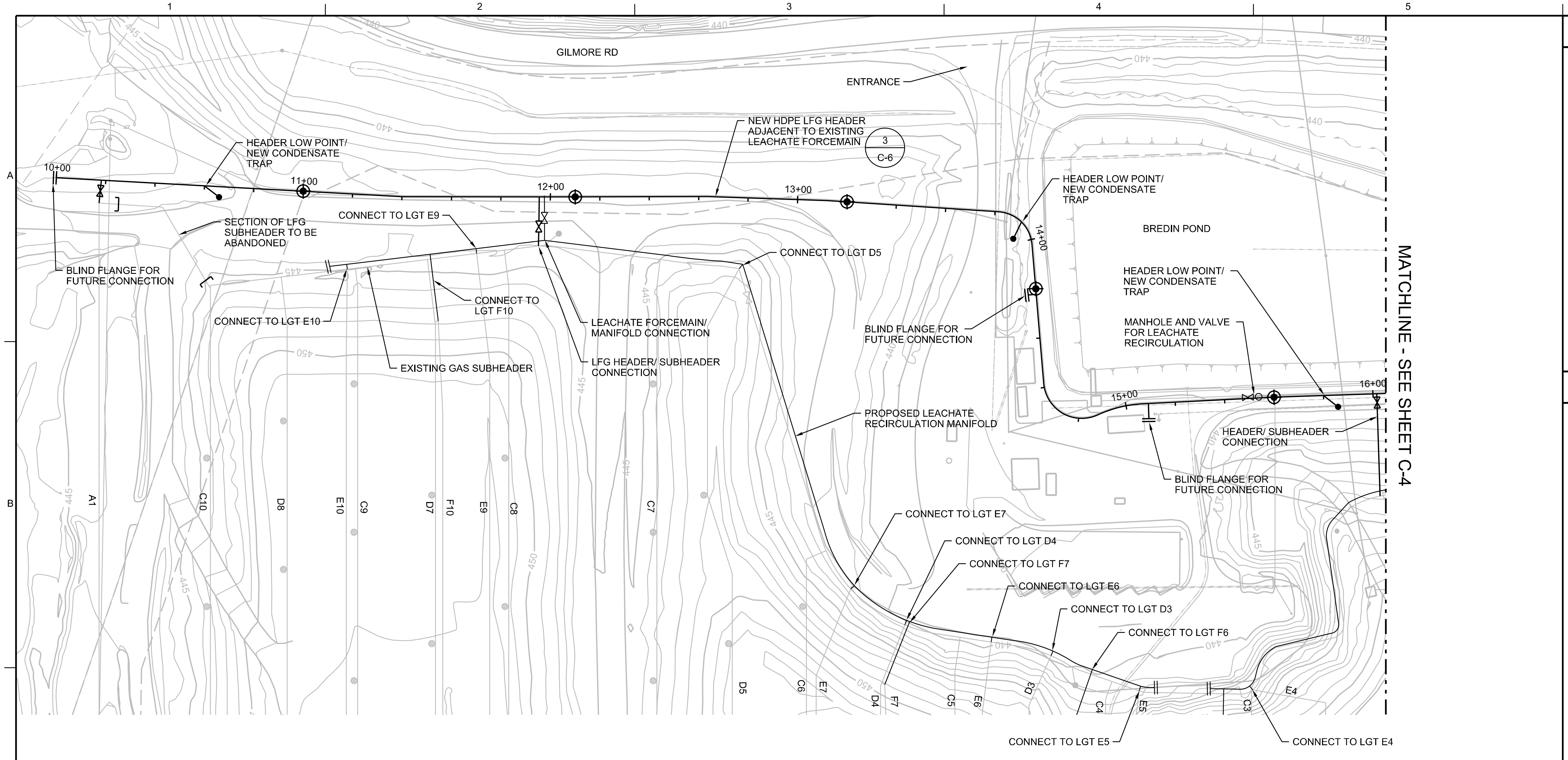
CH2MHILL®

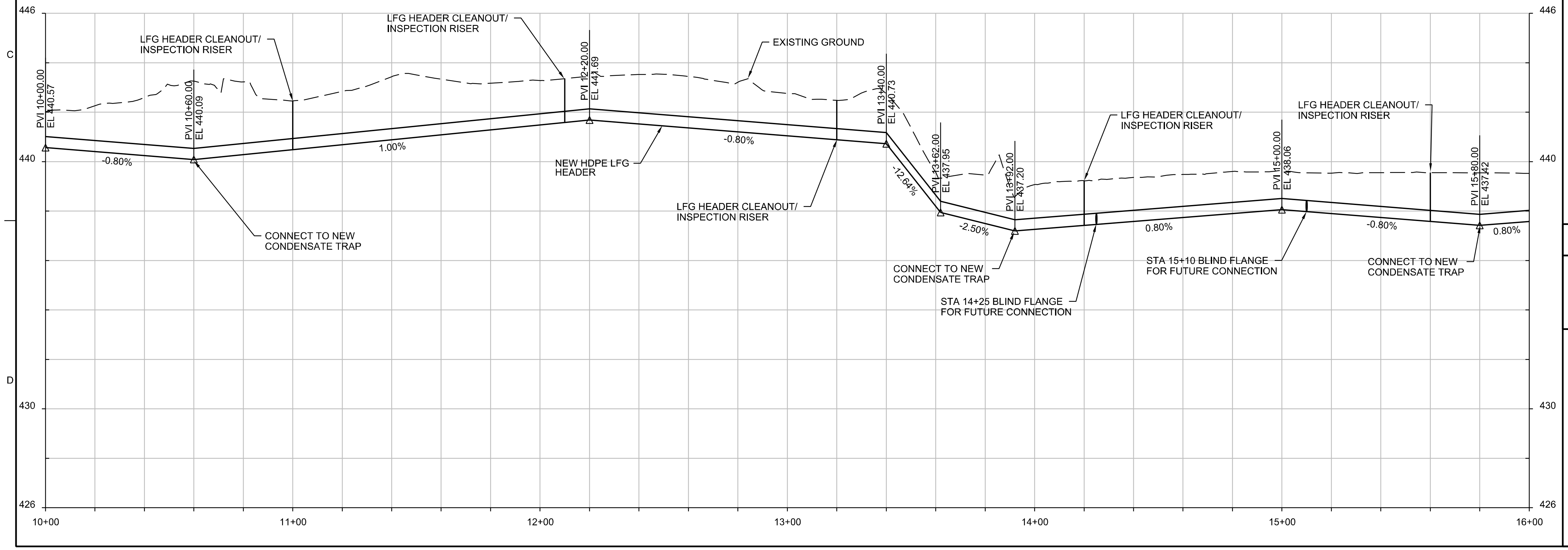
CIVIL

ENLARGED SITE PLAN
2015 LFG & LEACHATE DESIGN

DATE	DEC 2014
PROJ	653224
DWG	C-2
SHEET	535

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

N

0 25 50 100

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

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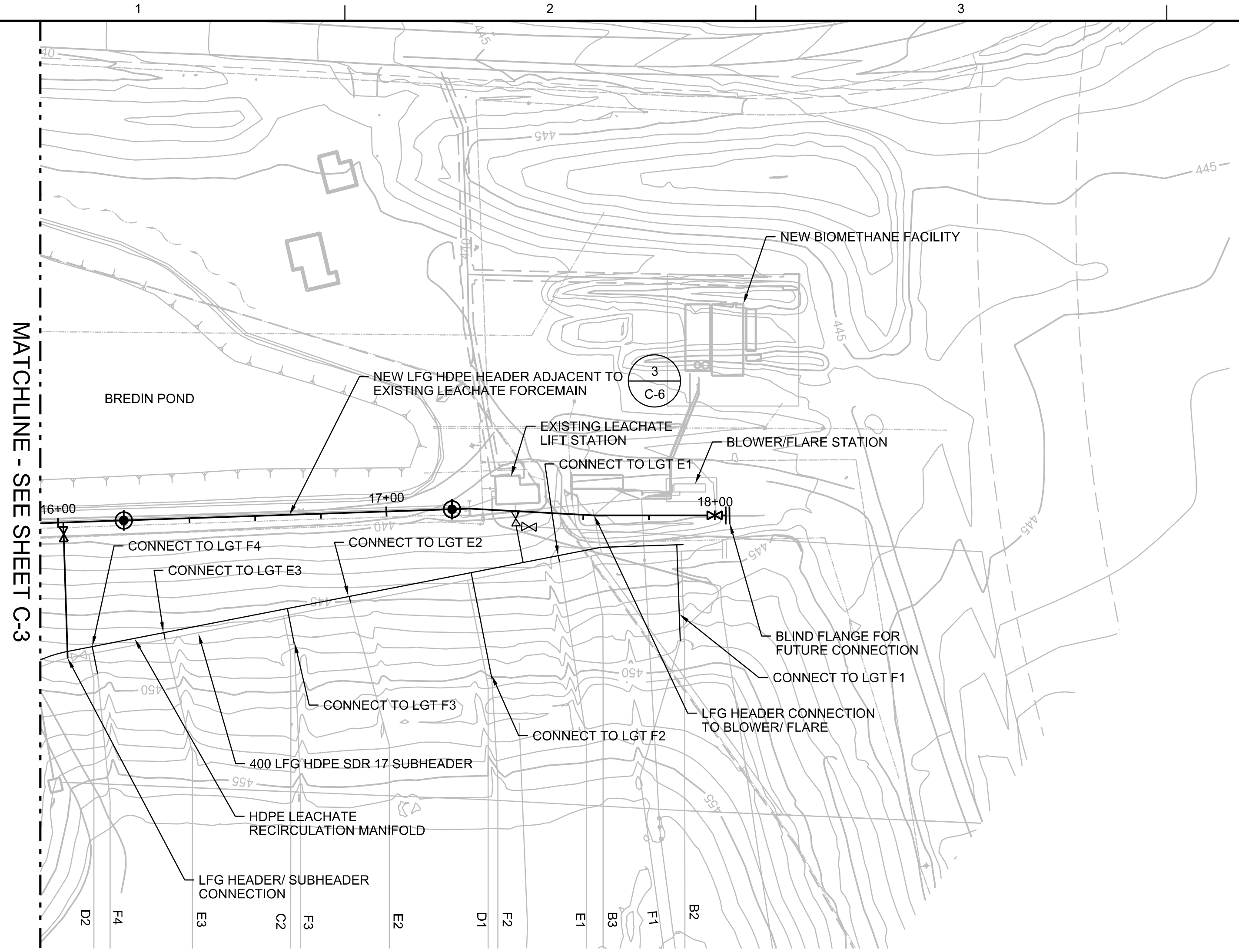
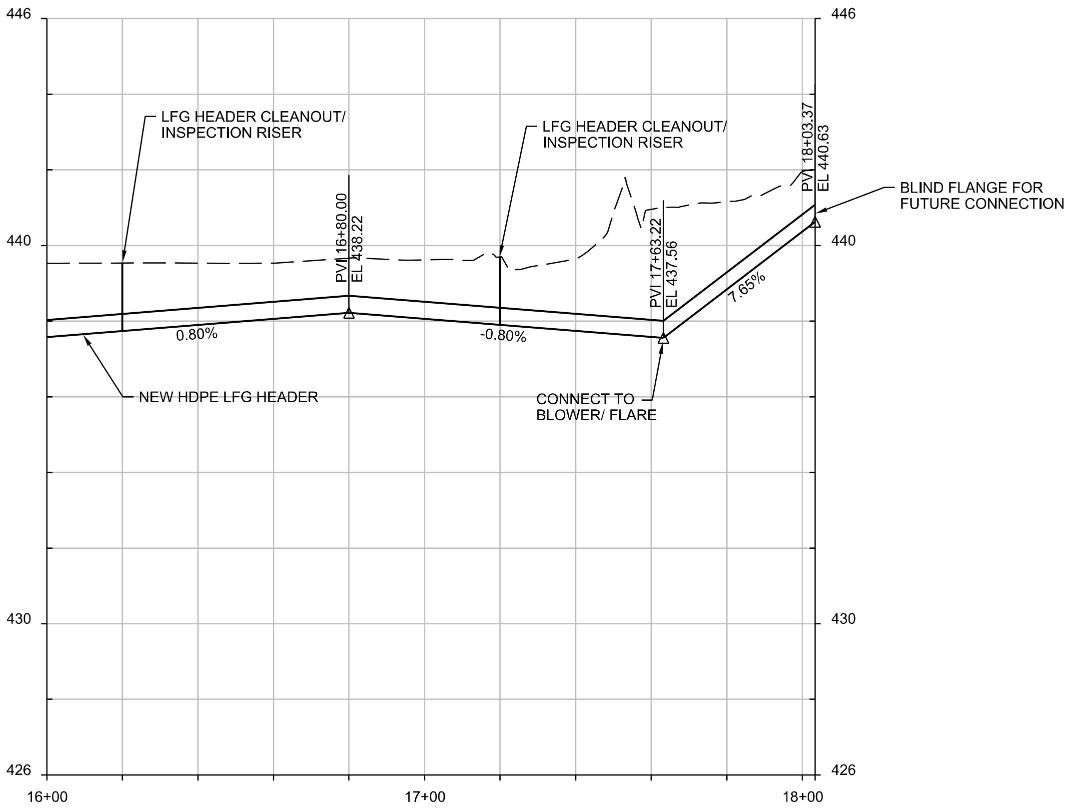
CIVIL

LFG HEADER PLAN AND PROFILE STA 10+00 TO STA 16+00

DATE DEC 2014
PROJ 653224
DWG C-3
SHEET 536

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

N

0 25 50 100

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	DR	CHK	APVD
E BUTTERFIELD	B BUTTERFIELD	T PYLE	R LI

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Leachate Recirculation and LFG Header Design
Glenmore Landfill
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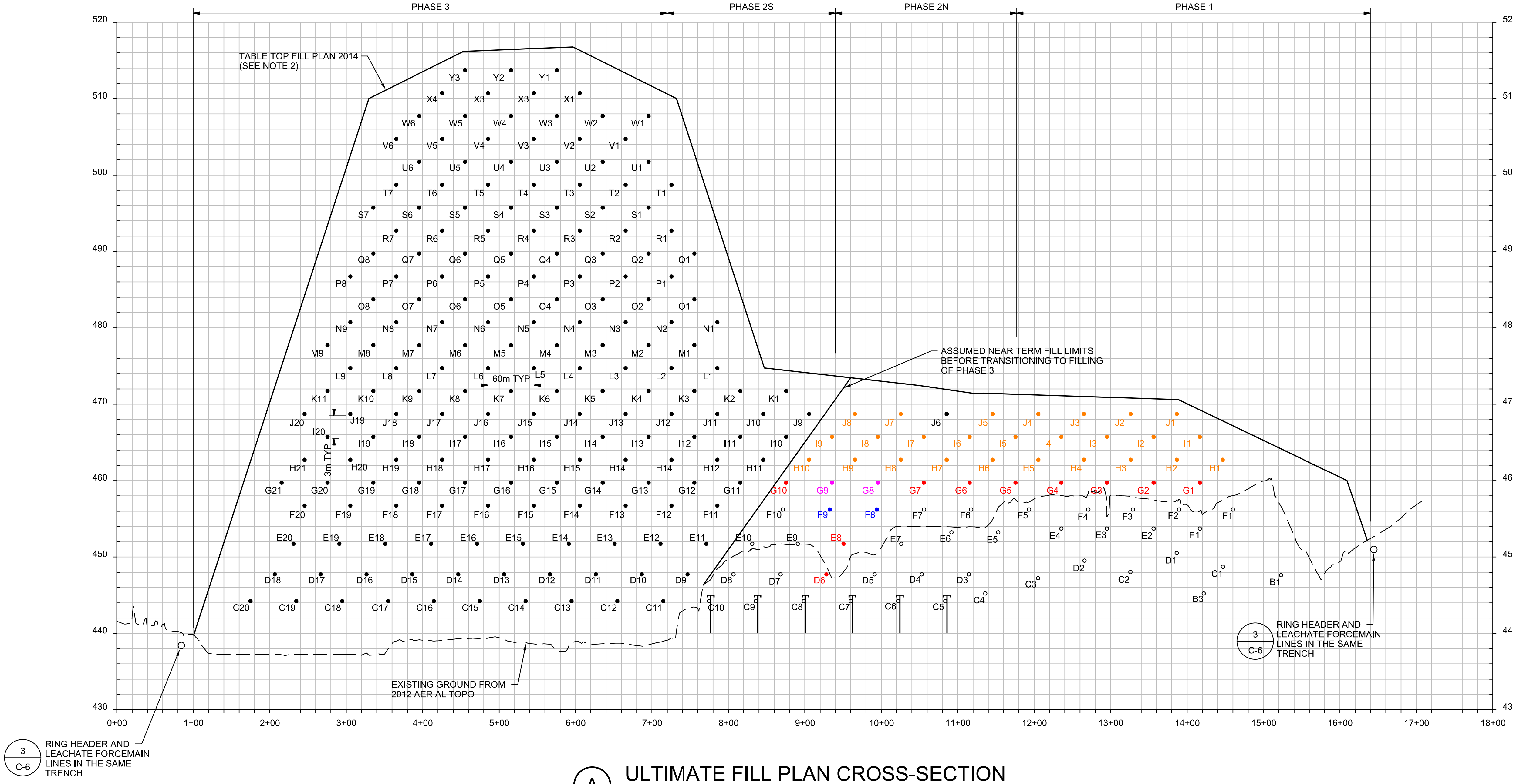
CIVIL
LFG HEADER PLAN AND PROFILE
STA 16+00 TO END

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).

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
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Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

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CIVIL
ULTIMATE FILL PLAN CROSS-SECTION

DATE DEC 2014
PROJ 653224
DWG C-5
SHEET

FILENAME: 005-C-3001_653224.dgn
PLOT DATE: 2015\03\20
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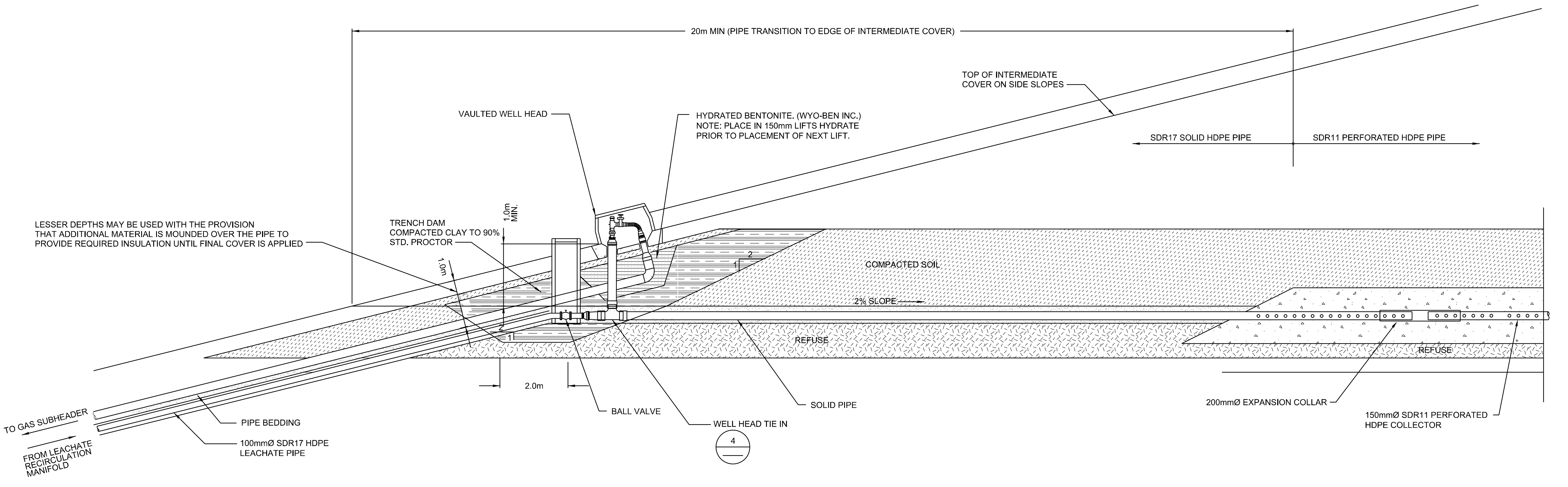
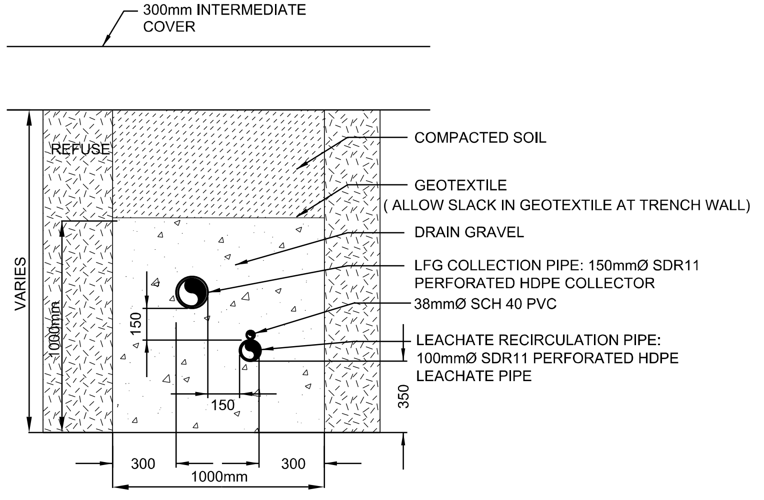


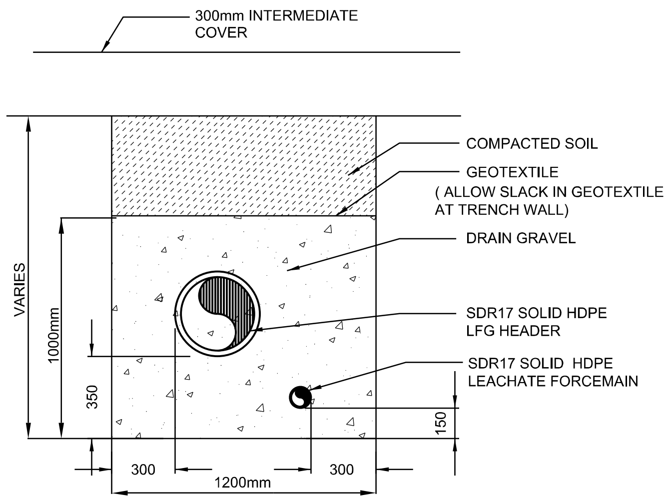
1 LGT/SUBHEADER/LEACHATE RECIRCULATION CONNECTION

NTS



2 TWINNED LGT AND LEACHATE RECIRCULATION LINES IN REFUSE

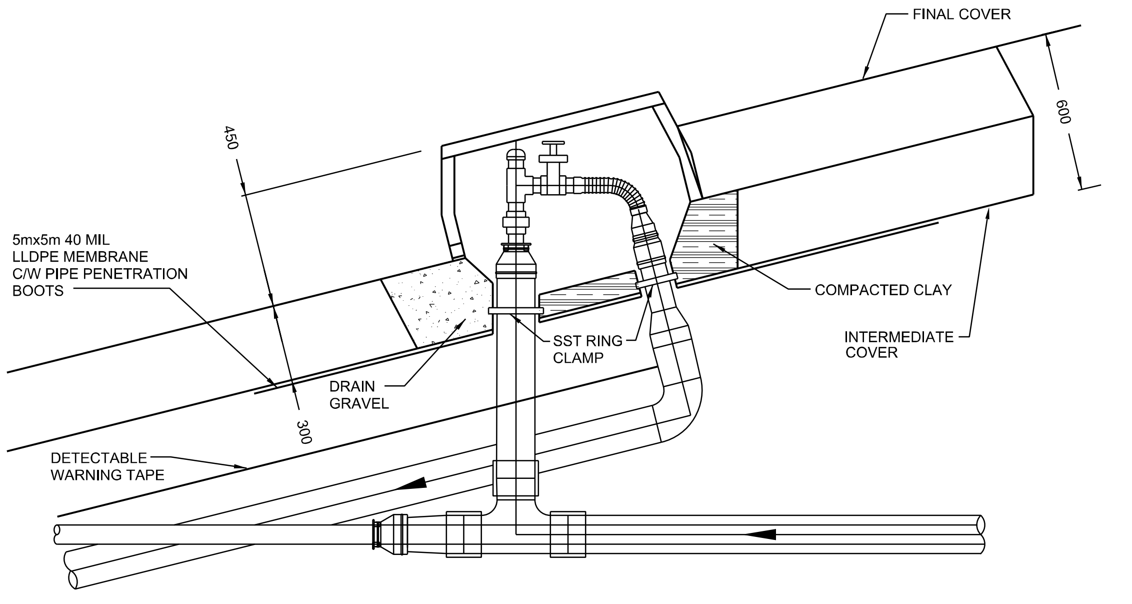
NTS



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 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

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CIVIL
DETAILS

DATE DEC 2014
PROJ 653224
DWG C-6
SHEET 539

FILENAME: 005-C-5001_653224.dgn
PLOT DATE: 2015\03\24
PLOT TIME: 2:07:05 PM

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)	

				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)
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

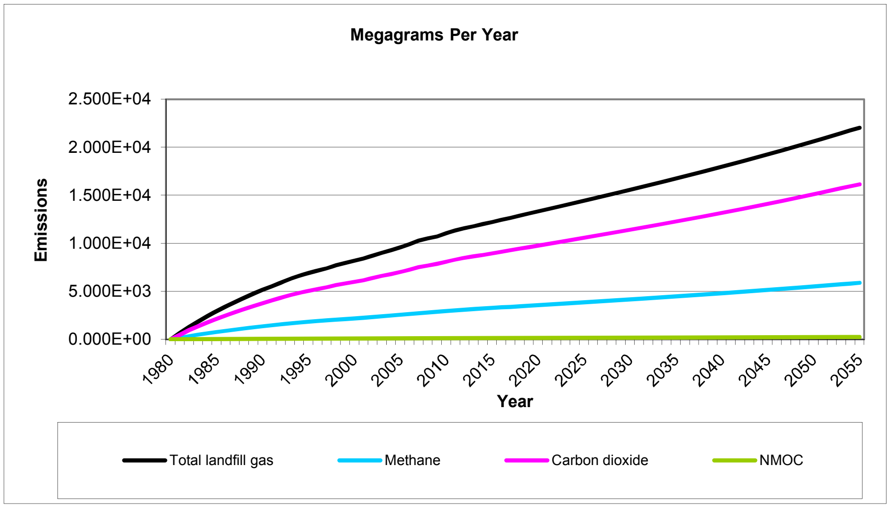
Pollutant Parameters

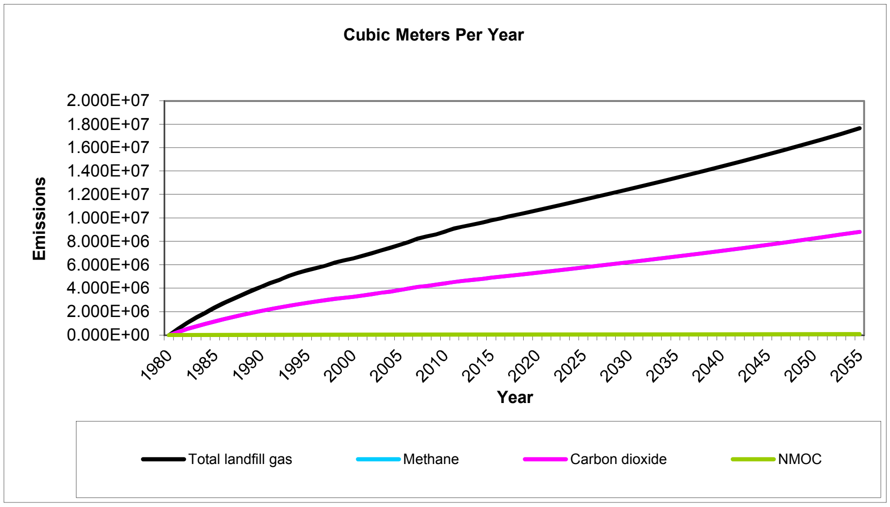
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl 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		

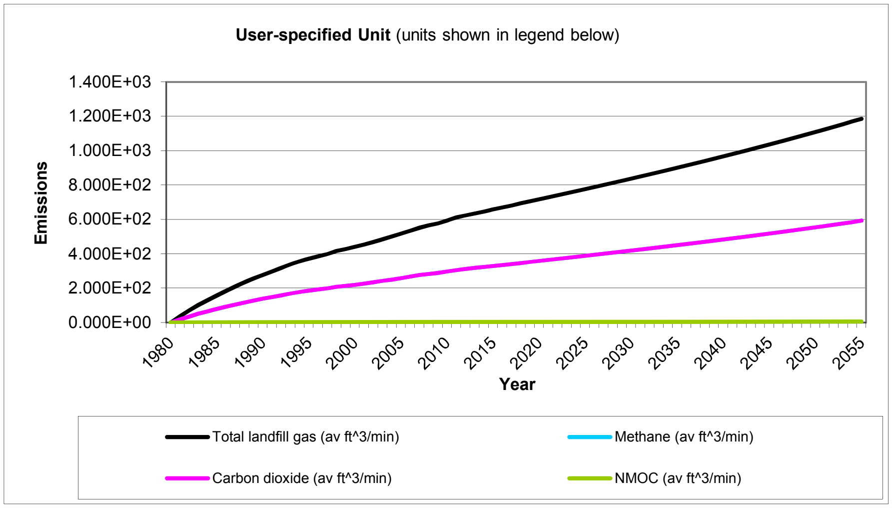
Pollutant Parameters (Continued)

		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_{CH_4} = 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

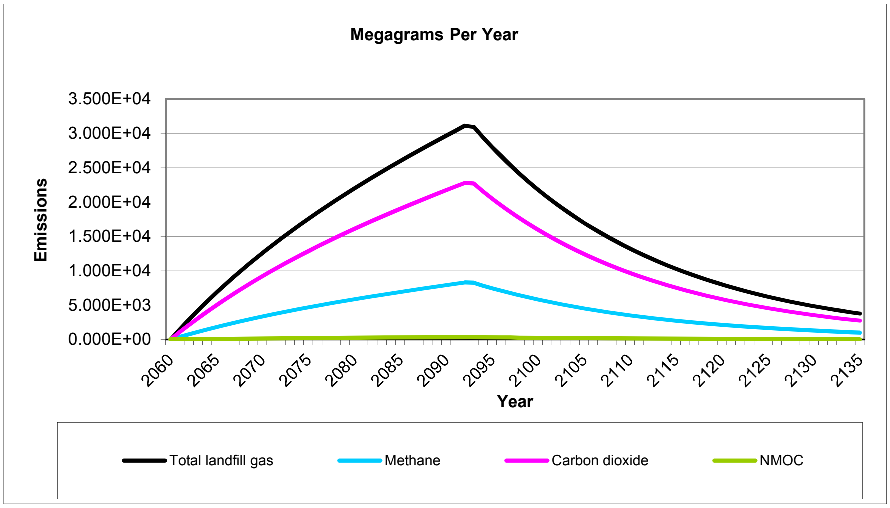
Pollutant Parameters

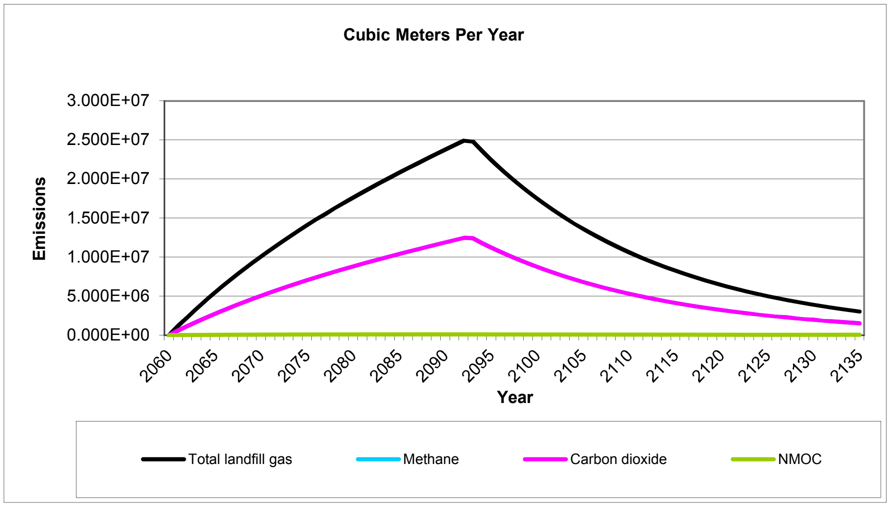
	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl 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		

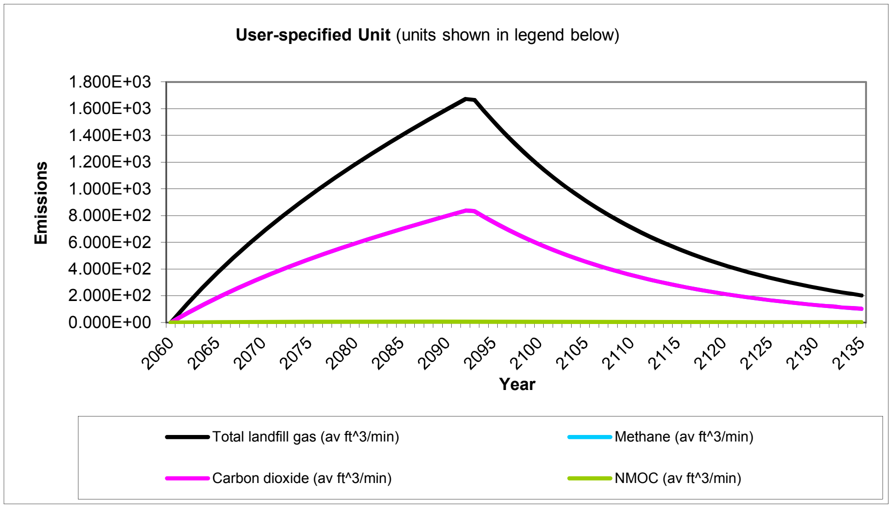
Pollutant Parameters (Continued)

	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
3.500E+04
3.000E+04
2.500E+04
2.000E+04
1.500E+04
1.000E+04
5.000E+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
3.000E+07
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+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)
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
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	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 - Version 3.02

US EPA Office of Research and Development

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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

EPA

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		

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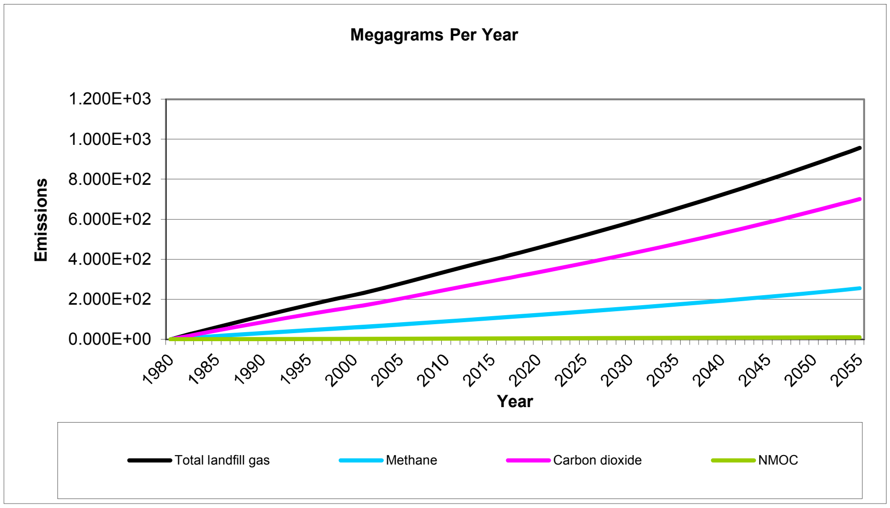
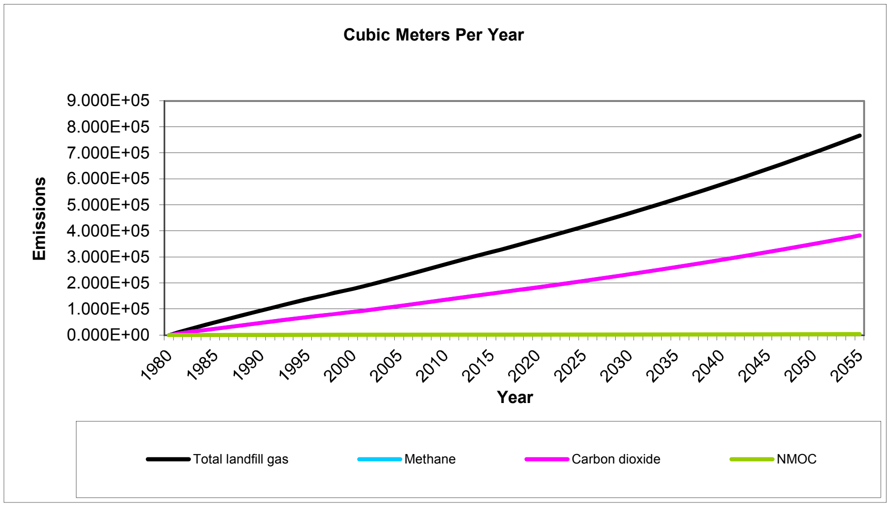
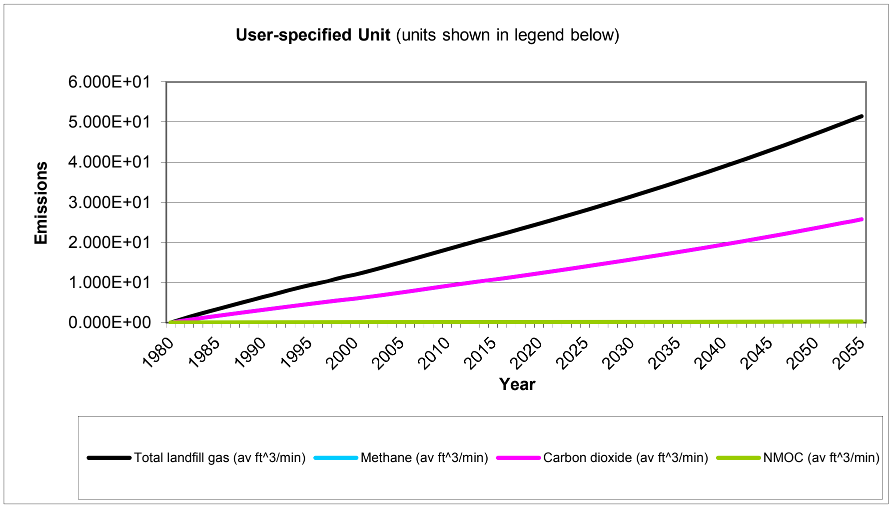
Graphs


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

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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	**0.010**	*$year^{-1}$*
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

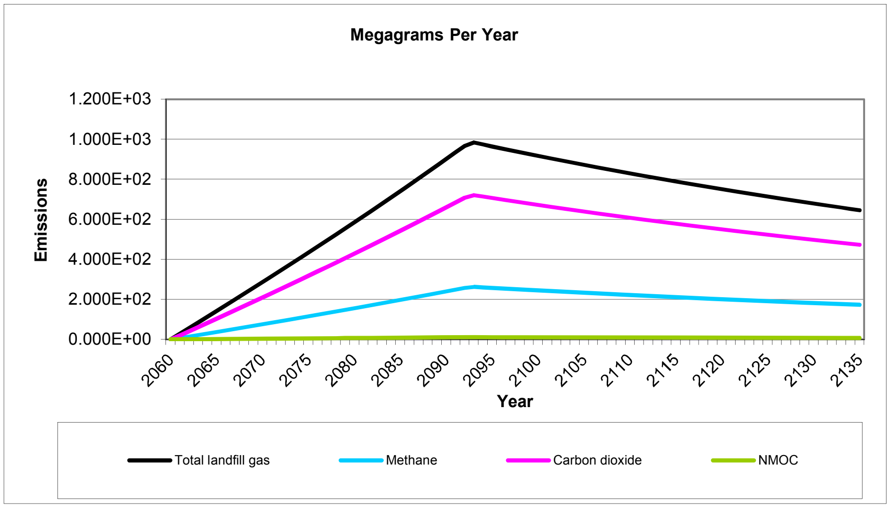
Pollutant Parameters

	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
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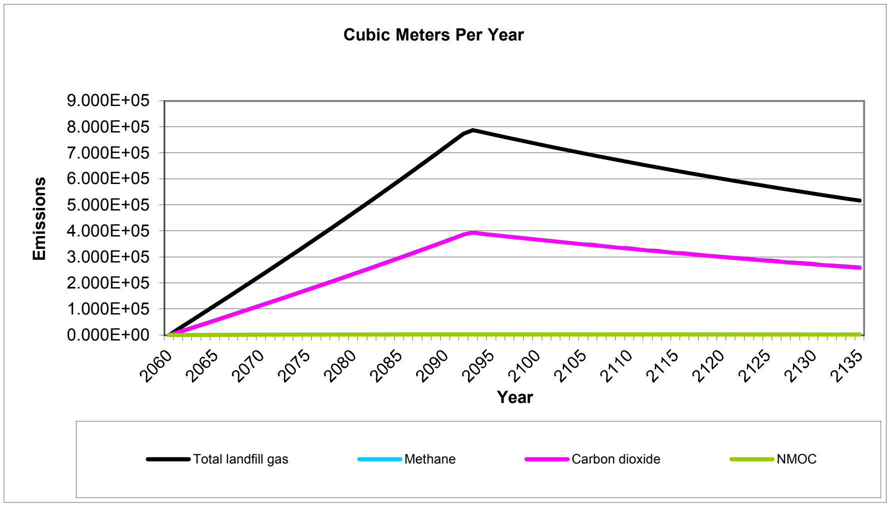
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
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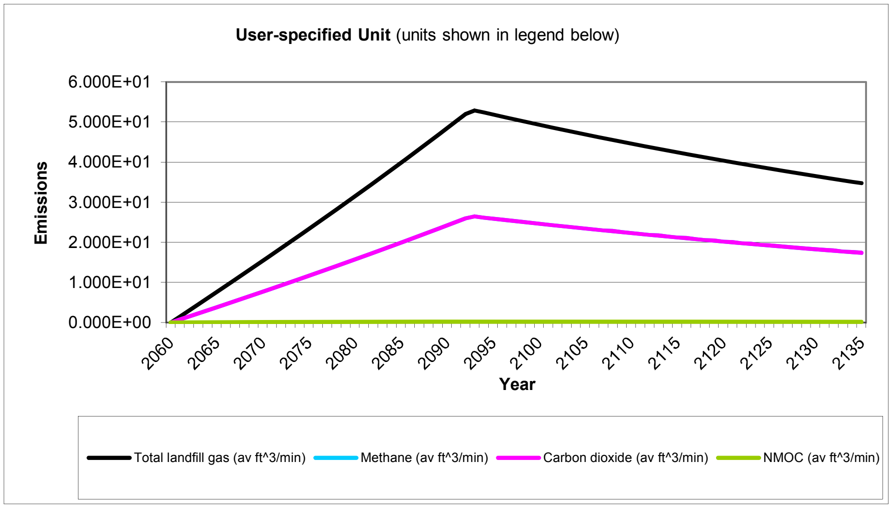
8.000E+05
7.000E+05
6.000E+05
5.000E+05
4.000E+05
3.000E+05
2.000E+05
1.000E+05
0.000E+00
Emissions
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


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

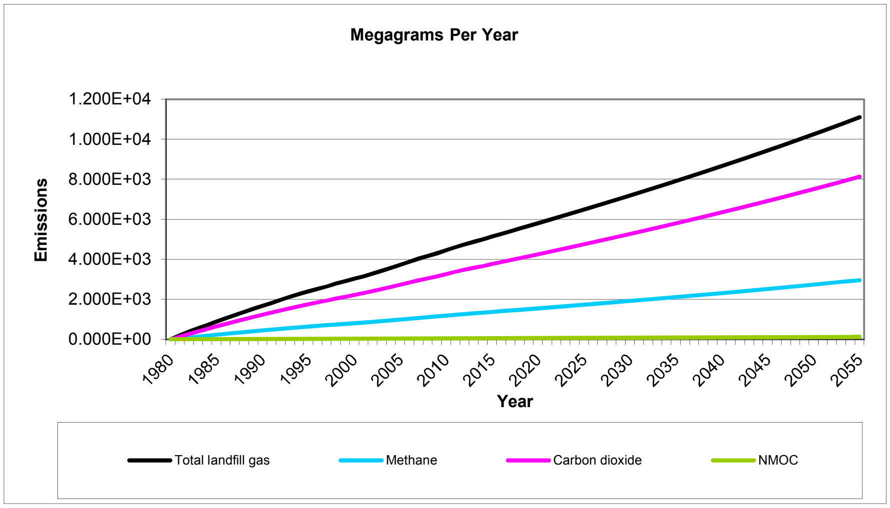
Pollutant Parameters

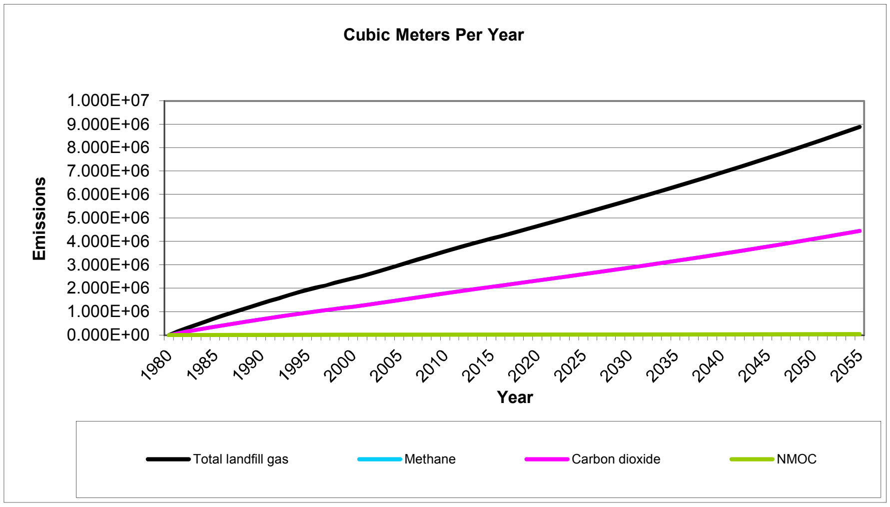
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl 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		

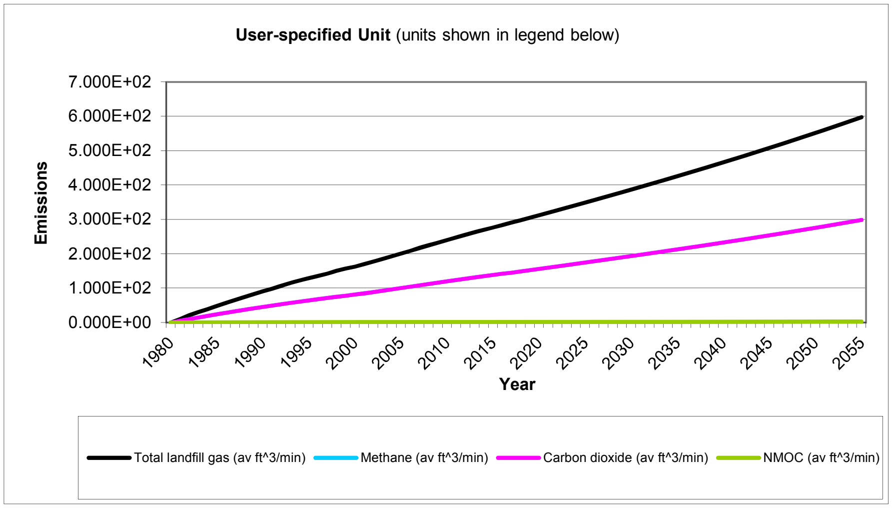
Pollutant Parameters (Continued)

		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
Emissions
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+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
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
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
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+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	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:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k L_o \left(\frac{M_i}{10} \right) e^{-k t_{ij}}$$

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

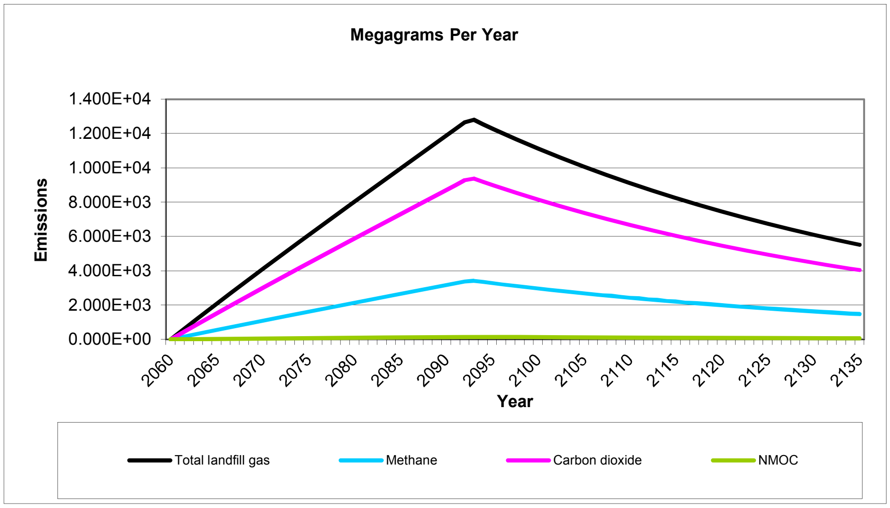
Pollutant Parameters

	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		

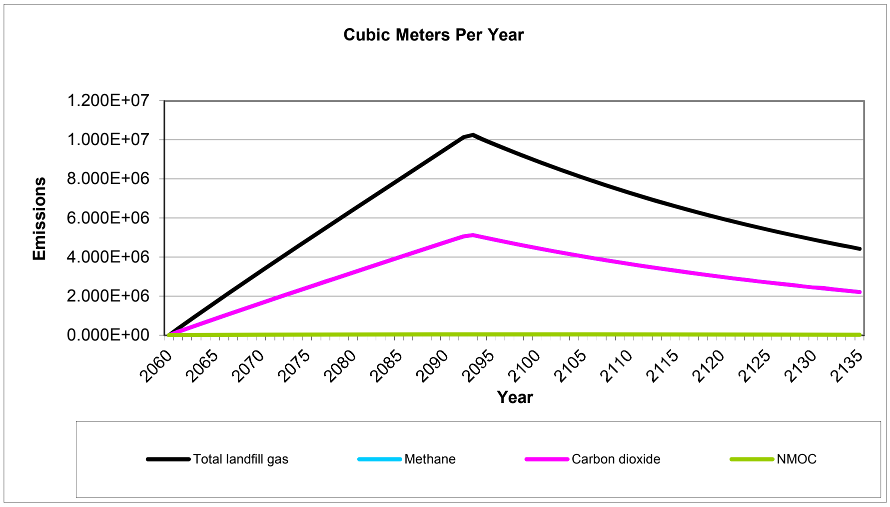
Pollutant Parameters (Continued)

	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		

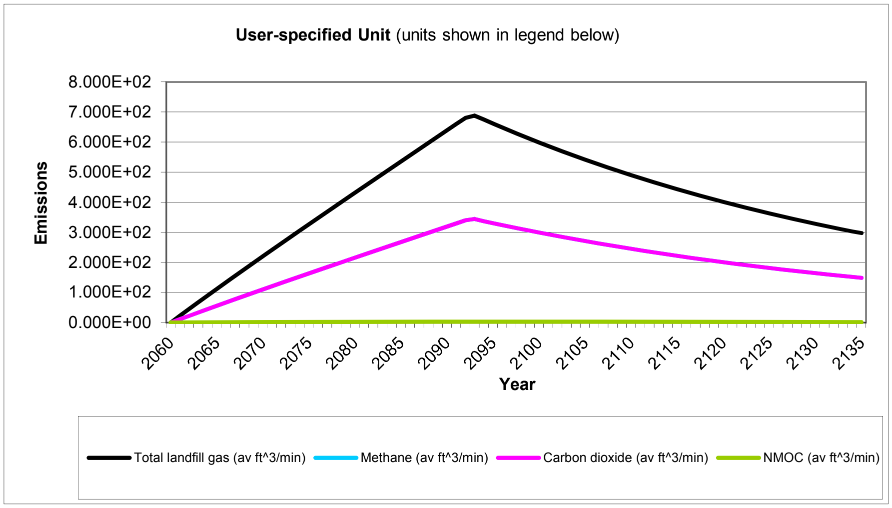
Graphs



Megagrams Per Year
Emissions
1.400E+04
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+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
1.200E+07
1.000E+07
8.000E+06
6.000E+06
4.000E+06
2.000E+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
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
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

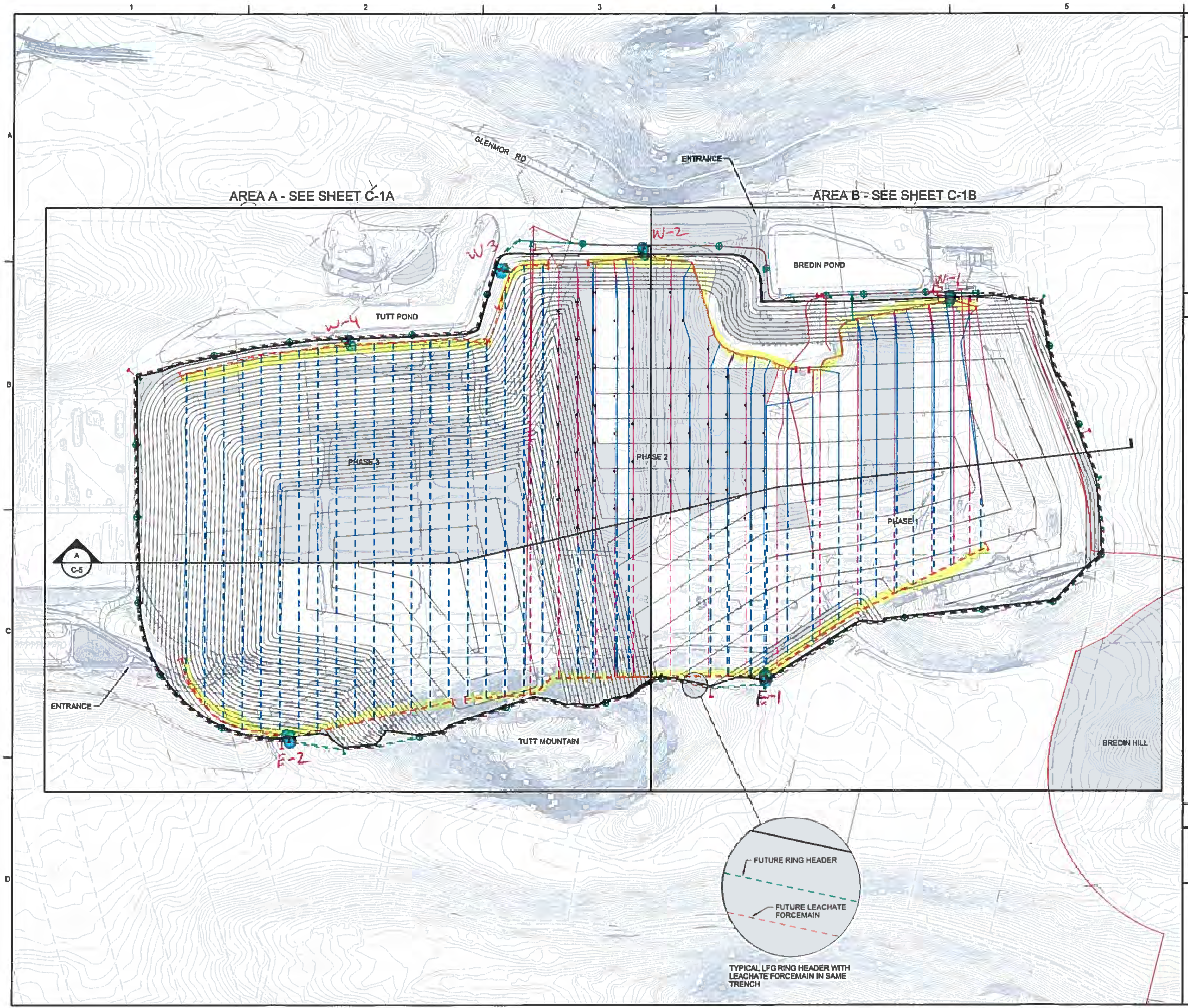
*May require a small section of 24" pipe if in counter-current flow regime here

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															
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	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									



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
- 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

N

0 50 100 150

NO.	DATE	REVISION	BY	APVD

DSGN E BUTTERFIELD
DR B BUTTERFIELD
CHK T PYLE
APVD R LI

CH2MHILL.

CITY OF KELOWNA

Leachate Recirculation and LFG Header Design
Glenmore Landfill
City of Kelowna
Kelowna, British Columbia

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\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

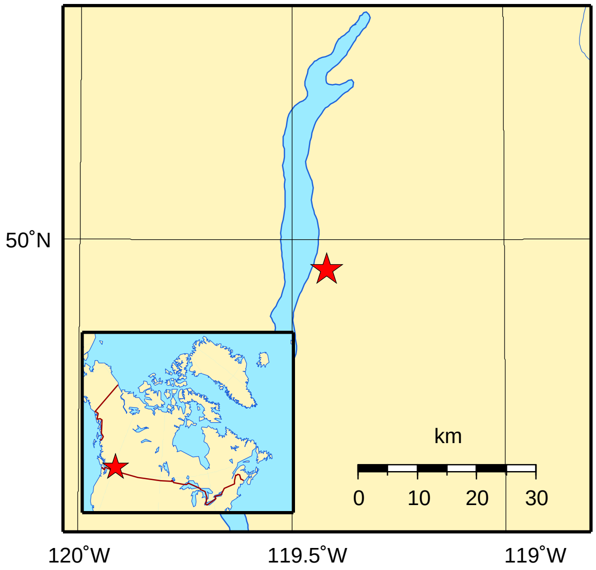
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

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

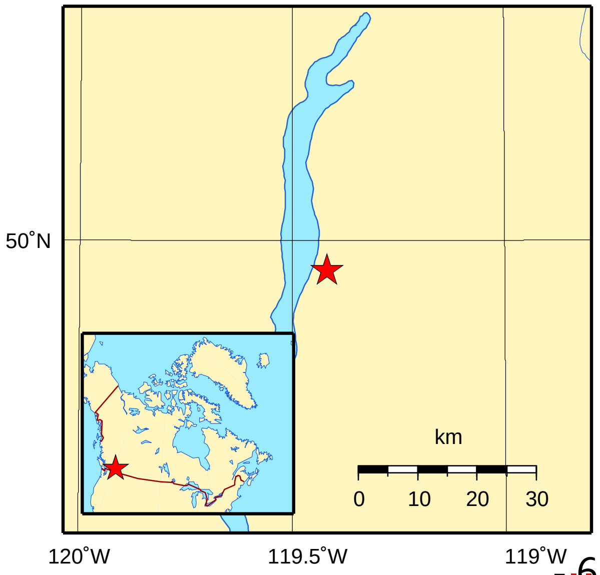
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

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

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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

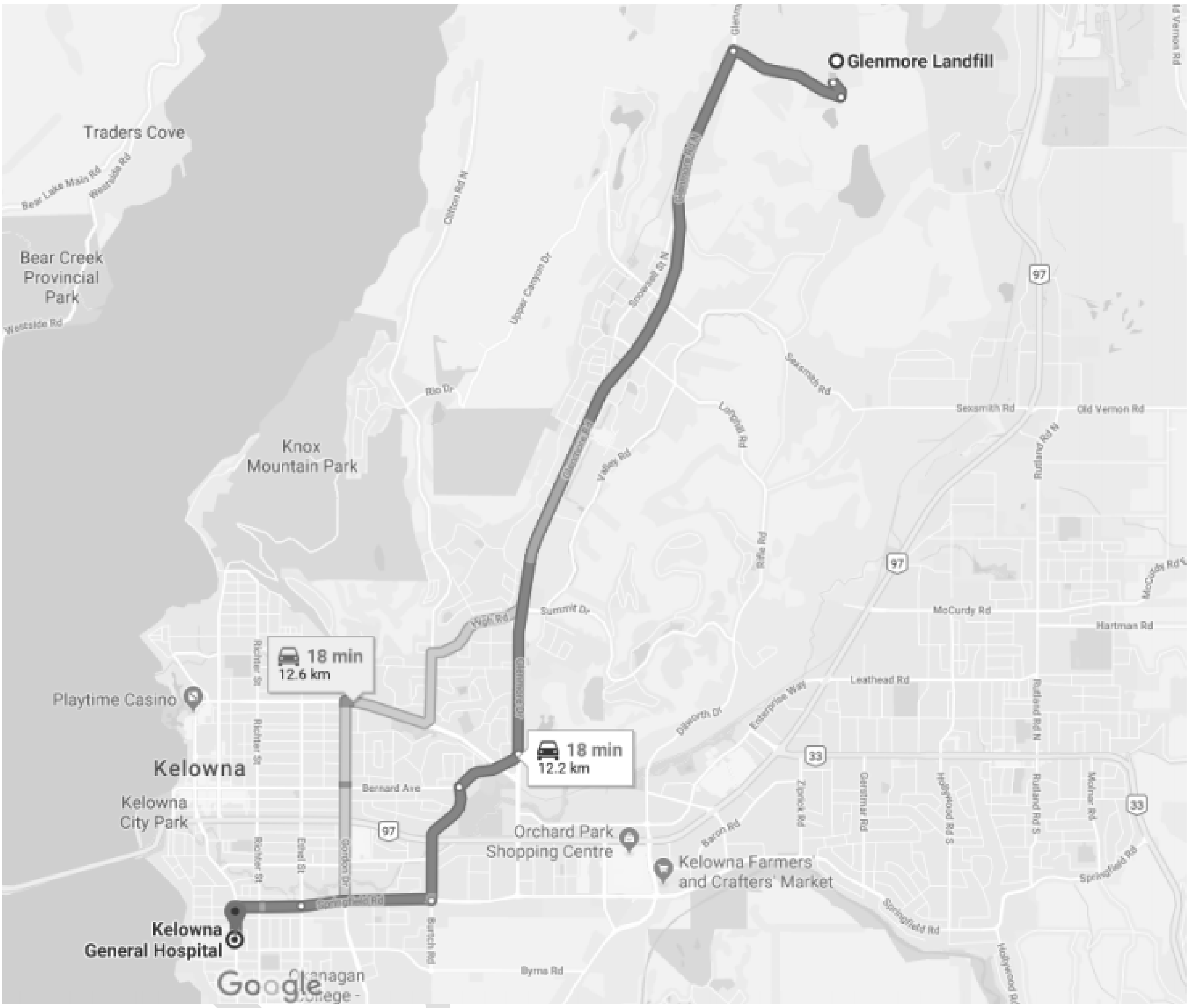
Provincial Emergency Program (PEP), 24 hour Spill Reporting:	1-800-663-3456
MOE Regional Waste Manager	250-490-8200
Ministry of Forest, Lands and Natural Resources	250-490-8200
Fire Department	250-469-8801
Forest Fire Reporting	1-800-663-5555 *5555 Cellular

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.

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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:

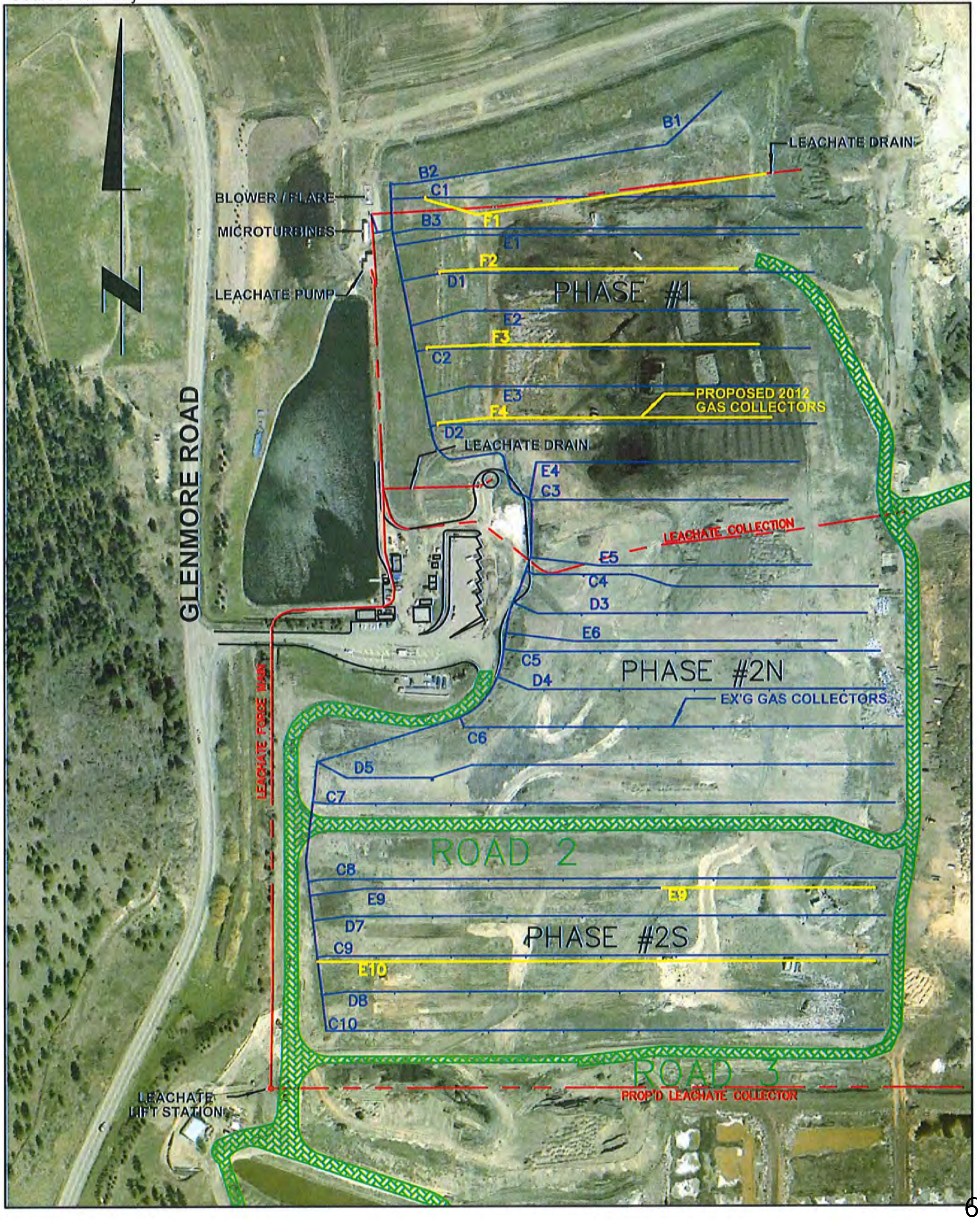
C.J. (Chuck) Smith, P.Eng .

Appendix A
Phase 1 and 2 Existing Conditions Drawings

GAS COLLECTION SYSTEM

Source: The City of Kelowna

As of December 2011



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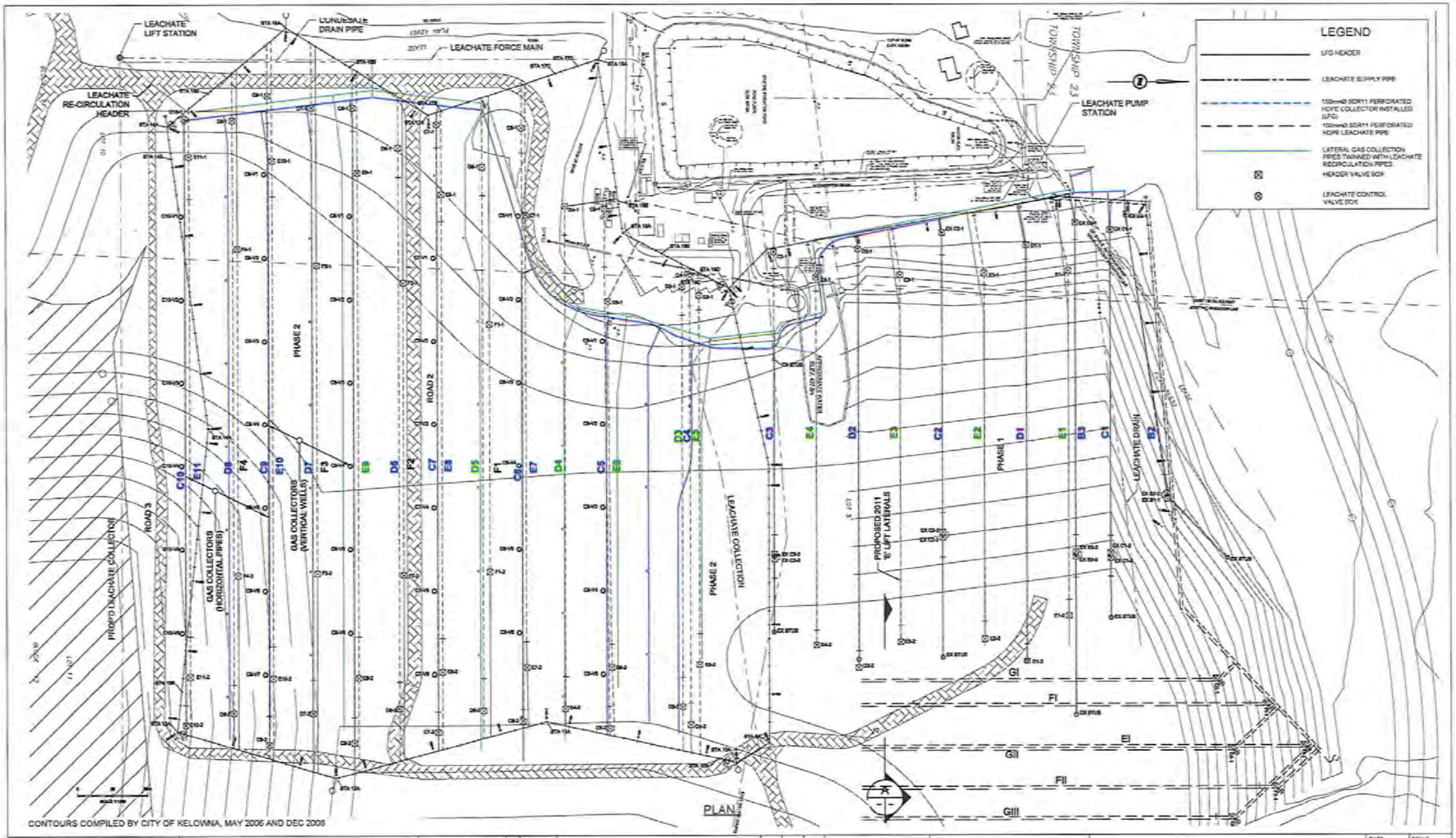


CONTOURS COMPILED BY CITY OF KELOWNA, MAY 2006 AND DEC 2006

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	21/02/2011	ISSUED FOR CLIENT REVIEW	MS	RL	

ENGINEER

CH2MHILL

CITY OF KELOWNA

PHASE 1 / PHASE 2 LFG WELLFIELD AND PIPING
EXISTING CONDITIONS
HEADER PLAN

DATE	SCALE
2011.02.21	AS SHOWN
DRAWN	REV. NO.
SES	△

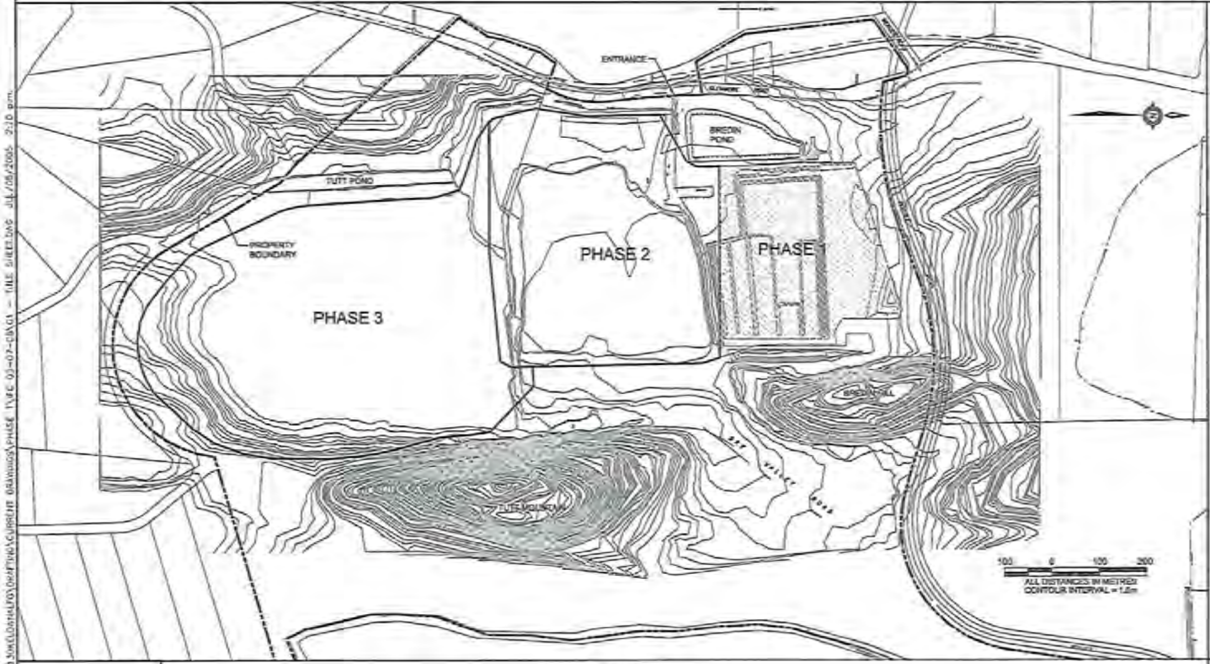
PROJECT NO.
417808

DRAWING NO.
FIGURE 1

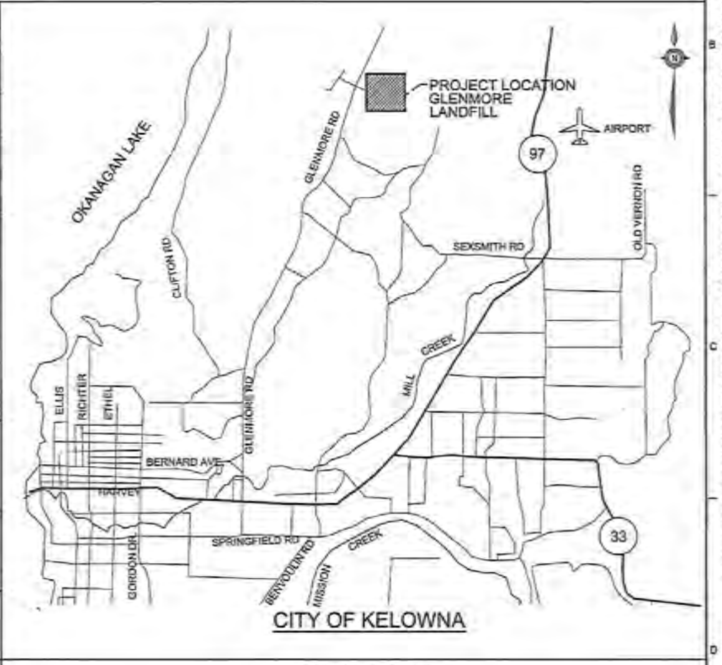
Appendix B
Phase 1 Detailed Design Drawings

CITY OF KELOWNA
GLENMORE LANDFILL

PHASE 1 NORTH LANDFILL GAS COLLECTION SYSTEM
REVISIONS TO DEC 2002 TENDER SET - JULY 2005



VICINITY MAP



PROJECT LOCATION

C. J. SMITH

1	05-07-08	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MS
0	05-02-23	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MS
NO.	DATE	REVISION	DSGN	DR	CHK	APVD

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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

CURRENT DRAWINGS\PHASE 1\FIG 03-07-CB\01 - TILE SHEET.DWG JUL/08/2005 2:10 pm

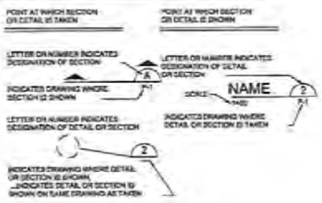
GENERAL LEGEND OF SYMBOLS

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.	GROUND SURFACE ELEV.	SPECS	SPECS
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		
MS	MASS 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 SHED BLDG & SECTIONS

PROFESSIONAL ENGINEER
C. J. SMITH

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RLI	KEW	CG	MB
0	05-02-23	ISSUE FOR 60% REVIEW	RLI	KEW	CG	MB

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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

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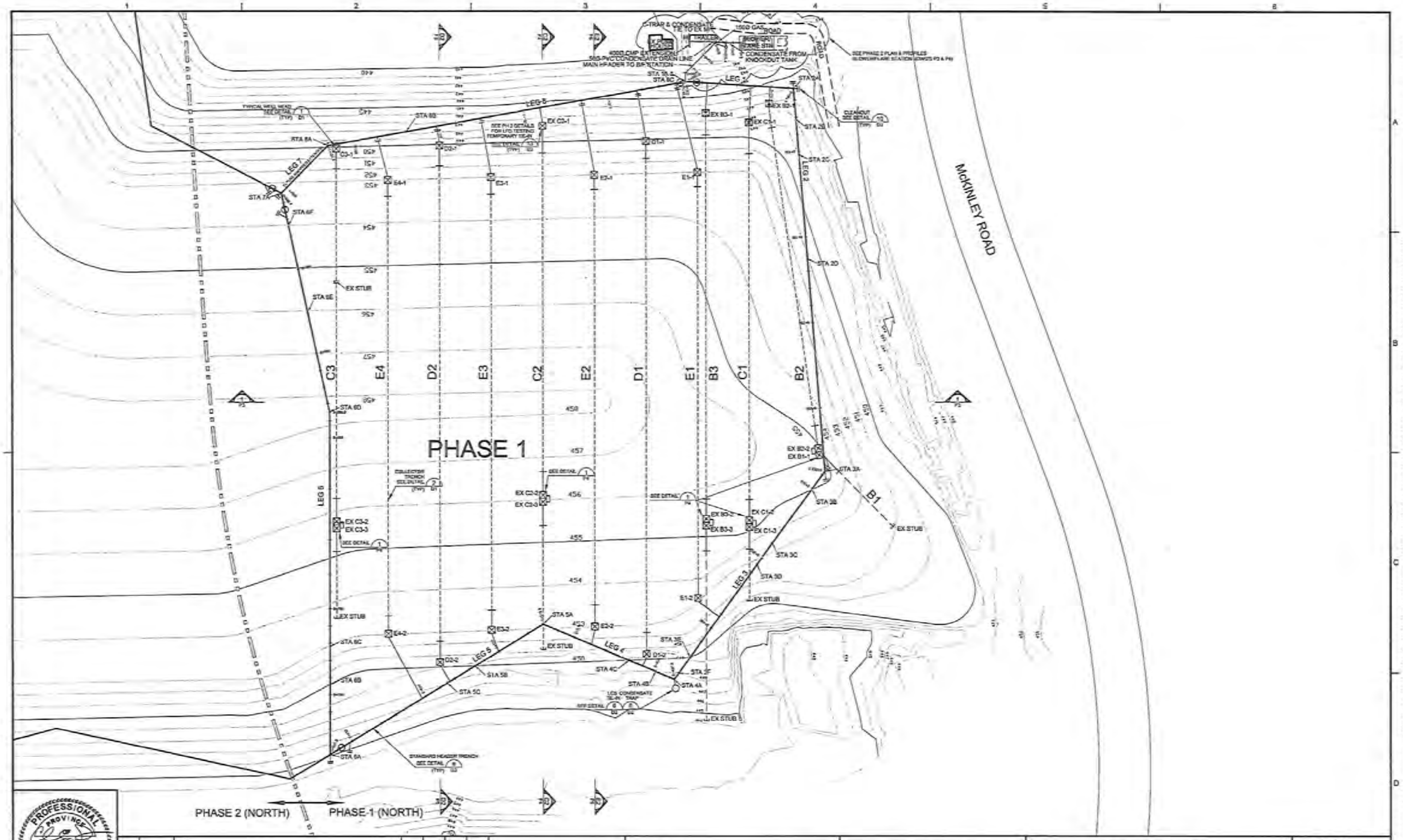

1	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
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NO.	DATE	REVISION	DSGN	DR	CHK	APVD

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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

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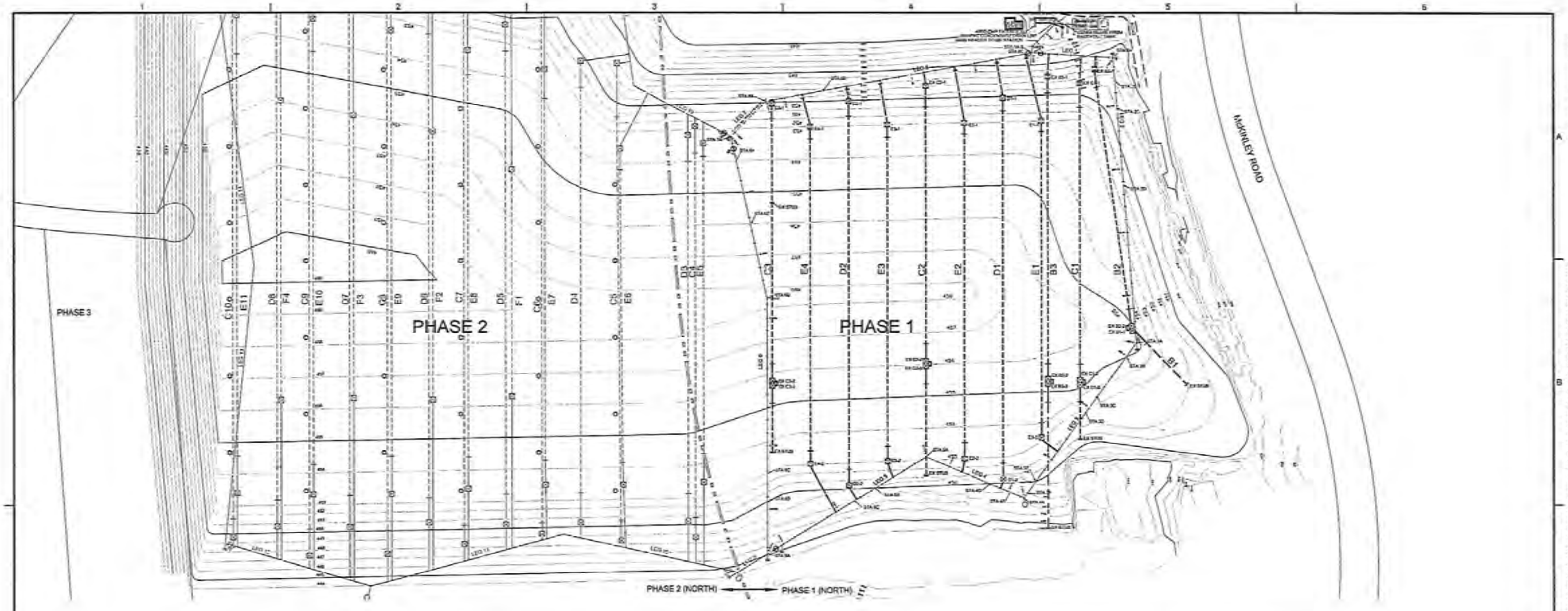

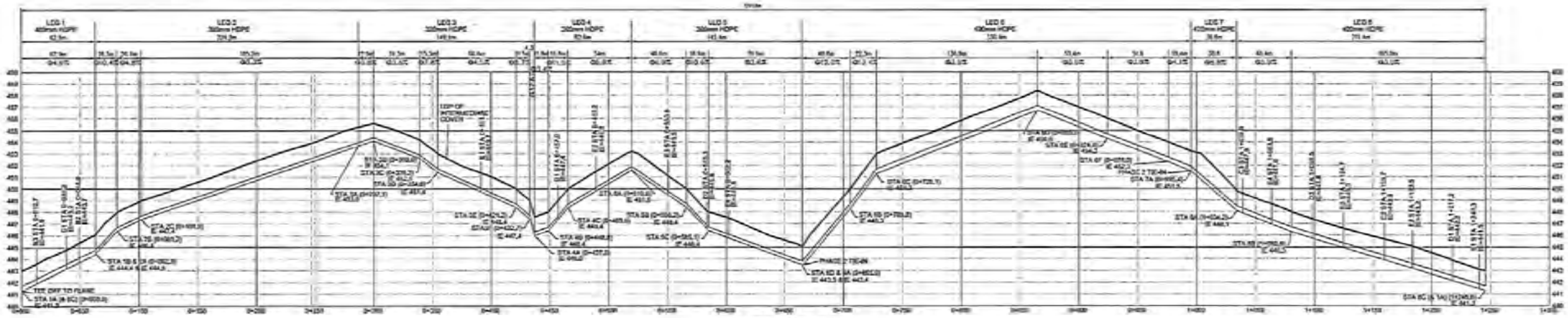

PHASE 1 RING HEADER PROFILE
SCALE: 1:2000 HORIZ.
1:200 VERT.

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-00	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
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PROVINCE OF BRITISH COLUMBIA
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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

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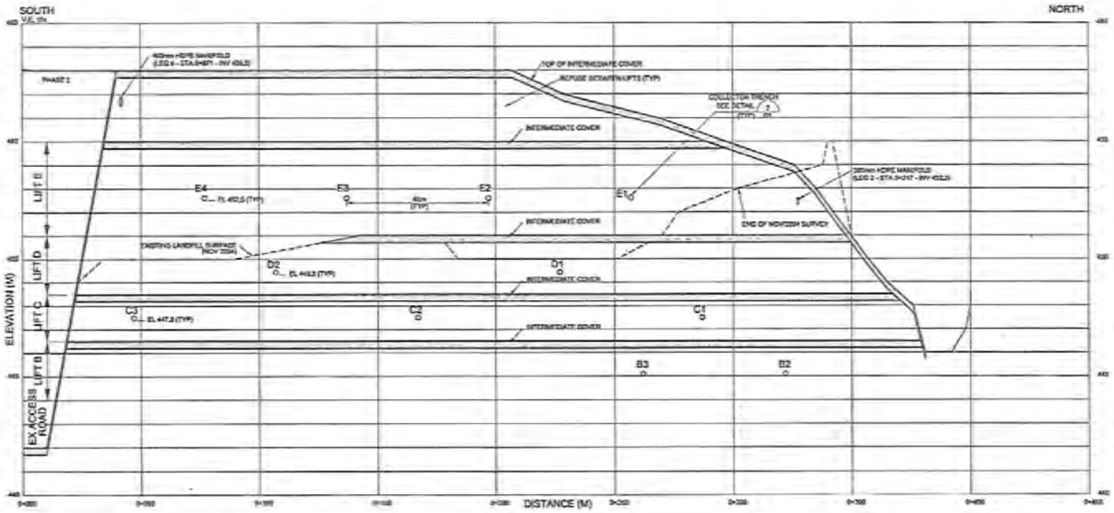

SECTION ①
SCALE 1:5000 HORIZ. P1
1:500 VERT.

C. J. SMITH
Tilley 7, 2005

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-08	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
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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
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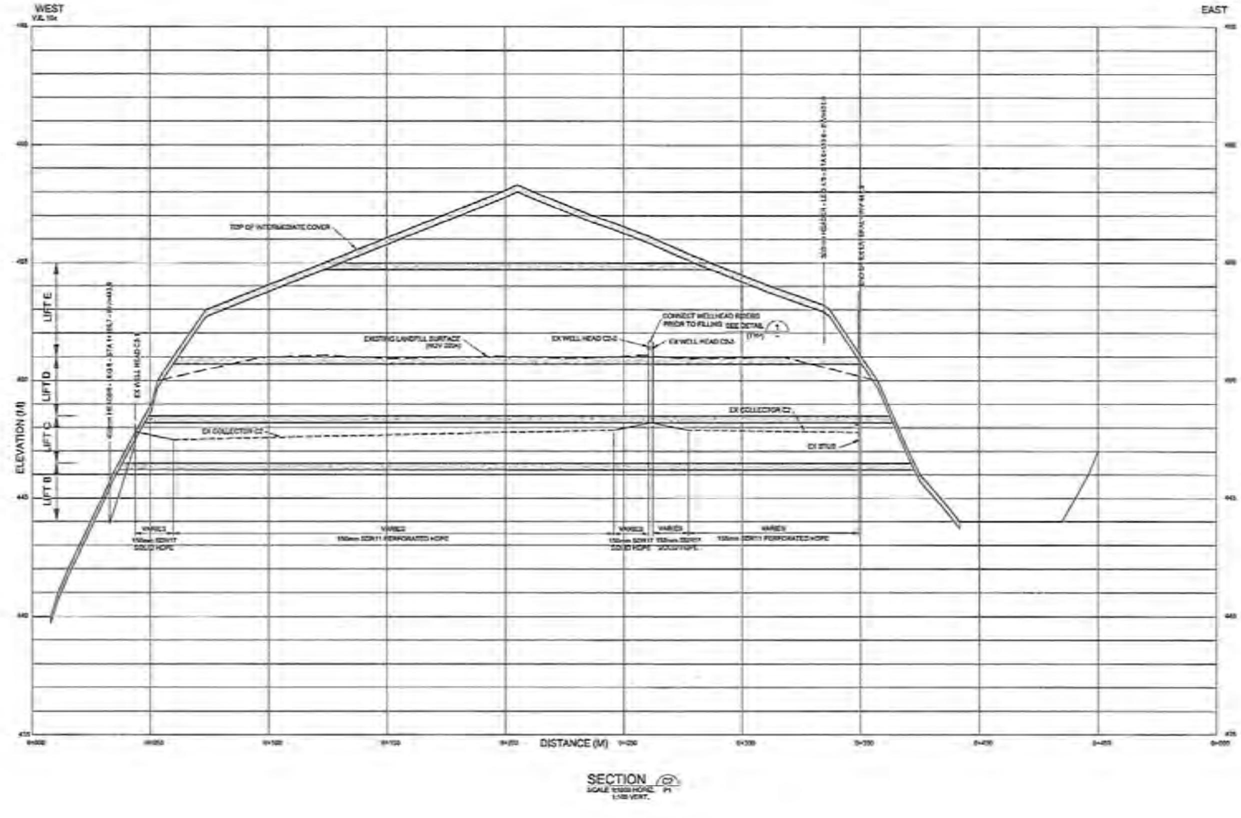
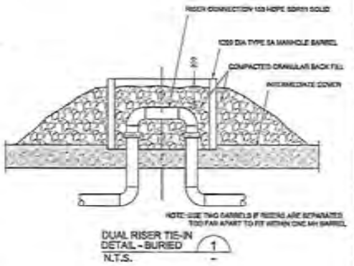


SECTION C2
SCALE 1:1000 HORZ. P1
1:100 VERT.



DUAL RISER TIE-IN DETAIL - BURIED 1
N.T.S.

C. J. SMITH

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1	05-07-05	ISSUE FOR CONSTRUCTION	RLI	KEW	CS	MB
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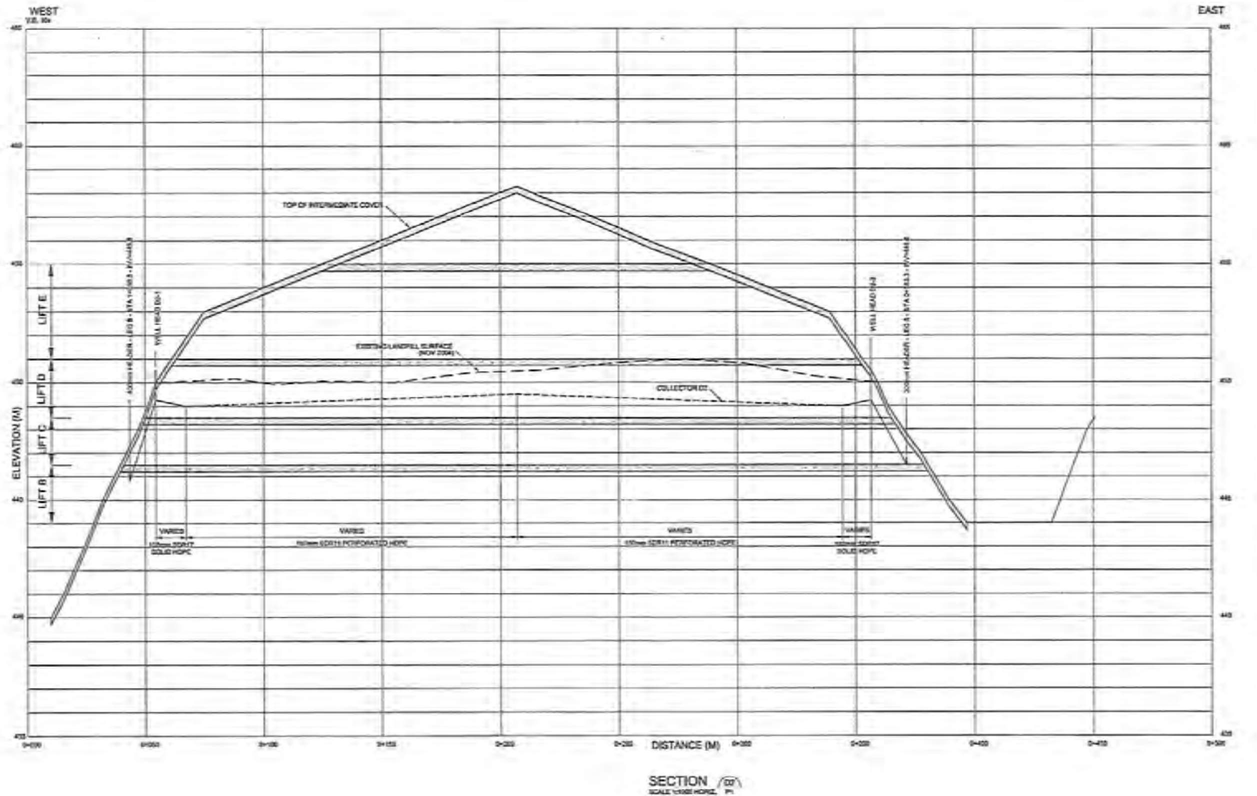
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

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
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0	05-02-23	ISSUE FOR 90% REVIEW	RLJ	KEW	CS	MB

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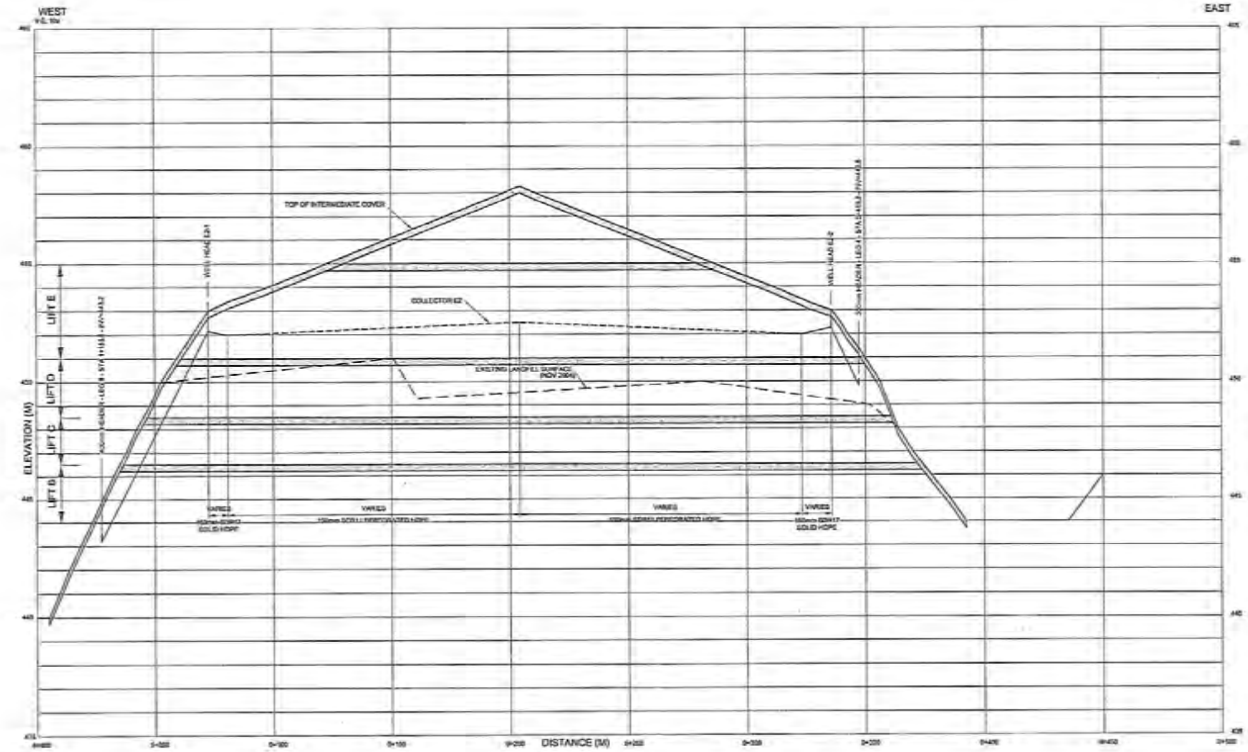
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
SECTION ALONG COLLECTOR D2 ALIGNMENT

SHEET 7 OF 11
DWG P5
DATE DEC 2004
PROJ 323443



SECTION (E2 / P1)
SCALE 1:2000 HORIZ.
1:500 VERT.

C.J. SMITH
July 8, 2005

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
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0	05-02-23	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

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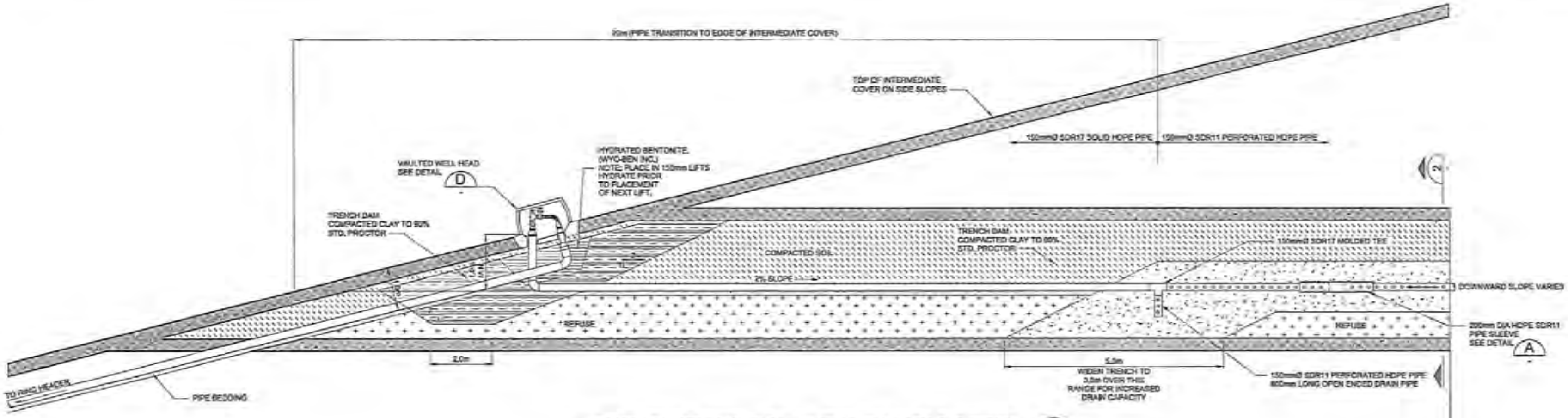
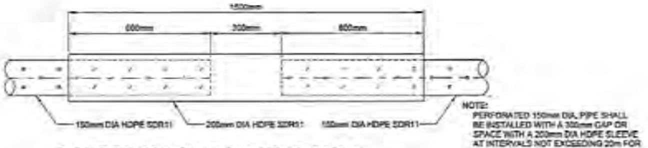
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
SECTION ALONG COLLECTOR E2 ALIGNMENT

SHEET 8 OF 11
DWG P6
DATE DEC 2004
PROJ 323443

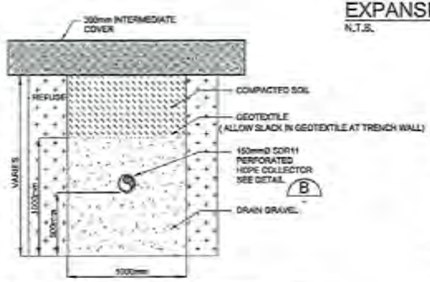


TRENCH TRANSITION AND WELL HEAD DETAIL (1) P1
SCALE 1:50

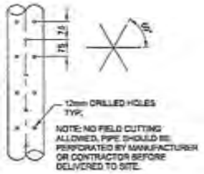


NOTE:
PERFORATED 150mm DIA. PIPE SHALL BE INSTALLED WITH A 300mm GAP OR SPACE WITH A 200mm DIA HDPE SLEEVE AT INTERVALS NOT EXCEEDING 20m FOR EXPANSION / CONTRACTION.

PERFORATED LFG COLLECTOR EXPANSION / CONTRACTION SLEEVE (A)
N.T.S.

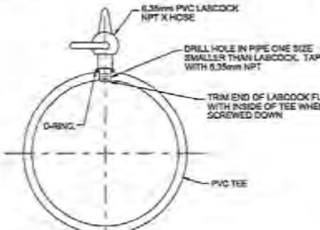


LFG COLLECTOR TRENCH IN REFUSE (2) P1.01, P3
NTS

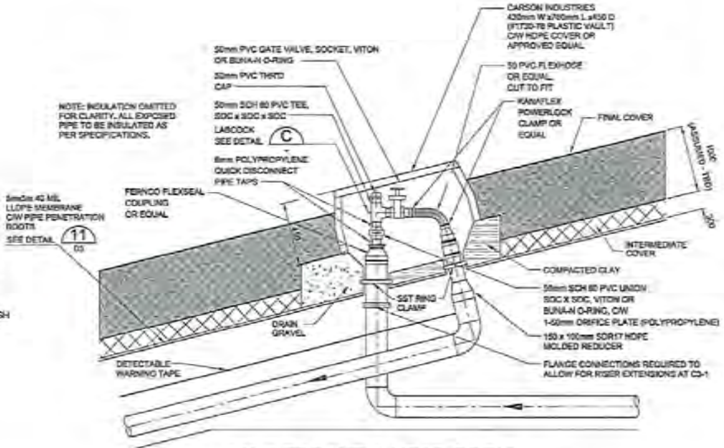


NOTE: NO FIELD CUTTING ALLOWED. PIPE SHOULD BE PERFORATED BY MANUFACTURER OR CONTRACTOR BEFORE DELIVERED TO SITE.

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.

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

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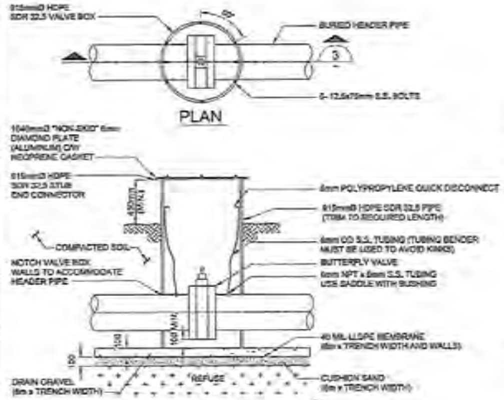
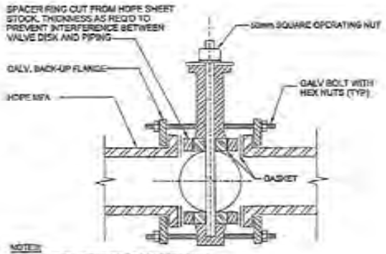
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
LANDFILL GAS DETAILS

SHEET 9 OF 11
DWG D1
DATE AUG, 2002
PROJ 121182

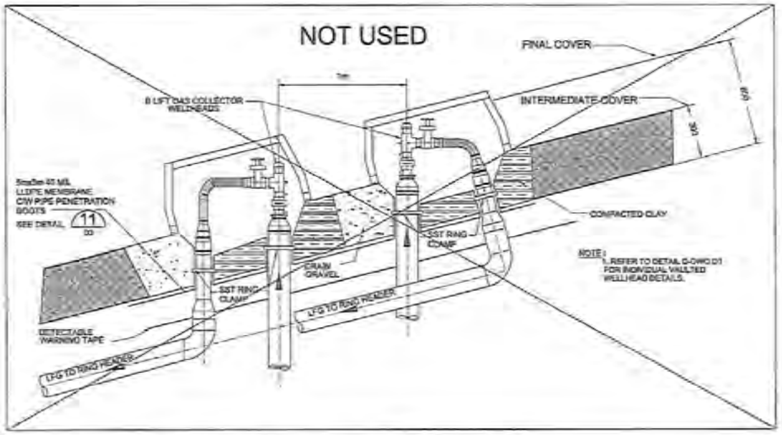


HEADER VALVE BOX (3)
NTS



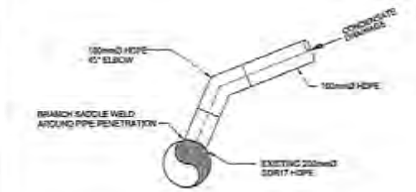
NOTES:
1. PROVIDE SPACER RINGS AS NECESSARY BETWEEN VALVE FACE AND MOLDED FLANGE ADAPTER SO THAT PIPE WALL DOES NOT INTERFERE WITH VALVE OPERATION.

BUTTERFLY VALVE INSTALLATION (4)
NTS

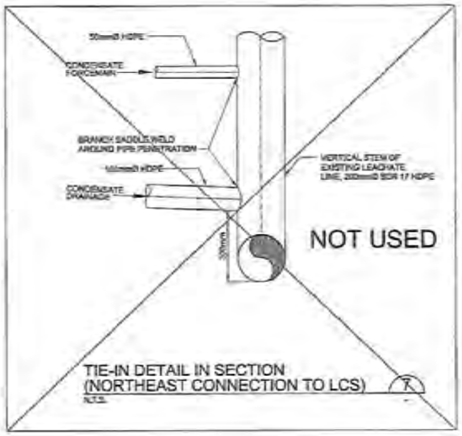


NOTE:
1. REFER TO DETAIL G-DWG D1 FOR INDIVIDUAL VAULTED WELLHEAD DETAILS.

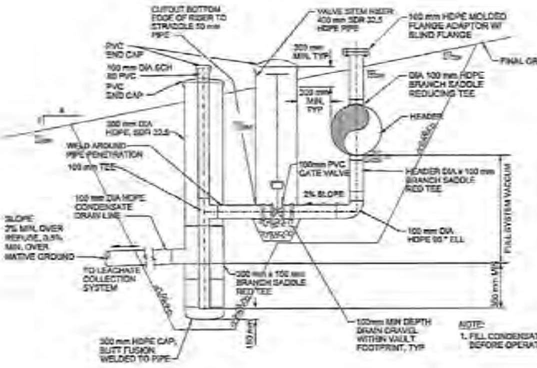
DUAL VAULTED WELL HEAD DETAIL (5) P1
SCALE N.T.S.



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) P1
NTS

W.S. BUBZIK
11.8/05

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

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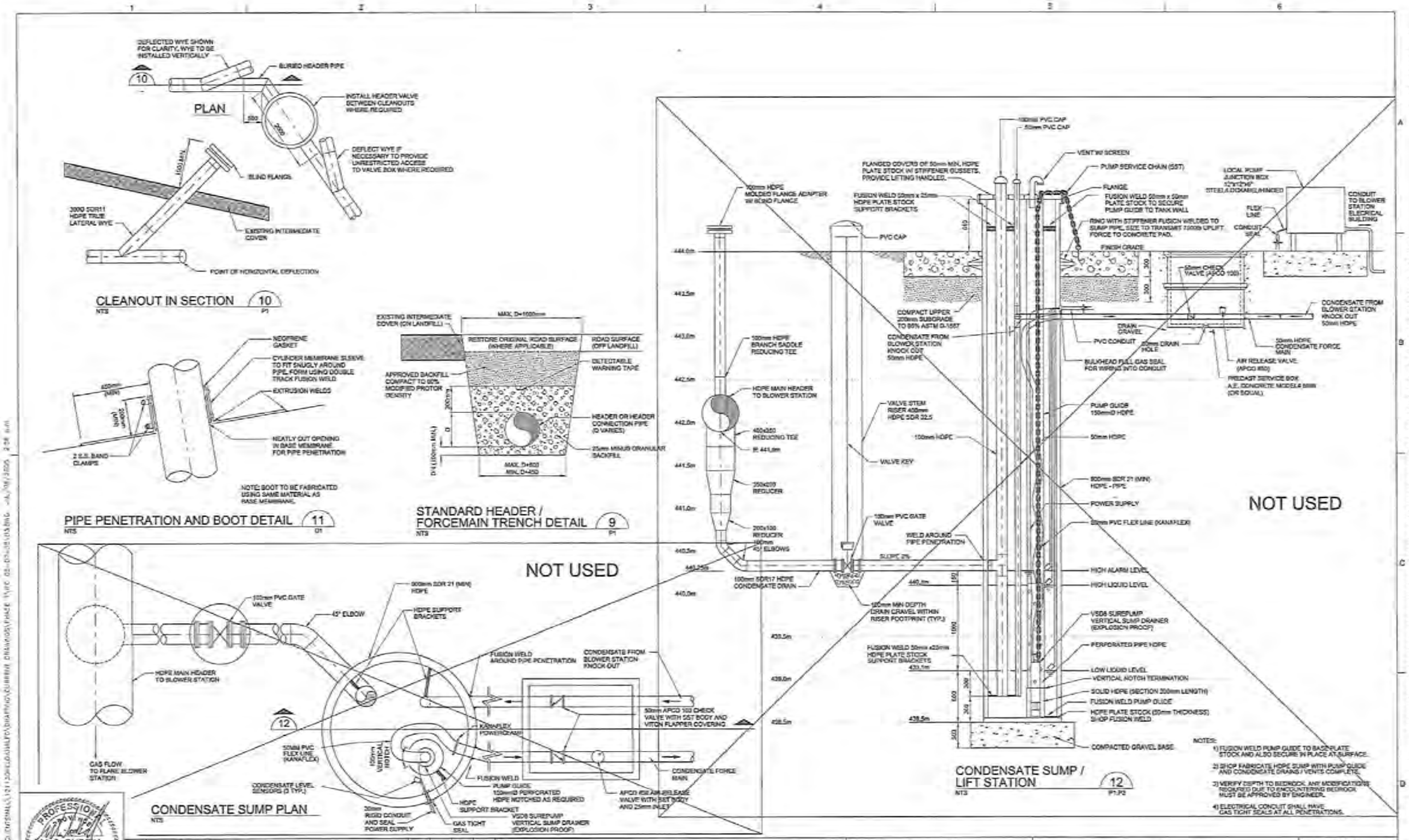
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

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
T.L. 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 90% 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

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GLENMORE LANDFILL
PHASE 1
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 1
LANDFILL GAS DETAILS

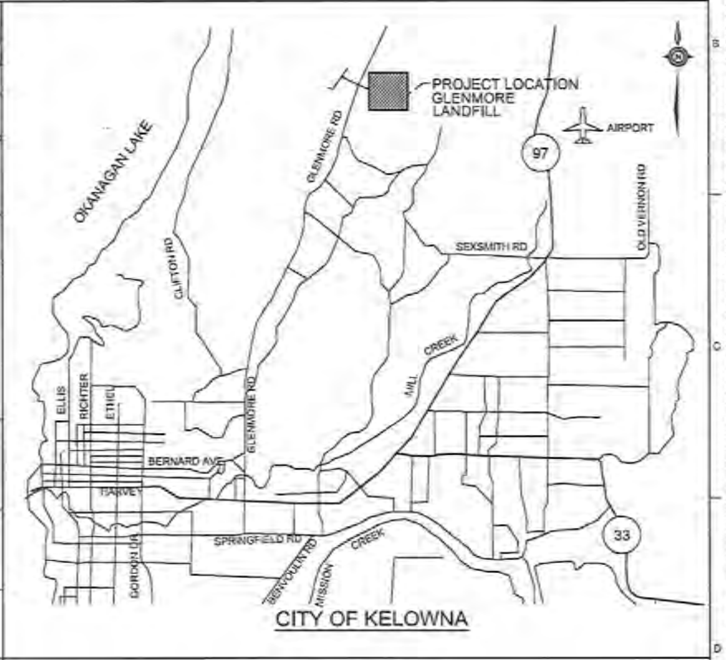
SHEET 11 OF 11
DWG D3
DATE AUG, 2002
PROJ 121182

Appendix C
Phase 2 Detailed Design Drawings

CITY OF KELOWNA
GLENMORE LANDFILL

PHASE 2 LANDFILL GAS COLLECTION SYSTEM
JULY 2005

VICINITY MAP



PROJECT LOCATION

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1	05-07-06	ISSUE FOR CONSTRUCTION	RJJ	KEW	CS	MB
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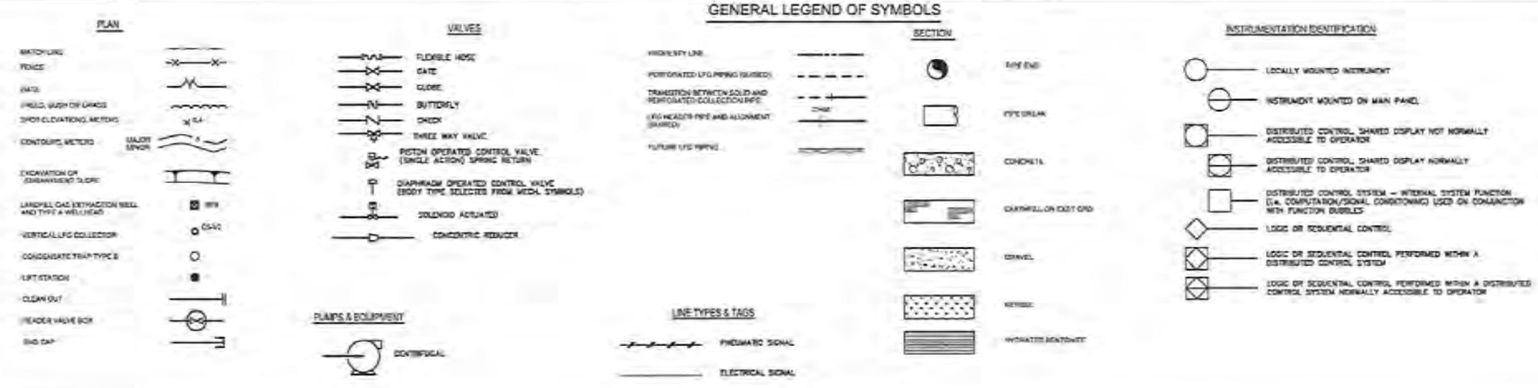
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

GENERAL
PHASE 2
VICINITY MAP AND KEY PLAN

SHEET 1 OF 22
DWG G1
DATE DEC 2004
PROJ. 323443

GENERAL LEGEND OF SYMBOLS



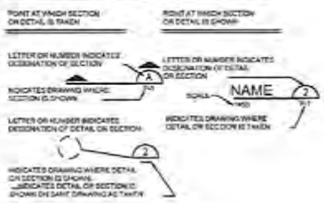
ABBREVIATIONS

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	SPECS	SPECS
G.S.	GROUND SURFACE ELEV.	S.S.	STAINLESS STEEL
HDPE	HIGH DENSITY POLYETHYLENE	STA	STATION
I.L.	INVERT ELEVATION	STL	STEEL
LCS	LEACHATE CONTROL SYSTEM	THR'D	THREADED
LFG	LANDFILL GAS	TYP	TYPICAL
MAX	MAXIMUM	W/	WITH
MFR	MANUFACTURER		
MH	MANHOLE		
MIN	MINIMUM		
MIL	MILLIMETRE		
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]
●	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 SECTION F
●	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 SKID BLDG & SECTIONS

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PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

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1	05-07-08	ISSUE FOR CONSTRUCTION	RJJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 50% REVIEW	RJJ	KEW	CS	MB

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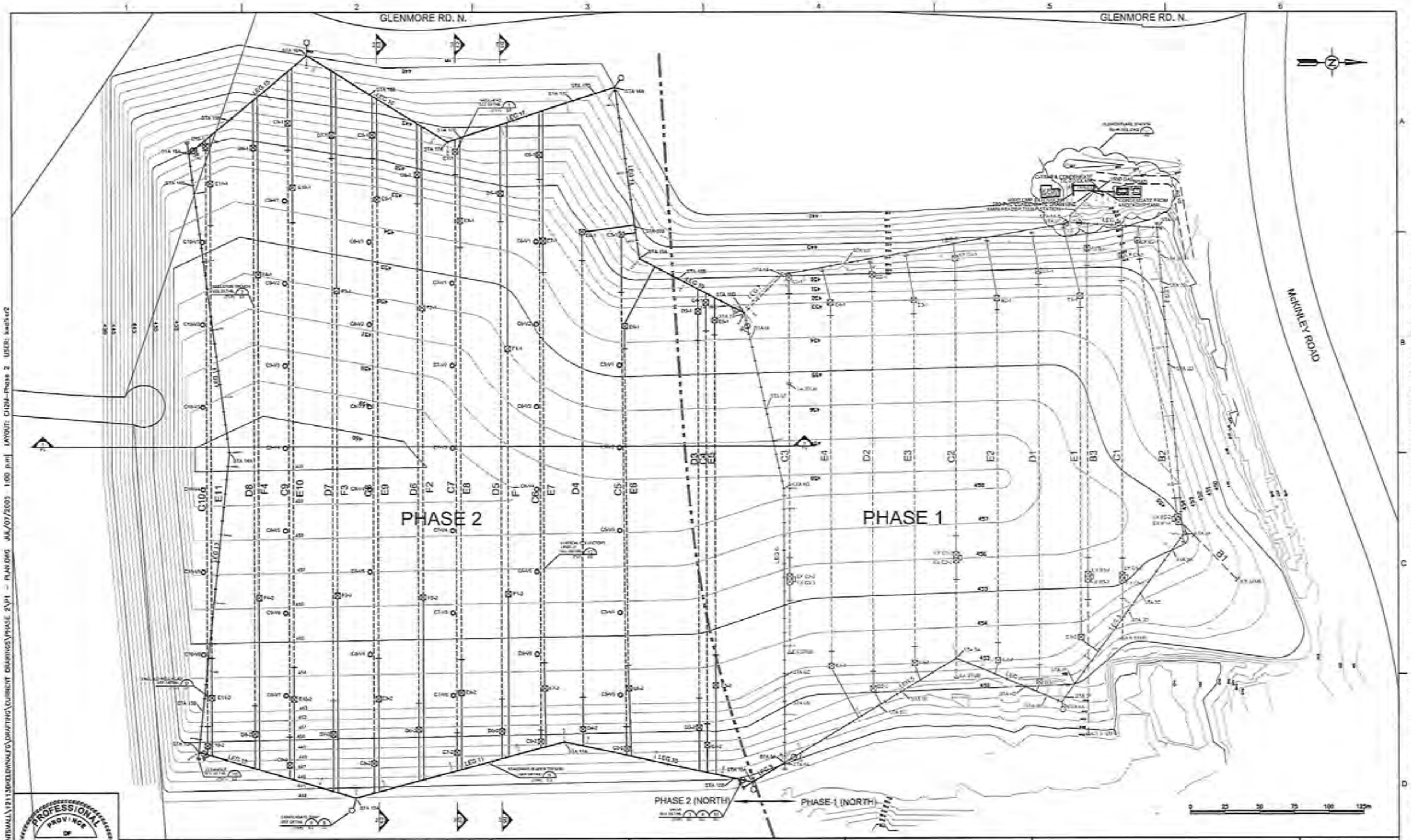
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

GENERAL
PHASE 2
SHEET INDEX, LEGEND, AND ABBREVIATIONS

SHEET 2 OF 22
DWG G2
DATE DEC 2004
PROJ 323443

G:\AFFILIATECLIENTS\SMALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\G2 – SHEET INDEX & LEGEND.DWG JUL/08/2005 7:29 p.m. LAYOUT: Layout1 USER: kwalker2



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0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

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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
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G:\AFFILIATECLIENTS\WALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P1 - PLAN.DWG JUL/07/2005 1:00 p.m. LAYOUT: CH2M-Phase 2 USER: kwalker2

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NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-00	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 60% REVIEW	RJ	KEW	CS	MB

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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

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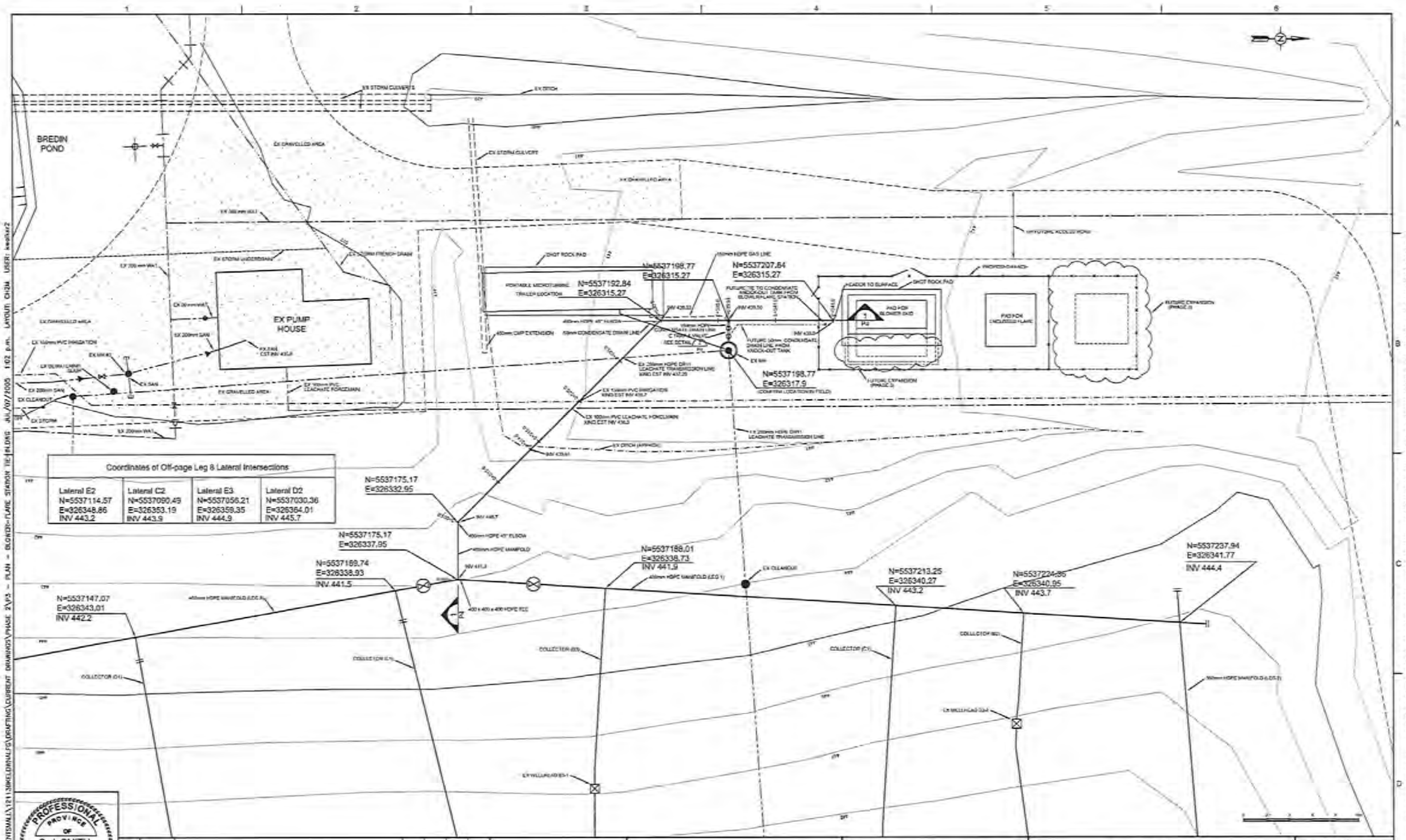

Coordinates of Off-page Leg 8 Lateral Intersections			
Lateral E2 N=5537114.57 E=326348.86 INV 443.2	Lateral C2 N=5537090.49 E=326353.19 INV 443.9	Lateral E3 N=5537056.21 E=326359.35 INV 444.9	Lateral D2 N=5537030.36 E=326364.01 INV 445.7

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 50% REVIEW	RLI	KEW	CS	MB

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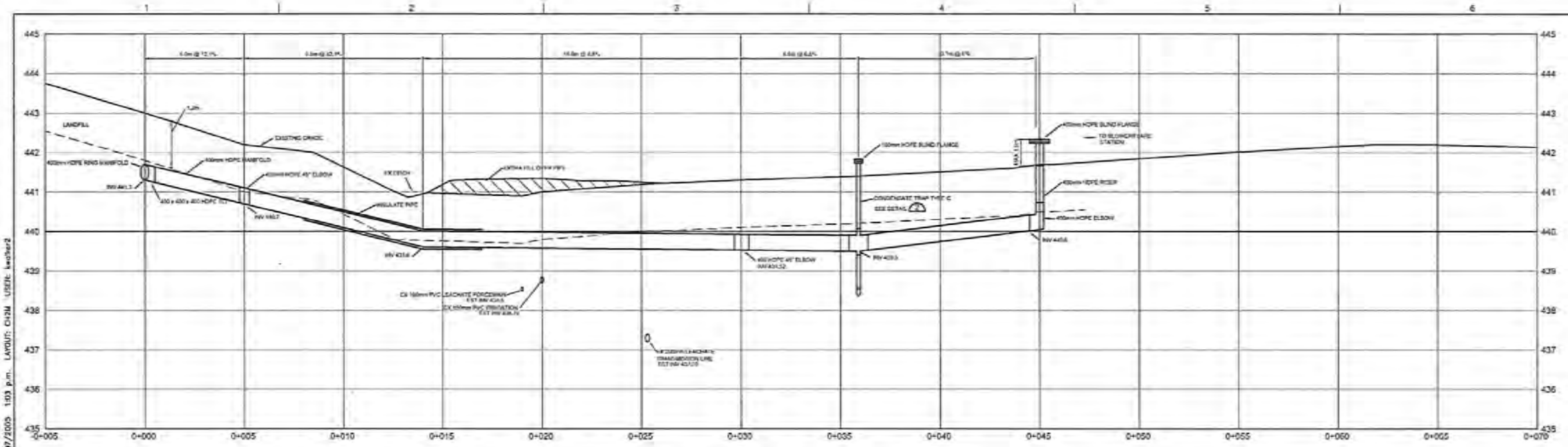
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

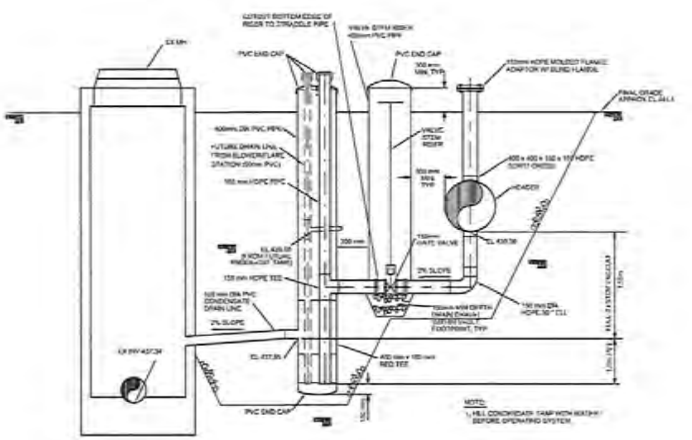
LFG WELLFIELD AND PIPING
PHASE 2
PLAN - BLOWER/FLARE STATION TIE IN

SHEET	5 OF 22
DWG	P3
DATE	DEC 2004
PROJ	323443

D:\AFFILIATECLIENTSMALL\121138KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\P3 - PLAN - BLOWER-FLARE STATION TIE-IN.DWG JUL/07/2005 1:02 p.m. LAYOUT: CH2M USER: kwalker2



SECTION THROUGH 400mm HDPE MANIFOLD 1 P3
SCALE: 1:100
VERT. 1:50



DETAIL - CONDENSATE TRAP TYPE C 2
NTS

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NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-05	ISSUE FOR CONSTRUCTION	RJJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RJJ	KEW	CS	MB

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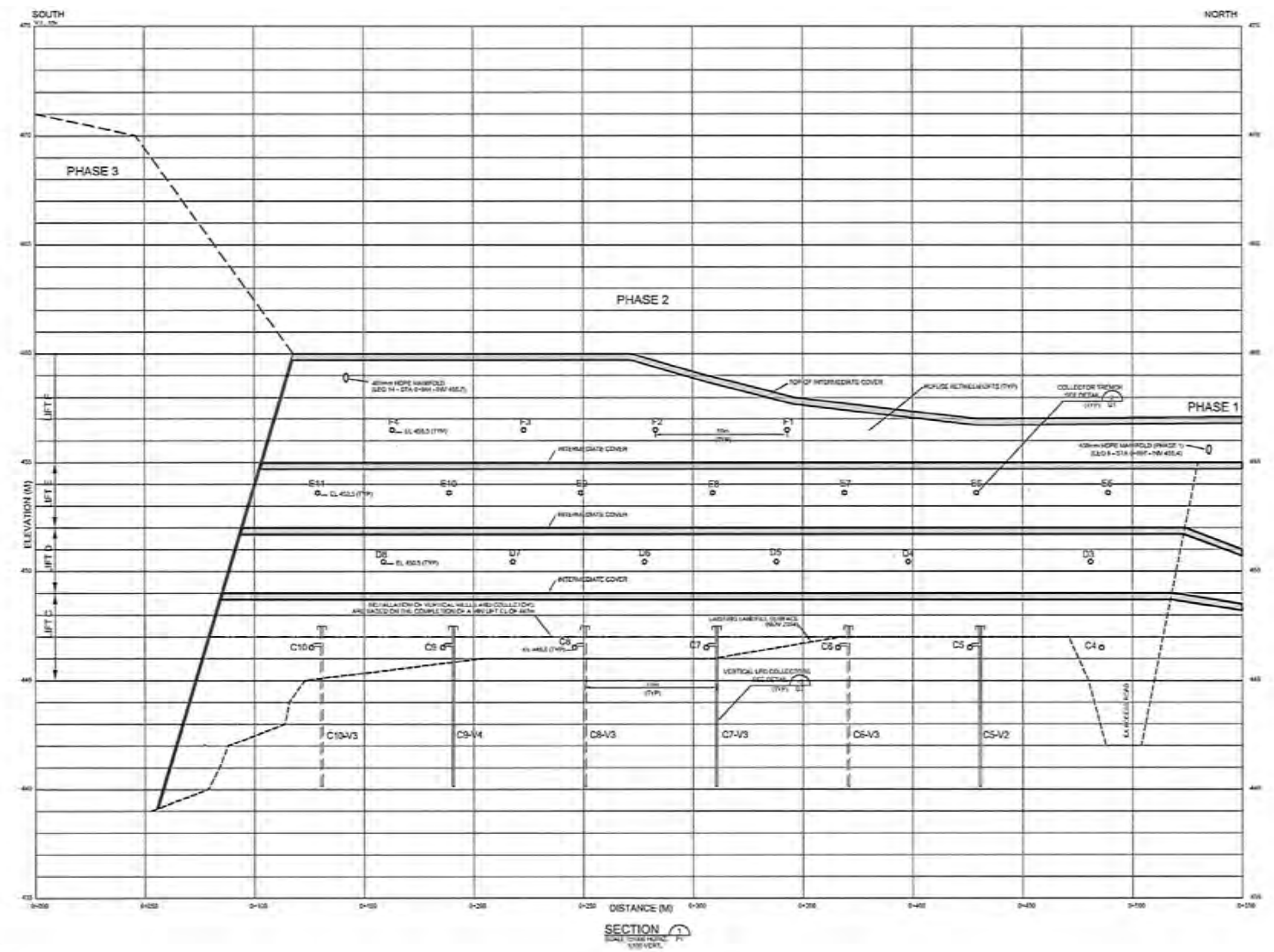
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

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

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-05	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MB

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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
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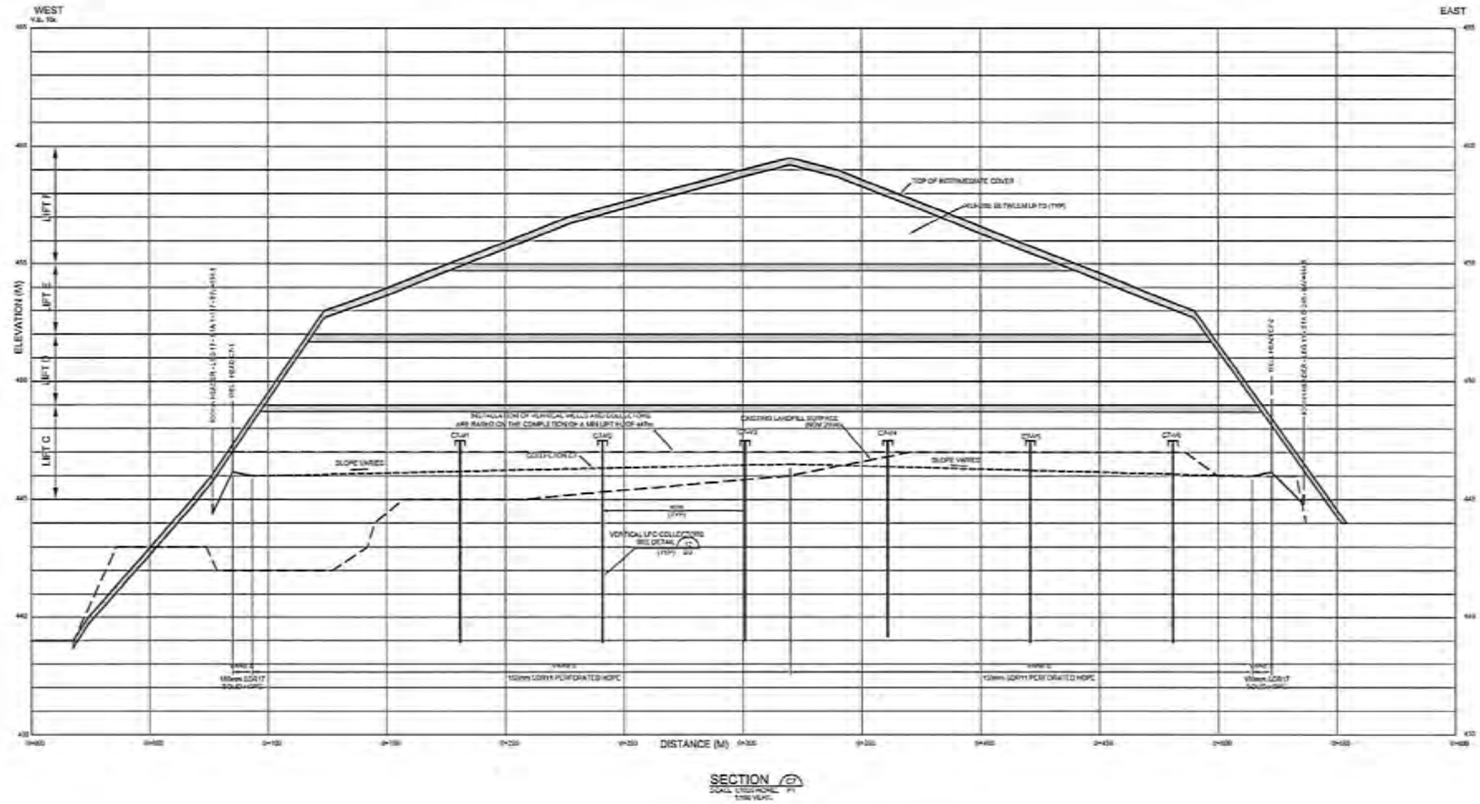

SECTION C7

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	RLI	KEW	CS	MB

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PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
SECTION ALONG COLLECTOR C7 ALIGNMENT

SHEET 8 OF 22
DWG. P6
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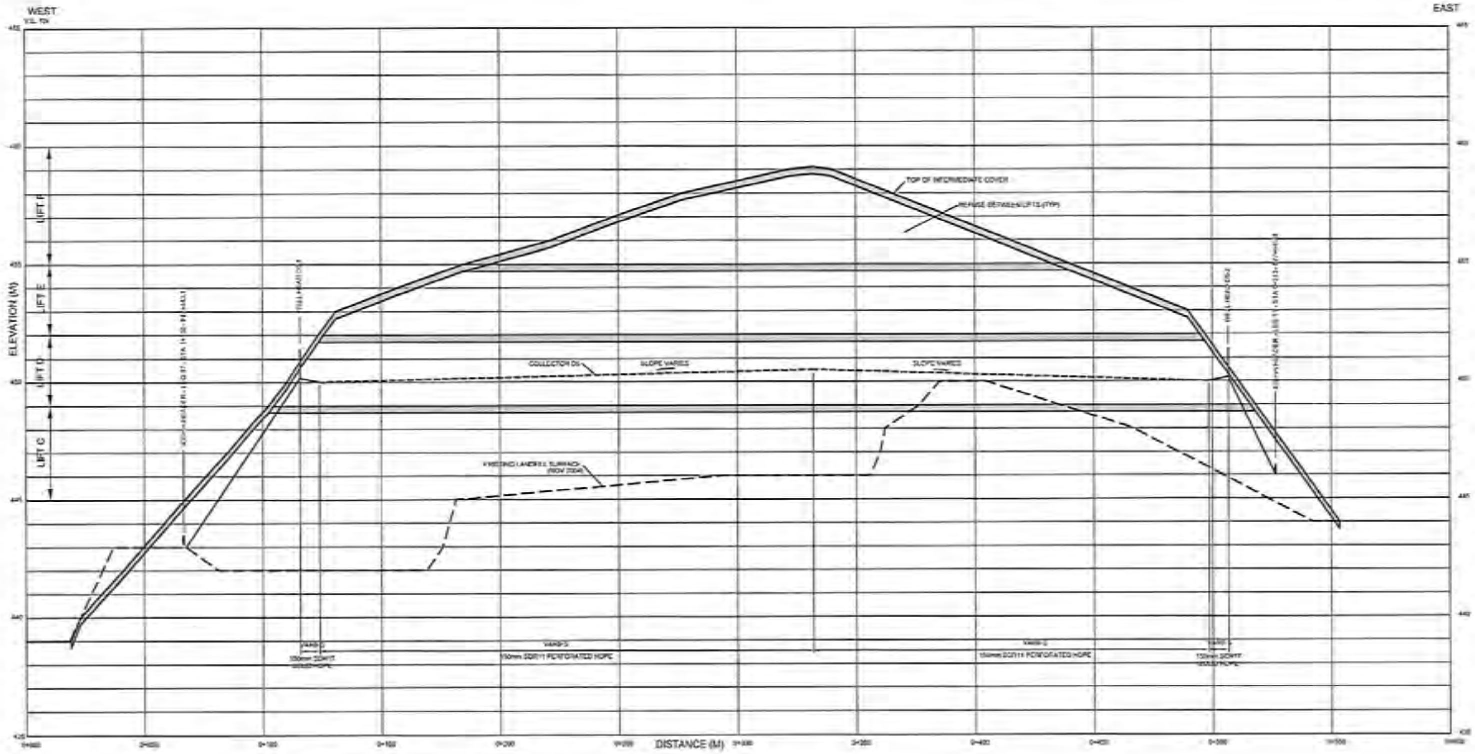

SECTION D5

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PROFESSIONAL PROVINCE OF BRITISH COLUMBIA ENGINEER
C. J. SMITH

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0	05-03-01	ISSUE FOR 90% REVIEW	RLI	KEW	CS	MB

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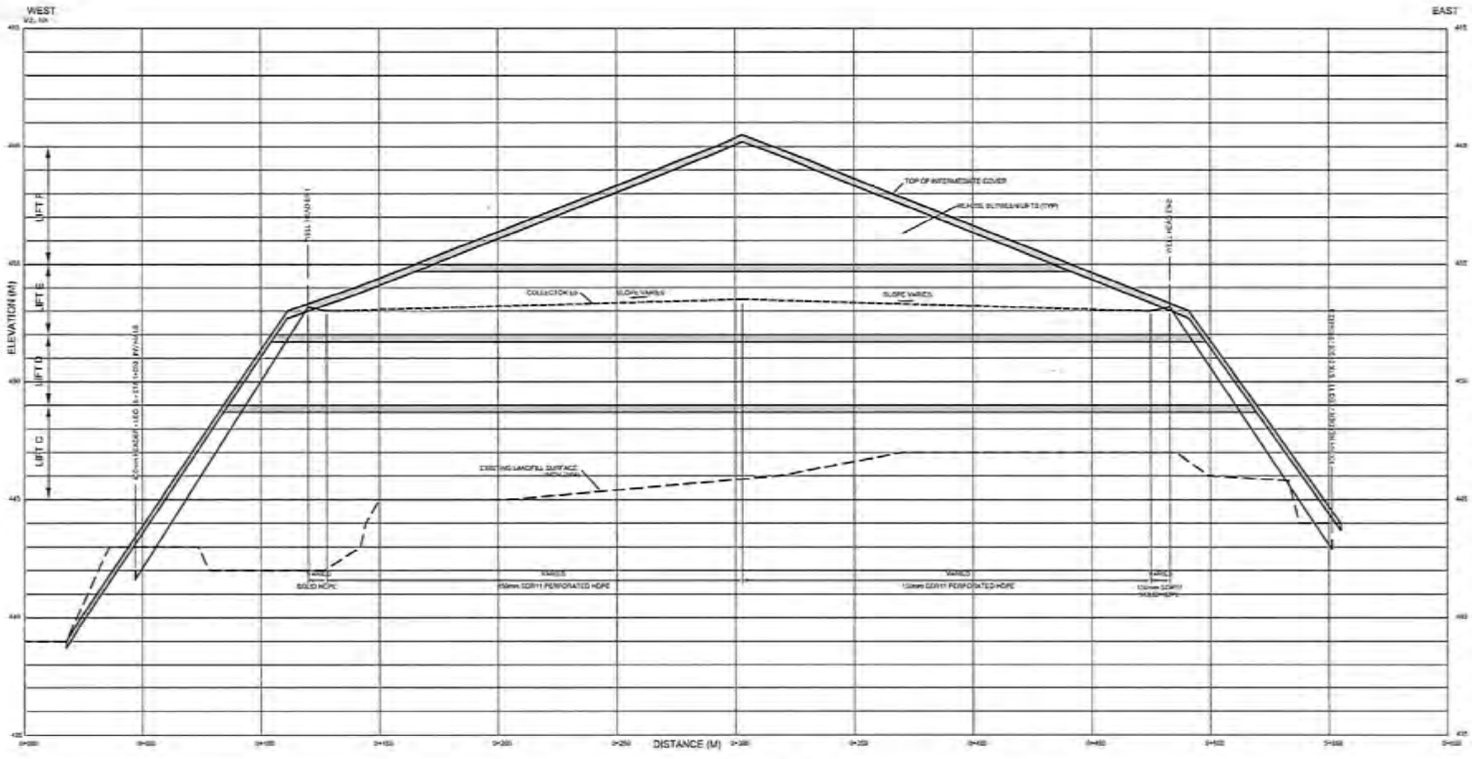
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
SECTION ALONG COLLECTOR D5 ALIGNMENT

SHEET 9 OF 22
DWG P7
DATE DEC 2004
PROJ 323443



SECTION P8

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 50% REVIEW	RJ	KEW	CS	MB

PROFESSIONAL ENGINEER
C. J. SMITH

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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

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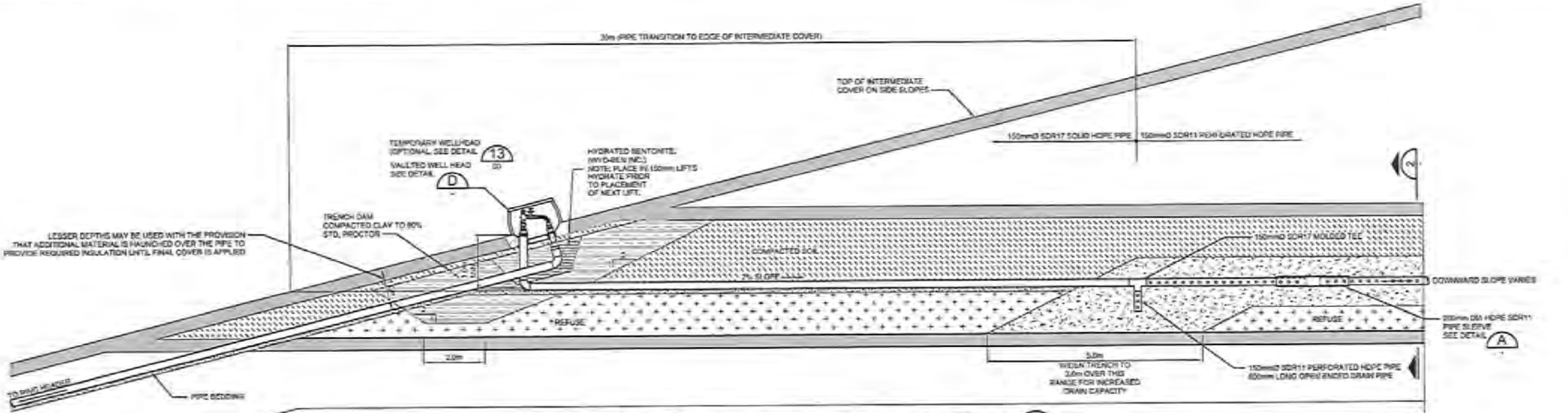
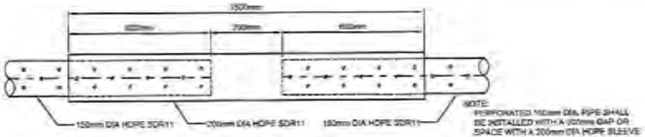


TRENCH TRANSITION AND WELL HEAD DETAIL (1) P1

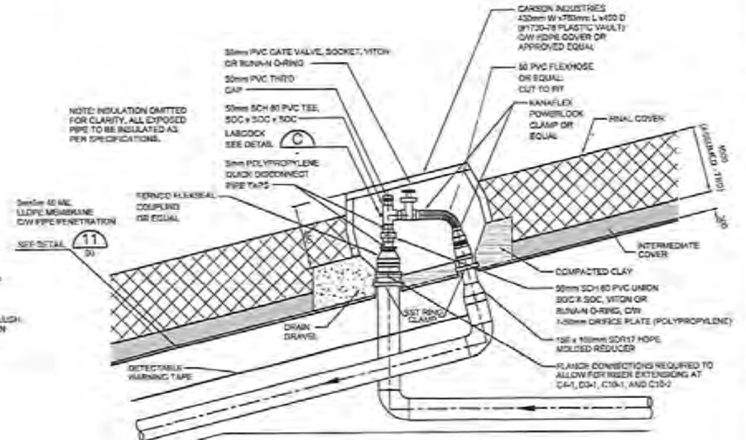
SCALE 1:50



NOTE: PERFORATED 150mm DIA PIPE SHALL BE INSTALLED WITH A 300mm GAP OR SPACE WITH A 200mm DIA HDPE SLEEVE AT INTERVALS NOT EXCEEDING 25m FOR EXPANSION / CONTRACTION.

PERFORATED LFG COLLECTOR EXPANSION / CONTRACTION SLEEVE (A)

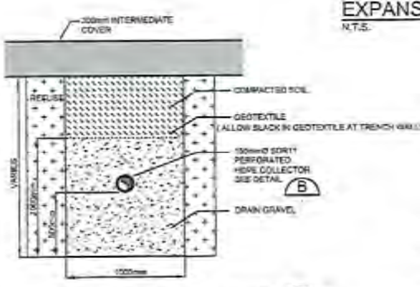
N.T.S.



NOTE: INSULATION OMITTED FOR CLARITY. ALL EXPOSED PIPE TO BE INSULATED AS PER SPECIFICATIONS.

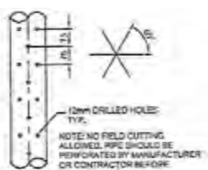
VAULTED WELL HEAD DETAIL AT FINAL COVER (D)

N.T.S.



LFG COLLECTOR TRENCH IN REFUSE (2) P1, 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

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PROVINCE OF BRITISH COLUMBIA
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NO.	DATE	REVISION	DSGN	DR	CHK	APVD
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0	05-03-01	ISSUE FOR 90% REVIEW	RJ	KEW	CS	MS

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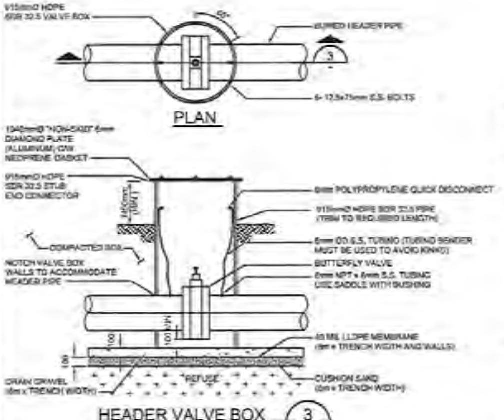
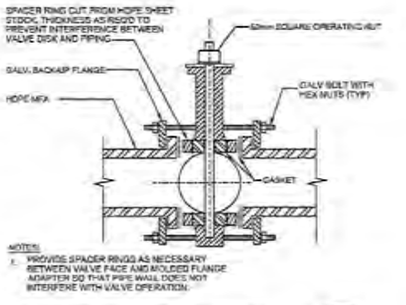
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
LANDFILL GAS DETAILS

SHEET 11 OF 22
DWG D1
DATE DEC 2004
PROJ 333443

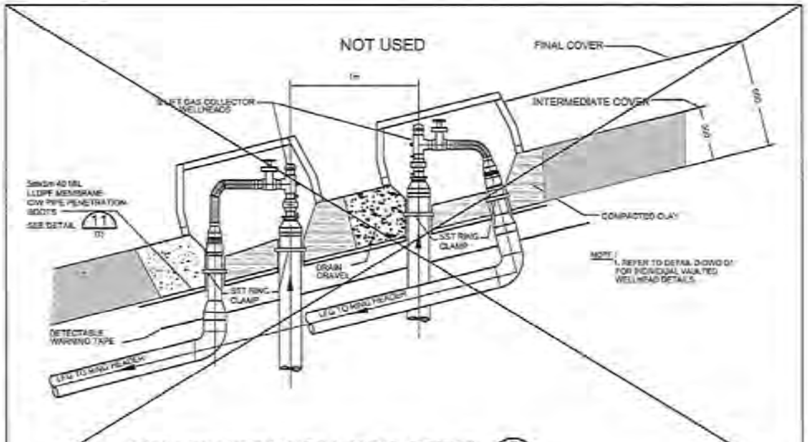


HEADER VALVE BOX (3)
NTS P1



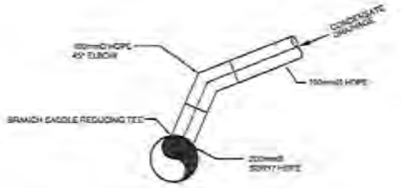
NOTES:
1. PROVIDE SPACER RINGS AS NECESSARY BETWEEN VALVE FACE AND MOLDED FLANGE ADAPTER SO THAT PIPE WALL DOES NOT INTERFERE WITH VALVE OPERATION.

BUTTERFLY VALVE INSTALLATION (4)
NTS P1



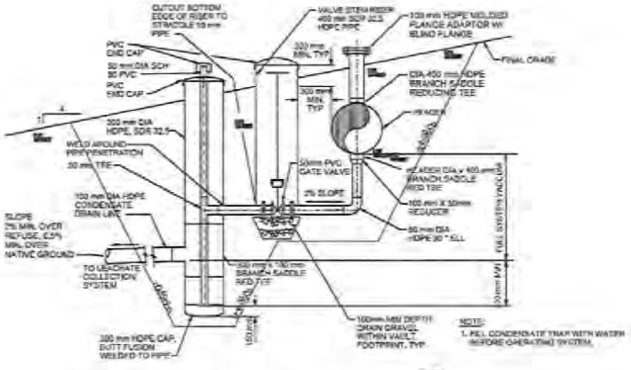
NOTE:
1. REFER TO DETAIL D/DWG D1 FOR INDIVIDUAL VAULTED WELLHEAD DETAILS.

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
BRITISH COLUMBIA

NO.	DATE	REVISION	DSGN	DR	CHK	APVD
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0	05-03-01	ISSUE FOR 90% REVIEW	RU	KEW	CS	MB

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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

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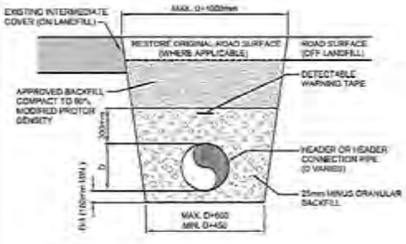
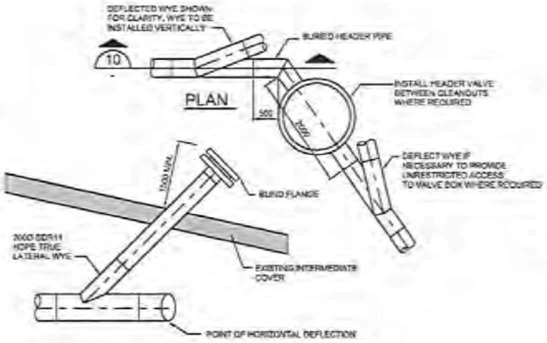
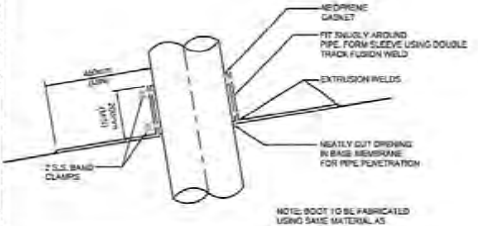


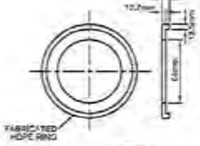
STANDARD HEADER DETAIL (9)
NTS P1



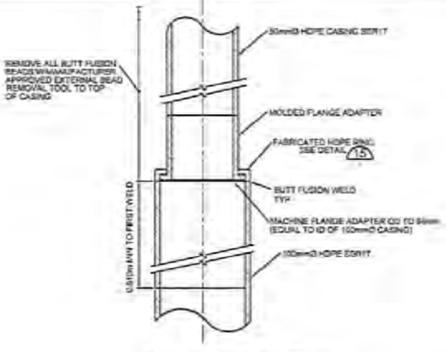
CLEANOUT IN SECTION (10)
NTS P1



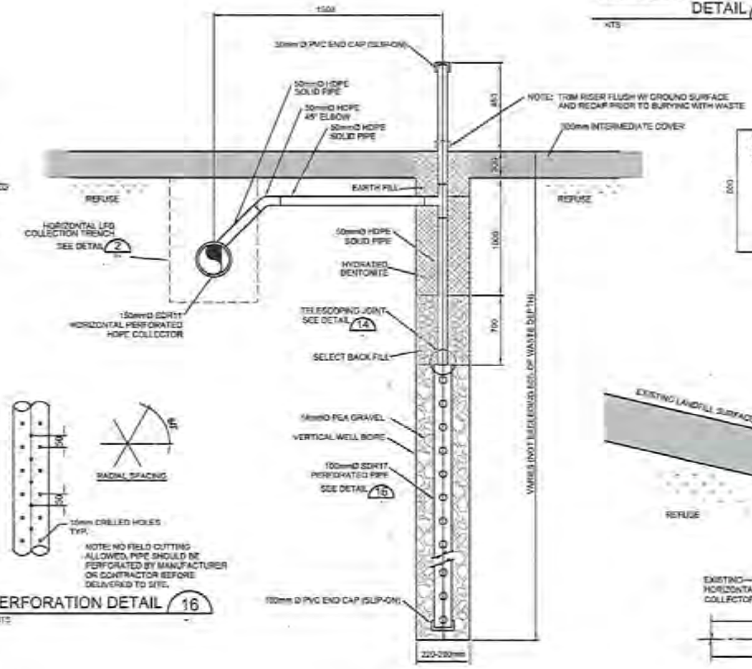
PIPE PENETRATION AND BOOT DETAIL (11)
NTS D1



DETAIL (15)

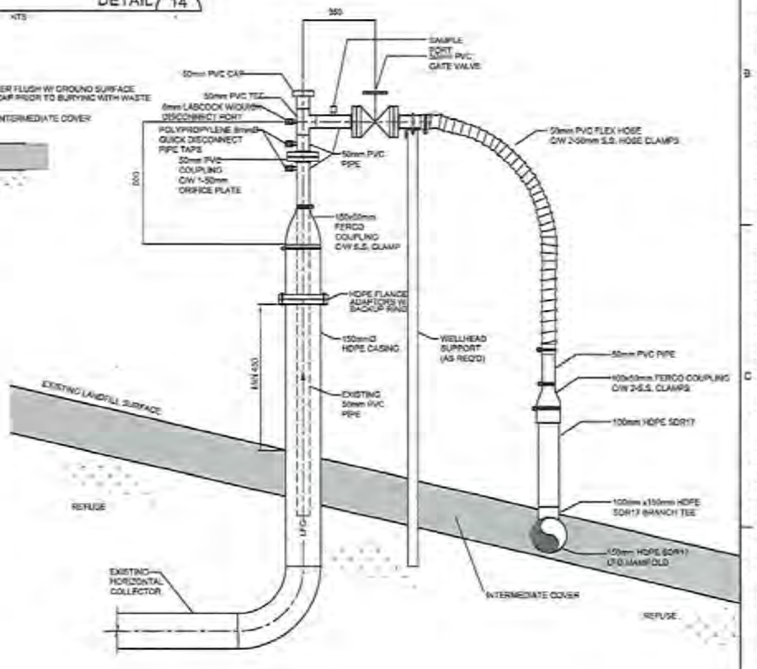


TELESCOPING JOINT DETAIL (14)
NTS



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

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NO.	DATE	REVISION	DSGN	DR.	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
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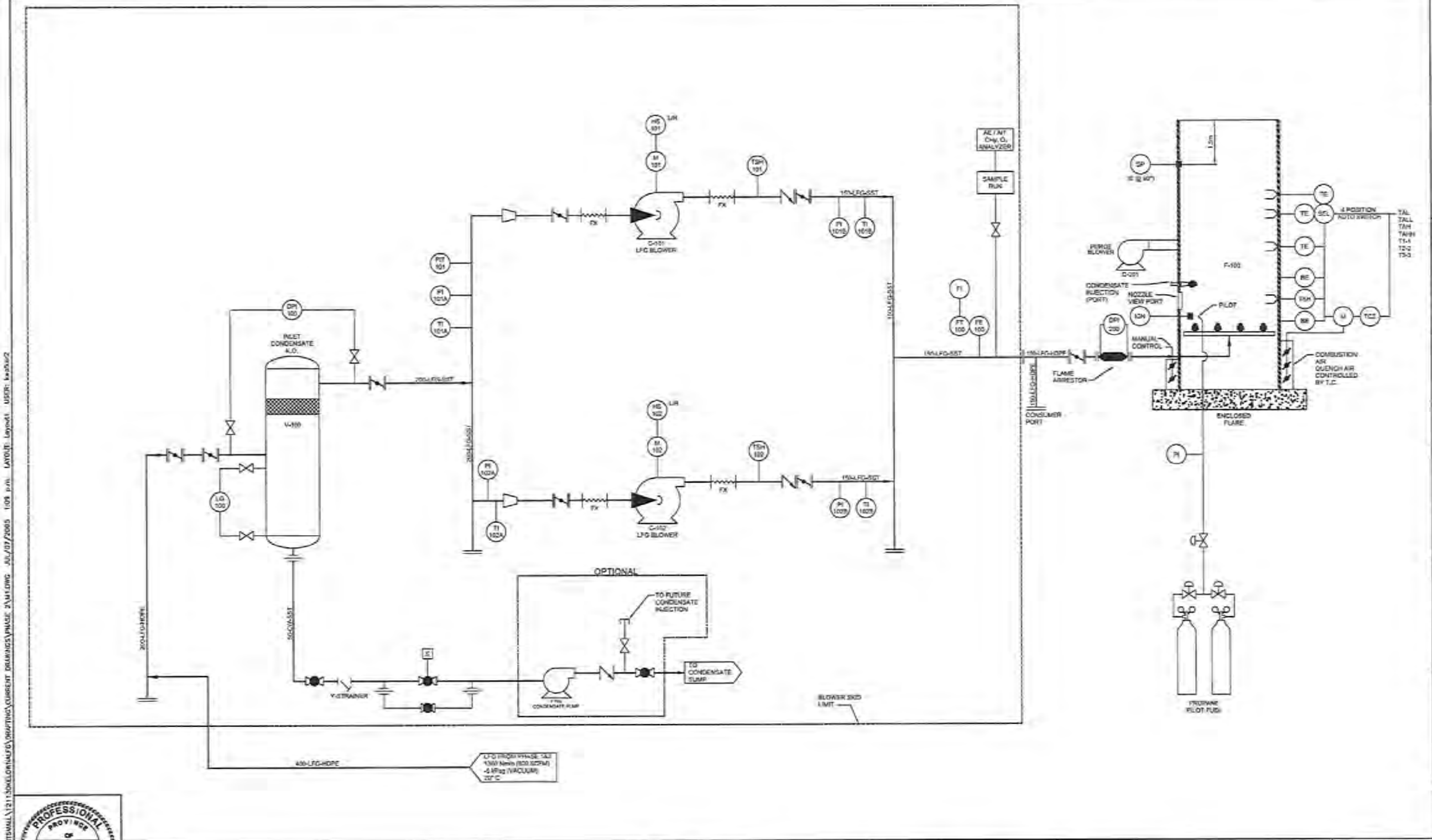
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

LFG WELLFIELD AND PIPING
PHASE 2
LANDFILL GAS DETAILS

SHEET 13 OF 22
DWG D3
DATE DEC 2004
PROJ 323443



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1	05-07-06	ISSUE FOR CONSTRUCTION	RJJ	KEW	CS	MB
0	05-03-01	ISSUE FOR 60% REVIEW	MB	TL	CS	MB
NO.	DATE	REVISION	DESGN	DR	CHK	APVD

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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

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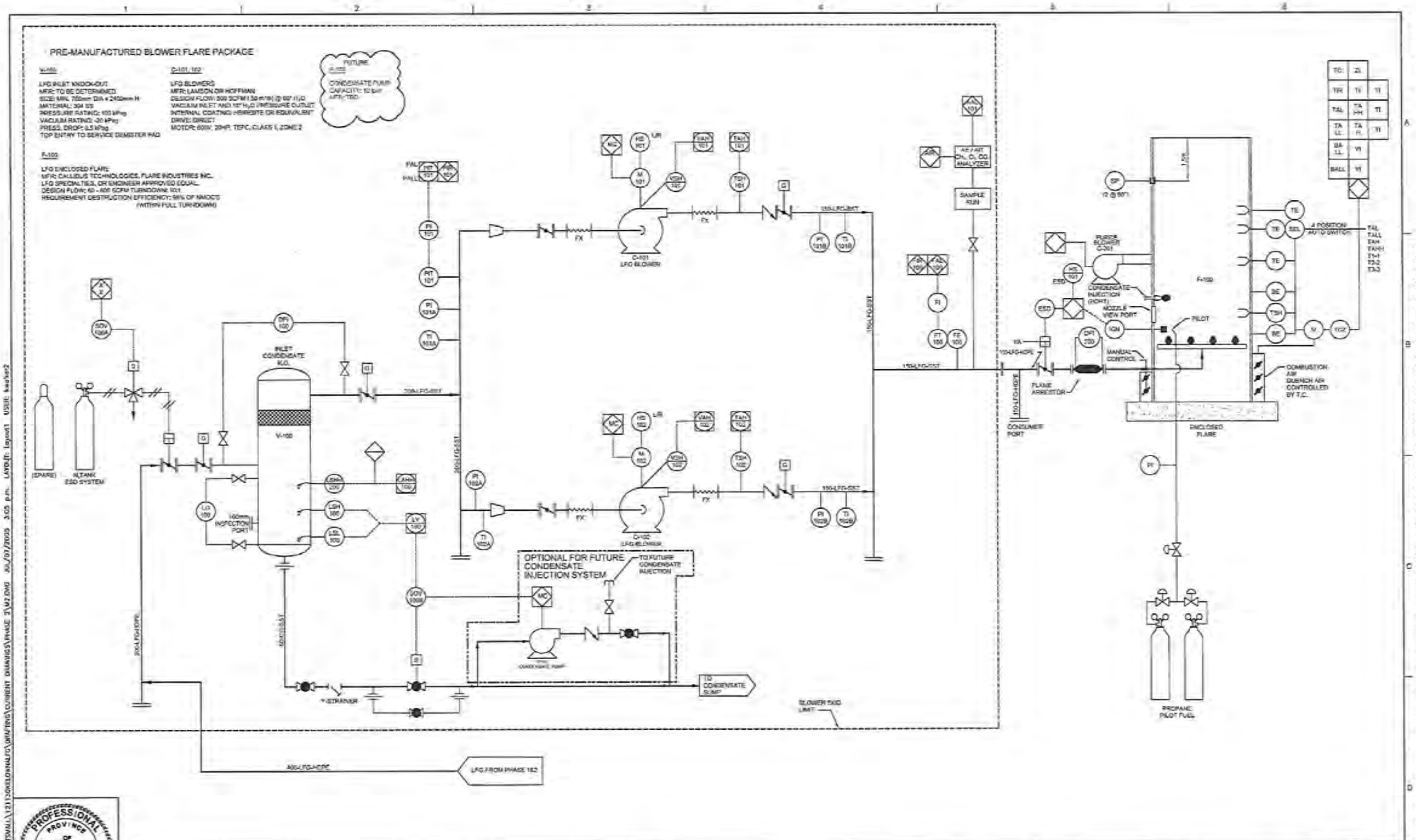

PRE-MANUFACTURED BLOWER FLARE PACKAGE

V-100

LFG INLET KNOCK-OUT
MFR: TO BE DETERMINED
SIZE: MIN. 700mm DIA x 2400mm H
MATERIAL: 304 SS
PRESSURE RATING: 100 kPag
VACUUM RATING: -20 kPag
PRESS. DROP: 0.5 kPag
TOP ENTRY TO SERVICE DEMISTER PAD

C-101, 102

LFG BLOWERS
MFR: LAMSON OR HOFFMAN
DESIGN FLOW: 500 SCFM (.59 m³/s) @ 60" H₂O
VACUUM INLET AND 10" H₂O PRESSURE OUTLET
INTERNAL COATING: HERESITE OR EQUIVALENT
DRIVE: DIRECT
MOTOR: 600V, 20HP, TEFC, CLASS I, ZONE 2

FUTURE
P-100

CONDENSATE PUMP
CAPACITY: 10 l/hr
MFR: TBD

F-100

LFG ENCLOSED FLARE
MFR: CALLIDUS TECHNOLOGIES, FLARE INDUSTRIES INC.
LFG SPECIALTIES, OR ENGINEER APPROVED EQUAL
DESIGN FLOW: 60 - 600 SCFM TURNDOWN: 10:1
REQUIREMENT DESTRUCTION EFFICIENCY: 98% OF NMOC'S
(WITHIN FULL TURNDOWN)

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 50% REVIEW	NB	TL	CS	MB

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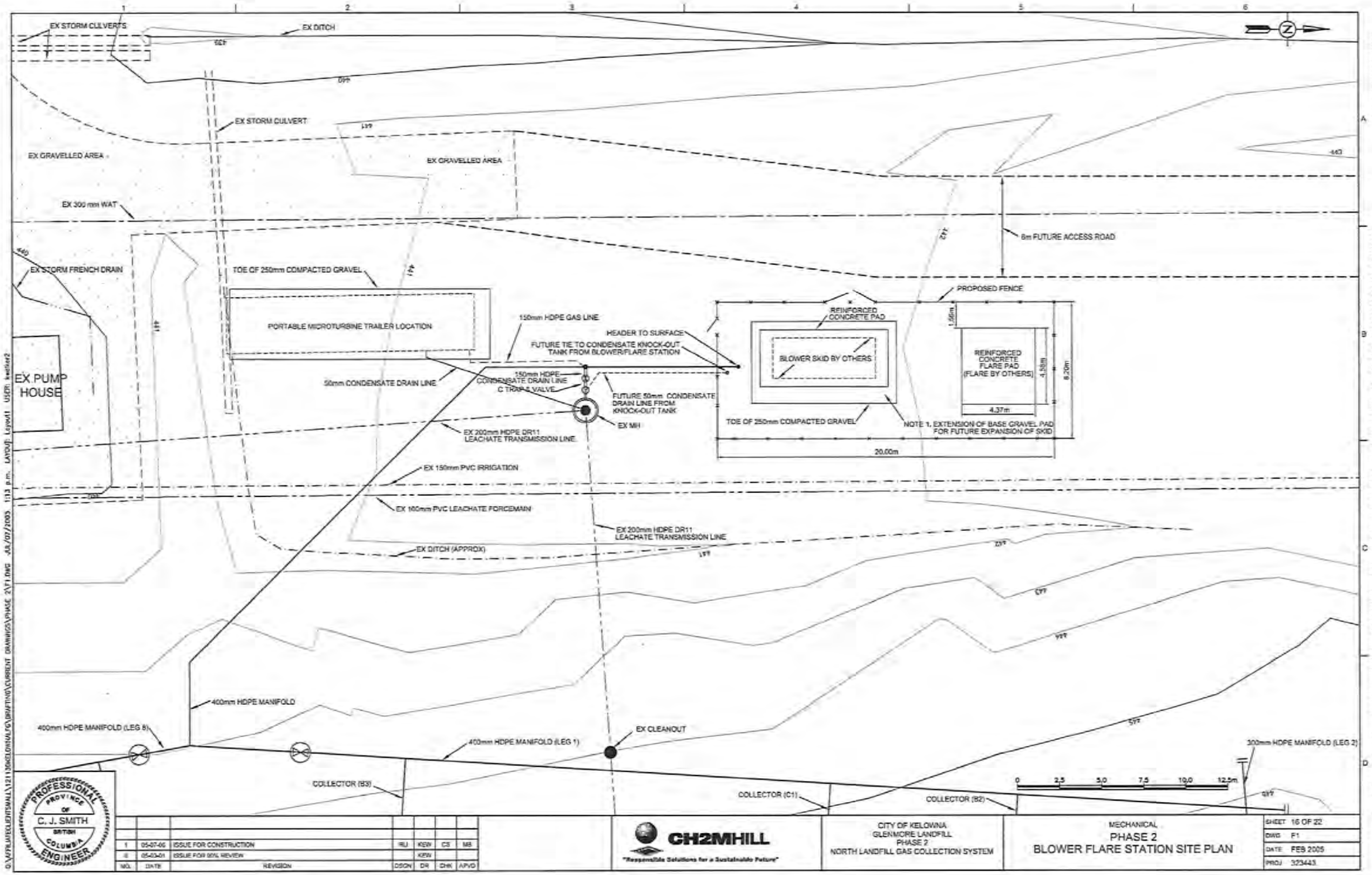
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

MECHANICAL
PHASE 2
BLOWER FLARE STATION P&ID

SHEET: 15 OF 22
DWG: M2
DATE: DEC 2004
PROJ: 323443



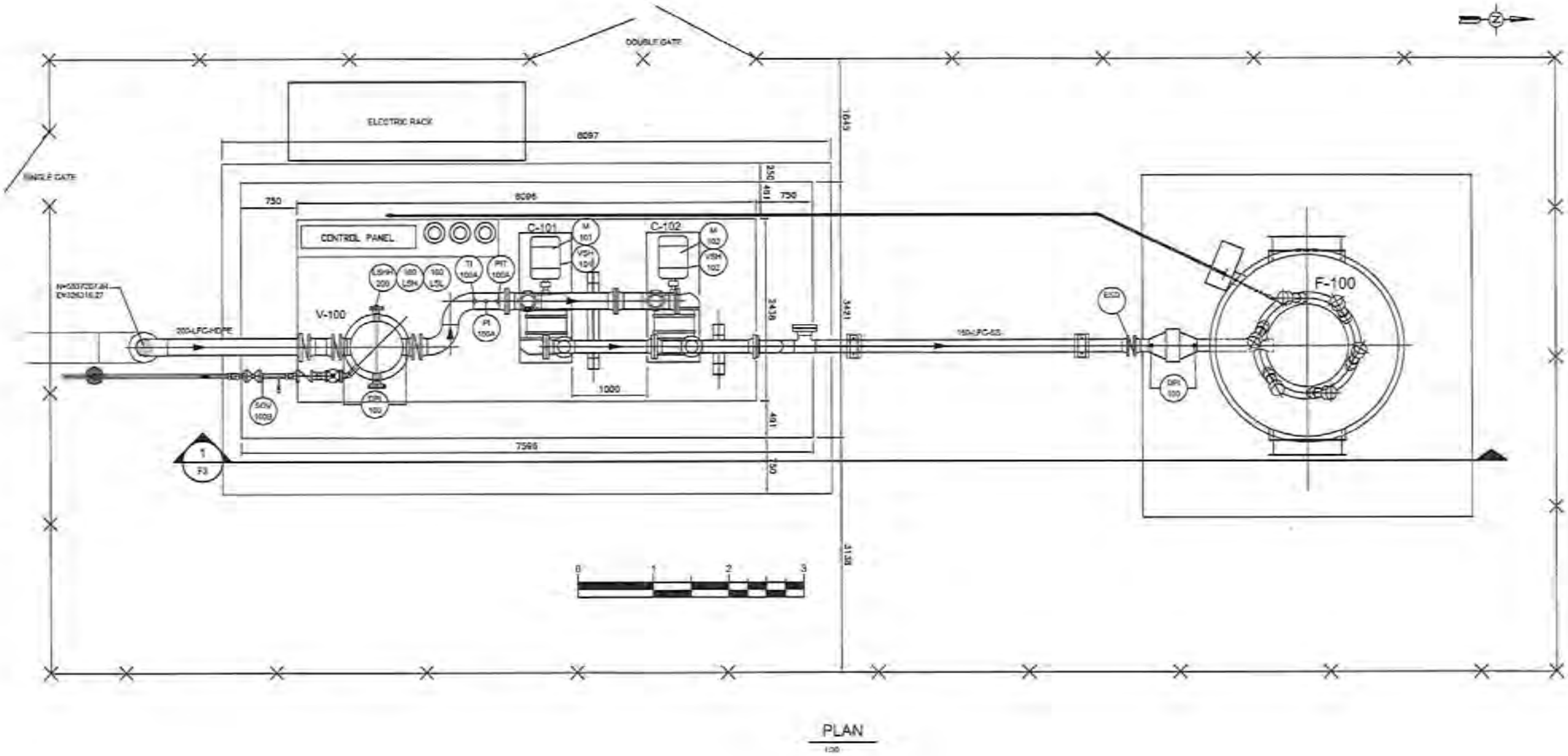
NO.	DATE	REVISION	DSGN	DR	CHK	APVD
1	05-07-06	ISSUE FOR CONSTRUCTION	RU	KEW	CS	MB
0	05-03-01	ISSUE FOR 90% REVIEW		KEW		

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

Q:\VFFILIATE\CLIENTSMALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\F1.DWG JUL/07/2005 1:13 p.m. LAYOUT: Layout1 USER: kwellser2



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

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. J. SMITH

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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
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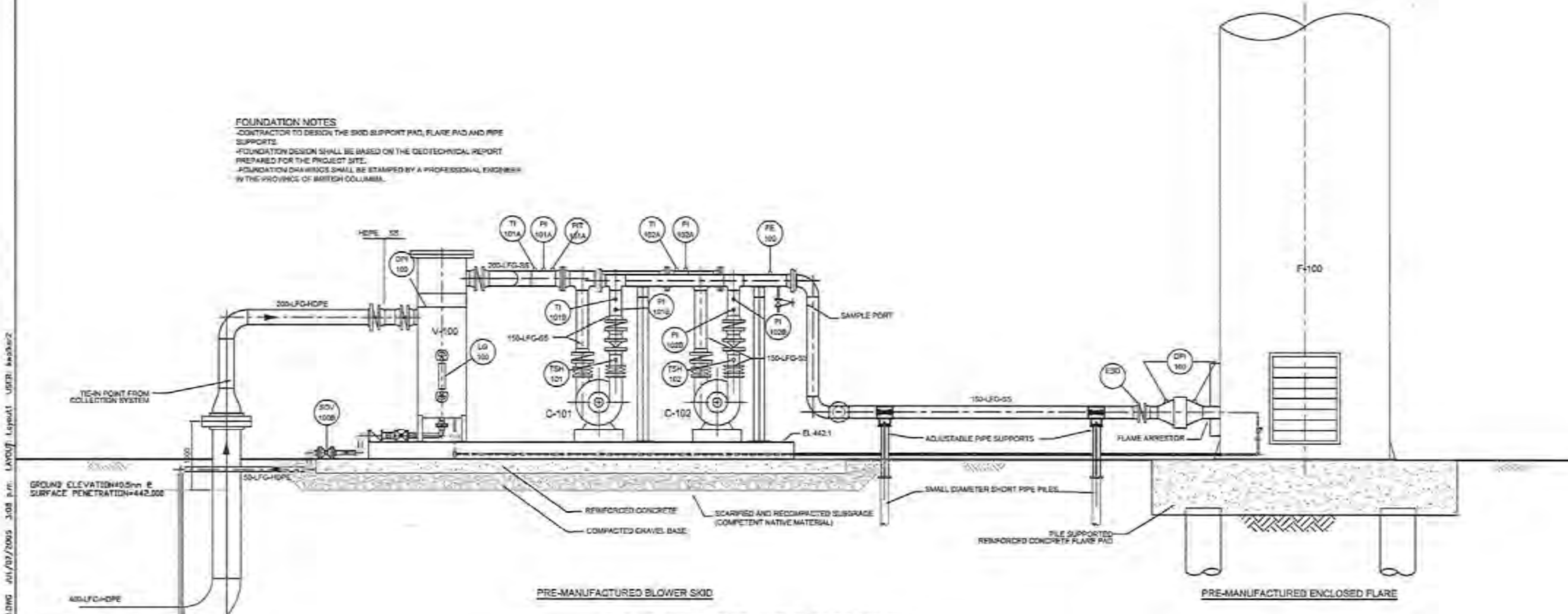
O:\AFFILIATECLIENTSWALL\121130KELOWNALFG\DRAWINGS\CURRENT DRAWINGS\PHASE 2\F2.DWG JUL/07/2005 1:10 p.m. LAYOUT: Layout1 USER: kwalker2

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.



1
F2
BLOWER SKID AND FLARE SECTION
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

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	MB	TL	CS	MB

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"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

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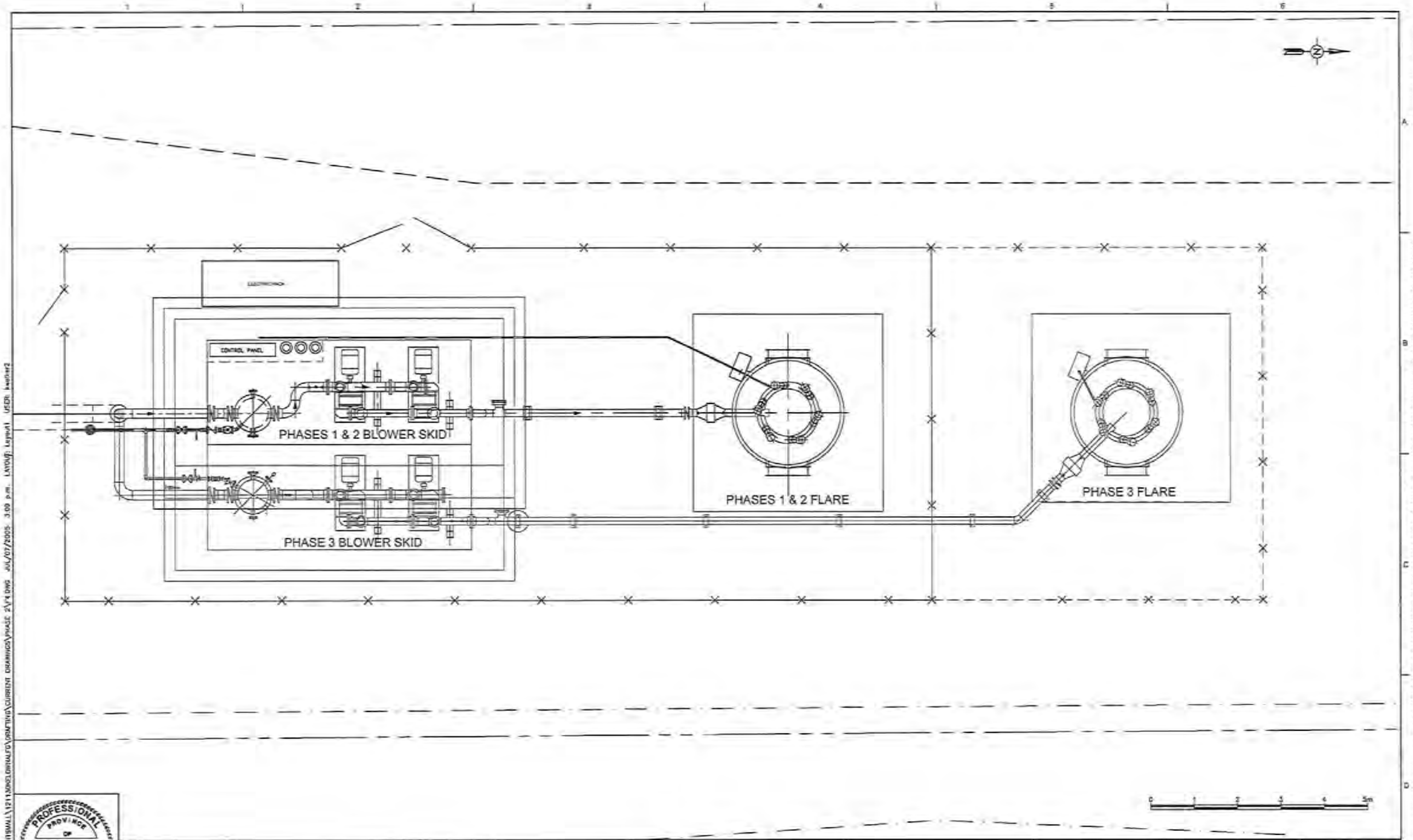

C. J. SMITH

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	NB	TL	CS	NB

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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

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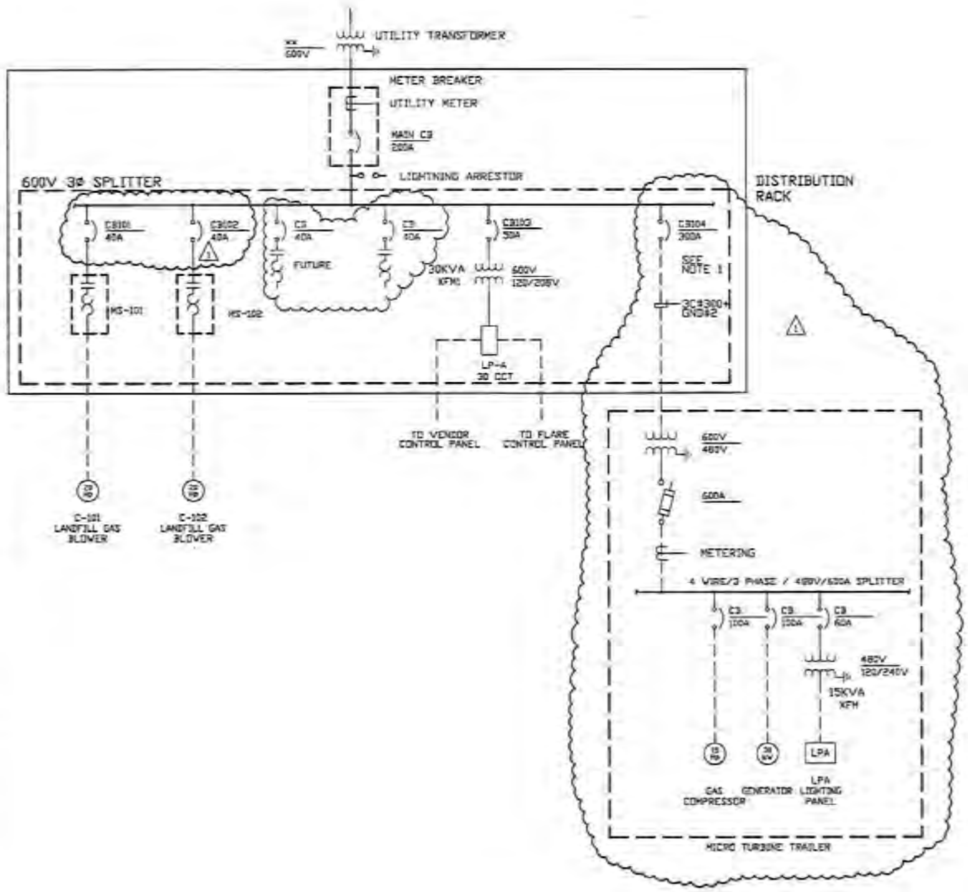

VOLTS 120/208
PHASE 3
WIRE 4
FEEDER

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.
(UNDER CURRENT CAPACITY, 100A 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

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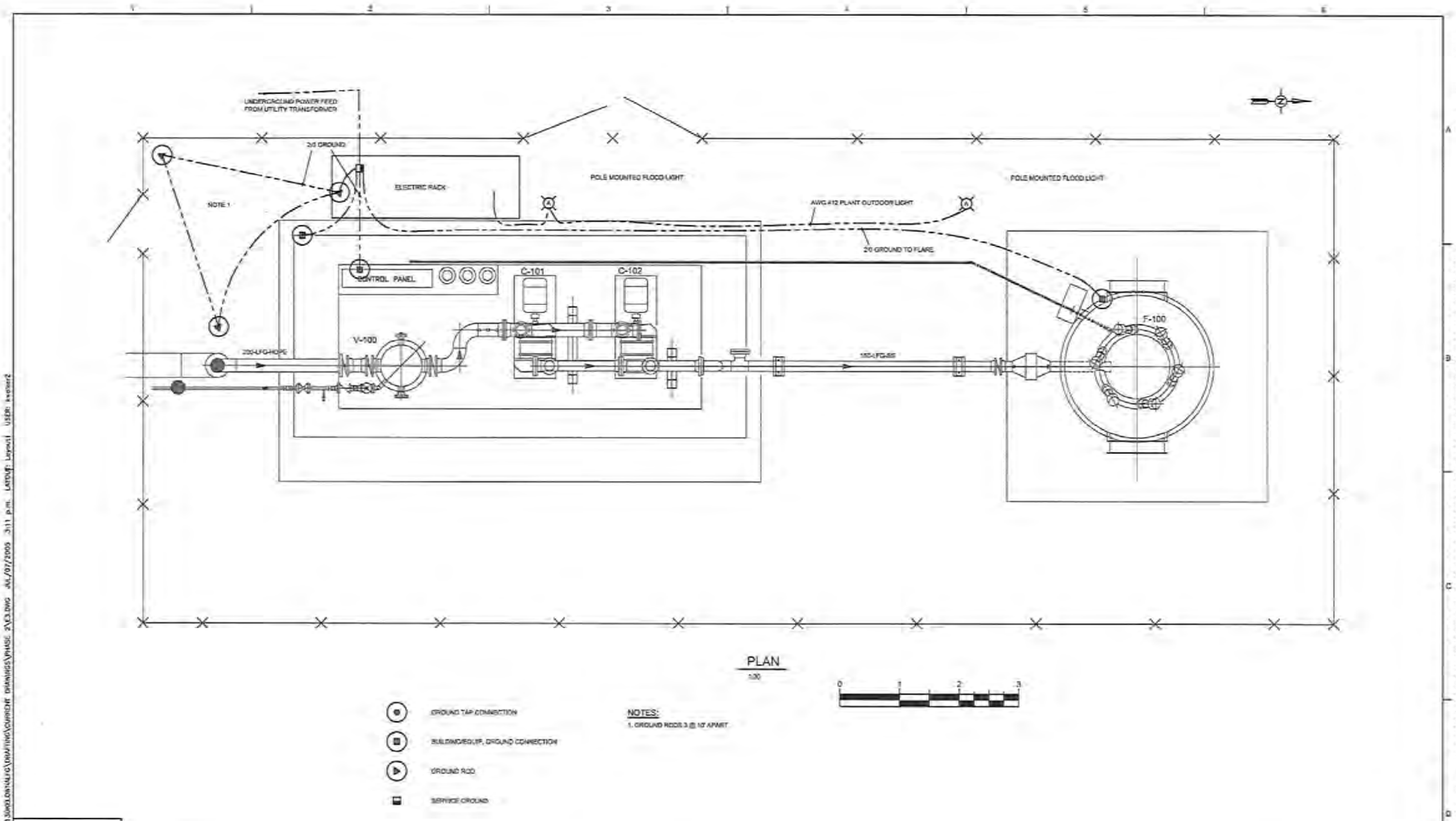
CITY OF KELOWNA
GLENMORE LANDFILL
PHASES 1 & 2
NORTH LANDFILL GAS COLLECTION SYSTEM

ELECTRICAL
PHASE 1 & 2
SINGLE LINE DIAGRAM AND PANEL SCHEDULE

SHEET 20 OF 22
DWG E-1
DATE DEC 2004
PROJ 323443



NOTES:
1. GROUND RODS 3 @ 10' APART

L. D. LLEWELLYN

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

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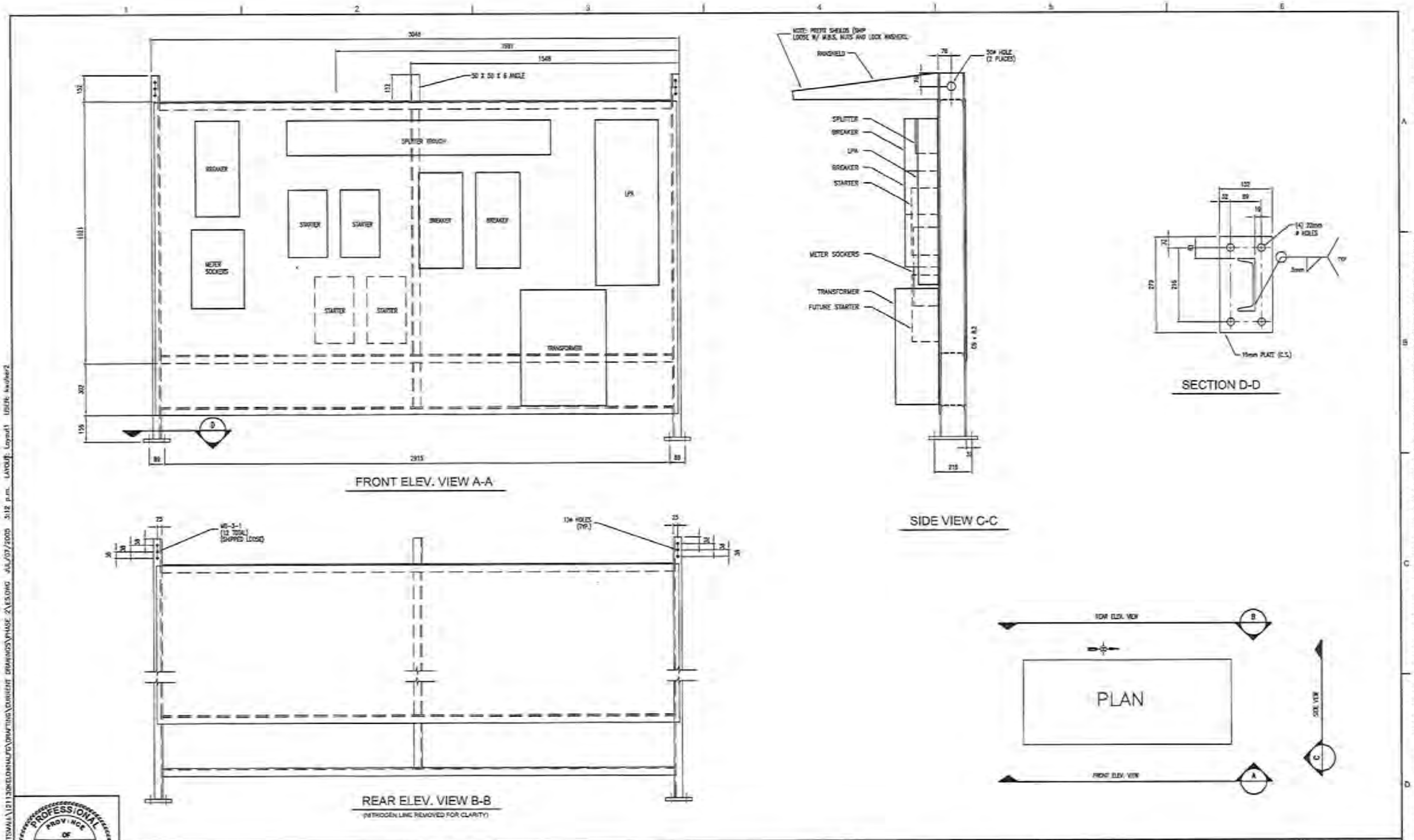
CITY OF KELOWNA
GLENMORE LANDFILL
PHASE 2
NORTH LANDFILL GAS COLLECTION SYSTEM

ELECTRICAL
PHASE 2
BLOWER FLARE STATION
POWER, LIGHTING & GROUNDING LAYOUT

SHEET 21 OF 22
DWG E3
DATE DEC 2004
PROJ 323443



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

PROFESSIONAL ENGINEER
L. D. LLEWELLYN

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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

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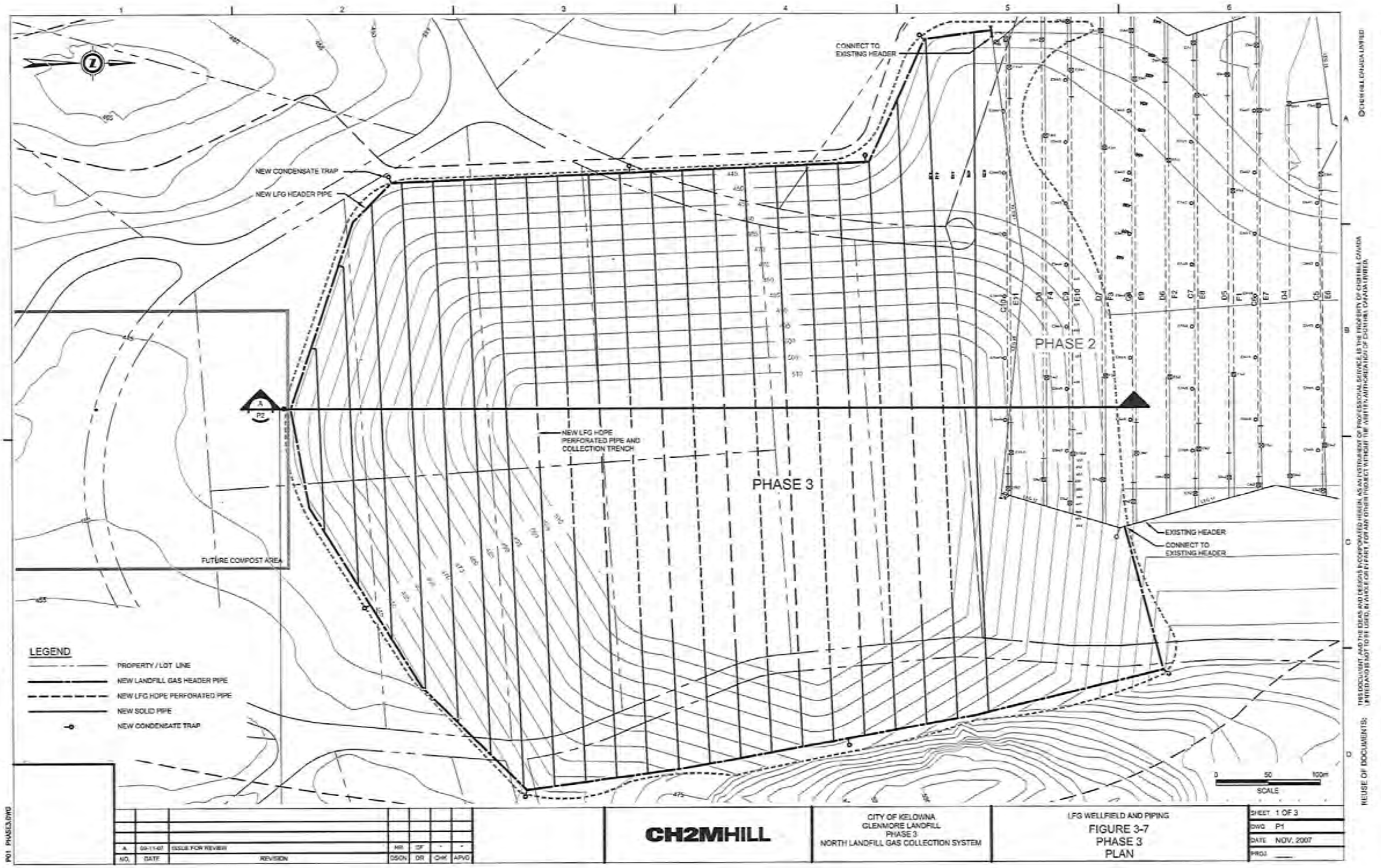
q:\AFFILIATECLIENTS\WALL\121130KELOWNALFG\DRAFTING\CURRENT DRAWINGS\PHASE 2\E5.DWG JUL/07/2005 3:12 p.m. LAYOUT: Layout1 USER: kaulhar2

Appendix D
Phase 3 Conceptual Design Drawings


CONNECT TO EXISTING HEADER
NEW CONDENSATE TRAP
NEW LFG HEADER PIPE
PHASE 2
PHASE 3
NEW LFG HDPE PERFORATED PIPE AND COLLECTION TRENCH
EXISTING HEADER
CONNECT TO EXISTING HEADER
FUTURE COMPOST AREA
A
P2
LEGEND
PROPERTY / LOT LINE
NEW LANDFILL GAS HEADER PIPE
NEW LFG HDPE PERFORATED PIPE
NEW SOLID PIPE
NEW CONDENSATE TRAP
0
50
100m
SCALE
1
2
3
4
5
6
A
B
C
D
C10
E11
D8
F4
C9
E10
D7
F3
C8
E9
D6
F2
C7
E8
D5
F1
C6
E7
D4
C5
E6
475
A
09-11-07
ISSUE FOR REVIEW
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DATE
REVISION
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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
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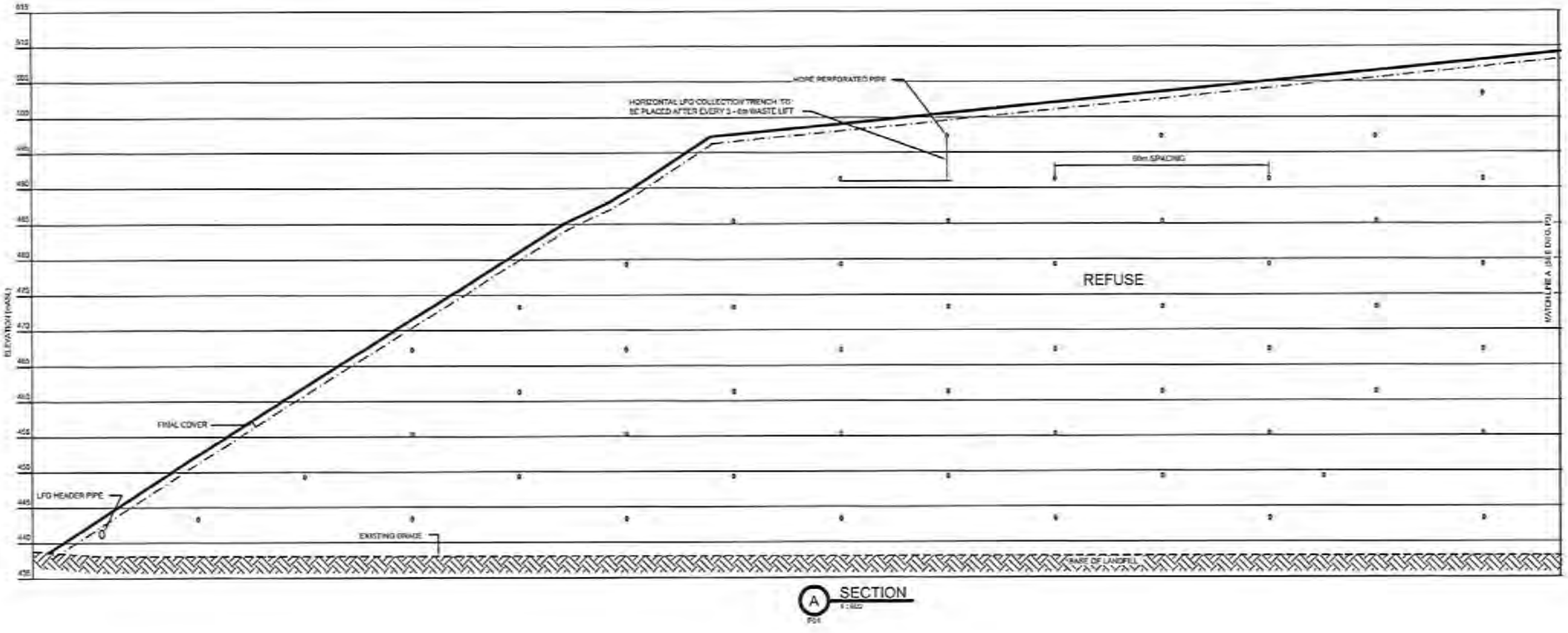


NO.	DATE	REVISION	DSGN	DR	CHK	APVD
A	29-11-07	ISSUE FOR REVIEW	NR	DF	-	-

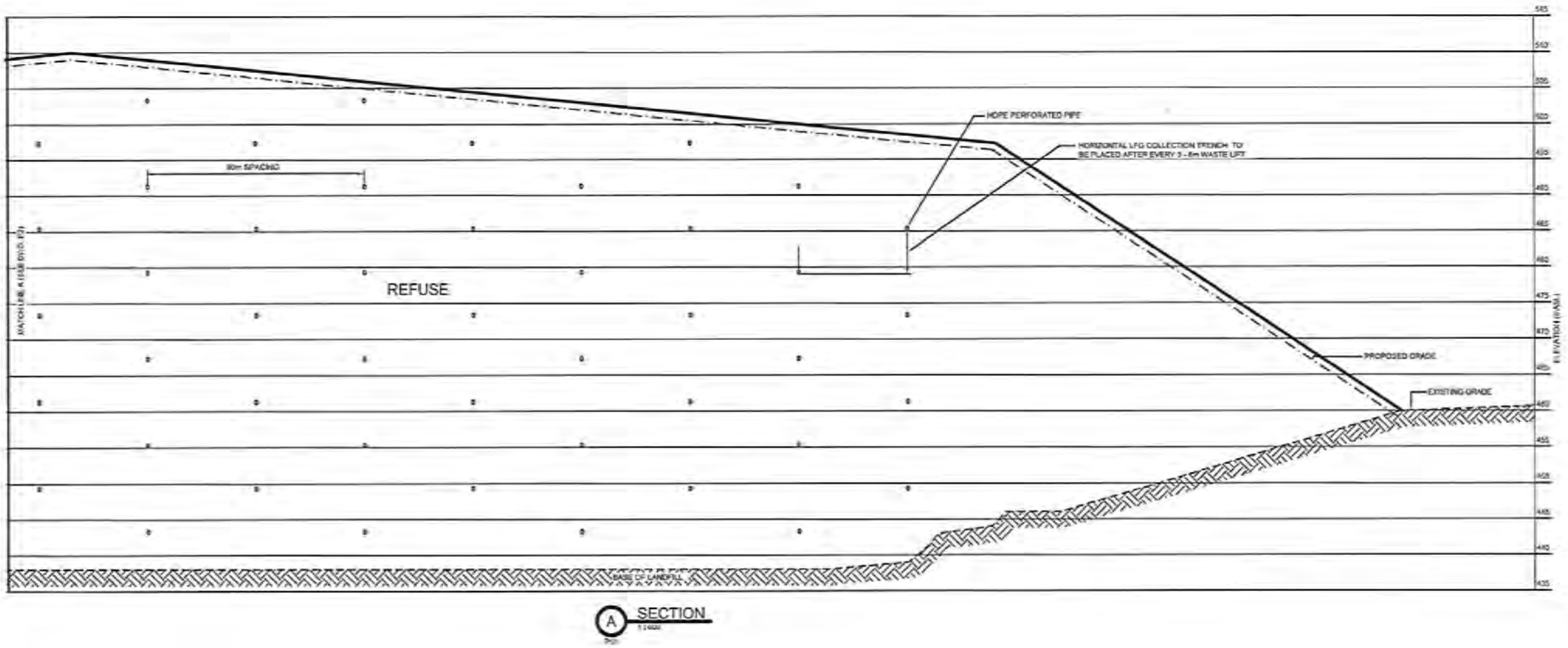
CH2MHILL

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

P01 PHASE3.DWG



A	20-11-07	ISSUE FOR REVIEW	NR	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 3-9
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
	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
P	E1	37,182	453.5									280		280				44
h	F2	37,155	456.0	207 est									207	207				31
a	D1	37,152	450.3				297							297				31
s	E2	37,122	453.5									268		268				34
e	F3	37,095	456.0	221 est									221	221				45
	C2	37,092	447.8			305								305				10
1	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
	E5	36,920	453.0	34 est								181		181				19
P	C4	36,903	445.0						276					276				8
h	D3	36,882	447.5								254			254	4	14	56	22
a	E6	36,860	453.0	28 est								196		196				28
s	C5	36,852	444.0						287					287	4	7	28	14
e	D4	36,822	447.5								268			268	5	14	70	27
	E7	36,800		258 est										0				
2	C6	36,792	444.0						351					351	6	7	42	9
N	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
P	D6	36,702		434 est										0				
h	C8	36,672	444.0					425	40					465	6	7	42	15
a	E9	36,664	454.5	134 est								228	134	362				55
s	D7	36,642	447.5						300		138			438	6	11	66	27
e	C9	36,611	444.0					359	100					459	7	7	49	8
	E10	36,606	454.5	368 est									368	368				48
2	D8	36,582	447.5						300		133			433	7	11	77	20
S	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

P:\Landfill\H-Wu\Solid waste\2011\Capitals\Gas collection\Gas Collector Pipe Inventory.xlsx

22/12/2011

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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

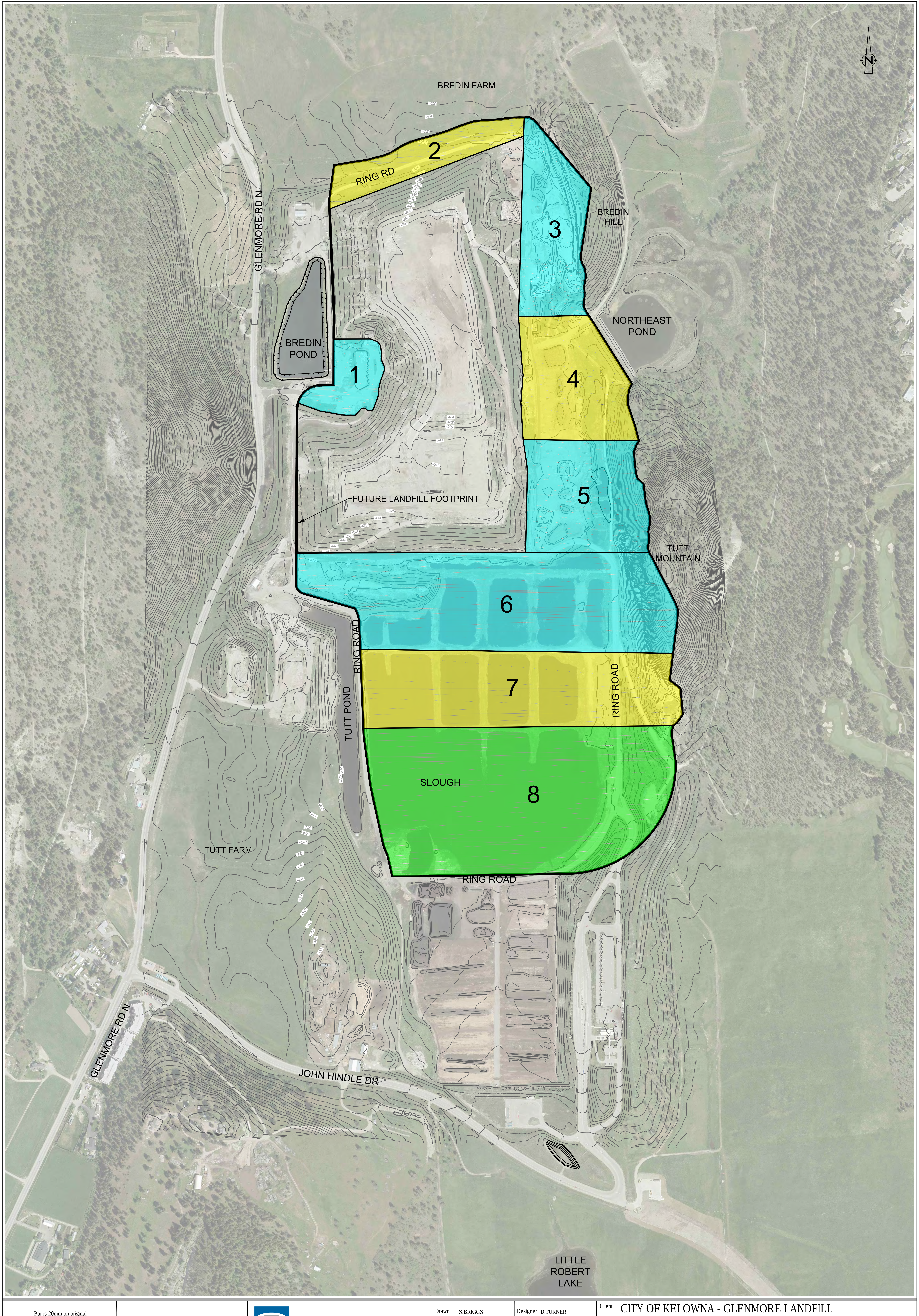
BC Ministry of Environment, June 2016, Landfill Criteria for Municipal Solid Waste, Second Edition, British Columbia

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



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Project Manager	D.LIDDY	Date	2018-03-01
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Client
Project CITY OF KELOWNA - GLENMORE LANDFILL DESIGN, OPERATIONS AND CLOSURE PLAN

Title LANDFILL AREAS

Project No. 084612-22

Original Size ANSI D

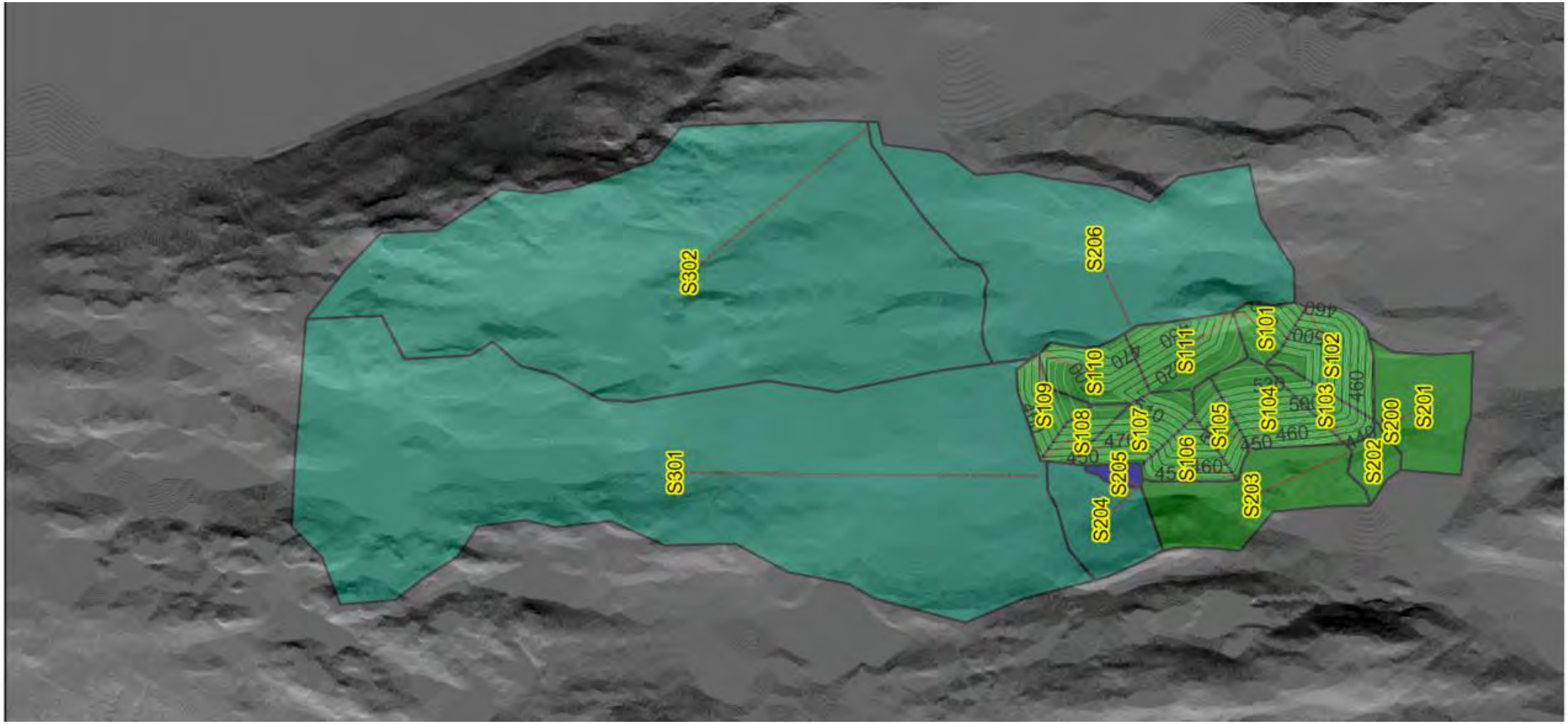
Sheet No. FIGURE-01

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

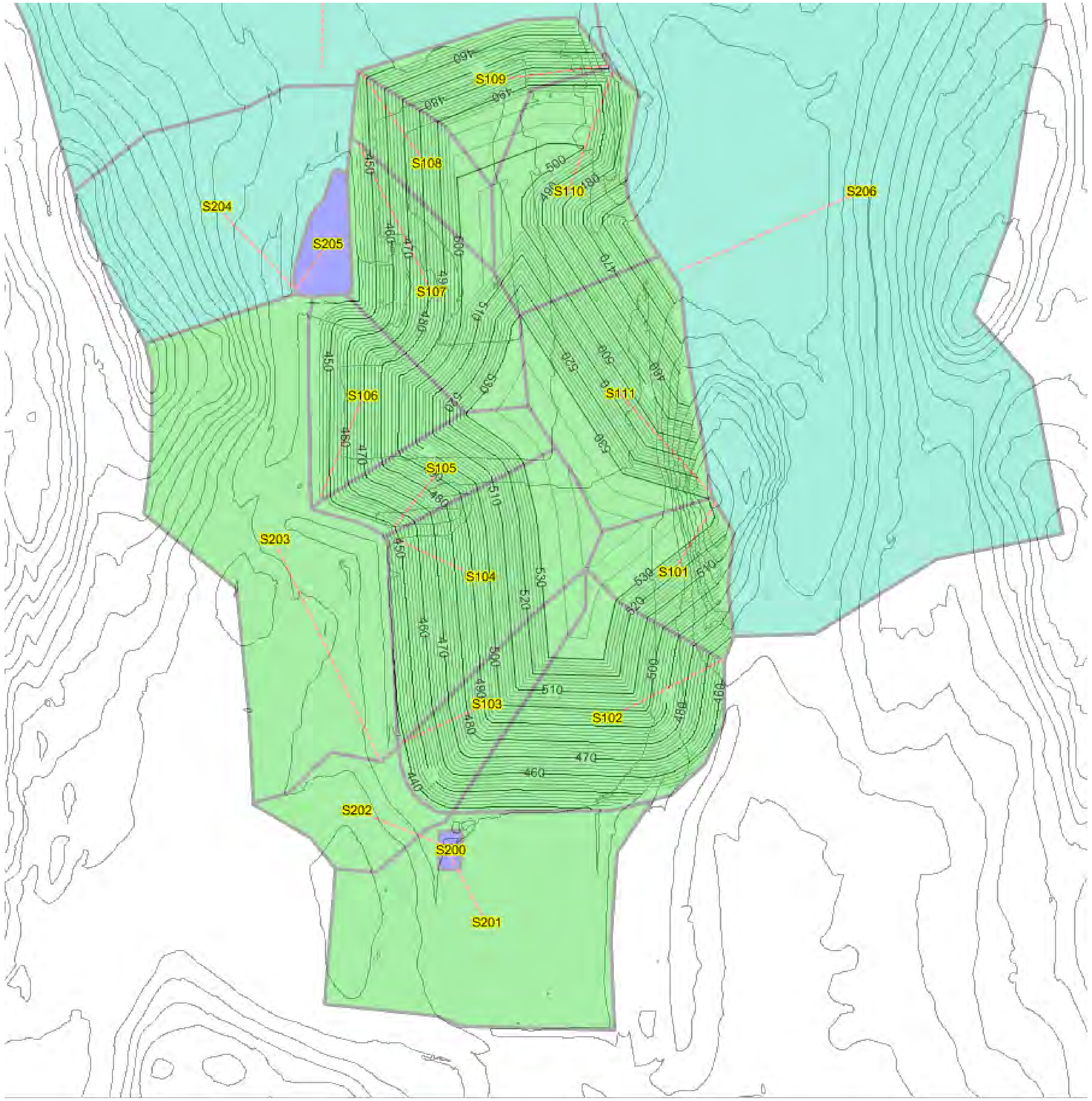


City of Kelowna
Glenmore Landfill
Design, Operation and Closure Plan - Surface Water Management Plan

PCSWMM MODEL EXTENTS

084612-22
3/9/2018

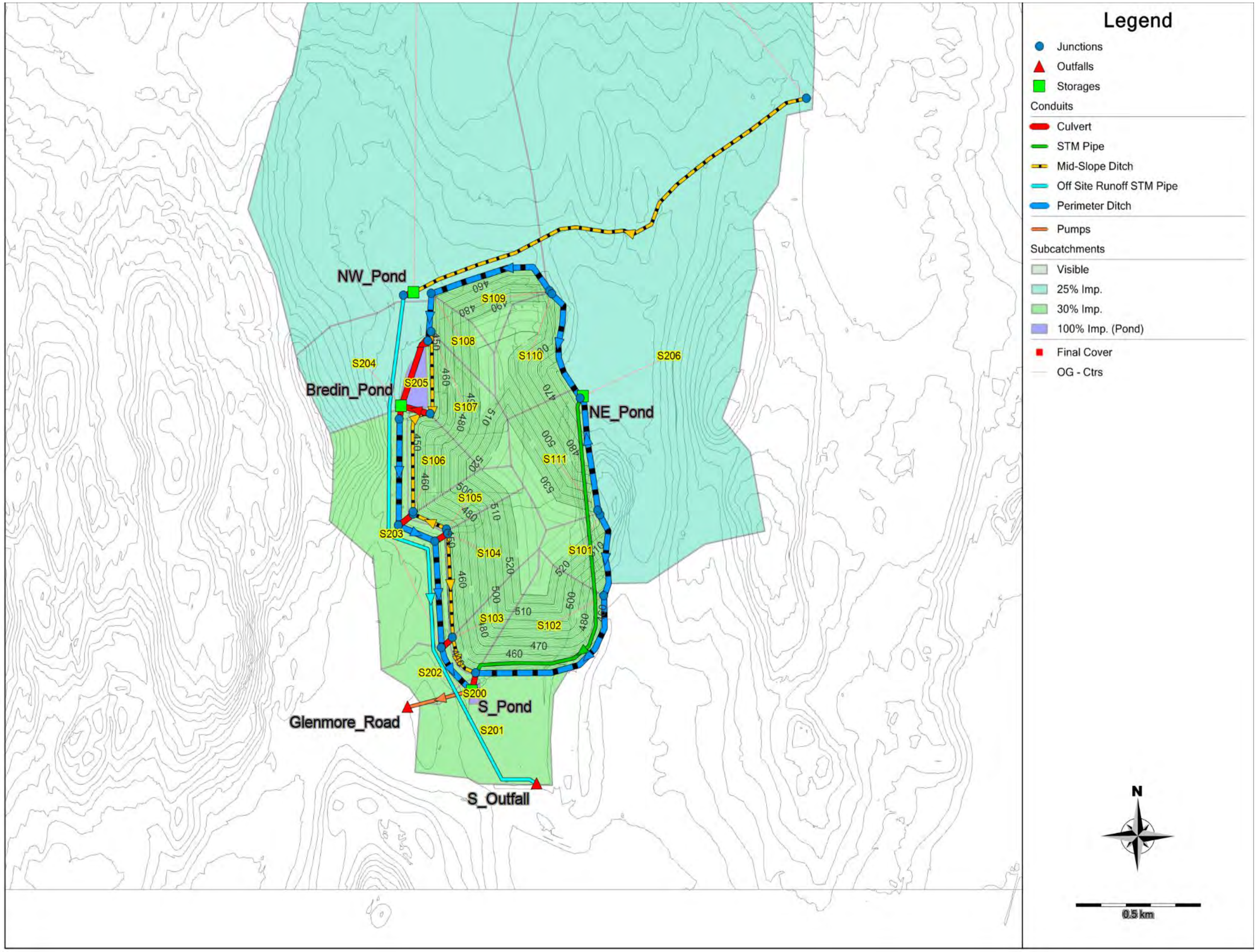
FIGURE NO. 2



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					Manning' n		Depression Storage		Infiltration	
ID	Area (ha)	Flow length (m)	Slope (%)	Imperviousness (%)	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 (m³/s)**	**10-year (m³/s)**	**100-year (m³/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 (m³)	Runoff Coefficient (-)	Runoff Volume (m³)	Runoff Coefficient (-)	Runoff Volume (m³)	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

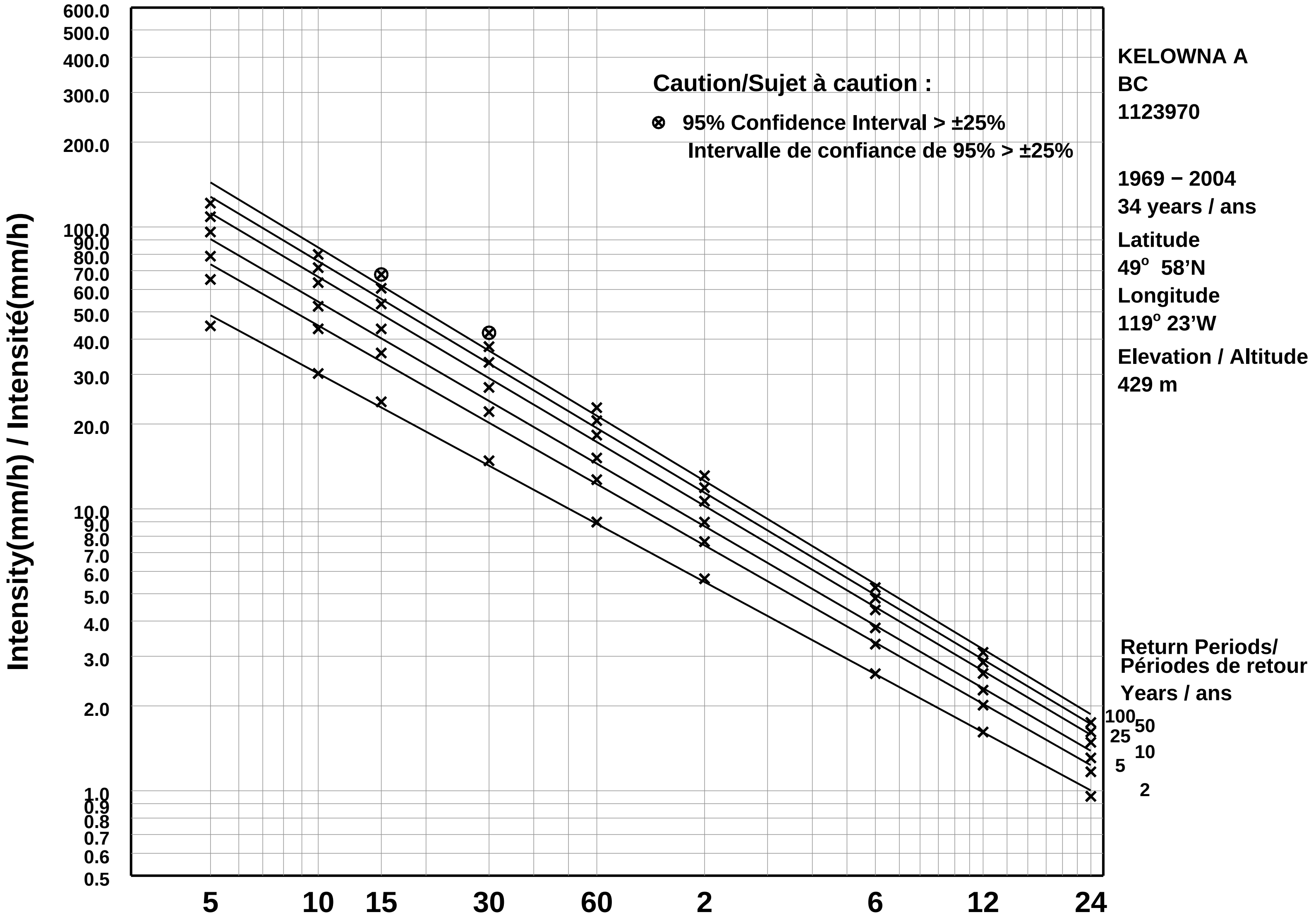
Design Storm	Peak Discharge (m^3/s)	Runoff Volume (m^3)
5-Year	0.38	34,515
10-Year	0.38	39,027
100-Year	0.39	54,209

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
```

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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
```

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*********************
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
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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	$\leq 1.25^1$	WSER
Nitrate	mg-N/L	$\leq 3.7^2$	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		$\pm 1°C^5$	BC WQG
Total Dissolved Solids	mg/L	-	Not regulated
Total Iron (Fe)	mg/L	1^6	BC WQG
Total Manganese (Mn)	mg/L	$\leq 0.77^7$	BC WQG
Total Suspended Solids	mg/L	≤25	WSER
Dissolved Oxygen	mg/L	$\geq 5^8$	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.

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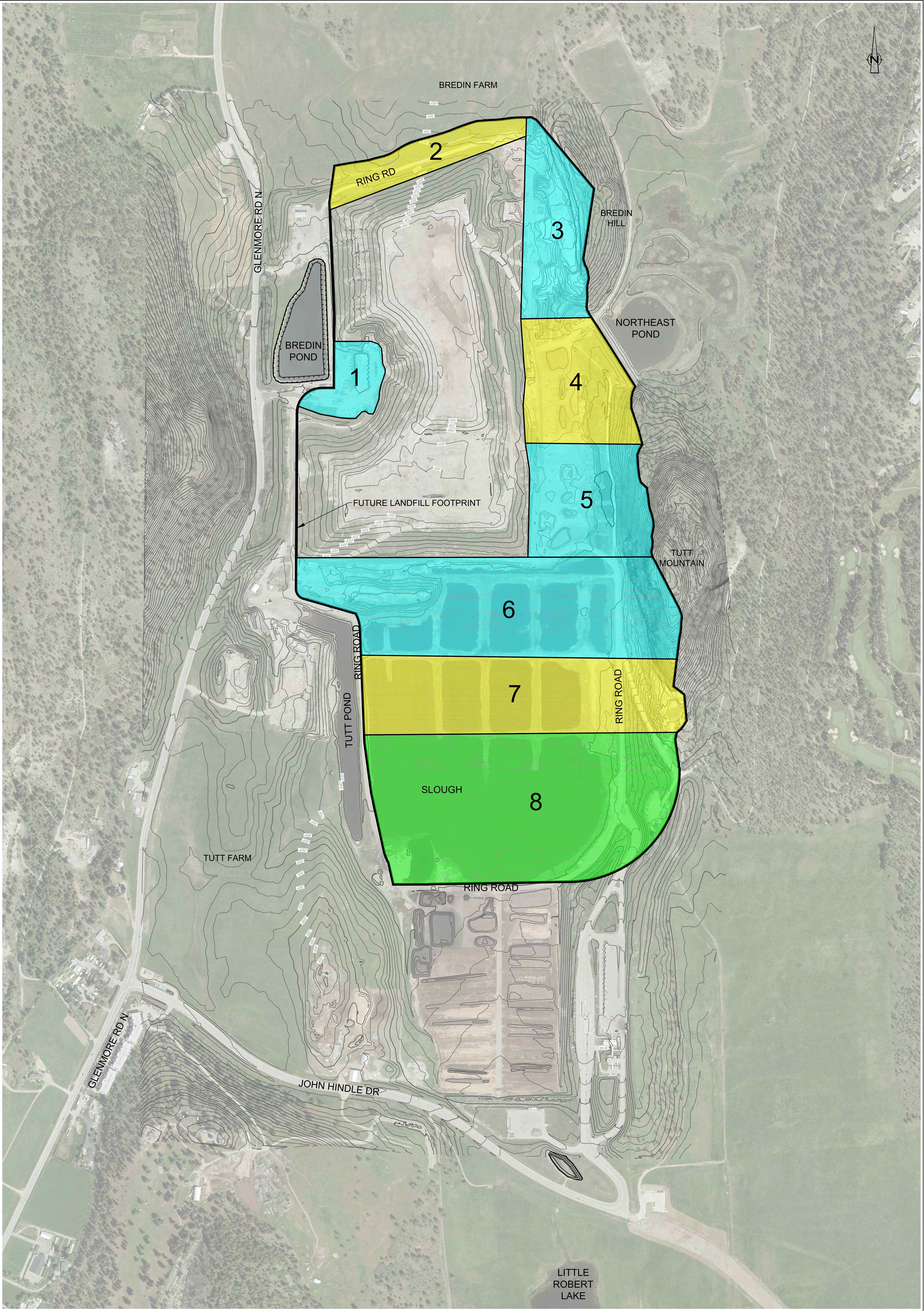

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Project No. 084612-22

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Sheet No. FIGURE-01

Sheet 1 of 2

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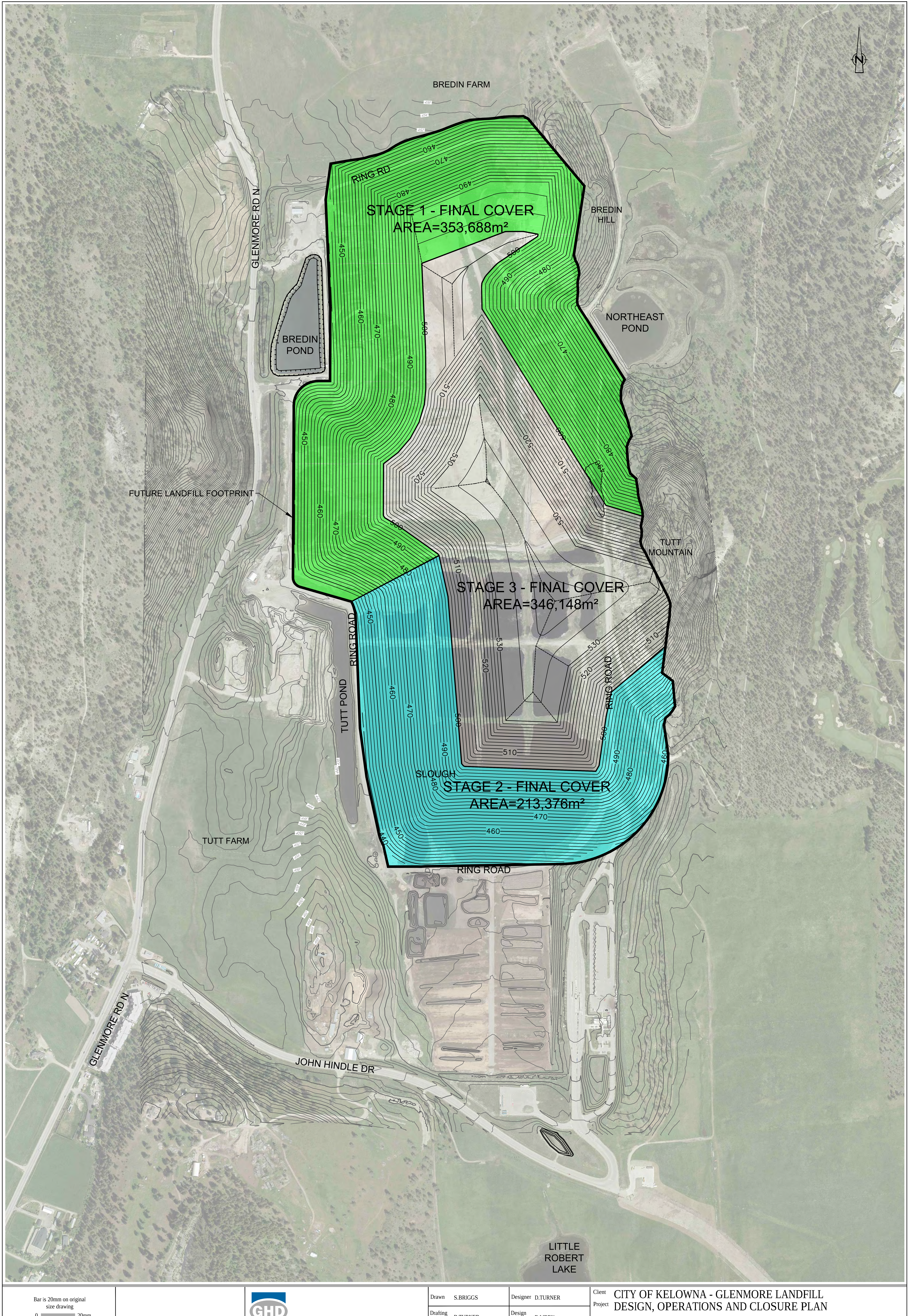

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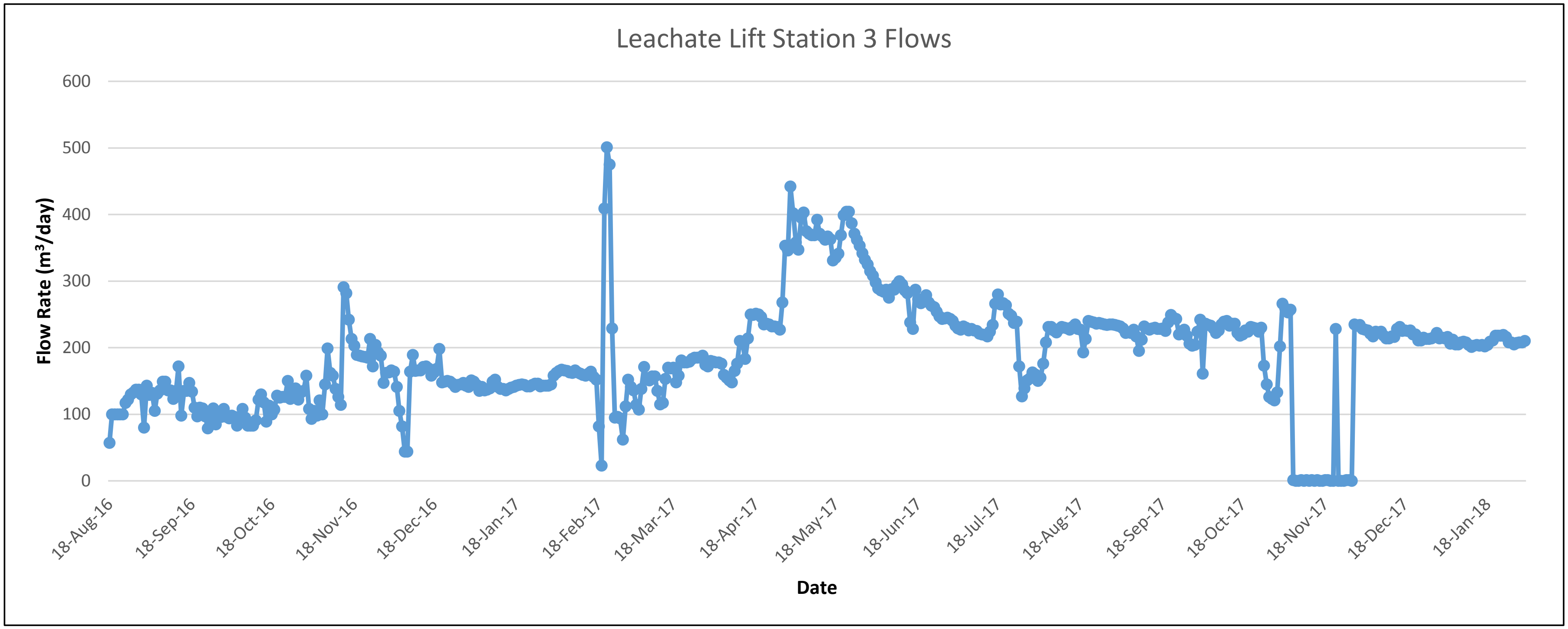


Maximum Flow Rate	500	m^3/Day
Average Flow Rate	190	m^3/Day

CITY OF KELOWNA, BRITISH COLUMBIA
GLENMORE LANDFILL

84612

3/2/2018

LEACHATE LIFT STATION 3 FLOWS

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

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

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: June 29, 2015
(most recent)

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:

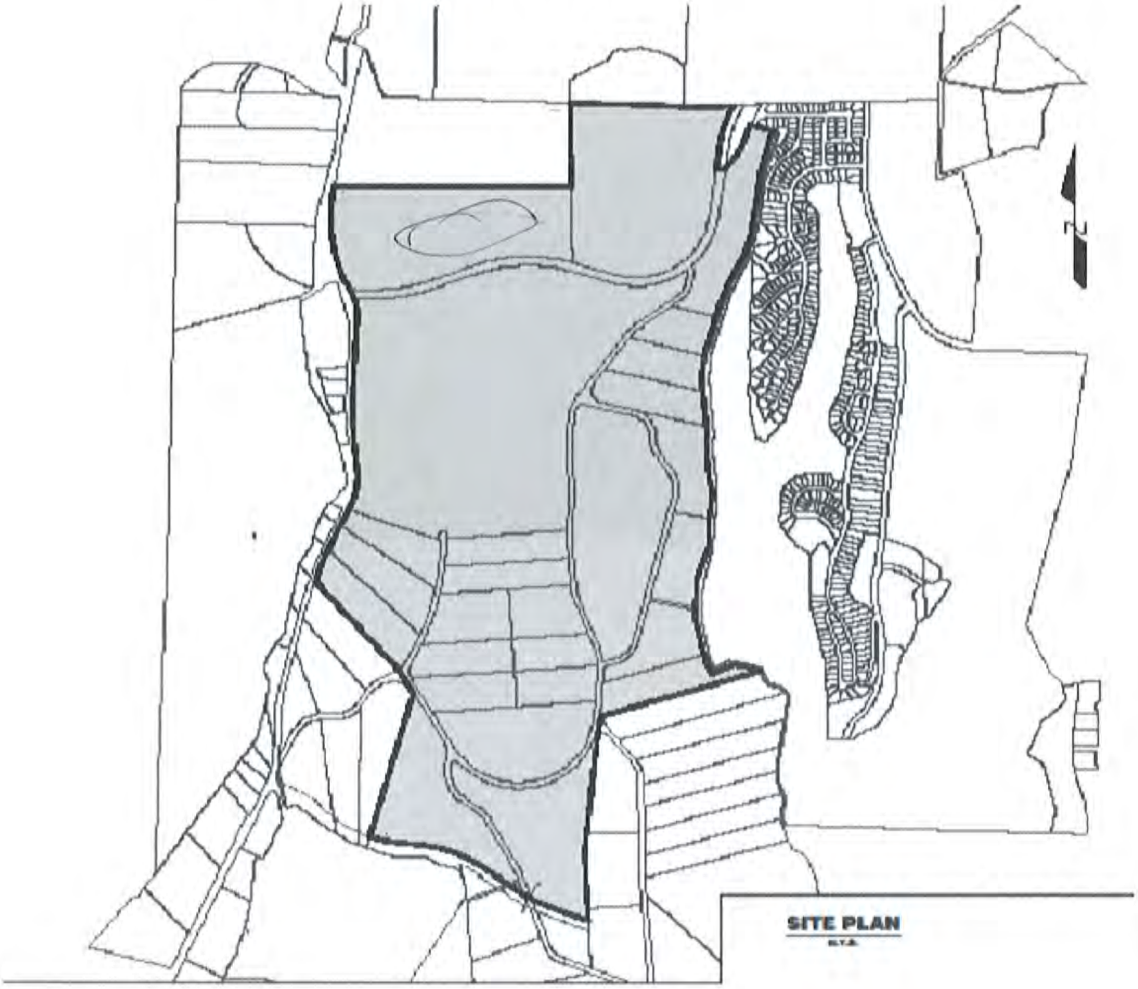
- Total volume, tonnage, and types of waste discharged into the landfill for the year.
- Types and tonnages of waste that were not directly disposed of into the landfill such as recycled, composted, etc.
- Leachate quantities collected, treated and discharged.
- Landfill gas quantities collected, flared 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 J
LFG Generation Assessment (2016)

FINAL REPORT

Landfill Gas Collection Efficiency Study –Glenmore Landfill Site

Prepared for

City of Kelowna

March 2017

540 12th Avenue SW
Calgary, AB T2R 0H4
CANADA

Contents

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).

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).

SECTION 3

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.

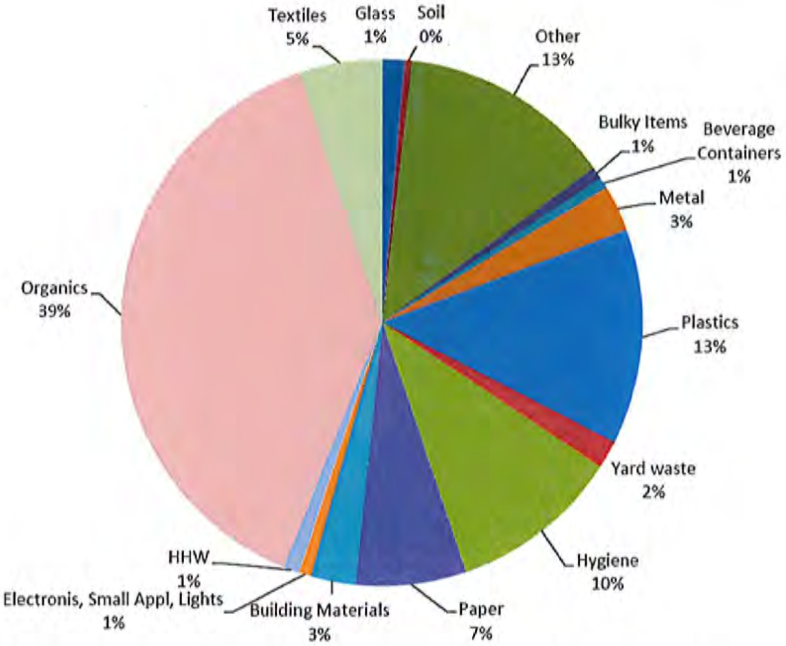


Figure 3-1. Waste Composition of Garbage Collected at Curbside from Residents
Source: Figure extracted from the 2013 Waste Composition Study of Regional District of Central Okanagan (RDCO) (Morrison Hershfield Ltd., 2016)

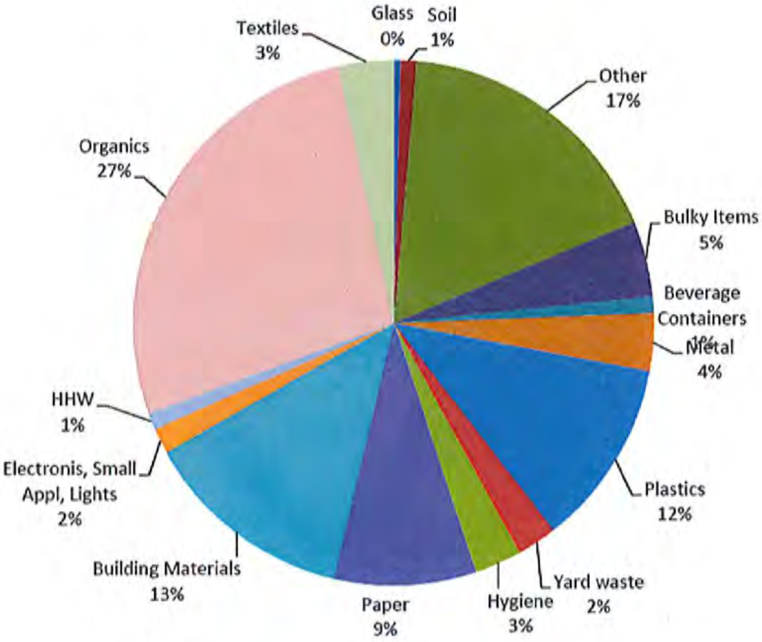


Figure 3-2. Waste Composition of ICI Garbage
Source: Figure extracted from the 2013 Waste Composition Study of Regional District of Central Okanagan (RDCO) (Morrison Hershfield Ltd., 2016)

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

Input Parameters or Constants	LFG Generation Model 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).

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.

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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)	

Year	Year Number	Annual Tonnage (tonnes)	Cumulative Waste-in-place (tonnes)	Waste Tonnage Relatively Inert (tonnes)	Waste Tonnage Moderately Decomposable (tonnes)	Waste Tonnage Decomposable (tonnes)	Methane Generation Rate, k Relatively Inert ($year^{-1}$)	Methane Generation Rate, k Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)
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.

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CITY OF KELOWNA

BYLAW NO. 11740

Road Closure and Removal of Highway Dedication Bylaw
(Adjacent to 1690 Saucier Road)

A bylaw pursuant to Section 40 of the Community Charter to authorize the City to permanently close and remove the highway dedication of a portion of highway on Saucier Road

---

NOW THEREFORE, the Municipal Council of the City of Kelowna, in open meeting assembled, hereby enacts as follows:

1. That portion of highway attached as Schedule "A" comprising 0.518ha shown in bold black as Closed Road on the Reference Plan prepared by Robert T. Macdonald, B.C.L.S., is hereby stopped up and closed to traffic and the highway dedication removed.

2. The Mayor and City Clerk of the City of Kelowna are hereby authorized to execute such conveyances, titles, survey plans, forms and other documents on behalf of the said City as may be necessary for the purposes aforesaid.

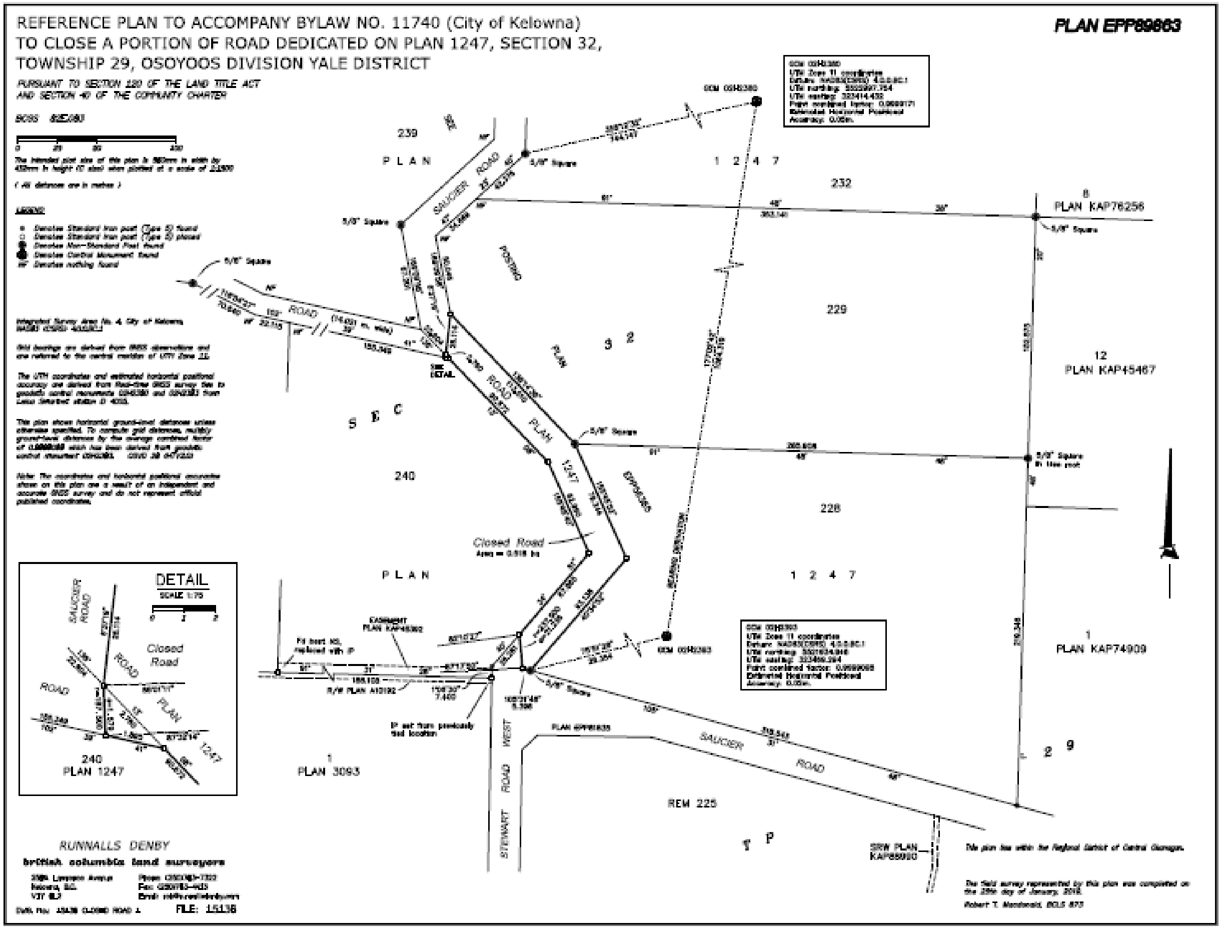
Read a first, second and third time by the Municipal Council this 4th day of February, 2019.

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Schedule "A"


REFERENCE PLAN TO ACCOMPANY BYLAW NO. 11740 (City of Kelowna)
TO CLOSE A PORTION OF ROAD DEDICATED ON PLAN 1247, SECTION 32,
TOWNSHIP 29, OSOYOOS DIVISION YALE DISTRICT
PURSUANT TO SECTION 120 OF THE LAND TITLE ACT
AND SECTION 40 OF THE COMMUNITY CHARTER
PLAN EPP89863
LEGEND
239
PLAN
SAUCIER ROAD
5/8" Square
1 2 4 7
232
8
PLAN KAP76256
ROAD
229
12
PLAN KAP45467
S E C
3 2
240
228
Closed Road
PLAN
1 2 4 7
1
PLAN KAP74909
DETAIL
SAUCIER ROAD
Closed Road
ROAD
PLAN
1247
240
PLAN 1247
1
PLAN 3093
STEWART ROAD WEST
SAUCIER ROAD
REM 225
T P
2 9
SRW PLAN KAP88980
RUNNALLS DENBY
british columbia land surveyors
FILE: 15136

CITY OF KELOWNA

BYLAW NO. 11741

Road Closure and Removal of Highway Dedication Bylaw
(Adjacent to 1651 Saucier Road)

A bylaw pursuant to Section 40 of the Community Charter to authorize the City to permanently close and remove the highway dedication of a portion of highway on Saucier Road

---

NOW THEREFORE, the Municipal Council of the City of Kelowna, in open meeting assembled, hereby enacts as follows:

1. That portion of highway attached as Schedule "A" 558.1m² shown in bold black as Closed Road on the Reference Plan prepared by Robert T. Macdonald, B.C.L.S., is hereby stopped up and closed to traffic and the highway dedication removed.

2. The Mayor and City Clerk of the City of Kelowna are hereby authorized to execute such conveyances, titles, survey plans, forms and other documents on behalf of the said City as may be necessary for the purposes aforesaid.

Read a first, second and third time by the Municipal Council this

Adopted by the Municipal Council of the City of Kelowna this

Mayor

City Clerk

Bylaw No. 11741 - Page 2

Schedule "A"