OLAND
ENGINEERING
LIMITED

District of Lake Country
10150 Bottom Wood Lake Road
Lake Country, BC, V4V 2M1

February 9, 2023

Re: Owl's Nest Proposed Sewerage Treatment and Dispersal Systems,
4111 Evans Road, Lake Country, BC
Lot 9, Plan 720, Sec. 11 & 14, Twp. 14, ODYD

Attention: Inonge Aliaga Labun, Senior Planner
Cc: Carlin Gurjar, Senior Manager, Cantiro, formerly Beaverbrook Communities
Cc: Sheldon Gull., Project Manager, Urban Systems

Dear Sir/Madam

In response to your email, sent January 13, 2023, I submit the requested information.

The property owners recognize the sensitive nature of the Owl's Nest development, and they are willing to take all necessary measures to enforce and protect the public's interests.

The operating plan for the Owl's Nest sewerage system will be worded like that of an operating plan under the Municipal Wastewater Regulation (MWR). A sample of a plan for a similar treatment facility is attached in **Appendix A**.

Testing and reporting will be required with the same parameters and at the same frequency as the MWR, outlined in Part 5, Division 4 of the regulation. The reports and sample results for system performance will be sent to a Qualified Professional Engineer on a prescribed regular basis for review.

I also attach a sample of a Risk Assessment Matrix (**Appendix B**), completed for a similar wastewater system. Prior to detailed design and construction, this same exercise will be completed as it applies to the components and operation of the Owl's Nest Sewerage Systems.

The Professional Engineer of record for the system, would be required, under the regulation, to address any problems with the system and report, to Interior Health Authority, any potential health risks, if the operation plan is not being followed or if the system is not meeting the set parameters for a Type 3 sewerage system as listed in the Sewerage System Regulation (SSR).

In addition to the regulation, the Strata Association Bylaws, registered with land titles, will include provision for funding to operate and maintain the sewerage system in keeping with the maintenance and operating plan and will require continuous retainment of a professional Engineer for maintenance supervision and to monitor reports on the system.

I also attach a Capital Reserve Funds plan prepared specifically for the Owl's Nest Sewerage Systems (**Appendix C**). This will ensure that there are funds available for ongoing maintenance and parts replacement as required.

Environmental concerns, as they relate to the sewerage system, have been addressed in the Watterson Environmental Impact Study as well as the Watterson Technical Memo that compares the original Owl's Nest sewerage system to the proposed system. **(Appendix D)**

In summary, the proposed sewerage systems will have operation and maintenance quality assurance supported by provincial regulation and enforcement under the Ministry of Health, Sewerage System Regulation.

C. Jeffrey Oland, P.Eng.

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URBAN SYSTEMS MEMORANDUM

DATE: January 31, 2023
TO: Carlin Gurjar
CC:
FROM: Sheldon Gull and Jason Barta
FILE: 4265.0001.02-R
SUBJECT: Owls Nest Development – Sanitary Sewer Collection System Risks and Design Mitigation

This memorandum discusses the potential risks associated with the sanitary sewer collection system – the portion of the system between each unit and the wastewater treatment plant.

1.0 SYSTEM OVERVIEW

Each unit has a gravity connection out of the building to a self-contained grinder pump station, with its own wetwell. Each pump has a service that connects the pump to a common low-pressure main that leads to one of the two treatment plants. There are four (4) low pressure mains in total – two that convey flow to the north treatment plant and two conveying flows to the south facility. Each low-pressure main includes access points for flushing and maintenance.

The low-pressure mains and access points are communal infrastructure. This will be referred to as the common collection system. The gravity service out of the building, the grinder pump and wetwell assembly and the service connection to the common low-pressure main are considered the responsibility of the unit owner. *The only exception is the complete service for the amenity building, which will be common infrastructure.*

2.0 RISKS AND MITIGATION - SERVICES

Each unit is protected from sewer backup by a backflow preventer, installed on the gravity line between the unit and grinder pump assembly.

There will also be a lateral kit (check valve assembly) and curb stop where each pressurized service meets the common low-pressure main. This prevents flow from the common infrastructure backing up into the wetwell and affecting storage capacity.

Each grinder pump will be housed in a solid FRP tank (wetwell). There are multiple tank options, ranging between 70 gallons (265 Litres) and 230 gallons (870 L). Installation of the larger tank provides more capacity in the event of a power failure in the neighbourhood. Sewer gases from the pump and wetwell assembly will be routed outside of the tank and vented either at surface, or at the roof line through a vent pipe attached to the side of the building unit.

Each pump unit will come equipped with an alarm panel mounted on the exterior of the unit. The panel will either flash a light or produce an audible alarm when the sewage level in the wetwell exceeds a specified maximum level. By mounting externally to the unit, the alarm can be seen/heard in cases where the homeowner is away. The monitoring can also be tied to a cell phone app as well. And since the wetwell and pumps are located external to the unit, a repair person can access the equipment, even if the homeowners are away.

In the case of a pump or lateral (check valve) kit failure, the curb stop at the connection point to the common low pressure main can be closed to allow for repair to the service while still allowing the other units to operate normally.

3.0 RISKS AND MITIGATION – COMMON COLLECTION SYSTEM

The common infrastructure (low pressure mains) is anticipated to be maintenance-free but has been provided with access points (cleanouts) in case of a blockage. Normal pump operations will provide adequate flushing velocity to prevent build-up on the inside of the low-pressure main. Fused HDPE pipe for low pressure application can be rated for up to 200 psi working pressure. This development will likely see operating pressures between 40 and 60 psi in the common low-pressure mains.

The cleanout locations will be equipped with cam-lock connections to allow a vactor-truck to pump out or flush the sewer main should there be an issue with either of the treatment plants (maintenance, equipment failure).

4.0 INSTALLATION COSTS AND REPLACEMENT TIMING

The replacement cost for all building services, grinder pumps and wetwells will be borne by each unit owner. Grinder pumps and station internals have an expected life of 20 years. Service pipe will likely last for 50 years or more. The initial installation cost of all 38 residential pump packages and services is $800,000 + GST.

The common system will include approximately 450 meters of common forcemain, four maintenance access points for flushing of the common mains and the pump station/service for the amenity building. The estimated installation cost of the common sewer collection system is $125,000. Of that total, $20,000 is allocated for the pump station and lateral kit (check valve), which has a design life of roughly 20 years. The remaining infrastructure is expected to last for at least 50 years.

Sincerely,

URBAN SYSTEMS LTD.

Jason Barta, B.Sc.
Project Designer

Sheldon Gull, AScT
Project Manager / Principal

/jb

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URBAN SYSTEMS MEMORANDUM

DATE: February 13, 2023
TO: Carlin Gurjar, Senior Development Manager
CC: Sheldon Gull, Project Manager
FROM: Rhonda Maskiewich
FILE: 4265.0001.02
SUBJECT: Owls Nest - Sewer System Ecological Impact

Below is an opinion on the potential ecological impact of the proposed sanitary sewer collection, treatment and dispersal system of the Owl's Nest development. This opinion has been developed based on a brief review of preliminary information, and on the understanding that further detailed engineering on this system will be undertaken once approvals are received from the District of Lake Country.

It is understood that the system is being developed by professional engineers and that they intend to go above and beyond the regulatory requirements in order to protect the ecological environment. The selection of a sophisticated biological treatment system (membrane bioreactor with UV disinfection), a higher effluent quality (i.e. at least a Type 3 quality as defined in the Sewerage System Regulation), use of multiple components, automation, alarm/notification systems, increased redundancy and environmental monitoring (i.e. groundwater sampling through monitoring wells) are all examples of the direction from the engineers to enhance ecological safety. In addition, although not required under the Sewerage System Regulation, the engineers are proposing to incorporate principles from the BC Municipal Wastewater Regulation, which is intended to apply to larger systems with potentially greater levels of ecological risk. An example of a principle from the Municipal Wastewater Regulation is the application of a Capital Reserve Fund to ensure that the system will continue to be upgraded and maintained into the future.

It our understanding that the engineering components that have been added to the system are included to increase the ability to manage and mitigate adverse ecological impact on the surrounding environment. Examples of some of these systems and how they mitigate ecological impact are provided in Mr. Oland's attached document. It is our understanding that a more detailed and prescriptive strategy for the Owl's Nest system will be developed, based on these examples, as detailed design is more advanced. As the design progresses, the potential ecological impacts will be further evaluated and addressed to ensure they are minimized or protected against.

As perhaps an added benefit, the land is currently in a disturbed state and is inundated with non-native weedy species. The locations of the proposed dispersal fields will be revegetated with native plants and grasses. This will help to restore some of the habitat that has been lost through previous development.

The above provides a high-level opinion based on currently available preliminary information. As the design process develops, we will be pleased to review future information to greater depth and provide assistance to the professional engineers regarding decisions to mitigate and/or avoid potential ecological risk.

Sincerely,

URBAN SYSTEMS LTD.

RMaskiewich

Rhonda Maskiewich MCIP, RPP, RPBio
Environmental Planner

/rm

Enclosure

file://usl.urban-systems.com/projects/Projects_KEL/4265/0001/02/R-Reports-Studies-Documents/R2-Memos/2023-02-13_Sewer%20System%20Ecological%20Impact%20Memo/2023-02-13%20Sewer%20System%20Ecological%20Impact%20Memo.docx

APPENDIX A

SAMPLE OPERATIONS & MAINTENANCE MANUAL

ECOFLUID SYSTEMS LTD.

[redacted]

WASTEWATER TREATMENT PLANT

[redacted]

OPERATIONS & MAINTENANCE MANUAL

[redacted]

PREPARED BY:
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OPERATIONS & MAINTENANCE MANUAL

APPENDICES

1 INTRODUCTION

1.1 GENERAL

This manual provides operating procedures for the Wastewater Treatment Plant (WWTP) at [redacted]. Also serving as a reference guide for operators, it is to be interpreted and followed with respect to the rules and regulations provided by WorkSafeBC, The Environmental Operators Certification Program (EOCP) and the British Columbia Water & Wastewater Association (BCWWA).

The facility consists of single sludge denitrification, extended aeration activated sludge process that incorporates a Toray membrane module for ultra-filtration. The entire system is comprised of the following equipment and components:

QTY	DESCRIPTION	TAG
1	Equalization Tank	EQT-100
1	Automated Bar Screen	SCR-101
2	Equalization Pump	P-101, 102
1	Anoxic Tank	ANT-110
1	Anoxic Mixer	MIX-111
1	Aeration Tank	AET-120
1	Membrane Bioreactor Tank	MBT-130
3	Membrane Module	MF-131, 132, 133
2	RAS/WAS Pump	P-131, 132
1	Sludge Holding Tank	SHT-140
2	Permeate Pump	P-201, 202
2	UV Disinfection	UV-201, 202
3	Aeration Blower	AB-201, 202, 203
1	Clean-In-Place Tank	CIPT-300
1	Clean-In-Place Pump	P-301
1	Alum Container	ALUT-310
1	Alum Dosing Pump	P-311

1.2 DESIGN PARAMETERS

The [redacted] WWTP will treat domestic wastewater originating from the [redacted] subdivision near Whistler, BC. The design parameters of the plant are presented in the table below.

Influent and Effluent Design Parameters

PARAMETER		UNITS	INFLUENT (1)	EFFLUENT (2)
Flow	Avg Day	[m^3/d]	40	
	Max Day	[m^3/d]	65	
	Peak Hour	[L/s]	3.2 (3)	
BOD_5		[mg/l]	250	< 5
		[kg/d]	10	
TSS		[mg/l]	250	< 5
		[kg/d]	10	
Turbidity		[NTU]		< 1
Total Nitrogen		[mg/l]	45	< 10
		[kg/d]	1.8	
Ammonia as NH4		[mg/L]		< 1.25
Total Phosphorus		[mg/L]		< 1
Fats, Oil and Grease (FOG)		[mg/l]	< 30 (biodegradable)	
pH	Min / Max		6.0 / 9.0	
Temperature	Min / Max	[deg C]	5 / 18	

Notes:
1. Plant is designed to receive wastewater having parameters lesser than or equal to the values shown.
2. Plant operated by qualified operators in accordance with ECOfluid operating manuals and instructions.
3. Instantaneous flow.

2 BIOLOGICAL TREATMENT PROCESS

2.1 INTRODUCTION

The following is an abbreviated description of the treatment processes. Additional details can be obtained from a variety of sources. The Environmental Operators Certification Program (EOCP) recommends the California State University, Sacramento, home study courses for water and wastewater operators. The "SAC Courses" as they are known, are the most popular and commonly used water and wastewater operators training manuals. Hundreds of BC operators have completed some of these courses. [1]

Influent wastewater is treated through an aerobic process by microorganisms such as zoogloea, protozoans and rotifers. These microorganisms consume the carbonaceous pollutants and produce flocculent particles that can be separated from the water in the membrane module. Microorganisms require a continuous source of oxygen to perform their function. They utilize carbon, nitrogen and phosphorus in the ratio of 100:5:1. If these nutrients are not present in the exact ratio, the final effluent may contain residues, or the operation may suffer from nutrient deficiencies.[2] The bioreactor volume provides the necessary retention time to allow for the maximum utilization of nutrients.

[1] Two copies of the manuals are available at the plant office. Additional information can be obtained from Office of Water Program, California State University, Sacramento, CA

[2] Nitrogen and phosphorus are usually present in larger quantities than required.

In the aeration compartment, nitrogen in the form of ammonia is oxidized to nitrate in a process referred to as *nitrification* and in the anoxic compartment it is converted to nitrogen gas by biological *denitrification*.

The activated sludge treatment process relies on simultaneously maintaining a number of **operating parameters** within specified ranges by controlling the **process input variables** as described below.

2.2 OPERATING PARAMETERS

SRT (Sludge Residence Time or Sludge Age): Sludge age is one of the most important parameters because it determines the nature of the bacteria in the system and ensures that the process of nitrification occurs effectively.[3] A relatively constant sludge age of 20-25 days is maintained in the plant and is regulated by periodically wasting a set amount of sludge (WAS) from the aeration tank.

MLSS (Mixed Liquor Suspended Solids): MLSS concentration is allowed to vary within the provided range. If a consistent increasing or decreasing trend becomes evident a small increase or decrease in the WAS rate will be required to compensate.

F/M (Food to Microorganism) Ratio: The F/M ratio indicates the degree of the plant loading. As the growth rate of microorganisms is proportional to the amount of food available, by maintaining a constant sludge age and allowing the MLSS concentration to vary, the F/M ratio will tend to stabilize.

DO_{ae} (Dissolved Oxygen in Aeration Compartment): The mixed liquor dissolved oxygen concentration in the aeration compartment (DO_{ae}) should be between 1.5 to 3.5 mg/l. This will help to ensure complete nitrification and carbonaceous oxidation, and it will help to prevent the growth of filamentous bacteria. The blowers are designed to deliver more air than required and their air delivery capacity may need to be manually controlled. For consistent test results, DO measurements should be taken at the same location and time of the day.

DO_{an} (Dissolved Oxygen in Anoxic Compartment): For effective denitrification dissolved oxygen concentration in the anoxic compartment should fall to less than 0.5 mg/l and preferably to as close to zero as possible.

SSV (Sludge Settled Volume): Although MLSS should be determined and F/M ratio calculated on a regular basis, day-to-day changes of the plant operation can be determined quickly by conducting a settled sludge volume test.

SVI (Sludge Volume Index): The sludge volume index provides a further measure of the settling characteristics of the sludge. Values of less than 120 are generally regarded as good.

pH: Biological activity is very pH dependent. Nitrification in particular is strongly inhibited outside the pH range of 6.5 – 8.5. During the production of nitrite, hydrogen ions are produced and result in the lowering of mixed liquor pH, i.e. alkalinity is consumed. During denitrification, however, hydrogen ions are consumed and the result is a partial recovery of the alkalinity lost during the nitrification process.

Sludge Colour: As sludge flocs start to develop, the mixed liquor should start losing its grey colour and appear light brown. As they continue to build up, the flocs should get larger, develop a somewhat earthy smell and the colour should change to brown.

[3] Sludge age of at least 15 days is sufficient to ensure complete reliable nitrification.

Ranges of Operating Parameters

PARAMETER		UNITS	VALUE OR RANGE
Sludge Residence Time/Sludge Age	SRT	[days]	20 – 25
Mixed Liquor Suspended Solid	MLSS	[mg/l]	8,000 – 10,000
Food to Microorganism Ratio	F/M		0.05 – 0.08
Mixed Liquor Dissolved Oxygen (Aeration Compartment)	DO_{ae}	[mg/l]	1.5 – 3.5
Mixed Liquor Dissolved Oxygen (Anoxic Compartment)	DO_{an}	[mg/l]	< 0.5
Sludge Volume Index @ 30 min.	SVI	[ml/g]	80 – 120
Mixed liquor pH	pH		6.5 – 8.0
Sludge Colour			Brown

2.3 PROCESS INPUT VARIABLES

Oxygen Input: Considering the importance of dissolved oxygen concentration for the processes of carbonaceous removal (*nitrification* and *denitrification*), careful management of oxygen input is required. Enough air must be supplied to ensure complete nitrification while not supplying too much thereby inhibiting denitrification. Monitoring the final effluent for ammonia, nitrate and nitrite nitrogen concentrations provides a sensitive measure of the required oxygen input. High ammonia (>5 mg/l) and low nitrite-nitrate nitrogen concentrations indicate that the nitrification process is not operative due to insufficient oxygen to completely oxidize ammonia. High nitrite-nitrate nitrogen concentrations indicate that denitrification is not operative due to high DO in the bioreactor anoxic compartment.[4]

RAS (Return Activated Sludge Recycle Ratio): The *recycle ratio* is a volumetric ratio of the plant's activated sludge recycled from the aeration compartment to the influent flow rate. The RAS rates are typically two to four times of the average daily flow.

WAS (Waste Activated Sludge): The plant's wasting regime should be aimed at maintaining a sludge residence time/sludge age of between 20 to 25 days. The quantity of wasted sludge will vary according to plant loading and sludge concentration.

3 PLANT AND PROCESS DESCRIPTION

The following process description should be read in conjunction with the process flowsheets and process control diagrams.

3.1 FLOW EQUALIZATION (DRAWING 17219-101)

Wastewater flows to the plant via forcemain from either the development's last lift station (Ø100) or the building sump (Ø75). It flows through a mechanically cleaned bar screen [SCR-101] having 1 mm openings. The screened influent then flows into the Equalization Tank [EQT-100]. In case of failure or overloading, there is a screen overflow/bypass that screens to 1.9 mm.

[4] This may also be due to low temperature or other causes.

EQT-100 is provided with coarse bubble sparger to keep the solids in suspension and to minimize odours within the tank. EQT-100 is equipped with a set of duplex submersible Equalization Pumps [P-101, 102], one duty and one standby. P-101/102 are controlled by a level transducer (HI – duty pump ON, LO – duty pump OFF) that is overridden by a resettable timer controlling the durations of the duty pump ON/OFF periods. The timer should be adjusted to match as closely as possible the EQP rate of flow to the Permeate Pump [P-201, 202] flow. For example:

Permeate pump flow:	1.2 L/s
EQP flow:	3.2 L/s
Timer setting:	60 seconds ON / 100 seconds OFF
EQP rate of flow:	(3.2 L/s ÷ 160 sec) × 60 sec = 1.2 L/s

Should both EQP pumps fail and/or the level in the EQT keeps rising due to high influent flow, an emergency alarm will be annunciated when the HI/HI level is reached, and an operator should immediately go to site and investigate. A pump out truck may need to be called.

To ensure trouble free operation, it is important that materials harmful to the treatment biology, such as the following, do not enter EQT:

- Oil and fat (in concentrations higher than 30 mg/l)
- Paints and paint thinners
- Acids and alkalis
- Petroleum products
- High strength cleaners and detergents
- Large quantities of chlorine (e.g. pool chlorine)

3.2 BIOREACTOR (DRAWING 17219-101, 801)

3.2.1 Anoxic Tank [ANT-110]

Raw sewage enters the Anoxic Tank where it is mixed with activated sludge recycled from the end of Aeration Tank by RAS Pump [P-131, 132]. The anoxic compartment is equipped with a submersible mixer [MIX-111] as well as a coarse bubble sparger to mix the liquid if needed. From the anoxic compartment, the mixed liquor flows to the aerobic compartment.

3.2.2 Aeration Tank [AET-120]

The Aeration Tank is equipped with fine bubble air diffusers. The diffusers are laid out in a manner to ensure even aeration of the entire volume of the compartment. The aeration pattern can be adjusted by valves on the air header. AET-120 is also equipped with a Dissolved Oxygen Sensor that displays on the HMI so that the operator can adjust the VFD for the Air Blower if required.

3.2.3 Membranes [MBT-130, MF-131, 132, 133] and Permeate Pumps [P-201, 202]

The effluent water is separated from the sludge by three Toray Submerged Membrane Modules installed within the Membrane Tank [MBT-130]. Each membrane module is composed of the element block and the aeration block. The element block contains 50 pieces of membrane elements, each of which has flat sheet membranes fixed on both sides of an ABS panel. Each element is connected via polyurethane tube to the permeate manifold. The aeration block consists of fine-bubble air diffusers to supply scouring air. Each membrane element can be taken out from the module separately for inspection or replacement.

The membrane permeate is pumped out from the manifolds by centrifugal type permeate pumps. Two pumps are installed, one duty and one stand-by. The duty permeate pump works intermittently with a vendor recommended time cycle of 9-minute ON (filtration) and 1-minute OFF.

There are three float switches to control the filtration process, with a redundant (fourth) switch for LO level. The LO/HI level switches control operation of P-201 (or P-202), but are overridden by a resettable timer that controls the duration of the duty ON/OFF periods. At HI/HI level, alarm is annunciated and a timely operator plant visit is required (MLSS will overflow to EQT-100).

The pressure transducers installed on the inlet line of the permeate pump monitor the Trans-Membrane Pressure (TMP). Once the TMP increases by 5 kPa (50 mbar) from its initial operating level at the same permeate flow rate or every 6 months, whichever comes first, the chemical Clean-In-Place procedure needs to be applied (see section 3.6).

Note that if the normal operating pressure should increase to but reach a steady operational state close to the CIP-requirement pressure, that could be indicative of an air bubble trapped in the permeate line. In this case, the permeate pumps should be shut down and re-primed using the potable water hose and opening the air bleeder valves at the MBR tank outlets to force the air out of the line.

See the Toray Membrane Manual in the separate Equipment Manual for proper operations and maintenance and troubleshooting issues.

3.2.4 Recycled Activated Sludge

Recycle of activated sludge from the end of Aeration Tank is accomplished by means of RAS pump [P-131, 132]. The rate of flow is adjusted from time to time to be approximately three to four times the average daily flow (1.4 to 1.85 L/s at [redacted] WWTP).

3.3 UV DISINFECTION (DRAWING 17219-102, 802)

Filtered effluent passes by gravity through the UV Disinfection channel [UV-201, 202]. UV units are supplied with intensity monitors.

3.4 AIR MANAGEMENT (DRAWING 17219-102, 802)

Air to fine bubble diffusers in AET-120, and coarse air spargers in EQT-100, ANT-120 and SHT-140 is supplied by Auxiliary Air Blower AB-201. Air to Membrane Modules MF-131, 132, 133 is supplied by Membrane Air Blower AB-203. Blower AB-202 acts as a standby backup to both blowers. In the event of either duty blower failure, corresponding Actuated Valve AV-201 or 202 will automatically open and AB-202 will start. Note that air to the membranes is essential for operation and if AB-203 and 202 have both failed, or if AV-201 is open, Permeate Pumps P-201 and 202 will be disabled.

Valves of the manifolds supplying the aeration diffusers are manually adjusted to ensure even distribution of air throughout the aeration compartment of the bioreactor. Small, periodic adjustments may be required. The DO level should be checked by DO-121 in AET-130 (displayed on HMI). The air to membrane scouring air diffusers can be measured by the respective flowmeters. Each Toray TMR140-050S module requires 30-60 m^3/h (17.6-35 cfm) scouring air.

When required, small adjustments to the VFD should be made based on DO trends and averages over a period of days. Adjustments should be made a minimum of 24 hours apart and DO readings taken at the same time each day. Should the DO remain high (too much air), the Operator can 'waste' extra air into the EQT or elsewhere (eg. from the manifold spare air valve).

When permeate pump stops on LO level in MBT-130, and does not restart within a pre-set time, the duty air blower will shut down (sleep mode). While the permeate pump is OFF, the duty air blower will run on a programmable timer intermittently (initial setting 10 minutes ON, 110 minutes OFF) until the permeate pump is called ON by the HI level in the aeration tank. At that time, if not running, duty air blowers are switched ON ahead of the duty permeate pump. **Permeate pump is not allowed to start if AB-203 (or if AB-203 has failed, AB-202 with AV-202 open) is not ON and running.**

3.5 SLUDGE MANAGEMENT (DRAWING 17219-101, 801)

Since the Sludge Residence Time (SRT) in the bioreactor is in excess of 20 days, less excess sludge is generated, it is stabilized and its dewatering characteristics significantly improve. WAS removal is automatic from MBT-130 via P-131 or 132 into SHT-140, which is equipped with coarse air spargers for further sludge stabilization and odour control. SHT-140 also has a camlock fitting and a HI level float which when engaged, signals the operator to call a vacuum truck to empty SHT-140.

3.6 SUPPLEMENTAL CHEMICAL SYSTEMS (DRAWING 17219-102, 802)

Trans-Membrane Pressure will indicate when the membranes require cleaning (approximately every 6 months). Prior to initiating the cleaning procedure, all membrane filtration must be shut down (P-201/202 turned to OFF) and Ø50 permeate isolation valves closed, then Ø25 CIP valves opened. A chlorine solution should be made up in the Clean-In-Place Tank CIPT-300 to a strength of 0.4%, which requires 20 L of standard 5% bleach and 230 L of water. Once mixed, CIP pump P-301 can be turned on and let run until the LO level float in CIPT-300 stops the pump. Consult Toray equipment manual for further details.

Phosphorus is partially eliminated by activated sludge absorbing it via “luxury uptake”, and then being removed as WAS. A metal salt flocculent such as aluminum sulfate (“alum”) helps further reduce total phosphorus levels in the plant effluent. Alum can be purchased at 49% solution strength in 20 L pails [ALUT-310]. Alum dosing pump P-311 will require adjustment by operator to fine tune dosage.

3.7 CONTROL SYSTEM (DRAWING 17219-801, 802)

The PLC control system monitors transmitting instruments and controls process equipment. The following table shows the inputs and outputs of the PLC for the WWTP.

Item	Equipment/ Location	Control	Function	Alarm
1	Automated Bar Screen	Float switch	HI: screen rakes ON	
		Motor overload		Yes
		Hour meter		
2	Equalization Tank/ Pumps	Level transducer	LO/HI Level: duty EQP OFF/ON	
			HI/HI Level	Yes
		Float switch	HI/HI Level (redundant)	Yes
		Programmable timer	On/off cycle specified	
		Motor overload		Yes
		Hour meter		
3	Anoxic Tank/ Anoxic Mixer	Programmable timer	On/off cycle specified	
		Motor overload		Yes
		Hour meter		
4	Aeration Tank	Dissolved oxygen meter	Monitor DO level in aeration tank	
5	Membrane Tank/ Permeate Pumps	Float switch	LO Level: stops permeate pump; stops duty air blower after delay	
			HI Level: if duty blower ON, starts duty permeate pump; if duty blower OFF, starts blower first and after resettable delay, starts duty permeate pump	
			HI/HI Level: alarm only	Yes
		Pressure transducer	HI Pressure: stop permeate pump, Clean-In-Place required	Yes
		Pressure indicator		
		Actuated valve	On/off cycle specified	
		Programmable timer	On/off cycle specified	
		Motor overload		Yes
		Hour meter		
6	Membrane Tank/ RAS WAS Pumps	Programmable timer	On/off cycle specified	
		Motor overload		Yes
		Hour meter		
6	Effluent Pipe	Flowmeter	Monitor effluent flow rate	
		Turbidity meter	Monitor turbidity	
7	UV Disinfection	Intensity monitor	LO: alarm only	Yes
8	Air Blowers	Pressure switch	LO: stop duty air blower, switch actuated valves, start stand-by air blower	Yes
		Pressure indicator		
		Actuated valve	For air blower failure	
		Pressure relief valve		
		Programmable timer	On/off cycle specified	
		Motor overload		Yes
		Hour meter		
9	Lift Station	Float switch	HI: alarm only	Yes
10	Emergency Power Generator	Common alarm		Yes
11	Process & Controls Building	Door intrusion	Alarm only	Yes

Note: The alarms are annunciated locally and via Ethernet communication for remote system monitoring.

3.7.1 Control System Response

The following Table lists provisions made to mitigate equipment failure and the control system response:

Failure	System Response
Bar screen fails	Situation alarmed, but no emergency. Influent overflows through stationary screen.
Duty equalization pump fails	Situation alarmed, but no emergency. Standby pump is provided and will auto start.
Both equalization pumps fail	Situation alarmed; operator on duty EMERGENCY INTERVENTION REQUIRED. On HI/HI level in equalization tank, 'pump & haul' truck is called.
Anoxic mixer fails	Situation alarmed, but no emergency. Process can run without mixer until operator intervention.
Duty RAS pump fails	Situation alarmed, but no emergency. Standby pump is provided and will auto start.
Both RAS pumps fail	Situation alarmed, but no emergency. Process can run briefly without RAS pump until operator intervention.
Duty permeate pump fails	Situation alarmed, but no emergency. Standby pump is provided and will auto start.
Both permeate pumps fail	Situation alarmed (HI/HI level); operator on duty EMERGENCY INTERVENTION REQUIRED.
Duty UV fails	Situation alarmed, but no emergency. Standby UV is in place and runs as a safeguard.
Both UV fail	Situation alarmed; operator on duty EMERGENCY INTERVENTION REQUIRED. If no disinfection, 'pump & haul' truck is called.
Air blower fails	Situation alarmed, but no emergency. Valves automatically rearrange and standby blower will auto start.
Both duty air blowers fail	Situation alarmed, operator on duty EMERGENCY INTERVENTION REQUIRED.

Note: The alarms are annunciated locally and via Ethernet communication for remote system monitoring.

3.7.2 Redundancy Features

The following Equipment Redundancy Table lists equipment and components of the facility which have installed standby equipment:

Item	Tag	Description	Total No. Installed	Installed Standby
1	P-101,102	Equalization Tank Pumps	2	1
2	P-201,202	Permeate Pumps	2	1
3	P-131,132	RAS/WAS Pumps	2	1
4	UV-201,202	UV Disinfection	2	1
5	AB-201,202, 203	Air blowers	3	1

4 PLANT OPERATION, MAINTENANCE, MONITORING & TROUBLESHOOTING

4.1 GENERAL INSTRUCTIONS

The following **General Instructions must be observed and followed at all times** when operating the plant:

ALWAYS CONSULT RESPECTIVE VENDOR EQUIPMENT OPERATING AND MAINTENANCE MANUAL PRIOR TO INDIVIDUAL EQUIPMENT START AND OPERATION. ALWAYS FOLLOW THE VENDOR'S SAFETY INSTRUCTIONS AND PROCEDURES.

THE INSTRUCTIONS MANDATE THAT WHEN WORKING ON EQUIPMENT, THE POWER IS DISCONNECTED BEFORE ACCESSING EQUIPMENT COMPONENTS AND SWITCHES ARE LOCKED OUT TO PREVENT ACCIDENTAL START. WHEN WORKING WITHIN CONFINED SPACES AND TANKS,[5] TESTING FOR TOXIC GASES AND VENTING IS CARRIED OUT IN THE SPACE PRIOR TO ENTRY. A TEAM APPROACH IS MANDATED. A STANDBY OPERATOR MUST BE PRESENT TO RAISE THE ALARM AND TO ASSIST IN THE RECOVERY OF PERSONNEL IN THE EVENT OF AN ACCIDENT. UNDER NO CIRCUMSTANCES IS THE STANDBY OPERATOR ALLOWED TO ENTER THE CONFINED SPACE IF PROBLEMS DEVELOP.

4.2 OPERATIONS AND MAINTENANCE PLAN

For a list of recommended maintenance tasks, refer to "Appendix B: Operations and Maintenance Plan". Operators are encouraged to amend the Plan and the Tasks from time to time to best reflect on the most current experience and practices.

4.3 PLANT MONITORING

To ensure good plant performance it is essential that a regular sampling and sample analysis program be established. Caution must be taken to ensure that the samples are representative. The latest edition of "Standard Methods" should be consulted for proper sampling methodology and analytical procedures, however the following guidelines for taking both composite and grab samples should be observed:

- Influent samples should be taken from the Equalization Tank; effluent samples from the end of UV disinfection prior to the overflow weir.
- Composite of refrigerated samples should not be used for settling tests because the settling characteristics change with time.
- Samples should be analyzed within 24 hours after collection.
- Larger volumes of samples than required for analysis should be collected.

[5] Please refer to WorkSafeBC "Confined Space Entry Program – A Reference Manual"

Wastewater Treatment Plant Recommended Monitoring Table

Parameter	Influent	Aeration	Anoxic	Effluent
BOD5	Q	-	-	Q
TSS	Q	-	-	Q
MLSS	-	W	-	-
DO	-	D	D	-
N-NH3	Q	-	-	Q
TN	Q	-	-	Q
Fecal Coliform	-	-	-	Q
Flow	-	-	-	C
Trans-membrane pressure	-	D	-	-
pH	-	W	-	-
Temperature	W	-	-	-

SA – semi-annually, Q – quarterly, D - daily (excludes weekends), W - weekly, M – monthly, C - continuous

All data will be recorded on log sheets and stored in a safe place. Quarterly Reports should be submitted to the owner and authorized others as may be determined in the future. Copies of all monitoring results will be kept at the treatment plant for viewing by operators and authorized others.

4.4 TROUBLESHOOTING

Problem	Possible Cause	Action Required
Foaming of liquor in aeration compartment	Low MLSS concentration	• Add activated sludge if possible. • Self-correcting in time.
	High dissolved oxygen content in aeration	• Break the foam down with water. • Reduce air supply to air diffusers.
Sludge floating on the surface of the bioreactor tank	High dissolved oxygen content in aeration	• Break the foam down with water. • Reduce air supply to air diffusers.
	High MLSS concentration	• Waste sludge.
	High influent flow	• Find cause (high infiltration, etc).
	High sludge volume index (SVI)	• Seed with sludge with lower index if possible. • Self- correcting in time.
	Inflow of toxic materials	• Report to owner.
High TSS in effluent (> 10 mg/L)	Membrane is damaged	• Check membrane and replace the damaged sheet.
Permeate pump is not pumping at the desired flow rate	Membrane needs back wash	• Clean membrane as per membrane manual
	Effluent throttling valve needs adjustment	• Adjust the throttling valve to have desired discharge rate
RAS pump is not working at desired flow rate	RAS pipe is plugged	• Blow-off plugged RAS pipe by opening throttling valve completely
	RAS throttling valve needs adjustment	• Adjust the throttling valve to have desired discharge rate
Low mixed liquor dissolved oxygen content in aeration	Air blower(s) malfunction	• Check blowers and air lines.
	High MLSS concentration	• Waste sludge.
	High influent loading	• Find cause
High ammonia (> 5 mg/l), low nitrite-nitrate nitrogen (< 1 mg/l) effluent concentration	Insufficient oxygen is available to oxidize ammonia	• Increase air supply.
Low ammonia, high nitrite-nitrate nitrogen (15-20 mg/l) effluent concentration	High DO in the anoxic compartment	• Reduce air supply • Check anoxic compartment DO. • Check activated sludge recycle rate.
High ammonia (> 5 mg/l), high nitrite-nitrate nitrogen (> 20 mg/l) effluent concentration	Low MLSS concentration	• Add activated sludge (with as low SVI as possible) • Self-correcting in time.

Note: For additional troubleshooting with membrane modules, please refer to Toray Membrane manual (Pg. 56).

5 SAFETY AND PERSONAL HYGIENE

THE FOLLOWING ARE GENERAL GUIDELINES ON SAFETY AND HYGIENE. REFER TO AND ALWAYS FOLLOW LOCAL WATER & WASTEWATER ASSOCIATIONS AND REGULATORS' RULES, REGULATIONS AND GUIDELINES.

5.1 SAFETY

Safe work practices include good habits, quality safety equipment and proper training. Safety equipment should include but is not limited to the following:

- Rubber or rubber-lined gloves
- Safety glasses for protection against splashing
- Safety harness and rope to be used whenever working around the tanks
- Rubber boots and rubber protective clothing
- Gas detector

When working on equipment, ensure that the power is disconnected before accessing equipment components. Switches should be locked out to prevent accidental start.

When working within confined spaces and tanks, always test for toxic gases and vent the space prior to entry. A team approach is essential. A standby operator must be present to raise the alarm and to assist in the recovery of personnel in the event of an accident. Under no circumstances should the standby operator enter the confined space if problems develop.

5.2 PERSONAL HYGIENE

Raw sewage and streams from various stages of the treatment plant contain human pathogenic organisms. Without limiting the forthcoming, it is essential that anyone coming into contact with sewage from any stage of the process take the following precautions to prevent exposure to any human pathogenic organism present:

- Wash hands with disinfectant soap before eating, drinking, smoking etc.
- Wear long-sleeved shirts and trousers to prevent sewage contact with skin
- Avoid immersing hands by using gloves and collectors
- Wear eye glasses/safety goggles
- Never store or consume food or drink in close proximity to sewage or sewage samples (never store samples in the same refrigerator as foodstuffs or drinks)
- Remove clothing splashed or wet with sewage and exchange for clean as soon as possible; wash with disinfectant soap
- Ensure that cuts and abrasions are immediately treated with antiseptic and suitably covered.

6 SAMPLES OF PARAMETER CALCULATIONS

6.1 SRT (SOLIDS RETENTION TIME) (OR SLUDGE AGE)

The solids retention time (SRT) is an important design and operating parameter for the activated sludge process. The SRT is the average time the activated sludge solids are in the system. The SRT is determined by dividing the mass of solids in the biological zone by the solids removed daily via the effluent and by wasting. It is calculated based on the following formula:

$SRT = V_B X / (Q_w X_w + Q X_e)$

Where:

SRT	=	Sludge Residence Time [days]
V_B	=	Biological zone (anoxic and aerobic compartments) volume [m^3];
X	=	Biomass (MLSS) concentration [kg/m^3]
X_e	=	Effluent suspended solids [kg/m^3] (use 10 mg/l = 0.01 kg/m^3)
Q_w	=	Waste sludge flow rate [m^3/day]
Q	=	Daily flow (Q_E should be used but negligible) [m^3/day]
X_w	=	Waste sludge suspended solids [kg/m^3]

Example:

The bioreactors' biological compartments volume is 65 m^3. Measured effluent flow is 40 m^3/d, MLSS concentration is 10,000 mg/l, effluent suspended solids concentration is 5 mg/l and waste sludge suspended solids concentration is 10 kg/m^3. How much sludge has to be wasted daily to achieve 30 days sludge age:

$Q_w = (V_B X / SRT – Q \times X_e) / X_w = (65 \times 10 / 30 – (40 \times 0.005)) / 10 = \sim 2.1\ m^3/day$

6.2 FOOD TO MICROORGANISM (F/M) RATIO

The Food to Microorganism ratio is a measure of the organic loading of the plant. It is calculated as follows:

$F/M = Q S_r / V_B / X / P$

Where:

F	=	Food entering the plant [kg/day]
M	=	Mass of bacteria in system [kg]
Q	=	Influent flow rate [m^3/day]
S_r	=	Influent BOD_5 concentration [kg/m^3] (= mg/l / 1000)
V_B	=	Biological zone (anoxic and aerobic compartments) volume [m^3]
X	=	Biomass (MLSS) concentration [kg/m^3]
P	=	Volatile solids fraction

Example:
Assuming the plant influent flow of 40 m^3/d and MLSS concentration from previous calculation, influent BOD_5 concentration of 400 mg/l and the volatile solids fraction of 65%, F/M ratio can then be calculated as follows:

$F/M = Q S_r / V_B / X / P = 40 \times 0.40 / 265 / 10 / 0.65 = 0.04$

APPENDIX B

SAMPLE RISK ASSESSMENT / ASSURANCE PLAN

OLAND ENGINEERING LTD.

[redacted]

Sewage System

[redacted]

Assurance Plan

August 21, 2005

Oland Engineering Limited
11183 Bond Road
Winfield, B.C.
V4V 1J6

ASSURANCE PLAN COMPONENTS

Signature Template

Assurance Plans Under the Municipal Sewage regulation

Risk Assessment

Company Policies and Procedures Manual

Equipment Warranty Schedule

Insurance Package

Financial Plan and Replacement fund Schedule

Signature Template

The following list identifies that this document has been reviewed and is satisfactory to the individuals listed.

Reviewed By	Position/Title	Signature	Date
Jeff Oland	Design Engineer		
Karl Galand	Plant Manufacturer		
[redacted]	Owner Representative		
[redacted]	Legal Representative		
	Ministry of Water Land and Air Protection Representative		

REVISION LOG

General Instructions
The following list identifies that this document has been revised and satisfactory to the individuals listed. The Revision Log reflects all changes since the documents initial issue (as shown on the cover).

Rev. No.	Page(s)	Description of Revision	Revision By	Reviewed By	Approved By	Date

RISK ASSESSMENT

Risk Assessment

A basic risk management framework is outlined on page 4 of 8 in the Ecofluid Introduction to the Assurance Plan. We have adopted a Risk Matrix methodology which combines the probability of a failure or accident with four levels of consequence severity. By combining probability and consequence in a matrix format, risk levels of 1, 2 or 3 are determined, with risk level 1 being high risk and level 3 low risk. Risk levels are typically used in larger corporations to determine which level of management would need to approve or veto the design or proposed operation. We will use the risk levels as a comparative scale and make recommendations to mitigate the risk to a lower level.

The “Consequence, Probability Definitions Utilized for Risk Matrix” is laid out on the following page. The probability definitions and consequence categories are open for discussion between the owner and approving authority and can be edited prior to adoption of the Assurance Plan. The “What If “ work sheets provide the main core for discussions among the approving authorities, the owner , the suppliers and design engineers. The initial frame work of the “ What If “ worksheets provided, are composed by the design engineer and should also be edited following input from the owners, the approving authorities and the design team.

An effective risk assessment will bring valuable mitigative recommendations to the forefront and assign the task of implementation of those recommendations to the appropriate team member. Prior to final commissioning of the installation, the what if work sheets will provide a valuable check list to help identify any short falls in the system.

The Risk Assessment along with the Assurance Plan as a whole should be reviewed on an annual basis or when required, to evaluate the accuracy of the predictions and make changes to the plan if needed. The risk assessment can be used as an effective management tool if revisited and kept up to date.

Risk Matrix Summery

The results from the risk assessment proved to be very useful in identifying practical ways of mitigating risk and reducing the risk levels. The Consequence, Probability and Risk Level (CPR) before and after recommendations are presented in the “What If” work sheets. In many cases the risk level can be reduced from a medium level “2” to a low level ”3”. Most of the “What If” scenarios involve an electrical or equipment failure which are mitigated by having equipment spares, procedures and the financial tools in place to minimize the impact to the residents. The highest risk levels were identified in items 7 and 9 where death and/or illness were the consequence. These items should be taken seriously and every effort should be made to mitigate the risks.

Most of the action items are assigned to the owner and/or the design engineer.

RISK MATRIX

CONSEQUENCE, PROBABILITY DEFINITIONS UTILISED FOR RISK MATRIX

PROBABILITY

CONSEQUENCE	A	B	C	D	E
I	1	1	1	2	2
II	1	1	2	2	2
III	1	2	2	3	3
IV	2	3	3	3	3

NOTE:

Facility life is deemed to be the design life which is estimated at 25 to 30 years

Risk Levels

Higher	Medium	Lower

Example Probability Definitions

Category	Definition	Working Definition
A	Possibility of Repeated Incidents	20 or more times per facility life
B	Possibility of Isolated Incidents	5 times in facility life
C	Possibility of Occurring Sometime	Once in facility life
D	Not Likely to Occur	Once in 10 facility lives
E	Practically Impossible	Once in 100 or more facility

Consequence Category	CONSEQUENCE CONSIDERATIONS			
	Health/Safety	**Public Disruption**	**Environmental Impact**	**Financial Impact**
I	*Fatalities/Serious Impact on Public* • One or more fatality • Serious long-term health impact on public	*Large Community* • Evacuation of more than 1000 people • Continuing national attention	*Major/Extended Duration/Full-Scale Response* • Major provincial wide emergency response • Major cleanup lasting for months/years • Potential widespread, long-term significant adverse effects on the environment (including soil and groundwater) or large community	• Loss due to damage, death or injury plus cost of lost sales or rent greater than $1 million
II	*Serious Injury to Personnel/Limited Impact on Public* • Permanent disabling injury, severe but non-fatal • Serious lost time injury (LTI)	*Small Community* • Evacuation of 25 to 1000 people • Provincial attention	*Serious/Significant Resource Commitment* • District emergency response • Significant cleanup for weeks/months • Potential localized, medium term significant adverse effects on the environment (including soil and groundwater) or small community	• Loss due to damage or injury plus cost of lost sales or rent greater than $100,000
III	*Medical Treatment for Personnel/No Impact on Public* • Minor lost time injury (ankle sprain) • Medical aid injuries • Restricted work	*Minor* • Evacuation of less than 25 people • Local attention	*Moderate/Limited Response of Short Duration* • Local emergency response • Cleanup for days/weeks • Potential short term minor adverse effects on the environment (including soil and groundwater) or a few members of the public	• Loss due to damage or injury plus cost of lost sales or rent greater than $ 10,000
IV	*Minor Impact on Personnel* • First aid only	*Minimal to None* • No evacuations • Minor inconveniences to a few	*Minor/Little or No Response Needed* • Confined to site or close proximity • Inconsequential or no adverse effects	• Loss due to damage or injury plus cost of lost sales or rent less than $ 10,000

What If...	Hazard	Consequences	Existing Safeguards	C	P	R	Recommendations	Action By	C	P	R
1.Power failure	1.No pumps 2. No Air blowers	1. Sewage treatment, lift station and disposal system cannot function 2. Odors from treatment plant.	1.Water supply needs power also. No water means practically no sewage. 2. Storage in lift station, man holes and sewerage lines.	III	A	2	1. Examine feasibility of Portable Emergency Gen. Set 2. Identify storage capability	[redacted] J. Oland	IV	B	3
2.Main lift station failure. Panel or pump	Only one pump no backup. If panel fails, possibly both pumps down.	1.If both pumps fail , sewage may overflow to ground water or river.	1.High Level Alarm 2.Storage in lift station and sewerage lines and manholes. 3.Over flow will enter ditch to storm drywell protecting river. 4. Duplex pump system	III	E	2	3. Alarm on separate circuit 4. Keep 1 spare pump on inventory. 5. Allow for manual control of pumps if panel fails 6. Ensure replacement funds are in place after warranty 7. Lightning arresters on panel	[redacted] J. Oland	IV	D	3
3.Dosing lift station failure. Panel or pump	Only one pump no backup. If panel fails, possibly both pumps down.	1.If both pumps fail , sewage may overflow to ground or backup into final clarifier.	1. High Level Alarm 2. Storage in lift station 3. Overflow confined to plant area 4. Duplex pump system	III	E	2	8. Keep 1 spare pump on inventory. (note 1 pump for both lift stations) 9. Alarm on separate circuit 10. Allow for manual control of pumps if panel fails 11. Ensure replacement funds are in place after warranty. 12. Lightning arresters on panel	[redacted] J. Oland	IV	D	3

What If...	Hazard	Consequences	Existing Safeguards	C	P	R	Recommendations	Action By	C	P	R
4.Blower fails	If 2nd blower fails, treatment will be impaired Thus Poor effluent quality	1. Odors from treatment plant. 2.Clogging of disposal field	1.Plant requires only 1 blower to operate. 2nd blower is a spare. 2.Approx. 48 hour before effluent deterioration. 3. Blower warranty	IV	B	3	13. Source blower availability 14. Review details and identify process if plant is temporarily used without air. 15. Ensure replacement funds are in place after warranty	[redacted] J. Oland	IV	C	3
5.Disposal field fails. Broken line, valve failure or disposal lines fill.	1. Effluent to surface. 2. Cannot pump effluent into field	1.Health hazard to residents. 2. Effluent overflow at lift station or backup into plant.	1.Regular inspections of disposal area and altering fields. 2. High level alarm 3. Field replacement area provided. 4. Effluent confined to plant area	IV	B	3	- Take dispersal field cell offline and mitigate - Pump from wet well with mobile unit. Dispose to approved facility until repair can be completed	[redacted] J. Oland	IV	B	3
6.Treatment biology upset due to toxic influent.	1.Poor effluent quality	1. Odors from treatment plant. 2.Clogging of disposal field long term	1. Plant over design with 2 cell process. 2. Warranty and manufacturer support. 3. Trained operator	IV	C	3	16. Locate source to haul in replacement mixed liquor or bacteria. 17. Ensure there is budget in place for proper operation and trucking. 18. Use advisory and education to users	[redacted] J. Oland	IV	C	3

What If...	Hazard	Consequences	Existing Safeguards	C	P	R	Recommendations	Action By	C	P	R
7. Worker or resident falls into plant or lift station.	1. Deep water 2. High concentration of bacteria / pathogens	1.Drowning 2.Serious injury	1.Locks on lower lift station. 2.Locked fence around treatment plant. 3. Safe work habits and use of appropriate safety equipment	I	C	1	19. Post Warning signs 20. Identify method of climbing out, life ring etc. 21. Use strict safety procedures when exposed to such hazards 22. Identify exposure and acquire appropriate liability insurance.	[redacted] J. Oland	I	D	2
8. Sewerage lines block.	1. Sewage to surface. 2. Sewage back up into home plumbing.	1.Health hazard to residents. 2. Odors.	1.Regular inspections of sewerage system. 2. Manholes for inspection and service access.	IV	B	3	23. Acquire servicing equipment. Such as 100m snake, pressure washer, 4" and 6" line plugs.	[redacted]	IV	C	3

Equipment Warranty Schedule

Warranty Schedule

Treatment Plant Tanks, Panel, Blowers, Pumps (ECOfluid)	1 year from _______
Main Lift Station Panel (Northwest Tec.- Con.)	1 year from _______
Disposal Field Lift Station Pumps (Barnes Pumps)	1 year from _______
Disposal field Valves (K-Rain)	1 year from _______
Disposal Field Construction `	1 year from _______
Collection System Construction	1 year from _______

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APPENDIX C

CAPITAL RESERVE FUND PLAN - ECOFLUID SYSTEMS LTD.

OWL'S NEST
RESIDENTIAL DEVELOPMENT
OYAMA, BC

WASTEWATER TREATMENT FACILITY

CAPITAL RESERVE FUND PLAN

PREPARED FOR: CANTIRO

PREPARED BY: ECOFLUID SYSTEMS INC

DATE: FEBRUARY 2, 2023

CONTENTS

A INTRODUCTION

On September 22, 2022, ECOfluid presented a proposal to Oland Engineering to design and supply two packaged wastewater treatment plants for a residential development to be built in Oyama, BC. The development consists of two sections of 20 residential lots each, North and South, with each having its own wastewater treatment facility, identical in process and similar if not identical in layout. The facilities are to meet the Ministry of Health Type 3 effluent standards.

To ensure that the wastewater treatment plants when built have sufficient technical, and financial resources available, the Developer (Cantiro) intends to set up reserve funds (Capital Reserve Funds) to provide for the ongoing operation, equipment and components upkeep, and replacement of the facility at the end of its life.

The following is based on the facility's preliminary design and budgetary estimates. The Capital Reserve Funds will be updated once the plants are built, and the actual costs are known.

B FACILITY DESCRIPTION

B1 Design Parameters

The design parameters for each identical plant are presented in Table 1 below.

Table BI – Design Parameters

Parameter	Unit of Measure	Influent	Effluent
Average Day Flow	[m^3/d]	11	
Max Day Flow	[m^3/d]	22	
Peak Instantaneous Flow	[m^3/h]	1.0	
BOD_5	[mg/L]	300	< 10 (3)
TSS	[mg/L]	300	< 10 (3)
Fecal Coliform	[MPN/100mL]		< 400 (3)
Fats, Oil and Grease	[mg/L]	< 50	
Temperature	[°C]	8-22	
pH		6-9	

B2 Plant Description (Each Individual Plant - See Preliminary Flow Diagram 1821-101 Rev C)

B2.1 Headworks

Influent enters the plant into Influent Coarse Bar Screen (ICBS) located within Trash Tank (TT). Objects larger than 20 mm are screened out and the influent passes into the Trash Tank. From the Trash Tank screened influent overflows to Equalization Tank (EQT) provided with coarse air bubble aeration and a set of duplex Equalization Pumps (EQP). Controlled by EQT level switches and resettable timer override influent is pumped from EQT into the Influent Fine Basket Screen (IFBS) having 2 mm openings. Screened influent passes into an Anoxic Compartment of the Bioreactor [BR]. Aided by two Anoxic Circulation Pumps (ACP) the influent mixes with activated sludge recycled from the membrane compartment.

B2.2 Biological Treatment, Filtration [MBR], and Disinfection

From the anoxic compartment, mixed liquor underflows to the aeration/membrane compartment. The membrane compartment is provided with one Membrane Filtration unit (MF) and two submersible Recirculation Pumps (RASP) used to recycle mixed liquor back to the anoxic compartment or for periodic sludge wasting.

Self-priming Permeate Pumps (PP) (one operating, one standby) pull out the permeate from the membranes and pump it through the UV Disinfection (UV) to the effluent dosing tank.

B2.3 Air Management

Three Air Blowers (AB) are provided, one supplying air to aeration, the second supplying air to membrane scouring, and a third common standby.

B2.4 Waste Sludge Management

Waste sludge (WAS) is transferred into a Sludge Holding Tank (SHT) by opening a bypass valve on the RAS re-circulation line and diverting the flow into the sludge tank. The SHT is fitted with a coarse-bubble aeration grid to reduce odours and with a small submersible Decant Pump (DC) with a flexible discharge hose suspended from a davit to gravity-thicken the waste thereby reducing the sludge haul-away costs. Gravity settling may thicken the sludge up to a 2.5% concentration.

B2.5 Control System

The control system consists of a programmable logic controller (PLC), auto-dial alarm capability, and an uninterrupted power supply (UPS). The system will incorporate a full system mimic panel on a touchscreen displaying running and alarm status.

B3 Plant Components

The following is a list of equipment and components for each of the two identical wastewater treatment plants.

Equalization Tank (EQT) and Trash Tank (TT) (1)
- 2,000 USG pre-cast concrete tank with solid cover and two access openings
- Trash Tank provided with Influent stainless steel Coarse Bar Screen

Equalization Pumps (EQP) (2)
- Solids handling submersible pump; 1/3 Hp

Membrane Bioreactor Tank (MBT) (1)
- 5,000 USG pre-cast concrete tank with an internal divider to separate anoxic and aerobic zones and precast lid.
- Anoxic compartment provided with manually cleaned Fine Bar Screen

Membrane Module (MBR) (1)
- Toray NHP-210-150S

RAS Pumps (RASP) (2)
- Submersible pump, ½ Hp

Anoxic Circulation Pump (ACP) (2)
- Submersible pump; 1/3 Hp

Air Blowers (AB) (3)
- FPZ (or equal); 4 Hp

Permeate Pumps (PP) (2)
- Centrifugal pumps; 3/4 Hp

UV Disinfection (UV) (2)
- Hallet units

Sludge Holding Tank (SHT) (1)
- 2,000 USG pre-cast concrete tank with solid cover and two access openings c/w coarse bubble aeration diffusers

Decant Pump (DP) (1)
- Solids handling submersible pump; 1/3 Hp

Control Panel and Instrumentation (lot)
- NEMA 12 enclosure c/w integrated PLC, HMI, and MCC
- Main circuit breaker w/ operator interlock
- Hand-Off-Auto (HOA) selector for each motor
- Variable Frequency Drives for each air blower
- Hour meters for each motor
- Uninterruptable power supply
- Process instruments: float switches, ultrasonic level sensor, dissolved oxygen sensor, transmembrane pressure sensor, effluent flowmeter, air flow meters, pressure switches

C FACILITY RISKS MITIGATION STRATEGY

Wastewater treatment plants are exposed to numerous inherent potential risks. They are mitigated by a number of undertakings including preventative mitigation, plant monitoring, system automatic response, operators' response, and having sufficient funding in place for timely remedial interventions.

C1 Preventative Risk Mitigation

Preventative risk mitigation is one of the most powerful risk mitigating factors. It consists of a number of undertakings, including routine plant and equipment inspection, residents' education, and health and safety precautions.

> *Routine Plant and Equipment Inspection and Maintenance*

The plant will be operated by appropriately certified operators and in accordance with the Equipment and Operating Manual. The manual outlines, among other, the requirements of routine inspection, preventative maintenance, and record keeping. Equipment vendor-prescribed preventative maintenance is performed as required and recorded together with equipment run times.

> *Residents' Education*

To ensure trouble-free operation, it is important that the presence in the influent of materials harmful to the treatment biology, such as oil and fat, rags/wipes, paints and paint thinners, acids and alkalis, petroleum products, high-strength cleaners and detergents, large quantities of chlorine (e.g. pool chlorine), is minimized. To that end, the residents of the development will be provided with advisory pamphlets.

➢ *Health and Safety Precautions*

Safe work practices referencing rules and regulations provided by WorkSafe B.C., EOCP, British Columbia Water & Wastewater Association, and including good habits, quality safety equipment, and proper training will be adopted. Safety equipment will include, but is not limited to rubber or rubber-lined gloves, safety glasses for protection against splashing, a safety harness, and rope to be used whenever working around the tanks, rubber boots and rubber protective clothing, a gas detector, etc.

C2 Plant Monitoring and Automatic Response

Each plant will be provided with a monitoring and control system and equipment redundancy. The system automatically responds to critical operating conditions, and it annunciates alarms to operators on duty. The equipment of each individual plant provided with installed standby is denoted in Table B1 below.

Table C1 – Equipment Redundancy

Item	Tag	Description	Installed	Installed Standby
1	EQP	Equalization pump	2	1
2	RASP	RAS pump	2	1
3	ACP	Anoxic Circulation Pump	2	1
4	MBR	Membrane unit	1	0
5	PP	Permeate pump	2	1
6	UV	UV disinfection unit	2	1
7	AB	Air blower	3	1
8	DP	Decant pump	1	0

C3 Operators' Response

Apart from regularly inspecting the plant by physical attendance, operators are notified of the critical components and features malfunctioning by the system remote alarm annunciation and respond accordingly.

C4 Remedial Interventions Funding

Having sufficient funds for timely remedial interventions is an important part of the risk mitigation strategy. Reserve fund planning leads to a disciplined approach to risk management and a proactive approach to potential risk mitigation. To that end, the Developer intends to set up Capital Reserve Fund as further described below.

D CAPITAL RESERVE FUNDS

The Developer will set up Capital Reserve Funds to provide for the ongoing operation, equipment, and components ongoing upkeep, and for the replacement of the facility at the end of its life.

Capital Reserve Fund will consist of two component funds, the Equipment and Components Renewal Fund (ECRF), and the longer life-cycle Infrastructure Replacement Fund (IIRF).

D1 Equipment and Components Renewal Fund (ECRF)

Equipment and Component Renewal Fund (ECRF) to maintain, improve, repair, and replace as and when required the equipment and components of the facility will be assembled as detailed below.

Potential risks inherent in the operation of wastewater treatment plants can be categorized as predictive and emergency.

- Predictive risks focus on the plant equipment and components failures or their end-of-life replacement or refurbishment. They have no residual impact on health/safety, public disruption, or the environment, and their financial impact is quantifiable as calculated in Table C1 below.

- Emergency incidents include events such as damage to property, personnel injuries, spills, toxic kill, Acts of God, terrorism, etc. Some are to a degree mitigated by the facility design, safety, and operational features (secure fence, bollards, protection of exposed PVC piping by steel guards, operation by qualified operators, restricted access, etc), however, they are unpredictable as to their occurrence and potential financial impact. Should they occur, their financial impact will need to be funded by insurance where applicable and by the Strata Corporation Contingency Reserve Fund. (Different from this Capital Reserve Fund)

The predictive annual financial risk values for both identical plants are presented in Table C1 below. They have been calculated using estimates of equipment and components replacement or refurbishment costs, and the frequency of the occurrences or life cycles. They have been generated based on ECOfluid's decades-long experience operating similar size, capacity, and configuration plants.

Table D1 – Equipment and Components Renewal Annual Financial Values (Two Plants)

Item	Incident / Component Upkeep	No	Action to Mitigate	Estimated Cost per Incident (2023 $)	Estimated Frequency (Years)	Annual Financial Value ($/y)
	Predictive					
1	Collection system incidents	-	Flush, clean, refurbish	1,500	3	500
2	Equalization pump fails	4	Replace	800	5	640
3	RAS pump fails	4	Replace	800	5	640
4	Anoxic circulation pump fails	4	Replace	600	5	480
5	Membrane module fails	2	Refurbish, replace	6,500	8	1,625
6	Permeate pump fails	4	Replace	1,500	7	857
7	UV disinfection lamps fails	4	Replace lamps	400	2	800
8	Air blower fails	6	Replace	3,000	10	1,800
9	Decant pump fails	2	Replace	400	5	160
10	Em generator annual service	2	Annual service	500	1	1,000
11	Control system components	2	Replace	400	1	800
12	Disposal field upkeep	-	Flush, refurbish	1,200	3	400
			E & C Renewal Annual Financial Value Total			**9,702**

Note: UV lamps, emergency generators, sewage collection systems, and effluent disposal fields are serviced on a scheduled regular basis.

D2 Infrastructure Replacement Reserve Fund (IRRF)

Infrastructure Replacement Reserve Fund will be established to build up capital reserves over twenty-five years to cover the longer life-cycle infrastructure of the facility replacement. As the detailed design has not been completed yet, the costs below are based on the preliminary design and budget estimates. The IRRF budget will be updated upon the detailed design.

Table D2 – Infrastructure Reserve Annual Financial Value (Two Plants)

Item	Description	Cost to Construct	Replacement Cost (2023 $)	Life Cycle (years)	Capital Reserve Financial Value ($/y)
1	**Civil & Structural Works** *Buildings	140,000	140,000	25	5,600
2	**Mechanical Works** * Piping & valves	40,000	40,000	25	1,600
3	**Electrical & Controls Works** * Control panel, generator, electricals	80,000	80,000	25	3,200
4	**Common Collection System** * Pump station & lateral kit - Amenity Building	20,000	20,000	20	1,000
5	**Common Collection System** * Piping , valves, cleanouts	105,000	105,000	50	2,100
	Infrastructure Replacement Cost Total	385,000	**385,000**		
	Annual Capital Reserve Financial Value Total				**13,500**

D3 Administration and Maintenance of Capital Reserve Fund

While the treatment facility may be initially administered by the Developer, it will ultimately be administered, maintained, and operated by Strata Corporation (Strata) established for the purpose.

D3.1 Equipment and Components Renewal Fund (ECRF)

The fund will be assembled through a fee assessment per annum against each residential lot. It will be administered by the Strata and the assessment fees will be included in the annual budgets as part of the operating costs.

The Strata will have unrestricted access to the ECRF to pay for repairs, maintenance, improvement, refurbishment, and replacement (Works) costs. Requests for Works will be originated by the plant operator and will be communicated to the Strata. It is recommended that the Strata Bylaws define the approval process such that approval is unhindered when timely response is required

Any excess in ECRF annual income will be credited to ECRF for the following year or applied to the IRRF until that fund has reached its goal amount described below. Any excess annual income after the fund goal is reached will be credited toward ECRF in the following year, and the ECRF annual contribution accordingly adjusted.

D3.2 Infrastructure Replacement Reserve Fund (IRRF)

The fund will be assembled through a fee assessment per annum against each residential lot. It is not intended to be used for any other purpose but to build up a sufficient capital reserve for the long-life infrastructure replacement at the end of its projected life. The annual contributions to the fund will continue until the then current Infrastructure Replacement Cost Total as stipulated above in Table C2, is reached. The annual contribution will then be adjusted to offset inflation only.

D3.3 Annual Budgets

The two component funds ECRF and IIRF will be included in the Strata Corporation's annual operating budgets as part of the operating costs. The fund's contributions calculations will be annually updated to account for changes in operating experience and for inflation if any.

It is intended that this Plan be included as part of the Developer's overall risk management strategy and that it be updated upon completion of the facility construction as part of the facility commissioning.

Prepared by: **ECOfluid Systems Inc**
EGBC Permit to Practice No. 1003403

PROFESSIONAL
PROVINCE OF
K. V. GALLAND
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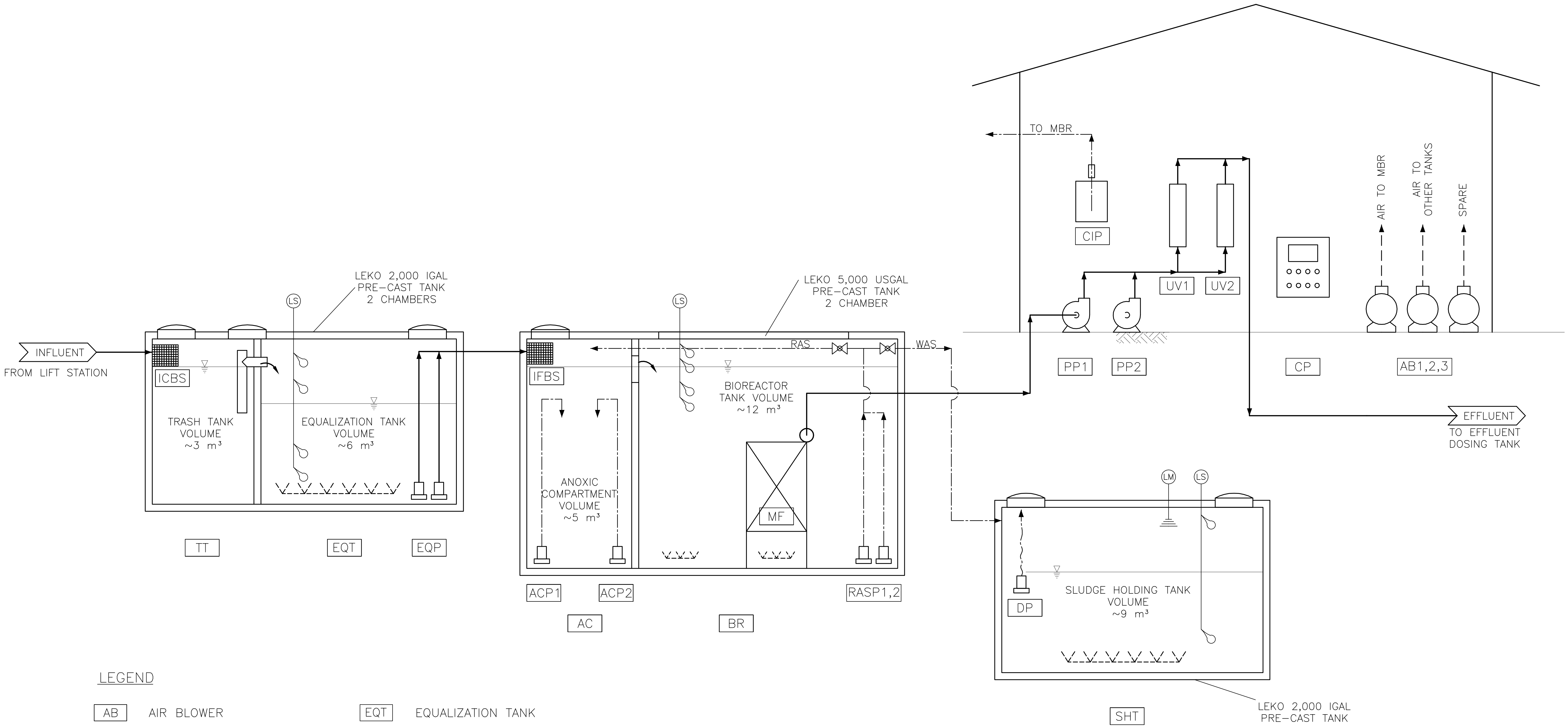

LEGEND

AB	AIR BLOWER	EQT	EQUALIZATION TANK
AC	ANOXIC COMPARTMENT	ICBS	INFLUENT COARSE BAR SCREEN
ACP	ANOXIC CIRCULATION PUMP	IFBS	INFLUENT FINE BAR SCREEN
BR	BIOREACTOR	MF	MEMBRANE FILTRATION MODULE
CIP	CLEAN-IN-PLACE SYSTEM	RASP	RAS PUMP
CP	CONTROL PANEL	PP	PERMEATE PUMP
DP	DECANT PUMP	SHT	SLUDGE HOLDING TANK
EQP	EQUALIZATION TANK PUMP	TT	TRASH TANK

PRELIMINARY FLOW DIAGRAM

REV	DATE	DRAWN	CHK'D	APP'D	DESCRIPTION
C	01/25/23	CL	-	-	ISSUED WITH PROPOSAL
B	07/29/21	ZL	-	-	ISSUED WITH PROPOSAL
A	04/29/21	ZL	-	-	ISSUED WITH PROPOSAL

PRELIMINARY

ECOfluid

ECOfluid Systems Inc.
Suite 1800 - 200 Granville St.
Vancouver, B.C. V6C 1S4

OWLS NEST
RESIDENTIAL DEVELOPMENT WWTP
KALAMALKA LAKE, BC

PRELIMINARY FLOW DIAGRAM

DWG. NO. Q1821-101 REV: C

DESIGNED: - DRAWN: - CHECKED: -

APPENDIX D

WATTERSON ENVIRONMENTAL IMPACT STUDY

WATTERSON MEMO – OLD VS NEW SEWERAGE

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TECHNICAL MEMO

TO: Mr. Jesse LaFrance, BBA
Beaverbrook Communities

Mr. Peter Gigliotti, P. Eng.
Urban Systems Ltd. (USL)

DATE: January 12, 2018

FROM: Daniel Watterson, P.Geo.

WGI Project No. 18-004

SUBJECT: **Field Assessment Summary and Preliminary Environmental Effects Analysis – Owls Nest Residential Development Onsite Waste Water Disposal**

In accordance with your request, WGI is pleased to provide this summary of the recently completed field investigation program. As previously discussed, the purpose of this program was to

- provide detailed subsurface information to support onsite treatment and disposal system design and implementation,
- explore subsurface conditions including soil characteristics and thickness, identify potential limiting layers including depth to bedrock and groundwater, and to provide groundwater quality monitoring locations downgradient of the proposed infiltration areas, and
- provide data and recommendations regarding the feasibility of using the North and South Areas for waste water disposal.

The field work and site assessment were completed in general accordance with site evaluation and system design guidelines established in the BC Ministry of Health Standard Practice Manual V3 (SPM).

The following field work was completed:

- Utility clearance, excavation and drilling equipment and operator services were provided by On-The-Mark Locates (OTML).
- Field supervision provided by Michael Schutten with Ecoscape Environmental Ltd., with senior support by WGI.
- The test pit program was completed on November 12, 2017 and the drilling and monitoring well program was completed on December 12 and 13, 2017.
- Four test pits (TP) were excavated in North Area, with five (5) excavated in the South Area.
- Five (5) soil percolation tests and four (4) constant-head permeability tests were completed.
- One monitoring well was installed in the North Area, while three (3) boreholes were completed and one (1) monitoring well was installed in the South Area.
- Test pit and drilling locations shown in attached Figures 1 and 2.

Findings

Test pit logs, borehole logs and monitoring well construction diagrams are attached. Soil permeability and percolation test results are included in the test pit logs and summarized in Table 1.

North Area

The North Area test pits ranged in depth between 3.35 and 3.96 m below ground surface (bgs). The upper 0.3 to 0.45 m of soil in these test pits consisted of organic rich topsoil. Below this was less than one (1) m of gravelly silt loam. Below this in all test pits was soft and structureless gravelly sand and sandy gravel, with a 0.3 m layer of gravelly loam present in TP-6. The TP-5 and TP-6 excavations terminated in this sandy gravel, while TP-7 encountered bedrock at 3.35 m bgs. Test pit TP-8 encountered approximately 0.5 m of gravely sand loam and till to about 2.3 m bgs, with sandy gravel to 3.96 m bgs.

Importantly, no evidence of groundwater or seasonally saturated soil (mottles, mineralization) was observed in any test pit.

Soil infiltration capacity tests conducted in the North Area were also completed between 0.4 and 1.22 m bgs, below surface topsoil and at the likely OTDS infiltration depth. As observed in the South Area the percolation test results varied widely with percolation rates ranging from less than 1 min/inch at TP-8 to over 2.5 min/inch in TP-7. Three saturated field conductivity (Kfs) measurements, conducted at TP-5, TP-6 and TP-8, indicated Kfs' ranging between 1895 and 3207 mm/day.

Borehole MW-1, completed in the North Area, extended to 11.25 m bgs and encountered topsoil above loose and damp sandy gravel overlying bedrock at 11.0 m bgs. Although groundwater was not encountered in this borehole during drilling, a monitoring well was installed to potentially monitor downslope effluent quality in the subsurface. The monitoring well was constructed of 52 mm (2 in) PVC casing with 1.5 m of PVC screen enclosed in a sand filter pack. Bentonite seals were installed above the filter pack and at the ground surface to prevent downward moisture movement along the casing annulus. A stand-up monument was installed to protect the casing at the ground surface. The monitoring well location is provided in Figure 1.

Groundwater was not present during a WGI site visit on December 20, 2017, however based on location it is possible to likely that groundwater may be present in this well during spring freshet.

South Area

The test pits in this area extended between 1.52 m and 4.27 m bgs. In general, all test pits encountered between 0 and 40 cm of topsoil and fill overlying loam[1] with variable amounts of silt, sand, clay and gravel. This loam varied from less than one (1) m thick in TP-3a to slightly over one (1) m thick in TP-1. This material was moderately dense with a weak blocky structure.

Sediments below this varied with test pit locations. TP-1 encountered medium brown sand to the test pit's total depth of 3.96 m bgs. TP-2 encountered sandy gravel and gravelly sand to 3.35 m bgs, with clay

[1] Loam is a soil composition term which describes the relative proportions of silt, clay and sand in the soil.

to 3.96 m bgs. Approximately 0.3 m of sandy gravel was present above bedrock at 1.52 m bgs in TP-3a, while TP-3b encountered about 0.17 m of till (dense clay, silt, sand and gravel mixture) above approximately 1.2 m of sandy gravel with bedrock encountered at 2.44 m bgs in this excavation. Test pit TP-4, excavated to 4.27 m bgs, encountered about 0.2 m of till above about 0.6 m of sandy clay loam. Below this extended gravelly sand and sand to the test pit's total depth.

All soil infiltration capacity tests were conducted between 0.4 and 1.22 m bgs, below surface topsoil and fill materials and at the likely OTDS infiltration depth. The percolation test results varied widely with percolation rates ranging from less than 1 min/inch at TP-2 to over 13 min/inch in TP-4. One saturated field conductivity (Kfs) measurement, conducted at TP-3b, measured soil permeability at 1785 mm/day.

Four boreholes were conducted in the South Area, with one completed as a groundwater monitoring well (Figure 2). Monitoring well MW-2 extended to 11 m bgs and encountered approximately 3 m of topsoil underlain by gravelly silt and sand loam. Loose sandy gravel was present below this to the borehole's total depth was. Groundwater was encountered at 8.6 m bgs.

Borehole BH3 encountered approximately 1.4 m of gravelly silt loam above sand to the borehole's total depth of approximately 2.4 m bgs, where bedrock was encountered. Borehole BH4 encountered bedrock at about 12.8 m bgs. Above this was gravelly sand and sand with decreasing gravel with depth. Borehole BH5 encountered approximately 0.8 m of gravelly silt loam above gravelly sand, sandy gravel and gravel to the borehole's total depth of 16.3 m bgs.

System Design with respect to SPM Guidelines

The SPM provides numerous evaluation criteria that are used to assess the site and soil's capacity to accept and properly treat infiltrated groundwater without negative downslope impacts. These include (but are not limited to) thickness, texture, consistency, structure, rock fragments and permeability. These criteria are used to identify whether the soils and location are favorable for infiltration or not, and to estimate the suitable hydraulic loading rate (HLR) for the sediment and location. HLR can be estimated using soil characteristics and using measured permeability rates, and will also depend on effluent quality, with higher quality effluent (Type 3) needing less infiltration area but slightly deeper soil than Type 2 effluent.

Summary soil characteristics and estimated HLRs for each test pit for depths at and below the likely infiltration depth, and for Type 2 and Type 3 effluent quality are provided in Table 2. Based on these estimates, for Type 2 effluent in the South Area, the average HLR based on soil type is **55 L/m^2/day** and based on soil permeability is **65 L/m^2/day**. The average HLRs for Type 2 effluent in the North Area are **50 L/m^2/day** and **64 L/m^2/day**, based on soil type and measured permeabilities, respectively.

For Type 3 effluent in the South Area, the average HLR based on soil type is **104 L/m^2/day** and based on soil permeability is **140 L/m^2/day**. The average HLRs for Type 3 effluent in the North Area are **94 L/m^2/day** and **115 L/m^2/day**, based on soil type and measured permeabilities, respectively.

<u>Based on these findings and previous site investigation work, as shown in Figures 1 and 2, approximately 600 m^2 is available for infiltration in both the South and North Areas.</u>

Therefore, assuming the maximum daily disposal volume for each area will be 22,000 L/day, for the South Area approximately **210 m^2** will be required to dispose of Type 3 effluent and approximately **400 m^2** will be needed to dispose of Type 2 effluent (Figure 2). Similarly, approximately **235 m^2** will be needed to dispose of Type 3 effluent in the North Area, while about **440 m^2** will be required to dispose of Type 2 effluent in this area (Figure 1).

Another key design guideline for OTDS is the minimum vertical separation (VS), also known as unsaturated soil thickness, between the infiltration area bottom and an underlying limiting layer. Per SPM Tables II-15 and II-16, the minimum VS for gravelly sand soils varies between 45 cm and 90 cm, depending on effluent quality and dosing method. Except for a thin (0.17 m) till layer encountered between 2.13 and 2.3 m bgs in TP-8, and bedrock present at 1.83 m bgs at TP-7, no limiting layers were encountered beneath the proposed north disposal area. The bedrock observed in TP-7 slopes steeply to the east, which corresponds to deeper bedrock further to the east in MW-1.

Sediment in the South Area thickens to the south with bedrock present at a relatively shallow depth in the north part of the South Area (TP-3 and 3a), and present at the ground surface further to the east. However, the test pit and boring data show the bedrock surface slopes steeply to the south and east below the southern part of the area and beneath the agricultural land to the south.

Except for bedrock encountered at 1.22 m bgs in TP-3a, and a thin layer of till in TP-3b at 1.03 m bgs and at 0.45 m bgs in TP-4, no near-surface impermeable barriers to downward effluent migration were encountered.

Another infiltration area design principle is to orient the dispersal field as perpendicular to ground slope as possible. As shown in Figure 1, this design principle can be met in the North Area, however the proposed property boundaries in the South Area will limit the ability to best orient the infiltration area. The bedrock surface beneath the South Area slopes both east and south, and most infiltrated effluent will flow to the south into sediments beneath the agricultural area. Effluent flow beneath the North Area should flow generally east along the top of bedrock with discharge into sediments beneath the rail trail.

An additional guideline is to limit potential effluent daylighting or breakout within 7.5 m of the infiltration boundary. Both proposed infiltration areas will meet this requirement. Although a sharp topographic break is situated downhill of the North Area and adjacent to the rail trail, the deep depth to bedrock, below the adjacent ground slope surface, indicates that effluent should not discharge from this slope.

Recommendations

Both proposed dispersal areas appear suited for long-term waste water infiltration. Several recommendations regarding site construction and layout can be provided:

- For both disposal areas, I suggest removal of all silty sand loam soil and low permeability sediments and replace with clean sand. Both areas have more permeable sediments at depth, so removing the shallower lower permeability materials will limit groundwater mounding and will improve infiltration capacity and effluent drainage.

- Further to this, the effluent flow pathways from the South Area are not exactly known but most effluent will travel south and some will flow east. I recommend removal of other lower permeability soil were encountered during site and residence construction east and below the infiltration area and ensure good drainage is present beneath all residences and roads.
- Ensure that all utility trenches are backfilled with lower permeability material; if this material is not available then install flow prevention dams in the trenches.
- All treatment plants and equipment should be located more than 30 m from lake high water, which is beyond the SSR criteria. In addition, the SPM stipulates that all tanks should be more than 10 m from Kalamalka Lake. Keeping all infrastructure beyond these setbacks will greatly simply IHA filing and review.

Discussion

Based on information provided by USL, effluent produced by the onsite treatment system will be of excellent quality with BOD_5 (5-day biological oxygen demand) and TSS (total suspended solids) concentrations at or better than 45 mg/L for Type 2 effluent, or at or better than 10 mg/L with fecal coliform concentrations below 400 CFU / 100 ml for Type 3 effluent (SPM V3, 2014).

Based on information provided in the SPM, the most important site feature that supports effective treatment of infiltrated effluent is the thickness of unsaturated soil. For both infiltration areas, the unsaturated zone is many meters thick. Normal operation of septic tank/subsurface infiltration systems results in retention and die-off of most, if not all, observed pathogenic bacterial pathogens within 60 to 90 centimeters of the infiltrative surface (US EPA, 2002). Fecal coliforms in the effluent will commonly bind to soil particles, fine-grained materials, and organic matter within the first meter or two from the surface (Brown, et al 1979). In addition, numerous studies have shown that coliforms do not survive longer than a few weeks in groundwater (Health Canada, 2006).

The most significant nutrient constituents in sewage effluent include nitrogen compounds including nitrate and phosphorus. Most phosphorus is retained in activated waste sludge and is effectively removed by settling and subsequent tank pumping. Phosphorus that is discharged to the environment is precipitated or adsorbed in soil, such that most to almost all discharged phosphorus is eliminated from effluent no more than a few meters from the infiltration area, even after years of effluent disposal (Scope, 2006).

Numerous studies have shown that depending on soil texture, structure and mineralogy; drainage and wetness; depth to a saturated zone and the degree to which it fluctuates; the amount of available organic carbon present; and infiltration system design and operation; nitrate concentrations in the receiving environment can be significantly reduced. The organic-rich soils such as those present beneath the infiltration area and along the lake shoreline along with dosing the effluent using timed cycles have been shown to reduce nitrate concentrations by as much as 60 to over 90 percent (Hazen and Sawyer, 2009).

Concentrations of other waste water constituents commonly decline due to aerobic and anaerobic biodegradation and by adsorption onto mineral surfaces in the unsaturated zone and in groundwater.

The proposed septic system's primary, treatment and dosing tanks will be constructed without seams joining the tank's sides and floor. This construction method will significantly minimize the potential for leakage. The only potential pathway for leaks would be from cracks through the tank wall or from piping connections, which are highly unlikely to occur under normal operating conditions.

Although the effluent will be disposed into moderately permeable sandy gravel sediment, the lack of groundwater beneath the infiltration areas and long travel path between the infiltration areas and the lake will result in additional subsurface treatment. The travel time for effluent to migrate from the infiltration area to the lake can be estimated using the relationship

Travel Time = D ÷ (K x I)) x N, where

Distance to lake (D) = ± 125 m (South Area), 25 m (North Area)
Soil hydraulic conductivity (K) = 1 X 10^{-5} m/sec (typical for med-grained permeability soils)
Hydraulic gradient (I) = 0.2 (20% slope between infiltration area and boundary)
Soil Porosity (N) = 0.25

This analysis demonstrates that the approximate travel time for the infiltrated effluent to reach the lake shoreline from the North Infiltration area will be over 36 days, and from the South Infiltration area will be over 180 days. This long travel time through unsaturated soil will further support effective natural biodegradation and attenuation of effluent constituents.

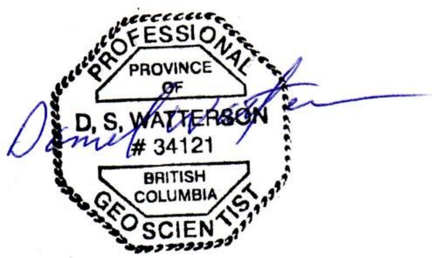
Conclusions

Based on the above data and analyses, it is my professional opinion that system construction and operation will not negatively affect water quality in Kalamalka Lake. The infiltration system’s distance from the lake and thick unsaturated soil will protect the adjacent lake waters from negative impacts. In addition, proper system design and operation, appropriate site construction practices, effective onsite water and stormwater management practices, and good residential housekeeping practices should also minimize the potential for effluent to compromise downslope surface water quality.

Please be advised that I am a member in good standing in the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) and I am acting within my area of expertise. In preparing this analysis I have relied in good faith on information provided by others, the accuracy of which I cannot attest. This assessment has been completed in accordance with generally accepted engineering and environmental practice. Please note, no hydrogeological investigation can wholly eliminate uncertainty regarding the potential for unrecognized conditions in connection with an aquifer or subsurface materials.

Do not hesitate contact the undersigned if you have any questions or wish to discuss any aspect of this report.

Watterson Geoscience Inc.



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Principal Hydrogeologist

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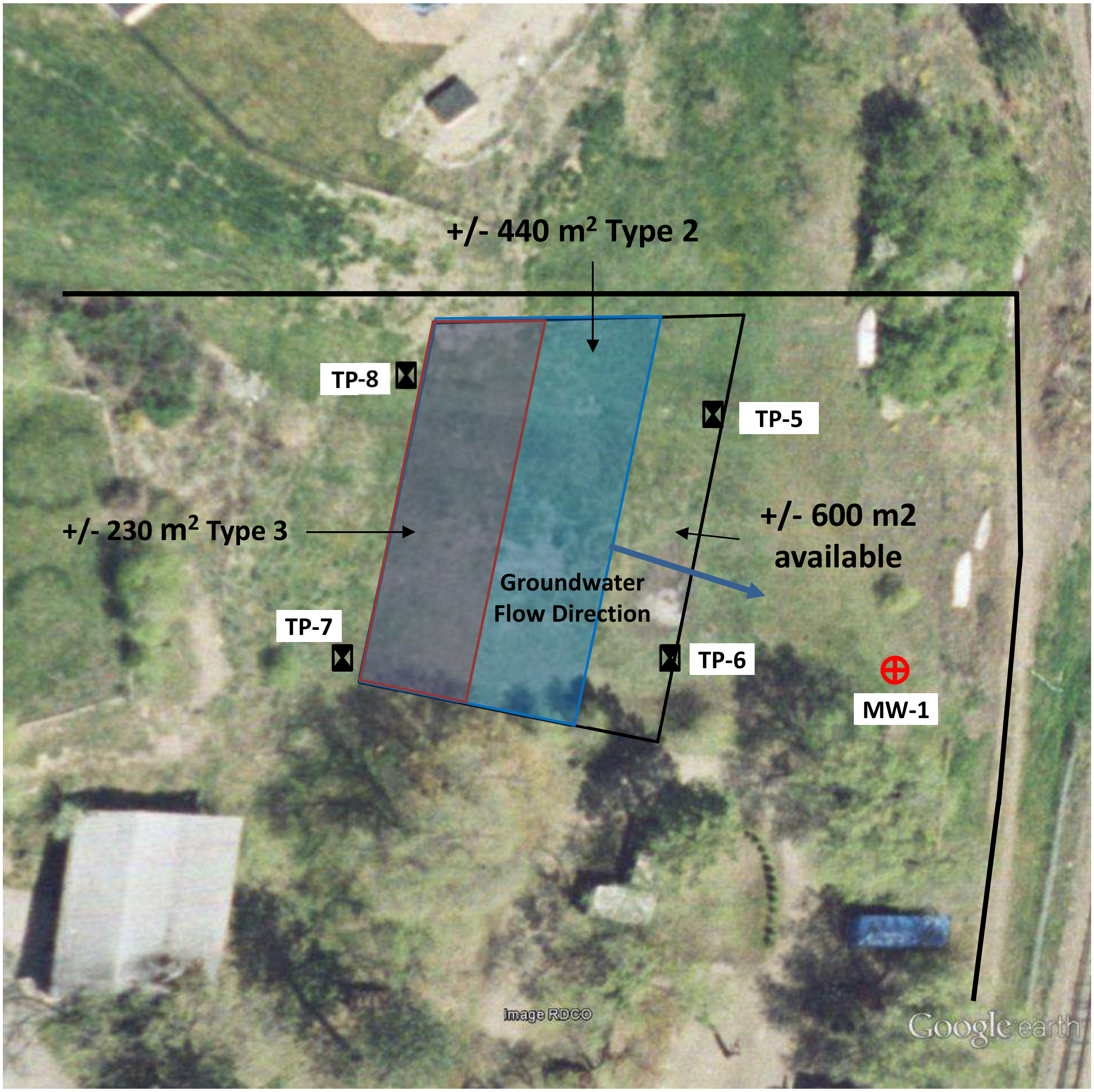
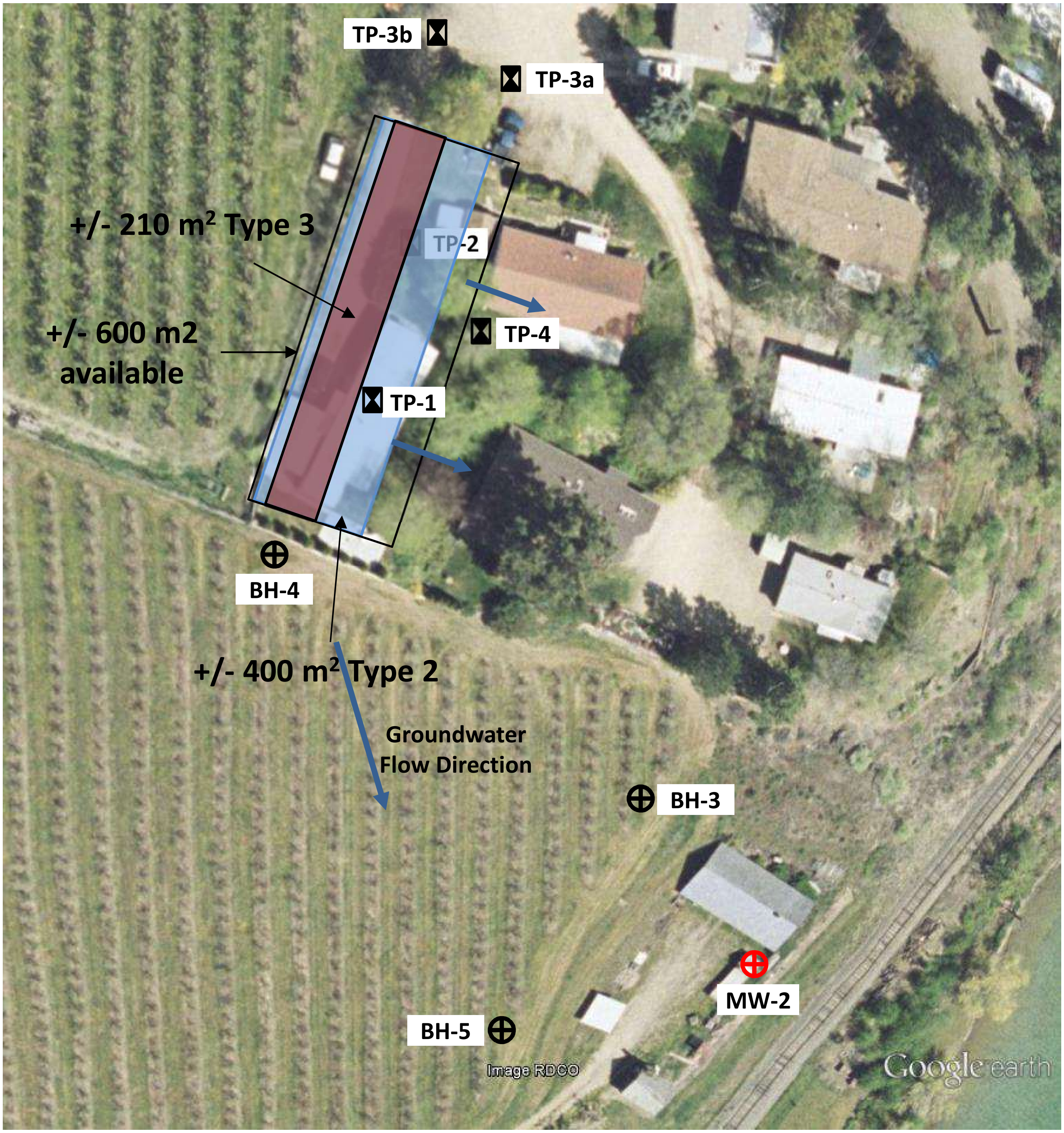


Watterson Geoscience Inc. Groundwater Consulting Services	Owls Nest Proposed Residential Subdivision	North Area – Test Pit and Monitoring Well Locations Available and Required Areas Project No. 18-004
Source: Central Okanagan Regional District Mapping	Client: Beaverbrook	Figure 1



Watterson Geoscience Inc. Groundwater Consulting Services	Owls Nest Proposed Residential Subdivision	South Area – Test Pit and Monitoring Well Locations Available and Required Areas Project No. 18-004
Source: Central Okanagan Regional District Mapping	Client: Beaverbrook	Figure 2

TABLE 1: TEST PIT LOGS

Test Pit No.	Soil Depth (m)	Soil Description	Notes / Observations	Permeameter Results (Kfs) mm/day	Percolation Test Results (min/inch)
TP-1	0 - 0.15	TOPSOIL; dark brown, abundant organics and roots, damp, firm, no structure, well graded	No mottling or groundwater seepage observed		
	0.15 - 1.22	GRAVELLY SILT LOAM (fill); dark brown, damp, firm to stiff, frequent small rootlets, some angular gravel and pebbles, weak to moderate blocky structure			
	1.22 - 2.13	GRAVELLY SAND; medium brown, damp, loose to compact, well graded, no structure, abundant gravel and pebbles, sand fining with depth; some sloughing			1.27
	2.13 - 3.96	SAND; medium brown, damp, compact to dense, no structure, well graded, one (1) large diameter root at 2.44 m			
TP-2	0 - 0.10	TOPSOIL; organic litter, dark brown, roots	No groundwater seepage observed		
	0.10 - 0.70	GRAVELLY SILT LOAM; dark brown, damp, firm to stiff, frequent small rootlets, some angular gravel and pebbles, weak to moderate blocky structure, slight red-brown mottling			
	0.70 - 1.83	SANDY GRAVEL; light brown, damp, compact, no structure, well graded, abundant angular pebbles, some small rootlets at 1.52 m			0.95
	1.83 - 3.35	GRAVELLY SAND; medium brown, damp, compact, well graded, no structure, abundant gravel and pebbles, sand fining with depth			
	3.35-3.96	CLAY; grey, moist, firm			
TP-3a	0 - 0.10	TOPSOIL; organic litter, dark brown, roots	No mottling or groundwater seepage observed		
	0.10 - 0.3	SANDY LOAM; yellowish brown, loose, damp, well graded, some roots			
	0.3 - 0.7	SILT LOAM; medium brown, some fine grained sand, firm to stiff, damp, weak blocky structure, some roots			
	0.7-1.05	AS ABOVE; light brown, increasing density with depth,			
	1.05 - 1.37	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles			
	1.22-1.52	BEDROCK; drastic slope towards southeast			
TP-3b	0 - 0.10	CRUSHED GRAVEL; grey, sandy, silty, damp, compact	No mottling or groundwater seepage observed		
	0.10 - 0.40	ORGANICS; dark brown, sandy, silty, organics, damp, firm			
	0.40 - 1.05	GRAVELLY SILT LOAM; medium brown, firm to stiff, damp, weak blocky structure, some angular gravel and pebbles, some small to medium sized roots		1785	
	1.05 - 1.22	TILL; grey, pebble, sand, silt, and clay cemented			
	1.22 - 2.44	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
	2.44	BEDROCK			
TP-4	0 - 0.15	TOPSOIL; dark brown, abundant organics and roots, damp, firm, no structure, well graded	No mottling or groundwater seepage observed		
	0.15 - 0.45	SANDY LOAM; medium brown, compact, damp, weak blocky structure, some angular gravel, abundant roots			
	0.45 - 0.61	TILL; light brown, cemented pebble, gravel, sand, and silt			
	0.61 - 1.22	GRAVELLY LOAM; medium brown, firm to stiff, damp, weak blocky structure, some angular gravel and pebbles, some roots			13.7
	1.22 - 1.52	TILL; light brown, hard, damp, primarily gravel and pebbles, some silt and sand, trace clay, no structure			
	1.52 - 2.13	SANDY CLAY LOAM; medium brown, firm to stiff, damp, weak blocky structure, trace angular gravel			
	2.13 - 3.05	GRAVELLY SAND; light brown, loose to compact, damp, coarse sand fining with depth, abundant angular gravel and cobbles; minor sloughing			
	3.05 - 4.27	SAND; light brown, compact, damp, medium to fine grained, trace angular gravel and cobble			
TP-5	0 - 0.45	ORGANICS; dark brown, sandy, silty, organics, damp, firm	No mottling or groundwater seepage observed		
	0.45 - 1.22	GRAVELLY SILT LOAM; light brown, soft to firm, damp, moderate blocky structure, some angular gravel		1895	
	1.22 - 3.96	VERY GRAVELLY SAND; medium brown, damp, loose to compact, well graded, no structure, abundant gravel and pebbles; minor sloughing			
TP-6	0 - 0.45	ORGANICS; dark brown, silty, organics, damp, firm, abundant roots	No mottling or groundwater seepage observed		
	0.45 - 0.75	GRAVELLY LOAM; light brown, firm to stiff, damp, weak blocky structure, some angular gravel		3207	
	0.75 - 3.66	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
TP-7	0 - 0.45	ORGANICS; dark brown, sandy, silty, organics, damp, firm	No mottling or groundwater seepage observed		
	0.45 - 1.22	GRAVELLY SILT LOAM; light brown, firm, damp, moderate blocky structure, some angular gravel and pebbles, some roots			2.54
	1.22 - 1.83	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
	1.83 - 3.35	BEDROCK; drastic slope eastwards towards Kalamalka Lake			
TP-8	0 - 0.30	ORGANICS; dark brown, silty, organics, damp, firm, abundant roots	No mottling or groundwater seepage observed		
	0.30 - 0.90	GRAVELLY SILT LOAM; light brown, firm, damp, moderate blocky structure, some angular gravel and pebbles, some roots		2216	
	0.90 - 1.35	SANDY GRAVEL; light brown, damp, loose, no structure, well graded, abundant angular pebbles; notable sloughing			0.07
	1.35 -1.83	GRAVELLY SAND; medium brown, damp, compact, well graded, no structure, abundant gravel and pebbles decreasing with depth, some fine to medium grained sand lenses, some silt			
	1.83 - 2.13	GRAVELLY SANDY LOAM; medium brown, damp, firm, some gravel and pebbles			
	2.13 - 2.30	TILL; grey, pebble, sand, silt and clay cemented			
	2.30 - 3.96	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			

TABLE 2: SOIL CHARACTERISTICS AND HLR VALUES

South Area - Maxiumum Allowable HLR Assuming Type 3 System						
Location	**Soil Type (Texture)**	**Depth (m bgs)**	**Consitency and Structure**	**Favourability**	**Max HLR based on Table II-22[a] (L/day/m^2)**	**Max HLR based on Table II-23[b] (L/day/m^2)**
TP-1	Gravelly Sand	1.22 - 2.13	Loose to Compact, Structureless	F	130	130
TP-1	Sand	2.13 - 3.96	Compact to Dense, Structureless	P	80	-
TP-2	Sandy Gravel / Gravelly Sand	0.70-1.83	Compact, Structureless	P	150	150
TP-2	Gravelly Sand	1.83-3.35	Compact, Structureless	P	120	-
TP-3b	Sandy Gravel / Gravelly Sand	1.22-2.44	Loose to Compact, Structureless	F	150	-
TP-4	Gravelly Loam	0.61-1.22	Firm to Stiff, Weak Blocky	VP	35	80
TP-4	Sandy Clay Loam	1.52-2.13	Firm to Stiff, Weak Blocky	VP	NA	-
TP-4	Gravelly Sand	2.13-3.05	Loose to Compact, Structureless	F	130	-
AVERAGE HLR Test Pits 1 - 4					**104**	**140**
South Area - Maxiumum Allowable HLR Assuming Type 2 System						
Location	**Soil Type**	**Depth (m bgs)**	**Consitency and Structure**	**Favourability**	**Max HLR based on Table II-22[a] (L/day/m^2)**	**Max HLR based on Table II-23[b] (L/day/m^2)**
TP-1	Gravelly Sand	1.22 - 2.13	Loose to Compact, Structureless	F	65	65
TP-1	Sand	2.13 - 3.96	Compact to Dense, Structureless	P	50	-
TP-2	Sandy Gravel / Gravelly Sand	0.70-1.83	Compact, Structureless	P	65	65
TP-2	Gravelly Sand	1.83-3.35	Compact, Structureless	P	65	-
TP-3b	Sandy Gravel / Gravelly Sand	1.22-2.44	Loose to Compact, Structureless	F	65	-
TP-4	Gravelly Loam	0.61-1.22	Firm to Stiff, Weak Blocky	VP	25	50
TP-4	Sandy Clay Loam	1.52-2.13	Firm to Stiff, Weak Blocky	VP	NA	-
TP-4	Gravelly Sand	2.13-3.05	Loose to Compact, Structureless	F	65	-
AVERAGE HLR Test Pits 1 - 4					**55**	**65**
North Area - Maxiumum Allowable HLR Assuming Type 3 System						
TP-5	Gravelly Silt Loam	0.45-1.22	Soft to Firm, Moderate Blocky	F	70	90
TP-5	Very Gravelly Sand	1.22-3.96	Loose to Compact, Structureless	F	150	150
TP-6	Gravelly Loam	0.45-0.75	Firm to Stiff, Weak Blocky	VP	35	100
TP-6	Sandy Gravel / Gravelly Sand	0.75-3.66	Loose to Compact, Structureless	F	150	-
TP-7	Gravelly Silt Loam	250	Firm, Moderate Blocky	P	50	100
TP-7	Sandy Gravel / Gravelly Sand	1.22-1.83	Loose to Compact, Structureless	F	150	150
TP-8	Gravelly Silt Loam	0.30-0.90	Firm, Moderate Blocky	P	50	90
TP-8	Sandy Gravel / Gravelly Sand	0.90 -1.35	Loose, Structureless	F	150	150
TP-8	Gravelly Sand	1.35-1.83	Compact, Structureless	P	120	-
TP-8	Sandy Gravel / Gravelly Sand	2.30 - 3.96	Loose to Compact, Structureless	F	150	-
AVERAGE HLR Test Pits 5 - 8					**94**	**115**
North Area - Maxiumum Allowable HLR Assuming Type 2 System						
TP-5	Gravelly Silt Loam	0.45-1.22	Soft to Firm, Moderate Blocky	F	60	60
TP-5	Very Gravelly Sand	1.22-3.96	Loose to Compact, Structureless	F	65	65
TP-6	Gravelly Loam	0.45-0.75	Firm to Stiff, Weak Blocky	VP	25	65
TP-6	Sandy Gravel / Gravelly Sand	0.75-3.66	Loose to Compact, Structureless	F	65	-
TP-7	Gravelly Silt Loam	0.45 - 1.22	Firm, Moderate Blocky	P	30	65
TP-7	Sandy Gravel / Gravelly Sand	1.22-1.83	Loose to Compact, Structureless	F	65	65
TP-8	Gravelly Silt Loam	0.30-0.90	Firm, Moderate Blocky	P	30	60
TP-8	Sandy Gravel / Gravelly Sand	0.90 -1.35	Loose, Structureless	F	65	65
TP-8	Gravelly Sand	1.35-2.30	Compact, Structureless	P	65	-
TP-8	Sandy Gravel / Gravelly Sand	2.30 - 3.96	Loose to Compact, Structureless	F	65	-
AVERAGE HLR Test Pits 5 - 8					**50**	**64**

Note: bolded Max HLRs represent the more conservative estimate, as per Section II-5.5 of the SPM Version 3

Shaded - Max allowable HLR for gravelly loams and silt loams are liklely higher than values assigned to loams and silt loams in Table II-22

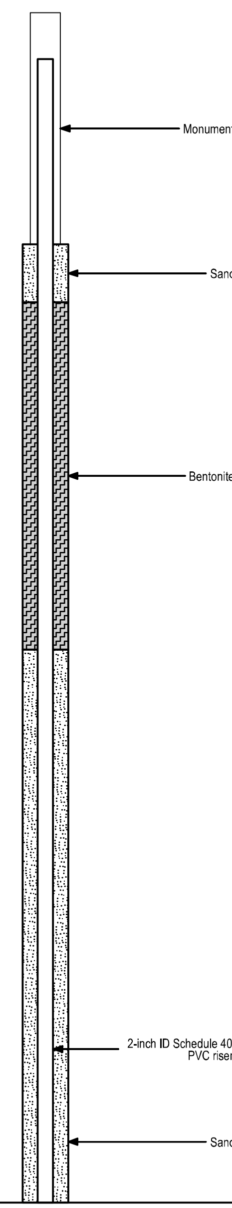
a - HLR based on soil type

b - HLR based on permeability

FIELD REP Mike Schutten	COMPLETION DATE: 12/12/2017	Watterson Geoscience Inc. Groundwater Consulting Services
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 403.07	
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl) 403.67	
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)	
HOLE DIAMETER (CM): 10.2	Northing 5554959.00 Easting 329782.00	
WATER ELEVATION (masl):		

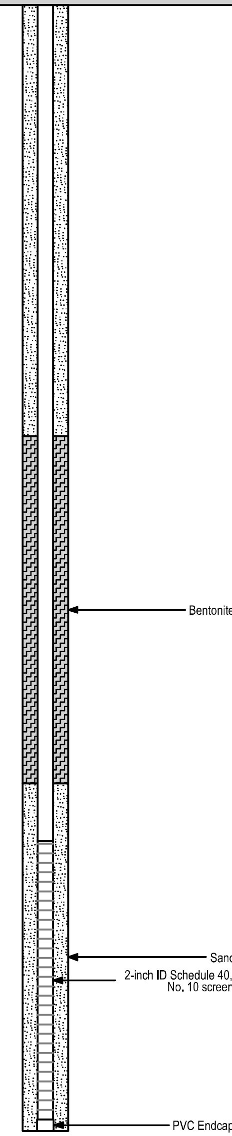
SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID
GROUND SURFACE	0			
ORGANICS; dark brown, sandy, silty, organics, damp, firm				SS 1A
GRAVELLY SILT LOAM; light brown, damp, firm				SS 1B
GRAVELLY SAND; brown, damp, very loose, well graded	1			SS 3
SANDY GRAVEL; brown, damp, loose, well graded				SS 3
	2			SS 4
				SS 5
	3			SS 6
	4			SS 7
	5			SS 8

WELL CONSTRUCTION



CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW1	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 2
		Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	WELL CONSTRUCTION
SANDY GRAVEL; brown, damp, loose, well graded	6, 7, 8			SS 9 SS 10 SS 11 SS 12	
SANDY GRAVEL; brown, moist, loose, well graded	9, 10			SS 13 SS 14 SS 15	
BEDROCK	11				
	12, 13				



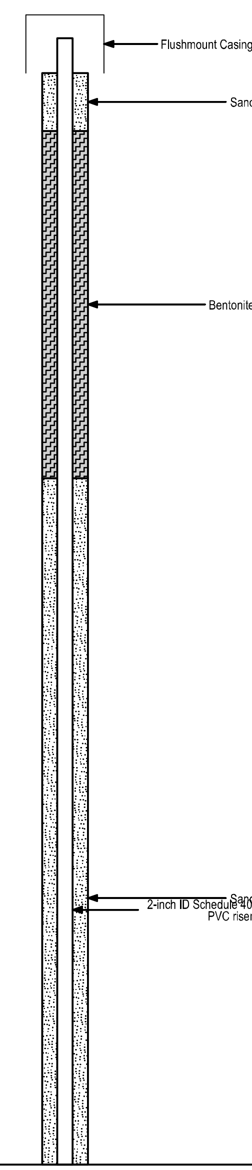
CLIENT:	LOG & RECORD OF WELL CONSTRUCTION MW1	WGI Job No. 18-004
Beaverbrook Developments	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 2 of 2 Issued:

FIELD REP Mike Schutten	COMPLETION DATE: 12/12/2017
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 399.00
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl) 398.90
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)
HOLE DIAMETER (CM): 10.2	Northing 5554752.00 Easting 329642.00
WATER ELEVATION (masl): 390.30	

Watterson Geoscience Inc.
Groundwater Consulting Services

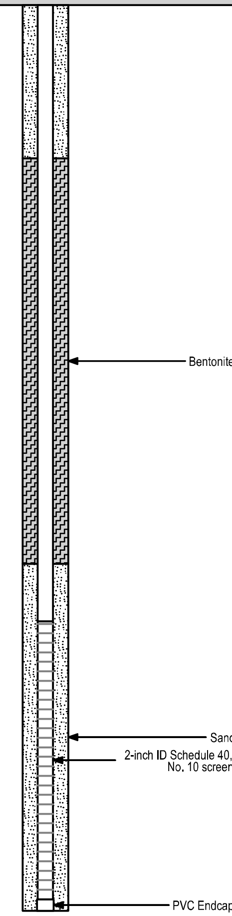
SOIL DESCRIPTION	DEPTH (m)	SAMPLE ID
GROUND SURFACE	0	
ORGANICS; dark brown, sandy, gravelly, silty, organics, damp, loose		SS 1
GRAVELLY SANDY LOAM (fill); brown, damp, firm	1	SS 2
GRAVELLY SILT LOAM; brown, damp, firm		SS 3A
GRAVELLY SILT and CLAY; brown, damp, firm, trace sand	2	SS 3B, SS 4
SANDY GRAVEL; brown, moist, loose, well graded, oxidation at 3.50 m bgs	3, 4, 5	SS 5, SS 6, SS 7, SS 8

WELL CONSTRUCTION



CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW2	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 2 Issued:

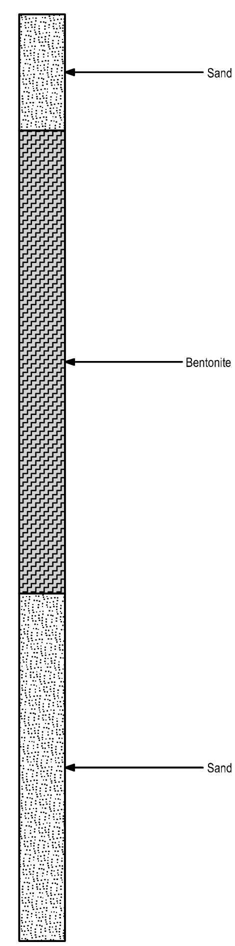
SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	WELL CONSTRUCTION
SANDY GRAVEL; brown, moist, loose, well graded, oxidation at 3.50 m bgs	7, 8, 9			SS 9 SS 10 SS 11	
SANDY GRAVEL; brown, wet, loose, well graded, thin fine grained sand lenses from 9.3 to 10 m bgs, strongly heaving	10			SS 12 SS 13	
	11, 12, 13				



CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW2 BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	WGI Job No. 18-004 Page 2 of 2 Issued:

FIELD REP: Mike Schutten	COMPLETION DATE: 12/13/2017	Watterson Geoscience Inc. Groundwater Consulting Services
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 403.00	
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl)	
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)	
HOLE DIAMETER (CM): 10.2	Northing 5554776.00 Easting 329634.00	
WATER ELEVATION (masl):		

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
GROUND SURFACE					
GRAVELLY SILT LOAM; light brown, moist, firm	0			SS 1	
GRAVELLY SILT LOAM; light brown, damp, stiff				SS 2A	
GRAVELLY SILT LOAM; light brown, damp, very stiff	1			SS 2B	
SAND; brown, damp, loose, well graded, some gravel, trace silt				SS 3	
	2			SS 4	
BEDROCK					



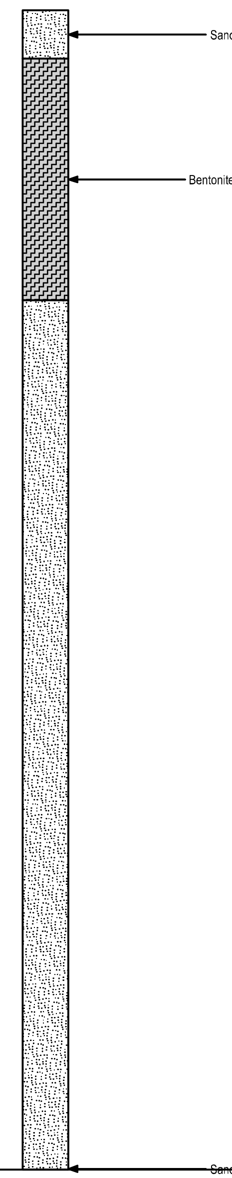
CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH3	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 1
		Issued:

FIELD REP Mike Schutten	COMPLETION DATE: 12/13/2017
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 414.85
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl)
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)
HOLE DIAMETER (CM): 10.2	Northing 5554813.00 Easting 329599.00
WATER ELEVATION (masl):	

Watterson Geoscience Inc.
Groundwater Consulting Services

SOIL DESCRIPTION	DEPTH (m)	SAMPLE ID
GROUND SURFACE	0	
GRAVELLY SILT LOAM; dark brown, damp, firm, some organics		SS 1A
GRAVELLY SAND; brown, damp, loose, well graded		SS 1B
GRAVELLY SAND; light brown, damp, loose, well graded, gravel size increasing with depth - generally larger than 1 cm diameter	1	SS 2
GRAVELLY SAND; light brown, damp, loose, well graded, coarse sand content increasing with depth	2	SS 3
GRAVELLY SAND; light brown, damp, loose, well graded	3	SS 4, SS 5, SS 6
Same as above, with increased moisture content	4, 5, 6, 7	SS 7, SS 8, SS 9, SS 10

BOREHOLE BACKFILL



CLIENT:	LOG & RECORD OF BOREHOLE	WGI Job No. 18-004
Beaverbrook Developments	BH4	Page 1 of 2
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
Same as above, with increased moisture content	8 9			SS 10 SS 11 SS 12	
Same as above, with decreased gravel diameter - generally less than 1 cm.	10			SS 13 SS 14A	
SAND; brown, moist to wet, moderately dense, some gravel - decreasing gravel content with depth, fining of sand with depth	11 12			SS 14B SS 15 SS 16	
CLAY; bluish grey, moist, firm, some silt				SS 17A	
SAND; brown, moist, loose, fine grained, highly oxidized,				SS 17B	
BEDROCK	13 14 15 16				

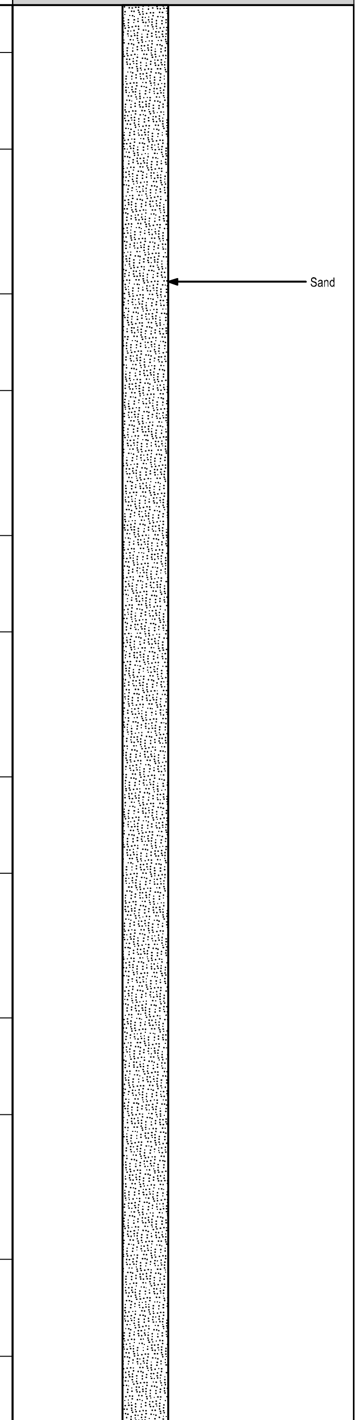
CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH4	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 2 of 2 Issued:

FIELD REP Mike Schutten DRILLING COMPANY: On The Mark DRILLING RIG: B-57 Truck Mount DRILLING METHOD: ODEX HOLE DIAMETER (CM): 10.2 WATER ELEVATION (masl):	COMPLETION DATE: 12/13/2017 GROUND SURFACE ELEV (masl) 402.00 TOP OF RISER ELEV (masl) UTM COORDINATES (NAD 1983 11N) Northing 5554746.00 Easting 329610.00	Watterson Geoscience Inc. Groundwater Consulting Services

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
GROUND SURFACE					
GRAVELLY SILT LOAM; dark brown, damp, stiff, some organics	0		X	SS 1	Sand
GRAVELLY SAND; light brown, dry, loose, well graded	1				Bentonite
	2		X	SS 2	
	3		X	SS 3	
	4				
GRAVELLY SAND; brown, damp, moderately dense, well graded, oxidation from 4.6 to 5.0 m bgs	5		X	SS 4	
	6		X	SS 5	
	7				

CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH5 BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	WGI Job No. 18-004 Page 1 of 2 Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
GRAVELLY SAND; brown, damp, moderately dense, well graded, oxidation from 4.6 to 5.0 m bgs					
GRAVELLY SAND; light brown, damp, moderately dense, well graded, increased gravel diameter (1-2 cm)	8			SS 6	
	9			SS 7	
	10				
GRAVELLY SAND; brown, wet, moderately dense, trace silt, heaving sand and gravel fining with depth	11			SS 8	
	12			SS 9	
	13				
SANDY GRAVEL; dark brown, wet, moderately dense, well graded	14			SS 10	
	15				
GRAVEL; grey, wet, moderately dense, some pebble, some sand	16			SS 11	



CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH5	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 2 of 2 Issued:

TECHNICAL MEMO

TO:	Mr. Jesse LaFrance, BBA Beaverbrook Communities Mr. Paul Dupuis District of Lake Country	**DATE:**	July 24, 2018
FROM:	Daniel Watterson, P.Geo.		
WGI Project No.	18-004		
SUBJECT:	**Owls Nest Residential Development: Onsite Treatment and Disposal System Comparison – Old vs Proposed New Systems**		

INTRODUCTION

In accordance with your request, Watterson Geoscience Inc. (WGI) is pleased to complete an assessment of historic and proposed onsite treatment and disposal system (OTDS) characteristics and performance. The purpose of this assessment is to demonstrate the significant improvements in effluent quality with subsequent reduced effects impacts on lake water quality from operation of the proposed new OTDS.

DESCRIPTION OF OLD SYSTEM

Available information regarding the Owl's Nest Resort and Marina history and occupancy is summarized below. Property use information was provided by Mr. Dean Bauman, and estimated effluent production rates for the various resort facilities were obtained from the BC Standard Practice Manual, Version 3 (SPM) and the US EPA Design Manual (SPM V3, 2014, EPA, 2002).

Owl's Nest Resort Units	Estimated Daily Flows	Occupancy
Seven (7) modular houses and one (1) stick-built house	1,300 L/day (based on 3 bedrooms each)	Year-round
Thirty-two (32) Full Connection Camping Sites	170 L/day	50% May 25% June 90% occupancy July and August 50% September
Thirty-eight (38) Camping Sites with No Connections	180 to 360 L/day	
Four-unit Motel with Laundry Room	250 to 400 L/day/unit	
Office / Concession Stand	50 to 75 L/day	

- All effluent was collected and routed to the treatment and dispersal area, located in the northeast corner of the property.
- The original effluent treatment and disposal system included three (3) tanks in series, installed in the 1960's.
- The tanks included one 600 gal tank, one 2,500 gal and a 500-gal pump chamber.

- A new 3000- gal tank was installed in md-1980's.
- All tanks were constructed of concrete.
- The original dispersal field was installed in a flat area adjacent to lake approximately 50 m from the lake High Water Mark.
- The original field was renovated in 1984 due to continued failure (effluent daylighting). The original field and poor soils were removed and a new field was installed into one (1) m gravel emplaced in same area. No infiltration issues were noted since then.
- Effluent drained by gravity from the development to the tanks, and then pumped to the dispersal field using pressure distribution.
- The main effluent tank was pumped every year.

DESCRIPTION OF NEW SYSTEM

This design summary is based on information provided by Mr. Jeff Oland, P.Eng. and by Beaverbrook:

- WGI understands that at the time of this letter, 43 residences and an amenity building are proposed for construction at the property.
- Domestic wastewater from the residences will be treated and disposed using two separate OTDS with one servicing the north end while the other servicing the south end.
- WGI understands the estimated maximum daily flows for each system will be 21 m^3/day and 22 m^3/day, respectively.
- Based on these flows, the systems will be designed, operated and maintained in accordance with the BC Sewerage System Regulation.
- The OTDS will be constructed using package treatment plants with nitrate reduction and disinfection. Effluent will be dispersed into laterals in trenches.
- The northern dispersal area will be situated approximately 60 m from the lake HWM in the northeast part of the property, and the southern dispersal area will be situated approximately 100 m from the HWM in the southwest part of the property.

EFFLUENT QUALITY COMPARISON

When in good operating order, effluent produced by the historic onsite treatment system was of good quality (Type 1) with BOD_5 (5-day biological oxygen demand) concentrations ranging between 150 and 300 mg/L, and TSS (total suspended solids) concentrations ranging between 50 and 80 mg/L or less (SPM V3, 2014). Bacteria concentrations, including total and fecal coliforms, commonly ranged around 1 X 10^6 CFU/100 mL.

Domestic effluent produced by the historic system also contained total nitrogen compounds at concentrations commonly ranging between 40 and 100 mg/L and nitrates at concentrations ranging between 20 and 100 mg/L. Phosphorus at concentrations ranging between about 5 to 15 mg/L was also present in the effluent.

The proposed OTDS will produce Type 3 quality effluent, defined in the SPM as effluent containing BOD_5 and TSS concentrations less than 10 mg/L, and fecal coliform concentrations less than 400 CFU/100 mL.

In addition, the Type 3 OTDS proposed for the community will include systems to reduce nitrate concentrations in the effluent and disinfection to reduce effluent pathogen concentrations. The systems are expected to produce effluent with nitrate at less than 10 mg/L and fecal coliform concentrations to less than the Type 3 SSR requirement. The systems will produce phosphorus at concentrations similar to the historic system.

LOADING TO LAKE COMPARISON

The quantity of each parameter that eventually could discharge to the lake from the historic and proposed systems was estimated by first estimating daily and annual flows for each source of effluent and then multiplying this volume by the estimated concentrations for each parameter. Estimated flows and load quantities are summarized below

Parameter	Old System Low[1]	Old System High[1]	New Systems
Estimated Annual Flow	5,140 m^3	5,842 m^3	15,695 m^3
BOD_5	771	1756	157 kg
TSS	257	468	157 kg
Total Nitrogen	206	585	471 kg
Nitrates	103	585	157 kg
Phosphorus	26	88	78 kg

1 – High and low estimates based on flow and concentration ranges provided in the SPM and EPA

Detailed calculation tables are attached.

DISCUSSION AND CONCLUSION

In general, published studies and treatment plant manufacturer specifications demonstrate that operation of a Type 3 system compared to a Type 1 system, for a given volume of effluent, will reduce BOD_5 concentrations by over 90%, TSS by 75 to 80%, nitrogen compounds by 25 to 70%, nitrates by 50 to 90% and pathogens by over six orders of magnitude. These literature review findings are supported by this assessment. Although the estimated annual flows from the proposed system will be almost three (3) times the estimated historic flows, all estimated parameter loading quantities will be less than the highest estimated loadings, and BOD_5 and TSS will be below than the lowest estimated historic loadings.

The only new system parameter which approaches the historic loading rate is phosphorus. Type 3 OTDS do not significantly remove more phosphorus from effluent compared to Type 1 systems. However, most phosphorus in both types of systems is retained in activated waste sludge and is effectively removed by settling and subsequent tank pumping. The remaining phosphorus that is discharged into the dispersal field is rapidly removed by adsorption and precipitation in the underlying sand and gravel sediments, even after years of effluent disposal, as shown by work completed by Zanini et al. (1998) and Ptacek (1998).

The original system was installed in poor soil followed by gravel on flat land not far from the lake. This location limited the vertical separation distance and unsaturated soil thickness. At times of high lake elevation, this reduced distance may have contributed to increased phosphorus loading to the lake. In contrast, phosphorus loading to the lake from the proposed systems will be greatly reduced because of the increased underlying soil thickness and increased distance from the lake.

In addition, the new system will offer numerous other advantages and improvements compared to the old system:

- The old system included other potential contaminants in the historic waste water such as fats and grease from the snack shop and concentrated chemicals from RV holding tanks, as these were not required to be empty prior to connecting to the resort system. These parameters likely significantly reduced the system effectiveness. These parameters will not be included in the new systems' effluent stream.
- In general, Type 1 systems have an effective life of approximately 30 years before needing replacement, even if working perfectly. Unfortunately, the historic system's lifetime expired +/- 15 years ago and system performance has likely degraded since then. In contrast, new treatment plant OTDS are designed to operate and perform well indefinitely.
- Although information provided by Mr. Bauman indicated the historic system functioned well, no information regarding how competently the old system was designed, installed or maintained is available. Further, essentially no regulatory requirements were in effect for the old system.
- The new system will be designed, constructed and maintained to significantly higher and more detailed and comprehensive regulatory, design criteria and maintenance standards. The sewerage system design engineer is required, under his license, to follow a design process and set of standards for a Type 3 system. Development of the operating plan is part of that process and will become part of the system certification. The operating plan thus becomes enforceable under the Health Regulation.
- It is unlikely the new system will operate continuously at full capacity thus the actual parameter loading to the lake will be less than estimated above.

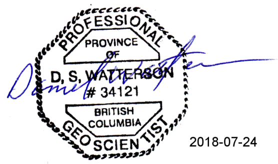
CLOSURE

Please be advised that I am a member in good standing in the Professional Engineers and Geoscientists of British Columbia (EGBC) and I am acting within my area of expertise. In preparing this analysis I have relied in good faith on information provided by others, the accuracy of which I cannot attest. This assessment has been completed in accordance with generally accepted engineering and environmental practice. Please note, no hydrogeological investigation can wholly eliminate uncertainty regarding the potential for unrecognized conditions in connection with an aquifer or subsurface materials.

Do not hesitate contact the undersigned if you have any questions or wish to discuss any aspect of this report.

Watterson Geoscience Inc.

Daniel Watterson, P.Geo. BC, LHG
Principal Hydrogeologist



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HISTORIC OTDS DAILY FLOWS AND LOADING

Permanent Residences[1]	L/day per SPM		Jan	Feb	Mar	April	May		June		July		Aug		Sept		Oct	Nov	Dec
Houses (8 X 1300 L/day)	10,400		10,400	10,400	10,400	10,400	10,400		10,400		10,400		10,400		10,400		10,400	10,400	10,400
Seasonal Residences and Occupancy[2]							***50%***		***25%***		***90%***		***90%***		***50%***				
Full Connection Camp Sites (32 @ 170 L/day each)	6,460						3,230		1,615		5,814		5,814		3,230				
No Connection Camp Sites (38 @ 180-360 L/day each)	6,840	13,680					3,420	6,840	1,710	3420	6,156	12312	6,156	12,312	3420	6,840			
Motel (4 units @ 250-400 L/day each)	1,000	1,600					500	800	250	400	900	1440	900	1,440	500	800			
Office/Concession Stand (50-75 L/day)	50	75					25	37.5	13	18.75	45	67.5	45	68	25	38			
Total Daily Flows (Liters)			**10,400**	**10,400**	**10,400**	**10,400**	**17,575**	**21,308**	**13,988**	**15,854**	**23,315**	**30,034**	**23,315**	**30,034**	**17,575**	**21,308**	**10,400**	**10,400**	**10,400**
Total Montly Flow			322,400	291,200	322,400	312,000	544,825	660,533	419,625	475,613	722,765	931,039	722,765	931,039	527,250	639,225	322,400	312,000	322,400
Est. Annual Flow Range	**5,142,030 Liters**	**5,842,247 Liters**																	
	5142 m^3	**5842 m^3**																	

Typical Type 1 Effluent Parameter Ranges (mg/L)[3]	gms/L		Jan		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec	
BOD5 (150 - 300)	0.15	0.3	1,560	3,120	1,560	3,120	1,560	3,120	1,560	3,120	2,636	6,392	2,098	4,756	3,497	9,010	3,497	9,010	2,636	6,392	1,560	3,120	1,560	3,120	1,560	3,120
TSS (50 - 80)	0.05	0.08	520	832	520	832	520	832	520	832	879	1,705	699	1,268	1,166	2,403	1,166	2,403	879	1,705	520	832	520	832	520	832
Total Nitrogen (40 - 100)	0.04	0.1	416	1,040	416	1,040	416	1,040	416	1,040	703	2,131	560	1,585	933	3,003	933	3,003	703	2,131	416	1,040	416	1,040	416	1,040
Nitrates (20 -100)	0.02	0.1	208	1,040	208	1,040	208	1,040	208	1,040	352	2,131	280	1,585	466	3,003	466	3,003	352	2,131	208	1,040	208	1,040	208	1,040
Phosphorus (5 - 15)	0.005	0.015	52	156	52	156	52	156	52	156	88	320	70	238	117	451	117	451	88	320	52	156	52	156	52	156

HISTORIC OTDS ANNUAL LOADING	Low		High		Low		High	
BOD5	771305	gms	1755794	gms	**771**	**kg**	**1756**	**kg**
TSS	257102	gms	468212	gms	**257**	**kg**	**468**	**kg**
Total Nitrogen	205681	gms	585265	gms	**206**	**kg**	**585**	**kg**
Nitrates	102841	gms	585265	gms	**103**	**kg**	**585**	**kg**
Phosphorus	25710	gms	87790	gms	**26**	**kg**	**88**	**kg**

1 - From SPM V3, 2014

2 - From Dean Bauman

3 - From SPM V3, 2014 and EPA Design Manual, 2002

PROPOSED NEW SYSTEM FLOWS and ESTIMATED LOADINGS

North Field	21,000	L/day	7665000	L/year	**7665**	**m^3/Year**
South Field	22,000	L/day	8030000	L/year	**8030**	**m^3/Year**
Total Annual Flow			15695000	L/year	**15695**	**m^3/Year**

Proposed Systems Daily Loading			
Typical Type 3 Parameter Loading (mg/L)	**gms/L**	**North Field/Day**	**South Field/Day**
BOD5 (10)	0.01	210	220
TSS (10)	0.01	210	220
Total Nitrogen (30)	0.03	630	660
Nitrates with Nitrate Reduction (10)	0.01	210	220
Phosphorus (5 - 15)	0.005	105	110

Proposed System Annual Loading (Grams)	**North Field / Year**	**South Field / Year**	**Total /Year**			
BOD5	76,650	80,300	156950	gms	**157**	**kg**
TSS	76,650	80,300	156950	gms	**157**	**kg**
Total Nitrogen	229,950	240,900	470850	gms	**471**	**kg**
Nitrates with Nitrate Reduction	76,650	80,300	156950	gms	**157**	**kg**
Phosphorus	38,325	40,150	78475	gms	**78**	**kg**

APPENDIX D

MEMO - FIELD ASSESSMENT SUMMARY & PRELIMINARY ENVIRONMENTAL EFFECTS ANALYSIS – DAN WATTERSON, P.GEO.

MEMO - OWLS NEST DEVELOPMENT – ONSITE TREATMENT AND DISPOSAL SYSTEM COMPARISON – OLD VS PROPOSED NEW SYSTEMS – DAN WATTERSON, P.GEO.

TECHNICAL MEMO

TO: Mr. Jesse LaFrance, BBA
Beaverbrook Communities

Mr. Peter Gigliotti, P. Eng.
Urban Systems Ltd. (USL)

DATE: January 12, 2018

FROM: Daniel Watterson, P.Geo.

WGI Project No. 18-004

SUBJECT: **Field Assessment Summary and Preliminary Environmental Effects Analysis – Owls Nest Residential Development Onsite Waste Water Disposal**

In accordance with your request, WGI is pleased to provide this summary of the recently completed field investigation program. As previously discussed, the purpose of this program was to

- provide detailed subsurface information to support onsite treatment and disposal system design and implementation,
- explore subsurface conditions including soil characteristics and thickness, identify potential limiting layers including depth to bedrock and groundwater, and to provide groundwater quality monitoring locations downgradient of the proposed infiltration areas, and
- provide data and recommendations regarding the feasibility of using the North and South Areas for waste water disposal.

The field work and site assessment were completed in general accordance with site evaluation and system design guidelines established in the BC Ministry of Health Standard Practice Manual V3 (SPM).

The following field work was completed:

- Utility clearance, excavation and drilling equipment and operator services were provided by On-The-Mark Locates (OTML).
- Field supervision provided by Michael Schutten with Ecoscape Environmental Ltd., with senior support by WGI.
- The test pit program was completed on November 12, 2017 and the drilling and monitoring well program was completed on December 12 and 13, 2017.
- Four test pits (TP) were excavated in North Area, with five (5) excavated in the South Area.
- Five (5) soil percolation tests and four (4) constant-head permeability tests were completed.
- One monitoring well was installed in the North Area, while three (3) boreholes were completed and one (1) monitoring well was installed in the South Area.
- Test pit and drilling locations shown in attached Figures 1 and 2.

Findings

Test pit logs, borehole logs and monitoring well construction diagrams are attached. Soil permeability and percolation test results are included in the test pit logs and summarized in Table 1.

North Area

The North Area test pits ranged in depth between 3.35 and 3.96 m below ground surface (bgs). The upper 0.3 to 0.45 m of soil in these test pits consisted of organic rich topsoil. Below this was less than one (1) m of gravelly silt loam. Below this in all test pits was soft and structureless gravelly sand and sandy gravel, with a 0.3 m layer of gravelly loam present in TP-6. The TP-5 and TP-6 excavations terminated in this sandy gravel, while TP-7 encountered bedrock at 3.35 m bgs. Test pit TP-8 encountered approximately 0.5 m of gravely sand loam and till to about 2.3 m bgs, with sandy gravel to 3.96 m bgs.

Importantly, no evidence of groundwater or seasonally saturated soil (mottles, mineralization) was observed in any test pit.

Soil infiltration capacity tests conducted in the North Area were also completed between 0.4 and 1.22 m bgs, below surface topsoil and at the likely OTDS infiltration depth. As observed in the South Area the percolation test results varied widely with percolation rates ranging from less than 1 min/inch at TP-8 to over 2.5 min/inch in TP-7. Three saturated field conductivity (Kfs) measurements, conducted at TP-5, TP-6 and TP-8, indicated Kfs' ranging between 1895 and 3207 mm/day.

Borehole MW-1, completed in the North Area, extended to 11.25 m bgs and encountered topsoil above loose and damp sandy gravel overlying bedrock at 11.0 m bgs. Although groundwater was not encountered in this borehole during drilling, a monitoring well was installed to potentially monitor downslope effluent quality in the subsurface. The monitoring well was constructed of 52 mm (2 in) PVC casing with 1.5 m of PVC screen enclosed in a sand filter pack. Bentonite seals were installed above the filter pack and at the ground surface to prevent downward moisture movement along the casing annulus. A stand-up monument was installed to protect the casing at the ground surface. The monitoring well location is provided in Figure 1.

Groundwater was not present during a WGI site visit on December 20, 2017, however based on location it is possible to likely that groundwater may be present in this well during spring freshet.

South Area

The test pits in this area extended between 1.52 m and 4.27 m bgs. In general, all test pits encountered between 0 and 40 cm of topsoil and fill overlying loam[1] with variable amounts of silt, sand, clay and gravel. This loam varied from less than one (1) m thick in TP-3a to slightly over one (1) m thick in TP-1. This material was moderately dense with a weak blocky structure.

Sediments below this varied with test pit locations. TP-1 encountered medium brown sand to the test pit's total depth of 3.96 m bgs. TP-2 encountered sandy gravel and gravelly sand to 3.35 m bgs, with clay

[1] Loam is a soil composition term which describes the relative proportions of silt, clay and sand in the soil.

to 3.96 m bgs. Approximately 0.3 m of sandy gravel was present above bedrock at 1.52 m bgs in TP-3a, while TP-3b encountered about 0.17 m of till (dense clay, silt, sand and gravel mixture) above approximately 1.2 m of sandy gravel with bedrock encountered at 2.44 m bgs in this excavation. Test pit TP-4, excavated to 4.27 m bgs, encountered about 0.2 m of till above about 0.6 m of sandy clay loam. Below this extended gravelly sand and sand to the test pit's total depth.

All soil infiltration capacity tests were conducted between 0.4 and 1.22 m bgs, below surface topsoil and fill materials and at the likely OTDS infiltration depth. The percolation test results varied widely with percolation rates ranging from less than 1 min/inch at TP-2 to over 13 min/inch in TP-4. One saturated field conductivity (Kfs) measurement, conducted at TP-3b, measured soil permeability at 1785 mm/day.

Four boreholes were conducted in the South Area, with one completed as a groundwater monitoring well (Figure 2). Monitoring well MW-2 extended to 11 m bgs and encountered approximately 3 m of topsoil underlain by gravelly silt and sand loam. Loose sandy gravel was present below this to the borehole's total depth was. Groundwater was encountered at 8.6 m bgs.

Borehole BH3 encountered approximately 1.4 m of gravelly silt loam above sand to the borehole's total depth of approximately 2.4 m bgs, where bedrock was encountered. Borehole BH4 encountered bedrock at about 12.8 m bgs. Above this was gravelly sand and sand with decreasing gravel with depth. Borehole BH5 encountered approximately 0.8 m of gravelly silt loam above gravelly sand, sandy gravel and gravel to the borehole's total depth of 16.3 m bgs.

System Design with respect to SPM Guidelines

The SPM provides numerous evaluation criteria that are used to assess the site and soil's capacity to accept and properly treat infiltrated groundwater without negative downslope impacts. These include (but are not limited to) thickness, texture, consistency, structure, rock fragments and permeability. These criteria are used to identify whether the soils and location are favorable for infiltration or not, and to estimate the suitable hydraulic loading rate (HLR) for the sediment and location. HLR can be estimated using soil characteristics and using measured permeability rates, and will also depend on effluent quality, with higher quality effluent (Type 3) needing less infiltration area but slightly deeper soil than Type 2 effluent.

Summary soil characteristics and estimated HLRs for each test pit for depths at and below the likely infiltration depth, and for Type 2 and Type 3 effluent quality are provided in Table 2. Based on these estimates, for Type 2 effluent in the South Area, the average HLR based on soil type is **55 L/m^2/day** and based on soil permeability is **65 L/m^2/day**. The average HLRs for Type 2 effluent in the North Area are **50 L/m^2/day** and **64 L/m^2/day**, based on soil type and measured permeabilities, respectively.

For Type 3 effluent in the South Area, the average HLR based on soil type is **104 L/m^2/day** and based on soil permeability is **140 L/m^2/day**. The average HLRs for Type 3 effluent in the North Area are **94 L/m^2/day** and **115 L/m^2/day**, based on soil type and measured permeabilities, respectively.

Based on these findings and previous site investigation work, as shown in Figures 1 and 2, approximately 600 m^2 is available for infiltration in both the South and North Areas.

Therefore, assuming the maximum daily disposal volume for each area will be 22,000 L/day, for the South Area approximately **210 m²** will be required to dispose of Type 3 effluent and approximately **400 m²** will be needed to dispose of Type 2 effluent (Figure 2). Similarly, approximately **235 m²** will be needed to dispose of Type 3 effluent in the North Area, while about **440 m²** will be required to dispose of Type 2 effluent in this area (Figure 1).

Another key design guideline for OTDS is the minimum vertical separation (VS), also known as unsaturated soil thickness, between the infiltration area bottom and an underlying limiting layer. Per SPM Tables II-15 and II-16, the minimum VS for gravelly sand soils varies between 45 cm and 90 cm, depending on effluent quality and dosing method. Except for a thin (0.17 m) till layer encountered between 2.13 and 2.3 m bgs in TP-8, and bedrock present at 1.83 m bgs at TP-7, no limiting layers were encountered beneath the proposed north disposal area. The bedrock observed in TP-7 slopes steeply to the east, which corresponds to deeper bedrock further to the east in MW-1.

Sediment in the South Area thickens to the south with bedrock present at a relatively shallow depth in the north part of the South Area (TP-3 and 3a), and present at the ground surface further to the east. However, the test pit and boring data show the bedrock surface slopes steeply to the south and east below the southern part of the area and beneath the agricultural land to the south.

Except for bedrock encountered at 1.22 m bgs in TP-3a, and a thin layer of till in TP-3b at 1.03 m bgs and at 0.45 m bgs in TP-4, no near-surface impermeable barriers to downward effluent migration were encountered.

Another infiltration area design principle is to orient the dispersal field as perpendicular to ground slope as possible. As shown in Figure 1, this design principle can be met in the North Area, however the proposed property boundaries in the South Area will limit the ability to best orient the infiltration area. The bedrock surface beneath the South Area slopes both east and south, and most infiltrated effluent will flow to the south into sediments beneath the agricultural area. Effluent flow beneath the North Area should flow generally east along the top of bedrock with discharge into sediments beneath the rail trail.

An additional guideline is to limit potential effluent daylighting or breakout within 7.5 m of the infiltration boundary. Both proposed infiltration areas will meet this requirement. Although a sharp topographic break is situated downhill of the North Area and adjacent to the rail trail, the deep depth to bedrock, below the adjacent ground slope surface, indicates that effluent should not discharge from this slope.

Recommendations

Both proposed dispersal areas appear suited for long-term waste water infiltration. Several recommendations regarding site construction and layout can be provided:

- For both disposal areas, I suggest removal of all silty sand loam soil and low permeability sediments and replace with clean sand. Both areas have more permeable sediments at depth, so removing the shallower lower permeability materials will limit groundwater mounding and will improve infiltration capacity and effluent drainage.

- Further to this, the effluent flow pathways from the South Area are not exactly known but most effluent will travel south and some will flow east. I recommend removal of other lower permeability soil were encountered during site and residence construction east and below the infiltration area and ensure good drainage is present beneath all residences and roads.
- Ensure that all utility trenches are backfilled with lower permeability material; if this material is not available then install flow prevention dams in the trenches.
- All treatment plants and equipment should be located more than 30 m from lake high water, which is beyond the SSR criteria. In addition, the SPM stipulates that all tanks should be more than 10 m from Kalamalka Lake. Keeping all infrastructure beyond these setbacks will greatly simply IHA filing and review.

Discussion

Based on information provided by USL, effluent produced by the onsite treatment system will be of excellent quality with BOD_5 (5-day biological oxygen demand) and TSS (total suspended solids) concentrations at or better than 45 mg/L for Type 2 effluent, or at or better than 10 mg/L with fecal coliform concentrations below 400 CFU / 100 ml for Type 3 effluent (SPM V3, 2014).

Based on information provided in the SPM, the most important site feature that supports effective treatment of infiltrated effluent is the thickness of unsaturated soil. For both infiltration areas, the unsaturated zone is many meters thick. Normal operation of septic tank/subsurface infiltration systems results in retention and die-off of most, if not all, observed pathogenic bacterial pathogens within 60 to 90 centimeters of the infiltrative surface (US EPA, 2002). Fecal coliforms in the effluent will commonly bind to soil particles, fine-grained materials, and organic matter within the first meter or two from the surface (Brown, et al 1979). In addition, numerous studies have shown that coliforms do not survive longer than a few weeks in groundwater (Health Canada, 2006).

The most significant nutrient constituents in sewage effluent include nitrogen compounds including nitrate and phosphorus. Most phosphorus is retained in activated waste sludge and is effectively removed by settling and subsequent tank pumping. Phosphorus that is discharged to the environment is precipitated or adsorbed in soil, such that most to almost all discharged phosphorus is eliminated from effluent no more than a few meters from the infiltration area, even after years of effluent disposal (Scope, 2006).

Numerous studies have shown that depending on soil texture, structure and mineralogy; drainage and wetness; depth to a saturated zone and the degree to which it fluctuates; the amount of available organic carbon present; and infiltration system design and operation; nitrate concentrations in the receiving environment can be significantly reduced. The organic-rich soils such as those present beneath the infiltration area and along the lake shoreline along with dosing the effluent using timed cycles have been shown to reduce nitrate concentrations by as much as 60 to over 90 percent (Hazen and Sawyer, 2009).

Concentrations of other waste water constituents commonly decline due to aerobic and anaerobic biodegradation and by adsorption onto mineral surfaces in the unsaturated zone and in groundwater.

The proposed septic system's primary, treatment and dosing tanks will be constructed without seams joining the tank's sides and floor. This construction method will significantly minimize the potential for leakage. The only potential pathway for leaks would be from cracks through the tank wall or from piping connections, which are highly unlikely to occur under normal operating conditions.

Although the effluent will be disposed into moderately permeable sandy gravel sediment, the lack of groundwater beneath the infiltration areas and long travel path between the infiltration areas and the lake will result in additional subsurface treatment. The travel time for effluent to migrate from the infiltration area to the lake can be estimated using the relationship

Travel Time = D ÷ (K x I)) x N, where

Distance to lake (D) = ± 125 m (South Area), 25 m (North Area)
Soil hydraulic conductivity (K) = 1 X 10^{-5} m/sec (typical for med-grained permeability soils)
Hydraulic gradient (I) = 0.2 (20% slope between infiltration area and boundary)
Soil Porosity (N) = 0.25

This analysis demonstrates that the approximate travel time for the infiltrated effluent to reach the lake shoreline from the North Infiltration area will be over 36 days, and from the South Infiltration area will be over 180 days. This long travel time through unsaturated soil will further support effective natural biodegradation and attenuation of effluent constituents.

Conclusions

Based on the above data and analyses, it is my professional opinion that system construction and operation will not negatively affect water quality in Kalamalka Lake. The infiltration system's distance from the lake and thick unsaturated soil will protect the adjacent lake waters from negative impacts. In addition, proper system design and operation, appropriate site construction practices, effective onsite water and stormwater management practices, and good residential housekeeping practices should also minimize the potential for effluent to compromise downslope surface water quality.

Please be advised that I am a member in good standing in the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) and I am acting within my area of expertise. In preparing this analysis I have relied in good faith on information provided by others, the accuracy of which I cannot attest. This assessment has been completed in accordance with generally accepted engineering and environmental practice. Please note, no hydrogeological investigation can wholly eliminate uncertainty regarding the potential for unrecognized conditions in connection with an aquifer or subsurface materials.

Do not hesitate contact the undersigned if you have any questions or wish to discuss any aspect of this report.

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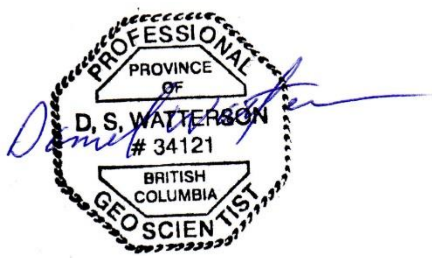

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Principal Hydrogeologist

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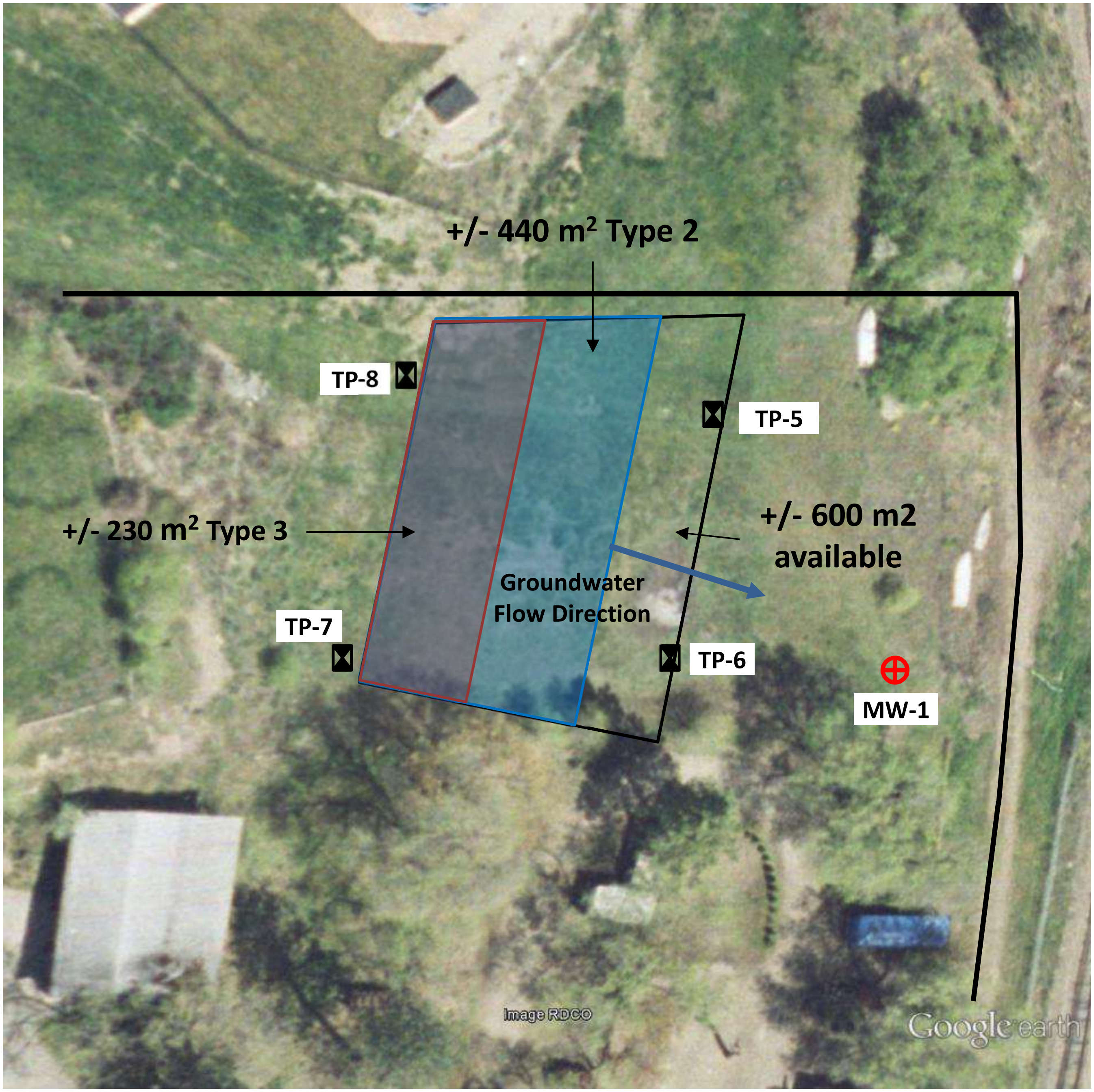
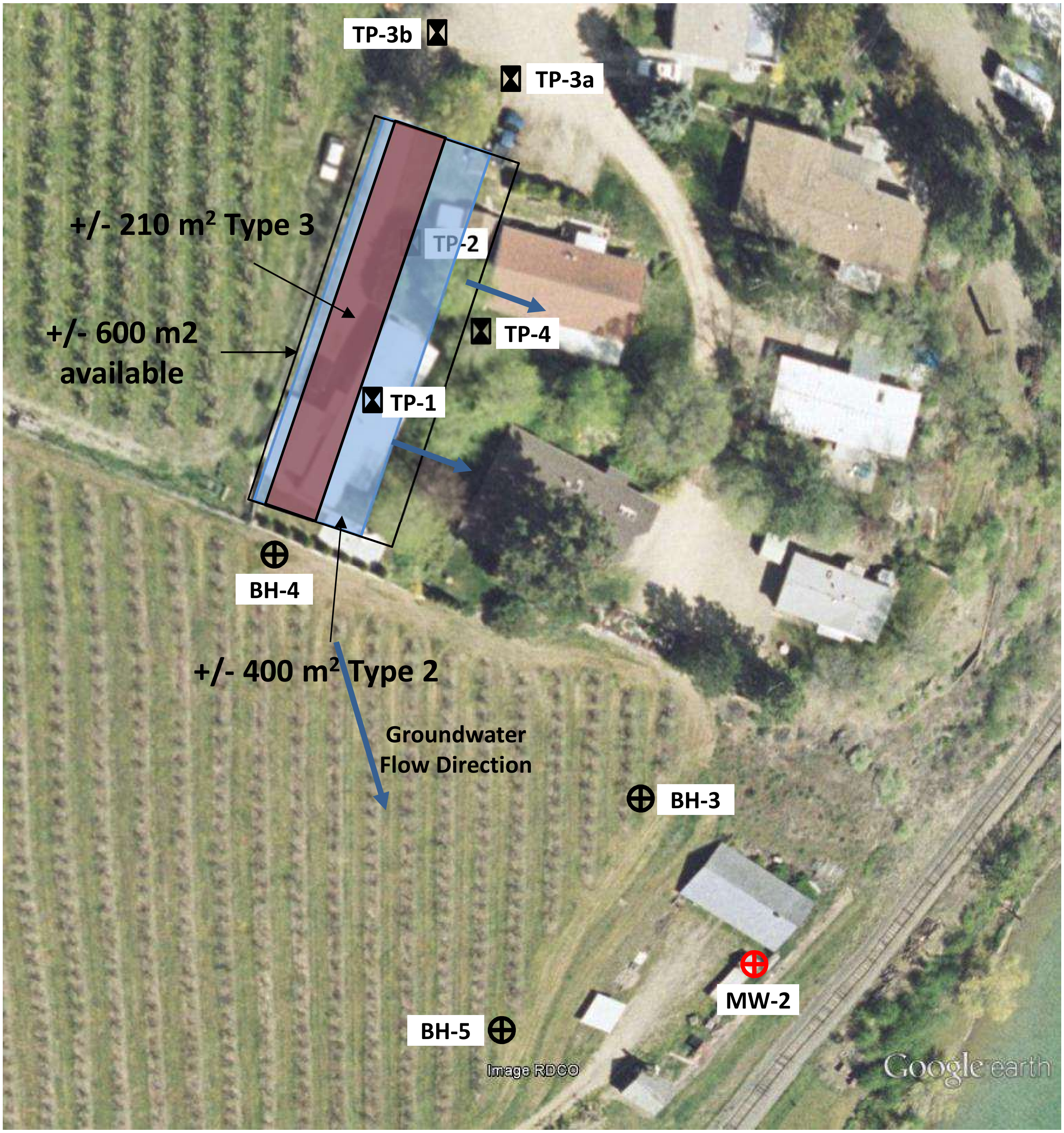


Watterson Geoscience Inc. Groundwater Consulting Services	Owls Nest Proposed Residential Subdivision	North Area – Test Pit and Monitoring Well Locations Available and Required Areas Project No. 18-004
Source: Central Okanagan Regional District Mapping	Client: Beaverbrook	Figure 1



Watterson Geoscience Inc. Groundwater Consulting Services	Owls Nest Proposed Residential Subdivision	South Area – Test Pit and Monitoring Well Locations Available and Required Areas Project No. 18-004
Source: Central Okanagan Regional District Mapping	Client: Beaverbrook	Figure 2

TABLE 1: TEST PIT LOGS

Test Pit No.	Soil Depth (m)	Soil Description	Notes / Observations	Permeameter Results (Kfs) mm/day	Percolation Test Results (min/inch)
TP-1	0 - 0.15	TOPSOIL; dark brown, abundant organics and roots, damp, firm, no structure, well graded	No mottling or groundwater seepage observed		
	0.15 - 1.22	GRAVELLY SILT LOAM (fill); dark brown, damp, firm to stiff, frequent small rootlets, some angular gravel and pebbles, weak to moderate blocky structure			
	1.22 - 2.13	GRAVELLY SAND; medium brown, damp, loose to compact, well graded, no structure, abundant gravel and pebbles, sand fining with depth; some sloughing			1.27
	2.13 - 3.96	SAND; medium brown, damp, compact to dense, no structure, well graded, one (1) large diameter root at 2.44 m			
TP-2	0 - 0.10	TOPSOIL; organic litter, dark brown, roots	No groundwater seepage observed		
	0.10 - 0.70	GRAVELLY SILT LOAM; dark brown, damp, firm to stiff, frequent small rootlets, some angular gravel and pebbles, weak to moderate blocky structure, slight red-brown mottling			
	0.70 - 1.83	SANDY GRAVEL; light brown, damp, compact, no structure, well graded, abundant angular pebbles, some small rootlets at 1.52 m			0.95
	1.83 - 3.35	GRAVELLY SAND; medium brown, damp, compact, well graded, no structure, abundant gravel and pebbles, sand fining with depth			
	3.35-3.96	CLAY; grey, moist, firm			
TP-3a	0 - 0.10	TOPSOIL; organic litter, dark brown, roots	No mottling or groundwater seepage observed		
	0.10 - 0.3	SANDY LOAM; yellowish brown, loose, damp, well graded, some roots			
	0.3 - 0.7	SILT LOAM; medium brown, some fine grained sand, firm to stiff, damp, weak blocky structure, some roots			
	0.7-1.05	AS ABOVE; light brown, increasing density with depth,			
	1.05 - 1.37	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles			
	1.22-1.52	BEDROCK; drastic slope towards southeast			
TP-3b	0 - 0.10	CRUSHED GRAVEL; grey, sandy, silty, damp, compact	No mottling or groundwater seepage observed		
	0.10 - 0.40	ORGANICS; dark brown, sandy, silty, organics, damp, firm			
	0.40 - 1.05	GRAVELLY SILT LOAM; medium brown, firm to stiff, damp, weak blocky structure, some angular gravel and pebbles, some small to medium sized roots		1785	
	1.05 - 1.22	TILL; grey, pebble, sand, silt, and clay cemented			
	1.22 - 2.44	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
	2.44	BEDROCK			
TP-4	0 - 0.15	TOPSOIL; dark brown, abundant organics and roots, damp, firm, no structure, well graded	No mottling or groundwater seepage observed		
	0.15 - 0.45	SANDY LOAM; medium brown, compact, damp, weak blocky structure, some angular gravel, abundant roots			
	0.45 - 0.61	TILL; light brown, cemented pebble, gravel, sand, and silt			
	0.61 - 1.22	GRAVELLY LOAM; medium brown, firm to stiff, damp, weak blocky structure, some angular gravel and pebbles, some roots			13.7
	1.22 - 1.52	TILL; light brown, hard, damp, primarily gravel and pebbles, some silt and sand, trace clay, no structure			
	1.52 - 2.13	SANDY CLAY LOAM; medium brown, firm to stiff, damp, weak blocky structure, trace angular gravel			
	2.13 - 3.05	GRAVELLY SAND; light brown, loose to compact, damp, coarse sand fining with depth, abundant angular gravel and cobbles; minor sloughing			
	3.05 - 4.27	SAND; light brown, compact, damp, medium to fine grained, trace angular gravel and cobble			
TP-5	0 - 0.45	ORGANICS; dark brown, sandy, silty, organics, damp, firm	No mottling or groundwater seepage observed		
	0.45 - 1.22	GRAVELLY SILT LOAM; light brown, soft to firm, damp, moderate blocky structure, some angular gravel		1895	
	1.22 - 3.96	VERY GRAVELLY SAND; medium brown, damp, loose to compact, well graded, no structure, abundant gravel and pebbles; minor sloughing			
TP-6	0 - 0.45	ORGANICS; dark brown, silty, organics, damp, firm, abundant roots	No mottling or groundwater seepage observed		
	0.45 - 0.75	GRAVELLY LOAM; light brown, firm to stiff, damp, weak blocky structure, some angular gravel		3207	
	0.75 - 3.66	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
TP-7	0 - 0.45	ORGANICS; dark brown, sandy, silty, organics, damp, firm	No mottling or groundwater seepage observed		
	0.45 - 1.22	GRAVELLY SILT LOAM; light brown, firm, damp, moderate blocky structure, some angular gravel and pebbles, some roots			2.54
	1.22 - 1.83	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			
	1.83 - 3.35	BEDROCK; drastic slope eastwards towards Kalamalka Lake			
TP-8	0 - 0.30	ORGANICS; dark brown, silty, organics, damp, firm, abundant roots	No mottling or groundwater seepage observed		
	0.30 - 0.90	GRAVELLY SILT LOAM; light brown, firm, damp, moderate blocky structure, some angular gravel and pebbles, some roots		2216	
	0.90 - 1.35	SANDY GRAVEL; light brown, damp, loose, no structure, well graded, abundant angular pebbles; notable sloughing			0.07
	1.35 -1.83	GRAVELLY SAND; medium brown, damp, compact, well graded, no structure, abundant gravel and pebbles decreasing with depth, some fine to medium grained sand lenses, some silt			
	1.83 - 2.13	GRAVELLY SANDY LOAM; medium brown, damp, firm, some gravel and pebbles			
	2.13 - 2.30	TILL; grey, pebble, sand, silt and clay cemented			
	2.30 - 3.96	SANDY GRAVEL; light brown, damp, loose to compact, no structure, well graded, abundant angular pebbles; notable sloughing			

TABLE 2: SOIL CHARACTERISTICS AND HLR VALUES

South Area - Maxiumum Allowable HLR Assuming Type 3 System						
Location	**Soil Type (Texture)**	**Depth (m bgs)**	**Consitency and Structure**	**Favourability**	**Max HLR based on Table II-22[a] (L/day/m^2)**	**Max HLR based on Table II-23[b] (L/day/m^2)**
TP-1	Gravelly Sand	1.22 - 2.13	Loose to Compact, Structureless	F	130	130
TP-1	Sand	2.13 - 3.96	Compact to Dense, Structureless	P	80	-
TP-2	Sandy Gravel / Gravelly Sand	0.70-1.83	Compact, Structureless	P	150	150
TP-2	Gravelly Sand	1.83-3.35	Compact, Structureless	P	120	-
TP-3b	Sandy Gravel / Gravelly Sand	1.22-2.44	Loose to Compact, Structureless	F	150	-
TP-4	Gravelly Loam	0.61-1.22	Firm to Stiff, Weak Blocky	VP	35	80
TP-4	Sandy Clay Loam	1.52-2.13	Firm to Stiff, Weak Blocky	VP	NA	-
TP-4	Gravelly Sand	2.13-3.05	Loose to Compact, Structureless	F	130	-
AVERAGE HLR Test Pits 1 - 4					**104**	**140**
South Area - Maxiumum Allowable HLR Assuming Type 2 System						
Location	**Soil Type**	**Depth (m bgs)**	**Consitency and Structure**	**Favourability**	**Max HLR based on Table II-22[a] (L/day/m^2)**	**Max HLR based on Table II-23[b] (L/day/m^2)**
TP-1	Gravelly Sand	1.22 - 2.13	Loose to Compact, Structureless	F	65	65
TP-1	Sand	2.13 - 3.96	Compact to Dense, Structureless	P	50	-
TP-2	Sandy Gravel / Gravelly Sand	0.70-1.83	Compact, Structureless	P	65	65
TP-2	Gravelly Sand	1.83-3.35	Compact, Structureless	P	65	-
TP-3b	Sandy Gravel / Gravelly Sand	1.22-2.44	Loose to Compact, Structureless	F	65	-
TP-4	Gravelly Loam	0.61-1.22	Firm to Stiff, Weak Blocky	VP	25	50
TP-4	Sandy Clay Loam	1.52-2.13	Firm to Stiff, Weak Blocky	VP	NA	-
TP-4	Gravelly Sand	2.13-3.05	Loose to Compact, Structureless	F	65	-
AVERAGE HLR Test Pits 1 - 4					**55**	**65**
North Area - Maxiumum Allowable HLR Assuming Type 3 System						
TP-5	Gravelly Silt Loam	0.45-1.22	Soft to Firm, Moderate Blocky	F	70	90
TP-5	Very Gravelly Sand	1.22-3.96	Loose to Compact, Structureless	F	150	150
TP-6	Gravelly Loam	0.45-0.75	Firm to Stiff, Weak Blocky	VP	35	100
TP-6	Sandy Gravel / Gravelly Sand	0.75-3.66	Loose to Compact, Structureless	F	150	-
TP-7	Gravelly Silt Loam	250	Firm, Moderate Blocky	P	50	100
TP-7	Sandy Gravel / Gravelly Sand	1.22-1.83	Loose to Compact, Structureless	F	150	150
TP-8	Gravelly Silt Loam	0.30-0.90	Firm, Moderate Blocky	P	50	90
TP-8	Sandy Gravel / Gravelly Sand	0.90 -1.35	Loose, Structureless	F	150	150
TP-8	Gravelly Sand	1.35-1.83	Compact, Structureless	P	120	-
TP-8	Sandy Gravel / Gravelly Sand	2.30 - 3.96	Loose to Compact, Structureless	F	150	-
AVERAGE HLR Test Pits 5 - 8					**94**	**115**
North Area - Maxiumum Allowable HLR Assuming Type 2 System						
TP-5	Gravelly Silt Loam	0.45-1.22	Soft to Firm, Moderate Blocky	F	60	60
TP-5	Very Gravelly Sand	1.22-3.96	Loose to Compact, Structureless	F	65	65
TP-6	Gravelly Loam	0.45-0.75	Firm to Stiff, Weak Blocky	VP	25	65
TP-6	Sandy Gravel / Gravelly Sand	0.75-3.66	Loose to Compact, Structureless	F	65	-
TP-7	Gravelly Silt Loam	0.45 - 1.22	Firm, Moderate Blocky	P	30	65
TP-7	Sandy Gravel / Gravelly Sand	1.22-1.83	Loose to Compact, Structureless	F	65	65
TP-8	Gravelly Silt Loam	0.30-0.90	Firm, Moderate Blocky	P	30	60
TP-8	Sandy Gravel / Gravelly Sand	0.90 -1.35	Loose, Structureless	F	65	65
TP-8	Gravelly Sand	1.35-2.30	Compact, Structureless	P	65	-
TP-8	Sandy Gravel / Gravelly Sand	2.30 - 3.96	Loose to Compact, Structureless	F	65	-
AVERAGE HLR Test Pits 5 - 8					**50**	**64**

Note: bolded Max HLRs represent the more conservative estimate, as per Section II-5.5 of the SPM Version 3

Shaded - Max allowable HLR for gravelly loams and silt loams are liklely higher than values assigned to loams and silt loams in Table II-22

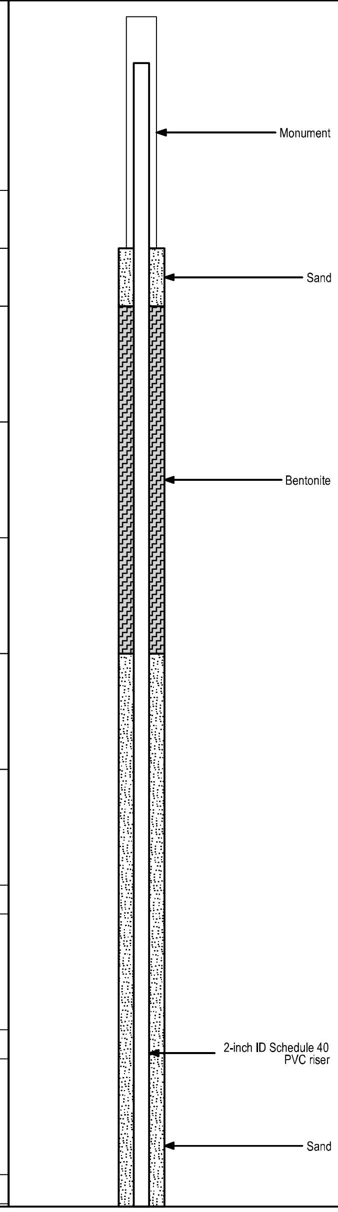
a - HLR based on soil type

b - HLR based on permeability

FIELD REP Mike Schutten	COMPLETION DATE: 12/12/2017	Watterson Geoscience Inc. Groundwater Consulting Services
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 403.07	
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl) 403.67	
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)	
HOLE DIAMETER (CM): 10.2	Northing 5554959.00 Easting 329782.00	
WATER ELEVATION (masl):		

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID
GROUND SURFACE	0			
ORGANICS; dark brown, sandy, silty, organics, damp, firm				SS 1A
GRAVELLY SILT LOAM; light brown, damp, firm				SS 1B
GRAVELLY SAND; brown, damp, very loose, well graded	1			SS 3
SANDY GRAVEL; brown, damp, loose, well graded				SS 3
	2			SS 4
				SS 5
	3			SS 6
	4			SS 7
	5			SS 8

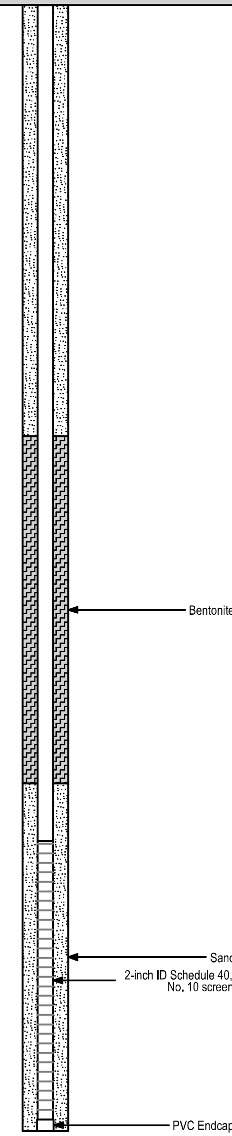
WELL CONSTRUCTION



CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW1	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 2
		Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID
SANDY GRAVEL; brown, damp, loose, well graded	6, 7, 8			SS 9, SS 10, SS 11, SS 12
SANDY GRAVEL; brown, moist, loose, well graded	9, 10			SS 13, SS 14, SS 15
BEDROCK	11			
	12, 13			

WELL CONSTRUCTION



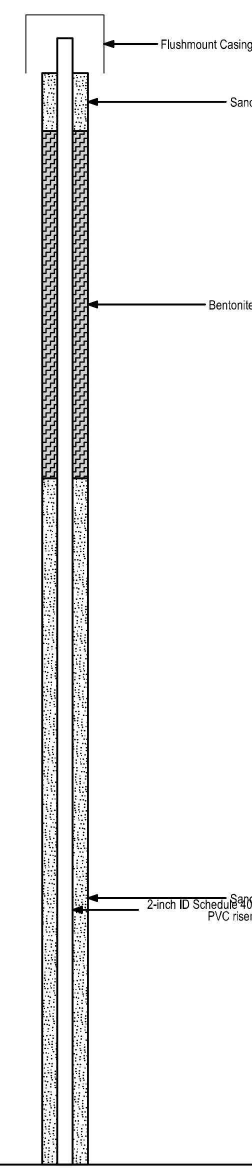
CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW1	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 2 of 2 Issued:

FIELD REP Mike Schutten	COMPLETION DATE: 12/12/2017
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 399.00
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl) 398.90
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)
HOLE DIAMETER (CM): 10.2	Northing 5554752.00 Easting 329642.00
WATER ELEVATION (masl): 390.30	

Watterson Geoscience Inc.
Groundwater Consulting Services

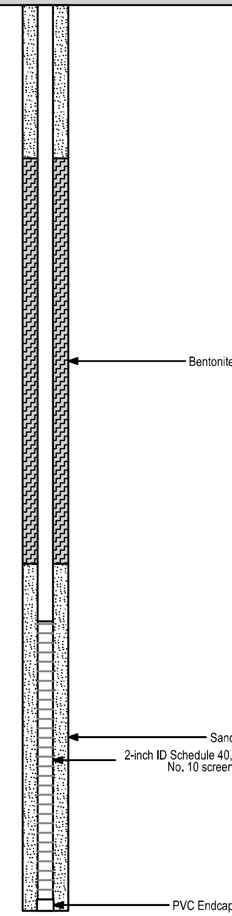
SOIL DESCRIPTION	DEPTH (m)	SAMPLE ID
GROUND SURFACE		
ORGANICS; dark brown, sandy, gravelly, silty, organics, damp, loose	0	SS 1
GRAVELLY SANDY LOAM (fill); brown, damp, firm	1	SS 2
GRAVELLY SILT LOAM; brown, damp, firm		SS 3A
GRAVELLY SILT and CLAY; brown, damp, firm, trace sand	2	SS 3B, SS 4
SANDY GRAVEL; brown, moist, loose, well graded, oxidation at 3.50 m bgs	3, 4, 5	SS 5, SS 6, SS 7, SS 8

WELL CONSTRUCTION



CLIENT: Beaverbrook Developments	LOG & RECORD OF WELL CONSTRUCTION MW2	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 2 Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	WELL CONSTRUCTION
SANDY GRAVEL; brown, moist, loose, well graded, oxidation at 3.50 m bgs	7 8			SS 9 SS 10 SS 11	
SANDY GRAVEL; brown, wet, loose, well graded, thin fine grained sand lenses from 9.3 to 10 m bgs, strongly heaving	9 10			SS 12 SS 13	
	11 12 13				



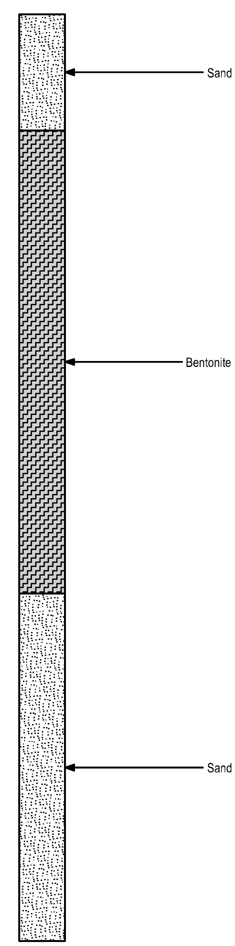
CLIENT:	LOG & RECORD OF WELL CONSTRUCTION MW2	WGI Job No. 18-004
Beaverbrook Developments	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 2 of 2 Issued:

FIELD REP Mike Schutten	COMPLETION DATE: 12/13/2017
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 403.00
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl)
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)
HOLE DIAMETER (CM): 10.2	Northing 5554776.00 Easting 329634.00
WATER ELEVATION (masl):	

Watterson Geoscience Inc.
Groundwater Consulting Services

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID
GROUND SURFACE				
GRAVELLY SILT LOAM; light brown, moist, firm	0			SS 1
GRAVELLY SILT LOAM; light brown, damp, stiff				SS 2A
GRAVELLY SILT LOAM; light brown, damp, very stiff	1			SS 2B
SAND; brown, damp, loose, well graded, some gravel, trace silt	2			SS 3
				SS 4
BEDROCK				

BOREHOLE BACKFILL



CLIENT:	LOG & RECORD OF BOREHOLE BH3	WGI Job No. 18-004
Beaverbrook Developments	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 1 Issued:

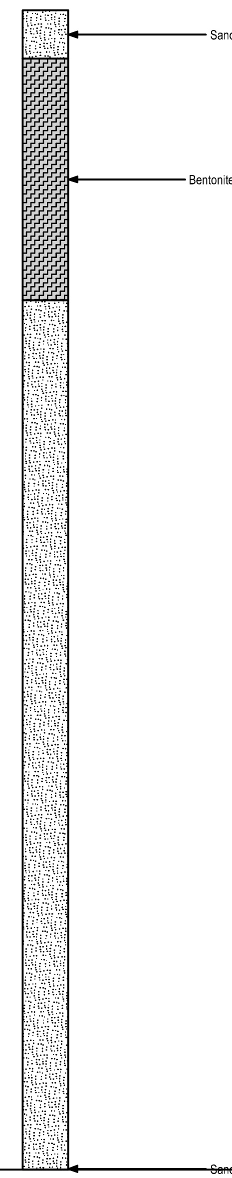
FIELD REP Mike Schutten	COMPLETION DATE: 12/13/2017
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 414.85
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl)
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)
HOLE DIAMETER (CM): 10.2	Northing 5554813.00 Easting 329599.00
WATER ELEVATION (masl):	

Watterson Geoscience Inc.
Groundwater Consulting Services

SOIL DESCRIPTION	SAMPLE ID
GROUND SURFACE	
GRAVELLY SILT LOAM; dark brown, damp, firm, some organics	SS 1A
GRAVELLY SAND; brown, damp, loose, well graded	SS 1B
GRAVELLY SAND; light brown, damp, loose, well graded, gravel size increasing with depth - generally larger than 1 cm diameter	SS 2
GRAVELLY SAND; light brown, damp, loose, well graded, coarse sand content increasing with depth	SS 3
GRAVELLY SAND; light brown, damp, loose, well graded	SS 4 SS 5 SS 6
Same as above, with increased moisture content	SS 7 SS 8 SS 9 SS 10

DEPTH (m): 0, 1, 2, 3, 4, 5, 6, 7

BOREHOLE BACKFILL



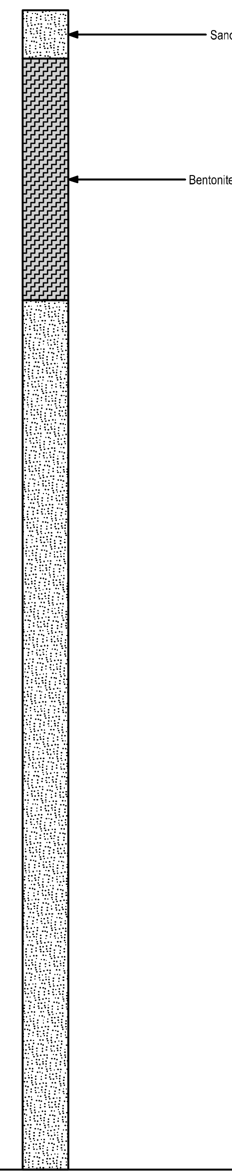
CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH4 BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	WGI Job No. 18-004 Page 1 of 2 Issued:

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
Same as above, with increased moisture content	8 – 9			SS 10 SS 11 SS 12	
Same as above, with decreased gravel diameter - generally less than 1 cm.	10			SS 13 SS 14A	
SAND; brown, moist to wet, moderately dense, some gravel - decreasing gravel content with depth, fining of sand with depth	11 – 12			SS 14B SS 15 SS 16	
CLAY; bluish grey, moist, firm, some silt				SS 17A	
SAND; brown, moist, loose, fine grained, highly oxidized,				SS 17B	
BEDROCK	13				
	14				
	15				
	16				

CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH4 BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	WGI Job No. 18-004 Page 2 of 2 Issued:

FIELD REP Mike Schutten	COMPLETION DATE: 12/13/2017	Watterson Geoscience Inc. Groundwater Consulting Services
DRILLING COMPANY: On The Mark	GROUND SURFACE ELEV (masl) 402.00	
DRILLING RIG: B-57 Truck Mount	TOP OF RISER ELEV (masl)	
DRILLING METHOD: ODEX	UTM COORDINATES (NAD 1983 11N)	
HOLE DIAMETER (CM): 10.2	Northing 5554746.00 Easting 329610.00	
WATER ELEVATION (masl):		

SOIL DESCRIPTION	DEPTH (m)	LITHOLOGY	SAMPLE	SAMPLE ID	BOREHOLE BACKFILL
GROUND SURFACE					
GRAVELLY SILT LOAM; dark brown, damp, stiff, some organics	0			SS 1	
GRAVELLY SAND; light brown, dry, loose, well graded	1				
	2			SS 2	
	3			SS 3	
	4				
GRAVELLY SAND; brown, damp, moderately dense, well graded, oxidation from 4.6 to 5.0 m bgs	5			SS 4	
	6			SS 5	
	7				



CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH5	WGI Job No. 18-004
	BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	Page 1 of 2
		Issued:

SOIL DESCRIPTION

SOIL DESCRIPTION	SAMPLE ID
GRAVELLY SAND; brown, damp, moderately dense, well graded, oxidation from 4.6 to 5.0 m bgs	
GRAVELLY SAND; light brown, damp, moderately dense, well graded, increased gravel diameter (1-2 cm)	SS 6 SS 7
GRAVELLY SAND; brown, wet, moderately dense, trace silt, heaving sand and gravel fining with depth	SS 8 SS 9
SANDY GRAVEL; dark brown, wet, moderately dense, well graded	SS 10
GRAVEL; grey, wet, moderately dense, some pebble, some sand	SS 11

DEPTH (m): 8, 9, 10, 11, 12, 13, 14, 15, 16

LITHOLOGY

SAMPLE

BOREHOLE BACKFILL

Sand

CLIENT: Beaverbrook Developments	LOG & RECORD OF BOREHOLE BH5 BC SSR and IHA Hydrogeological Assessment Owls' Nest Property, Oyama, BC	WGI Job No. 18-004 Page 2 of 2 Issued:

TECHNICAL MEMO

TO:	Mr. Jesse LaFrance, BBA Beaverbrook Communities Mr. Paul Dupuis District of Lake Country	**DATE:**	July 24, 2018
FROM:	Daniel Watterson, P.Geo.		
WGI Project No.	18-004		
SUBJECT:	**Owls Nest Residential Development: Onsite Treatment and Disposal System Comparison – Old vs Proposed New Systems**		

INTRODUCTION

In accordance with your request, Watterson Geoscience Inc. (WGI) is pleased to complete an assessment of historic and proposed onsite treatment and disposal system (OTDS) characteristics and performance. The purpose of this assessment is to demonstrate the significant improvements in effluent quality with subsequent reduced effects impacts on lake water quality from operation of the proposed new OTDS.

DESCRIPTION OF OLD SYSTEM

Available information regarding the Owl's Nest Resort and Marina history and occupancy is summarized below. Property use information was provided by Mr. Dean Bauman, and estimated effluent production rates for the various resort facilities were obtained from the BC Standard Practice Manual, Version 3 (SPM) and the US EPA Design Manual (SPM V3, 2014, EPA, 2002).

Owl's Nest Resort Units	Estimated Daily Flows	Occupancy
Seven (7) modular houses and one (1) stick-built house	1,300 L/day (based on 3 bedrooms each)	Year-round
Thirty-two (32) Full Connection Camping Sites	170 L/day	50% May 25% June 90% occupancy July and August 50% September
Thirty-eight (38) Camping Sites with No Connections	180 to 360 L/day	
Four-unit Motel with Laundry Room	250 to 400 L/day/unit	
Office / Concession Stand	50 to 75 L/day	

- All effluent was collected and routed to the treatment and dispersal area, located in the northeast corner of the property.
- The original effluent treatment and disposal system included three (3) tanks in series, installed in the 1960's.
- The tanks included one 600 gal tank, one 2,500 gal and a 500-gal pump chamber.

- A new 3000- gal tank was installed in md-1980's.
- All tanks were constructed of concrete.
- The original dispersal field was installed in a flat area adjacent to lake approximately 50 m from the lake High Water Mark.
- The original field was renovated in 1984 due to continued failure (effluent daylighting). The original field and poor soils were removed and a new field was installed into one (1) m gravel emplaced in same area. No infiltration issues were noted since then.
- Effluent drained by gravity from the development to the tanks, and then pumped to the dispersal field using pressure distribution.
- The main effluent tank was pumped every year.

DESCRIPTION OF NEW SYSTEM

This design summary is based on information provided by Mr. Jeff Oland, P.Eng. and by Beaverbrook:

- WGI understands that at the time of this letter, 43 residences and an amenity building are proposed for construction at the property.
- Domestic wastewater from the residences will be treated and disposed using two separate OTDS with one servicing the north end while the other servicing the south end.
- WGI understands the estimated maximum daily flows for each system will be 21 m^3/day and 22 m^3/day, respectively.
- Based on these flows, the systems will be designed, operated and maintained in accordance with the BC Sewerage System Regulation.
- The OTDS will be constructed using package treatment plants with nitrate reduction and disinfection. Effluent will be dispersed into laterals in trenches.
- The northern dispersal area will be situated approximately 60 m from the lake HWM in the northeast part of the property, and the southern dispersal area will be situated approximately 100 m from the HWM in the southwest part of the property.

EFFLUENT QUALITY COMPARISON

When in good operating order, effluent produced by the historic onsite treatment system was of good quality (Type 1) with BOD_5 (5-day biological oxygen demand) concentrations ranging between 150 and 300 mg/L, and TSS (total suspended solids) concentrations ranging between 50 and 80 mg/L or less (SPM V3, 2014). Bacteria concentrations, including total and fecal coliforms, commonly ranged around 1 X 10^6 CFU/100 mL.

Domestic effluent produced by the historic system also contained total nitrogen compounds at concentrations commonly ranging between 40 and 100 mg/L and nitrates at concentrations ranging between 20 and 100 mg/L. Phosphorus at concentrations ranging between about 5 to 15 mg/L was also present in the effluent.

The proposed OTDS will produce Type 3 quality effluent, defined in the SPM as effluent containing BOD_5 and TSS concentrations less than 10 mg/L, and fecal coliform concentrations less than 400 CFU/100 mL.

In addition, the Type 3 OTDS proposed for the community will include systems to reduce nitrate concentrations in the effluent and disinfection to reduce effluent pathogen concentrations. The systems are expected to produce effluent with nitrate at less than 10 mg/L and fecal coliform concentrations to less than the Type 3 SSR requirement. The systems will produce phosphorus at concentrations similar to the historic system.

LOADING TO LAKE COMPARISON

The quantity of each parameter that eventually could discharge to the lake from the historic and proposed systems was estimated by first estimating daily and annual flows for each source of effluent and then multiplying this volume by the estimated concentrations for each parameter. Estimated flows and load quantities are summarized below

Parameter	Old System Low[1]	Old System High[1]	New Systems
Estimated Annual Flow	5,140 m^3	5,842 m^3	15,695 m^3
BOD_5	771	1756	157 kg
TSS	257	468	157 kg
Total Nitrogen	206	585	471 kg
Nitrates	103	585	157 kg
Phosphorus	26	88	78 kg

1 – High and low estimates based on flow and concentration ranges provided in the SPM and EPA

Detailed calculation tables are attached.

DISCUSSION AND CONCLUSION

In general, published studies and treatment plant manufacturer specifications demonstrate that operation of a Type 3 system compared to a Type 1 system, for a given volume of effluent, will reduce BOD_5 concentrations by over 90%, TSS by 75 to 80%, nitrogen compounds by 25 to 70%, nitrates by 50 to 90% and pathogens by over six orders of magnitude. These literature review findings are supported by this assessment. Although the estimated annual flows from the proposed system will be almost three (3) times the estimated historic flows, all estimated parameter loading quantities will be less than the highest estimated loadings, and BOD_5 and TSS will be below than the lowest estimated historic loadings.

The only new system parameter which approaches the historic loading rate is phosphorus. Type 3 OTDS do not significantly remove more phosphorus from effluent compared to Type 1 systems. However, most phosphorus in both types of systems is retained in activated waste sludge and is effectively removed by settling and subsequent tank pumping. The remaining phosphorus that is discharged into the dispersal field is rapidly removed by adsorption and precipitation in the underlying sand and gravel sediments, even after years of effluent disposal, as shown by work completed by Zanini et al. (1998) and Ptacek (1998).

The original system was installed in poor soil followed by gravel on flat land not far from the lake. This location limited the vertical separation distance and unsaturated soil thickness. At times of high lake elevation, this reduced distance may have contributed to increased phosphorus loading to the lake. In contrast, phosphorus loading to the lake from the proposed systems will be greatly reduced because of the increased underlying soil thickness and increased distance from the lake.

In addition, the new system will offer numerous other advantages and improvements compared to the old system:

- The old system included other potential contaminants in the historic waste water such as fats and grease from the snack shop and concentrated chemicals from RV holding tanks, as these were not required to be empty prior to connecting to the resort system. These parameters likely significantly reduced the system effectiveness. These parameters will not be included in the new systems' effluent stream.
- In general, Type 1 systems have an effective life of approximately 30 years before needing replacement, even if working perfectly. Unfortunately, the historic system's lifetime expired +/- 15 years ago and system performance has likely degraded since then. In contrast, new treatment plant OTDS are designed to operate and perform well indefinitely.
- Although information provided by Mr. Bauman indicated the historic system functioned well, no information regarding how competently the old system was designed, installed or maintained is available. Further, essentially no regulatory requirements were in effect for the old system.
- The new system will be designed, constructed and maintained to significantly higher and more detailed and comprehensive regulatory, design criteria and maintenance standards. The sewerage system design engineer is required, under his license, to follow a design process and set of standards for a Type 3 system. Development of the operating plan is part of that process and will become part of the system certification. The operating plan thus becomes enforceable under the Health Regulation.
- It is unlikely the new system will operate continuously at full capacity thus the actual parameter loading to the lake will be less than estimated above.

CLOSURE

Please be advised that I am a member in good standing in the Professional Engineers and Geoscientists of British Columbia (EGBC) and I am acting within my area of expertise. In preparing this analysis I have relied in good faith on information provided by others, the accuracy of which I cannot attest. This assessment has been completed in accordance with generally accepted engineering and environmental

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practice. Please note, no hydrogeological investigation can wholly eliminate uncertainty regarding the potential for unrecognized conditions in connection with an aquifer or subsurface materials.

Do not hesitate contact the undersigned if you have any questions or wish to discuss any aspect of this report.

Watterson Geoscience Inc.

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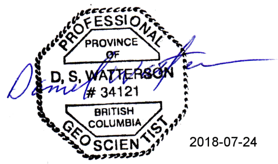
Principal Hydrogeologist



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HISTORIC OTDS DAILY FLOWS AND LOADING

Permanent Residences[1]	L/day per SPM			Jan	Feb	Mar	April	May		June		July		Aug		Sept		Oct	Nov	Dec
Houses (8 X 1300 L/day)	10,400			10,400	10,400	10,400	10,400	10,400		10,400		10,400		10,400		10,400		10,400	10,400	10,400
Seasonal Residences and Occupancy[2]								***50%***		***25%***		***90%***		***90%***		***50%***				
Full Connection Camp Sites (32 @ 170 L/day each)	6,460							3,230		1,615		5,814		5,814		3,230				
No Connection Camp Sites (38 @ 180-360 L/day each)	6,840	13,680						3,420	6,840	1,710	3420	6,156	12312	6,156	12,312	3420	6,840			
Motel (4 units @ 250-400 L/day each)	1,000	1,600						500	800	250	400	900	1440	900	1,440	500	800			
Office/Concession Stand (50-75 L/day)	50	75						25	37.5	13	18.75	45	67.5	45	68	25	38			
Total Daily Flows (Liters)				**10,400**	**10,400**	**10,400**	**10,400**	**17,575**	**21,308**	**13,988**	**15,854**	**23,315**	**30,034**	**23,315**	**30,034**	**17,575**	**21,308**	**10,400**	**10,400**	**10,400**
Total Montly Flow				322,400	291,200	322,400	312,000	544,825	660,533	419,625	475,613	722,765	931,039	722,765	931,039	527,250	639,225	322,400	312,000	322,400
Est. Annual Flow Range	**5,142,030**	**Liters**	**5,842,247 Liters**																	
	5142	**m³**	**5842 m³**																	

Typical Type 1 Effluent Parameter Ranges (mg/L)[3]	gms/L		Jan		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec	
BOD5 (150 - 300)	0.15	0.3	1,560	3,120	1,560	3,120	1,560	3,120	1,560	3,120	2,636	6,392	2,098	4,756	3,497	9,010	3,497	9,010	2,636	6,392	1,560	3,120	1,560	3,120	1,560	3,120
TSS (50 - 80)	0.05	0.08	520	832	520	832	520	832	520	832	879	1,705	699	1,268	1,166	2,403	1,166	2,403	879	1,705	520	832	520	832	520	832
Total Nitrogen (40 - 100)	0.04	0.1	416	1,040	416	1,040	416	1,040	416	1,040	703	2,131	560	1,585	933	3,003	933	3,003	703	2,131	416	1,040	416	1,040	416	1,040
Nitrates (20 -100)	0.02	0.1	208	1,040	208	1,040	208	1,040	208	1,040	352	2,131	280	1,585	466	3,003	466	3,003	352	2,131	208	1,040	208	1,040	208	1,040
Phosphorus (5 - 15)	0.005	0.015	52	156	52	156	52	156	52	156	88	320	70	238	117	451	117	451	88	320	52	156	52	156	52	156

HISTORIC OTDS ANNUAL LOADING	Low		High		Low		High	
BOD5	771305	gms	1755794	gms	**771**	**kg**	**1756**	**kg**
TSS	257102	gms	468212	gms	**257**	**kg**	**468**	**kg**
Total Nitrogen	205681	gms	585265	gms	**206**	**kg**	**585**	**kg**
Nitrates	102841	gms	585265	gms	**103**	**kg**	**585**	**kg**
Phosphorus	25710	gms	87790	gms	**26**	**kg**	**88**	**kg**

1 - From SPM V3, 2014

2 - From Dean Bauman

3 - From SPM V3, 2014 and EPA Design Manual, 2002

PROPOSED NEW SYSTEM FLOWS and ESTIMATED LOADINGS

North Field	21,000 L/day	7665000 L/year	**7665**	**m^3/Year**
South Field	22,000 L/day	8030000 L/year	**8030**	**m^3/Year**
Total Annual Flow		15695000 L/year	**15695**	**m^3/Year**

Proposed Systems Daily Loading			
Typical Type 3 Parameter Loading (mg/L)	**gms/L**	**North Field/Day**	**South Field/Day**
BOD5 (10)	0.01	210	220
TSS (10)	0.01	210	220
Total Nitrogen (30)	0.03	630	660
Nitrates with Nitrate Reduction (10)	0.01	210	220
Phosphorus (5 - 15)	0.005	105	110

Proposed System Annual Loading (Grams)	**North Field / Year**	**South Field / Year**	**Total /Year**			
BOD5	76,650	80,300	156950	gms	**157**	**kg**
TSS	76,650	80,300	156950	gms	**157**	**kg**
Total Nitrogen	229,950	240,900	470850	gms	**471**	**kg**
Nitrates with Nitrate Reduction	76,650	80,300	156950	gms	**157**	**kg**
Phosphorus	38,325	40,150	78475	gms	**78**	**kg**