

REGIONAL DISTRICT OF CENTRAL OKANAGAN

KILLINEY BEACH AND WESTSHORE ESTATES WATER SYSTEMS STUDY: SUMMARY AND EVALUATION OF SUPPLY AND TREATMENT OPTIONS (REV.5)

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DATE: JUNE 15, 2022

FILE:

1179.0109.01

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 3

1.1 BACKGROUND 3

1.2 OBJECTIVE 4

1.3 ORGANIZATION OF DOCUMENT 4

2.0 SUMMARY OF PAST RECOMMENDATIONS 4

2.1 GENERAL RECOMMENDATIONS 6

2.2 OPTION 1A: FINTRY/SHORTS CREEK GROUNDWATER SUPPLY WELL (SUBMARINE TRANSMISSION MAIN) 7

2.3 OPTION 1B: FINTRY/SHORTS CREEK GROUNDWATER SUPPLY WELL (OVERLAND TRANSMISSION MAIN) 8

2.4 OPTION 2A: INDEPENDENT INTAKES AND WTP'S FOR KILLINEY AND WESTSHORE 9

2.5 OPTION 2B: INDEPENDENT INTAKES AND DISINFECTION FOR KILLINEY AND WESTSHORE IN THE NEAR TERM; COMMON INTAKE AND FILTRATION WTP FOR BOTH SYSTEMS IN THE LONG TERM 10

2.6 OPTION 3: COMMON INTAKE AND WTP AT KILLINEY FOR BOTH WATER SYSTEMS 10

3.0 COMPARISON OF PAST RECOMMENDATIONS 11

4.0 ALTERNATIVE OPTIONS AND CONSIDERATIONS 21

4.1 OTHER OKANAGAN VALLEY WATER PROVIDERS 21

4.2 POINT OF ENTRY / POINT OF USE (POE / POU) 22

4.3 CONNECTION TO OKANAGAN INDIAN BAND 23

5.0 RECOMMENDATIONS 23

5.1 RECOMMENDED SUPPLY AND TREATMENT STRATEGY 24

5.2 DESIGN CRITERIA 24

5.2.1 HYDRAULIC CRITERIA 24

5.2.2 WATER TREATMENT CRITERIA 25
5.3 NEXT STEPS 27
6.0 CLOSURE 28

APPENDICES

APPENDIX A: FIGURES
APPENDIX B: REFERENCE INFORMATION
APPENDIX C: WESTERN WATER GROUNDWATER EXPANSION FEASIBILITY REPORT

EXECUTIVE SUMMARY

The Killiney Beach (Killiney) and Westshore Estates (Westshore) water systems are two small water systems owned and operated by the Regional District of Central Okanagan (RDCO). Both water systems are located on the northwest shore of Okanagan Lake and require upgrades to comply with the *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*.

Urban Systems was asked to review water system improvement recommendations provided by Larratt Aquatic (Larratt), AECOM, Associated Engineering (AE) and Agua Consulting (Agua) in the past, as well as an alternative option based in new information provided by Western Water Associates (Western Water). The options reviewed are:

Option 1A: Fintry/Shorts Creek Aquifer groundwater supply with a submarine transmission main submerged in Okanagan Lake.
Option 1B: Fintry/Shorts Creek Aquifer groundwater supply with an overland transmission main adjacent to Westside Road.
Option 2A: Independent intakes and WTP's (UV & chlorine disinfection and filtration) for Killiney and Westshore
Option 2B: Independent intakes and dual disinfection treatment facilities (UV and chlorine) for Killiney and Westshore in the near term; common intake, filtration WTP and submarine transmission main (submerged in Okanagan Lake) for both systems in the long term
Option 3: Common intake and WTP (UV & chlorine disinfection and filtration) at Killiney for both water systems and an interconnecting submarine transmission main submerged in Okanagan Lake.

Urban evaluated each option by looking at Technical, Financial and Environmental & Regulatory criteria. The results of the scoring for each option are presented below.

Scoring	Option 1A – Groundwater supply w submarine transmission main	Option 1B – Groundwater supply w overland transmission main	Option 2A – Independent intakes and WTP's	Option 2B – Independent intakes and disinfection WTP's initially; common intake and filtration WTP in future	Option 3 – Common intake and WTP
Technical	◕ (4)	◕ (4.2)	◐ (3.1)	◐ (3.1)	◐ (3.3)
Financial	◕ (4.2)	● (5)	● (1.4)	◔ (1.6)	◐ (3.2)
Environmental & Regulatory	● (1)	◔ (2)	◐ (3)	◔ (2)	◔ (2)
Average	◕ (3.7)	◕ (4.2)	◐ (2.6)	◐ (2.5)	◐ (3.1)
Weighted Average	◐ (3)	◕ (3.7)	◐ (2.5)	◔ (2.2)	◐ (2.8)

● Most Desirable (5) | ◕ Moderate/Highly Desirable (4) | ◐ Moderately Desirable (3) | ◔ Low/Moderately Desirable (2) | ● Least Desirable (1)

The highest possible score for each category is five. Please refer to Table 3.4 for further scoring information.

Based on the scoring for each option, we consider Option 1B, with a common groundwater source and WTP at the Fintry/Shorts Creek Aquifer, the most favourable of the options.

There are critical aspects of Option 1B that should be verified before it can be considered a viable supply and treatment strategy.

1. An overland transmission main alignment must be determined. If MoTI will not permit a transmission main within their ROW on Westside Road, an alternate alignment will need to be secured. There may be land negotiations and Crown Tenure applications required with this option.
2. An Environmental Assessment Officer (EAO) should be engaged to determine if an Environmental Certificate or Exemption is appropriate for groundwater extraction volumes required for build-out MDD.
3. Complete additional water quality monitoring and characterization that considers higher extraction rates per Western Water's report. Septic systems in Lower Fintry may cause higher chloride, sodium and nitrate concentrations in the aquifer at increased pump rates.

If the results of any of the above reveal that Option 1B is not feasible, Option 1A and 3 should be given consideration.

This report is intended to provide the information required for the RDCO to select a preferred path forward for providing the Killiney and Westshore water systems with a water supply and treatment plan that meets the British Columbia Drinking Water Protection Regulation and the Guidelines for Canadian Drinking Water Quality.

1.0 INTRODUCTION

1.1 BACKGROUND

The Killiney Beach (Killiney) and Westshore Estates (Westshore) water systems are two small water systems owned and operated by the Regional District of Central Okanagan (RDCO). Both water systems are located on the northwest shore of Okanagan Lake and require upgrades to comply with the *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*.

Larratt Aquatic (Larratt), AECOM, Associated Engineering (AE) and Agua Consulting (Agua) have provided recommended improvements for the water systems in the past. Western Water Associates (Western Water) completed a groundwater capacity study during the writing of this report. The RDCO invited Urban Systems (Urban) to complete a study for the Killiney and Westshore water systems to review previous recommendations, identify knowledge gaps and provide alternative options.

Table 1.1 provides a summary of the existing infrastructure at each water system

TABLE 1.1 – SUMMARY OF EXISTING INFRASTRUCTURE

Component	Killiney Beach	Westshore Estates
Source	Okanagan Lake	Okanagan Lake
Treatment provided	Chlorine disinfection	Chlorine disinfection
Intake size (mm), material[1]	250, PVC	450, CMP
Intake depth at average lake level (m)[2]	9.26	6.06
# of reservoirs[1]	3 (Killarney, Udell, Winchester)	2 (Mountain, Upper)
Total reservoir volume (m^3)[1]	1,377	1,610
# of pressure zones	4	4
# of pump stations	4	2
# of existing services[3]	268[4]	293
# of services at buildout[3]	427	526

Notes:

1. *taken from RDCO GIS*
2. *taken from Larratt 2012 report*
3. *provided by RDCO in 2022*
4. *# of existing services decreased from 295 to 268 due to the White Rock Lake wildfire.*

1.2 OBJECTIVE

The intent of this report is to summarize past recommendations made by others, provide alternative considerations, and evaluate the options to determine a preferred approach for achieving compliance with the Provincial drinking water objectives for the Killiney and Westshore water systems. The focus of this report is water supply and treatment. Distribution and fire protection were not reviewed.

1.3 ORGANIZATION OF DOCUMENT

The remainder of this report is divided into the sections shown below:

- 2.0 "Summary of Past Recommendations" provides an overview of the previous supply and treatment recommendations.
- 3.0 "Comparison of Past Recommendations" evaluates the past recommendations and identifies the most favourable approach.
- 4.0 "Alternative Options and Considerations" reviews what other water providers in the Okanagan Valley are doing to achieve drinking water objectives. Section 4.0 also considers Point of Entry / Point of Use (POE / POU) as an alternative water treatment strategy and touches on the possibility of tying into the Okanagan Indian Band (OKIB) distribution system with a shared water treatment plant (WTP).
- 5.0 "Recommendations" expands on the favourable option identified in section 3.0 and provides further considerations. We also provide the design criteria that will be used to further develop the recommended supply and treatment strategy.

2.0 SUMMARY OF PAST RECOMMENDATIONS

The RDCO provided thirteen relevant documents to review for this water study. They are listed below.

- Associated Engineering, *Killiney Beach Water System Review* (November 2010)
- Associated Engineering, *Westshore Estates Water System Review* (November 2010)
- Larratt Aquatic, *Source Assessment of the Regional District of Central Okanagan – Killiney Beach and Westshore Estates Water Systems* (September 5, 2012)
- AECOM, *Killiney Beach Water System Preliminary Design – Final* (April 2015)
- AECOM, *Source Water Investigations: Killiney Beach & Westshore Estates Water Systems – Final Report* (December 2015)
- Agua Consulting Inc., *Chlorine Contact Time Report – Killiney Beach Water System* (September 12, 2016)
- Agua Consulting Inc., *Disinfection Upgrade Report – Westshore Water Utility* (September 12, 2016)
- Associated Engineering, *Killiney Beach and Westshore Estates Water System Report Review* (September 18, 2017)

- Associated Engineering, *Technical Memorandum – Killiney Beach and Westshore Estates Water Systems Report Review* (August 30, 2018)
- Interior Health, *Killiney Beach Water Supply System* (February 1, 2019)
- Interior Health, *Westshore Estates Water Supply System* (February 15, 2019)
- Larratt Aquatic, *Near-Shore Water Quality and Periphyton Production in Okanagan Lake at Killiney Beach and Westshore Estates Area* (2021)
- Western Water Associates Ltd., *Feasibility Assessment of Sourcing Additional Groundwater Capacity from the Lower Fintry Community Water System Wells and Aquifer 358* (February 4, 2022)

The past reports reviewed the following source water supply options:

- Surface water supply:
    - Okanagan Lake: considered the most reliable source overall
    - Surface water source alternatives: Whiteman, Hope and Norris creeks
- Groundwater supply:
    - Fintry/Shorts Creek Aquifer (Aquifer 358): considered the most reliable groundwater source
    - Alternate groundwater sources: Sugarloaf Mountain and Whiteman Creek aquifers

The previous reports dismissed further consideration of the creek sources. We agree with not reviewing these creek water sources further because of their limited quantity and variable quality.

The Fintry/Shorts Creek Aquifer is the only groundwater source considered viable in the previous reports. We agree with the recommendations in AE's report that the Sugarloaf Mountain and Whiteman Creek aquifers should not be considered further due to their locations and yield uncertainty. We believe it is prudent to plan for long-term supply and treatment infrastructure upgrades around a more reliable water source, such as Okanagan Lake or the Fintry/Shorts Creek Aquifer.

There are five main options for the supply and treatment of drinking water for the Killiney and Westshore water systems. There are slight variations within each option (e.g., Option 3 has multiple options for siting the proposed WTP), but they fit into the following categories:

Option 1A: Fintry/Shorts Creek Aquifer groundwater supply with a submarine transmission main submerged in Okanagan Lake.
Option 1B: Fintry/Shorts Creek Aquifer groundwater supply with an overland transmission main adjacent to Westside Road.
Option 2A: Independent intakes and WTP's (UV & chlorine disinfection and filtration) for Killiney and Westshore
Option 2B: Independent intakes and dual disinfection treatment facilities (UV and chlorine) for Killiney and Westshore in the near term; common intake, filtration WTP

and submarine transmission main (submerged in Okanagan Lake) for both systems in the long term

Option 3: Common intake and WTP (UV & chlorine disinfection and filtration) at Killiney for both water systems and an interconnecting submarine transmission main submerged in Okanagan Lake.

Please refer to Figures 2.1 to 2.4 in Appendix A which show an overview of each option.

2.1 GENERAL RECOMMENDATIONS

Some of the past reports provided recommendations specific to certain aspects of the water systems, such as extending intakes, increasing chlorine contact time (CT), etc. Since these did not form complete water supply and treatment upgrade recommendations, they will be considered as general recommendations and are not evaluated against complete options.

INTAKES

- Intakes should be at least 20 m deep to reduce the risk of algae blooms with 3 m of clearance above the lake bottom to prevent sediment accumulation.
- Intakes would have to be extended to a 40 m depth or treatment added at the intake mouth to prevent zebra & quagga mussel contamination.
- There is not a marked difference between the 20 m depth and 30 m depth turbidities, which strengthens the case for extending the intakes to 20 m initially with the plan to continue monitoring the intake location at 30 m depth
- Larratt provided defined intake protection zones for each water system intake. Because water currents travel faster in shallow water, the recommended intake protection zones are larger than if the intakes were in deeper water.
- An application for Crown tenure of the intake protection zone(s) would have to be made to the Ministry of Forests, Lands, Natural Resource Operations and Rural Development .

CHLORINE CONTACT TIME

- Killiney Beach Water System:
    - There is sufficient chlorine contact time for 4-log removal of bacteria and viruses.
    - There is partially sufficient contact time for 3-log removal of *Giardia*; only upper two pressure zones have adequate contact time.
    - The Killiney system is non-compliant for inactivation of *Cryptosporidium*, which cannot be achieved through chlorination alone.
- Westshore Estates Water System:
    - There is sufficient contact time for 4-log inactivation of viruses and bacteria.
    - There is sufficient contact time for 3-log inactivation of *Giardia*.

- The Westshore system is non-compliant for inactivation of *Cryptosporidium*, which cannot be achieved through chlorination alone.

DRINKING WATER PROTECTION ACT COMPLIANCE

- Both the Killiney and Westshore water systems are non-compliant with the *Drinking Water Protection Act* and do not meet the treatment objectives set out in Section 4 of the *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*.
- Additionally, Interior Health (IH) has requested:
  - Provide treatment for the Killiney Beach and Westshore Estates Water Systems that meets the Drinking Water Treatment Objectives for Surface Water Supplies in B.C.
  - Provide IH with an updated Water Treatment Improvements implementation schedule.
  - Provide a Source Protection Plan for the Killiney and Westshore water system intakes and detail source protection activities in the annual report.
  - Update the Water Quality Monitoring Plan for each water system.
- The data for the Upper Fintry/Shalal Road/Valley of the Sun water system shows that the water quality has remained stable over time and continues to meet all Guidelines for Canadian Drinking Water Quality. There has been one occurrence where lead concentrations exceeded allowable levels, but this was an isolated incident (Western Water, 2022).

2.2 OPTION 1A: FINTRY/SHORTS CREEK GROUNDWATER SUPPLY WELL (SUBMARINE TRANSMISSION MAIN)

Key elements:

- Develop groundwater well in the Fintry/Shorts Creek Aquifer.
- Chlorine disinfection at Fintry pump station site in the near term. Chlorine will be used to dose water for the Upper Fintry/Shalal Road/Valley of the Sun water system (as it does presently) as well as for the transmission main to Killiney and Westshore. Because the transmission main is approximately 12 km long, there is potential for bacterial growth. It is recommended to chlorinate the water distributed in the transmission main initially and dose it again at each downstream system as required to achieve target residuals.
- Provisions for UV disinfection in the future to further protect against possible contaminants. It is possible UV may not be required in the future if water quality and regulations remain consistent, but planning to add UV in the future is a conservative approach.

- Pump groundwater to Killiney and Westshore pump stations via a submerged transmission main within Okanagan Lake.
- New pump station required to pump from Killiney to Westshore.
- Filtration may not be required if groundwater quality meets "non-groundwater at risk of containing pathogens" (non-GARP) status.
- The aquifer is likely to provide quantity required for build-out MDD.
- The aquifer water quality is good at existing pumping rates. Pumping the wells at higher rates (i.e., MDD) may result in reduced water quality due to the presence of septic systems in the area.
- A new Source Protection Plan would be required.
- A notification under the *BC Reviewable Projects Regulation* is required for large groundwater users within 15% of the *Environmental Assessment Act* extraction threshold of 75 L/s (Fintry, Killiney and Westshore combined build-out MDD = 79.9 L/s). An Environmental Assessment Officer (EAO) will use the Notification to determine if an Environmental Certificate or Exemption is appropriate. A notification is required even if initial extraction volumes are below the threshold because the system would be designed to ultimately operate at MDD. More discussion with an EAO is warranted before pursuing this option.
- A new water licence would be required to extract the build-out MDD volumes from the Fintry/Shorts Creek Aquifer. Existing water licences should be reviewed to see if any can be rescinded, which would likely bode well for a new licence application. Rescinding some surface water licences, such as Norris Creek and Hope Creek, will likely improve habitat quality in those drainages. Careful consideration must be made before rescinding any existing licences.
- Further testing at the build-out MDD will need to be completed to address quality concerns at higher demand.
- This option has the third lowest capital cost of the five options (Net Present Value (NPV) = $16,052,113), and the second lowest 40-year lifecycle cost (NPV = $18,346,686). The costs presented do not consider adding a filtration building in the future if the water quality ever fails to meet non-GARP criteria. The works for this option cannot be phased.
- This option has the second lowest estimated asset renewal cost of the five options ($206,005).

2.3 OPTION 1B: FINTRY/SHORTS CREEK GROUNDWATER SUPPLY WELL (OVERLAND TRANSMISSION MAIN)

Option 1B shares most of the key elements in Option 1A. The only difference is that Option 1B will convey groundwater via an overland transmission main adjacent to Westside Road.

Other key elements:

- This option has the lowest capital cost of the five options (NPV = $12,613,597), and the lowest 40-year lifecycle cost (NPV = $14,908,170). The costs presented do not consider adding a filtration building in the future if the water quality ever fails to meet non-GARP criteria. The works for this option cannot be phased.
- This option has the lowest estimated asset renewal cost of the five options ($171,620).

2.4 OPTION 2A: INDEPENDENT INTAKES AND WTP'S FOR KILLINEY AND WESTSHORE

Key elements:

- Extend intakes for each system.
- Chlorine and UV disinfection at each lake pump station site.
- Obtain filtration exemption for each water system in the near term.
- Plan for ultra-filtration (UF) membrane filtration at each WTP in the future. Concentrate from the UF membranes (i.e., wastewater from filtration process) would be stored at the plant site and trucked to the Westside Regional Wastewater Plant. It is estimated that the UF system would achieve 95% recovery (5% waste).
- An update to the Source Protection Plan for each water system would be required.
- This option has the second highest capital cost (NPV = $18,765,234) and the second highest 40-year lifecycle cost (NPV = $24,953,551) of the five options. The initial capital cost can be reduced if filtration is deferred and the work can be phased (NPV = $11,225,625) The estimate for this option in the past reporting assumed the cost to extend the Killiney and Westshore intakes would be the same (NPV = $453,351). Larratt reported that the Killiney intake will have to be extended 300 m to reach a depth of 20 m. For Westshore to achieve a 20 m intake depth, it would need to be extended 400 m. The difference is even greater when extending the intakes to 30 m deep (500 m for Killiney, 800 m for Westshore). We have increased the estimate for the Westshore intake extension and updated the total cost of this option accordingly.
- This option has the highest estimated asset renewal cost of the five options ($481,984).

2.5 OPTION 2B: INDEPENDENT INTAKES AND DISINFECTION FOR KILLINEY AND WESTSHORE IN THE NEAR TERM; COMMON INTAKE AND FILTRATION WTP FOR BOTH SYSTEMS IN THE LONG TERM

Option 2B is like 2A but adds only one filtration WTP to be shared by both systems in the future. Option 2B extends intakes and provides chlorine and UV disinfection for both systems in the near term, then adds a shared filtration WTP at Killiney for both systems in the long term. A transmission main between Killiney and Westshore is required in this option when the conditions for obtaining filtration exemption are no longer achievable. Key elements:

- Extend intakes at both Killiney and Westshore.
- Provide chlorine and UV disinfection for each system, with filtration exemption delaying the need for a transmission main in Okanagan Lake.
    - UV can be added at the Mountain reservoir site for the Westshore water system.
    - Add UV and CT tank at the Killiney intake location. Or, alternatively, install these components at Killarney reservoir if a dedicated main is installed from the lake to the Killarney reservoir.
- Apply for filtration exemption once the works have been completed.
- Plan for UF membrane filtration in the future. Concentrate from the UF membranes (i.e., wastewater from filtration process) would be stored at the plant site and trucked to the Westside Regional Wastewater Plant. It is estimated that the UF system would achieve 95% recovery (5% waste).
- An update to the Source Protection Plan for each water system would be required.
- An estimated capital cost of this option is NPV = $20,747,239, which is the highest of the options. If filtration exemption is acceptable, this option has an initial cost of NPV = $11,225,625. The estimated 40-year lifecycle cost for Option 2B is the highest of all options (NPV = $25,647,316).
- This option has the second highest estimated asset renewal cost of the five options ($445,108).

2.6 OPTION 3: COMMON INTAKE AND WTP AT KILLINEY FOR BOTH WATER SYSTEMS

Key elements include:

- Extend the intake at the Killiney lake pump station site.
- Abandon the intake at Westshore.
- Connect Killiney and Westshore with a submerged transmission main in Okanagan Lake.

- New pump station required to pump treated water from Killiney to Westshore.
- Chlorine and UV disinfection provided at Killiney lake pump station site.
- CT tank sized to achieve required contact time.
- Filtration exemption in the near term.
- Plan for UF membrane filtration WTP in the future. Concentrate from the UF membranes (i.e., wastewater from filtration process) would be stored at the plant site and trucked to the Westside Regional Wastewater Plant. It is estimated that the UF system would achieve 95% recovery (5% waste).
- An update to the Source Protection Plan for each water system would be required.
- This option presents the second lowest capital cost of the five options considered (NPV = $15,231,216), and the third lowest 40-year life cycle cost (NPV = $19,646,593). The initial capital cost can be reduced further if filtration is deferred (NPV = $10,509,125).
- This option has the third highest estimated asset renewal cost of the five options ($319,976).

Variations of this option include:

- Locate WTP at Udell reservoir as opposed to locating it at the Killiney lake pump station site.
- Locate WTP at Killiney lake pump station and dedicated transmission main to Killarney site as opposed to having a CT tank at the lake station.

3.0 COMPARISON OF PAST RECOMMENDATIONS

We have considered the following criteria in our evaluation:

1. Source Quantity – near term: both the Fintry/Shorts Creek Aquifer and Okanagan Lake provide adequate water quantity for both water systems. Okanagan Lake source is marginally more reliable given its large volume when compared to a groundwater source.

2. Source Quality – near term: the Fintry/Shorts Creek Aquifer provides good water quality at existing system demands. Okanagan Lake quality is generally good but experiences seasonal turbidity issues. There is also the concern of algae blooms, zebra and quagga mussels getting into the lake, as well as cyanobacteria at deeper levels in Okanagan Lake.

3. Risk to Quantity – long term: the quantity of water available in Okanagan Lake long term is marginally more reliable than the Fintry/Shorts Creek Aquifer. The aquifer

level is hydraulically controlled by the lake which somewhat offsets the risk of the groundwater levels decreasing over time.

4. Risk to Quality – long term: there is some in-situ filtration provided for groundwater in the Fintry/Shorts Creek Aquifer. There is also, however, uncertainty of the groundwater quality at MDD pumping rates due to presence of septic fields. Okanagan Lake is more susceptible to quality issues, (e.g., algae blooms, turbidity events, invasive mussels) over time as it is a surface water source.

5. Source Redundancy: if the options that have a single, common, point of diversion for both water systems experience a significant failure event at the intake site (i.e., reservoir storage can't compensate for entire duration of failure), both water systems will be without water. Options that have two intake sites can at least be configured to provide water to one system if the other goes down due to a failure.

6. Transmission: evaluates the piping required to convey treated water to each water system, the risk of failure to the transmission main and considers water age.

   Option 1A requires approximately 12 km of transmission main in Okanagan Lake. Option 1B requires approximately 8 km of transmission main adjacent to Westside Road to connect the Fintry groundwater site, Killiney Beach and Westshore Estates. MoTI has expressed that any watermain installed on Westside Road must be outside of the road prism (i.e., outside of the road structure itself). MoTI is not providing any approvals in the area until they can monitor how it reacts during the first freshet in spring of 2022 after the White Rock Lake wildfire of 2021. Because of this, MoTI is unable to give an indication whether a watermain in the Westside Road right-of-way will be approved. Should a watermain be approved, MoTI must be assured that the slope stability and integrity of the road prism will not be impacted by the installation, operation and maintenance of the watermain.

   Option 2A, with separate intakes and WTP's, requires no new transmission infrastructure to convey water to each system. Option 2B does not initially require new distribution infrastructure but will ultimately require a 4 km transmission main in Okanagan Lake. Option 3 requires additional piping by way of an approximately 4 km Okanagan Lake transmission main.

   Water age and risk of quality degrading increases as the length of the transmission main and associated travel time increase. Data provided by the RDCO showed that the winter day demands (WDD) in the last two years for the Killiney and Westshore water systems were 1.6 L/s and 2.1 L/s, respectively. Considering a 350 mm diameter transmission main between Fintry and Killiney, and a 250 mm diameter

transmission main between Killiney and Westshore, the water age for each system is summarized below in Table 3.1:

TABLE 3.1 – KILLINEY AND WESTSHORE WATER AGE

Parameter	Killiney Beach	Westshore Estates
WDD (L/s)	1.6	2.1
Transmission main diameter (mm)	350	250
Transmission main length (m)	8,000	4,000
Water Age (days)	2.41	1.08

Water age typically becomes an issue at five days or more, so it is unlikely that water age will present a concern for either system. It is still recommended that both the Killiney and Westshore water systems allow for chlorine boosting if Options 1A or 1B are considered.

By nature of a submarine pipeline, the more of it that is exposed, the more susceptible it is to being damaged. Examples of this could include boat anchors snagging the watermain.

Transmission also takes the ease of potential future connections to other water systems into account. Any of the submarine pipeline options make potential connections to areas such as Ewings Landing challenging. If MoTI was to approve a watermain installation inside the Westside Road right-of-way, connections to future service areas would be simpler than to a submarine transmission main.

7. Water Treatment: considers the *Drinking Water Protection Act* and the likely number of treatment processes required to meet water treatment objectives for each water system based on existing conditions. A groundwater supply in Options 1A and 1B will likely require the least amount of water treatment when compared to Options 2A, 2B and 3. Option 2A, 2B and 3, all using Okanagan Lake as a water source, will require the same level of treatment.

8. Source Protection Plan: accounts for the level of effort required to complete Source Protection Plans (SPP) for each option. Larratt Aquatic completed a combined SPP for the existing Killiney and Westshore intakes in 2016. Larratt also completed a Source Water Assessment in 2012. Both documents complement each other and should be updated to account for significant watershed changes, namely the 2021 White Rock Lake wildfire, that have occurred since they were issued.

A new groundwater SPP would be required for the options that use the Fintry/Shorts Creek Aquifer as a water source. There is no such document that currently exists that can be used as a baseline.

9. Operation Considerations – System Complexity: groundwater treatment is likely the least complex if groundwater remains non-GARP. The system complexity to run treatment facilities for surface water sources will likely have to consider residuals management in the future. Operating a single, common facility is preferred to running two, separate facilities for each water system from an operations standpoint.

10. Lifecycle Costs: compares the capital (NPV) and 40-year lifecycle costs (NPV) of the options. Capital cost estimates consider the ability to phase the work to spread costs out over time. Table 3.2 provides a summary of the costs for each option. Note that the values were taken from one of AECOM's 2015 reports and have been adjusted based on the current infrastructure construction price index (August 2021 dollars) made available by Statistics Canada. Values from AECOM's 2015 report were applied to AE's recommended option in 2018 (Option 2B) to see how all four options compare. AE commented on AECOM's estimates but did not provide a separate estimate for their recommended approach.

    High level asset renewal cost estimates are also provided for each option. Components were grouped into "long life" (i.e., pipe, buildings) and "short life" (i.e., pumps, electrical components, disinfection equipment) categories and an average service life was applied to each category for those categories; 100-years for "long life" and 25-years for "short life". The asset group costs were divided by their average service life to arrive at the yearly asset renewal costs.

Table 3.2 summarizes the NPV costs for each option.

TABLE 3.2 – NPV COST COMPARISON OF PAST RECOMMENDATIONS (FILTRATION COSTS BEGIN IN YEAR 20)[1]

		Option 1A – Groundwater supply w submarine transmission main	Option 1B – Groundwater supply w overland transmission main	Option 2A – Independent intakes and WTP's	Option 2B – Independent intakes and disinfection WTP's initially; common intake and filtration WTP in future	Option 3 – Common intake and WTP
Capital Costs		2021 NPV	2021 NPV	2021 NPV	2021 NPV	2021 NPV
Phase 1 Capital Costs (Filtration Exemption Achieved)	1. Fintry Pump Station	$2,016,974	$2,016,974	n/a	n/a	n/a
	2. Killiney Pump Station	$453,351	$453,351	n/a	n/a	$272,260
	3. Killiney Disinfection WTP	n/a	n/a	$3,839,119	$3,839,119	$4,437,342
	4. Killiney Filtration WTP	n/a	n/a	n/a	n/a	n/a
	5. Westshore Disinfection WTP	n/a	n/a	$4,328,687	$4,328,687	n/a
	6. Westshore Filtration WTP	n/a	n/a	n/a	n/a	n/a
	7. Killiney Intake	n/a	n/a	$453,351	$453,351	$453,351
	8. Westshore Intake	n/a	n/a	$604,468	$604,468	n/a
	9. Fintry to Killiney Transmission Main (submarine)	$8,692,344	n/a	n/a	n/a	n/a
	10. Fintry to Westshore Transmission Main (overland)[3]	n/a	$9,600,000	n/a	n/a	n/a
	11. Killiney to Westshore Transmission Main (submarine)	$4,346,172	n/a	n/a	n/a	$4,346,172
	12. Land Acquisition Costs[2]	$543,272	$543,272	$2,000,000	$2,000,000	$1,000,000
Subtotal: Phase 1 Capital Costs		***$16,052,113***	***$12,613,597***	***$11,225,625***	***$11,225,625***	***$10,509,125***
Phase 2 Capital Costs (Filtration Required)	1. Fintry Pump Station	n/a	n/a	n/a	n/a	n/a
	2. Killiney Pump Station	n/a	n/a	n/a	$453,351	n/a
	3. Killiney Disinfection WTP	n/a	n/a	n/a	n/a	n/a
	4. Killiney Filtration WTP	n/a	n/a	$3,609,321	$4,722,091	$4,722,091
	5. Westshore Disinfection WTP	n/a	n/a	n/a	n/a	n/a
	6. Westshore Filtration WTP	n/a	n/a	$3,930,288	n/a	n/a
	7. Killiney Intake	n/a	n/a	n/a	n/a	n/a
	8. Westshore Intake	n/a	n/a	n/a	n/a	n/a
	9. Fintry to Killiney Transmission Main (submarine)	n/a	n/a	n/a	n/a	n/a
	10. Fintry to Westshore Transmission Main (overland)[3]	n/a	n/a	n/a	n/a	n/a
	11. Killiney to Westshore Transmission Main	n/a	n/a	n/a	$4,346,172	n/a
	12. Land Acquisition Costs[2]	n/a	n/a	n/a	n/a	n/a
Subtotal: Phase 2 Capital Costs		***$0***	***$0***	***$7,539,609***	***$9,521,614***	***$4,722,091***
Total Capital Costs		***$16,052,113***	***$12,613,597***	***$18,765,234***	***$20,747,239***	***$15,231,216***
Regulatory Costs	1. Groundwater Environmental Certificate/Exemption	$350,000	$350,000	n/a	n/a	n/a
	2. Source Protection Plans required for groundwater and lake sources	$40,000	$40,000	$20,000	$20,000	$18,000
Total Regulatory Costs		***$390,000***	***$390,000***	***$20,000***	***$20,000***	***$18,000***
Operating Costs	1. Base Costs (years 1 – 40)	$1,353,808	$1,353,808	$2,374,159	$1,891,459	$1,408,759
	2. Future Treatment (years 20 – 40)[4]	$191,082	$191,082	$3,794,158	$2,988,618	$2,988,618
	3. Well Refurbishment	$359,683	$359,683	n/a	n/a	n/a
Total Operating Costs		***$1,904,573***	***$1,904,573***	***$6,168,317***	***$4,880,077***	***$4,397,377***
Total 40-year Life Cycle Cost		***$18,346,686***	***$14,908,170***	***$24,953,551***	***$25,647,316***	***$19,646,593***
Estimated Asset Renewal Cost ($/year)		***$206,005***	***$171,620***	***$481,984***	***$445,108***	***$319,976***

Notes:

1. *Majority of estimated values provided in AECOM 2015 report and adjusted to reflect August 2021 NPV*
2. *Land Acquisition Costs:*
    a. *Costs for options 1A & 1B provided in AECOM 2015 report*
    b. *Costs for options 2A, 2B & 3 provided by RDCO.*
3. *The following assumptions were made for the overland transmission main between Fintry and Westshore:*
    a. *$300/m for rock blasting and removal along entire alignment based on typical ground type in the area.*
    b. *$900/m for supply and install of pipe and bedding, considering project location*
    c. *Land acquisition costs not included but may be required depending on final alignment*
    d. *Power pole relocation costs not included but may be required depending on final alignment*
4. *UV added to Options 1A & 1B in year 20 | Filtration added to options 2A, 2B & 3 in year 20.*

Option 1A has the third lowest capital and second lowest 40-year lifecycle costs but cannot be phased.

Option 1B has the lowest capital and lowest 40-year lifecycle costs but cannot be phased.

Option 2A, with two WTPs and intake extensions, requires the most infrastructure and has the second highest initial and 40-year lifecycle costs but has the lowest initial cost as long as filtration exemption is approved by Interior Health.

Option 2B, where a common filtration WTP is added at the Killiney site in the future, would also make this option the lowest cost initially, but it has the highest ultimate capital cost when filtration is required. Option 2B also experiences a loss of initial capital investment of $605k when the Westshore intake is taken out of service in the future. The Westshore lake pump station, including disinfection equipment, will become a lost investment as well when the system is converted over to a common WTP.

Option 3 has the second lowest capital cost and third lowest 40-year lifecycle cost. By delaying construction of a filtration plant for as long as filtration exemption is acceptable, the initial capital investment of Option 3 is reduced further.

11. Operational Considerations – Staffing Level: long-term operations and maintenance (O&M) including filtration, disinfection and residuals management were considered. Options 1A and 1B, using a groundwater source, will likely require the least amount of effort.

    Option 2A, with two WTPs, will require the greatest amount of effort by Operators and have greater staffing requirements. This will become more pronounced when filtration is required. Option 2B will require the same level of effort as 2A in the near term, but less effort than 2A in the long term when a single filtration WTP is used.

    Option 3 will require a moderate level of effort to operate compared to Options 2A and 2B.

    If Options 1A and 1B end up requiring filtration based on water quality, then they will require a similar level of effort to operate as the single WTP in Option 3.

    Considerations must be made to have Operators on staff with the appropriate level of training to run the facility type of the preferred option based on the EOCP facility classification.

12. Environmental Considerations: Urban discussed the options with a Professional Biologist to gauge the environmental impact of construction for each option.

    In general, the options that require a submarine pipeline (1A, 2B and 3) will have the largest environmental impact. The longer the submarine pipeline, the larger the impact will be. This considers kokanee spawning zones that conflict with potential pipeline routing.

    Option 1A presents the second largest environmental impact because of the overland pipeline. Based on MoTI's feedback that any proposed watermain must be outside of the road prism, it is likely the proposed alignment will conflict with undisturbed areas which can be detrimental to habitat.

    Option 2A would have the lowest environmental impact despite having two facilities near the lakeshore because it does not require a transmission main.

    Environmental considerations do not account for operational differences between the options such as energy requirements for additional pumping, greenhouse gas emissions due to hauling filtration residuals off site, etc.

13. Regulatory Considerations considers the following Acts:
    - *Environmental Assessment Act* (Provincial)
    - *Water Sustainability Act* (Provincial)
    - *Land Act* (Provincial)
    - *Fisheries Act* (Federal)
    - *Navigable Waters Act* (Federal)

    This section also considers the level of effort and length of time necessary to receive certain approvals that relate to the above-mentioned Acts. Table 3.3 summarizes the regulatory considerations. Note that the Drinking Water Protection Act is not identified above but intent is to achieve compliance with each upgrade option that is identified.

Table 3.3 summarizes the regulatory considerations for each option:

TABLE 3.3 – REGULATORY CONSIDERATIONS

Regulation	Option 1A – Groundwater supply w submarine transmission main	Option 1B – Groundwater supply w overland transmission main	Option 2A – Independent intakes and WTP's	Option 2B – Independent intakes and disinfection WTP's initially; common intake and filtration WTP in future	Option 3 – Common intake and WTP
BC Land Act: Crown Tenure	Crown Tenure required for submarine pipeline option. First Nations consultation is part of the Crown tenure application process and can be lengthy.	Crown Tenure may be required.[1]	Crown Tenure required for intake protection zones. First Nations consultation is part of the Crown tenure application process and can be lengthy.	Crown Tenure required for submarine pipeline and intake protection zones. First Nations consultation is part of the Crown tenure application process and can be lengthy.	Crown Tenure required for submarine pipeline and intake protection zones. First Nations consultation is part of the Crown tenure application process and can be lengthy.
BC Water Sustainability Act: Water Licencing	New water licence required to extract additional groundwater from the Fintry/Shorts Creek aquifer.	New water licence required to extract additional groundwater from the Fintry/Shorts Creek aquifer.	Existing water licences will need to be amended to add the proposed facility, treatment, etc.	Existing water licences will need to be amended to add the proposed facility, treatment, etc.	Existing water licences will need to be amended to add the proposed facility, treatment, etc.
BC Environmental Assessment Act: Environmental Certificate/Exemption	Environmental Certificate process can take several years and cost hundreds of thousands of dollars. Applying for an exemption is an option but can still take 1 – 2 years and requires an early engagement plan. First Nations consultation is part of both the Environmental Certificate process and the Exemption process.	Environmental Certificate process can take several years and cost hundreds of thousands of dollars. Applying for an exemption is an option but can still take 1 – 2 years and requires an early engagement plan. First Nations consultation is part of both the Environmental Certificate process and the Exemption process.			
BC Water Sustainability Act: Section 11 Applications	Section 11 applies to work in and about a stream, which will apply to the submarine pipeline.	Section 11 applies to work in and about a stream, which will apply to the overland pipeline option for stream crossings.	Section 11 applies to work in and about a stream, which will apply to the intakes and facility construction near the shoreline.	Section 11 applies to work in and about a stream, which will apply to the submarine pipeline, intakes, and facility construction near the shoreline.	Section 11 applies to work in and about a stream, which will apply to the submarine pipeline, intakes, and facility construction near the shoreline.
Federal Fisheries Act	This Act should be reviewed to determine what is applicable to this project. Projects with the potential to adversely impact fish and/or fish habitat should be reviewed by Fisheries and Oceans Canada (DFO) through the Request for Review process. There are known "red" and "black" kokanee habitat areas near Fintry.		This Act should be reviewed to determine what is applicable to this project. Projects with the potential to adversely impact fish and/or fish habitat should be reviewed by Fisheries and Oceans Canada (DFO) through the Request for Review process.	This Act should be reviewed to determine what is applicable to this project. Projects with the potential to adversely impact fish and/or fish habitat should be reviewed by Fisheries and Oceans Canada (DFO) through the Request for Review process.	This Act should be reviewed to determine what is applicable to this project. Projects with the potential to adversely impact fish and/or fish habitat should be reviewed by Fisheries and Oceans Canada (DFO) through the Request for Review process.
Canadian Navigable Waters Act	This Act applies to work on navigable waters, which includes Okanagan Lake.		This Act applies to work on navigable waters, which includes Okanagan Lake.	This Act applies to work on navigable waters, which includes Okanagan Lake.	This Act applies to work on navigable waters, which includes Okanagan Lake.
Transportation Acts & Regulations	N/A	Pipe within MoTI right-of-way must be approved by MoTI. Westside Road has several "very high potential hazard areas" with respect to geotechnical risk, per MoTI, and construction approvals will be challenging.			

Notes:

1. *Depending on the proposed alignment and land ownership, the overland transmission main in Option 1B may also be subject to the following regulations:*
    a. *Species at Risk Act*
    b. *Migratory Birds Convention Act*
    c. *BC Land Act*
    d. *BC Wildlife Act*
    e. *BC Heritage Conservation Act*
2. *Local Government requirements (i.e., development permit requirements) were not considered*

Table 3.4 summarizes our comparison of each option:

TABLE 3.4 – PREVIOUS OPTION COMPARISON REV.1

Component	Option 1A – Groundwater supply w submarine transmission main	Option 1B – Groundwater supply w overland transmission main	Option 2A – Independent intakes and WTP's	Option 2B – Independent intakes and disinfection WTP's initially; common intake and filtration WTP in future	Option 3 – Common intake and WTP
TECHNICAL					
Source Quantity – near term	Fintry/Shorts Creek Aquifer provides adequate quantity. ◕ (4)	Fintry/Shorts Creek Aquifer provides adequate quantity. ◕ (4)	Okanagan Lake provides adequate quantity. Larger volume relative to the Fintry/Shorts Creek Aquifer ● (5)	Okanagan Lake provides adequate quantity. Larger volume relative to the Fintry/Shorts Creek Aquifer ● (5)	Okanagan Lake provides adequate quantity. Larger volume relative to the Fintry/Shorts Creek Aquifer ● (5)
Source Quality – near term	Quality is good at existing demands. ● (5)	Quality is good at existing demands. ● (5)	Okanagan Lake quality is generally good. Algae blooms, zebra and quagga mussels possible at shallow depths; cyanobacteria at deeper depths. Surface water has seasonal turbidity issues, ◐ (3)	Okanagan Lake quality is generally good. Algae blooms, zebra and quagga mussels possible at shallow depths; cyanobacteria at deeper depths. Surface water has seasonal turbidity issues, ◐ (3)	Okanagan Lake quality is generally good. Algae blooms, zebra and quagga mussels possible at shallow depths; cyanobacteria at deeper depths. Surface water has seasonal turbidity issues, ◐ (3)
Risk to Quantity – long term	Aquifer is somewhat more susceptible than Okanagan Lake to quantity issues, but marginal as level is controlled by Okanagan Lake ● (5)	Aquifer is somewhat more susceptible than Okanagan Lake to quantity issues, but marginal as level is controlled by Okanagan Lake ● (5)	Okanagan Lake provides adequate quantity. Less concern with quantity long term than the Fintry/Shorts Creek Aquifer ● (5)	Okanagan Lake provides adequate quantity. Less concern with quantity long term than the Fintry/Shorts Creek Aquifer ● (5)	Okanagan Lake provides adequate quantity. Less concern with quantity long term than the Fintry/Shorts Creek Aquifer ● (5)
Risk to Quality – long term	Some in-situ filtration and barrier provided for groundwater. There is uncertainty of the quality at MDD pumping rates due to presence of septic fields. ◕ (4)	Some in-situ filtration and barrier provided for groundwater. There is uncertainty of the quality at MDD pumping rates due to presence of septic fields. ◕ (4)	Okanagan Lake is more susceptible to quality changes over time. ◔ (2)	Okanagan Lake is more susceptible to quality changes over time. ◔ (2)	Okanagan Lake is more susceptible to quality changes over time. ◔ (2)
Source Redundancy	Single point of diversion. ◐ (3)	Single point of diversion. ◐ (3)	Two points of diversion. ● (5)	Two points of diversion initially. Westshore intake can be configured to be brought online in emergency situations. ◕ (4)	Single point of diversion. ◐ (3)
Transmission	High – Approximately 12 km of transmission main in Okanagan Lake required. Concerns with increased water age and pipeline failure (e.g., from boat anchors) ● (1)	Medium – Approximately 8 km of transmission main adjacent to Westside Road required. Concerns with increased water age. Future connections easier with overland pipeline. ◐ (3)	Lowest – No new transmission mains required. Future service area connections difficult. ◕ (4)	Medium – Approximately 4 km of transmission main in Okanagan Lake required when filtration exemption is not acceptable. Future service area connections difficult. Some concern with pipeline failure (e.g., from boat anchors) ◐ (3)	Medium – Approximately 4 km of transmission main in Okanagan Lake required. Future service area connections difficult. Some concern with pipeline failure (e.g., from boat anchors) ◐ (3)
Water Treatment	Least amount of treatment possible, but dependent on non-GARP status and effects of nearby septic fields at increased pump rates. ● (5)	Least amount of treatment possible, but dependent on non-GARP status and effects of nearby septic fields at increased pump rates. ● (5)	Highest level of treatment required – UV and chlorine initially, filtration eventually. ● (1)	Highest level treatment required – UV and chlorine initially, filtration eventually. ◔ (2)	Highest level treatment required – UV and chlorine initially, filtration eventually. ◐ (3)
Source Protection Plan[1]	New SPP for groundwater source required. ◕ (4)	New SPP for groundwater source required. ◕ (4)	Updated to the existing combined SPP required. Significant effort required to implement and manage SPP. ◔ (2)	Updated to the existing combined SPP required. Significant effort required to implement and manage SPP. ◔ (2)	Updated to the existing SPP required for the Killiney intake only. Significant effort required to implement and manage SPP. ◐ (3)
Operational Considerations – System Complexity	Least complex as long as groundwater remains non-GARP. ● (5)	Least complex as long as groundwater remains non-GARP. ● (5)	Two facilities to Operate. Residuals management will be required when filtration is implemented. ● (1)	Two disinfection facilities to run initially. One facility to Operate ultimately. Residuals management will be required when filtration is implemented. ◔ (2)	One facility to Operate. Residuals management will be required when filtration is implemented. ◐ (3)
Sum	36	38	28	28	30
Average	◕ (4)	◕ (4.2)	◐ (3.1)	◐ (3.1)	◐ (3.3)

FINANCIAL[2]					
Capital Costs – Grant Eligible	Medium lifecycle Cost: Ph. 1 Capital: $16.052M Ph. 2 Capital: $0 Total: $16.1M ◐ (3)	Low lifecycle Cost: Ph. 1 Capital: $12.614M Ph. 2 Capital: $0 Total: $12.6M ● (5)	High lifecycle Cost: Ph. 1 Capital: $11.225M Ph. 2 Capital: $7.540M Total: $18.8M ◔ (2)	Highest lifecycle Cost: Ph. 1 Capital: $11.225M Ph. 2 Capital: $9.522M Total: $20.7M ● (1)	Medium lifecycle Cost: Ph. 1 Capital: $10.509M Ph. 2 Capital: $4.772M Total: $15.2M ◕ (4)
Regulatory and Operation Costs – non-Grant Eligible	Regulatory: $390K O&M (1 – 40-yrs): $1.354M O&M (20 – 40-yrs): +$191K Well refurb.: $360K Total: $2.3M ● (5)	Regulatory: $390K O&M (1 – 40-yrs): $1.354M O&M (20 – 40-yrs): +$191K Well refurb.: $360K Total: $2.3M ● (5)	Regulatory: $20K O&M (1 – 40-yrs): $2.374M O&M (20 – 40-yrs): $3.794M Well refurb.: $0 Total: $6.2M ● (1)	Regulatory: $20K O&M (1 – 40-yrs): $1.891M O&M (20 – 40-yrs): $2.989M Well refurb.: $0 Total: $4.9M ◔ (2)	Regulatory: $18K O&M (1 – 40-yrs): $1.409M O&M (20 – 40-yrs): $2.989M Well refurb.: $0 Total: $4.4M ◐ (3)
Lifecycle Cost - Total	Total (40-yrs): $18.347M ◕ (4)	Total (40-yrs): $14.908M ● (5)	Total (40-yrs): $24.954M ◔ (2)	Total (40-yrs): $25.647M ● (1)	Total (40-yrs): $19.647M ◐ (3)
Asset Renewal Cost	$206K/yr – Second lowest annual cost ◕ (4)	$172K/yr – Lowest annual cost ● (5)	$482K/yr – Highest annual cost ● (1)	$445K/yr – Second highest annual cost ◔ (2)	$320K/yr – Third lowest annual cost. ◐ (3)
Operational Considerations – Staffing Levels	Lowest level of effort. Lower level of treatment required compared to surface water. ● (5)	Lowest level of effort. Lower level of treatment required compared to surface water. ● (5)	Highest level of effort. Two facilities to operate. ● (1)	Medium to high level of effort. Two facilities to operate initially; one facility to operate ultimately ◔ (2)	Medium level of effort. One facility to operate. ◐ (3)
Sum	21	25	7	8	16
Average	◕ (4.2)	● (5)	● (1.4)	◔ (1.6)	◐ (3.2)
ENVIRONMENTAL & REGULATORY					
Environmental Considerations	High impact – Portion of 12 km transmission main is adjacent to “red” and “black” Kokanee habitat. ● (1)	Medium to high impact – 8 km of overland transmission main alignment can may be detrimental to habitat. ◔ (2)	Medium to high impact – two facilities in or near the riparian area and two lake intakes required. ◐ (3)	Medium to high impact – two facilities in or near the riparian area and two lake intakes required initially; 4 km submarine transmission main required eventually. ◔ (2)	Medium to high impact – one facility in or near the riparian area, one lake intake and 4 km transmission main required. ◔ (2)
Regulatory Considerations	Highest time and effort – Crown Tenure required for submarine pipeline option. New water licence required for additional groundwater extraction. Environmental Certificate or Exemption required for groundwater extraction. Section 11 applies. ● (1)	High time and effort – MoTI approval required. Areas along alignment are considered “very high potential hazard areas”. Several other Acts may apply to this Option, depending on final alignment and land ownership. New water licence required for additional groundwater extraction. Environmental Certificate or Exemption required for groundwater extraction. Section 11 applies. ◔ (2)	Medium time and effort – Crown Tenure required for intakes. Section 11 applies. Water licence amendments are required. ◐ (3)	Medium to high time and effort – Crown tenure required for intakes and submarine pipeline. Section 11 applies. Water licence amendments are required. ◔ (2)	Medium to high time and effort – Crown tenure required for intakes and submarine pipeline. Section 11 applies. Water licence amendments are required. ◔ (2)
Sum	2	4	6	4	4
Average	● (1)	◔ (2)	◐ (3)	◔ (2)	◔ (2)
COMBINED					
Total Sum	59	67	41	40	50
Average	◕ (3.7)	◕ (4.2)	◐ (2.6)	◐ (2.5)	◐ (3.1)
Weighted Average: Technical: 33.3% Financial: 33.3% Environmental and Regulatory: 33.3%	◐ (3)	◕ (3.7)	◐ (2.5)	◔ (2.2)	◐ (2.8)

● Most Desirable (5) | ◕ Moderate/Highly Desirable (4) | ◐ Moderately Desirable (3) | ◔ Low/Moderately Desirable (2) | ● Least Desirable (1)

Notes:

General - Effects of climate change have been considered as much as possible with the information available.

1. *Effort to implement and manage an SPP for surface water based on:*
   a. *RDCO feedback,*
   b. *challenges protecting large bodies of water compared to groundwater*
   c. *high risk contributors to source water quality (e.g., boat launch, beach access, wildfires, etc.)*
2. *Cost values reflect August 2021 NPV.*

4.0 ALTERNATIVE OPTIONS AND CONSIDERATIONS

4.1 OTHER OKANAGAN VALLEY WATER PROVIDERS

This section considers what other Okanagan Valley water purveyors are doing to provide water to their customers.

VERNON

Greater Vernon Water operates two water treatment plants: Duteau Creek and Mission Hill. The Duteau Creek WTP uses a creek water source and has a three-step treatment process that includes clarification with Dissolved Air Floatation (DAF), UV and chlorine disinfection.

The Mission Hill WTP draws water from a 20 m deep intake in Kalamalka Lake and currently provides UV and chlorine disinfection. Greater Vernon Water has received federal funding to add filtration to the Mission Hill WTP.

LAKE COUNTRY

The District of Lake Country uses four surface water sources: Okanagan, Kalamalka, Beaver and Oyama lakes. Each source is disinfected with chlorine. UV disinfection is provided for Okanagan Lake and Kalamalka Lake sources. Okanagan Lake and Kalamalka Lake provide the best raw water quality of the four sources. The District of Lake Country has constructed interconnects to supplement the Beaver Lake and Oyama Lake distribution systems when water quality in those systems is poor.

Lake Country's Water Master Plan includes an objective to add a water treatment plant in the future to provide a reliable, high quality water supply for each of their distribution systems.

There were discussions entertaining the possibility of connecting the Lake Country Okanagan Lake system with Killiney and Westshore, but this was ultimately ruled out due to limited residual capacity in Lake Country's system and challenges with installing a submarine transmission main across the lake.

KELOWNA

Kelowna uses four different water providers to supply residents with water:

- City of Kelowna Water Utility (CITY)
- Glenmore Ellison Irrigation District (GEID)
- Rutland Waterworks (RWD)
- Black Mountain Irrigation District (BMID)

Two of the water providers, CITY and GEID, rely on Okanagan Lake as a primary water source and supply water to more than half of Kelowna's population. CITY draws water from four different lake intakes and disinfects using UV and chlorination. GEID primarily provides water from a 34 m deep lake intake and uses UV and chlorine disinfection as treatment.

The City of Kelowna has developed an Integrated Water Supply Plan which uses filtration exemption in its approach. Filtration will be added in the future after raw water quality has deteriorated or it is required by drinking water quality regulations.

WEST KELOWNA

The City of West Kelowna operates four separate water systems. The water systems will be combined into two after the completion of the Rose Valley Water Treatment Plant, which is under construction.

The Powers Creek WTP uses a combined DAF clarification and filtration process, followed by UV and chlorine disinfection. The Rose Valley WTP will use a similar treatment process. Neither of the two systems uses Okanagan Lake as a water source.

PEACHLAND

The District of Peachland's water source is Peachland Lake, which flows into Peachland Creek. Peachland has a new WTP which treats water using DAF clarification and dual media filtration, followed by UV and chlorine disinfection.

The District of Peachland considered using Okanagan Lake as a water source, but ultimately selected Peachland Creek based on two main factors:

1. Peachland is located on a long hill and pumping costs would be prohibitively expensive if their WTP site was at the lake.
2. Peachland Creek provides reliable source water in terms of both quality and quantity.

SUMMERLAND

The District of Summerland uses Trout Creek as a water source. Treatment is provided using a micro-sand ballasted clarification process, filtration, and chlorine disinfection.

PENTICTON

The City of Penticton uses water from two sources: Penticton Creek and Okanagan Lake. Penticton's WTP can treat a single or blended source. The treatment process uses DAF, filtration and chlorine disinfection.

4.2 POINT OF ENTRY / POINT OF USE (POE / POU)

A POE water treatment process treats all water entering a home, whereas a POU system treats water at a single location inside a home (i.e., a faucet). Although the water treatment

equipment is installed at each individual residence, the equipment is typically owned and maintained by the water purveyor and not the homeowner. Every single homeowner must agree to POE / POU treatment and sign a letter of consent for it to be approved of as a water treatment strategy in a water system.

POE / POU systems are approved for water systems that service 500 or fewer individuals and are typically considered by communities with fewer than 40 homes (Small Water Systems BC, 2021). In BC, communities with POE / POU typically have 15 or fewer connections. The British Columbia Water & Waste Association (BCWWA) recently completed a small water system project and found that the cost/benefit begins to drop after five installations.

Given that the ultimate build-out for Killiney and Westshore are 427 and 526 residential connections, respectively, we do not believe that POE / POU water treatment should be considered further.

4.3 CONNECTION TO OKANAGAN INDIAN BAND

The RDCO requested that Urban explore the possibility of a shared WTP and connection with Okanagan Indian Band (OKIB), who has a distribution system north of Westshore. OKIB has indicated that they are in the process of developing improvements to their own system and are not interested in joining a shared system at this time.

5.0 RECOMMENDATIONS

Overall, we consider Option 1B, with a common groundwater source and WTP at the Fintry/Shorts Creek Aquifer, the most favourable of the options. Here is a summary of why Option 1B was selected:

- Lifecycle Costs – Its estimated total capital cost is the lowest of the options. Option 1B also has the lowest 40-year lifecycle cost.
- Eliminates Waste – There are no lost investments in infrastructure with Option 1B. All work that would be completed in the initial phase is used in the ultimate scenario.
- Operations - From an operations standpoint, one site for all disinfection is preferred. As long as the groundwater remains non-GARP, filtration will likely not be required with current regulations.
- Grant Funding - Combining the water systems will likely be viewed positively by the Province of BC if grant funding is sought.
- Service Extension – the overland transmission main alignment may create opportunities for extending servicing to new areas

5.1 RECOMMENDED SUPPLY AND TREATMENT STRATEGY

There are critical aspects of Option 1B that should be verified before it can be considered a viable supply and treatment strategy.

1. An overland transmission main alignment must be determined. If MoTI will not permit a transmission main within their ROW on Westside Road, an alternate alignment will need to be secured. There may be land negotiations and Crown Tenure applications required with this option.
2. An Environmental Assessment Officer (EAO) should be engaged to determine if an Environmental Certificate or Exemption is appropriate.
3. Complete additional water quality monitoring and characterization that considers higher extraction rates per Western Water's report. Septic systems in Lower Fintry may cause higher chloride, sodium and nitrate concentrations in the aquifer at increased pump rates.

If the results of any of the above reveal that Option 1B is not feasible, Option 1A and 3 should be given consideration.

5.2 DESIGN CRITERIA

We will consider the following design criteria when expanding on the preferred option in Urban's subsequent report:

5.2.1 HYDRAULIC CRITERIA

DEMANDS

The water supply and treatment equipment will be sized to supply up to the maximum day demand (MDD). Fire flows and peak flows would be supplied by reservoirs.

The previous reports offered conflicting build-out connection numbers for the Killiney and Westshore Water Systems. The RDCO verified the correct values to use. The build-out also needs to include the Upper Fintry/Shahal Road/Valley of the Sun service area, which is presently supplied by the Fintry/Shorts Creek Aquifer:

- Upper Fintry/Shahal Road/Valley of the Sun: 325 connections
- Killiney: 427 connections
- Westshore: 526 connections

The RDCO Subdivision Servicing Bylaw domestic demand criteria for designing water distribution systems in residential areas is 2,100 L/cap/day for maximum day demands. The City of Kelowna uses 1,800 L/cap/day for the same criteria and 3.0 people per dwelling. Flow data for Killiney and Westshore provided by the RDCO from 2020 and 2021 compares more closely to the 1,800 L/cap/day while considering three people per household with the existing number of connections. Note that the flow data is from the last 12 months, while the connection totals were provided in June 2022:

	Upper Fintry/Shahal Road/ Valley of the Sun	Killiney	Westshore
# of ex. connections	159	295	293
Calculated MDD (using 1,800 L/cap/day)	9.9 L/s	18.4 L/s	18.3 L/s
Actual MDD (from 2021 data)[1]	17.1	17.3 L/s	15.21 L/s

Notes:

1. *Actual 2021 MDD for the existing water system service area was significantly higher than typical (more than 3x higher than 2020) due to the prolonged drought and forest fires which impacted the west side of Okanagan Lake. (Western Water, 2022)*

Given that the actual MDD values for Killiney & Westshore from the current data (outside of 2021 where the water demand was significantly higher than usual due to the White Rock Lake fire) are lower than the calculated demand estimates, we believe that 1,800 L/cap/day is a reasonable, conservative value for estimating build-out water demands as noted below:

- Upper Fintry/Shahal Road/Valley of the Sun: 20.3 L/s
- Killiney: 26.7 L/s
- Westshore: 32.9 L/s
- **Combined: 79.9 L/s**

5.2.2 WATER TREATMENT CRITERIA

CHLORINE DISINFECTION

As mentioned previously in this report, the Killiney water system does not provide adequate CT time for 3-log removal of *Giardia* in the two lowest pressure zones. Agua used 7.5 °C as the minimum temperature to calculate the required CT time (Agua, 2016). Larratt reported that that the minimum measured water temperature at the proposed intake depths (20 m to 40 m deep) was 4 °C (Larratt, 2012). We will use 4 °C as the minimum water temperature when calculating the required CT time for each system.

The transmission main between Killiney and Westshore should provide ample CT time between the two water systems and may even require that chlorine is boosted at some point along the main. We will determine if chlorine boosting is likely in the subsequent "concept refinement" stage.

We will also need to determine if the chlorine contact time for the Upper Fintry/Shahal Road/Valley of the Sun area is adequate with the proposed changes (i.e., increased pump rates).

WATER QUALITY – SURFACE WATER

The Drinking Water Treatment Objectives for Surface Water Supplies in British Columbia provides the microbiological targets for treating surface water in BC (Province of British Columbia, 2012). They are:

- 4-log reduction or inactivation of viruses.
- 3-log reduction or inactivation of *Giardia* and *Cryptosporidium*.
- Two treatment processes for surface water.
- Less than or equal to (≤) one (1) nephelometric turbidity unit (NTU).
- No detectable E. Coli, fecal coliform and total coliform

Raw water quality must meet, and continue to meet, the following criteria for filtration exemption to be accepted:

- Minimum of two disinfections, providing 4-log reduction of viruses and 3-log reduction of *Cryptosporidium* and *Giardia*.
- The number of *E. coli* in raw water does not exceed 20/ 100 mL in at least 90% of the weekly samples in the past six months.
- Average daily turbidity levels measured at equal intervals (at least every four hours) immediately before the disinfectant is applied are around 1 NTU, but do not exceed 5 NTU for more than two days in a 12-month period.
- A watershed control program is maintained that minimizes the potential for fecal contamination in the source water (Health Canada, 2012b).

WATER QUALITY – GROUNDWATER

The Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia provides guidance on what microbiological objectives need to be achieved for a groundwater source to be considered potable (Province of British Columbia, 2015). They are:

- Groundwater supplies determined to be 'at risk' of containing pathogens (GARP): Two disinfection methods equivalent to surface water sources required at a minimum.
- Groundwater supplies determined to be 'at risk' of containing viruses (GARP-viruses only): 4-log removal of viruses required.
- Groundwater supplies determined to be at 'low risk' of containing pathogens: disinfection not required for water source to be considered potable.

Given the stability of the existing water quality, it is likely that filtration deferral will continue to be acceptable for the Fintry groundwater source with increased demands. Turbidity is expected to remain consistently below 1 NTU (Western Water, 2022). Filtration exemption is also more likely to be approved if a well is properly constructed and protected to minimize the potential for fecal or other pathogenic-related contamination in the source water, and a Well Protection Plan (or equivalent satisfactory to the Drinking Water Officer) is in place (Province of British Columbia, 2015).

It should be noted that groundwater turbidity samples may be required not to exceed 3.0 NTU for filtration exemption to be acceptable, which is lower than the 5.0 NTU limit for surface water filtration exemption. Per the BC Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia:

> "For subsurface filtration, an increase in turbidity at the well may be indicative of a failure of the treatment barrier provided by subsurface filtration. In comparison, a system with a filtration exemption (as outlined in Ministry of Health's "Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia" does not rely on filtration to help reduce Giardia and Cryptosporidium, rather sufficient disinfection technologies are employed. This is why the allowable upper limit for turbidity in systems that have credit for subsurface filtration is lower (3.0 NTU) than the 5.0 NTU maximum permitted for a system that has a filtration exemption."

To confirm turbidity level requirements for filtration exemption, the credit for subsurface filtration will have to be determined in accordance with the Guidelines for Pathogen Log Reduction Credit Assignment (Province of British Columbia, 2022).

If a filtration exemption is approved by the Ministry of Health, it is likely to be accepted indefinitely so long as the RDCO is able to demonstrate acceptable water quality data to a Drinking Water Officer through regular reporting.

5.3 NEXT STEPS

Our next step is to move to the "concept refinement" stage for the preferred option. Provided RDCO is in agreement with the recommended option per Section 5.1, we suggest that the following items be reviewed as part of the concept refinement work:

System Component	Items to be Reviewed
Groundwater Well	Engage an EAO to better understand the Environmental Certificate or Exemption process and requirements.
	Determine the extent of the required well upgrades to supply the build-out MDD.
	Optional – additional water quality monitoring & characterization considering high extraction rates per Western Water's report.
Treatment	Review available source water quality and identify if any parameters do not meet filtration exemption criteria
	Confirm requirements to achieve required chlorine contact time in the Killiney and

	Westshore water systems using a lower temperature than that used in past reports.
	Determine if there is adequate chlorine contact time for treated water conveyed to the Upper Fintry/Shahal Road/Valley of the Sun service area due to higher pump/flow rates.
	Determine if chlorine boosting is required for water conveyed to Killiney and Westshore.
	Update past conceptual site layout and verify that there is adequate space for proposed works
	Continue to communicate with MoTI to assess the feasibility of placing a watermain in the Westside Road ROW. Review alternate alignments if MoTI won't permit the watermain within their ROW.
High Lift Pump Station and Transmission Main	Review regulatory requirements for the watermain alignment.
	Confirm sizing for the proposed pump station
	Confirm the site location of the proposed treatment facility.
	Identify a preferred tie-in location for the transmission main to the Killiney and Westshore water systems
	Review past cost estimate in detail and update as required based on recent tender prices in the Interior. Prepare updated cost estimate for the works that incorporates findings from the above tasks
Costs	Prepare an updated cost estimate that incorporates findings from the above tasks.

6.0 CLOSURE

We trust this report includes the information required for the RDCO to select a preferred path forward for providing the Killiney and Westshore water systems with a supply and treatment plan that meets the British Columbia Drinking Water Protection Regulation or

Groundwater Protection Regulation, and the Guidelines for Canadian Drinking Water Quality.

If you have any questions regarding the content of this report, please feel free to contact us.

Sincerely,

URBAN SYSTEMS LTD.



2022-06-29

Jeremy Clowes, P.Eng.
Principal, Water and Wastewater Engineer



2022-06-29

Ryan Stewart, P.Eng.
Project Engineer

PERMIT TO PRACTICE
URBAN SYSTEMS LTD.
Signature
Date 2022-06-29
PERMIT NUMBER: 1000527
Engineers and Geoscientists BC (EGBC)

/rs
Enclosure

U:\Projects_KEL\1179\0109\01\R-Reports-Studies-Documents\R1-Reports\1.1 Summary and Evaluation of Supply and Treatment\2022-06-15 - Summary and Evaluation of Supply and Treatment Options_tech memo_Rev5_final.docx

CITED LITERATURE

BC Water Resources Atlas, (2021)

Health Canada

Province of British Columbia, Drinking water treatment objectives (microbiological) for ground water supplies in British Columbia (2015)

Province of British Columbia, Drinking water treatment objectives for surface water supplies in British Columbia (2012)

Province of British Columbia, Guidelines for Pathogen Log Reduction Credit Assignment (2022)

Small Water Systems BC (2021)

Statistics Canada. Infrastructure construction price index, annual (2021)

APPENDIX A

FIGURES

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Regional District of Central Okanagan

Regional District of Central Okanagan

Killiney and Westshore Water Systems Study

Option 1A: Fintry/Short Creek Aquifer Groundwater Supply Well & Submarine Transmission Main

FIGURE 2.1

Legend

- PS — Pump Station
- Disinfection WTP
- Reservoir
- Distribution Main
- Transmission Main

Data Sources:
- Fresh Water Atlas
- ESRI Basemap

Coordinate System:

Name: NAD 1983 UTM Zone 11N

N

0 200 400 600

Meters

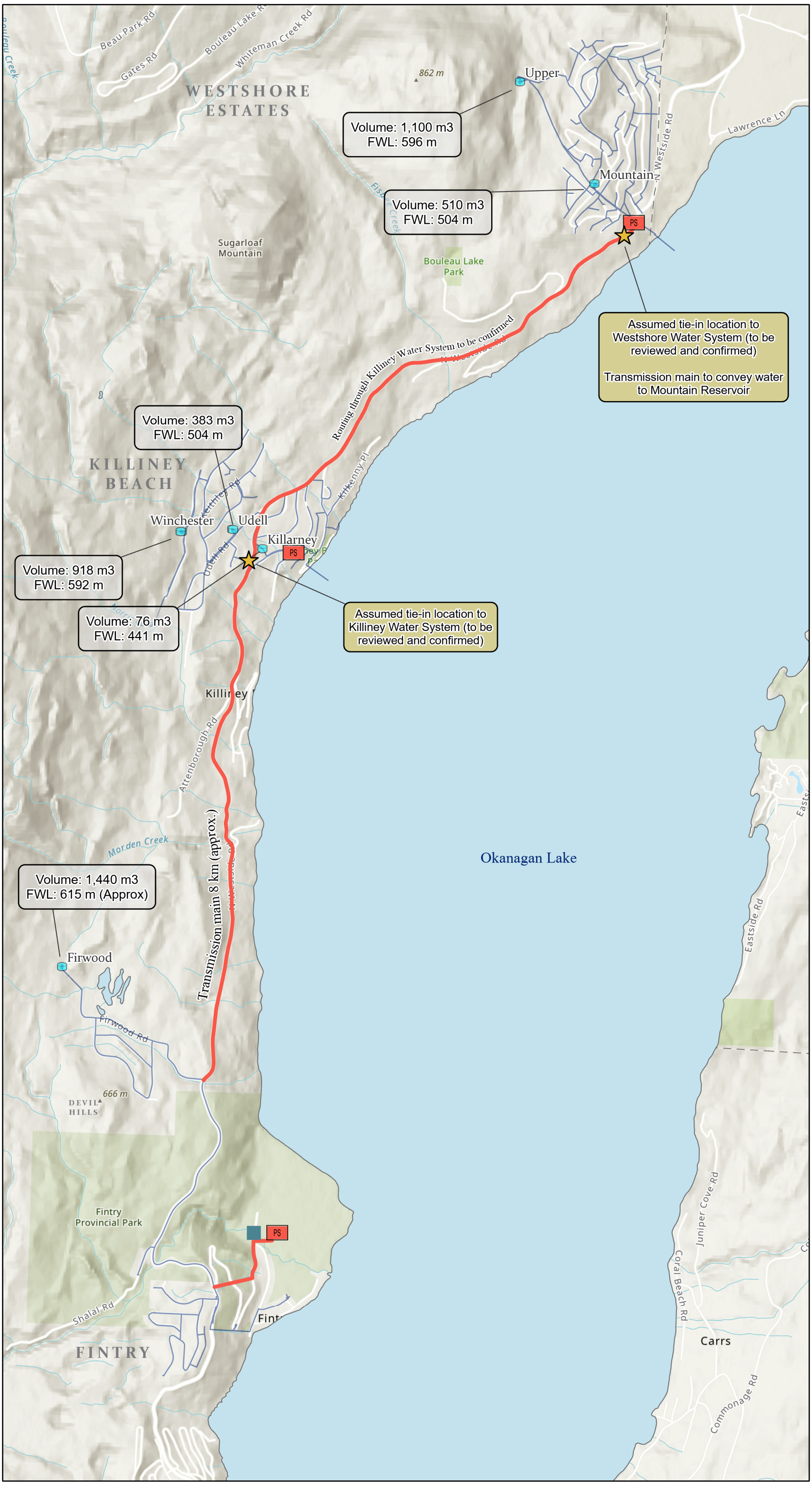
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Revision:	A
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Regional District of Central Okanagan

Regional District of Central Okanagan

Killiney and Westshore Water Systems Study

Option 1B: Fintry/Short Creek Aquifer Groundwater Supply Well & Overland Transmission Main

FIGURE 2.2

Legend

- PS — Pump Station
- Disinfection WTP
- Reservoir
- Distribution Main
- Transmission Main

Data Sources:
- Fresh Water Atlas
- ESRI Basemap

Coordinate System:

Name: NAD 1983 UTM Zone 11N

N

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Meters

Scale: 1:30,000
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Regional District of Central Okanagan

Killiney and Westshore Water Systems Study

Option 2A: Independent intakes and WTP's for Killiney and Westshore

FIGURE 2.3

Legend

- Disinfection WTP
- Future Filtration WTP
- PS Pump Station
- Reservoir
- Extended Intake
- Distribution Main

Data Sources:
- Fresh Water Atlas
- ESRI Basemap

Coordinate System:

Name: NAD 1983 UTM Zone 11N

N

0 200 400 600

Meters

Scale: 1:24,000
(When plotted at 11"x17")

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Regional District of Central Okanagan

Killiney and Westshore Water Systems Study

Option 2B: Independent intakes and disinfection WTP's for Killiney and Westshore in the near term; common intake and filtration WTP for both systems in the long term

FIGURE 2.4

Legend

- Disinfection WTP
- Future Filtration WTP
- PS Pump Station
- Reservoir
- Distribution Main
- Extended Intake
- Future Transmission Main

Data Sources:
- Fresh Water Atlas
- ESRI Basemap

Coordinate System:

Name: NAD 1983 UTM Zone 11N

N

0 200 400 600

Meters

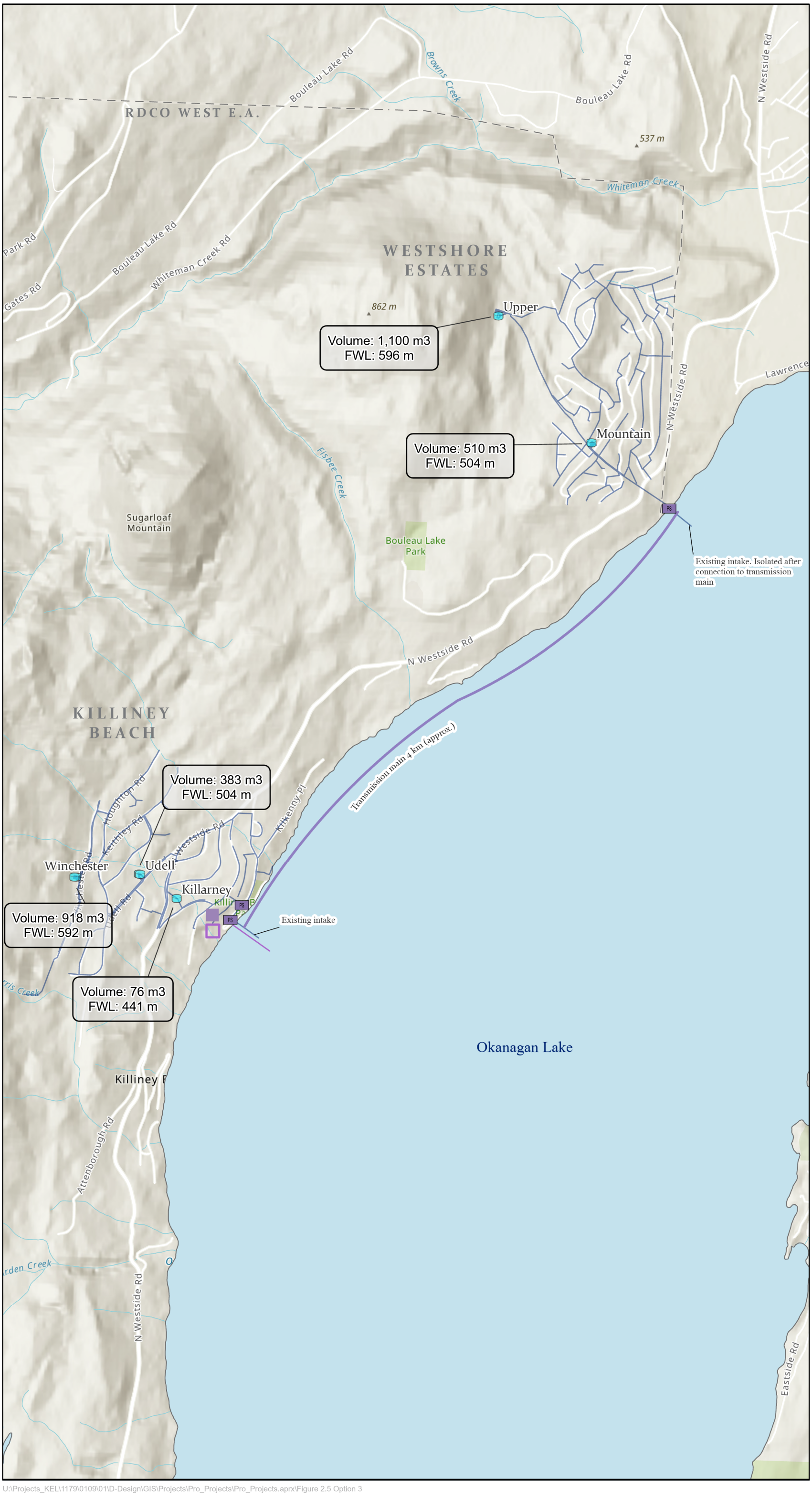
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Status:	
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Regional District of Central Okanagan

Regional District of Central Okanagan

Killiney and Westshore Water Systems Study

Option 2A: Common intake and WTP at Killiney for both water systems

FIGURE 2.5

Legend

- Disinfection WTP
- Future Filtration WTP
- Pump Station
- Reservoir
- Distribution Main
- Transmission Main
- Extended Intake

Data Sources:
- Fresh Water Atlas
- ESRI Basemap

Coordinate System:

Name: NAD 1983 UTM Zone 11N

N

0 200 400 600

Meters

Scale: 1:24,013
(When plotted at 11"x17")

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Revision:	A
Date:	2022 / 6 / 1

APPENDIX B

REFERENCE INFORMATION

Report

Associated Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

Regional District of Central Okanagan

Killiney Beach Water System Review

November 2010



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Table of Contents

SECTION			PAGE NO.
Table of Contents			**i**
1	**Overview**		**1**
2	**Background**		**1**
3	**Objective**		**1**
4	**Existing System**		**2**
	4.1	Existing Infrastructure	2
5	**Water Demand**		**3**
	5.1	Design Criteria	3
6	**Water Treatment**		**4**
	6.1	Raw Water Quality	4
	6.2	Water Quality Objectives	5
	6.3	Filtration Deferral	6
	6.4	Water Treatment Strategy	8
7	**Distribution System Evaluation**		**9**
	7.1	Steady State	9
	7.2	Extended Period Simulation	9
8	**Water System Upgrades**		**10**
	8.1	Discussion Items	13
9	**Cost Estimate**		**13**
10	**Fee Recovery**		**13**
	10.1	Review of Expenses	14
	10.2	RDCO Funds	16

10.3 RDCO Rates 16
10.4 Fee Recovery to 2030 17
10.5 Detailed Income and Expenditures 18

11 Recommendations 19

Enclosure A - Cost Estimating Data 1

Enclosure B – Distribution System Mapping 1

Enclosure C – IHA Filtration Deferral Document 1

Enclosure D – Killiney Beach Model Output 1

REPORT

District of Central Okanagan
Killiney Beach Water System Review

Issued: November 26, 2010
Previous Issue: November 12, 2010

1 Overview

The Regional District of Central Okanagan (RDCO) retained Associated Engineering to review the Killiney Beach water system and to provide the following:

- Review and comment on the CTQ Consultants report entitled "Killiney Beach Review."
- Update the existing computerized water system hydraulic model to a functional extended period simulation model.
- Provide a review of alternatives for major system upgrades listed in the CTQ report and provide any alternative solutions based on an analysis of the distribution system.
- Evaluate the system to comply with the Guidelines for Canadian Drinking Water Quality, Interior Health Authority (IHA) regulations and Regional District of Central Okanagan's (RDCO) Bylaw 704.
- Develop an Operations and Maintenance Fee Recovery Strategy.
- Prepare a Capital Improvements Plan with estimated project costs for recommended water system improvements and project sequencing.

2 Background

The Killiney Beach water system is located on the west side of Okanagan Lake, approximately six kilometres north of Fintry, BC. The water system is currently operated and maintained by the RDCO. Recently, the RDCO has undertaken a water metering program and is investigating required upgrading that is consistent with the RDCO Subdivision and Development Servicing Bylaw N.704.

3 Objective

The purpose of this water system review is to assess the infrastructure needs over the next 20 years and establish financing strategies for which to base user and maintenance fees. This report involved review of past studies, construction documents, files and other relevant information, and visits to each site as required in order to develop plans allowing for managed growth and responsible infrastructure replenishment.

In 2009 CTQ Consultants Ltd of Kelowna BC completed a comprehensive review on the Killiney Beach water system. This review included an assessment of the existing infrastructure and short term and long term capital improvements. An evaluation of a long term financial strategy for the collection of user and maintenance fees was not included.

4 Existing System

4.1 Existing Infrastructure

The Killiney Beach water system currently serves 279 domestic connections with future full build out at 427 connections. The system, shown in **Figure 1** in **Enclosure B**, includes the following existing components:

Lake Intake: The existing Okanagan Lake intake consists of approximately 150 metres of 250 mm PVC pipe in the lake to a depth of 10 m below average lake level

Lake Pump House: the existing pump station consists of two 30 hp vertical turbine pumps, a chlorine gas feed disinfection system and associated mechanical and electrical equipment. Water is boosted via a 200 mm ductile iron (di) main that leads to the distribution system and balanced by Killarney Reservoir.

Killarney Reservoir and Pump Station: A 76 m^3 concrete reservoir sits below the pump station and balances the Low pressure zone. The pump station contains two 15 HP submersible pumps with associated mechanical and electrical equipment. Water is pumped to the Udell Reservoir.

Udell Reservoir and Pump Station: A 76 m^3 concrete reservoir sits below the pump station and balances the mid pressure zone. The pump station contains two 10 HP submersible pumps with associated mechanical and electrical equipment. Water is pumped to the Winchester Reservoir.

Winchester Reservoir and Pump Station: A 416 m^3 concrete reservoir sits below the pump station and balances the Upper pressure zone. The pump station contains two 5 HP submersible pumps with associated mechanical and electrical equipment. Water is pumped to the Hope Creek Reservoir.

Hope Creek Reservoir: A 76 m^3 concrete reservoir sits below a small building with no pump station and balances the High pressure zone.

Distribution System: The distribution system is split into four pressure zones; with each reservoir feeding the pressure zone below it. There are two functioning PRVs that are listed below:

- Corner of Udell and Keithley: a 100 mm PRV reduces pressure to the properties on Lester Road.
- Moody Drive: a 50 mm PRV reduces pressure to the Fire Hall.

- A third PRV exists at Corner of Houghton and Keithley: a 100 mm PRV that is assumed to be closed. It does not seem to serve a purpose.

The majority of the distribution piping is 100 mm with some 150 mm. Many of the deadend lines are between 50 mm and 100 mm pipe. The piping material is assumed to be PVC based on drawings, but operations reports other piping material that was previously installed in some locations. Operations also reports system leakage. Residential water meters are currently being installed.

Fire Protection: There are 26 fire hydrants that are generally connected to 100 mm distribution lines. The hydrants are fed from the reservoirs and therefore not reliant on pumps.

Water Treatment: The current water treatment consists of chlorine gas injection at the Lakeside pump station. The main from the Lakeside pump station is not a dedicated main to the Killarney Reservoir, therefore contact times to several connections are not adequate to disinfect pathogens or viruses.

5 Water Demand

The water supply and treatment components should be designed to meet maximum day demand. The reservoirs should be designed to contain enough balancing volume to meet peak hour demands. The following confirms the water demand design criteria used in this report for the purposes of comparing upgrading options.

5.1 Design Criteria

The RDCO bylaw states the following design criteria for single family residential connections:

Average Day Demand (ADD): 1000 l/ca/d
Maximum Day Demand (MDD): 3000 l/ca/d
Peak Hour Demand (PHD): 5000 l/ca/d

These demands are conservative and ensure new developments are constructed with adequate water supply throughout the development. The Killiney Beach utility is an existing development that the RDCO has taken over. The District is required to plan for future demand criteria that is more in line with actual demand criteria.

For comparison purposes, 2009 pumps records were obtained which showed the maximum flow rate of 4294 m^3 over a 77 hour period. This translates to a system MDD of 15.5 l/s or, based on 270 connections, a demand of 4960 l/connection/day. Using 3 people per connection, this is calculated to be 1653 l/ca/d. This is lower than the water use patterns at the nearby Westshores area. We agree that a demand criteria of 2400 l/ca/d for MDD is still be a reasonable and conservative assumption.

A further reduction in demand may be expected when the meters on each connection are operational. Significant reductions in demand, due to water meter installations, were observed for other communities around the Okanagan.

The following demand criteria are suggested for the Killiney Beach community which are the same criteria set out in City of Kelowna's bylaw for residential units and are in line with existing demands.

ADD: 900 l/ca/d
MDD: 2400 l/ca/d
PHD: 4000 l/ca/d

The Killiney Beach water model was therefore evaluated using a MDD criteria of 2400 l/ca/d for existing and future build out connections.

Ultimate build out with 430 lots, using a demand criteria of 7200 l/conn/d would yield a MDD of 35.8 l/s. This should be the target design for the distribution system.

6 Water Treatment

6.1 Raw Water Quality

The Killiney Beach water supply is drawn from Okanagan Lake, where water quality is generally considered to be very good. Raw water quality characterization presented in Table 6-1 is based on a review of data from the City of Kelowna and the City of Penticton, and provides an indicator of the raw water quality since 1990. Data collected from the Killiney Beach intake is also shown in the table for comparison. Water quality in the lake is relatively consistent and not subject to rapid significant changes. This is due to the size and volume of the lake. Kelowna and Penticton both withdraw their water from depths greater than 25 metres where the seasonal water quality is very consistent, thereby simplifying its treatability.

Table 6-1
Raw Water Quality

Parameters	Units	Min.	Max.	Normal	Killiney Beach June 2009
Alkalinity	mg/l	101	122	109	106
Colour	TCU	0	5	2	<5
Hardness	mg/l	105	130	117	128
pH	pH	7.5	9.1	8.0	7.9
Turbidity	NTU	0.1	4	0.5	0.7
Calcium	mg/l	30	38	34	34.8
Iron	mg/l	.01	.11	.02	<0.1
UV Transmittance	%	83	94	87	90.5

The existing intake depth at Killiney Beach is only 10 metres which is significantly less than the City of Kelowna and Penticton intake depths. Experience has shown that water extracted at this depth is prone to more frequent spikes in turbidity. Operations reports turbidity spikes above 1.0 NTU at the lake intake. Water sampling from February to May of this year showed maximum turbidity in the range of 0.7 NTU. E-coli and total coliforms were found to be less than 1 count per 100 ml sampled.

6.2 Water Quality Objectives

In 2006, the Interior Health Authority (IHA) established the 4.3.2.1.0 Drinking Water Objective. Under this objective the following criteria were established:

- 4 log virus removal
- 3 log Giardia and Cryptosporidium removal or inactivation
- 2 stages of treatment – see below
- 1 NTU turbidity maximum
- 0 bacterial indicators

Under the new objective a minimum of 2 stages of treatment is required for water that is at risk of containing pathogens. Filtration and disinfection should be considered on most water supplies to ensure a safe supply of water. UV light and chlorination can be considered for source water that meets the criteria for filtration deferral as outlined in the next section.

IHA now requires purveyors to issue a water quality advisory when turbidity values exceed 1.0 NTU and a boil water advisory if turbidity exceeds 5.0 NTU. Ultimately, all surface waters are to be filtered and this is to be taken into account in the planning of water treatment improvements by each water purveyor.

6.3 Filtration Deferral

Deferral of Filtration is presently a key strategy in place for utilities that have surface water sources. This is a viable option for the Killiney Beach water system assuming the following criteria can be met.

In February 2008 the IHA published an Issue Paper defining the criteria for the "Deferral of Filtration".

As described in more detail in **Enclosure C**, the following are the basic requirements that must be met in order for a water source to be considered for deferral of filtration:

1. 4-log removal or inactivation of viruses and 3-log inactivation of protozoa is achieved using a minimum of 2 disinfection processes.
2. A watershed control program designed with the express purpose of minimizing fecal contamination in the source water is being implemented. Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the Comprehensive Source to Tap Assessment Guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO (basically Modules 1, 2, 7 and 8) and may be included in conditions of the operating permit.
3. Background baseline levels of Cryptosporidium and Giardia, adequate to establish trends, have been established.
4. No more than 10% of source/raw water E.coli samples exceed 20/100 mL in any 6-month period.
5. No more than 10% of source/raw water total coliform samples exceed 100/100 mL in any 6-month period.
6. Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.*
7. Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period.
8. Expected average annual total Trihalomethanes at locations farthest from treatment will not exceed 0.100 mg/L or 100 µg/L.

* This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that might not always meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that

identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month". It is also important to remember that the GCDWQ is only a guideline. Turbidity is not necessarily a sure sign that pathogens are present, however, it is indicative of the possibility of their presence.

UV disinfection with chlorine achieves requirement No. 1 providing that the source water is of sufficiently good quality for the processes to be technically feasible. Okanagan Lake water would be sufficiently good.

The IHA Deferral of Filtration document in **Enclosure C** expands on the criteria for meeting Requirement No. 2. Regardless of the method used and plan developed, it is expected that the following elements will be included:

1. Characterization of the source water and delineation of the area of the watershed from which source water originates. This should include an evaluation of the pathways and estimated time of travel for fecal pathogens to the intake from different areas in watershed.
2. Identification of potential sources of fecal pollution within the watershed that pose a threat of introducing pathogenic organisms to the drinking water system.
3. An assessment of the risks to public health posed by the identified sources of fecal pollution.
4. A plan to mitigate the risks posed by sources of fecal pathogens in the capture zone and limit future contamination of the water source.

The document in **Enclosure C** clarifies that it is not necessary to have exclusive use of a watershed to have a watershed control program.

Monitoring must be done to achieve requirement Nos. 3 through 8. **Enclosure C** provides the following typical levels of monitoring:

Microbes

- E.coli & Total Coliforms (minimum weekly samples)
- Protozoa (monthly samples)

Physical Parameters

- Temperature (minimum weekly)
- Turbidity (daily averages based on minimum of 1 sample every 4 hours. However, elsewhere in **Enclosure E** on-line continuous turbidity monitoring is specified as being required)
- Colour (minimum weekly)
- UV transmittance (minimum weekly)

Chemical Parameters

- Alkalinity & Hardness (minimum bi-weekly)
- Total Organic Carbon (minimum bi-weekly)
- pH (minimum weekly)

Source monitoring to establish compliance with filtration deferral criteria should be conducted over at least a one year period, preferably longer. Testing should be done by an approved laboratory with samples collected using appropriate methods.

It must be noted that these are the monitoring requirements necessary to obtain and sustain deferral of filtration from the Regulator. However, if filtration is deferred and there are subsequently problems, then filtration may be required. Thus, if the current data is presently inconclusive that deferral of filtration would be viable, gathering additional data would be prudent. We must note that while the filtration deferral may decrease costs in the short term, there are risks in adopting the policy. Okanagan Lake is always at risk of external pollutants, algae blooms and other bacteriological or organic changes due changes in water temperature. Intakes are also at risk from creek outflows, recreation and lake hydraulics.

6.4 Water Treatment Strategy

The Project Team met with local IHA representatives. To assure full compliance with the 4-3-2-1-0 Drinking Water Objective, multi-stage treatment incorporating filtration would be required. Depending on the quality of the source water, there are numerous ways of achieving filtered water including direct filtration, clarification and filtration, and membrane filtration.

In order to eliminate Boil Water Advisories or Notices at Killiney Beach, we recommend the RDCO develop a plan to meet IHA's 4-3-2-1-0 guideline. As Okanagan Lake is generally considered a good quality water source, the RDCO should initiate an application for Filtration Deferral. While this will meet most of the requirements (4-3-2-1-0), it would lower some costs in the short term. As part of the application, a comprehensive source water study would be required to prove that local external factors, intake depth or lake hydraulics for each water intake do not adversely affect the raw water quality to the point where UV light is rendered ineffective.

The selected treatment strategy will be dependent on further source monitoring with the existing intake once it has been cleaned. It will be important to observe the turbidity throughout a full year since operations reports turbidity readings over 1.0 NTU during the lake turnover. If it becomes obvious that the existing system cannot meet the deferral criteria, it is recommended that the intake line be extended further into the lake to obtain a depth of greater than 25 metres below the surface of Okanagan Lake.

7 Distribution System Evaluation

Modeling of the Killiney Beach distribution system was conducted using WaterCAD 8.0 with a model derived from the RDCO's GIS system and record drawings.

Detailed design parameters for pumps, reservoirs and pressure reducing valves were incorporated in the model. This information was extracted from design reports, operations manuals, design changes and any recent adjustments noted by operations staff.

The software is equipped to provide a variety of analytical methods, including steady state and extended-period simulations.

WaterCAD modelling output for the existing infrastructure is provided in **Enclosure D**. The daily water use patterns, pump controls, water demands, and fire flow simulation results are also supplied.

7.1 Steady State

Steady state analysis is useful in determining where potential trouble spots can occur in the system, such as excess pipeline velocities, typical pressures, under-pressures and fire flow requirements. Older popular distribution models used a steady state solution, which iterated calculations to create an average distribution pattern and hydraulic grade line for a particular scenario. As described in AWWA M32 (2005), the steady state model is used to:

- Calibrate the system to ensure that it predicts distribution system behaviour with sufficient accuracy.
- Select limiting conditions for design scenarios.
- Establish design criteria.
- Develop system improvements.
- Evaluate fire flow conditions.

7.2 Extended Period Simulation

Extended-period simulations (EPS) are useful to examine the behaviours in a distribution system based on demand patterns and operations over a period of 24 hours or longer. EPS is useful for ensuring the distribution system including pump controls, and reservoirs, is adequately sized to meet MDD over the course of a full day. EPS can greatly improve water system planning and operation at a relatively low cost.

8 Water System Upgrades

The following section outlines the review of the CTQ Consultants report entitled "Water System Review". Upgrades were analyzed and are recommended based on scenarios developed from the water model and IHA's water quality requirements. **Figures 2 and 3** of **Enclosure B** show the upgrades recommended for these scenarios. Options were evaluated and determined to be feasible, and the following items were sized to provide a more accurate cost estimate.

Scenario A – Upper Reservoir Construction

This option would provide adequate storage in a newly proposed reservoir above Winchester reservoir or at Hope Creek and, if the distribution network was upgraded, could provide a volume of water large enough to supply a residential fire. By supplying the reservoir directly from the lake, the other pump stations in the system could be eliminated.

Reservoir:

The required size for this reservoir would be:

Total Storage Requirement = A + B + C

Where A = Fire Storage
B = Equalization Storage
C = Emergency Storage

Useful Existing Reservoir Capacity = 416 m^3 (Winchester), 76 m^3 (Udell), 76 m^3 (Killarney)

Future Build Out: A = 60 l/s x 1.5 hours = 324 m^3
B = 25% x 427 conn x 7200 l/conn/day = 769 m^3
C = 25% x (324 + 769) = 273 m^3
Total = 1366 m^3

Therefore the new reservoir would be approximately 1366 m^3 – 416 m^3 (Winchester) – 76 m^3 (Udell) – 76 m^3 (Killarney) = 798 m^3, or 0.80 LM.

Pipeline:

We conservatively estimate 2000 m of a new 250 mm pipeline from Lakeside pump station to the new reservoir. This could be reduced depending on the right of way access that the RDCO is able to obtain, and where the location of the reservoir is placed. This will require greater than class 350 ductile iron to meet the higher pressure requirements.

Pumps:

Pumps at Lakeside would be upgraded to flow against 295 m of head at 40 l/s. Water hammer and structural strengthening will be key design features. The pump, fittings and piping would be rated for higher class pressure ratings. Emergency backup power would be required for, at a minimum, one pump motor at this location only.

Fire Protection:
In order to supply fire flow to the distribution system, the majority of the distribution lines would require upsizing. The existing distribution system is undersized in all locations to provide the required 60 l/s at 140 kPa. The hydrants should be tied into new 150 mm or 200 mm mains.

Scenario B – Udell Reservoir Upgrade

This option would provide adequate storage in the Udell and Hope Creek reservoirs. The Udell reservoir would be supplied by the Lakeside pump station and pumps at the Udell pump station would supply the Hope Reservoir. The other pump stations in the system could be eliminated.

Reservoir:
For this Option, Hope creek and Udell Reservoirs would be expanded and Winchester reservoir would be kept the same size.

As above, required total storage capacity would be 1366 m^3.
Useful Existing Reservoir Capacity = 416 m^3 (Winchester), 76m3 (Udell), 76 m3 (Killarney)

An additional reservoir upgrade at Hope Creek would be required to ensure that adequate fire protection volume is available for all areas within the distribution system.
The required size for Hope Creek would be:

Future Build Out: A = 60 l/s x 1.5 hours = 324 m^3
B = 25% x 98 conn x 7200 l/conn/day = 176 m^3
C = 25% x (324 + 176) = 125 m^3
Total = 625 m^3

The proposed Hope Creek reservoir would be 0.63 ML.

The required storage at Udell Reservoir would be 1366 m^3 – 625m3 (Hope)– 416 m^3 (Winchester) – 76 m^3 (Killarney) = 249 m^3.

Therefore Udell reservoir would be upsized to a total size of 0.25 ML

Pipeline:
Requires 900 m of a new 250 mm pipeline from Lakeshore to Udell reservoir and 1200 m of new 200 mm pipeline from Udell to Hope Creek reservoir. The pipeline would be pressure class 250 and would likely be Ductile Iron.

Pumps:
The Lakeside pump station would be upgraded to pump 165 m of head at 40 l/s. The upgraded Udell pump station would pump 130 m of head at approximately 25 l/s. Emergency backup power would be required for, at a minimum, one pump motor at both pump stations.

Fire Protection:

In order to supply fire flow to the distribution system, the majority of the distribution lines would require upsizing. The existing distribution system is undersized in all locations to provide the required 60 l/s at 140 kPa. The hydrants should be tied into new 150 mm or 200 mm mains.

Scenario C - Upgrade Existing Infrastructure

A third Option that was not included in the CTQ report, was evaluated that represents a more status quo approach and would allow for a more staged approach to upgrading. **Figure 4** in **Enclosure B**, shows the upgrades recommended in this scenario.

This option would provide adequate fire storage in the Udell and Hope Creek reservoirs. Winchester and Killarney reservoirs would remain and be used for balancing. All the pump stations would remain, but would require upgrading.

Reservoir:

For this Option, all reservoirs except Winchester Reservoir would be upgraded to the following sizes:

Table 8-1
Proposed Reservoir Sizes

Name	Existing Size (m^3)	Proposed Size (m^3)
Hope Creek	76	625
Winchester	416	416
Udell	76	650
Killarney	76	200

The Hope Creek and Udell reservoirs would be sized for fire supply and the Winchester and Killarney would be sized only for balancing their respective pressure zones and would receive fire supply from the reservoir above them through pressure reducing stations. The total combined reservoir volume is greater than Scenario A and B due to the hydraulic breaks in the system between pressure zones and the fewer PRV stations that allow water to cascade from the higher pressure zones.

Pipeline:

Requires 700 m of a new dedicated raw water 250mm PVC pipeline from Lakeshore to Killarney reservoir.

Pumps:

The Lakeside pump station would be upgraded to pump 40 l/s at the same head pressure. Killarney would be upgraded to flow approximately 30 l/s. Udell would be upgraded to flow approximately 20 l/s. Winchester would be required to flow 8 /ls and therefore would only require a new spare pump at this pump station. Each pump station should have a lead and a lag pump and

one spare pump. Emergency backup power would be required for, at a minimum, one pump motor at each pump station.

Fire Protection:
In order to supply fire flow to the distribution system, the majority of the distribution lines would require upsizing. The existing distribution system is undersized in almost all locations to provide the required 60 l/s at 140 kPa. The hydrants should be tied into new 150 mm or 200 mm mains. If hydrants are tied into 100 mm mains, the velocity in the pipe exceeds 4 m/s when the required 60 l/s flows through the pipe.

8.1 Discussion Items

Fire Flow:
Based on a review of the Fire Underwriters Survey, we recommend a fire flow of 60 l/s based on the location of Killiney Beach. The lots are fairly closely spaced and when full build-out is reached, it is assumed that many of the structures will be less than 10 metres apart. Also, the area is heavily treed so a conservative fire flow of 60 l/s is recommended.

9 Cost Estimate

Cost estimates for Options 1 and 2 represent estimates with Filtration and with a Filtration deferral are shown in **Enclosure A** with the unit cost tables directly following. Both Options 1 and 2 contain all three evaluated Scenarios A, B and C as described in the previous section.

10 Fee Recovery

The RDCO requires a fee recovery strategy to offset the anticipated capital costs required as part of this 20 year plan.

Water rates should:
1. Recover all costs of utility operations, short and long term capital costs, etc.
2. Encourage customers to be water smart.
3. Be affordable, and considerate to the economy and demographics.

The fee recovery strategy should include:
1. Annual operations and maintenance,
2. Offset long-term capital improvement costs,
3. Asset management, depreciation and inflation,
4. Forecasting of operational/regulatory/administrative changes.

10.1 Review of Expenses

For this study, historical annual statements from the RDCO were examined for the Killiney Beach system. Historically, the RDCO financial statements are reported as Revenue, and two forms of expenses:

1. Salaries and Administration
2. Operations and Maintenance (O&M). All Capital Works funds were included in this expense.

For this study, we rearranged the expense statements to reflect three items:

1. *Annual Operations:* Those expenses required annually to operate the system. These operations apply to the 279 current users on the system.
2. *Capital Operations and Maintenance:* Those expenses required to maintain the existing system. These operations apply to all 427 parcels that are or can be connected to the system.
3. *Capital Works:* Those Project Expenses which add or provide system improvement. These projects or works are often eligible for government funding through municipal programs or gas tax rebates. These divisions are based on Associated Engineering's best estimate to where the fees have been allocated in the past and budgeted in the future.

Table 10-1
Summary of RDCO Revenue and Expenses for the Killiney Beach System (2007-2010)

	2010 (Budgeted)	2009 (Actual)	2008 (Actual)	2007 (Actual)
Revenue				
Water User Fees	126,000	112,041	116,426	117,263
Connection Inspection Fee	6,000	6,215	6,595	5,380
Total Revenue	132,000	118,256	123,021	122,643
Expenses				
Annual Operations				
Salaries - Full Time	32,781	31,901	28,696	28,417
Salaries - Over Time	2,500	4,148	2,381	851
Previous Year Net Balance (-ve = Surplus)	5,067	4,620	-466	1,146
Admin Overhead Recoverable	18,083	13,550	13,771	15,780
Payroll Overhead	8,115	7,977	6,935	6,669
Memberships	250	650	553	436
Training/Education	1,000	1,006	817	0
Publications/Subscriptions			337	356
Telephone	6,500	9,431	1,996	2,122
Travel	5,200	5,401	5,159	4,649
Power	24,000	22,826	22,627	19,818
Chlorine	3,000	361	3,028	
Ministry Testing	2,500	1,941	4,132	2,182
Insurance	2,123	2,030	1,853	1,598
Sub-Total Administration	111,119	105,842	91,819	84,024
Capital Operations and Maintenance				
Small Tools	250	266	174	525
Water Rates (Licenses)	650	339	645	1,254
Equipment Repairs & Maintenance	10,000	11,669	6,838	8,797
Contract Services	7,500	5,209	11,275	19,470
Sub-Total O&M	18,400	17,483	18,932	30,046
Capital Works Projects				
Water Meter Installation	185,000			615
Reservoirs		23,797		
SCADA	60,000			
Engineering/Planning/Design	15,000			
Transfer to (+) Equipment Reserve	2,481		16,890	544
Transfer from (-) Equip't Reserve	-260,000	-23,797		
Transfer from (-) Water Cpt'l Fund				6,949
Sub-Total Capital Works	2,481	0	16,890	8,108
Total Expenses	132,000	123,325	127,641	122,178

Column A in Table 10-2 is a summary of expenses for the period 2007 to 2009 extracted from base information in Table 10-1. Column B represents the 2010 budgeted expenditures.

Assuming that Annual Operations are paid for entirely by the 279 existing users, and that the rest is paid by all 427 parcels on the system, Columns D and E represent historical and 2010 budgeted expenditures per group.

Table 10-2
Summary of Expenditures per Unit Charged

	A	B	C	D	E
Expense Category	Average Expenditures 2007-2009	Budgeted Expenditures 2010	Units	Average Historical Expenditures per unit 2007-2009	Estimated 2010 Allocation
Annual Operations	$93,895	$106,052	279	$337	$380
Annual O&M Replacement	$22,159	$18,400	427	$52	$43
Annual Capital Replacement	$8,333	$7,548	427	$20	$18
Total	$124,387	$132,000			

Note: Units are expressed in number of connections for User Fees, and number of Parcels for O&M and Capital

10.2 RDCO Funds

The RDCO currently maintains two funds where fees are allocated:

1. A Water Revenue Fund (WRF) is an operating account for annual Operations and Maintenance. This account is the annual utility budget used to pay for daily operations and for short term emergencies.
2. An Equipment Replacement Reserve Fund (ERRF) for capital replacement. The ERRF is an interest bearing reserve account of the District for water system improvements. This fund can be used for debt servicing or funding capital expenditures. To date, unused annual fees are placed into this Fund.

10.3 RDCO Rates

Two forms of water rates are charged by the RDCO:

1. User Fees are charged for every residence currently connected to the water distribution system. In 2010, 279 residences pay user fees out of a possible 427 connections at Killiney Beach.
2. Annual Maintenance Fees are charged to all 427 parcels within the Killiney Beach development, whether connected or vacant.

For reference, the 2010 water rates are shown in Table 10-3, Column A.

10.4 Fee Recovery to 2030

This water master plan outlines the capital works project required to meet future demands, fire flows, and water quality parameters that meet all minimum regulatory requirements. The RDCO, through their fee structure, must be able to recuperate all costs.

All annual Operation and Maintenance replacement costs must be funded at 100 percent by residential users and lot owners. Capital Works must also be funded by users and lot owners, however the District can apply for municipal grants, or Gas Tax grants (as was the case in 2010) to partially fund these types of projects.

Annual Operation expenses must be recovered through user fees charged to each resident as shown in Column E of Table 10-2. In 2012, the user fee identified in Column C of Table 10-3 is recommended. In the future, this portion of the fees could be related to consumption type fees (i.e. cost per cubic meter).

Column A in Table 10-3 identifies the rates approved by the RDCO Board for 2010. In 2011, the Annual Maintenance Fee will be increased to $200. Column C of Table 10-3 shows the estimated Capital O&M and Capital Works annual costs per parcel based on future capital works costs estimates detailed in Table 7 in **Enclosure B**. Government funding of the capital works is a real possibility; we estimate that 30 percent funding can be achieved. Therefore, the Killiney Beach fees should be set to approximately the rates shown in Column D of Table 10-3.

Table 10-3
Recommended Future Collection Fees

	A	B	C	D
Expense Category	2010 Rates	2011 Rates	2012 Fees (assuming no funding)	2012 Fees (Assuming 30% funding from outside sources)
User Fee per Residential Unit	$226	$232	$380	$380
Annual Maintenance Fee				
Capital O&M	$150	$200	$43	$43
Capital Works	$0	$0	$733	$489
Maximum Fee	$376	$432	$1,156	$912

Notes: Units expressed in number of connections for User Fees, and number of Parcels for O&M and Capital

10.5 Detailed Income and Expenditures

Table 7 in **Enclosure B** is a detailed account of income and expenditures required each year to complete the capital works plan over the 20 year period to the year 2030. The Filtration Deferral option was examined as this is the recommended option to pursue.

The rates are divided into 3 categories in Table 7.

1. Annual Operations and Maintenance: Rates recommended in Table 10-3, with 2% annual increases starting in 2012. Rate increases occur the year following implementation of individual projects.
2. Annual Maintenance Fee:
    a. O&M: Rates per parcel identified in Table 10-3, with 2% annual increase for inflation, starting in 2012,
    b. Capital: Calculated as the total capital funds required to maintain a net positive capital fund balance of $50,000 in the year 2030. No interest or inflation is assumed in this calculation, since loans for these projects are not permitted without the consent of the electorate.

Figure 1 in **Enclosure B** provides a graphical summary of the anticipated rates over 20 years. This assumes an implementation plan where projects are spread out over the 20 years, as demonstrated in Table 7.

11 Recommendations

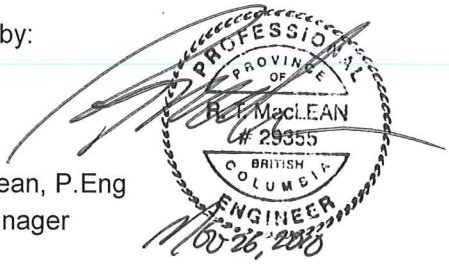
1. We recommend that the Regional District proceed with either Options B or C. Option B is more expensive, but involves fewer pumps and would be simpler to operate. Both options meet maximum day and fire flow requirements for all users.
2. We recommend that the Regional District proceed with the filtration deferral application process.
3. We recommend the rate increases as outlined in this report to meet both operational and capital replacement obligations to the year 2030.
4. We recommend that this capital plan be adopted.

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ML/RM/cb

Enclosure A - Cost Estimating Data
Enclosure B – Distribution System Mapping
Enclosure C – IHA Filtration Deferral Document
Enclosure D – Killiney Beach Model Output

Enclosure A - Cost Estimating Data

Table 1
OPTION 1
Killiney Beach - Filtration Deferral Option

					Scenario A		Scenario B		Scenario C	
Item	Quantity	Unit	Unit Cost	Extension	Cost	2011 O&M Cost	Cost	2011 O&M Cost	Cost	2011 O&M Cost
Watermain Replacement										
150 mm PVC	7,000	m	255	1,785,000	1,785,000	8,925	1,785,000	8,925	1,785,000	8,925
200 mm PVC	3,400	m	310	1,054,000	1,054,000	5,270	1,054,000	5,270	1,054,000	5,270
New Intake	1	LS	25,000	25,000	25,000	125	25,000	125	25,000	125
Additional 400 mm Pipe	1,050	m	400	420,000	420,000	2,100	420,000	2,100	420,000	2,100
SCADA	1	LS	50,000	50,000	50,000	250	50,000	250	50,000	250
Water Meters										
Pumpstation	3	ea	4,000	12,000	12,000	60	12,000	60	12,000	60
Backup Generators	1	ea	250,000	250,000	250,000	2,500	250,000	2,500	250,000	2,500
Additional Hydrants	5	ea	10,000	50,000	50,000	250	50,000	250	50,000	250
Scenario A - CTQ Option - Single pump to High Zone										
High Zone Reservoir	800	/m^3	500	400,000	400,000	2,000				
250 mm DI (Restrained, High Pressure Class)	2,000	m	600	1,200,000	1,200,000	6,000				
Pump Replacement (Lakeshore)	3	LS	60,000	180,000	180,000	18,000				
Upgrade Mechanical components (400psi)	3	ea	40,000	120,000	120,000	600				
Pressure Reducing Stations	5	ea	25,000	125,000	125,000	625				
Scenario B - CTQ Option - 2 pump systems										
Reservoir (Udell)	250	/m^3	500	125,000			125,000	625		
Reservoir (Hope Creek)	625	/m^3	500	312,500			312,500	1,563		
250 mm DI (Restrained, 250 Class)	900	m	500	450,000			450,000	2,250		
200 mm DI (Restrained, 250 Class)	1,200	m	400	480,000			480,000	2,400		
Pump Replacement (Lakeshore)	3	LS	50,000	150,000			150,000	15,000		
Pump Replacement (Udell)	3	LS	40,000	120,000			120,000	12,000		
Upgrade Mechanical components (250psi)	3	ea	30,000	90,000			90,000	9,000		
Pressure Reducing Stations	5	ea	25,000	125,000			125,000	625		
Scenario C - Upgrade Current System (AE)										
Reservoir (Udell)	650	/m^3	500	325,000					325,000	1,625
Reservoir (Hope Creek)	625	/m^3	500	312,500					312,500	1,563
Reservoir (Killarney)	200	/m^3	500	100,000					100,000	500
250 mm PVC	700	m	365	255,500					255,500	1,278
Pump Replacement (Lakeshore)	3	ea	30,000	90,000					90,000	9,000
Pump Replacement (Killarney)	3	ea	25,000	75,000					75,000	7,500
Pump Replacement (Udell)	3	ea	20,000	60,000					60,000	6,000
Upgrade Mechanical components	3	ea	10,000	30,000					30,000	150
Pump Addition (Winchester)	1	ea	10,000	10,000					10,000	1,000
Pressure Reducing Stations	2	ea	25,000	50,000					50,000	250
Subtotal					**$5,671,000**	**$47,000**	**$5,499,000**	**$63,000**	**$4,954,000**	**$48,000**
Engineering and Contingencies		30%			**$1,701,300**	**$14,100**	**$1,649,700**	**$18,900**	**$1,486,200**	**$14,400**
Total Distribution system					**$7,372,300**	**$61,100**	**$7,148,700**	**$81,900**	**$6,440,200**	**$62,400**
Water Treatment (Incl. Eng & Contingencies)										
Chemical Coagulation and Mixing	3.07	ML/d								
Flocculation										
Clarification										
Filtration										
Primary Disinfection (Chlorination - Existing)										
Secondary Disinfection (UV)					$479,606		$479,606		$479,606	
Source Assessment Study					$50,000		$50,000		$50,000	
Residuals Management										
Subtotal Water Treatment					**$529,606**	**$29,451**	**$529,606**	**$29,451**	**$529,606**	**$29,451**
TOTAL					**$7,901,906**	**$90,551**	**$7,678,306**	**$111,351**	**$6,969,806**	**$91,851**

Table 2
OPTION 2
Killiney Beach - Full Treatment or Filtration Option

Item	Quantity	Unit	Unit Cost	Extension	Scenario A Cost	Scenario A 2011 O&M Cost	Scenario B Cost	Scenario B 2011 O&M Cost	Scenario C Cost	Scenario C 2011 O&M Cost
Watermain Replacement										
150 mm PVC	7,000	m	255	1,785,000	1,785,000	8,925	1,785,000	8,925	1,785,000	8,925
200 mm PVC	3,400	m	310	1,054,000	1,054,000	5,270	1,054,000	5,270	1,054,000	5,270
New Intake	1	LS	25,000	25,000	25,000	125	25,000	125	25,000	125
SCADA	1	LS	50,000	50,000	50,000	250	50,000	250	50,000	250
Water Meters										
Pumpstation	3	ea	4,000	12,000	12,000	60	12,000	60	12,000	60
Backup Generators	1	ea	250,000	250,000	250,000	2,500	250,000	2,500	250,000	2,500
Additional Hydrants	5	ea	10,000	50,000	50,000	250	50,000	250	50,000	250
Scenario A - CTQ Option - Single pump to High Zone										
High Zone Reservoir	800	/m^3	500	400,000	400,000	2,000				
250 mm DI (Restrained, High Pressure Class)	2,000	m	600	1,200,000	1,200,000	6,000				
Pump Replacement (Lakeshore)	3	LS	60,000	180,000	180,000	18,000				
Upgrade Mechanical components (400psi)	3	ea	40,000	120,000	120,000	600				
Pressure Reducing Stations	5	ea	25,000	125,000	125,000	625				
Scenario B - CTQ Option - 2 pump systems										
Reservoir (Udell)	250	/m^3	500	125,000			125,000	625		
Reservoir (Hope Creek)	625	/m^3	500	312,500			312,500	1,563		
250 mm DI (Restrained, 250 Class)	900	m	500	450,000			450,000	2,250		
200 mm DI (Restrained, 250 Class)	1,200	m	400	480,000			480,000	2,400		
Pump Replacement (Lakeshore)	3	LS	50,000	150,000			150,000	15,000		
Pump Replacement (Udell)	3	LS	40,000	120,000			120,000	12,000		
Upgrade Mechanical components (250psi)	3	ea	30,000	90,000			90,000	9,000		
Pressure Reducing Stations	5	ea	25,000	125,000			125,000	625		
Scenario C - Upgrade Current System (AE)										
Reservoir (Udell)	650	/m^3	500	325,000					325,000	1,625
Reservoir (Hope Creek)	625	/m^3	500	312,500					312,500	1,563
Reservoir (Killarney)	200	/m^3	500	100,000					100,000	500
250 mm PVC	700	m	365	255,500					255,500	1,278
Pump Replacement (Lakeshore)	3	ea	30,000	90,000					90,000	450
Pump Replacement (Killarney)	3	ea	25,000	75,000					75,000	375
Pump Replacement (Udell)	3	ea	20,000	60,000					60,000	300
Upgrade Mechanical components	3	ea	10,000	30,000					30,000	150
Pump Addition (Winchester)	1	ea	10,000	10,000					10,000	50
Pressure Reducing Stations	2	ea	25,000	50,000					50,000	250
Subtotal					**$5,251,000**	**$45,000**	**$5,079,000**	**$61,000**	**$4,534,000**	**$24,000**
Engineering and Contingencies		30%			**$1,575,300**	**$13,500**	**$1,523,700**	**$18,300**	**$1,360,200**	**$7,200**
Total Distribution system					**$6,826,300**	**$58,500**	**$6,602,700**	**$79,300**	**$5,894,200**	**$31,200**
Water Treatment										
Chemical Coagulation and Mixing	3.07	ML/d			$95,921		$95,921		$95,921	
Flocculation					$287,764		$287,764		$287,764	
Clarification					$671,448		$671,448		$671,448	
Filtration					$1,007,172		$1,007,172		$1,007,172	
Primary Disinfection (Chlorination - Existing)					$0		$0		$0	
Secondary Disinfection (UV)					$0		$0		$0	
Source Assessment Study					$0		$0		$0	
Residuals Management					$191,842		$191,842		$191,842	
Subtotal					**$2,254,148**	**$129,159**	**$2,254,148**	**$129,159**	**$2,254,148**	**$129,159**
TOTAL					**$9,080,448**	**$187,659**	**$8,856,848**	**$208,459**	**$8,148,348**	**$160,359**

Table 3
Unit Costs - Buried Pipe

Diameter	Pipe Supply & Install (1)	Hydrants & Valves (2)	Pavement Restoration	Total Excl Pavement	Total Incl Pavement
25	$70	$25	$75	$95	$170
50	$80	$25	$75	$105	$180
75	$90	$25	$75	$115	$190
100	$120	$25	$75	$145	$220
150	$140	$40	$75	$180	$255
200	$190	$45	$75	$235	$310
250	$240	$50	$75	$290	$365
300	$290	$55	$75	$345	$420
350	$340	$60	$90	$400	$490
400	$390	$65	$90	$455	$545
450	$440	$70	$90	$510	$600
600	$590	$75	$100	$665	$765
750	$740	$80	$100	$820	$920
900	$890	$90	$100	$980	$1,080

Notes:

(1) PVC or DI Pipe

(2) Assumes buried line valves, one hydrant per 100m, one air valve assembly per 500m

(3) Costs do not include engineering and contingencies

Table 4.
Water Treatment Unit Costs

Process	Larger System Base Cost Per ML/d (> 5 ML/d)	Smaller System Base Cost Per ML/d (< 5 ML/d)
Chemical Coagulation and Mixing	$26,000	$31,200
Flocculation	$78,000	$93,600
Clarification		
-Conventional Tube or Plate Settler	$182,000	$218,400
Filtration		
-High Rate (12 m/hr)	$273,000	$327,600
-High Rate (18 m/hr)	$221,000	$265,200
-Membrane	$416,000	$499,200
Primary Disinfection		
-Chlorine	$39,000	$46,800
-Ultraviolet	$130,000	$156,000
-Ozone	$260,000	$312,000
Residuals Treatment		
-Plate Settler/Thickener Centrifuge	$52,000	$62,400
Add this when no san sewer available		

Notes
(1) Based on 5 ML/d plant size and larger
(2) Based on 4 ML/d plant size and smaller
(3) All costs include a 30% allowance for engineering & contingencies

Table 5. Water Treatment Cost Breakdown - Estimates **Killiney Beach**

	Killiney Residential
Current MDD (L/s)	22.5
Build-out MDD (L/s)	35.8
ADD (L/s)	13.44
ADD (ML/d)	1.16
Plant Capacity (ML/d):	3.10
Ave. Ann. Demand (ML)	424

270	connections	
2400	L/Cap/d	
3	people/Conn	
430	connections	Buildout

TREATMENT OPTION	ESTIMATED COST (See Note 1) Chemical Coagulation and Mixing	Flocculation	Clarification	Filtration	Primary Disinfection	Secondary Disinfection	Residuals Treatment	TOTAL CAPITAL COST	ANNUAL O&M COST	20 YEAR O&M COST	PRESENT VALUE O&M
Option 1 - Okanagan Lake - Filtration Deferral					3.10 ML/day						3%
DISINFECTION (WITHOUT FILTRATION)											
Chlorination								$0	$678	$ 13,560	$10,087
Ozone/Chlorination								$0	$8,475	$ 169,506	$126,091
UV/Chlorination						$482,975		$482,975	$29,658	$ 593,154	$441,232
FILTRATION											
Direct Filtration/UV								$0	$9,323	$ 186,456	$138,700
Conventional Filtration								$0	$9,323	$ 186,456	$138,700
Membrane Filtration								$0	$8,475	$ 169,506	$126,091
Option 2 - Okanagan Lake - Full 4.3.2.1.0 - Full Filtration and Treatment					3.10 ML/day						
DISINFECTION (WITHOUT FILTRATION)											
Chlorination					$144,893			$144,893	$7,923	$ 158,453	$117,869
Ozone/Chlorination					$965,951	$144,893		$1,110,844	$64,017	$ 1,280,349	$952,418
UV/Chlorination						$482,975		$482,975	$29,658	$ 593,154	$441,232
FILTRATION											
Direct Filtration/UV	$96,595	$289,785		$1,014,248	$482,975	$144,893	$193,190	$2,221,687	$120,407	$ 2,408,143	$1,791,355
Conventional Filtration	$96,595	$289,785	$676,166	$1,014,248	$144,893		$193,190	$2,414,877	$130,067	$ 2,601,334	$1,935,064
Membrane Filtration	$96,595	$289,785		$1,014,248	$144,893		$193,190	$1,738,712	$129,219	$ 2,584,383	$1,922,455

Note 1: Cost estimates for each treatment process include process equipment, all associated ancillary equipment, electrical & instrumentation, associated structures and siteworks, and associated residuals handling plus 30% allowance for engineering and contingencies.

Table 6 - Omit

Table 7. Project Implementation Plan and Financial Requirements
Killiney Beach - Water Master Plan 2011 - 2030
Option 1 - Scenario C: Filtration Deferral

	2009[1]	2010[2]	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. New Projects												
Water Meters		185,000										
SCADA upgrades		60,000										
Killarney Reservoir Storage			100,000									
150 mm Water Main Replacement						85,000						150,000
200 mm Water Main Replacement				100,000		100,000				100,000		
Backup Generators				250,000								
Udell Reservoir Storage							125,000					
Hope Creek Storage							312,500					
New Intake Screen										25,000		
Intake Pipeline Addition (UV Requirement)										420,000		
UV Disinfection											371,520	
Pump Replacement - Lakeshore											90,000	
Pump Replacement - Killarney											75,000	
Pump Replacement - Udell											60,000	
Pump Addition - Winchester												10,000
Upgrade PS Mechanical Components						30,000						
PRV's											50,000	
New Hydrants								10,000		10,000		10,000
Gas Tax Capital Fund (2010 only)		- 260,000										
Contingency (15%)				52,500	-	32,250	65,625	1,500	-	83,250	96,978	25,500
Engineering												
Source Assessment Study			25,000									
Planning[3]		15,000					15,000					15,000
Engineering of Capital Works (15%)[3]	-	15,000.00	52,500	-	32,250	65,625	1,500	-	83,250	96,978	25,500	38,100
Sub-Total Capital Works		15,000	177,500	402,500	32,250	312,875	519,625	11,500	83,250	735,228	768,998	248,600
Equipment Fund Revenue		2,481	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070
Equipment Fund Balance[1]	$248,354	235,835	371,405	281,974	562,794	562,988	356,433	658,002	887,822	465,663	9,735	74,204
O&M Additions			0	500	0	1,236	328	58	0	466	735	928
Connections (2% percent growth per year)		279	284	289	294	299	304	310	316	322	328	334
Anticipated Annual O&M Rate Increase		0	0	2	0	4	1	0	0	1	2	3
Projected Rates												
User Fee (with Annual Inflation 2% after 2012)		226	232	380	388	400	409	417	425	435	446	458
Annual Maintenance Fee - O&M (with Inflation 2%)		150	200	43	44	45	46	47	48	49	49	50
Annual Maintenance Fee - Capital Works		0	0	733	733	733	733	733	733	733	733	733
Projected Rate (Single Lot with Residence)		376	432	1,156	1,165	1,178	1,188	1,197	1,206	1,217	1,229	1,242
Assume 30% Grant Availability on all Capital Works in 2012												
UFRU (with Annual Inflation 2% after 2012)		226	232	380	388	400	409	417	425	435	446	458
AMF - O&M (with Annual Inflation 2%)		150	200	43	44	45	46	47	48	49	49	50
AMF - Capital Works (Assuming 30% Grant)		0	0	489	489	489	489	489	489	489	489	489
Projected Rate (Single Lot with Residence)		376	432	912	920	933	943	952	962	973	985	997

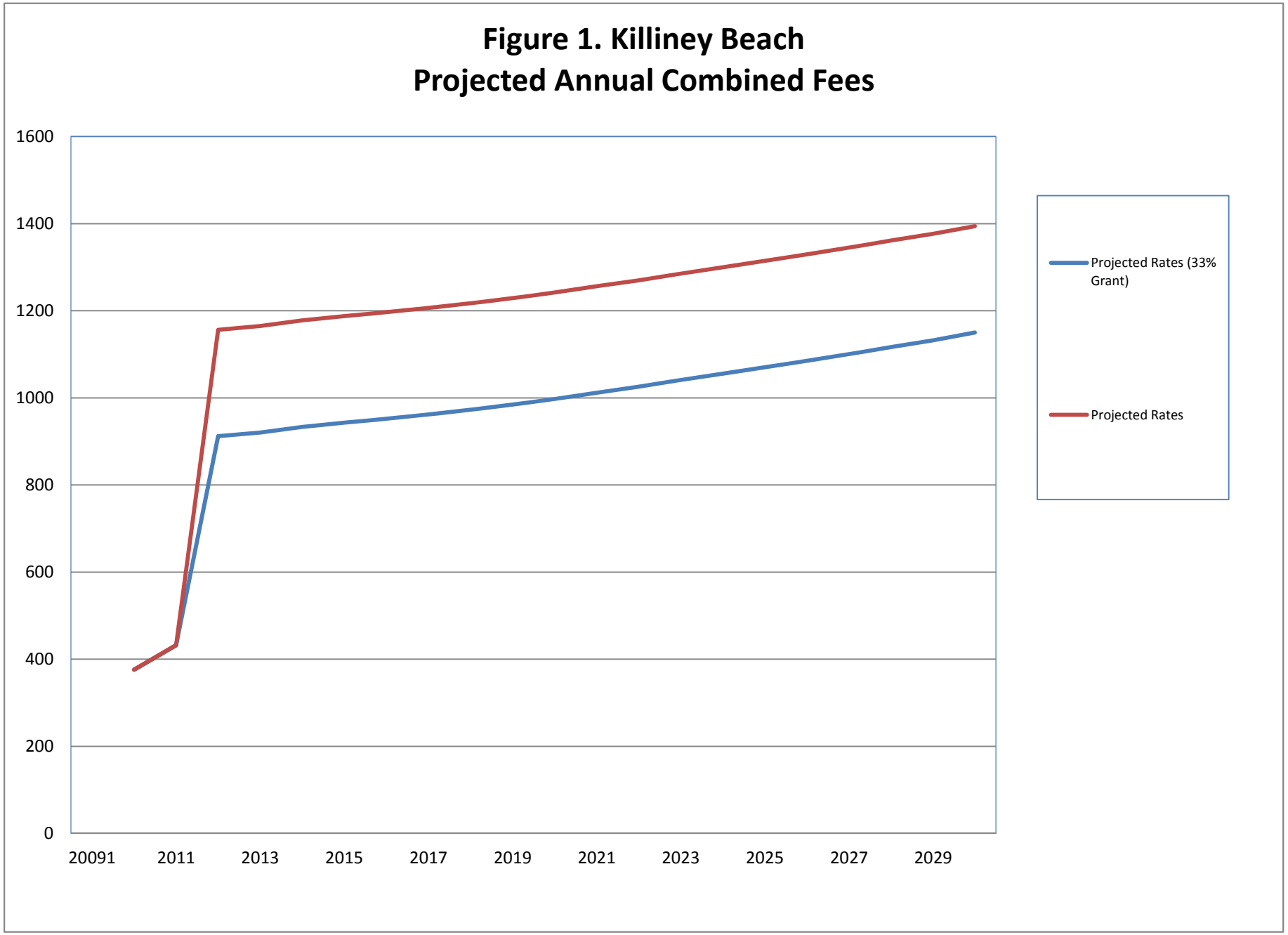
6,462,226 total capital required
427 Connections
$15,134 over 20 years
$733 Annual Capital Rate Required to maintain minimum $50,000 in Water Capital Fund in 2030

Notes
1. From Exhibit 21, RDCO Statement of Financial Position, Equipment Replacement Reserve Fund.
2. Anticipated Expenses from 2010 Financial Plan and estimated 2011 Engineering of new projects
3. Engineering of Capital Works calculated as a 15% of value of all new projects in following year, including contingency.
4. Equipment Fund Balance assumed to be at $50,000 in 2030.

Table 7. Project Implementation Plan and Financial Requirements
Killiney Beach - Water Master Plan 2011 - 2030
Option 1 - Scenario C: Filtration Deferral

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL	O&M
1. New Projects												
Water Meters					30,000						**$ 215,000**	
SCADA upgrades			50,000								**$ 110,000**	**$ 1,100**
Killarney Reservoir Storage											**$ 100,000**	**$ 500**
150 mm Water Main Replacement	100,000	100,000	100,000	100,000	100,000	100,000	250,000	250,000	200,000	250,000	**$ 1,785,000**	**$ 8,925**
200 mm Water Main Replacement	154,000	100,000	100,000	100,000	100,000	100,000				100,000	**$ 1,054,000**	**$ 5,270**
Backup Generators											**$ 250,000**	**$ 2,500**
Udell Reservoir Storage											**$ 125,000**	**$ 625**
Hope Creek Storage											**$ 312,500**	**$ 1,563**
New Intake Screen											**$ 25,000**	**$ 125**
Intake Pipeline Addition (UV Requirement)											**$ 420,000**	**$ 2,100**
UV Disinfection											**$ 368,928**	**$ 29,451**
Pump Replacement - Lakeshore											**$ 90,000**	**$ 4,500**
Pump Replacement - Killarney											**$ 75,000**	**$ 3,750**
Pump Replacement - Udell											**$ 60,000**	**$ 3,000**
Pump Addition - Winchester											**$ 10,000**	**$ 1,000**
Upgrade PS Mechanical Components											**$ 30,000**	**$ 150**
PRV's											**$ 50,000**	**$ 250**
New Hydrants				10,000			10,000				**$ 50,000**	**$ 250**
Gas Tax Capital Fund (2010 only)											**-$ 260,000**	
Contingency (15%)	38,100	30,000	37,500	31,500	34,500	30,000	39,000	37,500	30,000	52,500	**$ 718,203**	**$ 3,591**
Engineering												
Source Assessment Study											**$ 25,000**	
Planning[3]					15,000					15,000	**$ 75,000**	
Engineering of Capital Works (15%)[3]	30,000	37,500	31,500	34,500	30,000	39,000	37,500	30,000	52,500	37,800	**$ 771,003**	
Sub-Total Capital Works	322,100	267,500	319,000	276,000	309,500	269,000	336,500	317,500	282,500	455,300	**6,462,226**	
Equipment Fund Revenue	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070	313,070	**6,263,872**	
Equipment Fund Balance[1]	65,174	110,744	104,813	141,883	145,452	189,522	166,091	161,661	192,230	50,000	50,000	
O&M Additions	1,461	1,150	1,688	1,208	1,173	1,150	1,495	1,438	1,150	2,013		
Connections (2% percent growth per year)	340	346	352	359	366	373	380	387	394	401		
Anticipated Annual O&M Rate Increase	4	3	5	3	3	3	4	4	3	5		
Projected Rates												
User Fee (with Annual Inflation 2% after 2012)	471	484	499	512	525	539	554	569	583	600		
Annual Maintenance Fee - O&M (with Inflation 2%)	51	53	54	55	56	57	58	59	60	62		
Annual Maintenance Fee - Capital Works	733	733	733	733	733	733	733	733	733	733		
Projected Rate (Single Lot with Residence)	1,256	1,270	1,285	1,300	1,314	1,329	1,345	1,361	1,376	1,394		
Assume 30% Grant Availability on all Capital Works in 2012												
UFRU (with Annual Inflation 2% after 2012)	471	484	499	512	525	539	554	569	583	600		
AMF - O&M (with Annual Inflation 2%)	51	53	54	55	56	57	58	59	60	62		
AMF - Capital Works (Assuming 30% Grant)	489	489	489	489	489	489	489	489	489	489		
Projected Rate (Single Lot with Residence)	1,012	1,026	1,041	1,055	1,070	1,085	1,101	1,116	1,132	1,150		

Figure 1. Killiney Beach
Projected Annual Combined Fees



Enclosure B – Distribution System Mapping

N

HIGH

UPPER

MIDDLE

LOW

Winchester Reservoir
W1-5HP
W2-5HP

Udell Reservoir
U2-10HP Lead
U1-10HP Lag

Killarney Reservoir
K1-10HP
K2-15HP

Lakeside Pumphouse
L1-30HP
L2-30HP

Hope Creek Reservoir

Limits of pressure zone

72.8 psi
75.8 psi
62.4 psi
68.1 psi
43.1 psi
53.1 psi
55.9 psi
71.5 psi
71.5 psi
69.5 psi
68.1 psi
66.7 psi
66.7 psi
88.3 psi
89.2 psi
92.1 psi
42.4 psi
67.1 psi
58.6 psi
79.3 psi
53.8 psi
53.8 psi
70.3 psi
117.7 psi
106.3 psi
36.7 psi
78.9 psi
44.3 psi
101.4 psi
103.6 psi
48.6 psi
79.4 psi
86.5 psi
89.4 psi
40.2 psi
47.3 psi
58.0 psi
146.3 psi
90.8 psi
53.8 psi
106.3 psi
89.4 psi
72.6 psi
8.5 psi
8.5 psi
70.7 psi
7.2 psi
179.3 psi
17.5 psi
1.9 psi
13.5 psi
152.1 psi
96.4 psi
70.7 psi
70.9 psi
75.8 psi
64.2 psi
75.4 psi
75.5 psi
76.3 psi
76.8 psi
109.3 psi
1.8 psi
1.9 psi
137.4 psi
65.1 psi
85.1 psi
90.9 psi
49.8 psi
118.0 psi
80.6 psi
114.6 psi
13.8 psi
55.4 psi
41.4 psi
116.7 psi
41.4 psi
102.5 psi
102.5 psi
79.8 psi
79.8 psi
79.6 psi
1.4 psi
147.2 psi
89.4 psi
87.6 psi
112.4 psi
55.4 psi
71.2 psi
73.1 psi
91.0 psi
101.0 psi
11.4 psi
71.1 psi
89.6 psi

COLOR CODING LEGEND
PIPE: DIAMETER (mm)

	<= 50.0
	<= 75.0
	<= 100.0
	<= 150.0
	<= 200.0
	<=Other

COLOR CODING LEGEND
JUNCTION: PRESSURE (psi)

	<= 20.0
	<= 40.0
	<= 80.0
	<= 145.0
	<=Other

NOTE:
PRESSURES SHOWN ARE FOR CURRENT MAXIMUM DAY DEMAND.

PROJECT No.	20102583
DATE	08/27/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	1

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
KILLINEY BEACH

FIGURE 1:
EXISTING SYSTEM
AND PRESSURE ZONES

Associated Engineering

N

New PRV and loop

Connect

New PRV

Winchester Reservoir
W1-5HP
W2-5HP

Udell Reservoir
U2-10HP Lead
U1-10HP Lag

Killarney Reservoir
K1-10HP
K2-15HP

Lakeside Pumphouse
L1-30HP
L2-30HP

Hope Creek Reservoir

Replace pump station with PRV station

Replace pump station with PRV station

Replace pump station with PRV station

Upgrade pump station

Upgrade Reservoir

Proposed 250mm dedicated water pipeline

COLOR CODING LEGEND
PIPE: DIAMETER (mm)

- <= 50.0
- <= 75.0
- <= 100.0
- <= 150.0
- <= 200.0
- <=Other

COLOR CODING LEGEND
JUNCTION: PRESSURE (psi)

- <= 20.0
- <= 40.0
- <= 80.0
- <= 145.0
- <=Other

NOTE:
PRESSURES SHOWN ARE FOR FULL BUILD OUT MAXIMUM DAY DEMAND.

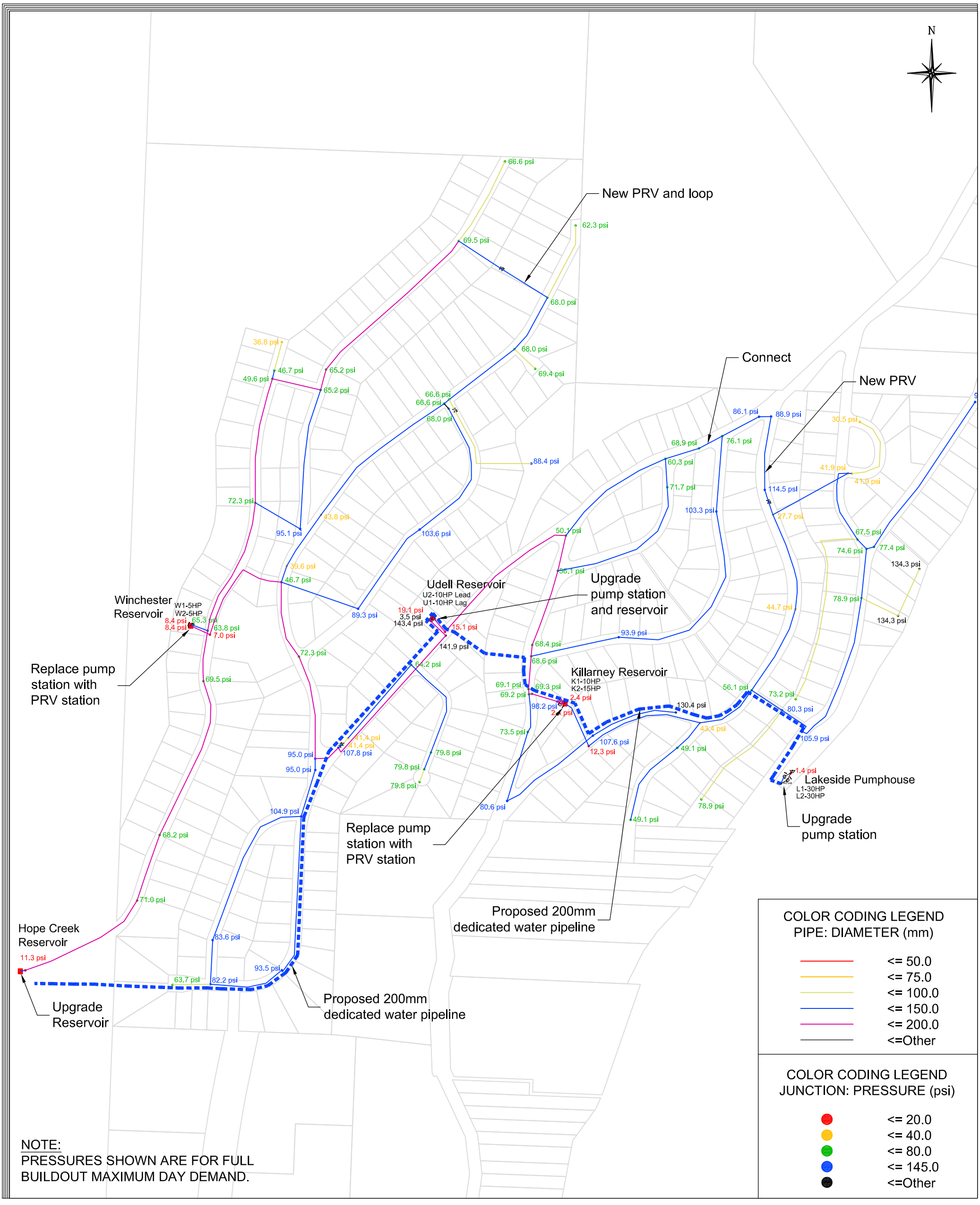
PROJECT No.	20102583
DATE	08/27/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	2

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
KILLINEY BEACH

FIGURE 2:
SCENARIO A
UPPER RESERVOIR CONSTRUCTION

Associated Engineering



PROJECT No.	20102583
DATE	08/27/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	3

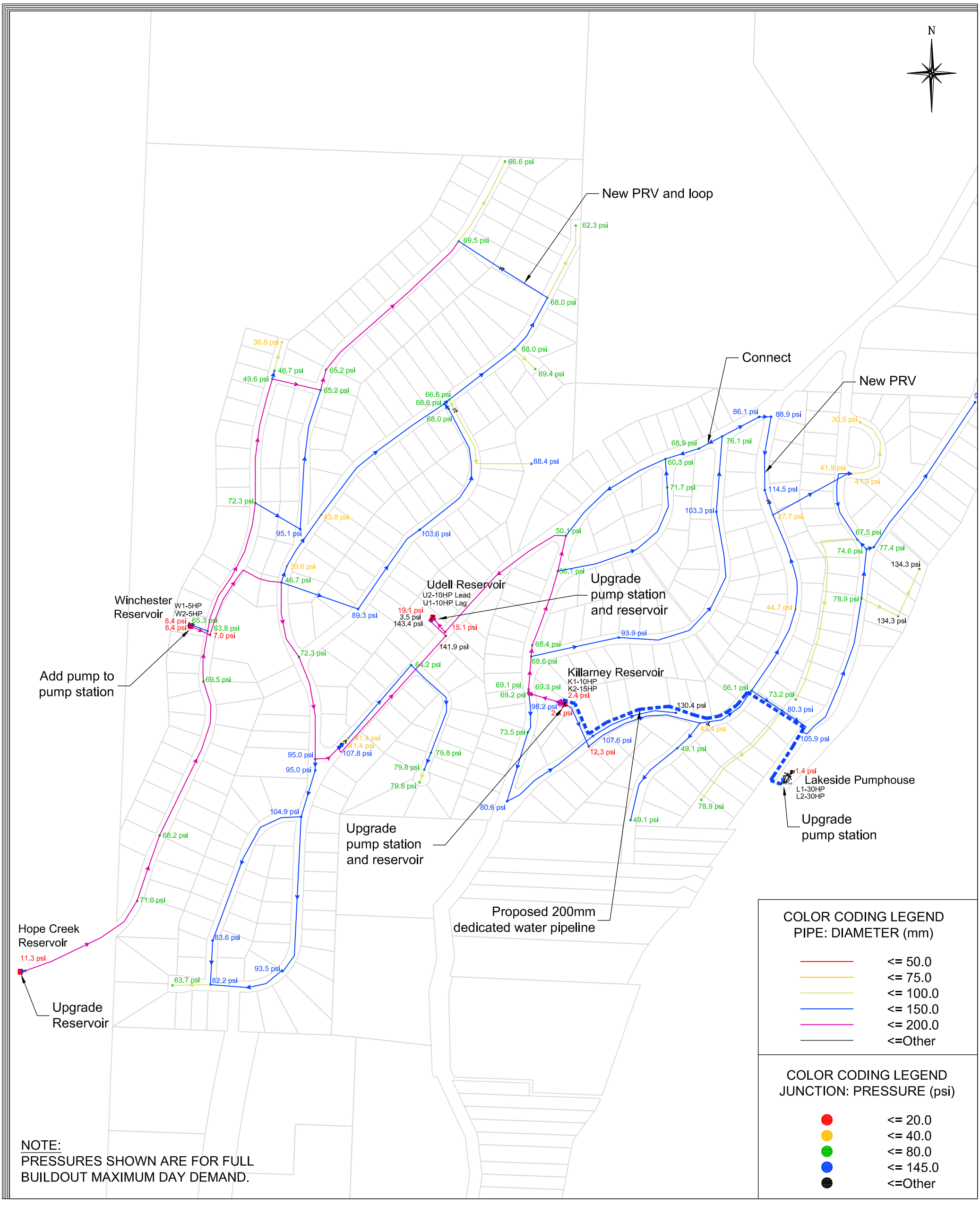
REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
KILLINEY BEACH

FIGURE 3:
SCENARIO B
RESERVOIR UPGRADE UDELL

RDCO REGIONAL DISTRICT of CENTRAL OKANAGAN

Associated Engineering



PROJECT No.	20102583
DATE	08/27/10
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SCALE:	N.T.S.
FIGURE No.	4

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
KILLINEY BEACH

FIGURE 4:
SCENARIO C
UPGRADE EXISTING INFRASTRUCTURE

Associated Engineering

Enclosure C – IHA Filtration Deferral Document

Interior Health

ISSUE PAPER: PLANNING FOR DRINKING WATER FILTRATION RECOMMENDATION

Name of Issue: Criteria required for the Deferral of Filtration

Background and Issue Analysis:

Interior Health Authority (IHA) expects water suppliers to provide filtration for all water supply systems using surface water sources or ground water under the direct influence of surface water. Source water monitoring data may also provide information to indicate the need to initiate filtration. Water suppliers that want to apply for deferral of filtration in accordance with the *Guidelines for Canadian Drinking Water Quality* (GCDWQ) exclusion criteria must make a proposal to Interior Health that defines their watershed control program and dual treatment technologies. The proposal must be further supported by suitable source monitoring data trended over a minimum of one year and preferably several years.

Interior Health's direction on drinking water quality and treatment standards is based on the GCDWQ and other regulatory documents. The GCDWQ provide "Criteria for the Exclusion of Filtration in Waterworks Systems". Water supply systems that currently meet the exclusion criteria cannot guarantee they will do so indefinitely. Therefore the focus of this document is filtration "deferral" criteria not "exclusion" criteria.

A suggestion is that long term improvement plans that propose to "defer" filtration be reviewed on a case-by-case basis.

The IH Water Excellence Team (WET) agreed that the following questions be discussed with the Senior Water Excellence Team (SWET) since they set the strategic direction for WET:

1. Should we define "watershed control program" under the 4th exclusion criteria?
2. Should we develop criteria & expectations for long term planning?
3. Should IH take direction from the *Guidelines for Canadian Drinking Water Quality* for filtration?

The response by SWET was:

- Agreement there is potential for deferral of filtration;
- To take direction from the GCDWQ for filtration and the exclusion criteria for deferral. IHA will need to develop an understanding of the exclusion criteria;
- There is a need to identify factors that will be considered for deferral of filtration;
- IHA and the water supplier will never guarantee that deferral of filtration will be permanent;
- Criteria will be developed by WET for deferral monitoring and triggers for filtration.
- Interior Health will have a primary program objective to provide criteria outlining the expectations of water suppliers;
- Water suppliers will be provided with clear expectations from Interior Health to assist them in long term planning for filtration and UV treatment to meet 43210 treatment objectives.

- Medical Health Officers will not accept differing water treatment standards that may correlate to inequitable distribution of health outcomes.
- Acceptance that water suppliers have requested from Interior Health:
  - acknowledgement of the positive health impacts of UV treatment; and
  - support for UV treatment (dependant on suitable source water characteristics) as an interim measure towards full implementation of 43210 treatment infrastructure

Options:

1. Deal with each proposal on a case-by-case basis (in the absence of a filtration deferral policy).
   Discussion: The disadvantage to this approach is the hesitation of water suppliers to make long term plans because of the uncertainty of requirements. They are unable to accurately identify costs of their infrastructure options.

2. Provide guidance on expectations for general source water situations, including triggers that would remove the deferral for filtration.
   Discussion: The advantage is to provide water suppliers with some guidelines that they can use for planning. The risk is that they will not plan for filtration because they hope to avoid it, rather than planning to accomplish filtration in a reasonable timeframe.

3. Same as 2 with expectations of timelines for installation.
   Discussion: The risk of this would be the use of timelines without due consideration of the individual water supply system's unique characteristics.

Recommendations:

Choose option 3 with clarification that the guidance of timelines for installation is *for consideration only.* A decision tree format could be included as an appendix to the Drinking Water Quality Improvement Program Booklet.

It is worth noting that not all water systems will be able to apply for a "deferral of filtration", and the following implementation plan should be considered in that context. Water suppliers that have any of the following conditions should be excluded from consideration for a deferral of filtration:

- poor source water quality (as determined by the Drinking Water Officer)
- uncontrolled watershed
- plan for only a single disinfection process

Individual and site-specific treatment strategies are required for water suppliers to adequately address public health risks in relation to their source(s).

Implementation:

Plans for Establishing Criteria for Filtration and the Deferral of Filtration

1. Development of policy regarding filtration and the potential for deferral. Refer to Appendix A.

2. Identify a method for water suppliers to determine whether or not they potentially qualify for deferral. Develop reasonable timelines for planning to achieve the 43210 objectives with or without filtration deferral. Refer to Appendix B "Factors For Water Suppliers To Determine Filtration Or Filtration Deferral Planning Requirements".

   Water suppliers using a surface water source, or a groundwater source under the direct influence of surface water, need to have a system assessment completed by a qualified Professional Engineer. The system assessment should identify infrastructure and life cycle costs, including rate structures and development cost charges.

   An implementation plan to achieve 43210 Treatment Objectives, including filtration, needs to be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train can accommodate filtration at a later date.

3. Develop the criteria that a water supplier could use to demonstrate achievement of the GCDWQ exclusion criteria for a filtration deferral proposal. Refer to Appendix C "Criteria To Demonstrate That A Water Supplier Can Achieve The GCDWQ Filtration Exclusion Criteria".

   Water Supply systems that may currently meet the exclusion criteria cannot guarantee they will do so indefinitely. Water suppliers wishing to apply for deferral of filtration as per the GCDWQ exclusion criteria must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years. Source water monitoring data may also provide information to indicate the need to initiate filtration.

   The following information could be included in future revisions of the Conditions on Operating Permits booklet:

   - **Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit.**
   - Water suppliers must provide progress reports with implementation of treatment infrastructure upgrades.
   - Water suppliers must provide water monitoring data to show continued achievement of deferral criteria.
   - Water suppliers must make documentation of filtration deferral to their consumers available in their annual reports

4. Develop strategy for IH responses to deferral proposals.

   Implementation of filtration deferral decisions will be accomplished through typical "deferral" Conditions on Operating Permit.

- Prior to a decision to defer treatment, the Drinking Water Official must undertake internal consultation that includes but is not limited to the: Senior Public Health Inspector, Public Health Engineer, Senior Drinking Water Officer, and Medical Health Officer.
- Water supply system file information must contain discussion and decision documentation regarding deferral.

5. Develop clarification of planning criteria for groundwater at risk of containing pathogens

   Through the policy review process is was recognized that further clarification is required to address questions of groundwater under the direct influence of surface water in the context of long term planning to achieve 43210 treatment objectives. Policy development regarding groundwater will be undertaken as a separate process.

6. Many requests for clarification were accumulated during the review process. The responses are provided in Appendix E.

Desired Outcomes:

- Drinking Water Quality Improvement Program COP booklet should have factors to consider for deferral of filtration. Appendix D provides information for consideration of site-specific monitoring programs.
- Communications directed towards water suppliers should identify Interior Health's expectations regarding filtration and the potential for deferral of filtration.

Prepared by:	Dale Thomas, Mike Adams, Elizabeth Sigalet	
Reviewed by:	WET	Date: May 28, 2007
Revised by:	WET	Date: June 13, 2007
Submitted to:	IH Material Development	Date: July 12, 2007
External review:	BCWWA and water suppliers	Date: December, 2007
Revised by:	Elizabeth Sigalet	Date: February 15, 2008
Submitted to:	Ken Christian	Date: February 21, 2008

Interior Health
Health Protection

Drinking Water Program

DRINKING WATER FILTRATION POLICY

1.0 PURPOSE

To clarify Interior Health's expectations for the filtration of drinking water from sources of surface water or ground water under the direct influence of surface water.

2.0 DEFINITIONS

Filtration: is a process whereby particulate material is removed from solution by passing the solution through a porous media.

3.0 POLICY

Water suppliers must provide filtration for all water supply systems using surface water sources or ground water under the direct influence of surface water. Water suppliers wishing to apply for deferral of filtration as per the GCDWQ exclusion criteria must make a written proposal to Interior Health.

4.0 PROCEDURE

4.1 Drinking Water Officials must consider the provincial *Drinking Water Officers' Guide* in the exercise of their duties and discretion. They are, however, able to depart from the guide in any case where sound reason exists to do so. In the performance of their duties, Drinking Water Officials will review, in the following order:

- provincial and other legislation,
- the Provincial Drinking Water Officer's Guide and other provincial directives,
- the Canadian Drinking Water Quality Guidelines or other federal – provincial guidelines, and
- credible resources prepared by other organizations

4.2 Interior Health's direction on drinking water quality and treatment standards is based on the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* and policy developed by other credible organizations.

4.3 The *GCDWQ* provide "Criteria for the Exclusion of Filtration in Waterworks Systems". Water Supply systems that currently meet the exclusion criteria cannot guarantee they will do so indefinitely and the criteria may change; therefore, the focus of this document is filtration "deferral" criteria not "exclusion" criteria.

4.4 Drinking Water Officials, under the guidance provided in the *Guidelines for Canadian Drinking Water Quality (GCDWQ),* Interior Health's' Drinking Water Quality Improvement Program (DWQIP) and Small Water System Strategy (SWSS)

programs, will direct water supply system suppliers that use a surface water source or a groundwater source under the direct influence of surface water to provide filtration prior to public consumption.

4.5 Water supply systems are expected to meet *43210 Drinking Water Objective* and provide filtration as part of a satisfactory application for a construction permit. The issuing official should consider whether the proposed treatment is adequate as part of their decision-making process whether to issue the construction permit.

4.6 Existing water systems suppliers need to develop long term plans and have an acceptable implementation strategy to adequately address public health risks in relation to their source(s). Drinking Water Officials, through the application of Conditions on Operating Permits (DWQIP) or Multiple Barriers of Protection (SWSS), should engage the water supplier to ensure there is an adequate plan in place for the provision of drinking water that meets the *Guidelines for Canadian Drinking Water Quality* and the *43210 Drinking Water Objectives.*

4.7 Water suppliers wishing to apply for deferral of filtration must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years.

5.0 REFERENCES

- BC Drinking Water Protection Act [SBC 2001] Chapter 9
- BC Drinking Water Protection Regulation [inc. amendments up to B.C. Reg. 352/2005, December 9, 2005]
- BC Drinking Water Officer's Guide [Version 7]
- Guidelines for Canadian Drinking Water Quality [Modified 2005-01-13]
- Drinking Water Quality Improvement Program COP Booklet
- Issue Paper: Filtration Deferral

Interior Health
Health Protection

Drinking Water Program

FILTRATION OR FILTRATION DEFERRAL PLANNING REQUIREMENTS

1.0 Introduction

- All water supply systems in Interior Health's Drinking Water Quality Improvement Program are required to assess source water quality and provide long term plans to achieve 43210 as a condition on their operating permits.

- An implementation plan to achieve 43210 Treatment Objectives, including filtration, must be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train that can accommodate filtration at a later date.

- For systems that have source water that is surface water or under the direct influence of surface water, the plans must include filtration.

- For plans including filtration without deferral – refer to timelines and milestones in Part 2.

- For plans proposing deferral of filtration – refer to timelines, milestones and proposal requirements in Part 3.

- Plans including the deferral of filtration are less capital intensive and should not be delayed. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.

2.0 Plans Including Filtration

If a water supply system using surface water as a water source cannot meet the *Canadian Drinking Water Quality Guidelines* for exclusion of filtration they are required to plan for filtration. The water supplier, in collaboration with IH, will establish timelines specific to their individual systems. Factors such as outbreaks may shorten timelines. Drinking Water Officers (DWO) may set milestone targets on operating permits.

2.1 Components of filtration (which may be applied as conditions on operating permits) include:

- assessment and planning for financing
- completion of a (long term) plan to achieve 43210 objectives
- design
- construction

2.2 Interior Health (IH) expects water suppliers to reduce risk to public health by achieving the shortest possible timelines for implementation. Experience has indicated that it is reasonable to achieve filtration within 7 years. Milestones can be delineated as follows:

- 2 years for assessment and planning to achieve 43210
- 3 years for design and planning for financing

- 2 years for construction and implementation

2.3 It is reasonable and achievable for water supply systems existing in 2007 serving more than 500 people per day to have filtration operational by 2015. It is reasonable for the public to expect that:
- 50% of water supply systems will have filtration in place by 2012
- 90% of water supply systems will have filtration in place by 2015

Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve filtration.

3.0 Plans Including Deferral of Filtration

If a water supply system using surface water as a water source cannot meet the *Canadian Drinking Water Quality Guidelines* for exclusion of filtration they are required to plan for filtration.

3.1 Water supplier must submit a plan for achieving the long term objectives of 43210.

3.2 Water supplier must submit a proposal (with at least one year of data) for deferral of filtration, including:

a) Demonstration of meeting the Canadian Drinking Water Quality Guidelines for exclusion from filtration
   i. *E.coli* and coliform monitoring
   ii. on-line continuous turbidity monitoring to provide daily average
   iii. performance monitoring of disinfection processes to achieve credit for 4-log removal of viruses and 3-log removal of *Cryptosporidium* and *Giardia*
   iv. annual update or review of changes to the watershed and control program (e.g. sewage outfalls, mining, forestry, agriculture). Note that Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit. It is not necessary to have exclusive use of a watershed to have a watershed control program.

b) Site-specific monitoring identified by DWO which might include:
   i. monitoring the presence of *Giardia* or *Cryptosporidium* and establishing baseline data
   ii. constituents identified by the EPA guidelines (e.g. algae, dissolved organics, conductivity)
   iii. process concerns (e.g.disinfection interuptions)

3.3 Water suppliers must be prepared to install filtration if any of the following occur:
a) waterborne illness outbreak
b) excesses of avoidable disinfection byproducts, refer to Canadian Drinking Water Quality Guidelines for guidance
c) failure to provide or meet the exclusion criteria monitoring requirements
d) significant degradation of raw water quality identified by the DWO
e) health threats

3.4 Timelines and Milestones

The water supplier must be prepared to meet the expectation of construction and implementation of filtration within 2 years of being unable to meet the deferral criteria.

It is reasonable and achievable for water supply systems serving more than 500 people per day and existing in 2007 to have two methods of disinfection operational by 2013. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.

Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve disinfection objectives. Some systems may be further ahead than others and will, therefore, be required to move ahead more quickly.

Criteria to Demonstrate That a Water Supplier Can Achieve the GCDWQ Filtration Exclusion Criteria

Systems may qualify for deferral of filtration if they demonstrate the following:

- ☐ 4 log removal or inactivation of viruses and 3 log inactivation of protozoa is achieved using a minimum of 2 disinfection processes.
- ☐ Background baseline levels of *Cryptosporidium* and *Giardia*, adequate to establish trends, have been established.
- ☐ A watershed control program designed with the express purpose of minimizing fecal contamination in the source water is being implemented. Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit.
- ☐ No more than 10% of source/raw water *E.coli* samples exceed 20/100 ml in any 6-month period.
- ☐ No more than 10% of source/raw water total coliform samples exceed 100/100 ml in any 6-month period.
- ☐ Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.*
- ☐ Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period.
- ☐ Expected average annual total Trihalomethanes at locations farthest from treatment will not exceed 0.100 mg/L or 100 µg/L.

* This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that <u>might not always</u> meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month"

Considerations for Ongoing Monitoring Programs for Systems with Filtration Deferral

Water quality in BC can fluctuate daily, weekly and over long periods of time. Drinking water systems that have raw water quality that currently meets the *GCDWQ Filtration Exclusion Criteria* need to monitor their raw water to detect changes that will affect treatment efficiency.

It is recommended that purveyors refer to the Modules 1, 2, 7, and 8 of the Provincial *Comprehensive Source to Tap Assessment Guideline* as an example of how to develop a source protection plan. **Watershed control programs expressly intended to minimize fecal contamination can be accomplished using the Guideline.** Regardless of the method used and plan developed, it is expected that the following elements will be included:

1. Characterization of the source water and delineation of the area of the watershed from which source water originates. This should include an evaluation of the pathways and estimated time of travel for fecal pathogens to the intake from different areas in watershed.
2. Identification of potential sources of fecal pollution within the watershed that pose a threat of introducing pathogenic organisms to the drinking water system.
3. An assessment of the risks to public health posed by the identified sources of fecal pollution, and
4. A plan to mitigate the risks posed by sources of fecal pathogens in the capture zone and limit future contamination of the water source.

Evaluating background microbial contamination and identifying trends in water quality linked to fecal contamination levels is crucial to building an effective source protection plan. The data collected, sampling locations, and frequency of sampling to characterize the source water should be established by the source protection planning team. Monitoring plans to support source protection planning for filtration deferral will typically include the following elements:

Microbes

- *E.coli* & Total Coliforms (minimum weekly samples)
- Protozoa (monthly samples)

Chemical parameters

- Alkalinity & Hardness (minimum bi-weekly)
- Total Organic Carbon (minimum bi-weekly)
- pH (minimum weekly)

Physical parameters

- Turbidity (daily averages based on minimum of 1 sample every 4 hours)
- Temperature (minimum weekly)
- Colour (minimum weekly)
- UV transmittance (minimum weekly)

Source monitoring to establish compliance with filtration referral criteria should be conducted over at least a one year period, preferably longer. Testing should be done by an approved laboratory with samples collected using appropriate methods.

Questions and Responses from the Internal and External Review Process - Filtration Deferral

Questions posed regarding the Filtration Deferral Issue Paper and points where clarification was requested:

Section 1 - Are the factors clear? How can we clarify?		
Clarify whether this a "deferral" document or an "exemption" or "waiver" document	Accept	Issue Paper -Name of issue: Criteria for the Deferral of Filtration
Define the time line associated with deferrals (e.g. evergreen, or 2 – 5)	Accept	There is no timeline. The deferral concept is for planning purposes. The intent is to identify for water supply systems the conditions they must have for filtration deferral to be possible. If the criteria are not met, the deferral is revoked.
Title should reflect what the document is (e.g. "Requirement for Filtration Treatment", or "Planning for Filtration or Options"	Accept	Issue Paper Title: Planning for Drinking Water Filtration Policy Title: Drinking Water Filtration Policy
Clarify how this fits into the Drinking Water Protection Act as "outcome based" legislation that does not prescribe treatment	Accept	Section 4.5 of the Policy addresses the need for achieving 43210 objectives as part of a satisfactory construction permit application. The issuing official must consider if the proposed treatment is adequate. The 43210 is not a standard, but reasonable guidance to consider for treatment. The issuing official must consider each construction permit on the merit of the submission to ensure that public health issues related to the source water characteristics are addressed.
Clarify how this policy addresses groundwater that may contain pathogens	Decline	
Clarify what Interior Health considers to be a "watershed control program"	Accept	Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in the conditions on operating permit.
Clarify that a multiple use watershed could qualify as having a "watershed control program"	Accept	It is not necessary to have exclusive use of a watershed to have a watershed control program.
Provide a better definition of "filtration"	Accept	Filtration: is a process whereby particulate material is removed from solution by passing the solution through a porous media.
Clarify that Appendix B 3 2 a) iii) requires both UV and chlorination	Decline	The form of removal is not prescribed.
Clarify whether UV must be installed and operating before deferral granted	Decline	Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve disinfection objectives. Some systems may be further ahead than

		others and will, therefore, be required to move ahead more quickly.
Clarify whether 43210 requires two forms of treatment for each form of inactivation or removal	Accept	43210 refers to two forms of treatment, not for each inactivation or removal requirement. However, the CDWQG filtration exclusion criteria note: Filtration of a surface water source or a groundwater source under the direct influence of surface water may not be necessary if the following conditions are met: Overall inactivation is met using a minimum of two disinfectants: • ultraviolet irradiation or ozone to inactivate cysts/oocysts; • chlorine (free chlorine) to inactivate viruses; and • chlorine or chloramines to maintain a residual in the distribution system
Define "avoidable disinfection by products"	Accept	Excesses of avoidable disinfection byproducts, refer to Canadian Drinking Water Quality Guidelines for guidance
Clarify which guidelines are dominant Canadian Drinking Water Quality Guidelines or EPA	Accept	In the performance of their duties, Drinking Water Officials will review, in the following order: • provincial and other legislation, • the Provincial Drinking Water Officer's Guide and other provincial directives, • the Canadian Drinking Water Quality Guidelines or other federal – provincial guidelines, and • credible resources prepared by other organizations
Clarify that these expectations are for large water supply systems	Accept	All water supply systems in Interior Health's Drinking Water Quality Improvement Program are required to assess source water quality and provide long term plans to achieve 43210 as a condition on their operating permits. Small water systems are not included in the Drinking Water Quality Improvement Program. All new systems (regardless of size) must meet 43210 objectives.
Clarify "coagulant break through"	Accept	Removed from document
Clarify that new systems require filtration regardless of meeting deferral criteria	Decline	All new systems (regardless of size) must meet 43210 objectives as a minimum. Filtration may be required by the issuing official.
Clarify that future failure to meet deferral criteria invalidates the deferral	Accept	Timelines and Milestones: The water supplier must be prepared to meet the expectation of construction and implementation of filtration within 2 years of being unable to meet the deferral criteria.
Clarify that planning to meet the deferral criteria does not mean postponement of timelines to achieve 43210 objectives.	Accept	It is reasonable and achievable for water supply systems serving more than 500 people per day and existing in 2007 to have two methods of disinfection operational by 2013. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.
Clarify that filtration could have equivalent processes of equal public health protection	Accept	This document is intended to identify equivalent protection to filtration. There may be others. Individual

		and site-specific treatment strategies are required for water suppliers to adequately address public health risks in relation to their source(s).
Clarify that surface water could be considered in three categories "run of river", "lake intakes" or "groundwater under influence of surface water"	Decline	Prefer to use simple inclusive terminology
Clarify that groundwater under the direct influence of surface water may achieve some credit for filtration as defined by the *Guidance Document for Determining Ground Water at Risk of Containing Pathogens and Ground Water Under Direct Influence of Surface Water*	Decline	The Guidance document is relevant. The process for identifying how the filtration deferral would be achieved is valid for systems that have water that may contain pathogens. The issues of how to define GUDI are best left to different documents.
Clarify 43210 planning requirements for groundwater sources under direct influence of surface water.	Decline	The process for identifying how GUDI systems meet 43210 objectives and equivalency for filtration is best left to different documents still in development
USEPA and GCDWQ documents have summary pages that are one page long. The final document from IHA should follow that format.	Accept	The document circulates provides background discussion and the Interior Health policy. Material to be provided to water suppliers could be limited to one page depending on the approach they wish to consider.
Clarify whether IH would consider that removal of rangeland cattle would constitute enough of a reduction of health risk that filtration and enhanced disinfection would not be required.	Decline	Rangeland cattle are not the only health risk posed to surface water. Giardia and Cryptosporidium have been shown to be present in all surface waters with or without cattle. IH requires long term planning for source protection "AND" treatment, not "EITHER/OR"

Section 2 - Are the expectations reasonable? Are there other alternatives we should consider?		
Debate whether it is necessary for all communities to filter their water.	Decline	4.2 Interior Health's direction on drinking water quality and treatment standards is based on the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* and policy developed by other credible organizations.
Canadian Drinking Water Quality Guidelines should be viewed as guidelines, not standards. Equivalencies to filtration should be considered.	Accept	Issuing officials must consider each construction permit application on the merit of the individual system. The issuing official should consider whether the proposed treatment is adequate as part of their decision-making process whether to issue the construction permit.
If exemption criteria are met, Interior Health should require a redirection of funds from filtration to improvement distribution system deficiencies.	Decline	Interior Health does not direct or redirect funding available drinking water improvements. The Drinking Water Quality Improvement Program requires long term plans for improvements of sources, treatment and distribution systems.
Other water quality improvement strategies should also be considered (e.g. storage volumes, monitoring, and trending analysis).	Decline	Other water quality improvement strategies are addressed in other documents.
It would be unreasonable to expect that a community would have chlorination and UV treatment in place before being granted filtration deferral.	Accept	4.7 Water suppliers wishing to apply for deferral of filtration must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years.
Monitoring for Giardia and Cryptosporidium	Accept	Evaluating background microbial contamination and

is expensive and test results have limitations. and Clarify that total coliform data has limitations as health risk data because it is not a good indicator of fecal loading, but provides general water quality information that would allow trending analysis and identification of dramatic changes in water quality.		identifying trends in water quality linked to fecal contamination levels is crucial to building an effective source protection plan. The data collected, sampling locations, and frequency of sampling to characterize the source water should be established by the source protection planning team. Monitoring plans to support source protection planning for filtration deferral will typically include the following elements: Microbes • *E.coli* & Total Coliforms (minimum weekly samples) • Protozoa (monthly samples) Continued monitoring for Giardia and Cryptosporidium may not be required if there is a demonstration of other baseline data that can identify trends in water quality linked to fecal contamination levels. The same would apply to total coliforms.
UV calibration reports may serve as a measure of UV efficacy for Giardia and Cryptosporidium inactivation or removal	Decline	See answer above.
Expectations are not appropriate for small systems	Accept	With the exception that new small systems are expected to achieve 43210 criteria. Filtration may be preferable to validation required to achieve deferral.
Turbidity of 1 NTU should not be a definitive turbidity limit. Preference for the wording used in the Canadian Drinking Water Quality Guidelines. and Preference for a range of numerical values for turbidity with acceptable frequency and variation of magnitude of excursions	Decline	• Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.* • Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period. * This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that might not always meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month"
Process for determining rationale for deferral should be transparent and available to public	Accept	The following information could be included in future revisions of the Conditions on Operating Permits booklet: • Water suppliers must make documentation of filtration deferral to their consumers available in their annual reports

Section 3 - Are the expectations achievable? If not, what are the barriers?		
Financial • competing demands for community resources • grants are not available to all water supply systems equally • it may take longer than the period	Accept	Without defining expectations and undertaking planning activities the financial implications are speculation. On average, the rates for drinking water in BC are lower than most of the rest of Canada. Canadian rates for municipal water are consistently lower than other

allowed to accumulate financial resources to undertake works • community referendums for approval of borrowing funds could fail • cost of completing a comprehensive source to tap assessment		developed countries. Expectations of citizens in BC for drinking water quality may not match their expectation or water rates. Rick Thorpe: *"A clean and reliable water source is the right of al British Columbians"*. Steve Hrudey: *"There is no cheap way to achieve safety"*.
Timeline of 2 years – may be difficult to achieve if a community does not have a preliminary engineering report and community support plan in place at all times.	Accept	An implementation plan to achieve 43210 Treatment Objectives, including filtration, must be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train can accommodate filtration at a later date.
Consistency – this is not policy for other Health Authorities	Accept	We have shared our policy development process through the provincial Drinking Water Leadership Council and considered input from other Health Authorities in our policy.

Enclosure D – Killiney Model Output

Fire Flow Node FlexTable: Fire Flow Report (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)
42	9	True	60.00	83.63	60.00	83.63	20.0	48.7	0.0
47	3	False	60.00	7.02	60.10	7.12	20.0	20.1	0.0
45	11	False	60.00	19.66	60.47	20.13	20.0	48.7	0.0
90	4	False	60.00	24.37	60.31	24.69	20.0	20.0	0.0
9	3	False	60.00	10.38	60.31	10.70	20.0	20.1	0.0
44	13	True	60.00	79.88	60.31	80.20	20.0	76.0	0.0
56	16	False	60.00	17.20	60.21	17.41	20.0	20.2	0.0
30	11	False	60.00	7.49	60.37	7.85	20.0	25.8	0.0
105	16	False	60.00	26.98	60.16	27.14	20.0	20.3	0.0
39	4	True	60.00	83.56	60.26	83.82	20.0	20.0	0.0
21	4	False	60.00	6.17	60.16	6.32	20.0	20.0	0.0
100	12	False	60.00	18.75	60.21	18.96	20.0	28.4	0.0
101	3	False	60.00	15.32	60.63	15.95	20.0	20.2	0.0
33	3	False	60.00	3.84	60.58	4.42	20.0	60.1	0.0
46	4	False	60.00	7.75	60.00	7.75	20.0	72.8	0.0
20	4	False	60.00	17.43	60.94	18.37	20.0	20.0	0.0
2	24	True	60.00	80.62	60.00	80.62	20.0	103.0	0.0
32	4	False	60.00	24.21	60.00	24.21	20.0	20.0	0.0
109	14	False	60.00	11.04	60.42	11.46	20.0	36.7	0.0
23	17	False	60.00	11.63	60.37	12.00	20.0	44.5	0.0
48	15	False	60.00	17.08	60.00	17.08	20.0	44.4	0.0
35	3	False	60.00	52.08	60.00	52.08	20.0	25.1	0.0
22	3	True	60.00	70.52	60.00	70.52	20.0	20.0	0.0
34	3	True	60.00	69.47	60.37	69.84	20.0	20.0	0.0
61	17	False	60.00	11.64	60.42	12.06	20.0	22.7	0.0
92	31	False	60.00	22.03	60.73	22.76	20.0	27.3	0.0
96	10	False	60.00	12.19	60.58	12.77	20.0	20.1	0.0
37	3	False	60.00	52.50	60.58	53.08	20.0	30.8	0.0
11	15	False	60.00	9.73	60.00	9.73	20.0	20.2	0.0
6	8	False	60.00	43.02	60.31	43.34	20.0	66.7	0.0
72	11	False	60.00	25.70	60.63	26.32	20.0	28.6	0.0
36	3	False	60.00	27.38	60.47	27.85	20.0	20.0	0.0
10	4	False	60.00	4.30	60.26	4.56	20.0	20.0	0.0
63	8	False	60.00	17.47	60.00	17.47	20.0	20.2	0.0
82	3	False	60.00	30.27	60.00	30.27	20.0	44.3	0.0
80	4	False	60.00	25.39	60.00	25.39	20.0	20.0	0.0
8	1	False	60.00	0.00	60.00	0.00	20.0	7.2	0.0
74	3	False	60.00	28.96	60.21	29.17	20.0	66.8	0.0
12	17	False	60.00	11.65	60.37	12.02	20.0	24.3	0.0
29	4	False	60.00	27.07	60.00	27.07	20.0	20.0	0.0
51	10	False	60.00	12.11	60.00	12.11	20.0	20.1	0.0
15	3	False	60.00	4.91	60.16	5.06	20.0	20.1	0.0
13	3	False	60.00	10.82	60.63	11.45	20.0	20.1	0.0
94	16	False	60.00	17.02	60.00	17.02	20.0	20.2	0.0
38	1	False	60.00	0.00	60.00	0.00	20.0	13.6	0.0

Fire Flow Node FlexTable: Fire Flow Report (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)
76	8	False	60.00	27.54	60.73	28.27	20.0	20.1	0.0
50	10	False	60.00	17.11	60.52	17.64	20.0	39.6	0.0
14	14	False	60.00	4.56	60.26	4.82	20.0	20.5	0.0
53	3	False	60.00	4.08	60.10	4.19	20.0	20.1	0.0
25	10	False	60.00	42.21	60.00	42.21	20.0	31.7	0.0
52	3	False	60.00	3.16	60.21	3.37	20.0	20.2	0.0
24	3	False	60.00	45.05	60.31	45.36	20.0	30.7	0.0
118	3	False	60.00	30.27	60.00	30.27	20.0	39.7	0.0
55	10	False	60.00	10.41	60.42	10.83	20.0	20.1	0.0
19	8	False	60.00	17.17	60.00	17.17	20.0	20.2	0.0
27	3	False	60.00	28.96	60.31	29.27	20.0	57.1	0.0
98	15	False	60.00	17.08	60.00	17.08	20.0	46.2	0.0
108	3	False	60.00	19.21	60.63	19.84	20.0	20.2	0.0
54	4	False	60.00	7.75	60.10	7.85	20.0	26.5	0.0
18	4	False	60.00	7.64	60.21	7.85	20.0	26.7	0.0
104	4	False	60.00	7.75	60.10	7.85	20.0	29.3	0.0
26	10	False	60.00	42.68	60.00	42.68	20.0	37.5	0.0
78	4	False	60.00	28.66	60.84	29.50	20.0	24.7	0.0
107	3	False	60.00	22.07	60.58	22.65	20.0	20.0	0.0
57	4	False	60.00	16.27	60.26	16.53	20.0	20.0	0.0
31	4	False	60.00	30.27	60.58	30.84	20.0	23.9	0.0
103	1	False	60.00	0.00	60.31	0.31	20.0	13.5	0.0
113	3	False	60.00	54.37	60.00	54.37	20.0	33.3	0.0
110	1	False	60.00	0.00	60.00	0.00	20.0	1.4	0.0
117	3	False	60.00	30.27	60.00	30.27	20.0	40.0	0.0
84	16	False	60.00	27.85	60.63	28.48	20.0	20.3	0.0
64	10	False	60.00	14.09	60.47	14.56	20.0	36.1	0.0
112	3	False	60.00	52.43	60.00	52.43	20.0	20.1	0.0
28	6	False	60.00	30.98	60.21	31.19	20.0	30.5	0.0
88	9	False	60.00	31.00	60.00	31.00	20.0	34.7	0.0
49	10	False	60.00	16.60	60.00	16.60	20.0	37.2	0.0
119	1	False	60.00	0.00	60.00	0.00	20.0	11.4	0.0
41	6	True	60.00	81.98	60.37	82.35	20.0	28.5	0.0
116	3	False	60.00	52.45	60.00	52.45	20.0	31.5	0.0
106	3	False	60.00	30.27	60.37	30.63	20.0	22.1	0.0
17	8	False	60.00	15.25	60.00	15.25	20.0	20.2	0.0
66	3	False	60.00	27.70	60.26	27.96	20.0	29.3	0.0
40	4	False	60.00	22.81	60.42	23.23	20.0	20.0	0.0
16	8	False	60.00	14.06	60.16	14.22	20.0	20.2	0.0
43	3	False	60.00	5.65	60.26	5.91	20.0	20.1	0.0
70	12	False	60.00	19.82	60.47	20.29	20.0	33.0	0.0
86	3	False	60.00	29.53	60.58	30.11	20.0	46.7	0.0
J-3	8	False	60.00	43.08	60.00	43.08	20.0	67.4	0.0
J-7	4	False	60.00	51.37	60.00	51.37	20.0	20.0	0.0
J-9	12	False	60.00	18.79	60.00	18.79	20.0	29.1	0.0

Fire Flow Node FlexTable: Fire Flow Report (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)	Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
J-10	4	False	60.00	51.73	60.31	52.04	20.0	20.0	0.0	0.0	0.0	55	True
J-14	1	False	60.00	0.00	60.00	0.00	20.0	1.9	0.0	1.4	1.4	110	True
J-16	1	False	60.00	0.00	60.00	0.00	20.0	1.9	0.0	0.1	0.1	52	True
J-21	1	False	60.00	0.00	60.00	0.00	20.0	8.5	0.0	1.4	1.4	110	True
J-32	1	False	60.00	0.00	60.00	0.00	20.0	1.8	0.0	7.2	1.4	110	True
J-33	1	False	60.00	0.00	60.00	0.00	20.0	17.5	0.0	0.0	0.0	52	True
J-34	1	False	60.00	0.00	60.00	0.00	20.0	8.5	0.0	13.2	1.4	110	True
										1.9	1.4	110	True
										13.1	1.4	110	True
										1.4	1.4	110	True
										1.9	1.4	110	True
										0.0	0.0	10	True
										1.9	1.4	110	True
										1.9	1.4	110	True
										1.4	1.4	110	True
										1.9	1.4	110	True
										0.0	0.0	52	True
										1.9	1.4	110	True
										13.3	1.4	110	True
										0.3	0.3	10	True
										0.2	0.2	52	True
										11.9	1.4	110	True
										1.9	1.4	110	True
										10.4	1.4	110	True
										0.2	0.2	10	True
										0.3	0.3	57	True
										1.4	1.4	110	True
										11.9	1.4	110	True
										8.5	1.4	110	True
										0.0	0.0	30	True
										0.0	0.0	10	True
										13.0	1.4	110	True
										8.5	1.4	110	True

Fire Flow Node FlexTable: Fire Flow Report (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
1.9	1.4	110	True
13.0	1.4	110	True
1.9	1.4	110	True
1.9	1.4	110	True
1.9	1.4	110	True
0.2	0.2	10	True
1.4	1.4	110	True
1.4	1.4	110	True
1.9	1.4	110	True
4.9	1.4	110	True
13.2	1.4	110	True
1.4	1.4	110	True
1.9	1.4	110	True
0.0	0.0	52	True
8.5	1.4	110	True
1.4	1.4	110	True
0.0	0.0	30	True
1.4	1.4	110	True
1.9	1.4	110	True
1.9	1.4	110	True
1.4	1.4	110	True
1.9	1.4	110	True
1.9	1.4	110	True
0.2	0.2	52	True
1.9	1.4	110	True
13.3	1.4	110	True
1.9	1.4	110	True
13.3	1.4	110	True
0.0	0.0	30	True
0.0	0.0	30	True
1.9	1.4	110	True
13.2	1.4	110	True
1.9	1.4	110	True
17.5	1.4	110	True
11.9	1.4	110	True
1.8	1.8	J-32	True
1.9	1.4	110	True
13.1	1.4	110	True
0.0	0.0	10	True
12.0	1.4	110	True
0.0	0.0	10	True
1.4	1.4	110	True
0.1	0.1	52	True
8.5	1.4	110	True

Fire Flow Node FlexTable: Fire Flow Report (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
0.0	0.0	55	True
11.9	1.4	110	True
13.0	1.4	110	True
1.9	1.4	110	True
1.9	1.4	110	True
1.4	1.4	110	True
1.9	1.4	110	True
1.4	1.4	110	True
0.0	0.0	10	True
13.0	1.4	110	True
0.0	0.0	30	True
12.1	1.4	110	True
0.0	0.0	10	True
12.0	1.4	110	True
1.9	1.4	110	True
7.2	1.4	110	True
11.4	1.4	110	True
1.4	1.4	110	True
13.5	1.4	110	True
1.9	1.4	110	True

FlexTable: Junction Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
147	119	625.00	0.00	633.02	11.4
89	10	607.00	0.27	634.46	39.1
83	11	600.00	0.00	634.50	49.1
55	9	598.00	0.33	634.50	51.9
63	100	588.00	0.22	635.47	67.5
98	12	587.00	0.38	634.40	67.4
341	J-9	587.00	0.00	635.82	69.4
78	61	587.00	0.44	634.38	67.4
94	8	586.00	0.00	591.04	7.2
109	14	586.00	0.27	634.19	68.5
87	72	585.00	0.65	633.94	69.6
549	J-34	585.00	0.00	591.00	8.5
427	J-21	585.00	0.00	591.00	8.5
162	70	584.00	0.49	635.05	72.6
104	13	584.00	0.65	634.30	71.5
143	28	583.00	0.22	633.60	72.0
141	64	582.00	0.49	634.89	75.2
72	23	566.00	0.38	634.39	97.3
154	66	563.00	0.27	591.18	40.1
130	107	560.00	0.60	590.86	43.9
75	22	558.00	0.00	591.28	47.3
103	15	547.00	0.16	590.18	61.4
59	30	546.00	0.38	597.82	73.7
67	20	544.00	0.98	590.24	65.8
119	19	544.00	0.00	590.24	65.8
90	63	543.00	0.00	590.24	67.2
153	17	543.00	0.00	590.23	67.2
159	16	543.00	0.16	590.22	67.2
126	18	542.00	0.22	590.20	68.6
116	24	540.00	0.33	594.14	77.0
100	29	533.00	0.00	597.91	92.3
107	76	532.00	0.76	597.91	93.7
64	101	528.00	0.65	590.09	88.3
129	78	525.00	0.87	597.91	103.7
96	74	524.00	0.22	598.10	105.4
113	25	524.00	0.00	598.13	105.4
123	108	518.00	0.65	590.12	102.6
121	27	517.00	0.33	597.99	115.2
128	26	515.00	0.00	599.71	120.5
117	118	514.00	0.00	543.13	41.4
139	117	514.00	0.00	543.13	41.4
62	21	510.00	0.16	572.08	88.3
413	J-16	501.00	0.00	502.31	1.9
132	31	498.00	0.60	543.07	64.1
134	103	493.00	0.33	502.48	13.5
85	6	491.00	0.33	601.17	156.7
547	J-33	490.00	0.00	502.29	17.5

FlexTable: Junction Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
321	J-3	490.00	0.00	601.38	158.4
65	33	487.00	0.60	542.75	79.3
93	80	487.00	0.00	543.05	79.7
70	32	487.00	0.00	543.04	79.7
77	34	470.00	0.38	504.05	48.4
74	35	466.00	0.00	506.68	57.9
88	36	463.00	0.49	504.05	58.4
150	116	458.00	0.00	507.62	70.6
373	J-10	458.00	0.33	511.99	76.8
142	112	458.00	0.00	511.40	75.9
336	J-7	458.00	0.00	512.40	77.4
82	37	458.00	0.60	507.74	70.7
127	104	457.00	0.11	504.04	66.9
91	82	455.00	0.00	511.97	81.0
71	109	455.00	0.44	504.22	70.0
131	57	452.00	0.27	507.40	78.8
151	106	450.00	0.38	511.92	88.1
105	94	445.00	0.00	507.40	88.7
58	56	443.00	0.22	507.40	91.6
163	86	440.00	0.60	507.59	96.1
545	J-32	438.00	0.00	439.28	1.8
135	113	438.00	0.00	515.79	110.6
404	J-14	438.00	0.00	439.33	1.9
79	92	433.00	0.76	507.41	105.8
140	84	431.00	0.65	511.88	115.0
106	38	431.00	0.00	440.53	13.6
124	54	425.00	0.11	507.38	117.2
118	55	420.00	0.44	445.14	35.8
114	52	418.00	0.22	446.80	41.0
60	105	415.00	0.16	511.88	137.8
102	51	410.00	0.00	446.87	52.4
80	96	410.00	0.60	446.87	52.4
61	39	409.00	0.27	443.50	49.1
54	90	408.00	0.33	445.16	52.8
144	88	405.00	0.00	443.50	54.8
155	40	405.00	0.44	443.49	54.7
149	41	400.00	0.38	445.18	64.3
145	49	392.00	0.00	446.89	78.1
111	53	388.00	0.11	446.85	83.7
73	48	387.00	0.00	446.90	85.2
122	98	385.00	0.00	446.90	88.0
160	43	384.00	0.27	446.06	88.3
53	45	384.00	0.49	446.95	89.5
50	42	383.00	0.00	446.21	89.9
108	50	372.00	0.54	446.87	106.5
56	44	365.00	0.33	447.24	117.0
66	46	345.00	0.00	446.93	145.0

FlexTable: Junction Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
68	2	345.00	0.00	447.83	146.3
52	47	345.00	0.11	446.91	145.0
136	110	342.00	0.00	342.98	1.4

FlexTable: Pipe Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
249	14	89.90	9	12	100.0	130.0	2.12	0.27
176		5.70	J-32	K1-10HP	150.0	130.0	10.16	0.57
228	54	192.10	31	80	100.0	130.0	0.60	0.08
229	72	75.42	57	94	100.0	130.0	0.33	0.04
232	17	336.09	61	13	100.0	130.0	0.92	0.12
234	25	149.62	17	19	100.0	130.0	-0.54	0.07
235	43	80.06	76	29	100.0	130.0	0.23	0.03
236	87	116.81	39	41	150.0	130.0	-24.93	1.41
239	76	59.62	112	37	100.0	130.0	18.80	2.39
240	24	51.63	17	18	50.0	130.0	0.22	0.11
242	86	162.93	88	40	100.0	130.0	0.44	0.06
243	15	38.36	12	61	100.0	130.0	1.36	0.17
244	5	207.09	22	8	150.0	130.0	6.37	0.36
224	9	250.87	100	64	100.0	130.0	3.21	0.41
247	41	301.26	27	76	100.0	130.0	1.00	0.13
222	11	228.52	64	9	100.0	130.0	2.72	0.35
252	40	87.97	74	27	100.0	130.0	2.34	0.30
253	84	61.40	39	88	100.0	130.0	0.44	0.06
257	47	68.56	29	30	50.0	130.0	0.38	0.19
258	121	142.50	35	116	150.0	130.0	-16.24	0.92
259	99	23.83	48	49	100.0	130.0	0.92	0.12
260	28	12.25	20	63	100.0	130.0	1.31	0.17
261	46	139.10	78	29	100.0	130.0	0.15	0.02
264	110	303.94	20	107	100.0	130.0	-2.99	0.38
266	114	51.71	36	109	50.0	130.0	-0.63	0.32
267	115	282.65	109	35	50.0	130.0	-1.06	0.54
269	111	111.99	107	66	100.0	130.0	-3.59	0.46
270	44	291.92	27	78	100.0	130.0	1.02	0.13
246	94	93.34	46	47	50.0	100.0	0.11	0.06
209	104	365.32	49	53	50.0	130.0	0.11	0.06
177		6.21	K1-10HP	113	150.0	130.0	10.16	0.57
180		6.26	J-32	K2-15HP	150.0	130.0	10.16	0.57
181		7.13	K2-15HP	113	150.0	130.0	10.16	0.57
188		13.54	110	L1-30HP	600.0	100.0	14.36	0.05
192		2.04	J-34	W1-5HP	150.0	130.0	0.00	0.00
196		13.41	110	L2-30HP	600.0	100.0	14.39	0.05
197	PP	14.30	L2-30HP	2	100.0	100.0	14.39	1.83
200	26	11.79	19	20	100.0	130.0	-0.71	0.09
201	69	369.12	86	92	100.0	130.0	1.36	0.17
202	34	143.48	22	24	100.0	130.0	-10.24	1.30
203	52	293.77	6	26	150.0	130.0	14.32	0.81
204	96	13.95	48	98	100.0	130.0	0.54	0.07
226	1	4.48	Lakeside	110	200.0	130.0	28.74	0.91
206	95	89.53	45	48	100.0	130.0	1.47	0.19
273	113	183.19	108	101	100.0	130.0	0.65	0.08
210	50	125.64	72	28	100.0	130.0	3.47	0.44
211	38	20.58	25	74	100.0	130.0	2.56	0.33

FlexTable: Pipe Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
212	48	301.29	70	72	100.0	130.0	4.12	0.52
213	13	53.10	11	10	50.0	130.0	0.27	0.14
214	57	24.12	32	33	37.5	130.0	0.60	0.54
215	33	30.90	66	22	100.0	130.0	-3.86	0.49
216	65	63.80	36	104	50.0	130.0	0.11	0.06
217	83	160.81	84	105	100.0	130.0	0.16	0.02
218	12	15.57	9	11	100.0	130.0	0.27	0.03
219	56	33.18	80	32	100.0	130.0	0.60	0.08
220	64	65.47	35	34	100.0	130.0	15.18	1.93
221	82	218.48	38	39	150.0	130.0	-24.23	1.37
205	51	49.99	25	26	100.0	130.0	-13.12	1.67
415	P-35	2.14	J-16	Udell	150.0	130.0	14.50	0.82
326	P-8	3.36	U1-10HP Lag	J-3	150.0	130.0	7.32	0.41
340	P-15	2.25	J-34	W2-5HP	150.0	130.0	8.04	0.45
342	P-16	2.05	W1-5HP	J-9	100.0	130.0	0.00	0.00
344	P-18	2.47	W2-5HP	J-9	100.0	130.0	8.04	1.02
374	P-19	9.52	J-10	112	100.0	130.0	18.80	2.39
375	P-20	70.09	J-10	82	100.0	130.0	1.20	0.15
377	P-22	5.73	J-7	J-10	100.0	130.0	20.32	2.59
380	P-24	2.63	J-33	U2-10HP Lead	150.0	130.0	7.32	0.41
381	P-25	3.32	J-33	U1-10HP Lag	152.4	130.0	7.32	0.40
400	P-26	20.56	116	37	152.4	130.0	-16.24	0.89
401	P-27	11.68	117	118	152.4	130.0	1.20	0.07
405	P-29	87.64	38	J-14	150.0	130.0	24.23	1.37
271	62	232.05	34	36	100.0	130.0	-0.03	0.00
414	P-34	32.24	103	J-16	150.0	130.0	14.50	0.82
311	90	64.28	42	44	150.0	130.0	-26.35	1.49
428	P-42	36.97	8	J-21	150.0	130.0	6.37	0.36
429	P-43	1.29	J-21	Wincheste r	150.0	130.0	6.37	0.36
453	P-59	47.83	113	J-7	100.0	130.0	20.32	2.59
457	P-61	40.37	J-3	6	150.0	130.0	14.64	0.83
463	P-65	27.88	J-9	100	100.0	130.0	8.04	1.02
489	P-70	13.65	L1-30HP	2	152.4	100.0	14.36	0.79
546	P-76	2.73	J-32	Killarney	152.4	130.0	-20.32	1.11
548	P-77	2.32	J-33	Udell	152.4	130.0	-14.64	0.80
550	P-78	2.37	Winchest er	J-34	152.4	130.0	8.04	0.44
559	P-80	6.37	26	PRV-14	100.0	130.0	1.20	0.15
560	P-81	6.27	PRV-14	117	100.0	130.0	1.20	0.15
562	P-82	21.57	19	PRV-15	50.0	130.0	0.16	0.08
406	P-30	2.73	J-14	Killarney	150.0	130.0	24.23	1.37
292	67	162.66	37	86	100.0	130.0	1.96	0.25
563	P-83	205.94	PRV-15	21	50.0	130.0	0.16	0.08
274	7	92.30	100	70	100.0	130.0	4.61	0.59

FlexTable: Pipe Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
276	127	245.39	119	28	100.0	130.0	-3.25	0.41
277	124	176.03	118	31	100.0	130.0	1.20	0.15
278	61	287.53	103	34	150.0	130.0	-14.83	0.84
279	108	130.58	82	106	100.0	130.0	1.20	0.15
280	109	196.29	106	84	100.0	130.0	0.82	0.10
281	71	137.20	92	57	100.0	130.0	0.60	0.08
284	105	168.41	41	90	100.0	130.0	0.76	0.10
285	102	7.19	96	51	100.0	130.0	0.22	0.03
286	103	149.93	51	52	50.0	130.0	0.22	0.11
287	100	147.06	49	96	100.0	130.0	0.82	0.10
322	P-5	2.84	U2-10HP Lead	J-3	150.0	130.0	7.32	0.41
291	23	111.70	16	17	100.0	130.0	-0.33	0.04
313	88	66.14	41	42	150.0	130.0	-26.08	1.48
293	98	320.84	98	50	100.0	130.0	0.54	0.07
294	75	134.02	56	54	50.0	130.0	0.11	0.06
295	93	73.71	45	46	50.0	100.0	0.11	0.06
298	74	21.97	94	56	100.0	130.0	0.33	0.04
299	92	280.64	44	45	100.0	130.0	2.07	0.26
300	21	143.16	15	16	50.0	130.0	-0.16	0.08
302	19	167.19	13	14	50.0	130.0	0.27	0.14
303	37	189.51	24	25	100.0	130.0	-10.56	1.34
304	126	9.12	Hope Creek	119	100.0	130.0	-3.25	0.41
305	91	128.85	2	44	200.0	130.0	28.74	0.91
306	20	256.33	12	23	100.0	130.0	0.38	0.05
308	89	219.93	42	43	50.0	130.0	0.27	0.14
272	112	269.88	63	108	100.0	130.0	1.31	0.17
290	107	179.38	90	55	100.0	130.0	0.44	0.06

FlexTable: Pump Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Pump Definition	Status (Initial)	Hydraulic Grade (Suction) (m)	Hydraulic Grade (Discharge) (m)	Flow (Total) (L/s)	Pump Head (m)
175	K1-15HP	438.00	K1-15 hp	On	439.27	517.01	10.07	77.74
179	K2-15HP	438.00	K2-15 hp	On	439.27	517.01	10.07	77.74
183	U2-10HP Lead	490.00	Udell 10 hp	On	502.29	603.41	7.15	101.12
187	L1-30HP	335.00	Lake Pump 30 hp	On	342.98	448.58	14.13	105.60
191	W1-5HP	588.00	Winchester 5 hp	On	591.00	637.89	0.00	0.00
195	L2-30HP	335.00	Lake Pump 30 hp	On	342.98	448.50	14.16	105.52
327	U1-10HP Lag	490.00	Udell 10 hp	On	502.29	603.41	7.15	101.12
345	W2-5HP	588.00	Winchester 5 hp	On	590.99	637.90	7.84	46.90

FlexTable: Tank Table (Killiney_Base_2010.wtg)

Current Time: 0.000 hours

ID	Label	Zone	Elevation (Base) (m)	Elevation (Minimum) (m)	Elevation (Initial) (m)	Elevation (Maximum) (m)	Volume (Inactive) (m³)	Diameter (m)	Net Outflow (L/s)	Hydraulic Grade (m)
165	Winchester	Winchester	587.70	588.62	591.00	591.36	0.00	13.91	-1.68	591.00
166	Hope Creek	Hope	629.41	630.33	633.00	633.07	0.00	4.38	-5.07	633.00
167	Udell	Udell	501.09	502.00	502.30	504.75	0.00	5.97	-0.91	502.30
168	Killarney	Killarney	438.09	439.00	439.30	441.75	0.00	5.86	-7.12	439.30

Controls Summary

Simple Control: LC501

IF {"Killarney" Hydraulic Grade > 441.60 m}
THEN {"L1-30HP" Pump Status = Off }

Simple Control: LC502

IF {"Killarney" Hydraulic Grade <= 439.60 m}
THEN {"L1-30HP" Pump Status = On }

Simple Control: LC503

IF {"Udell" Hydraulic Grade > 504.65 m}
THEN {"K2-15HP" Pump Status = Off }

Simple Control: LC505

IF {"Winchester" Hydraulic Grade > 591.20 m}
THEN {"U1-10HP Lag" Pump Status = Off }

Simple Control: LC506

IF {"Winchester" Hydraulic Grade <= 589.20 m}
THEN {"U1-10HP Lag" Pump Status = On }

Simple Control: LC507

IF {"Hope Creek" Hydraulic Grade <= 630.60 m}
THEN {"W1-5HP" Pump Status = On }

Simple Control: LC508

IF {"Hope Creek" Hydraulic Grade > 632.80 m}
THEN {"W1-5HP" Pump Status = Off }

Logical Control: LC522

IF {"W1-5HP" Status = On }
THEN {"W2-5HP" Pump Status = On }
ELSE {"W2-5HP" Pump Status = Off }

Logical Control: LC525

IF {"K2-15HP" Status = On }
THEN {"K1-10HP" Pump Status = On }
ELSE {"K1-10HP" Pump Status = Off }

Simple Control: LC526

IF {"Udell" Hydraulic Grade <= 504.30 m}
THEN {"K2-15HP" Pump Status = On }

Simple Control: LC530

IF {"Killarney" Hydraulic Grade <= 439.40 m}
THEN {"L2-30HP" Pump Status = On }

Logical Control: LC533

IF {"L1-30HP" Status = On }
THEN {"L2-30HP" Pump Status = On }
ELSE {"L2-30HP" Pump Status = Off }

Logical Control: LC556

IF {"Winchester" Hydraulic Grade <= 590.50 m}
THEN {"U2-10HP Lead" Pump Status = On }

Controls Summary

Logical Control: LC557

IF {"Winchester" Hydraulic Grade > 591.20 m}
THEN {"U2-10HP Lead" Pump Status = Off }

Pattern Detailed Report: Residential

Element Details			
ID	47	Notes	
Label	Residential		

<Pattern Summary>			
Start Time	12:00:00 AM	Pattern Category Type	Hydraulic
Starting Multiplier	0.600	Pattern Format	Stepwise

Pattern Curve

Time from Start (hours)	Multiplier
1.000	0.600
2.000	1.000
3.000	1.600
4.000	1.600
5.000	1.600
6.000	1.600
7.000	1.600
8.000	1.200
9.000	0.600
10.000	0.600
11.000	0.600
12.000	0.600
13.000	0.600
14.000	0.600
15.000	0.600
16.000	0.600
17.000	0.750
18.000	1.100
19.000	1.250
20.000	1.400
21.000	1.340
22.000	0.950
23.000	0.750
24.000	0.600

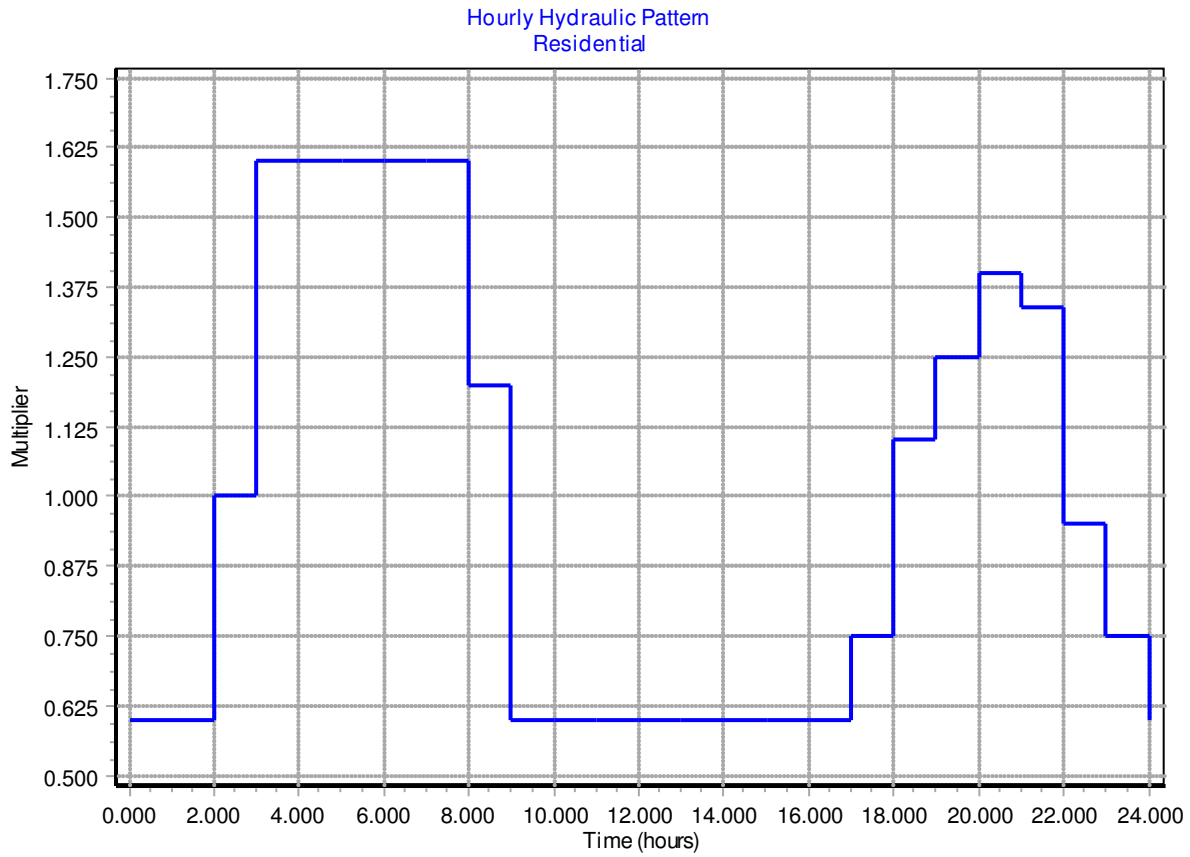
Pattern - Daily Multipliers

	Multiplier
Mon	1.000
Tue	1.000
Wed	1.000
Thur	1.000
Fri	1.000
Sat	1.000
Sun	1.000

Pattern Detailed Report: Residential

Pattern - Monthly Multipliers

	Multiplier
Jan	1.000
Feb	1.000
Mar	1.000
Apr	1.000
May	1.000
Jun	1.000
Jul	1.000
Aug	1.000
Sept	1.000
Oct	1.000
Nov	1.000
Dec	1.000



Pump Definition Detailed Report: K2-15 hp

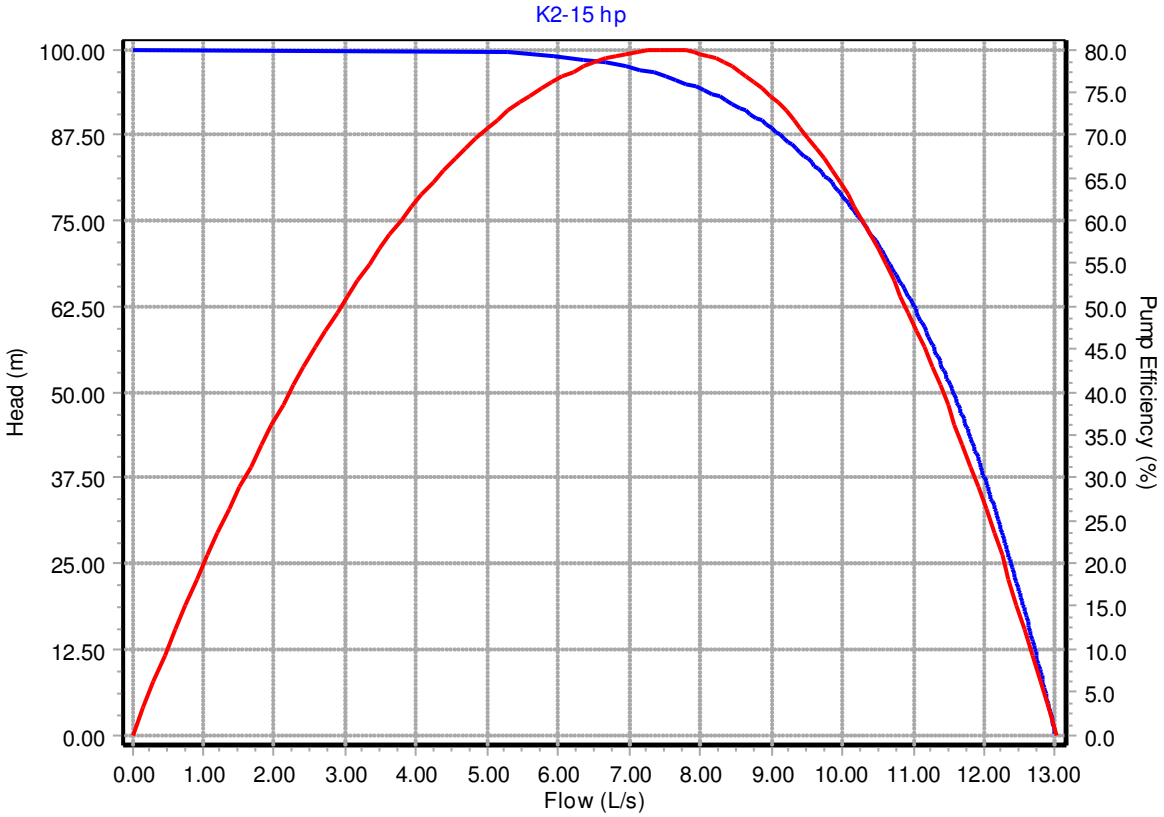
Element Details			
ID	182	Notes	
Label	K2-15 hp		

Pump Definition Type			
Pump Definition Type	Standard (3 Point)	Design Head	78.60 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	13.00 L/s
Shutoff Head	100.00 m	Maximum Operating Head	0.00 m
Design Flow	10.00 L/s		

Pump Efficiency			
Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	80.0 %	Is Variable Speed Drive?	False
BEP Flow	7.57 L/s		

Transient (Physical)			
Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: K2-15 hp



Coefficients: a = 100.00 m; b = 2.844e-005 m/(L/s)^c; c = 5.876

Pump Definition Detailed Report: Lake Pump 30 hp

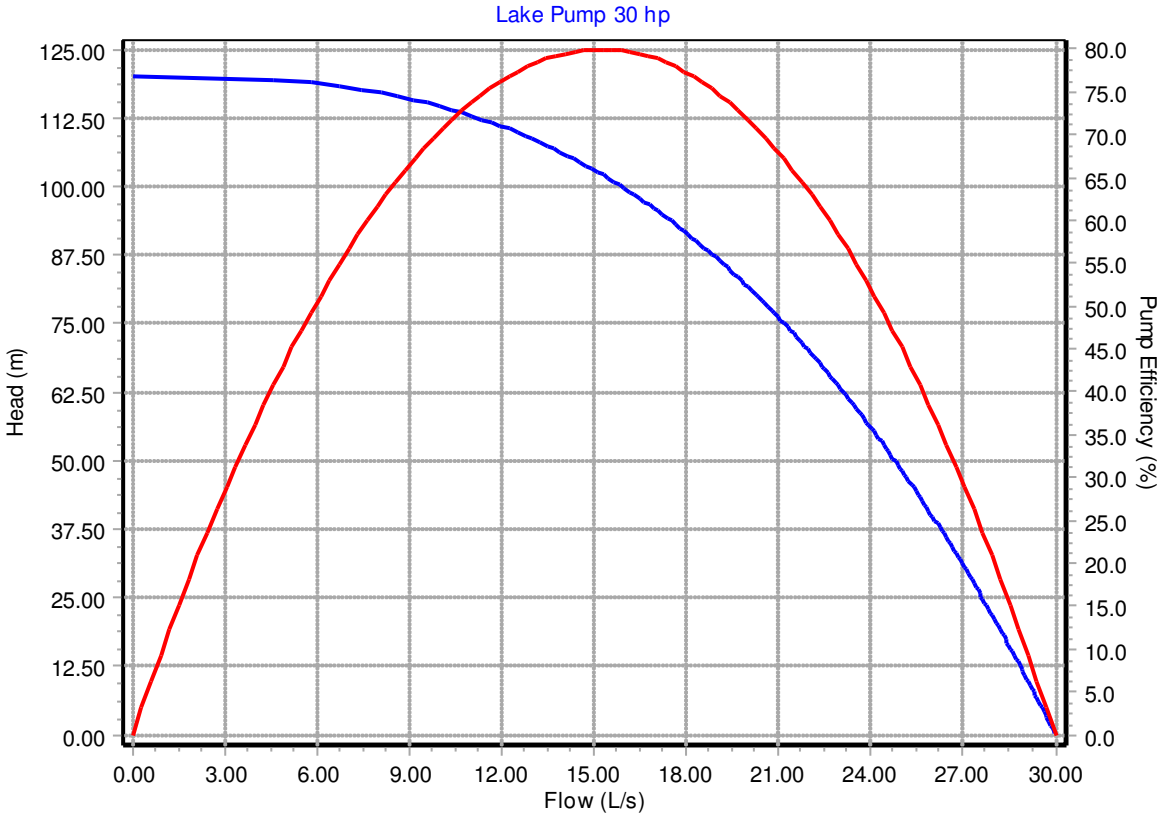
Element Details			
ID	198	Notes	
Label	Lake Pump 30 hp		

Pump Definition Type			
Pump Definition Type	Standard (3 Point)	Design Head	102.00 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	30.00 L/s
Shutoff Head	120.00 m	Maximum Operating Head	0.00 m
Design Flow	15.30 L/s		

Pump Efficiency			
Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	80.0 %	Is Variable Speed Drive?	False
BEP Flow	15.30 L/s		

Transient (Physical)			
Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: Lake Pump 30 hp



Coefficients: a = 120.00 m; b = 8.269e-003 m/(L/s)^c; c = 2.817

Pump Definition Detailed Report: Udell 10 hp

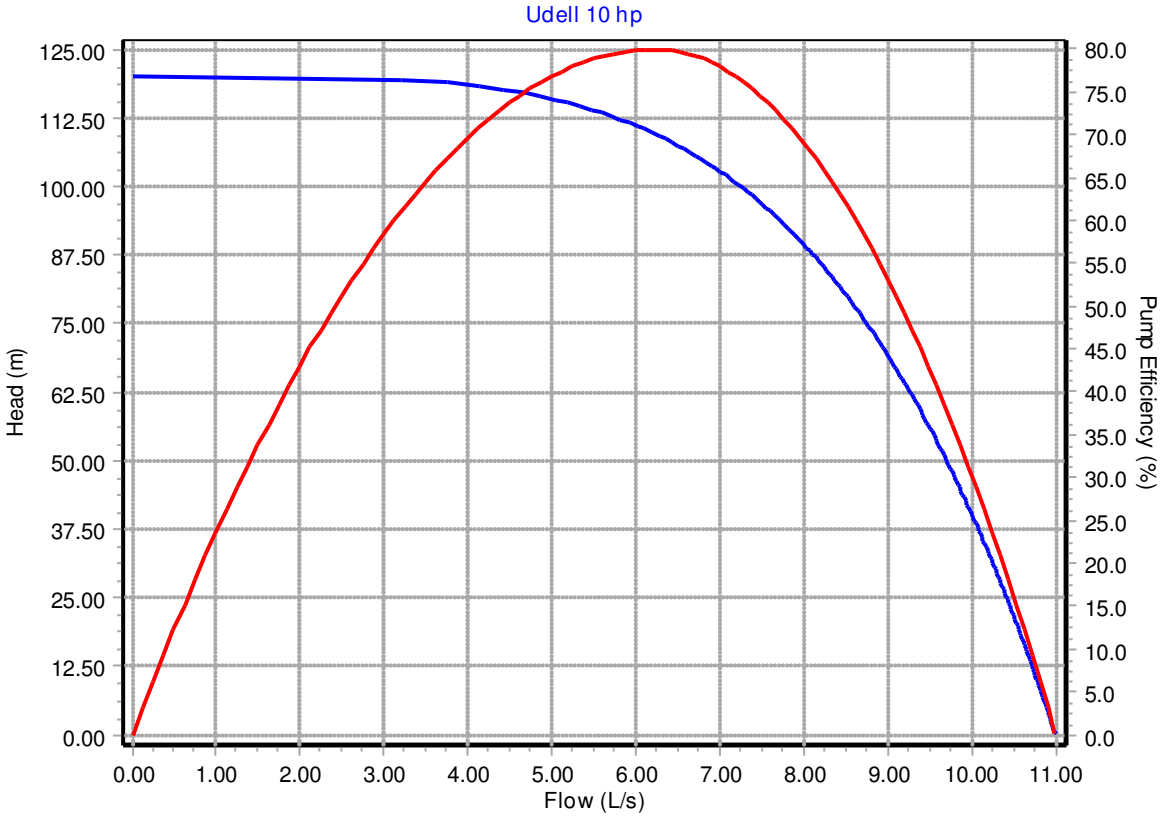
Element Details			
ID	186	Notes	
Label	Udell 10 hp		

Pump Definition Type			
Pump Definition Type	Standard (3 Point)	Design Head	93.60 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	11.00 L/s
Shutoff Head	120.00 m	Maximum Operating Head	0.00 m
Design Flow	7.73 L/s		

Pump Efficiency			
Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	80.0 %	Is Variable Speed Drive?	False
BEP Flow	6.25 L/s		

Transient (Physical)			
Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: Udell 10 hp



Coefficients: a = 120.00 m; b = 4.070e-003 m/(L/s)^c; c = 4.292

Pump Definition Detailed Report: Winchester 5 hp

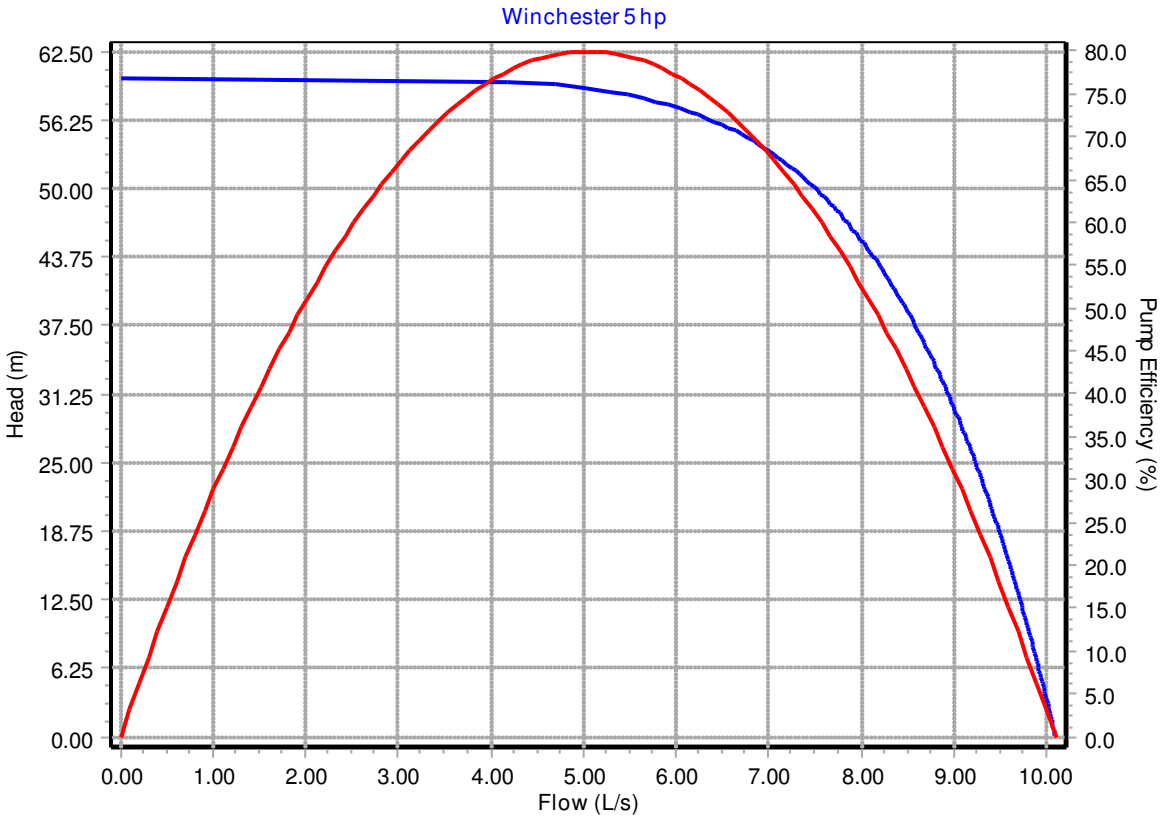
Element Details			
ID	194	Notes	
Label	Winchester 5 hp		

Pump Definition Type			
Pump Definition Type	Standard (3 Point)	Design Head	48.00 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	10.09 L/s
Shutoff Head	60.00 m	Maximum Operating Head	0.00 m
Design Flow	7.73 L/s		

Pump Efficiency			
Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	80.0 %	Is Variable Speed Drive?	False
BEP Flow	5.05 L/s		

Transient (Physical)			
Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: Winchester 5 hp



Coefficients: a = 60.00 m; b = 5.283e-005 m/(L/s)^c; c = 6.031

Report

Associated Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

Regional District of Central Okanagan

Westshore Estates Water System Review

November 2010



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Table of Contents

SECTION			PAGE NO.
Table of Contents			**i**
1	**Overview**		**1**
2	**Background**		**1**
3	**Objective**		**1**
4	**Existing System**		**2**
	4.1	Existing Infrastructure	2
5	**Water Demand**		**3**
	5.1	Design Criteria	3
6	**Water Treatment**		**4**
	6.1	Raw Water Quality	4
	6.2	Water Quality Objectives	5
	6.3	Filtration Deferral	5
	6.4	Water Treatment Strategy	7
7	**Distribution System Evaluation**		**8**
	7.1	Steady State	8
	7.2	Extended Period Simulation	8
8	**Water System Upgrades**		**9**
	8.1	Pump Capacity	9
	8.2	Reservoir Capacity	10
	8.3	Distribution System	10
	8.4	Intake	11
	8.5	Water Treatment at Pump Station	12
	8.6	Electrical	12

9 Cost Estimates 12

9.1 Life Cycle Costing Basis – Assuming Filtration Deferral Obtained from IHA 12

10 Fee Recovery 13

10.1 Review of Expenses 13
10.2 RDCO Funds 15
10.3 RDCO Rates 15
10.4 Fee Recovery to 2030 16
10.5 Detailed Income and Expenditures 17

11 Recommendations 17

11.1 Water Quality 17
11.2 Water Distribution 18

Enclosure A – Bathymetric Mapping 1

Enclosure B - Cost Estimating Data 1

Enclosure C - Distribution System Mapping 1

Enclosure D - Diving Inspection Report 1

Enclosure E - IHA Filtration Deferral Document 1

Enclosure F – Westshore Model Output 1

REPORT

Regional District of Central Okanagan
Westshore Estates Water System Review

Issued: November 12, 2010
Previous Issue: October 19, 2010

1 Overview

The Regional District of Central Okanagan (RDCO) retained Associated Engineering to review the Westshore Estates water system and to provide the following:

- Create/update on inventory of existing water system facilities.
- Prepare a computerized water system hydraulic model.
- Analyze the system's source supply and distribution system for existing and future requirements.
- Evaluate the system to comply with the Guidelines for Canadian Drinking Water Quality, Interior Health Authority (IHA) regulations and Regional District of Central Okanagan's (RDCO) Bylaw 704.
- Develop an Operations and Maintenance Fee Recovery Strategy.
- Prepare a Capital Improvements Plan with estimated project costs for recommended water system improvements and project sequencing.

2 Background

The Westshore Estates water system is located on the west side of Okanagan Lake, approximately 10 km north of Fintry, BC. The system has been operated and maintained by the RDCO since the mid 1990's. Recently, the RDCO has undertaken a water metering program and is investigating required upgrading that is consistent with the Subdivision and Development Servicing Bylaw N.704.

3 Objective

The purpose of this water system review is to assess the infrastructure needs over the next 20 years and establish financing strategies for which to base user and maintenance fees. This report involved review of past studies, construction documents, files and other relevant information, and visits to each site as required in order to develop plans allowing for managed growth and responsible infrastructure replenishment. This review included an assessment of the existing infrastructure and short term and long term capital improvements. An evaluation of a long term financial strategy for the collection of user and maintenance fees was also included.

4 Existing System

4.1 Existing Infrastructure

The Westshore water system currently serves 235 domestic connections with a potential full build out of 522 connections. The system currently includes:

Lake Intake
An intake pipeline extending into the Okanagan Lake with approximately 170 metres of 450 mm corrugated steel pipe to a depth of 6 m below average lake level. At the end of the pipeline is an intake screen with approximately 2.0 m^2 surface area.

Lake Pump House
The existing lake pump station consists of two 50 HP vertical turbine pumps, a chlorine gas feed system and associated mechanical and electrical equipment. A digital screen displays the online turbidity reading and water level in the Mountain Reservoir. Water is boosted via a dedicated 200 mm ductile iron (DI) main that leads to the Mountain Reservoir.

Mountain Reservoir and Pump Station
Three interconnected 2.44 metre diameter corrugated steel tanks make up a 341 m^3 reservoir. Water is pumped via a dedicated 250 mm DI main to the Upper reservoir using a single 60 HP vertical turbine pump and a newly installed 60 HP standby pump.

Upper Reservoir
Four interconnected 2.44 metre diameter corrugated steel tanks make up a 455 m^3 reservoir. A valve chamber adjacent to the tanks contains the inlet piping. An altitude valve is positioned on the inlet piping but is blocked in by isolation valves and water is diverted through the bypass piping around the altitude valve.

Distribution System
The distribution system is split into two main pressure zones; the Lower pressure zone with a hydraulic grade of 504 m and the Upper pressure zone with a hydraulic grade of 594 m (see Enclosure C, Figure 1). The hydraulic grade is set by the Upper and Mountain Reservoirs and one Pressure Reducing Valve (PRV) separates the two main pressure zones. There are also two small pressure zones controlled by PRV's with hydraulic grades set at 545 m and 570 m. The majority of the distribution piping is 150 mm PVC, with some 200 mm and 250 mm PVC mains connecting the reservoirs. Some laterals use 50 mm and 100 mm PVC piping. Water meters are currently being installed for all current users of the water system.

Fire Protection
There are 34 fire hydrants connected to either 150 mm or 200 mm distribution lines. The hydrants are fed from the reservoirs and therefore not reliant on pumps.

Water Treatment
The current water treatment consists of chlorination using chlorine gas injection at the Lake Pump House. A dedicated main from the Lake Pump House to the Mountain Reservoir allows for longer chlorine contact times.

5 Water Demand

The water supply and treatment components should be designed to meet maximum day demand (MDD). The reservoirs should be designed to contain enough balancing volume to meet peak hour demands (PHD). The following confirms the water demand design criteria used in this report for the purposes of comparing upgrading options.

5.1 Design Criteria

The RDCO bylaw states the following design criteria for single family residential connections:

Average Day Demand (ADD): 1000 l/cap/d
Maximum Day Demand (MDD): 3000 l/cap/d
Peak Hour Demand (PHD): 5000 l/cap/d

These demands are conservative to ensure new developments are constructed with adequate water supply throughout the development. The community of Westshore Estates is an existing development that the RDCO has taken over. The District is required to plan for future demand criteria that are more in line with actual demand criteria.

For comparison purposes, 2009 pumps records were obtained which showed the maximum flow rate of 4261 m^3 over a 72 hour period, or a system MDD of 16.4 l/s or, based on 207 connections, a demand of 6845 l/connection/day. This is calculated to be 2282 l/cap/d based on 3 persons per connection. A demand criterion of 2400 l/ca/d for MDD is a reasonable assumption.

It is expected that further reductions in demand are expected when the meters become operational. Recent water metering has shown that significant reductions in demand are observed in several Okanagan communities.

The following demand criteria are suggested for the Westshore Estates community and are the same criteria set out in City of Kelowna's bylaw for residential units and are in line with existing demands.

- ADD: 900 l/ca/d
- MDD: 2400 l/ca/d
- PHD: 4000 l/ca/d

The Westshore water model developed in this process was therefore evaluated using MDD criteria of 2400 l/ca/d for existing and future build out connections.

6 Water Treatment

6.1 Raw Water Quality

The Westshore water supply is drawn from Okanagan Lake, where water quality is generally considered to be very good. Raw water quality characterization presented in Table 6-1 is based on a review of data from the City of Kelowna and the City of Penticton, and provides an indicator of the raw water quality since 1990. Data collected from the Westshore intake is also shown in the table for comparison. Water quality in the lake is relatively consistent and not subject to rapid significant changes. This is due to the size and volume of the lake. Kelowna and Penticton withdraw their water from depths greater than 25 metres where the seasonal water quality is very consistent, thereby simplifying its treatability.

Table 6-1
Raw Water Quality

Parameters	Units	Min.	Max.	Normal	Westshore June 2009
Alkalinity	mg/l	101	122	109	111
Colour	TCU	0	5	2	<5
Hardness	mg/l	105	130	117	139
pH	pH	7.5	9.1	8.0	7.9
Turbidity	NTU	0.1	4	0.5	0.7
Calcium	mg/l	30	38	34	35.4
Iron	mg/l	.01	.11	.02	<0.1
UV Transmittance	%	83	94	87	89.8

The existing intake depth at Westshore is only 6 metres which is significantly less than the City of Kelowna and Penticton intake depths. Experience has shown that water extracted at this depth is prone to more frequent spikes in turbidity. Operations reports turbidity spikes above 1.0 NTU at the lake intake. Water sampling from February to May of this year showed maximum turbidity in the range of 0.7 NTU. E-coli and total coliforms were found to be less than 1 count per 100 ml sampled.

6.2 Water Quality Objectives

In 2006, the Interior Health Authority (IHA) established the 4.3.2.1.0 Drinking Water Objective. Under this objective the following criteria were established:

- 4 log virus removal
- 3 log Giardia and Cryptosporidium removal or inactivation
- 2 stages of treatment – see below
- 1 NTU turbidity maximum
- 0 bacterial indicators

Under the new objective a minimum of 2 stages of treatment is required for water that is at risk of containing pathogens. Filtration and disinfection should be considered on most water supplies to ensure a safe supply of water. UV light and chlorination can be considered for source water that meets the criteria for filtration deferral as outlined in the next section.

IHA now requires purveyors to issue a water quality advisory when turbidity values exceed 1.0 NTU and a boil water advisory if turbidity exceeds 5.0 NTU. Ultimately, all surface waters are to be filtered and this is to be taken into account in the planning of water treatment improvements by each water purveyor.

6.3 Filtration Deferral

Deferral of Filtration is presently a key strategy in place for utilities that have surface water sources. This is a viable option for the Westshore water system assuming the following criteria can be met.

In February 2008 the IHA published an Issue Paper defining the criteria for the “Deferral of Filtration”.

As described in more detail in **Enclosure E**, the following are the basic requirements that must be met in order for a water source to be considered for deferral of filtration:

1. 4-log removal or inactivation of viruses and 3-log inactivation of protozoa is achieved using a minimum of 2 disinfection processes.
2. A watershed control program designed with the express purpose of minimizing fecal contamination in the source water is being implemented. Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the Comprehensive Source to Tap Assessment Guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO (basically Modules 1, 2, 7 and 8) and may be included in conditions of the operating permit.
3. Background baseline levels of Cryptosporidium and Giardia, adequate to establish trends, have been established.
4. No more than 10% of source/raw water E.coli samples exceed 20/100 mL in any 6-month period.

5. No more than 10% of source/raw water total coliform samples exceed 100/100 mL in any 6-month period.
6. Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.*
7. Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period.
8. Expected average annual total Trihalomethanes at locations farthest from treatment will not exceed 0.100 mg/L or 100 µg/L.

* This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that might not always meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month". It is also important to remember that the GCDWQ is only a guideline. Turbidity is not necessarily a sure sign that pathogens are present; however, it is indicative of the possibility of their presence.

UV disinfection with chlorine achieves requirement No. 1 providing that the source water is of sufficiently good quality for the processes to be technically feasible. Okanagan Lake water would be sufficiently good.

The IHA Deferral of Filtration document in Enclosure E expands on the criteria for meeting Requirement No. 2. Regardless of the method used and plan developed, it is expected that the following elements will be included:

.1 Characterization of the source water and delineation of the area of the watershed from which source water originates. This should include an evaluation of the pathways and estimated time of travel for fecal pathogens to the intake from different areas in watershed.
.2 Identification of potential sources of fecal pollution within the watershed that pose a threat of introducing pathogenic organisms to the drinking water system.
.3 An assessment of the risks to public health posed by the identified sources of fecal pollution.
.4 A plan to mitigate the risks posed by sources of fecal pathogens in the capture zone and limit future contamination of the water source.

The document in Enclosure E clarifies that it is not necessary to have exclusive use of a watershed to have a watershed control program.

Monitoring must be done to achieve requirement Nos. 3 through 8. Enclosure E provides the following typical levels of monitoring:

Microbes

- E.coli & Total Coliforms (minimum weekly samples)
- Protozoa (monthly samples)

Physical Parameters

- Temperature (minimum weekly)
- Turbidity (daily averages based on minimum of 1 sample every 4 hours. However, elsewhere in Enclosure E on-line continuous turbidity monitoring is specified as being required)
- Colour (minimum weekly)
- UV transmittance (minimum weekly)

Chemical Parameters

- Alkalinity & Hardness (minimum bi-weekly)
- Total Organic Carbon (minimum bi-weekly)
- pH (minimum weekly)

Source monitoring to establish compliance with filtration deferral criteria should be conducted over at least a one year period, preferably longer. Testing should be done by an approved laboratory with samples collected using appropriate methods.

It must be noted that these are the monitoring requirements necessary to obtain and sustain deferral of filtration from the Regulator. However, if filtration is deferred and there are subsequently problems, then filtration may be required. Thus, if the current data is presently inconclusive that deferral of filtration would be viable, gathering additional data would be prudent. We must note that while the filtration deferral may decrease costs in the short term, there are risks in adopting the policy. Okanagan Lake is always at risk of external pollutants, algae blooms and other bacteriological or organic changes due changes in water temperature. Intakes are also at risk from creek outflows, recreation and lake hydraulics.

6.4 Water Treatment Strategy

The Project Team met with local IHA representatives. To assure full compliance with the 4-3-2-1-0 Drinking Water Objective, multi-stage treatment incorporating filtration would be required. Depending on the quality of the source water, there are numerous ways of achieving filtered water including direct filtration, clarification and filtration, and membrane filtration.

In order to eliminate Boil Water Advisories or Notices at Westshore Estates, we recommend the RDCO develop a plan to meet IHA's 4-3-2-1-0 guideline. As Okanagan Lake is generally considered a good quality water source, the RDCO should initiate an application for Filtration Deferral. As part of the application, a comprehensive source water study would be required to prove that local external factors, intake depth or lake hydraulics for each water intake do not adversely affect the raw water quality to the point where UV light is rendered ineffective.

The selected treatment strategy will be dependant on further source monitoring with the existing intake. It will be important to observe the turbidity throughout a full year since operations reports

turbidity readings over 1.0 NTU during the lake turnover. If it becomes obvious that the existing system cannot meet the deferral criteria, it is recommended that the intake line be extended further into the lake to obtain a depth of greater than 25 metres below the surface of Okanagan Lake.

7 Distribution System Evaluation

Modeling of the Westshore distribution system was conducted using WaterCad 8.0 with a model derived from the RDCO's GIS system and record drawings.

Detailed design parameters for pumps, reservoirs and pressure reducing valves were incorporated in the model. This information was extracted from design reports, operations manuals, design changes and any recent adjustments noted by operations staff.

A map showing the system is provided in **Figure 1** in **Enclosure C**. The piping is color coded to show the diameter of the piping in the distribution system.

WaterCAD modelling output for the existing infrastructure is provided in **Enclosure F**. The daily water use patterns, pump controls, water demands, and fire flow simulation results are also supplied.

The software is equipped to provide a variety of analytical methods, including steady state and extended-period simulations.

7.1 Steady State

Steady state analysis is useful in determining where potential trouble spots can occur in the system, such as excess pipeline velocities, typical pressures, under-pressures and fire flow requirements. Older popular distribution models used a steady state solution, which iterated calculations to create an average distribution pattern and hydraulic grade line for a particular scenario. As described in AWWA M32 (2005), the steady state model is used to:

- Calibrate the system to ensure that it predicts distribution system behaviour with sufficient accuracy.
- Select limiting conditions for design scenarios.
- Establish design criteria.
- Develop system improvements.
- Evaluate fire flow conditions.

7.2 Extended Period Simulation

Extended-period simulations (EPS) are useful to examine the behaviours in a distribution system based on demand patterns and operations over a period of 24 hours or longer. EPS is useful for ensuring the distribution system including pump controls, and reservoirs, is adequately sized to

meet MDD over the course of a full day. EPS can greatly improve water system planning and operation at a relatively low cost.

8 Water System Upgrades

The following section outlines the findings from the water modeling and system analysis. Upgrades are recommended based on the water model and water quality guideline. **Figure 2** in **Enclosure C** shows the recommended upgraded distribution system at full build-out conditions.

8.1 Pump Capacity

8.1.1 Lakeside Station

Current MDD = 235 connections x 7200 l/conn/day = 19.6 l/s
Current Pump Run Time = 71% of both pumps at Lakeside
Future Build Out = 522 connections x 7200 l/conn/day = 43.5 l/s

Installation of one additional pump is recommended at current conditions at the Lakeside pump station because both existing pumps are required at MDD conditions. This will provide adequate redundancy.

To improve operations and create some redundancy, it is recommended at full build out, to have four duty and one spare pump at the Lake pump station, assuming that additional pumps flow at the same flow rate as the existing pumps. The number of pumps may be reduced if the pumping efficiencies or capacities are increased, or if demands are reduced due to metering and demand side management.

8.1.2 Mountain Pump Station

Approximate Current MDD = 153 connections x 7200 l/conn/day = 12.8 l/s

Rated Pump Capacity = 32.5 l/s (Assume 70% Efficiency)

The existing pump station has sufficient capacity for existing demand. The newly installed standby pump provides adequate redundancy.

Future Build Out = 339 connections x 7200 l/conn/day = 28.3 l/s

At full build-out it is recommended to have two duty pumps with one spare at Mountain pump station, assuming that additional pumps flow at the same flow rate as the existing pumps.

Actual pump capacity is most likely less than the rated pump capacity but installing a flow meter would give a more accurate reading of capacity.

8.2 Reservoir Capacity

The RDCO bylaw recommends the following formula to be used for determining the recommended reservoir capacity:

Total Storage Requirement = A + B + C

Where A = Fire Storage
B = Equalization Storage
C = Emergency Storage

Existing Reservoir Capacity = 341 m^3 (Mountain) + 455 m^3 (Upper) = 796 m^3

Existing System:

A = 60 l/s x 1.5 hours = 324 m^3
B = 25% x 235 conn x 7200 l/conn/d = 423 m^3
C = 25% x (324m^3 + 423m^3) = 187 m^3
Total = 934 m^3

Future Full Build Out:

A = 324 m^3
B = 25% x 522 conn x 7200 l/s/conn = 937 m^3
C = 25% x (324m^3 + 937m^3) = 315 m^3
Total = 1576 m^3

Reservoir capacity is marginally inadequate at the current conditions. The WaterCAD model shows the reservoirs cycling properly throughout the day, but additional reservoir storage would provide smoother cycling which results in less starting and stopping of supply pumps. One concern is the condition of the reservoirs as they have been constructed from CSP pipes and may have some leakage or seepage. This could affect water quality if seepage is allowed into the reservoir. It is recommended to regularly inspect these for leaks.

Full replacement to full build-out capacity is recommended as a capital works plan within the next 20 years. The Upper reservoir supplies a greater amount of residents than the Mountain reservoir and therefore requires more balancing and emergency volume. The future recommended sizes of the Upper and Mountain reservoirs are 1.0 ML and 0.6 ML respectively. This is based on a future build out of 339 connections to be supplied by the Upper reservoir and 183 to be supplied by the Mountain reservoir.

8.3 Distribution System

The condition of the distribution mains is reported as good according to operations. There have been minimal leaks found to date. During MDD conditions the velocities within the pipes are below the recommended maximum velocity of 1.5 m/s.

8.3.1 Static Pressure

There is one location where the static pressure at the property line is below the minimum static pressure of 275 kPa set by the RDCO bylaw. The properties, shown on **Figure 1 (Enclosure C)** in a tan color, are on the northern most section of Westshore Drive. A solution to the low pressure would be to tie these properties into the High pressure zone fed by the upper reservoir to increase the pressure. This would require the installation of approximately 150 metres of 150 mm water main. The resultant pressures are shown in **Figure 2 (Enclosure C)** and are slightly higher than the allowable 1000 kPa (145 psi) stated in the RDCO bylaw. If this is not acceptable to the RDCO, an additional PRV could be added to the new water main, but this has not been added to the capital works estimate.

8.3.2 Fire Flow

During fire flow conditions it was found that only two hydrants could not deliver the required 60 l/s per second. These hydrants are listed below:

- Hydrant at lot 98 Mountain Drive: Flow: 58 l/s
- Hydrant at lot 57 Westshore Rd (at Bluebird Dr): Flow 44 l/s

The hydrant on Mountain Drive is within 2 l/s of the recommended 60 l/s which could be accounted for under the standard error within the water model and therefore we would recommend flow testing the hydrant to ensure adequate flow. The hydrant on Westshore is not able to supply the required flow and therefore we recommended providing an additional looped pipe to this hydrant location. As per the Fire Underwriters Survey (FUS), hydrant spacing should be every 180 m. **Figure 3** in **Enclosure C** shows the hydrant spacing with several areas that are not covered. As part of the 20-year Capital Works Plan, additional hydrants should be added.

8.4 Intake

The screen requires regular cleaning and maintenance. The Aquability diving report **(Enclosure D)** suggests that the screen does not meet current MOE standards. The MOE standard screen size opening is a maximum opening of 2.54 mm. The current overall screen area is sufficient as long as the screen is clean. The intake itself may have to be positioned further into Okanagan Lake, depending on the source assessment results. Based on bathymetric mapping **(Enclosure A)** approximately 1600 m of pipeline would be required to reach a submergence of 25 m. With the existing intake at 170 m into the lake, an additional length of 1430m would be required.

8.5 Water Treatment at Pump Station

If filtration deferral is approved, UV lamps are recommended as the second level of disinfection to chlorination. The pump house building footprint would require enlargement. The RDCO owns the parcel of land housing the Lakeside Pump Station and Lot B Plan 24681.

8.6 Electrical

The Lake Pump Station and Mountain Pump Station are both supplied with 3 phase 600 V power. Back up generators can be added to each pump station for emergency power in the case of a power outage which historically is not uncommon. The backup generators should be sized to supply, at a minimum, power to run one pump motor at each pump station. Some of the items to consider when installing back up generators are:

- Fuel Management Strategy – Diesel fuel should not remain in the holding tank for greater than six months.
- Test Runs – should be performed weekly.
- Load Tests – should be performed monthly.
- Engine Service – should be performed yearly or after extended operation.

The fuel holding tank may have to be sized for a 12 hour power outage since in the past the region has experienced extended power outages.

9 Cost Estimates

Detailed capital cost estimates for the Filtration option and Filtration Deferral option can be found in **Tables 1 and 2 – Enclosure B**.

9.1 Life Cycle Costing Basis – Assuming Filtration Deferral Obtained from IHA

Capital costs were applied in the life cycle costing throughout the 20 year life cycle. It was assumed that there would be phasing of the capital works.

Operation and maintenance costs were projected over a 20 year life. It was assumed that demands would rise based on full build-out for the 20 year period. An inflation factor of 2.1% per annum was applied to future operating costs.

10 Fee Recovery

The RDCO requires a fee recovery strategy to offset the anticipated capital costs required as part of this 20 year plan.

Water rates should:
1. Recover all costs of utility operations, short and long term capital costs, etc.
2. Encourage customers to be water smart.
3. Be affordable, and considerate to the economy and demographics.

The fee recovery strategy should include:
1. Annual operations and maintenance.
2. Offset long-term capital improvement costs.
3. Asset management, depreciation and inflation.
4. Forecasting of operational/regulatory/administrative changes.

10.1 Review of Expenses

For this study, historical annual statements from the RDCO were examined for the Westshore Estates system. Historically, the RDCO financial statements are reported as Revenue, and two forms of expenses:
1. Salaries and Administration
2. Operations and Maintenance (O&M). All Capital Works funds were included in this expense.

For this study, we rearranged the expense statements to reflect three items:
1. Annual operations: Those expenses required annually to operate the system. These operations apply to the 235 current users on the system.
2. Capital Operations and Maintenance: Those expenses required to maintain the existing system. These operations apply to all 522 parcels that are or can be connected to the system.
3. Capital Works: Those Project Expenses which add or provide system improvement. These projects or works are often eligible for government funding through municipal programs or gas tax rebates. These divisions are based on Associated Engineering's best estimate to where the fees have been allocated in the past and budgeted in the future

Table 10-1
Summary of RDCO Revenue and Expenses for the Westshore Estates System (2007-2010)

	2010 (Budgeted)	2009 (Actual)	2008 (Actual)	2007 (Actual)
Revenue				
Water User Fees	131,000	118,354	112,829	109,893
Connection Inspection Fee	2,000	1,920	11,850	9,555
Previous Year Surplus	-97	-17,632	24,293	6,955
Admin Overhead Recoverable	-17,923	-11,798	-12,358	-15,490
Total Revenue	114,980	90,844	136,614	110,913
Expenses				
Annual Operations				
Salaries - Full Time	32,219	20,676	30,750	28,937
Salaries - Over Time	2,500	3,625	1,829	703
Payroll Overhead	7,985	5,359	7,264	6,817
Memberships	250	700	553	436
Training/Education	1,000	896	767	0
Insurance	724	608	337	895
Telephone	4,000	4,052	926	1,048
Publications/Subscriptions		0	337	356
Power	30,000	29,775	34,314	8,447
Travel	5,000	4,332	4,788	4,649
Chlorine	3,000	361	3,028	
Ministry Testing	2,500	2,316	3,601	2,182
Sub-Total	89,178	72,702	88,493	54,470
Capital Operations and Maintenance				
Water Rates (Licenses)	1,000	627	1,100	1,518
Small Tools	250	182	91	221
Equipment Repairs & Maintenance	10,000	9,378	6,369	8,041
Contract Services	5,000	5,948	14,484	2,840
Emergency Projects (Contingency Fund)				1,172
Sub-Total	16,250	16,134	22,043	13,793
Capital Works Projects				
Water Meter Installation	120,000	1,103	1,011	2,809
Pump/Mechanical	75,000	9,399		26,227
SCADA/Controls	55,000			
Engineering/Planning/Design	15,000			2,842
Transfer to (+) Equipment Reserve		1,003	42,699	15,548
Gas Tax	-190,000			
Transfer from (-) Equip't Reserve	-75,000	-9,399		-29,069
Transfer from (-) Water Cpt'l Fund				
Sub-Total	0	2,106	43,710	18,356
Total Expenses	105,428	90,942	154,246	86,619

Column A in Table 10-2 is a summary of expenses for the period 2007 to 2009 extracted from base information in Table 10-1. Column B represents the 2010 budgeted expenditures.

Assuming that Annual Operations are paid for entirely by the 235 existing users, and that the rest is paid by all 522 parcels on the system, Columns D and E represent historical and 2010 budgeted expenditures per group.

Table 10-2
Summary of Expenditures per Unit Charged

	A	B	C	D	E
Expense Category	Average Expenditures 2007-2009	Budgeted Expenditures 2010	Units	Average Historical Expenditures per unit 2007-2009	Estimated 2010 Allocation
Annual Operations	$71,888	$89,178	235	$306	$379
Annual O&M Replacement	$17,323	$16,250	522	$33	$31
Annual Capital Replacement	$21,390	$0	522	$41	$0
Total	$110,602	$105,428			

Note: Units are expressed in number of connections for User Fees, and number of Parcels for O&M and Capital

10.2 RDCO Funds

The RDCO currently maintains two funds where fees are allocated:

1. A Water Revenue Fund (WRF) is an operating account for annual Operations and Maintenance. This account is the annual utility budget used to pay for daily operations and for short term emergencies.
2. An Equipment Replacement Reserve Fund (ERRF) for capital replacement. The ERRF is an interest bearing reserve account of the District for water system improvements. This fund can be used for debt servicing or funding capital expenditures. To date, unused annual fees are placed into this Fund.

10.3 RDCO Rates

Two forms of water rates are charged by the RDCO:

1. User Fees are charged for every residence currently connected to the water distribution system. In 2010, 235 residences pay user fees out of a possible 522 connections at Westshore Estates.
2. Annual Maintenance Fees are charged to all 522 parcels within the Westshore Estates development, whether connected or vacant.

For reference, the 2010 water rates are shown in Table 10-3, Column A.

10.4 Fee Recovery to 2030

This water master plan outlines the capital works project required to meet future demands, fire flows, and water quality parameters that meet all minimum regulatory requirements. The RDCO, through their fee structure, must be able to recuperate all costs.

All annual Operation and Maintenance replacement costs must be funded at 100 percent by residential users and lot owners. Capital Works must also be funded by users and lot owners, however the District can apply for municipal grants, or Gas Tax grants (as was the case in 2010) to partially fund these types of projects.

Annual Operation expenses must be recovered through user fees charged to each resident as shown in Column E of Table 10-2. In 2012, the user fee identified in Column C of Table 10-3 is recommended. In the future, this portion of the fees could be related to consumption type fees (i.e. cost per cubic metre).

Column A in Table 10-3 identifies the rates approved by the RDCO Board for 2010. In 2011, the Annual Maintenance Fee will be increased to $200. Column C of Table 10-3 shows the estimated Capital O&M and Capital Works annual costs per parcel based on future capital works costs estimates detailed in Table 7 in **Enclosure B**. Government funding of the capital works is a real possibility; we estimate that 30 percent funding can be achieved. Therefore, the Westshore Estates fees should be set to approximately the rates shown in Column D of Table 10-3.

Table 10-3
Recommended Future Collection Fees

	A	B	C	D
Expense Category	2010 Rates	2011 Rates	2012 Fees (assuming no funding)	2012 Fees (Assuming 30% funding from outside sources)
User Fee per Residential Unit	$226	$232	$379	$379
Annual Maintenance Fee				
Capital O&M	$150	$200	$31	$31
Capital Works	$0	$0	$309	$206
Maximum Fee	$376	$432	$720	$617

Notes: Units are expressed in number of connections for User Fees, and number of Parcels for O&M and Capital

10.5 Detailed Income and Expenditures

Table 7 in **Enclosure B** is a detailed account of income and expenditures required each year to complete the capital works plan over the 20 year period to the year 2030. The Filtration Deferral option was examined as this is the recommended option to pursue.

The rates are divided into 3 categories in Table 7.

1. Annual Operations and Maintenance: Rates recommended in Table 10-3, with 2% annual increases starting in 2012. Rate increases occur the year following implementation of individual projects.
2. Annual Maintenance Fee:
   a. O&M: Rates per parcel identified in Table 10-3, with 2% annual increase for inflation, starting in 2012,
   b. Capital: Calculated as the total capital funds required to maintain a net positive capital fund balance of $50,000 in the year 2030. No interest or inflation is assumed in this calculation, since loans for these projects are not permitted without the consent of the electorate.

Figure 1 in **Enclosure B** provides a graphical summary of the anticipated rates over 20 years. This assumes an implementation plan where projects are spread out over the 20 years, as demonstrated in Table 7.

11 Recommendations

11.1 Water Quality

1. Based on successful UV treatment of Okanagan Lake water by other local communities in the area, a treatment option that includes filtration deferral (UV and chlorination) should be chosen.

2. RDCO should immediately begin monitoring the source water from Okanagan Lake to determine if the intake should be moved deeper into the lake and to evaluate the merit of filtration deferral.

3. Limnological studies on Okanagan Lake near the intake should proceed immediately to obtain the necessary data for obtaining the IHA Construction Approvals and filtration deferral.

4. Obtain written clarification from IHA regarding acceptable treatment strategies for Westshore Estates.

11.2 Water Distribution

1. An additional pump at the Lakeside Pump Station should be added immediately to ensure redundancy.

2. The reservoirs should be inspected regularly to ensure that no seepage is occurring.

3. The items in the capital works plan are based on full build-out by the year 2030. If the rate of build-out increases or decreases the priority of the infrastructure upgrading will change accordingly, based on demand.

4. The household metering program should be commissioned immediately and demand monitored as demand reduction may allow some of the capital works projects to be delayed.

5. This Water Management Plan should be updated every five years.

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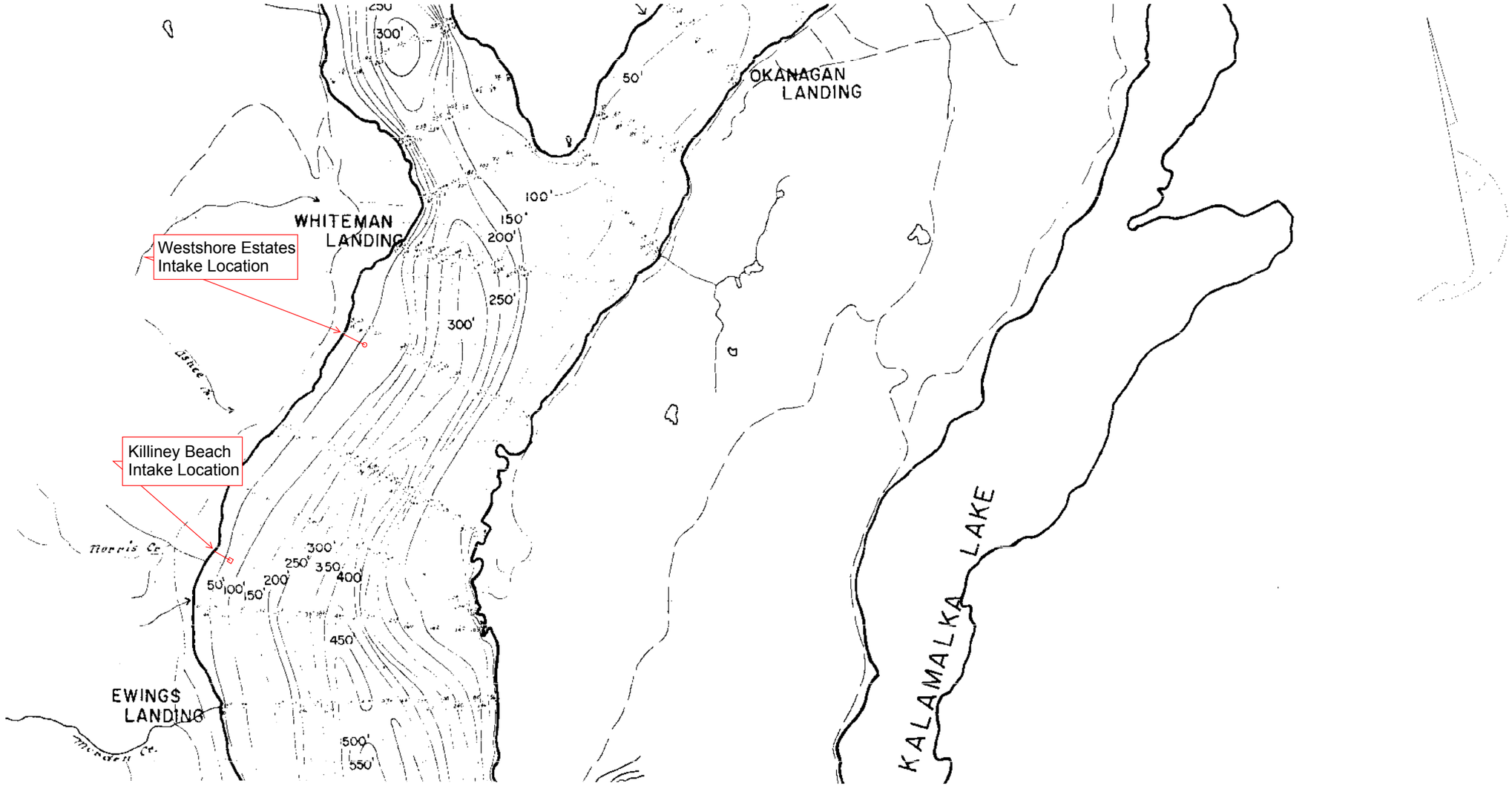
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ML/RM/cb

Enclosure A – Bathymetric Mapping
Enclosure B – Cost Estimating Data
Enclosure C – Distribution System Mapping
Enclosure D – Diving Inspection Report
Enclosure E – IHA Filtration Deferral Document
Enclosure F – Westshore Model Output

Enclosure A – Bathymetric Mapping



1 0 1 3 5 Miles

CAUTION: DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions. Uncharted hazards may exist.

OKANAGAN NAVIGATION CHART

SURVEYED BY [illegible] IN [illegible] AUG. 1966
SOUNDINGS APPROVED BY [illegible]

STATISTICS OF LAKE SURVEY
1. ELEVATION 1122.6'
2. SURFACE AREA 85107 ACRES (132.98 SQ.M.)
3. VOLUME 2,020,858 ACRE FT.
4. MEAN DEPTH 24' FT.
5. MAXIMUM DEPTH 284' FT.
6. LENGTH 885,760' (167,825 V.)
7. MAX. WIDTH 1124.2' FT.
8. MEAN WIDTH 1119.2' FT.

DEPARTMENT OF LANDS, WATER AND FORESTS
DEPARTMENT OF RECREATION AND CONSERVATION

OKANAGAN LAKE

(SHEET 5 OF 6)

DRAWN: G.A.B. CHECKED: G.A.B. 2640'
SURVEYED BY: G.A.B. & J.C. CHECKED: G.A.B. & J.C.

SCALE NO.
82 / 92 / 93 / 94 & 82 / 93 S

Enclosure B - Cost Estimating Data

Table 1
Westshore Estates - Filtration Deferral Option

Item	Quantity	Unit	Unit Cost	Extension	Total Costs	Annual O&M Cost
Watermain Replacement						
150 mm PVC	350	m	255	89,250	89,250	446
200 mm PVC	200	m	310	62,000	62,000	310
Watermain Looping Installation						
150 mm PVC	250	m	255	63,750	63,750	319
PRV Station						
200 mm PRV Station	1	LS	150,000	150,000	150,000	750
New Intake	1	LS	25,000	25,000	25,000	125
450 mm CSP	1,400	m	300	420,000	420,000	2,100
SCADA	1	LS	120,000	120,000	120,000	1,200
Additional Pumps (Redundancy)						
Lakeside Pump Station	3	ea	25,000	75,000	75,000	7,500
Mountain Pump Station	2	ea	25,000	50,000	50,000	5,000
Backup Generator	1	ea	200,000	200,000	200,000	2,000
New Hydrants	7	ea	10,000	70,000	70,000	350
Reservoir Storage (Option 1)						
Middle Reservoir (0.9 ML)	900	cu.m	400	360,000	360,000	1,800
Upper Reservoir (0.7 ML)	700	cu.m	400	280,000	280,000	1,400
Subtotal					**$1,965,000**	**$23,000**
Engineering and Contingencies		30%			**$589,500**	**$2,950**
Total Distribution system					**$2,554,500**	**$25,950**
Water Treatment (Incl. Eng & Contingencies)						
Chemical Coagulation and Mixing	3.74	ML/d				
Flocculation						
Clarification						
Filtration						
Primary Disinfection (Chlorination - Existing)						
Secondary Disinfection (UV)					$583,614	
Source Assessment Study					$50,000	
Residuals Management						
Subtotal Water Treatment					**$633,614**	**$35,838**
TOTAL					**$3,188,114**	**$61,788**

Assumed Annual O&M Cost Breakdown	**% of capital Cost**
Pumpstations, Pumps - Includes power, repair, O&M	10%
UV, Chlorination - Includes power, repair, bulb replacement	As shown, but typically between 5% and 10%
SCADA, Controls, Instrumentation, programming	1%
All other pipelines, valves, concrete work	0.5%

Table 2
OPTION 2
Westshore Estates - Full Treatment or Filtration Option

Item	Quantity	Unit	Unit Cost	Extension	Total Costs Option 1	2011 O&M Cost
Watermain Replacement						
150 mm PVC	200	m	255	51,000	51,000	255
200 mm PVC	200	m	310	62,000	62,000	310
Watermain Looping Installation						
150 mm PVC	250	m	255	63,750	63,750	319
PRV Station						
200 mm PRV Station	1	LS	150,000	150,000	150,000	750
New Intake Screen	1	LS	25,000	25,000	25,000	125
SCADA	1	LS	120,000	120,000	120,000	600
Additional Pumps (Redundancy)						
Lakeside Pump Station	3	ea	25,000	75,000	75,000	375
Mountain Pump Station	2	ea	25,000	50,000	50,000	250
Backup Generator	1	ea	200,000	200,000	200,000	2,000
New Hydrants	7	ea	10,000	70,000	70,000	350
Reservoir Storage (Option 1)						
Middle Reservoir (0.9 ML)	900	cu.m	400	360,000	360,000	1,800
Upper Reservoir (0.7 ML)	700	cu.m	400	280,000	280,000	1,400
Subtotal					**$1,507,000**	**$8,000**
Engineering and Contingencies		30%			**$452,100**	**$2,260**
Total Distribution system					**$1,959,100**	**$10,260**
Water Treatment						
Chemical Coagulation and Mixing	3.74	ML/d			$116,723	
Flocculation					$350,168	
Clarification					$817,060	
Filtration					$1,225,590	
Primary Disinfection (Chlorination - Existing)					$0	
Secondary Disinfection (UV)					$0	
Source Assessment Study					$50,000	
Residuals Management					$233,446	
Subtotal					**$2,792,986**	**$157,169**
TOTAL					**$4,752,086**	**$167,429**

Notes:
1. Pumps include upgrade to electrical and Mechanical

Assumed Annual O&M Cost Breakdown	**% of capital Cost**
Pumpstations, Pumps - Includes power, repair, O&M	10%
UV, Chlorination - Includes power, repair, bulb replacement	As shown, but typically between 5% and 10%
SCADA, Controls, Instrumentation, programming	1%
All other pipelines, valves, concrete work	0.5%

Table 3
Unit Costs - Buried Pipe

Diameter	Pipe Supply & Install (1)	Hydrants & Valves (2)	Pavement Restoration	Total Excl Pavement	Total Incl Pavement
25	$70	$25	$75	$95	$170
50	$80	$25	$75	$105	$180
75	$90	$25	$75	$115	$190
100	$120	$25	$75	$145	$220
150	$140	$40	$75	$180	$255
200	$190	$45	$75	$235	$310
250	$240	$50	$75	$290	$365
300	$290	$55	$75	$345	$420
350	$340	$60	$90	$400	$490
400	$390	$65	$90	$455	$545
450	$440	$70	$90	$510	$600
600	$590	$75	$100	$665	$765
750	$740	$80	$100	$820	$920
900	$890	$90	$100	$980	$1,080

Notes:

(1) PVC or DI Pipe

(2) Assumes buried line valves, one hydrant per 100m, one air valve assembly per 500m

(3) Costs do not include engineering and contingencies

Table 4.
Water Treatment Unit Costs

Process	Larger System Base Cost Per ML/d (> 5 ML/d)	Smaller System Base Cost Per ML/d (< 5 ML/d)
Chemical Coagulation and Mixing	$26,000	$31,200
Flocculation	$78,000	$93,600
Clarification		
-Conventional Tube or Plate Settler	$182,000	$218,400
Filtration		
-High Rate (12 m/hr)	$273,000	$327,600
-High Rate (18 m/hr)	$221,000	$265,200
-Membrane	$416,000	$499,200
Primary Disinfection		
-Chlorine	$39,000	$46,800
-Ultraviolet	$130,000	$156,000
-Ozone	$260,000	$312,000
Residuals Treatment		
-Plate Settler/Thickener Centrifuge	$52,000	$62,400
Add this when no san sewer available		

Notes
(1) Based on 5 ML/d plant size and larger
(2) Based on 4 ML/d plant size and smaller
(3) All costs include a 30% allowance for engineering & contingencies

Table 5. Water Treatment Cost Breakdown - Estimates **Westshore Estates**

	Westshore Residential
Current MDD (L/s)	17.35
Build-out MDD (L/s)	43.3
ADD (L/s)	16.24
ADD (ML/d)	1.40
Plant Capacity (ML/d):	3.74
Ave. Ann. Demand (ML)	512

	ESTIMATED COST (See Note 1)										
TREATMENT OPTION	Chemical Coagulation and Mixing	Flocculation	Clarification	Filtration	Primary Disinfection	Secondary Disinfection	Residuals Treatment	TOTAL CAPITAL COST	ANNUAL O&M COST	20 YEAR O&M COST	PRESENT VALUE O&M
Option 1 - Okanagan Lake - Filtration Deferral					3.74 ML/day						3%
DISINFECTION (WITHOUT FILTRATION)											
Chlorination								$0	$819	$ 16,386	$12,189
Ozone/Chlorination								$0	$10,241	$ 204,826	$152,365
UV/Chlorination						$583,614		$583,614	$35,838	$ 716,751	$533,172
FILTRATION											
Direct Filtration/UV								$0	$11,265	$ 225,309	$167,601
Conventional Filtration								$0	$11,265	$ 225,309	$167,601
Membrane Filtration								$0	$10,241	$ 204,826	$152,365
Option 2 - Okanagan Lake - Full 4.3.2.1.0 - Full Filtration and Treatment					3.74 ML/day						
DISINFECTION (WITHOUT FILTRATION)											
Chlorination					$175,084			$175,084	$9,574	$ 191,470	$142,430
Ozone/Chlorination					$1,167,228	$175,084		$1,342,312	$77,357	$ 1,547,138	$1,150,876
UV/Chlorination						$583,614		$583,614	$35,838	$ 716,751	$533,172
FILTRATION											
Direct Filtration/UV	$116,723	$350,168		$1,225,590	$583,614	$175,084	$233,446	$2,684,625	$145,497	$ 2,909,933	$2,164,623
Conventional Filtration	$116,723	$350,168	$817,060	$1,225,590	$175,084		$233,446	$2,918,070	$157,169	$ 3,143,379	$2,338,277
Membrane Filtration	$116,723	$350,168		$1,225,590	$175,084		$233,446	$2,101,011	$156,145	$ 3,122,896	$2,323,041

Note 1: Cost estimates for each treatment process include process equipment, all associated ancillary equipment, electrical & instrumentation, associated structures and siteworks, and associated residuals handling plus 30% allowance for engineering and contingencies.

Table 6. Omitted

Table 7 Project Implementation Plan and Financial Requirements
Westshore Estates - Water Master Plan 2011 - 2030
Option 1 - Filtration Deferral

	2009[1]	2010[2]	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1. New Projects													
Water Meters (2010)		120,000											
Mountain Pump Station		75,000											
SCADA upgrades		55,000											
150 mm Water Main Looping			63,750										
150 mm Water Main Replacement					89,250								
200 mm Water Main Replacement						62,000							
UV Disinfection													
New Intake Screen										25,000			
Intake Pipeline Addition (450 mm CSP)										442,000			
Backup Generator					200,000								
200 mm PRV Station													
Lakeside Pump Station													
Middle Reservoir (0.9 ML)													
Upper Reservoir (0.7 ML)													
New Hydrants										10,000			10,000
Contingency (15%)			9,563	-	43,388	9,300	-	-	-	71,550	-	-	1,500
Gas Tax Capital Fund (2010 only)		- 190,000											
Engineering													
Source Assessment Study			25,000										
Plan Update (5 years)		15,000					20,000					20,000	
Engineering of Capital Works (15%) [3]	-	10,996.88	-	43,388	9,300	-	-	-	71,550	-	-	1,500	68,840
Sub-Total Capital Works		85,997	98,313	43,388	341,938	71,300	20,000	0	71,550	548,550	0	21,500	80,340
Equipment Fund Revenue		2,481	33,930	161,465	161,465	161,465	161,465	161,465	161,465	161,465	161,465	161,465	161,465
Equipment Fund Balance[1]	$243,296	159,780	95,398	213,475	33,003	123,168	264,634	426,099	516,014	128,930	290,395	430,360	511,485
O&M Additions			367	0	2,663	357	0	0	0	2,743	0	0	58
Connections (2% percent growth per year)		235	239	243	247	251	256	261	266	271	276	281	286
Anticipated Annual O&M Rate Increase			2	0	11	1	0	0	0	10	0	0	0
Projected Rates													
User Fee (with Annual Inflation 2% after 2012)		226	232	379	398	407	415	423	432	451	460	469	478
Annual Maintenance Fee - O&M (with Inflation 2%)		132	135	31	32	32	33	34	34	35	36	36	37
Annual Maintenance Fee - Capital Works		0	65	309	309	309	309	309	309	309	309	309	309
Projected Rate (Single Lot with Residence)		358	432	720	739	749	758	766	776	795	805	815	825
Assume 30% Grant Availability on all Capital Works in 2012													
UFRU (with Annual Inflation 2% after 2012)		226	232	379	398	407	415	423	432	451	460	469	478
AMF - O&M (with Annual Inflation 2%)		132	135	31	32	32	33	34	34	35	36	36	37
AMF - Capital Works (Assuming 30% Grant)		0	65	206	206	206	206	206	206	206	206	206	206
Projected Rate (Single Lot with Residence)		358	432	617	636	646	654	663	673	692	702	711	722

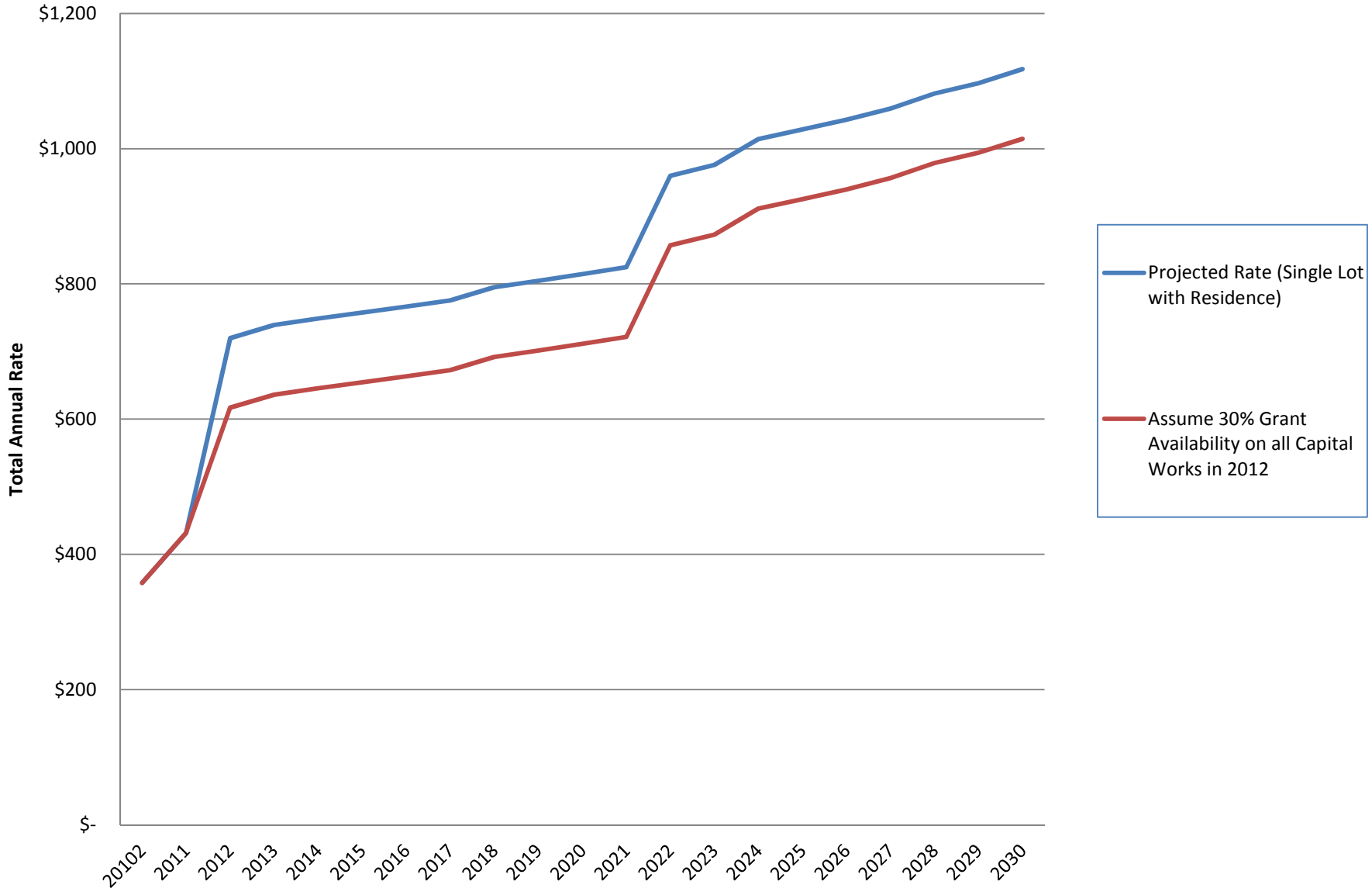
$3,297,547 total capital required
522 Connections
$6,317 per connection to 2030
$309 Annual Capital Rate to 2030

Notes
1. From Exhibit 21, RDCO Statement of Financial Position, Equipment Replacement Reserve Fund.
2. Anticipated Expenses from 2010 Financial Plan and estimated 2011 Engineering of new projects
3. Engineering of Capital Works calculated as a 15% of value of all new projects in following year, including contingency.
4. Equipment Fund Balance assumed to be at $50,000 in 2030.

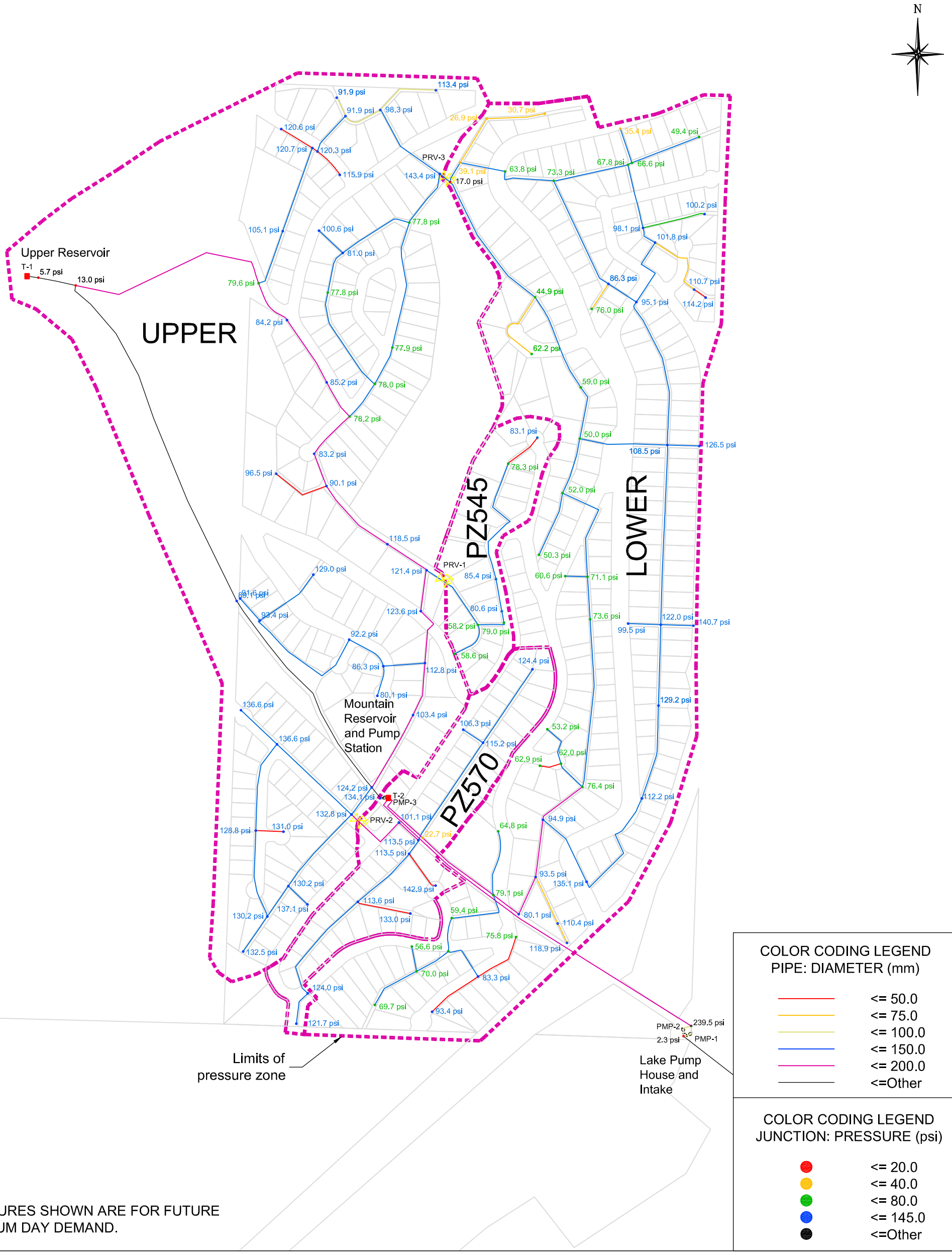
Table 7 Project Implementation Plan and Financial Requirements
Westshore Estates - Water Master Plan 2011 - 2030
Option 1 - Filtration Deferral

	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL	O&M Costs
1. New Projects											
Water Meters (2010)										**$ 120,000**	
Mountain Pump Station										**$ 75,000**	**$ 7,500**
SCADA upgrades						65,000				**$ 120,000**	**$ 1,200**
150 mm Water Main Looping										**$ 63,750**	**$ 319**
150 mm Water Main Replacement										**$ 89,250**	**$ 446**
200 mm Water Main Replacement										**$ 62,000**	**$ 310**
UV Disinfection	448,934									**$ 448,934**	**$ 35,838**
New Intake Screen										**$ 25,000**	**$ 125**
Intake Pipeline Addition (450 mm CSP)										**$ 442,000**	**$ 2,210**
Backup Generator										**$ 200,000**	**$ 2,000**
200 mm PRV Station		150,000								**$ 150,000**	**$ 750**
Lakeside Pump Station			75,000							**$ 75,000**	**$ 7,500**
Middle Reservoir (0.9 ML)							360,000			**$ 360,000**	**$ 1,800**
Upper Reservoir (0.7 ML)									280,000	**$ 280,000**	**$ 1,400**
New Hydrants	10,000	10,000	10,000		10,000		10,000			**$ 70,000**	**$ 350**
Contingency (15%)	68,840	24,000	12,750	-	1,500	9,750	55,500	-	42,000	**$ 349,640**	**$ 1,748**
Gas Tax Capital Fund (2010 only)										**-$ 190,000**	**-$ 950**
Engineering											
Source Assessment Study			68,000							**$ 93,000**	
Plan Update (5 years)				20,000					20,000	**$ 95,000**	
Engineering of Capital Works (15%) [3]	24,000	12,750	-	1,500	9,750	55,500	-	42,000	17,899	**$ 368,973**	
Sub-Total Capital Works	551,774	196,750	165,750	21,500	21,250	130,250	425,500	42,000	359,899	**3,297,547**	
Equipment Fund Revenue	161,465	161,465	161,465	161,465	161,465	161,465	161,465	161,465	161,465	**3,104,251**	
Equipment Fund Balance [1]	121,177	85,892	81,607	221,572	361,788	393,003	128,968	248,434	50,000	50,000	
O&M Additions	36,232	920	7,614	0	58	699	2,128	0	1,610		
Connections (2% percent growth per year)	291	296	301	307	313	319	325	331	337		
Anticipated Annual O&M Rate Increase	125	3	25	0	0	2	7	0	5		
Projected Rates											
User Fee (with Annual Inflation 2% after 2012)	613	628	666	679	692	708	729	744	764		
Annual Maintenance Fee - O&M (with Inflation 2%)	38	39	39	40	41	42	43	44	44		
Annual Maintenance Fee - Capital Works	309	309	309	309	309	309	309	309	309		
Projected Rate (Single Lot with Residence)	960	976	1,014	1,028	1,043	1,059	1,081	1,097	1,118		
Assume 30% Grant Availability on all Capital Works in 2012											
UFRU (with Annual Inflation 2% after 2012)	613	628	666	679	692	708	729	744	764		
AMF - O&M (with Annual Inflation 2%)	38	39	39	40	41	42	43	44	44		
AMF - Capital Works (Assuming 30% Grant)	206	206	206	206	206	206	206	206	206		
Projected Rate (Single Lot with Residence)	857	873	911	925	940	956	978	994	1,015		

Figure 1. Projected Annual Combined Rates
Westshore Estates



Enclosure C - Distribution System Mapping



NOTE:
PRESSURES SHOWN ARE FOR FUTURE MAXIMUM DAY DEMAND.

COLOR CODING LEGEND
PIPE: DIAMETER (mm)

- <= 50.0
- <= 75.0
- <= 100.0
- <= 150.0
- <= 200.0
- <=Other

COLOR CODING LEGEND
JUNCTION: PRESSURE (psi)

- <= 20.0
- <= 40.0
- <= 80.0
- <= 145.0
- <=Other

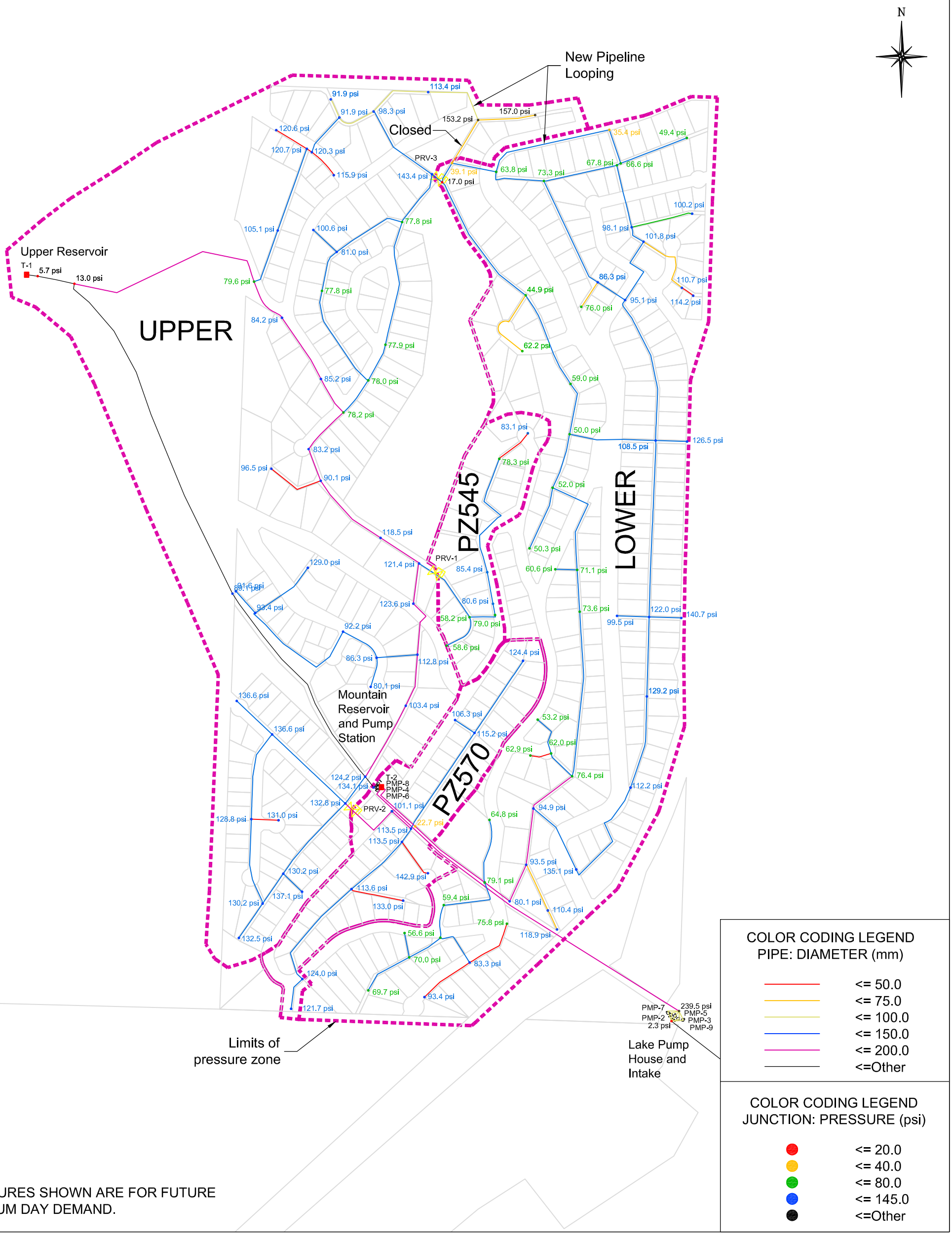
PROJECT No.	20102583
DATE	09/08/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	1

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
WESTSHORE

FIGURE 1:
EXISTING SYSTEM
PIPE DIAMETERS AND STATIC PRESSURES

Associated Engineering



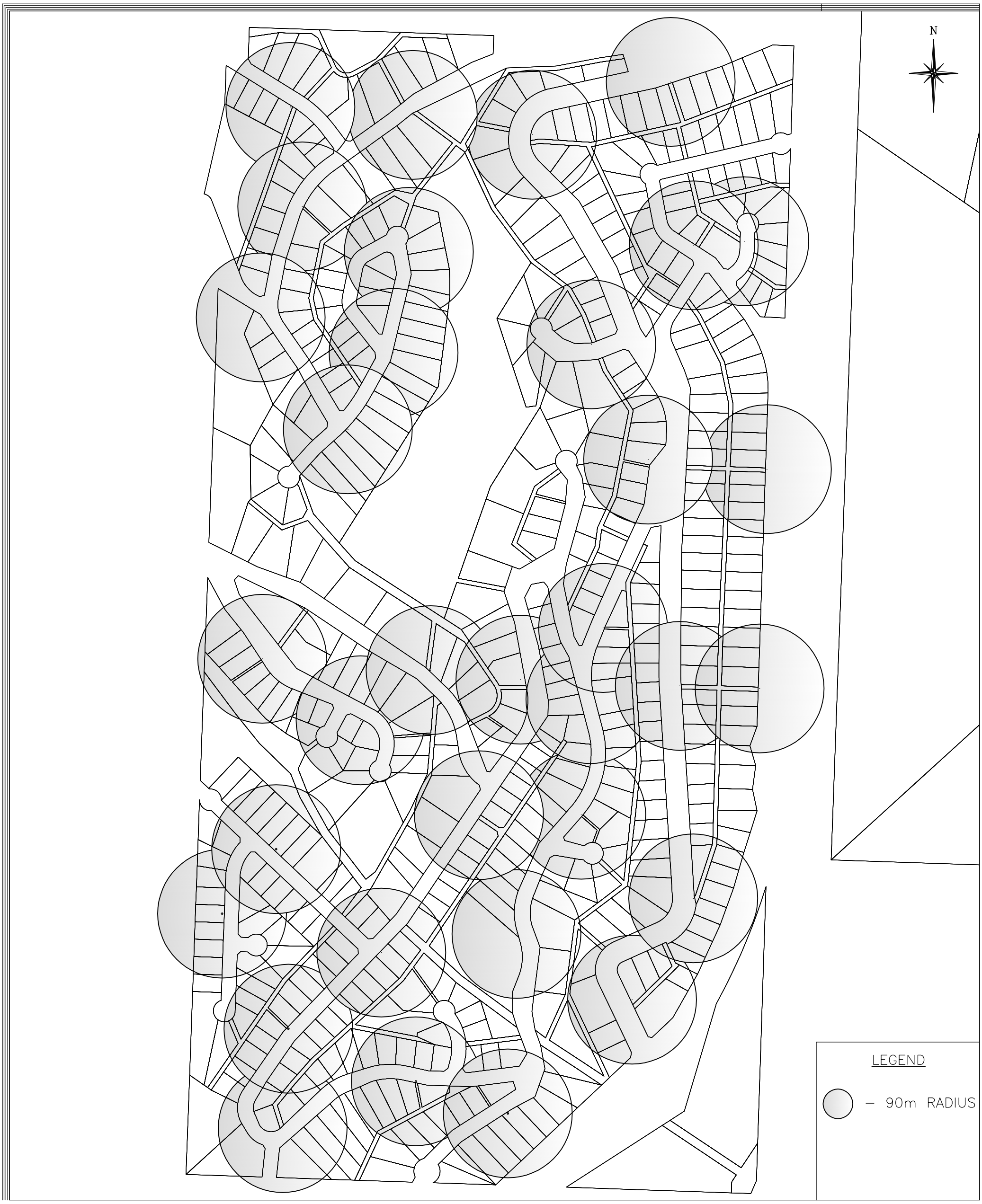
PROJECT No.	20102583
DATE	09/08/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	2

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
WESTSHORE

FIGURE 2:
RECOMMENDED FUTURE SYSTEM
PIPE DIAMETERS AND STATIC PRESSURES

Associated Engineering



PROJECT No.	20102583
DATE	09/08/10
APPROVED	ML
SCALE:	N.T.S.
FIGURE No.	3

REGIONAL DISTRICT OF CENTRAL OKANAGAN

WATER SYSTEM REVIEW
WESTSHORE

FIGURE 3:
HYDRANT SPACING

Associated Engineering

Enclosure D - Diving Inspection Report

AQUA-BILITY PROJECTS LTD.

REGIONAL DISTRICT OF CENTRAL OKANAGAN

DIVING INSPECTION REPORT

May 2010

AQUA-BILITY PROJECTS Ltd.

4679 Westridge Drive
Kelowna, B.C. V1W 3A8

Cell: (250) 826-2967
Res: (250) 764-0643

Report #1021

Regional District of Central Okanagan
1450 K.L.O. Road
Kelowna, B.C.
V1W 3Z4

May 20, 2010.

Attn.: Delphine Maja

Killiney Intake System.
A WCB certified dive crew dove, inspected and videoed the Killiney Beach intake system. The following was observed:

Intake pipe
The intake pipe is 10" PVC bell and spigot pipe and extended approximately 500' into the lake. No signs of leakage or damage to the pipe were observed.

Intake Screen
A single screen 25" x 25" x 25" is located in 36' of water with the top of the intake at 31'.
The screen has 1/8" to ¼" hydrophyte growth on it and is 90% plugged. It requires cleaning using a high pressure pump.
The north panel of the screen has collapsed due to greater suction on the screen caused by flow restrictions.

Wet well
Wet well is concrete with 1/2" – 1" of sediment in throughout the well floor. A 4"-6" high pile of sediment is located at the well ladder.

Summary:
Actual Intake installation does not match customer supplied drawings
Intake pipe: pipe is in good condition.
Intake screen: New screen panels should be installed. The screen should be cleaned now and annually.
Wet well: Cleaning in conjunction with Westshore well cleaning is highly recommended.

Westshore Estates Intake System
A WCB certified dive crew dove, inspected and videoed the Westshore Estates intake system. The following was observed:

Intake pipe
The intake pipe is in 18" corrugated steel pipe which has been repaired (slip lined) several years ago. The repair work is in good condition with no physical signs of wear or damage. The remainder of the Cmp is in good condition with no visible signs of wear of damage.
Two holes that were repaired using concrete bags are still in place, resulting in a positive seal to the pipe.
cables holding clump weights on pipe have corroded away.

Intake screen
A single drum style screen is located in 25' of water with the top of the screen being in 20' of water.
The screen is approximately 36" in diameter and 12" wide.
The screen is 95% plugged with ¼" – ½" sediment and hydrophyte growth.
It requires cleaning using a high pressure pump. In addition, I believe the intake screen does not meet present M.O.E. specifications.

Wet well
Wet well has minimum of 4" of organic material and up to 10" of sediment depth measurement was noted. Pump bowls has a small amount of twigs and sticks stuck to it.

SUMMARY
Actual intake installation does not match customer supplied drawings.
Intake pipe: in good condition. Monitoring of old pipe condition is recommended.
Intake screen: intake requires cleaning and should be upgraded to a larger size.
Wet well: cleaning of wet well is highly recommended. This could be completed in conjunction with cleaning of Killiney Beach wet well.

All cleaning and repair work could be completed by Aqua-bility if requested

If you have any questions or require further assistance please contact me on my cell at (250) 826-2967 or at my residence at (250) 764-0643.

I look forward to being of service to you.
Regards,

Neal Klose
Aqua-Bility Projects Ltd.

Enclosure E - IHA Filtration Deferral Document

Interior Health

ISSUE PAPER: PLANNING FOR DRINKING WATER FILTRATION RECOMMENDATION

Name of Issue: Criteria required for the Deferral of Filtration

Background and Issue Analysis:

Interior Health Authority (IHA) expects water suppliers to provide filtration for all water supply systems using surface water sources or ground water under the direct influence of surface water. Source water monitoring data may also provide information to indicate the need to initiate filtration. Water suppliers that want to apply for deferral of filtration in accordance with the *Guidelines for Canadian Drinking Water Quality* (GCDWQ) exclusion criteria must make a proposal to Interior Health that defines their watershed control program and dual treatment technologies. The proposal must be further supported by suitable source monitoring data trended over a minimum of one year and preferably several years.

Interior Health's direction on drinking water quality and treatment standards is based on the GCDWQ and other regulatory documents. The GCDWQ provide "Criteria for the Exclusion of Filtration in Waterworks Systems". Water supply systems that currently meet the exclusion criteria cannot guarantee they will do so indefinitely. Therefore the focus of this document is filtration "deferral" criteria not "exclusion" criteria.

A suggestion is that long term improvement plans that propose to "defer" filtration be reviewed on a case-by-case basis.

The IH Water Excellence Team (WET) agreed that the following questions be discussed with the Senior Water Excellence Team (SWET) since they set the strategic direction for WET:

1. Should we define "watershed control program" under the 4th exclusion criteria?
2. Should we develop criteria & expectations for long term planning?
3. Should IH take direction from the *Guidelines for Canadian Drinking Water Quality* for filtration?

The response by SWET was:

- Agreement there is potential for deferral of filtration;
- To take direction from the GCDWQ for filtration and the exclusion criteria for deferral. IHA will need to develop an understanding of the exclusion criteria;
- There is a need to identify factors that will be considered for deferral of filtration;
- IHA and the water supplier will never guarantee that deferral of filtration will be permanent;
- Criteria will be developed by WET for deferral monitoring and triggers for filtration.
- Interior Health will have a primary program objective to provide criteria outlining the expectations of water suppliers;
- Water suppliers will be provided with clear expectations from Interior Health to assist them in long term planning for filtration and UV treatment to meet 43210 treatment objectives.

- Medical Health Officers will not accept differing water treatment standards that may correlate to inequitable distribution of health outcomes.
- Acceptance that water suppliers have requested from Interior Health:
  - acknowledgement of the positive health impacts of UV treatment; and
  - support for UV treatment (dependant on suitable source water characteristics) as an interim measure towards full implementation of 43210 treatment infrastructure

Options:

1. Deal with each proposal on a case-by-case basis (in the absence of a filtration deferral policy).
   Discussion: The disadvantage to this approach is the hesitation of water suppliers to make long term plans because of the uncertainty of requirements. They are unable to accurately identify costs of their infrastructure options.

2. Provide guidance on expectations for general source water situations, including triggers that would remove the deferral for filtration.
   Discussion: The advantage is to provide water suppliers with some guidelines that they can use for planning. The risk is that they will not plan for filtration because they hope to avoid it, rather than planning to accomplish filtration in a reasonable timeframe.

3. Same as 2 with expectations of timelines for installation.
   Discussion: The risk of this would be the use of timelines without due consideration of the individual water supply system's unique characteristics.

Recommendations:

Choose option 3 with clarification that the guidance of timelines for installation is *for consideration only.* A decision tree format could be included as an appendix to the Drinking Water Quality Improvement Program Booklet.

It is worth noting that not all water systems will be able to apply for a "deferral of filtration", and the following implementation plan should be considered in that context. Water suppliers that have any of the following conditions should be excluded from consideration for a deferral of filtration:

- poor source water quality (as determined by the Drinking Water Officer)
- uncontrolled watershed
- plan for only a single disinfection process

Individual and site-specific treatment strategies are required for water suppliers to adequately address public health risks in relation to their source(s).

Implementation:

Plans for Establishing Criteria for Filtration and the Deferral of Filtration

1. Development of policy regarding filtration and the potential for deferral. Refer to Appendix A.

2. Identify a method for water suppliers to determine whether or not they potentially qualify for deferral. Develop reasonable timelines for planning to achieve the 43210 objectives with or without filtration deferral. Refer to Appendix B "Factors For Water Suppliers To Determine Filtration Or Filtration Deferral Planning Requirements".

   Water suppliers using a surface water source, or a groundwater source under the direct influence of surface water, need to have a system assessment completed by a qualified Professional Engineer. The system assessment should identify infrastructure and life cycle costs, including rate structures and development cost charges.

   An implementation plan to achieve 43210 Treatment Objectives, including filtration, needs to be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train can accommodate filtration at a later date.

3. Develop the criteria that a water supplier could use to demonstrate achievement of the GCDWQ exclusion criteria for a filtration deferral proposal. Refer to Appendix C "Criteria To Demonstrate That A Water Supplier Can Achieve The GCDWQ Filtration Exclusion Criteria".

   Water Supply systems that may currently meet the exclusion criteria cannot guarantee they will do so indefinitely. Water suppliers wishing to apply for deferral of filtration as per the GCDWQ exclusion criteria must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years. Source water monitoring data may also provide information to indicate the need to initiate filtration.

   The following information could be included in future revisions of the Conditions on Operating Permits booklet:

   - **Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit.**
   - Water suppliers must provide progress reports with implementation of treatment infrastructure upgrades.
   - Water suppliers must provide water monitoring data to show continued achievement of deferral criteria.
   - Water suppliers must make documentation of filtration deferral to their consumers available in their annual reports

4. Develop strategy for IH responses to deferral proposals.

   Implementation of filtration deferral decisions will be accomplished through typical "deferral" Conditions on Operating Permit.

- Prior to a decision to defer treatment, the Drinking Water Official must undertake internal consultation that includes but is not limited to the: Senior Public Health Inspector, Public Health Engineer, Senior Drinking Water Officer, and Medical Health Officer.
- Water supply system file information must contain discussion and decision documentation regarding deferral.

5. Develop clarification of planning criteria for groundwater at risk of containing pathogens

   Through the policy review process is was recognized that further clarification is required to address questions of groundwater under the direct influence of surface water in the context of long term planning to achieve 43210 treatment objectives. Policy development regarding groundwater will be undertaken as a separate process.

6. Many requests for clarification were accumulated during the review process. The responses are provided in Appendix E.

Desired Outcomes:

- Drinking Water Quality Improvement Program COP booklet should have factors to consider for deferral of filtration. Appendix D provides information for consideration of site-specific monitoring programs.
- Communications directed towards water suppliers should identify Interior Health's expectations regarding filtration and the potential for deferral of filtration.

Prepared by:	Dale Thomas, Mike Adams, Elizabeth Sigalet	
Reviewed by:	WET	Date: May 28, 2007
Revised by:	WET	Date: June 13, 2007
Submitted to:	IH Material Development	Date: July 12, 2007
External review:	BCWWA and water suppliers	Date: December, 2007
Revised by:	Elizabeth Sigalet	Date: February 15, 2008
Submitted to:	Ken Christian	Date: February 21, 2008

Interior Health
Health Protection

Drinking Water Program

DRINKING WATER FILTRATION POLICY

1.0 PURPOSE

To clarify Interior Health's expectations for the filtration of drinking water from sources of surface water or ground water under the direct influence of surface water.

2.0 DEFINITIONS

Filtration: is a process whereby particulate material is removed from solution by passing the solution through a porous media.

3.0 POLICY

Water suppliers must provide filtration for all water supply systems using surface water sources or ground water under the direct influence of surface water. Water suppliers wishing to apply for deferral of filtration as per the GCDWQ exclusion criteria must make a written proposal to Interior Health.

4.0 PROCEDURE

4.1 Drinking Water Officials must consider the provincial *Drinking Water Officers' Guide* in the exercise of their duties and discretion. They are, however, able to depart from the guide in any case where sound reason exists to do so. In the performance of their duties, Drinking Water Officials will review, in the following order:

- provincial and other legislation,
- the Provincial Drinking Water Officer's Guide and other provincial directives,
- the Canadian Drinking Water Quality Guidelines or other federal – provincial guidelines, and
- credible resources prepared by other organizations

4.2 Interior Health's direction on drinking water quality and treatment standards is based on the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* and policy developed by other credible organizations.

4.3 The *GCDWQ* provide "Criteria for the Exclusion of Filtration in Waterworks Systems". Water Supply systems that currently meet the exclusion criteria cannot guarantee they will do so indefinitely and the criteria may change; therefore, the focus of this document is filtration "deferral" criteria not "exclusion" criteria.

4.4 Drinking Water Officials, under the guidance provided in the *Guidelines for Canadian Drinking Water Quality (GCDWQ),* Interior Health's' Drinking Water Quality Improvement Program (DWQIP) and Small Water System Strategy (SWSS)

programs, will direct water supply system suppliers that use a surface water source or a groundwater source under the direct influence of surface water to provide filtration prior to public consumption.

4.5 Water supply systems are expected to meet *43210 Drinking Water Objective* and provide filtration as part of a satisfactory application for a construction permit. The issuing official should consider whether the proposed treatment is adequate as part of their decision-making process whether to issue the construction permit.

4.6 Existing water systems suppliers need to develop long term plans and have an acceptable implementation strategy to adequately address public health risks in relation to their source(s). Drinking Water Officials, through the application of Conditions on Operating Permits (DWQIP) or Multiple Barriers of Protection (SWSS), should engage the water supplier to ensure there is an adequate plan in place for the provision of drinking water that meets the *Guidelines for Canadian Drinking Water Quality* and the *43210 Drinking Water Objectives.*

4.7 Water suppliers wishing to apply for deferral of filtration must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years.

5.0 REFERENCES

- BC Drinking Water Protection Act [SBC 2001] Chapter 9
- BC Drinking Water Protection Regulation [inc. amendments up to B.C. Reg. 352/2005, December 9, 2005]
- BC Drinking Water Officer's Guide [Version 7]
- Guidelines for Canadian Drinking Water Quality [Modified 2005-01-13]
- Drinking Water Quality Improvement Program COP Booklet
- Issue Paper: Filtration Deferral

Interior Health
Health Protection

Drinking Water Program

FILTRATION OR FILTRATION DEFERRAL PLANNING REQUIREMENTS

1.0 Introduction

- All water supply systems in Interior Health's Drinking Water Quality Improvement Program are required to assess source water quality and provide long term plans to achieve 43210 as a condition on their operating permits.

- An implementation plan to achieve 43210 Treatment Objectives, including filtration, must be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train that can accommodate filtration at a later date.

- For systems that have source water that is surface water or under the direct influence of surface water, the plans must include filtration.

- For plans including filtration without deferral – refer to timelines and milestones in Part 2.

- For plans proposing deferral of filtration – refer to timelines, milestones and proposal requirements in Part 3.

- Plans including the deferral of filtration are less capital intensive and should not be delayed. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.

2.0 Plans Including Filtration

If a water supply system using surface water as a water source cannot meet the *Canadian Drinking Water Quality Guidelines* for exclusion of filtration they are required to plan for filtration. The water supplier, in collaboration with IH, will establish timelines specific to their individual systems. Factors such as outbreaks may shorten timelines. Drinking Water Officers (DWO) may set milestone targets on operating permits.

2.1 Components of filtration (which may be applied as conditions on operating permits) include:

- assessment and planning for financing
- completion of a (long term) plan to achieve 43210 objectives
- design
- construction

2.2 Interior Health (IH) expects water suppliers to reduce risk to public health by achieving the shortest possible timelines for implementation. Experience has indicated that it is reasonable to achieve filtration within 7 years. Milestones can be delineated as follows:

- 2 years for assessment and planning to achieve 43210
- 3 years for design and planning for financing

- 2 years for construction and implementation

2.3 It is reasonable and achievable for water supply systems existing in 2007 serving more than 500 people per day to have filtration operational by 2015. It is reasonable for the public to expect that:
- 50% of water supply systems will have filtration in place by 2012
- 90% of water supply systems will have filtration in place by 2015

Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve filtration.

3.0 Plans Including Deferral of Filtration

If a water supply system using surface water as a water source cannot meet the *Canadian Drinking Water Quality Guidelines* for exclusion of filtration they are required to plan for filtration.

3.1 Water supplier must submit a plan for achieving the long term objectives of 43210.

3.2 Water supplier must submit a proposal (with at least one year of data) for deferral of filtration, including:

a) Demonstration of meeting the Canadian Drinking Water Quality Guidelines for exclusion from filtration
   i. *E.coli* and coliform monitoring
   ii. on-line continuous turbidity monitoring to provide daily average
   iii. performance monitoring of disinfection processes to achieve credit for 4-log removal of viruses and 3-log removal of *Cryptosporidium* and *Giardia*
   iv. annual update or review of changes to the watershed and control program (e.g. sewage outfalls, mining, forestry, agriculture). Note that Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit. It is not necessary to have exclusive use of a watershed to have a watershed control program.

b) Site-specific monitoring identified by DWO which might include:
   i. monitoring the presence of *Giardia* or *Cryptosporidium* and establishing baseline data
   ii. constituents identified by the EPA guidelines (e.g. algae, dissolved organics, conductivity)
   iii. process concerns (e.g.disinfection interuptions)

3.3 Water suppliers must be prepared to install filtration if any of the following occur:
a) waterborne illness outbreak
b) excesses of avoidable disinfection byproducts, refer to Canadian Drinking Water Quality Guidelines for guidance
c) failure to provide or meet the exclusion criteria monitoring requirements
d) significant degradation of raw water quality identified by the DWO
e) health threats

3.4 Timelines and Milestones

The water supplier must be prepared to meet the expectation of construction and implementation of filtration within 2 years of being unable to meet the deferral criteria.

It is reasonable and achievable for water supply systems serving more than 500 people per day and existing in 2007 to have two methods of disinfection operational by 2013. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.

Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve disinfection objectives. Some systems may be further ahead than others and will, therefore, be required to move ahead more quickly.

Criteria to Demonstrate That a Water Supplier Can Achieve the GCDWQ Filtration Exclusion Criteria

Systems may qualify for deferral of filtration if they demonstrate the following:

- ☐ 4 log removal or inactivation of viruses and 3 log inactivation of protozoa is achieved using a minimum of 2 disinfection processes.
- ☐ Background baseline levels of *Cryptosporidium* and *Giardia*, adequate to establish trends, have been established.
- ☐ A watershed control program designed with the express purpose of minimizing fecal contamination in the source water is being implemented. Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in conditions of the operating permit.
- ☐ No more than 10% of source/raw water *E.coli* samples exceed 20/100 ml in any 6-month period.
- ☐ No more than 10% of source/raw water total coliform samples exceed 100/100 ml in any 6-month period.
- ☐ Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.*
- ☐ Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period.
- ☐ Expected average annual total Trihalomethanes at locations farthest from treatment will not exceed 0.100 mg/L or 100 µg/L.

* This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that <u>might not always</u> meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month"

Considerations for Ongoing Monitoring Programs for Systems with Filtration Deferral

Water quality in BC can fluctuate daily, weekly and over long periods of time. Drinking water systems that have raw water quality that currently meets the *GCDWQ Filtration Exclusion Criteria* need to monitor their raw water to detect changes that will affect treatment efficiency.

It is recommended that purveyors refer to the Modules 1, 2, 7, and 8 of the Provincial *Comprehensive Source to Tap Assessment Guideline* as an example of how to develop a source protection plan. **Watershed control programs expressly intended to minimize fecal contamination can be accomplished using the Guideline.** Regardless of the method used and plan developed, it is expected that the following elements will be included:

1. Characterization of the source water and delineation of the area of the watershed from which source water originates. This should include an evaluation of the pathways and estimated time of travel for fecal pathogens to the intake from different areas in watershed.
2. Identification of potential sources of fecal pollution within the watershed that pose a threat of introducing pathogenic organisms to the drinking water system.
3. An assessment of the risks to public health posed by the identified sources of fecal pollution, and
4. A plan to mitigate the risks posed by sources of fecal pathogens in the capture zone and limit future contamination of the water source.

Evaluating background microbial contamination and identifying trends in water quality linked to fecal contamination levels is crucial to building an effective source protection plan. The data collected, sampling locations, and frequency of sampling to characterize the source water should be established by the source protection planning team. Monitoring plans to support source protection planning for filtration deferral will typically include the following elements:

Microbes

- *E.coli* & Total Coliforms (minimum weekly samples)
- Protozoa (monthly samples)

Chemical parameters

- Alkalinity & Hardness (minimum bi-weekly)
- Total Organic Carbon (minimum bi-weekly)
- pH (minimum weekly)

Physical parameters

- Turbidity (daily averages based on minimum of 1 sample every 4 hours)
- Temperature (minimum weekly)
- Colour (minimum weekly)
- UV transmittance (minimum weekly)

Source monitoring to establish compliance with filtration referral criteria should be conducted over at least a one year period, preferably longer. Testing should be done by an approved laboratory with samples collected using appropriate methods.

Questions and Responses from the Internal and External Review Process - Filtration Deferral

Questions posed regarding the Filtration Deferral Issue Paper and points where clarification was requested:

Section 1 - Are the factors clear? How can we clarify?		
Clarify whether this a "deferral" document or an "exemption" or "waiver" document	Accept	Issue Paper -Name of issue: Criteria for the Deferral of Filtration
Define the time line associated with deferrals (e.g. evergreen, or 2 – 5)	Accept	There is no timeline. The deferral concept is for planning purposes. The intent is to identify for water supply systems the conditions they must have for filtration deferral to be possible. If the criteria are not met, the deferral is revoked.
Title should reflect what the document is (e.g. "Requirement for Filtration Treatment", or "Planning for Filtration or Options"	Accept	Issue Paper Title: Planning for Drinking Water Filtration Policy Title: Drinking Water Filtration Policy
Clarify how this fits into the Drinking Water Protection Act as "outcome based" legislation that does not prescribe treatment	Accept	Section 4.5 of the Policy addresses the need for achieving 43210 objectives as part of a satisfactory construction permit application. The issuing official must consider if the proposed treatment is adequate. The 43210 is not a standard, but reasonable guidance to consider for treatment. The issuing official must consider each construction permit on the merit of the submission to ensure that public health issues related to the source water characteristics are addressed.
Clarify how this policy addresses groundwater that may contain pathogens	Decline	
Clarify what Interior Health considers to be a "watershed control program"	Accept	Watershed control programs expressly intended to minimize fecal contamination can be accomplished by completing appropriate modules of the comprehensive source to tap assessment guide developed by MOE and MOH. Modules appropriate to the water supply system will be identified by the DWO and may be included in the conditions on operating permit.
Clarify that a multiple use watershed could qualify as having a "watershed control program"	Accept	It is not necessary to have exclusive use of a watershed to have a watershed control program.
Provide a better definition of "filtration"	Accept	Filtration: is a process whereby particulate material is removed from solution by passing the solution through a porous media.
Clarify that Appendix B 3 2 a) iii) requires both UV and chlorination	Decline	The form of removal is not prescribed.
Clarify whether UV must be installed and operating before deferral granted	Decline	Emphasis is placed on the health risk reduction with the shortest timelines possible to achieve disinfection objectives. Some systems may be further ahead than

		others and will, therefore, be required to move ahead more quickly.
Clarify whether 43210 requires two forms of treatment for each form of inactivation or removal	Accept	43210 refers to two forms of treatment, not for each inactivation or removal requirement. However, the CDWQG filtration exclusion criteria note: Filtration of a surface water source or a groundwater source under the direct influence of surface water may not be necessary if the following conditions are met: Overall inactivation is met using a minimum of two disinfectants: • ultraviolet irradiation or ozone to inactivate cysts/oocysts; • chlorine (free chlorine) to inactivate viruses; and • chlorine or chloramines to maintain a residual in the distribution system
Define "avoidable disinfection by products"	Accept	Excesses of avoidable disinfection byproducts, refer to Canadian Drinking Water Quality Guidelines for guidance
Clarify which guidelines are dominant Canadian Drinking Water Quality Guidelines or EPA	Accept	In the performance of their duties, Drinking Water Officials will review, in the following order: • provincial and other legislation, • the Provincial Drinking Water Officer's Guide and other provincial directives, • the Canadian Drinking Water Quality Guidelines or other federal – provincial guidelines, and • credible resources prepared by other organizations
Clarify that these expectations are for large water supply systems	Accept	All water supply systems in Interior Health's Drinking Water Quality Improvement Program are required to assess source water quality and provide long term plans to achieve 43210 as a condition on their operating permits. Small water systems are not included in the Drinking Water Quality Improvement Program. All new systems (regardless of size) must meet 43210 objectives.
Clarify "coagulant break through"	Accept	Removed from document
Clarify that new systems require filtration regardless of meeting deferral criteria	Decline	All new systems (regardless of size) must meet 43210 objectives as a minimum. Filtration may be required by the issuing official.
Clarify that future failure to meet deferral criteria invalidates the deferral	Accept	Timelines and Milestones: The water supplier must be prepared to meet the expectation of construction and implementation of filtration within 2 years of being unable to meet the deferral criteria.
Clarify that planning to meet the deferral criteria does not mean postponement of timelines to achieve 43210 objectives.	Accept	It is reasonable and achievable for water supply systems serving more than 500 people per day and existing in 2007 to have two methods of disinfection operational by 2013. It is reasonable for the public to expect that if filtration deferral is proposed, that the additional required disinfection would be installed as quickly as possible.
Clarify that filtration could have equivalent processes of equal public health protection	Accept	This document is intended to identify equivalent protection to filtration. There may be others. Individual

		and site-specific treatment strategies are required for water suppliers to adequately address public health risks in relation to their source(s).
Clarify that surface water could be considered in three categories "run of river", "lake intakes" or "groundwater under influence of surface water"	Decline	Prefer to use simple inclusive terminology
Clarify that groundwater under the direct influence of surface water may achieve some credit for filtration as defined by the *Guidance Document for Determining Ground Water at Risk of Containing Pathogens and Ground Water Under Direct Influence of Surface Water*	Decline	The Guidance document is relevant. The process for identifying how the filtration deferral would be achieved is valid for systems that have water that may contain pathogens. The issues of how to define GUDI are best left to different documents.
Clarify 43210 planning requirements for groundwater sources under direct influence of surface water.	Decline	The process for identifying how GUDI systems meet 43210 objectives and equivalency for filtration is best left to different documents still in development
USEPA and GCDWQ documents have summary pages that are one page long. The final document from IHA should follow that format.	Accept	The document circulates provides background discussion and the Interior Health policy. Material to be provided to water suppliers could be limited to one page depending on the approach they wish to consider.
Clarify whether IH would consider that removal of rangeland cattle would constitute enough of a reduction of health risk that filtration and enhanced disinfection would not be required.	Decline	Rangeland cattle are not the only health risk posed to surface water. Giardia and Cryptosporidium have been shown to be present in all surface waters with or without cattle. IH requires long term planning for source protection "AND" treatment, not "EITHER/OR"

Section 2 - Are the expectations reasonable? Are there other alternatives we should consider?		
Debate whether it is necessary for all communities to filter their water.	Decline	4.2 Interior Health's direction on drinking water quality and treatment standards is based on the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* and policy developed by other credible organizations.
Canadian Drinking Water Quality Guidelines should be viewed as guidelines, not standards. Equivalencies to filtration should be considered.	Accept	Issuing officials must consider each construction permit application on the merit of the individual system. The issuing official should consider whether the proposed treatment is adequate as part of their decision-making process whether to issue the construction permit.
If exemption criteria are met, Interior Health should require a redirection of funds from filtration to improvement distribution system deficiencies.	Decline	Interior Health does not direct or redirect funding available drinking water improvements. The Drinking Water Quality Improvement Program requires long term plans for improvements of sources, treatment and distribution systems.
Other water quality improvement strategies should also be considered (e.g. storage volumes, monitoring, and trending analysis).	Decline	Other water quality improvement strategies are addressed in other documents.
It would be unreasonable to expect that a community would have chlorination and UV treatment in place before being granted filtration deferral.	Accept	4.7 Water suppliers wishing to apply for deferral of filtration must make a proposal to Interior Health that defines their watershed control program, dual treatment technologies and is supported by suitable source monitoring data trended over a minimum of one year and preferably several years.
Monitoring for Giardia and Cryptosporidium	Accept	Evaluating background microbial contamination and

is expensive and test results have limitations. and Clarify that total coliform data has limitations as health risk data because it is not a good indicator of fecal loading, but provides general water quality information that would allow trending analysis and identification of dramatic changes in water quality.		identifying trends in water quality linked to fecal contamination levels is crucial to building an effective source protection plan. The data collected, sampling locations, and frequency of sampling to characterize the source water should be established by the source protection planning team. Monitoring plans to support source protection planning for filtration deferral will typically include the following elements: Microbes • *E.coli* & Total Coliforms (minimum weekly samples) • Protozoa (monthly samples) Continued monitoring for Giardia and Cryptosporidium may not be required if there is a demonstration of other baseline data that can identify trends in water quality linked to fecal contamination levels. The same would apply to total coliforms.
UV calibration reports may serve as a measure of UV efficacy for Giardia and Cryptosporidium inactivation or removal	Decline	See answer above.
Expectations are not appropriate for small systems	Accept	With the exception that new small systems are expected to achieve 43210 criteria. Filtration may be preferable to validation required to achieve deferral.
Turbidity of 1 NTU should not be a definitive turbidity limit. Preference for the wording used in the Canadian Drinking Water Quality Guidelines. and Preference for a range of numerical values for turbidity with acceptable frequency and variation of magnitude of excursions	Decline	• Turbidity in source immediately before disinfection does not exceed 1NTU 95% of the time in any 30-day period.* • Peak turbidity readings do not exceed 5NTU for more than 2 days in a 1-year period. * This is intended to clarify "average daily turbidity around 1 NTU". For planning purposes it is important to recognize that some systems will clearly achieve the criteria. Systems that might not always meet the criteria must recognize that they may be required to implement filtration if they do not meet the criteria identified. This interpretation is drawn as a parallel to the treatment requirements for "slow sand or diatomaceous earth filtration" in the Turbidity Guideline that identifies turbidity levels "shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month"
Process for determining rationale for deferral should be transparent and available to public	Accept	The following information could be included in future revisions of the Conditions on Operating Permits booklet: • Water suppliers must make documentation of filtration deferral to their consumers available in their annual reports

Section 3 - Are the expectations achievable? If not, what are the barriers?		
Financial • competing demands for community resources • grants are not available to all water supply systems equally • it may take longer than the period	Accept	Without defining expectations and undertaking planning activities the financial implications are speculation. On average, the rates for drinking water in BC are lower than most of the rest of Canada. Canadian rates for municipal water are consistently lower than other

allowed to accumulate financial resources to undertake works • community referendums for approval of borrowing funds could fail • cost of completing a comprehensive source to tap assessment		developed countries. Expectations of citizens in BC for drinking water quality may not match their expectation or water rates. Rick Thorpe: *"A clean and reliable water source is the right of al British Columbians"*. Steve Hrudey: *"There is no cheap way to achieve safety"*.
Timeline of 2 years – may be difficult to achieve if a community does not have a preliminary engineering report and community support plan in place at all times.	Accept	An implementation plan to achieve 43210 Treatment Objectives, including filtration, must be developed. The implementation plan should include a selected technology and identify staged and continuous benchmarks with clear target dates. The implementation plan should allow for future filtration, i.e. ensure land footprint available in conceptual layout and a treatment train can accommodate filtration at a later date.
Consistency – this is not policy for other Health Authorities	Accept	We have shared our policy development process through the provincial Drinking Water Leadership Council and considered input from other Health Authorities in our policy.

Enclosure F – Westshore Model Output

Fire Flow Node FlexTable: Fire Flow Report (Westshore Base.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)	Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
J-108	3	True	60.00	246.66	60.00	246.66	20.0	20.0	0.3	2.1	2.1	J-5443	True
J-204	2	True	60.00	78.13	60.11	78.24	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-208	3	True	60.00	86.99	60.38	87.37	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-313	15	False	60.00	11.30	60.23	11.52	20.0	20.6	0.3	2.5	2.5	J-7274	True
J-327	3	False	60.00	13.71	60.00	13.71	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-329	3	False	60.00	11.07	60.08	11.15	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-376	3	False	60.00	11.41	60.23	11.64	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-561	3	False	60.00	7.47	60.15	7.62	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-603	15	False	60.00	13.63	60.11	13.74	20.0	20.5	0.3	2.5	2.5	J-7274	True
J-621	3	True	60.00	97.35	60.08	97.43	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-625	3	False	60.00	54.80	60.23	55.03	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-631	4	True	60.00	240.80	60.11	240.91	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-647	3	False	60.00	17.25	60.11	17.36	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-795	3	False	60.00	8.71	60.11	8.83	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-804	3	True	60.00	200.66	60.08	200.73	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-1084	3	True	60.00	62.74	60.23	62.97	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-1121	15	True	60.00	72.08	60.27	72.34	20.0	20.1	0.3	2.5	2.5	J-7274	True
J-1561	3	True	60.00	146.55	60.27	146.82	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-1571	4	True	60.00	240.39	60.00	240.39	20.0	29.5	0.3	0.3	0.3	J-5443	True
J-1744	10	True	60.00	125.77	60.00	125.77	20.0	20.1	0.3	2.5	2.5	J-7274	True
J-1839	4	True	60.00	143.09	60.00	143.09	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2117	3	True	60.00	62.30	60.15	62.45	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2218	3	True	60.00	144.75	60.38	145.13	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2222	4	True	60.00	114.11	60.23	114.34	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2235	3	False	60.00	16.91	60.00	16.91	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2241	3	False	60.00	3.24	60.08	3.32	20.0	20.1	0.3	2.5	2.5	J-7274	True
J-2308	3	True	60.00	108.76	60.53	109.29	20.0	20.0	0.3	2.5	2.5	J-7274	True

Fire Flow Node FlexTable: Fire Flow Report (Westshore Base.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)	Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
J-2622	3	True	60.00	207.50	60.11	207.61	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2626	4	True	60.00	186.15	60.19	186.34	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2726	2	True	60.00	60.88	60.19	61.07	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2732	3	False	60.00	55.22	60.19	55.41	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2776	3	False	60.00	49.34	60.30	49.65	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2819	6	True	60.00	102.86	60.42	103.28	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2821	3	False	60.00	49.79	60.11	49.90	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-2831	9	True	60.00	153.07	60.27	153.33	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-3081	3	True	60.00	136.33	60.30	136.64	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-3117	3	True	60.00	121.24	60.23	121.46	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-3137	3	True	60.00	119.33	60.42	119.74	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-3289	4	True	60.00	246.92	60.23	247.15	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-4215	2	True	60.00	250.00	60.00	250.00	20.0	34.7	0.3	2.3	2.3	J-7274	True
J-4809	1	False	60.00	0.00	60.00	0.00	20.0	17.8	0.3	2.5	2.5	J-7274	True
J-4810	5	True	60.00	122.91	60.00	122.91	20.0	41.5	0.3	0.3	0.3	J-6936	True
J-4818	15	False	60.00	13.64	60.11	13.75	20.0	20.8	0.3	2.5	2.5	J-7274	True
J-4895	5	True	60.00	86.52	60.27	86.78	20.0	32.8	0.3	0.3	0.3	J-6946	True
J-4896	5	True	60.00	84.06	60.23	84.29	20.0	31.6	0.3	0.3	0.3	J-6946	True
J-5041	15	False	60.00	13.14	60.27	13.40	20.0	20.3	0.3	2.5	2.5	J-7274	True
J-5154	6	True	60.00	171.96	60.61	172.56	20.0	37.0	0.3	0.3	0.3	J-6946	True
J-5399	20	True	60.00	81.82	60.00	81.82	20.0	21.9	0.3	0.4	0.4	J-2732	True
J-5443	3	True	60.00	104.05	60.34	104.39	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-5446	15	False	60.00	9.74	60.15	9.90	20.0	20.3	0.3	2.5	2.5	J-7274	True
J-5566	3	True	60.00	187.03	60.15	187.18	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-5717	3	True	60.00	86.66	60.00	86.66	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-5739	3	True	60.00	107.14	60.38	107.52	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-5865	15	False	60.00	13.32	60.15	13.47	20.0	20.6	0.3	2.5	2.5	J-7274	True
J-5876	3	True	60.00	104.15	60.27	104.41	20.0	20.0	0.3	2.5	2.5	J-7274	True

Fire Flow Node FlexTable: Fire Flow Report (Westshore Base.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)	Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
J-6227	2	True	60.00	250.00	60.23	250.23	20.0	56.4	0.3	2.5	2.5	J-7274	True
J-6357	3	True	60.00	112.07	60.11	112.18	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6449	3	True	60.00	95.17	60.30	95.47	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6457	6	True	60.00	111.45	60.38	111.83	20.0	39.1	0.3	0.3	0.3	J-6946	True
J-6484	3	False	60.00	15.95	60.23	16.18	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6599	3	True	60.00	106.32	60.00	106.32	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6611	3	True	60.00	89.41	60.23	89.63	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6708	4	True	60.00	154.33	60.00	154.33	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6717	11	True	60.00	113.75	60.38	114.13	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6736	3	True	60.00	191.60	60.23	191.83	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6741	3	True	60.00	211.76	60.00	211.76	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6782	3	True	60.00	136.04	60.23	136.27	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6796	6	True	60.00	97.48	60.08	97.55	20.0	58.0	0.3	0.3	0.3	J-6946	True
J-6797	6	True	60.00	94.63	60.19	94.82	20.0	55.6	0.3	0.3	0.3	J-6946	True
J-6806	3	True	60.00	78.01	60.00	78.01	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6838	3	True	60.00	82.66	60.00	82.66	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6839	3	True	60.00	106.68	60.34	107.02	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6840	4	True	60.00	131.33	60.15	131.48	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6842	3	True	60.00	132.15	60.00	132.15	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6852	3	True	60.00	149.75	60.38	150.13	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6854	3	True	60.00	104.61	60.49	105.10	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6855	3	True	60.00	92.22	60.00	92.22	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6857	3	False	60.00	57.69	60.00	57.69	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6858	3	True	60.00	73.89	60.34	74.23	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6860	3	True	60.00	93.60	60.11	93.71	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6865	4	True	60.00	151.18	60.00	151.18	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6876	3	True	60.00	108.87	60.00	108.87	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6877	3	True	60.00	133.70	60.00	133.70	20.0	20.0	0.3	2.5	2.5	J-7274	True

Fire Flow Node FlexTable: Fire Flow Report (Westshore Base.wtg)

Current Time: 0.000 hours

Label	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (psi)	Pressure (Calculated Residual) (psi)	Pressure (Zone Lower Limit) (psi)	Pressure (Calculated Zone Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Is Fire Flow Run Balanced?
J-6883	3	True	60.00	70.37	60.00	70.37	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6898	2	True	60.00	66.99	60.00	66.99	20.0	20.1	0.3	2.5	2.5	J-7274	True
J-6910	3	True	60.00	134.39	60.00	134.39	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6911	5	True	60.00	141.08	60.76	141.84	20.0	22.8	0.3	0.3	0.3	J-6928	True
J-6916	3	True	60.00	88.88	60.30	89.18	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6917	3	True	60.00	79.93	60.27	80.20	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6920	3	True	60.00	104.85	60.00	104.85	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6922	6	True	60.00	227.50	60.00	227.50	20.0	32.9	0.3	0.3	0.3	J-5443	True
J-6923	6	True	60.00	111.95	60.49	112.45	20.0	52.7	0.3	0.3	0.3	J-6946	True
J-6928	3	True	60.00	106.83	60.00	106.83	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6929	12	True	60.00	131.51	60.23	131.74	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6932	3	True	60.00	201.04	60.00	201.04	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6933	11	True	60.00	104.76	60.38	105.14	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6936	3	True	60.00	92.25	60.11	92.36	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6940	4	True	60.00	201.67	60.00	201.67	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6946	3	False	60.00	43.26	60.00	43.26	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6951	3	True	60.00	82.32	60.27	82.58	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6952	3	True	60.00	140.89	60.00	140.89	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6963	1	False	60.00	0.00	60.00	0.00	20.0	13.0	0.3	2.5	2.5	J-7274	True
J-6964	1	False	60.00	0.00	60.00	0.00	20.0	5.7	0.3	2.5	2.5	J-7274	True
J-6975	3	True	60.00	93.21	60.27	93.48	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-6981	4	True	60.00	225.30	60.00	225.30	20.0	20.0	0.3	1.8	1.8	J-7080	True
J-6982	6	True	60.00	208.80	60.19	208.99	20.0	33.9	0.3	0.3	0.3	J-7080	True
J-7008	9	False	60.00	54.13	60.00	54.13	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7019	6	True	60.00	109.64	60.38	110.02	20.0	36.6	0.3	0.3	0.3	J-6946	True
J-7025	15	False	60.00	8.77	60.23	9.00	20.0	20.4	0.3	2.5	2.5	J-7274	True
J-7028	8	False	60.00	3.61	60.08	3.68	20.0	20.1	0.3	2.5	2.5	J-7274	True
J-7059	4	True	60.00	112.44	60.42	112.86	20.0	20.0	0.3	2.5	2.5	J-7274	True

Fire Flow Node FlexTable: Fire Flow Report (Westshore Base.wtg)

Current Time: 0.000 hours

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J-7079	6	True	60.00	136.37	60.15	136.53	20.0	23.5	0.3	0.3	0.3	J-7080	True
J-7080	3	True	60.00	66.36	60.15	66.51	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7095	3	False	60.00	14.74	60.08	14.82	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7188	4	True	60.00	162.73	60.00	162.73	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7189	4	True	60.00	108.68	60.19	108.87	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7223	3	True	60.00	82.29	60.11	82.41	20.0	20.0	0.3	2.5	2.5	J-7274	True
J-7251	6	True	60.00	188.05	60.15	188.20	20.0	38.5	0.3	0.3	0.3	J-7080	True
J-7263	2	True	60.00	250.00	60.00	250.00	20.0	35.8	0.3	2.5	2.5	J-7274	True
J-7274	1	False	60.00	0.00	60.00	0.00	20.0	2.5	0.3	5.7	5.7	J-6964	True
J-7275	2	True	60.00	250.00	60.00	250.00	20.0	63.8	0.3	2.5	2.5	J-7274	True
J-7276	6	True	60.00	233.30	60.00	233.30	20.0	22.8	0.3	0.3	0.3	J-6857	True

FlexTable: Junction Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
11112	J-6964	591.00	0.00	595.01	5.7
11111	J-6963	585.93	0.00	595.05	13.0
8765	J-5566	540.00	0.15	595.11	78.2
10624	J-6717	540.00	0.38	595.09	78.2
11054	J-6933	540.00	0.38	595.08	78.2
4386	J-2819	540.00	0.42	595.08	78.2
11045	J-6929	540.00	0.23	595.09	78.2
8565	J-5443	539.34	0.34	595.29	79.4
10664	J-6741	539.02	0.00	595.08	79.6
9257	J-5876	537.77	0.27	595.08	81.4
10655	J-6736	536.62	0.23	595.13	83.1
4086	J-2622	535.81	0.11	595.08	84.1
1243	J-804	535.05	0.08	595.10	85.2
10865	J-6842	534.97	0.00	595.30	85.6
11782	J-7263	533.09	0.00	595.29	88.3
11051	J-6932	531.81	0.00	595.15	89.9
10980	J-6898	531.27	0.00	595.29	90.9
9036	J-5739	530.83	0.38	595.29	91.5
4253	J-2732	530.00	0.19	595.08	92.4
10952	J-6883	530.00	0.00	595.08	92.4
1733	J-1121	530.00	0.27	595.29	92.7
11241	J-7025	527.03	0.23	595.09	96.6
11060	J-6936	525.46	0.11	595.08	98.8
11028	J-6920	523.96	0.00	595.08	101.0
5096	J-3289	523.18	0.23	595.36	102.5
4404	J-2831	521.00	0.27	595.08	105.1
11032	J-6922	516.36	0.00	595.30	112.0
4389	J-2821	514.78	0.11	595.08	114.0
941	J-603	513.03	0.11	595.07	116.5
983	J-631	511.94	0.11	595.20	118.2
186	J-108	510.00	0.00	595.22	121.0
9238	J-5865	510.00	0.15	595.06	120.7
8491	J-5399	510.00	0.00	595.08	120.8
2713	J-1744	510.00	0.00	595.08	120.8
9812	J-6227	508.87	0.23	595.45	122.9
2439	J-1571	508.56	0.00	595.25	123.1
10746	J-6782	505.51	0.23	595.41	127.6
337	J-204	504.90	0.11	595.29	128.3
2423	J-1561	504.51	0.27	595.42	129.0
11090	J-6952	504.49	0.00	595.41	129.1
10936	J-6876	504.19	0.00	545.01	57.9
11088	J-6951	503.91	0.27	545.01	58.3
10236	J-6484	503.84	0.23	595.39	129.9
4867	J-3137	502.88	0.42	595.41	131.3
11067	J-6940	502.73	0.00	595.42	131.6
17983	J-7275	502.00	0.00	595.48	132.7

FlexTable: Junction Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
4837	J-3117	500.00	0.23	595.41	135.4
10884	J-6852	500.00	0.38	595.41	135.4
10939	J-6877	499.66	0.00	595.42	135.9
10908	J-6865	498.74	0.00	570.01	101.2
10889	J-6855	495.08	0.00	570.01	106.4
7454	J-4810	493.69	0.00	595.08	143.9
7453	J-4809	493.00	0.00	505.51	17.8
2865	J-1839	490.01	0.00	570.01	113.6
11204	J-7008	490.00	0.00	506.12	22.9
4244	J-2726	490.00	0.19	545.00	78.1
10607	J-6708	490.00	0.00	570.01	113.6
11315	J-7059	489.90	0.42	570.01	113.7
10022	J-6357	489.49	0.11	545.01	78.8
10888	J-6854	488.77	0.49	570.01	115.3
10426	J-6599	488.38	0.00	545.01	80.4
11248	J-7028	486.72	0.08	505.50	26.7
8569	J-5446	486.52	0.15	544.99	83.0
10176	J-6449	485.00	0.30	545.01	85.2
11022	J-6917	484.20	0.27	570.01	121.8
3493	J-2241	484.04	0.08	505.50	30.5
9002	J-5717	482.62	0.00	570.01	124.0
343	J-208	482.31	0.38	570.01	124.5
11078	J-6946	480.00	0.00	505.51	36.2
10861	J-6840	477.45	0.15	505.51	39.8
501	J-313	476.00	0.23	569.95	133.4
11020	J-6916	473.35	0.30	505.53	45.7
974	J-625	470.10	0.23	505.51	50.3
11606	J-7189	469.78	0.19	505.56	50.8
3304	J-2117	469.53	0.15	505.58	51.2
7470	J-4818	469.27	0.11	570.00	143.0
11131	J-6975	468.40	0.27	505.58	52.8
11359	J-7080	467.93	0.15	505.83	53.8
10895	J-6857	465.82	0.00	506.00	57.0
10446	J-6611	463.90	0.23	506.00	59.8
3464	J-2222	463.44	0.23	505.55	59.8
10857	J-6838	462.38	0.00	505.65	61.4
10791	J-6806	461.77	0.00	506.00	62.8
10899	J-6860	461.68	0.11	505.83	62.7
7906	J-5041	461.08	0.27	505.51	63.1
525	J-329	461.05	0.08	505.83	63.6
968	J-621	460.10	0.08	506.01	65.2
7679	J-4896	457.96	0.23	505.51	67.5
7678	J-4895	457.13	0.27	505.51	68.7
1677	J-1084	456.64	0.23	506.00	70.1
10896	J-6858	456.44	0.34	506.00	70.4
10858	J-6839	454.96	0.34	505.65	71.9

FlexTable: Junction Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (psi)
11225	J-7019	453.28	0.38	505.51	74.1
3595	J-2308	453.27	0.53	505.68	74.4
878	J-561	452.17	0.15	505.97	76.4
11358	J-7079	451.60	0.15	505.83	77.0
1007	J-647	451.38	0.11	505.51	76.8
18001	J-7276	450.00	0.00	506.01	79.5
11143	J-6981	449.26	0.00	505.98	80.5
11686	J-7223	447.00	0.11	506.00	83.7
10189	J-6457	444.09	0.38	505.51	87.2
1229	J-795	439.86	0.11	505.98	93.9
11144	J-6982	439.74	0.19	505.94	94.0
11751	J-7251	438.64	0.15	505.89	95.4
11034	J-6923	437.91	0.49	505.51	96.0
10776	J-6797	435.78	0.19	505.51	99.0
11043	J-6928	434.92	0.00	505.61	100.3
4319	J-2776	434.27	0.30	505.50	101.1
10775	J-6796	433.16	0.08	505.51	102.7
8086	J-5154	428.53	0.61	505.56	109.3
3484	J-2235	427.84	0.00	505.94	110.9
522	J-327	426.79	0.00	505.48	111.7
4783	J-3081	426.13	0.30	505.72	113.0
597	J-376	424.28	0.23	505.46	115.2
11394	J-7095	421.82	0.08	505.94	119.4
11010	J-6911	419.08	0.76	505.61	122.8
11605	J-7188	415.85	0.00	505.56	127.3
3458	J-2218	414.08	0.38	505.66	130.0
4092	J-2626	410.16	0.19	505.82	135.8
11009	J-6910	405.86	0.00	505.61	141.6
6501	J-4215	345.35	0.00	508.60	231.7
17968	J-7274	340.20	0.00	341.95	2.5

FlexTable: Pipe Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
17817	P-17817	72.47	J-3137	J-6952	150.0	120.0	-0.42	0.02
17855	P-17855	71.74	J-6860	J-7080	150.0	120.0	0.15	0.01
17851	P-5663	54.68	J-7188	J-5154	150.0	120.0	0.00	0.00
17848	P-17848	70.45	J-804	J-5566	200.0	120.0	-3.48	0.11
17847	P-17847	69.59	J-6981	J-6982	200.0	120.0	8.63	0.27
17843	P-17843	71.03	J-1571	J-108	200.0	120.0	7.48	0.24
17829	P-17829	57.84	J-6611	J-6806	150.0	120.0	0.95	0.05
7677	4435	7.62	J-4895	J-4896	150.0	120.0	0.46	0.03
17818	P-17818	63.13	J-6952	J-1561	150.0	120.0	-0.60	0.03
17863	P-17863	88.05	J-6736	J-5566	200.0	120.0	5.88	0.19
17813	P-17813	110.73	J-6797	J-4895	150.0	120.0	0.07	0.00
17808	P-17808	71.82	J-6876	J-6951	150.0	120.0	0.27	0.02
17784	P-17784	45.33	J-6877	J-1561	150.0	120.0	0.00	0.00
17780	P-17780	55.69	J-6449	J-6599	150.0	120.0	-0.65	0.04
17778	P-17778	64.22	J-6806	J-6858	150.0	120.0	0.57	0.03
17777	P-17777	58.77	J-6917	J-5717	150.0	120.0	-0.27	0.02
17828	P-17828	48.52	J-6357	J-6876	150.0	120.0	-0.76	0.04
17889	P-17889	173.24	J-6916	J-2222	150.0	120.0	-1.64	0.09
17903	P-17903	142.13	J-6227	J-3289	200.0	120.0	8.81	0.28
17902	P-17902	84.70	J-6852	J-3117	150.0	120.0	0.23	0.01
17898	P-17898	176.24	J-6840	J-7019	150.0	120.0	0.76	0.04
17895	P-17895	150.63	J-1744	J-2831	150.0	120.0	-0.11	0.01
17894	P-17894	101.69	J-2831	J-6741	150.0	120.0	-0.38	0.02
17893	P-17893	122.02	J-1121	J-204	150.0	120.0	0.11	0.01
17860	P-17860	100.37	J-4810	J-6933	150.0	120.0	-0.57	0.03
17890	P-17890	129.81	J-7019	J-4895	150.0	120.0	0.66	0.04
17861	P-17861	150.43	J-5154	J-7189	150.0	120.0	-0.55	0.03
17878	P-17878	98.04	J-6975	J-7189	150.0	120.0	2.61	0.15
17877	P-17877	92.53	J-7189	J-2222	150.0	120.0	1.86	0.11
17875	P-17875	113.31	J-2117	J-6975	150.0	120.0	-0.15	0.01
17870	P-17870	94.62	J-6858	J-1084	150.0	120.0	0.23	0.01
17866	P-17866	69.12	J-6929	J-6717	150.0	120.0	1.08	0.06
17865	P-17865	72.70	J-2308	J-6839	150.0	120.0	3.37	0.19
17748	P-17748	74.98	J-2819	J-5876	150.0	120.0	0.52	0.03
17892	P-17892	132.04	J-5876	J-6933	150.0	120.0	0.25	0.01
11042	2387	55.87	J-6911	J-6928	150.0	120.0	0.00	0.00
17775	P-17775	52.19	J-5443	J-6842	150.0	120.0	-0.34	0.02
12800	P-992	48.00	J-6484	J-6782	50.0	120.0	-0.23	0.12
11802	4489	612.17	J-7263	J-6963	250.0	120.0	12.69	0.26
11187	2265	77.88	J-6883	J-5399	150.0	120.0	0.16	0.01
11156	2770	71.19	J-6842	J-6922	150.0	120.0	-1.10	0.06
11110	4501	65.07	J-6963	J-6964	250.0	120.0	15.61	0.32
13384	P-1576	67.28	J-5446	J-2726	50.0	120.0	-0.15	0.08
11050	2802	58.95	J-6736	J-6932	200.0	120.0	-6.11	0.19
13816	P-2008	73.19	J-4818	J-1839	50.0	120.0	-0.11	0.06
11027	1682	55.76	J-5876	J-6920	150.0	120.0	0.00	0.00

FlexTable: Pipe Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
11008	2388	55.84	J-6910	J-6911	150.0	120.0	0.00	0.00
10937	2766	44.94	J-6865	J-6708	200.0	120.0	1.90	0.06
10894	2652	41.05	J-6857	J-6858	150.0	120.0	0.00	0.00
10887	2649	40.10	J-6854	J-6855	150.0	120.0	0.00	0.00
10856	2352	38.09	J-6838	J-6839	150.0	120.0	0.00	0.00
8490	4454	10.63	J-1744	J-5399	50.0	120.0	-0.04	0.02
11077	1562	61.43	J-4896	J-6946	150.0	120.0	0.00	0.00
17648	P-5836	19.93	J-6599	J-6357	150.0	120.0	-0.65	0.04
17908	P-17908	131.15	J-6796	J-6923	150.0	120.0	-0.86	0.05
17737	P-17737	56.69	J-6457	J-6923	150.0	120.0	-0.77	0.04
17731	P-17731	55.69	J-5399	J-603	50.0	120.0	0.11	0.06
17730	P-17730	61.73	J-5865	J-1744	50.0	120.0	-0.15	0.08
17729	P-17729	37.51	J-4809	J-6840	150.0	120.0	1.07	0.06
17708	P-5896	36.64	J-329	J-6860	50.0	120.0	-0.08	0.04
13174	P-1366	76.65	J-6806	J-7223	150.0	120.0	0.38	0.02
17663	P-5851	50.65	J-1121	J-6898	150.0	120.0	0.00	0.00
17752	P-17752	70.72	J-5566	J-6929	150.0	120.0	2.25	0.13
17630	P-5818	36.03	J-6796	J-6797	150.0	120.0	0.56	0.03
17623	P-5811	34.71	J-2732	J-6883	100.0	120.0	-0.19	0.02
17609	P-5797	36.82	J-7095	J-2235	60.0	120.0	-0.08	0.03
17585	P-5773	27.97	J-6708	J-1839	150.0	120.0	1.03	0.06
17508	P-5696	23.93	J-376	J-327	50.0	120.0	-0.23	0.12
14805	P-2997	54.73	J-7079	J-6860	150.0	120.0	0.34	0.02
14331	P-2523	132.31	J-7251	J-2626	150.0	120.0	3.82	0.22
17671	P-5859	50.71	J-647	J-6457	60.0	120.0	-0.11	0.04
17961	P-17961	357.14	J-6741	J-6963	200.0	120.0	2.92	0.09
17952	P-17952	100.60	J-7025	J-6932	50.0	120.0	-0.23	0.12
17977	P-5673	11.66	PMP-3	J-7274	100.0	120.0	0.00	0.00
17976	P-5672	15.53	J-4215	PMP-3	100.0	120.0	0.00	0.00
17974	P-5671	16.18	PMP-2	J-4215	100.0	120.0	11.65	1.48
17973	P-5670	11.13	J-7274	PMP-2	100.0	120.0	11.65	1.48
17970	P-5668	681.59	J-7274	R-1	450.0	120.0	-23.32	0.15
17984	P-5675	23.82	J-6227	J-7275	250.0	120.0	-25.37	0.52
17962	P-17962	82.52	J-6741	J-2622	200.0	120.0	-3.29	0.10
17987	P-5677	7.34	J-7275	PMP-4	250.0	120.0	-25.37	0.52
17960	P-17960	139.58	J-6916	J-5041	70.9	120.0	0.27	0.07
17959	P-17959	395.23	J-7263	J-6227	250.0	120.0	-12.69	0.26
17958	P-17958	218.81	J-6933	J-6717	150.0	120.0	-0.70	0.04
17957	P-17957	225.21	J-5739	J-1121	150.0	120.0	0.38	0.02
17956	P-17956	101.69	J-7008	T-2	200.0	120.0	-9.88	0.31
17954	P-17954	205.24	J-7059	J-5717	150.0	120.0	0.27	0.02
17904	P-17904	152.91	J-4810	J-6936	150.0	120.0	0.57	0.03
17963	P-17963	187.12	J-6975	J-6839	150.0	120.0	-3.02	0.17
17999	P-5685	10.31	J-4809	PRV-3	150.0	120.0	0.00	0.00
18012	P-5695	8.74	T-2	PMP-6	152.4	120.0	0.00	0.00
18009	P-5693	10.61	PMP-5	J-4215	100.0	120.0	11.67	1.49

FlexTable: Pipe Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
18008	P-5692	10.77	J-7274	PMP-5	100.0	120.0	11.67	1.49
18005	P-5690	112.80	J-7276	J-6611	150.0	120.0	1.18	0.07
18004	P-5689	111.39	J-621	J-7276	150.0	120.0	-0.08	0.00
18003	P-5688	156.14	J-7276	J-7008	200.0	120.0	-9.88	0.31
17980	P-5674	20.02	T-1	J-6964	250.0	120.0	-15.61	0.32
18000	P-5686	12.52	PRV-3	J-4810	150.0	120.0	0.00	0.00
17951	P-17951	201.83	J-6457	J-7019	150.0	120.0	0.27	0.02
17997	P-5684	98.42	PRV-2	J-6865	162.5	120.0	1.90	0.09
17996	P-5683	15.11	J-6940	PRV-2	162.5	120.0	1.90	0.09
17994	P-5682	57.81	J-6940	J-6227	150.0	120.0	-3.65	0.21
17993	P-5681	163.22	J-1561	J-6940	150.0	120.0	-0.86	0.05
17992	P-5680	102.93	PRV-1	J-6876	150.0	120.0	1.03	0.06
17991	P-5679	27.58	J-108	PRV-1	150.0	120.0	1.03	0.06
17988	P-5678	7.10	PMP-4	T-2	250.0	120.0	-25.37	0.52
18002	P-5687	53.27	J-6981	J-7276	200.0	120.0	-8.63	0.27
17920	P-17920	183.29	J-6929	J-2819	150.0	120.0	0.93	0.05
17953	P-17953	199.92	J-6708	J-6854	150.0	120.0	0.87	0.05
17929	P-17929	108.88	J-6797	J-2776	100.0	120.0	0.30	0.04
17928	P-17928	68.76	J-6883	J-6936	100.0	120.0	-0.35	0.04
17927	P-17927	174.66	J-6940	J-6852	150.0	120.0	0.89	0.05
17926	P-17926	150.93	J-6782	J-6952	150.0	120.0	-0.18	0.01
17924	P-17924	157.08	J-6782	J-6852	150.0	120.0	-0.28	0.02
17931	P-17931	102.38	J-1571	J-6922	200.0	120.0	-7.48	0.24
17921	P-17921	120.17	J-1839	J-7059	150.0	120.0	0.91	0.05
17932	P-17932	92.61	J-6922	J-3289	191.6	120.0	-8.58	0.30
17919	P-17919	151.33	J-6854	J-208	150.0	120.0	0.38	0.02
17917	P-17917	259.55	J-6923	J-5154	150.0	120.0	-2.13	0.12
17916	P-17916	207.11	J-2626	J-3081	150.0	120.0	3.63	0.21
17914	P-17914	162.55	J-3081	J-2218	150.0	120.0	3.32	0.19
17913	P-17913	138.05	J-2218	J-6911	150.0	120.0	2.94	0.17
17911	P-17911	123.63	J-4896	J-625	150.0	120.0	0.23	0.01
18013	P-5696	8.37	PMP-6	J-7275	152.4	120.0	0.00	0.00
17923	P-17923	234.94	J-2726	J-6449	150.0	120.0	-0.34	0.02
17941	P-17941	80.84	J-108	J-631	200.0	120.0	6.45	0.21
17950	P-17950	98.60	J-6982	J-7251	200.0	120.0	8.36	0.27
17949	P-17949	99.75	J-7028	J-2241	60.0	120.0	0.08	0.03
17948	P-17948	87.89	J-6840	J-7028	60.0	120.0	0.15	0.05
17947	P-17947	306.76	J-6911	J-5154	150.0	120.0	2.18	0.12
17946	P-17946	88.03	J-2235	J-6982	60.0	120.0	-0.08	0.03
17945	P-17945	247.66	J-4809	J-6916	150.0	120.0	-1.07	0.06
17930	P-17930	111.11	J-6936	J-2821	100.0	120.0	0.11	0.01
17943	P-17943	89.07	J-7251	J-7079	151.6	120.0	4.39	0.24
17906	P-17906	76.37	J-6842	J-5739	150.0	120.0	0.76	0.04
17940	P-17940	99.24	J-795	J-7223	50.0	120.0	-0.11	0.06
17939	P-17939	126.16	J-2622	J-804	200.0	120.0	-3.41	0.11
17938	P-17938	99.46	J-7223	J-561	50.0	120.0	0.15	0.08

FlexTable: Pipe Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (Maximum) (m/s)
17937	P-17937	145.33	J-631	J-6932	200.0	120.0	6.34	0.20
17935	P-17935	663.08	J-4215	T-2	200.0	120.0	23.32	0.74
17934	P-17934	93.24	J-7059	J-313	50.0	120.0	0.23	0.12
17933	P-17933	125.98	J-327	J-6796	60.0	120.0	-0.23	0.08
17944	P-17944	287.40	J-7079	J-2308	150.0	120.0	3.90	0.22

FlexTable: Pump Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Elevation (m)	Pump Definition	Status (Initial)	Hydraulic Grade (Suction) (m)	Hydraulic Grade (Discharge) (m)	Flow (Total) (L/s)	Pump Head (m)
17972	PMP-2	345.35	Lake Pump	On	341.63	509.08	11.65	167.45
17975	PMP-3	345.35	Lake Pump	Off	341.95	508.60	0.00	0.00
17986	PMP-4	500.60	Booster Pump	On	506.19	595.53	25.36	89.34
18007	PMP-5	345.35	Lake Pump	On	341.64	508.92	11.67	167.28
18011	PMP-6	500.60	Booster Pump	Off	506.20	595.52	0.00	0.00

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FlexTable: Tank Table (Westshore Base.wtg)

Current Time: 0.000 hours

ID	Label	Zone	Elevation (Base) (m)	Elevation (Minimum) (m)	Elevation (Initial) (m)	Elevation (Maximum) (m)	Volume (Inactive) (ML)	Diameter (m)	Net Outflow (L/s)	Hydraulic Grade (m)
17981	T-1	<None>	592.90	592.90	595.00	595.30	0.00	3.05	-16.83	595.00
17982	T-2	<None>	504.13	504.20	506.20	506.57	0.00	3.05	10.67	506.20

Controls Summary

Logical Control: LC18025

IF {"T-1" Hydraulic Grade < 594.50 m}
THEN {"PMP-4" Pump Status = On }

Logical Control: LC18026

IF {"T-1" Hydraulic Grade > 595.00 m}
THEN {"PMP-4" Pump Status = Off }

Logical Control: LC18031

IF {"T-2" Hydraulic Grade > 506.50 m}
THEN {"PMP-2" Pump Status = Off }

Logical Control: LC18032

IF {"T-2" Hydraulic Grade < 506.00 m}
THEN {"PMP-2" Pump Status = On }

Logical Control: LC18036

IF {"T-2" Hydraulic Grade < 506.00 m}
THEN {"PMP-5" Pump Status = On }

Logical Control: LC18037

IF {"T-2" Hydraulic Grade > 506.50 m}
THEN {"PMP-5" Pump Status = Off }

Pattern Detailed Report: Residential Pattern

Element Details			
ID	17964	Notes	
Label	Residential Pattern		

<Pattern Summary>			
Start Time	12:00:00 AM	Pattern Category Type	Hydraulic
Starting Multiplier	0.600	Pattern Format	Stepwise

Pattern Curve

Time from Start (hours)	Multiplier
1.000	0.600
2.000	1.000
3.000	1.600
4.000	2.100
5.000	2.280
6.000	2.000
7.000	1.600
8.000	1.200
9.000	0.600
10.000	0.500
11.000	0.460
12.000	0.480
13.000	0.490
14.000	0.460
15.000	0.470
16.000	0.600
17.000	0.750
18.000	1.100
19.000	1.250
20.000	1.400
21.000	1.340
22.000	0.950
23.000	0.750
24.000	0.600

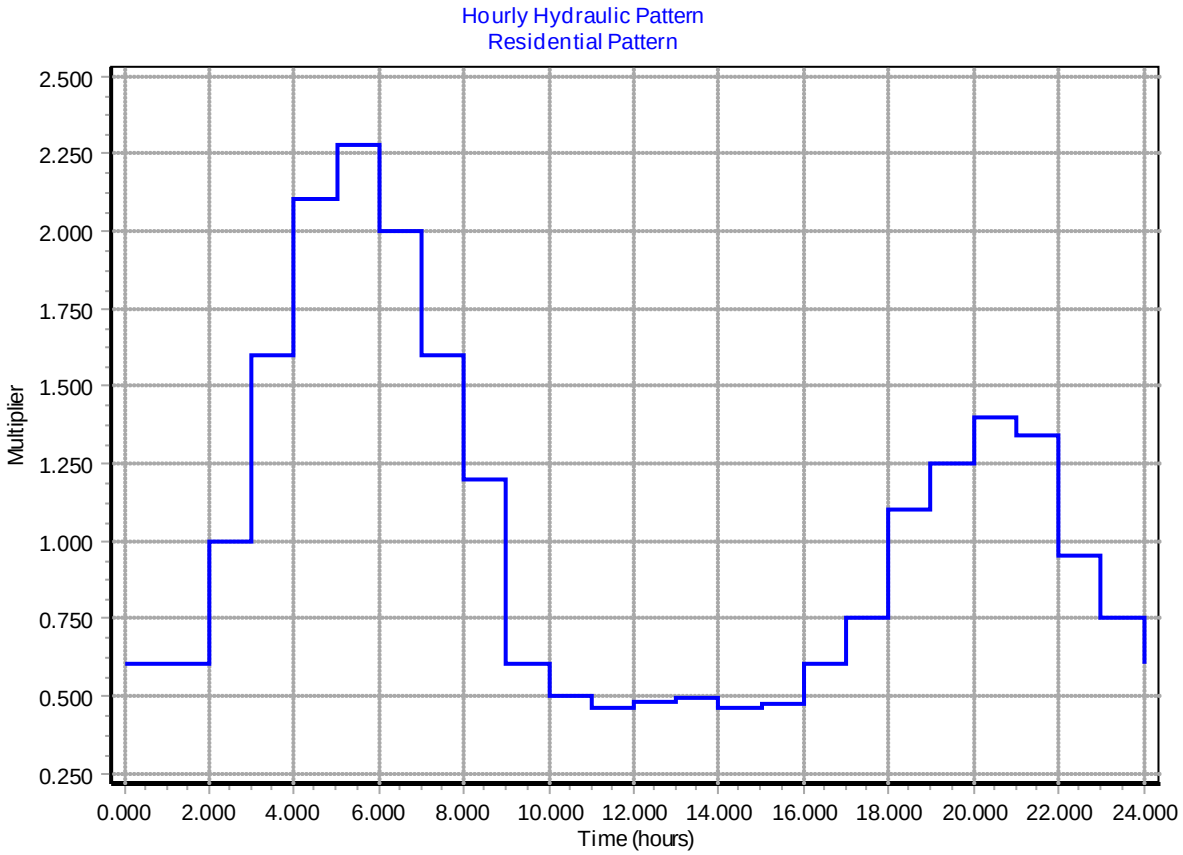
Pattern - Daily Multipliers

	Multiplier
Mon	1.000
Tue	1.000
Wed	1.000
Thur	1.000
Fri	1.000
Sat	1.000
Sun	1.000

Pattern Detailed Report: Residential Pattern

Pattern - Monthly Multipliers

	Multiplier
Jan	1.000
Feb	1.000
Mar	1.000
Apr	1.000
May	1.000
Jun	1.000
Jul	1.000
Aug	1.000
Sept	1.000
Oct	1.000
Nov	1.000
Dec	1.000



Pump Definition Detailed Report: Booster Pump

Element Details

ID	17989	Notes	60 hp
Label	Booster Pump		

Pump Definition Type

Pump Definition Type	Design Point (1 Point)	Design Head	107.90 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	0.00 L/s
Shutoff Head	0.00 m	Maximum Operating Head	0.00 m
Design Flow	20.60 L/s		

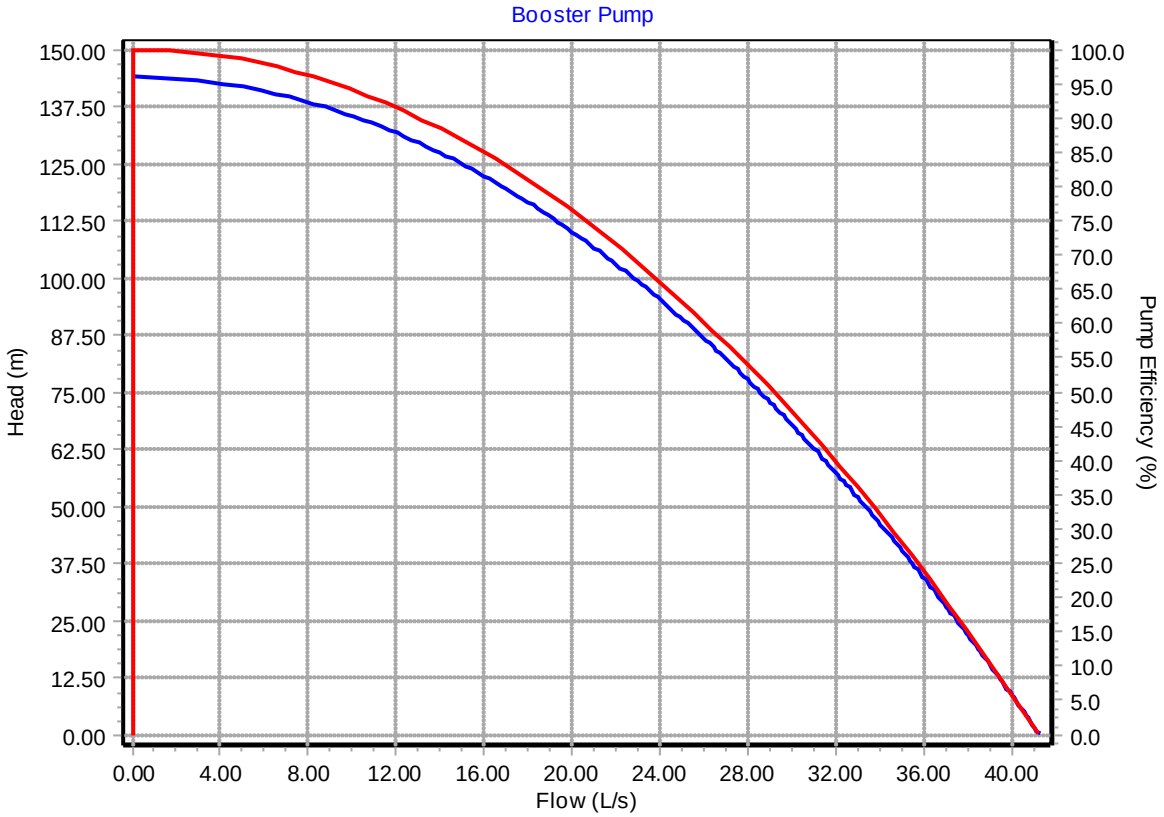
Pump Efficiency

Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	100.0 %	Is Variable Speed Drive?	False
BEP Flow	0.00 L/s		

Transient (Physical)

Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: Booster Pump



Coefficients: a = 143.87 m; b = 8.476e-002 m/(L/s)^c; c = 2.000

Pump Definition Detailed Report: Lake Pump

Element Details

ID	17978	Notes	
Label	Lake Pump		

Pump Definition Type

Pump Definition Type	Design Point (1 Point)	Design Head	167.00 m
Shutoff Flow	0.00 L/s	Maximum Operating Flow	11.00 L/s
Shutoff Head	170.00 m	Maximum Operating Head	150.00 m
Design Flow	11.70 L/s		

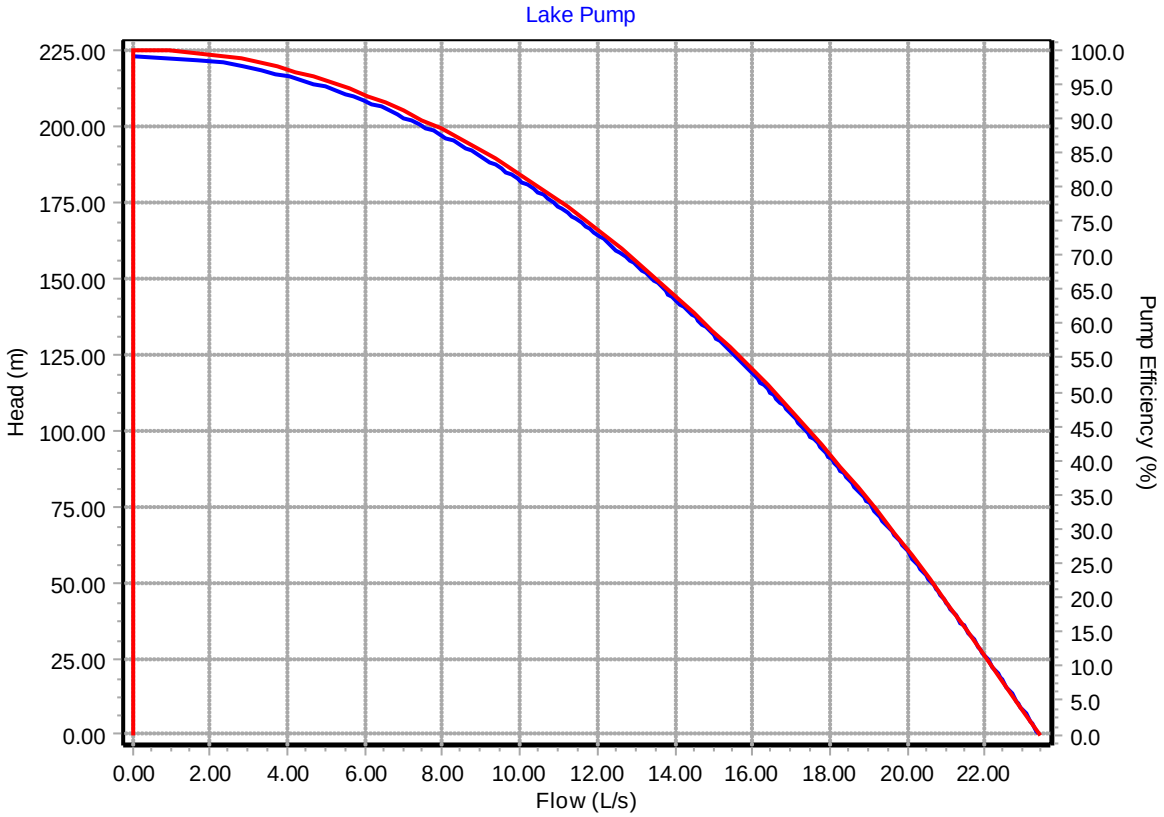
Pump Efficiency

Pump Efficiency	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	100.0 %	Is Variable Speed Drive?	False
BEP Flow	0.00 L/s		

Transient (Physical)

Inertia (Pump and Motor)	0.000 kg·m²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Pump Definition Detailed Report: Lake Pump



Coefficients: a = 222.67 m; b = 4.067e-001 m/(L/s)^c; c = 2.000

Source Assessment of the Regional District of Central Okanagan – Killiney Beach and Westshore Estates Water Systems. September 5 2012

Executive Summary

The objective of this assessment of two RDCO North Okanagan Lake intakes was to identify current and forecast future drinking water hazards and vulnerabilities, characterize the risk posed by each hazard, and provide recommendations to reduce impacts on the intake. This report is not provided as evidence for filtration deferral, but contributes to the research available to RDCO for that purpose.

This assessment characterizes natural and man-induced hazards to drinking water quality as physical, chemical or biological. As these risks change over time, revisions of this document will be needed. Existing research was augmented by 2010-2011 field studies of water currents, sedimentation rates, water quality profiles and algae sampling near and from the intakes. This research was used to define two proposed Intake Protection Zones (IPZ), based on a two hour travel time of water currents to the intake under moderate winds. At both intakes, the shallow intake depths are partially compensated by the rural nature of the region. The largest potential impacts identified in this study include shoreline residential use, power boating and local roads.

Specific recommendations and action plans were developed with the dual aim of providing the best water quality and providing support to a future RDCO application to IHA for deferral of filtration. Key recommendations include: applying best management practices for shoreline protection, conducting a cost-benefit analysis for extending the intakes to >20 m with 3 m clearance from the substrate, and applying to ILMB for a license of occupation for the intake protection zones.

Acknowledgements:

Funding by Regional District of Central Okanagan (RDCO) and Province of BC Infrastructure Planning Grant Program

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Table of Contents

EXECUTIVE SUMMARY

1.0 Introduction 6
1.1 Study Background 6
1.2 Study Purpose 6
1.3 Study Plan 6
1.4 Definitions and Abbreviations 7
2.0 North Okanagan Intakes Module 1: Characterization of Source 10
2.1 Description of System: Intake, Design, Construction and Maintenance 10
2.1.1 Water Licenses 10
2.1.2 Intake Location and Depth 10
2.1.3 Water Treatment, Distribution and Monitoring Overview 11
2.1.4 Routine Monitoring and Emergency Planning 11
2.2 Limnology of Okanagan Lake as it affects intakes 12
2.2.1 Thermal Behaviour 12
2.2.2 Temperature and Dissolved Oxygen Profiles 16
2.2.3 Turbidity and Water Clarity 16
2.2.4 Nutrients 16
2.2.5 Sodium and Chloride 52
2.2.6 Metals and Pesticide Scans 52
2.3 Biology of Okanagan Lake with the potential to impact the intakes 17
2.3.1 Protozoan Pathogens in Water Column 17
2.3.2 Bacteria in Water Column 17
2.3.3 Bacteria in Sediments 18
2.3.4 Sediment Contaminants 19
2.3.5 Algae and Cyanobacteria in Okanagan Lake 20
2.3.6 Cyanobacteria and Algae in RDCO North Basin Intake Samples 26
2.3.7 UV Transmissivity 27
2.3.8 Taste and Odor 27
2.3.9 Turbidity 27
2.3.10 Sewage/Septage 45
2.3.11 Storm Water Locations ..... **Error! Bookmark not defined.**
2.3.12 Trihalomethane Formation Potential 47
2.3.13 Biofilm Development 48
2.4 Calculation of Intake Protection Zone for RDCO North Basin Intakes 30
2.4.1 Vertical Transport – Fall Velocity 30
2.4.2 Vertical Transport – Vertical Currents 31
2.4.3 Vertical Transport – Seiche Transport and Autumn Overturn Turbulence 31
2.4.4 Water Currents (Horizontal transport) 32
2.4.5 Drogue Travel in North Okanagan Lake near RDCO Intakes 32
2.4.6 Calculation of RDCO Intake Protection Zones (IPZ) 36
3.0 North Okanagan Lake Intakes Module 2 Contaminant Inventory 42
3.1 Anthropogenic Potential Water Borne Hazards to RDCO North Basin Intakes 42
3.1.1 Intake Depth 44
3.1.1 Inflows 44

3.1.2 Storm Water Outfalls 44
3.1.3 Septic Fields and Package Treatment Plants 46
3.1.4 Moorage, Docks and Powerboat Recreation 48
3.1.5 Adjacent Land Use 49
3.1.6 Vandalism and Accidental Introductions 52
3.2 Natural Contaminants or Factors that Influence Susceptibility of Okanagan Lake to Contamination ..... **Error! Bookmark not defined.**
3.2.1 Cyanobacteria in Okanagan Lake ..... **Error! Bookmark not defined.**
3.2.2 Shoreline Wildlife 18
4.0 Okanagan Lake Intake Module 7: Risk Characterization and Analysis 58
4.1 Condition of Source 64
4.2 Physical Integrity of Intake, Treatment and Distribution System 64
4.3 Risk Assessment for Healthy and Health compromised Individuals 64
4.4 Additional Treatment Options 65
4.4.1 Intake Extension 65
4.4.2 UV Disinfection 66
4.5 Strength/Weakness Opportunities/Threats SWOT Analysis 67
5.0 RDCO North Basin Okanagan Lake Intake Module 8: Recommendations 68
5.1 Source Protection Action Plan 68
5.2 High Priority Recommendations Based on Risk Rating 68
5.3 Moderate Priority Recommendations Based on Risk Rating 72
Literature Cited or Consulted 75

Disclaimer: This report is based on limited, cost-constrained research on complex lake systems. Larratt Aquatic Consulting Ltd (LAC) and its associates have made a best attempt at accuracy in data collection and presentation. No liability is incurred by LAC or RDCO for accidental omissions or errors made in the preparation of this report.

Figures, Tables and Appendices

Appendix 1 Data Collected for RDCO N Basin Intake Source Assessment Supporting Documentation 80
Appendix 2 Supporting Documentation 89
Appendix 3 Activities Impacting the Intake Protection Zone Checklist 91
Appendix 4 E. coli Source Tracking in City of Kelowna Creeks Receiving Storm Water and at Beaches 93
Appendix 5 Storm Drainage Requirements for Killiney Beach and Westshore Estates 94

Figure 1.1 Service areas for RDCO N Basin intakes 6
Figure 2.1 Schematic of RDCO North Basin Intakes 10
Figure 2.10 Schematic Cross Section of Deployed Drogues 34
Figure 2.11 North Basin Okanagan Lake Drogue Trials, 2010 - 2011 Killiney Beach 36
Figure 2.12 North Basin Okanagan Lake Drogue Trials, 2010 - 2011 Westshore Estates.. 37
Figure 2.13 Proposed Intake Protection Zones for Killiney Beach Intake 39
Figure 2.14 Proposed Intake Protection Zones for Westshore Estates Intake 40
Figure 2.2 Map of Okanagan Lake Showing Tributaries and Profile 13
Figure 2.3 Thermistor Data for Proposed GEID Okanagan Lake Intake, 2006 14
Figure 2.4 Thermistor Data for Proposed Okanagan Lake Intake 2007-2009 15
Figure 2.5 Correlation Between Freshet and Phosphorus Loading to Okanagan Lake 17
Figure 2.6 Surface Cyanobacteria “Bloom” in Okanagan Lake 21
Figure 2.7 Algae and Cyanobacterial Profiles from the South, Central and North Basins of Okanagan Lake, 2008-2009 24
Figure 2.8 Algae and Cyanobacteria from Killiney Beach and Westshore Estates 2010 - 2011 25
Figure 2.9 Turbidity at RDCO North Okanagan Intakes, 2010 - 2011 28
Figure 3.1 Features of the North Basin Okanagan Lake Killiney Beach Intake 43
Figure 3.2 Features of the North Basin Okanagan Lake Westshore Estates Intake 44
Figure 4.1 Possible RDCO Intake Locations, North Basin, Okanagan Lake 64

Table 1.1 Summary of RDCO North Basin intake parameters 11
Table 2.1 Maximum Seiche-Induced Temperature Fluctuations at Okanagan Lake Intake Depths 16
Table 2.2 Bacteria in Re-suspended Sediment beneath RDCO North Basin Intakes 19
Table 2.3 Sediment under RDCO North Okanagan Lake Intakes 19
Table 2.4 Toxins Produced by Blue-green Algae (Cyanobacteria) 21
Table 2.5 Size and Fall Velocity Estimates for Lake Particulates 33
Table 2.6 Drogue Results for RDCO North Basin Intakes, 2010 - 2011 35
Table 2.7 MODULE 1 Hazard and Contaminant Table – Killiney Beach Intake 41
Table 2.8 MODULE 1 Hazard and Contaminant – Westshore Estates Intake 42
Table 3.1 SUMMARY MODULE 2 Contaminant Source Inventory Killiney Beach 52
Table 3.2 Summary MODULE 2 Hazard from Contaminants Identification Table Killiney Beach 53
Table 3.3 SUMMARY MODULE 2 Contaminant Source Inventory Westshore Estates 54
Table 3.4 Summary MODULE 2 Hazard from Contaminants Identification Table Westshore Estates 55
Table 4.1 Module 7 Hazard and Risk Tables 56

Table 4.2 Risks Inside Intake Protection Zone (IPZ) with the Potential to Impact the Killiney Beach Intake 58
Table 4.3 Risks Outside Intake Protection Zone (IPZ) with the Potential to Impact the Killiney Beach Intake 59
Table 4.4 Risks Inside Intake Protection Zone (IPZ) with the Potential to Impact the Westshore Estates Intake 60
Table 4.5 Risks Outside Intake Protection Zone (IPZ) with the Potential to Impact the Westshore Estates Intake 61
Table 4.6 Intake Extension information for Killiney Beach System 63
Table 4.7 Intake Extension information for Westshore Estates System 63
Table 4.8 Strength/Weakness Opportunities/Threats Analysis Summary of the RDCO North Basin Okanagan Lake Intakes 65

1.0 Introduction

1.1 Study Background

Monitoring and research on Okanagan Lake can be used to meet most of the criteria for the IHA requested Modules 1, 2, 7 and 8 of the Drinking Water Source Assessment for the two RDCO North Basin Okanagan Lake Intakes. Information from RDCO intake monitoring and the extensive data base collected by Ministry of the Environment were utilized in this report. Additional innovative research was undertaken to round out the data base for the RDCO Killiney Beach and Westshore Estates Source Assessments.

1.2 Study Purpose

This report compiles new research and known data into the IHA Source Assessment format for use identifying RDCO's Killiney Beach and Westshore Estates intake's strengths, their liabilities and to identify future needs to maintain this excellent quality, cost-effective water supply to residents.

1.3 Study Plan

Reports created by Provincial agencies including Ministry of Environment were reviewed. Several reports prepared for the City of Kelowna by Hay and Company were also utilized.

The research/sampling component of this report was completed in 2010 - 2011 and it involved:

- Sediment samples were collected from the sediments beneath the intake for total coliforms and *E. coli*
- Sediment traps were deployed near the intake from September 2010 to September 2011
- Drogue studies of long-shore currents near the North Basin Intakes were conducted on three dates to provide localized current data to compare to water current modeling for Okanagan Lake
- Multi-meter profiles of: dissolved oxygen, temperature, pH, conductivity, and total dissolved solids were collected adjacent to the intakes on three dates.
- Monthly algae samples from the intakes and samples from the lake at the surface and at depth were collected on three field trips

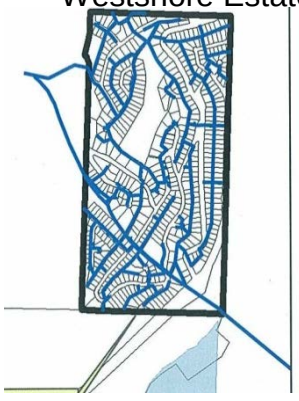
Biological samples were enumerated on a phase contrast inverted microscope by H. Larratt and any results of immediate concern were reported promptly to RDCO. This report summarizes the findings of 2010 and 2011, and compares them to previous results from the Deep Okanagan Lake Biology Study funded by OBWB (Larratt, 2009).

Figure 1.1: Service areas for RDCO N Basin intakes

Killiney Beach



Westshore Estates



1.4 Definitions and Abbreviations

The following terms are defined as they are used in this report.

ALGAE BLOOM: A superabundant growth of algae. Many species are capable of coloring the water or covering the surface of a lake.

ANAEROBIC or ANOXIC ZONE: A zone that develops along the sediments where decomposition of algae etc. consumes oxygen faster than it is supplied by the surrounding water. Anaerobic zones accumulate color, nutrients, tri-halomethane (THM) precursors and taste & odor.

Anions: Negatively charged ions (cations are positively charged ions).

ATP: ATP or Adenosine Tri-Phosphate is a chemical compound that breaks down to release the energy responsible for muscle contraction. It is the only useable form of energy in a body and is found in every living cell.

BENTHIC: Organisms that dwell on or are associated with the sediments.

BIOFILM: A thin, usually resistant layer of microorganisms that form on and coat surfaces such as water pipes. Biofilms usually include bacteria.

BLUE-GREEN ALGAE (CYANOBACTERIA): The family of bacteria-like algae having cyanochrome as the main photosynthetic pigment and chlorophyll as a secondary pigment. Many members of this family reproduce rapidly and some cause algae blooms. They are notorious for taste and odor problems.

CONDUCTIVITY: Electrical conductivity of water samples is used as an indicator of how salt-free, ion-free, or impurity-free the sample is; the purer the water, the lower its conductivity.

DIATOMS: The family of algae containing chlorophyll as the primary photosynthetic pigment and having hard, silica-based "shells" (frustules). Diatoms affect filtration and produce a range of taste and odors.

DIMICTIC: Refers to a lake that has two periods of water column mixing, one in the spring and one in the fall.

DROGUE: Float used to track current paths at a depth below the water surface determined by the position of vanes (or other surface to intercept currents) suspended beneath the float.

EUTROPHIC: Refers to a nutrient-rich, biologically productive water body where concentrations of mineral and organic nutrients have reduced dissolved oxygen, producing environments that frequently favor plant over animal life.

Lake Classification by Trophic Status Indicators After Nordin 1985

Trophic Status	Chlorophyll-a ug/L	Total P ug/L	Total N ug/L	Secchi disc m	Primary Production mg $C/m^2/day$
Oligotrophic	0 – 2	1 – 10	<100	> 6	50- 300
Mesotrophic	2 – 5	10 – 20	100 – 500	3 – 6	250 – 1000
Eutrophic	>5	> 20	500 - 1000	< 3	>1000

FALL OVERTURN: In fall, surface waters cool and sink, eroding the thermocline until a wind storm mixes the entire water column.

FRESHET: Freshet is commonly referred to as "spring runoff" and is the period when accumulated winter snow melts, causing substantially increased stream flow.

GENERA: The usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

GREEN ALGAE: The large family of algae containing chlorophyll as the primary photosynthetic pigment.

IRON RELATED BACTERIA: Non-disease-producing bacteria that grow in water and use dissolved iron as part of their metabolism.

LIMITED, NUTRIENT LIMITATION: In any environment, a nutrient or other growth requirement will limit or restrict the potential growth of organisms. For example, phosphorus usually limits algae production in lakes; if there is an increase in all of the other nutrients, no increase in algae growth will result because phosphorus is the "bottleneck". Conversely, even a small increase in the phosphorus supply will result in increased algae growth.

LIMNOLOGY: The study of freshwater; physical and chemical considerations such as lake thermal behavior, nutrient cycling, basin morphology, sediment structure, etc.

LITTORAL: Of or pertaining to the bio-geographic zone between the high and low water marks, usually the most productive area of a lake that supports rooted aquatic plants.

MACRONUTRIENT: Macronutrients are the major constituents of cellular protoplasm and usually limit biological production. (They include nitrogen, phosphorus, carbon, hydrogen sulphur.)

MARL: A marl event involves the precipitation of calcium carbonate, magnesium carbonate and calcium sulphate (gypsum) when the lake water warms or pH increases.

MESOTROPHIC: Refers to a lake or pond, etc., having a moderate amount of plant growth: the mesotrophic stage is intermediate between the oligotrophic and eutrophic stages.

METALIMNION: The water layer containing the thermocline that is between the surface epilimnion and the bottom hypolimnion.

MICRONUTRIENT: Relatively minute amounts of a micronutrient are required to maintain plant growth within its environmental constraints. These include; Mn, Fe, Co, Zn, Cu, Mo etc.

MONOMICTIC: Refers to a lake that experiences only one period of mixing that extends from fall, through the winter, to early spring.

OLIGOTROPHIC: Designating or of a lake, pond, etc. poor in plant nutrient minerals and organisms and usually rich in oxygen at all depths.

PAHs Polynuclear (or polycyclic) aromatic hydrocarbons: PAHs are typical components of asphalts, fuels, oils, and greases. They are produced as byproducts of fuel burning and are therefore detected in storm water. As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic. PAHs are also found in oily foods cooked at high temperatures.

PHYTOPLANKTON: Algae that float, drift or swim in standing water.

PHOTIC ZONE: The zone in a water body that receives sufficient sunlight for photosynthesis.

PLANKTON: Organisms that float or swim in water. Phytoplankton refers to plants; zooplankton to animals.

RIPARIAN: A riparian zone or riparian area is the interface between land and a stream or lake. Plant communities along the river margins are called riparian.

SECCHI DEPTH: The Secchi disk is used to measure water transparency in oceans and lakes. The depth at which the disk is no longer visible is taken as a measure of water transparency. This is known as the Secchi depth and is related to water turbidity.

SEICHE: Wind-driven tipping of the water layers during the summer. Seiches cause the water layers to oscillate for days after a wind storm.

THERMOCLINE: The zone of greatest change in water temperature with depth (> 1°C/m) that separates the surface water (epilimnion) from the underlying cold hypolimnion.

ZOOPLANKTON: Minute animals that graze algae, bacteria and detritus.

Report Abbreviations:

Entities

GEID = Glenmore Ellison Improvement District
IHA = Interior Health Authority
LAC = Larratt Aquatic Consulting;
MFLNRO = Ministry of Forests, Lands, and Natural Resources
MoE = Ministry of Environment
MoTI = Ministry of Transportation and Infrastructure
OBWB = Okanagan Basin Water Board
RDCO = Regional District of Central Okanagan
SIDWT = Southern Interior Drinking Water Team

Technical Phrases, Regulations

BCERMS =British Columbia Emergency Response Management Systems
BCWQ = BC Water Quality
BMP = Best Management Practices
FIM = Foreshore Inventory mapping
GCDWQ = Guidelines for Canadian Drinking Water Quality
GUDI = Groundwater Under Direct Influence (of surface water)
IPZ =Intake Protection Zone
OKBS =Okanagan Basin Study
SCADA =Supervisory Control And Data Acquisition (system)
SHIM = Sensitive Habitat Inventory Mapping
WTP = Water Treatment Plant

2.0 North Okanagan Intakes Module 1: Characterization of Source

Module 1 of the IH Source Assessment Protocol is a characterization of the water source for Killiney Beach and Westshore Estates and that is the North Basin of Okanagan Lake. It involves creating a summary of all available data relevant to domestic water intakes.

2.1 Description of System Intake Location, Design, Construction and Maintenance

2.1.1 Water Licenses The water license held by RDCO for Killiney Beach allows 364,221 m^3 of lake water use per year. Additionally, Killiney Beach holds two inactive creek licenses; one on Norris Creek for 112,834 m^3 and one on Hope Creek for 76,993 m^3. On the Westshore Estates system, there are two licenses totalling 422,209 m^3 /yr. The full allocation is not utilized every year, in part because the subdivisions are not at full build-out.

2.1.2 Intake Location and Depth Killiney Beach intake is located on Hodges Road and is 198 m out and 9.26 m deep. Westshore Estates intake is located near Westshore Road and is 171 m out and 7.71 m deep. In both cases, the clearance of the screened intakes from the substrate is less than 1 m. In the Killiney Beach system, sandbags support the intake stand pipe 3' above the sediments. At Westshore Estates, there are three small screened stand pipes supplying the intake pipeline (Figure 2.1).

Figure 2.1: Schematic of RDCO North Basin Intakes

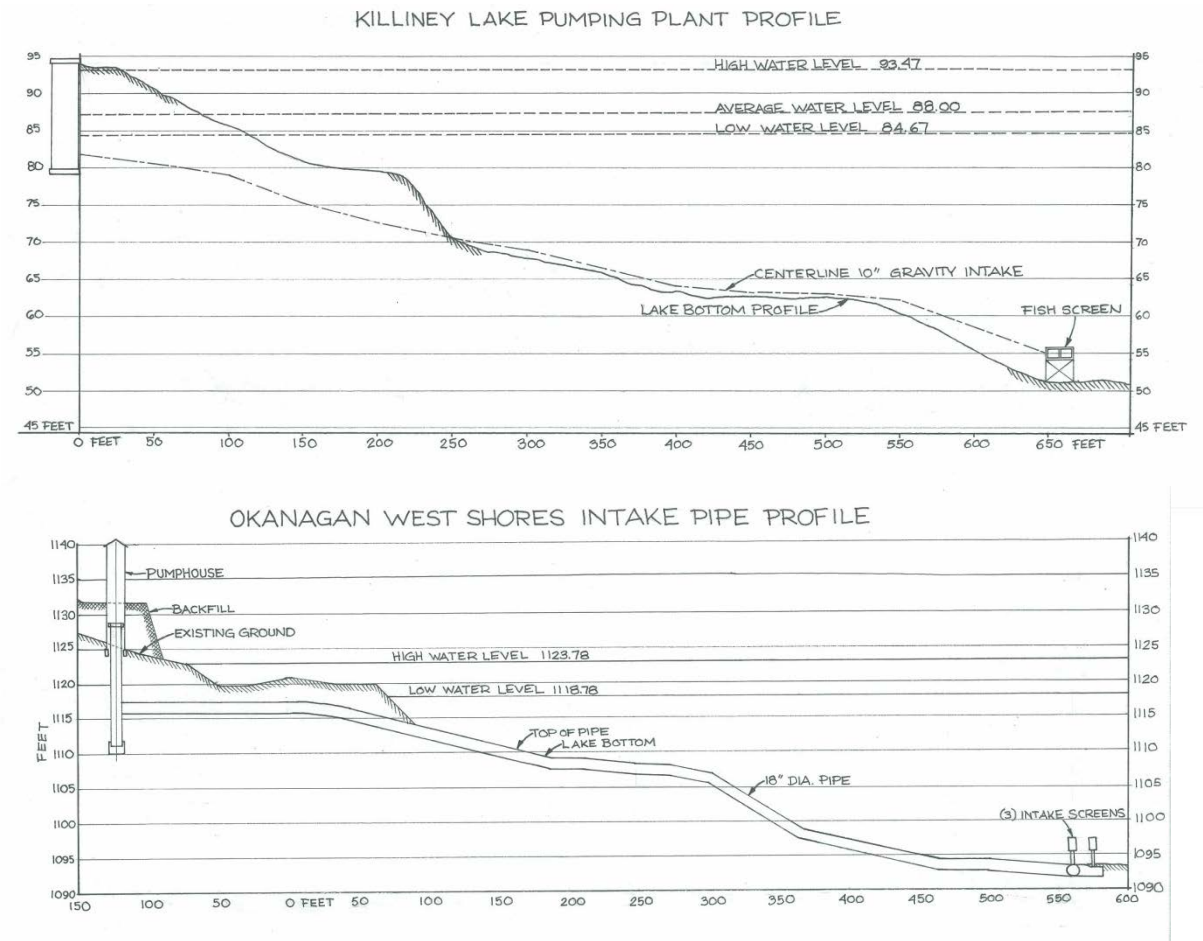


Table 1.1 summarizes the details on the intake and distribution systems

Table 1.1 Summary of RDCO North Basin intake parameters

Parameter	Killiney Beach	Westshore Estates
Depth (m) at low lake elevation	9.26 (30.3')	6.6 (21.7')
Depth (m) at average lake elevation	11.3	7.62
Clearance from substrate (as built)	< 1 m	< 1 m
Length (m) to wet well	198 (650')	171 (560')
Diameter (cm)	25.4 cm (10")	45.7 cm (18")
Pipe material	pvc	cm
Year of intake installation	1982	1973
Age of distribution system	30 yrs	39 yrs
Balancing reservoirs in system	5	3
Number of connections (full build-out)	285 (427)	245 (528)
Sediment accum. in wet well (cm/yr)	Heavy – 30-36 cm	Heavy - 90 cm+
Intake last cleaned	2010	2010

2.1.3 Water Treatment, Distribution and Monitoring Overview Killiney Beach uses gas chlorination. It has on-line turbidity and in 2010 pH, temp, chlorine was added at Killarney Way Reservoir. There are five balancing reservoirs in the Killiney system. From lake upwards they are: Killiney Lake intake reservoir, Killarney Way reservoir, Udell Road reservoir, Winchester Road reservoir, and Hope Creek reservoir.

Westshore also has gas chlorination and has on-line turbidity at the lake station and in 2010 pH, temp and chlorine was added at the Mountain Road Reservoir. There are three balancing reservoirs in the Westshore system. From lake upwards they are: Lake Intake reservoir, Mountain Drive reservoir, and Upper reservoir.

Distribution system maintenance includes line flushing and is scheduled for spring and fall and reservoir cleaning every couple of years. Hydrants are serviced annually as well as other on-going routine daily maintenance.

Both systems have an emergency response plan in place that is updated every year.

The pump houses consists of a wood frame or metal building containing the wet well, pumps, chlorination equipment and chlorine gas cylinders.

2.1.4 Routine Monitoring and Emergency Planning Routine sampling by RDCO staff includes sampling for total and free chlorine, conductivity, hardness, pH, color, temperature, turbidity, UV transmissivity as well as total coliforms and *E. coli.* Monthly monitoring reports are e-mailed to the Interior Health Drinking Water Officer.

The emergency plan includes emergency contact numbers, steps to follow, agencies to notify, protocols to follow for public notice, etc. It is required under the "conditions to operate" of RDCO's Operational Permit administered by IHA. RDCO also has procedures for releasing water quality advisories and boil water alerts.

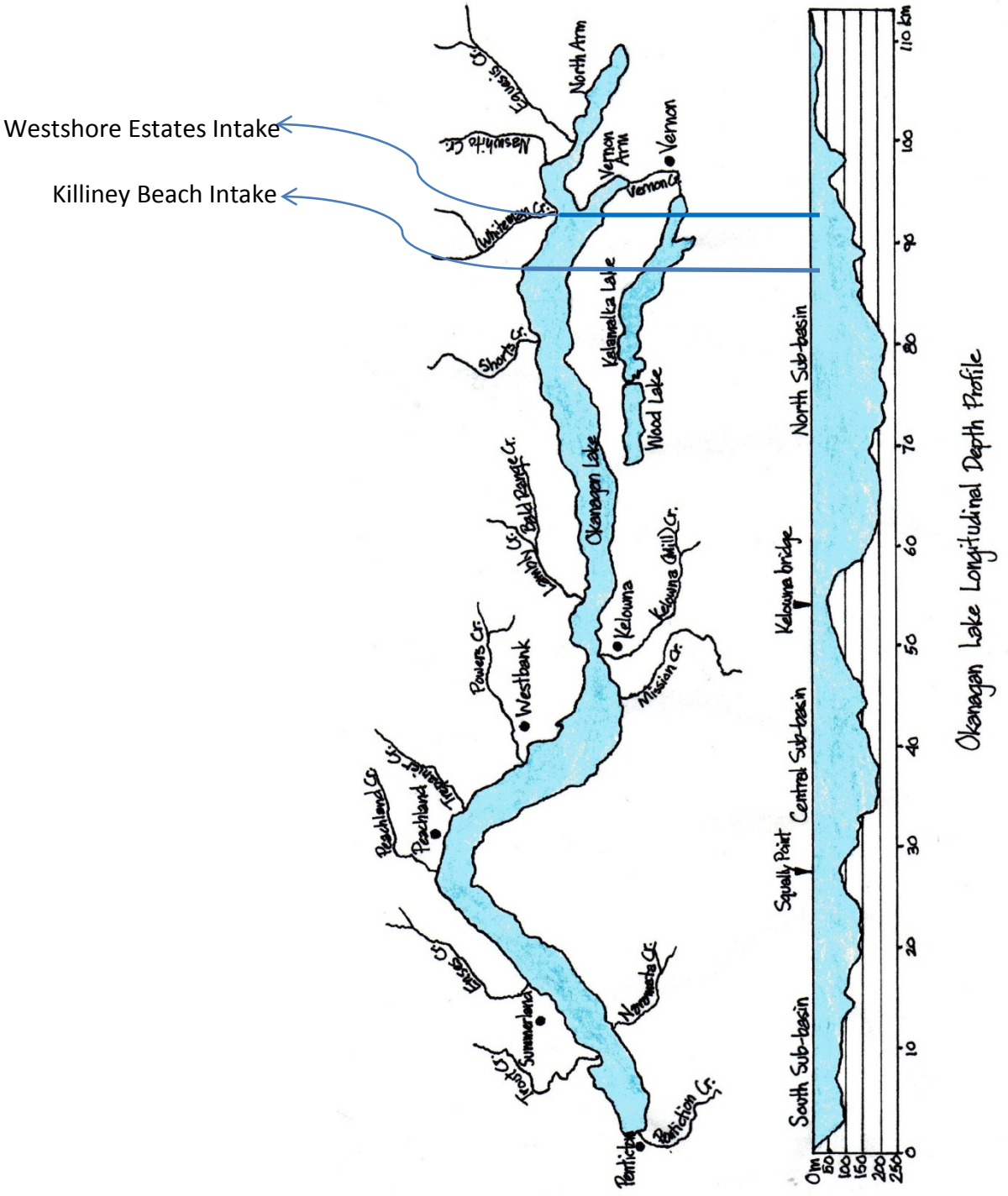
2.2 Limnology of Okanagan Lake as it affects RDCO intakes

Okanagan Lake is a large, deep lake with low nutrient levels. It is approximately 135 km long, 1-5 km wide and has a surface area of 35,000 hectares (Figure 1). It takes about 52.8 years to replace all of the water in the lake. Its maximum depth is 230 m with a mean depth of 76 m. It receives flow from Kalamalka Lake in the north via Vernon Creek and releases water to the south through Okanagan River to Skaha Lake (Bryan and Jensen, 1989). It receives water from 19 major tributaries of which Mission Creek, Trout Creek and Bear (Lambly) Creek are the largest. Treated wastewater is discharged into Okanagan Lake from Kelowna, West Kelowna, Summerland and periodically from Vernon. Every year, the single greatest impact on water quality in Okanagan Lake is the size of the freshet, with its variable imports of nitrogen, phosphorus, pH, calcium, sulphate and organic/inorganic particulates (MoE data, Larratt 2009). Generally, years of increased runoff (indicated by increased water discharge from October to May) correspond with increased concentrations of spring total phosphorus and in drier years, spring phosphorus levels are lower (Sokal, 2011).

2.2.1 Thermal Behavior Okanagan Lake forms distinct water temperature layers during the spring and remains stratified through the summer. The water layers erode during the fall until a wind storm mixes the water column, usually in November. The lake becomes one temperature top to bottom and remains fully mixed until stratification commences again in early May. Large freshets and cool spring weather delay stratification. Okanagan Lake is therefore monomictic (one mixing). Its surface temperatures reach 23^{o}C during most summers. The thermocline occurs at 8-15 m in early to mid-summer, and deepens to 15-20 m in early fall (Andrusak et al., 2005; Hayco 2000; Larratt, 2009). The entire lake has only had complete ice cover in 3 of the past 100 years, in the early 1900's. Partial freezing of sheltered areas such as the North Arm occurs more frequently (Bryan and Jensen, 1996).

Like most large lakes, Okanagan Lake experiences wind-generated internal waves called seiches during the stratified season (May – early November). Figures 2.2 and 2.3 illustrate seiching. During seiches, deeper intakes collect alternately cold deep water and warm surface water as the internal waves travel back and forth past an intake after a wind event. Overall, deep intakes draw colder water and experience fewer seiches while shallow intakes draw warm water during the summer and experience many powerful seiches. Intakes on Okanagan Lake shallower than 10 m such as Westshore Estates can abstract surface water for much of the stratified period each summer.

Figure 2.2: Map of Okanagan Lake Showing Tributaries and Profile

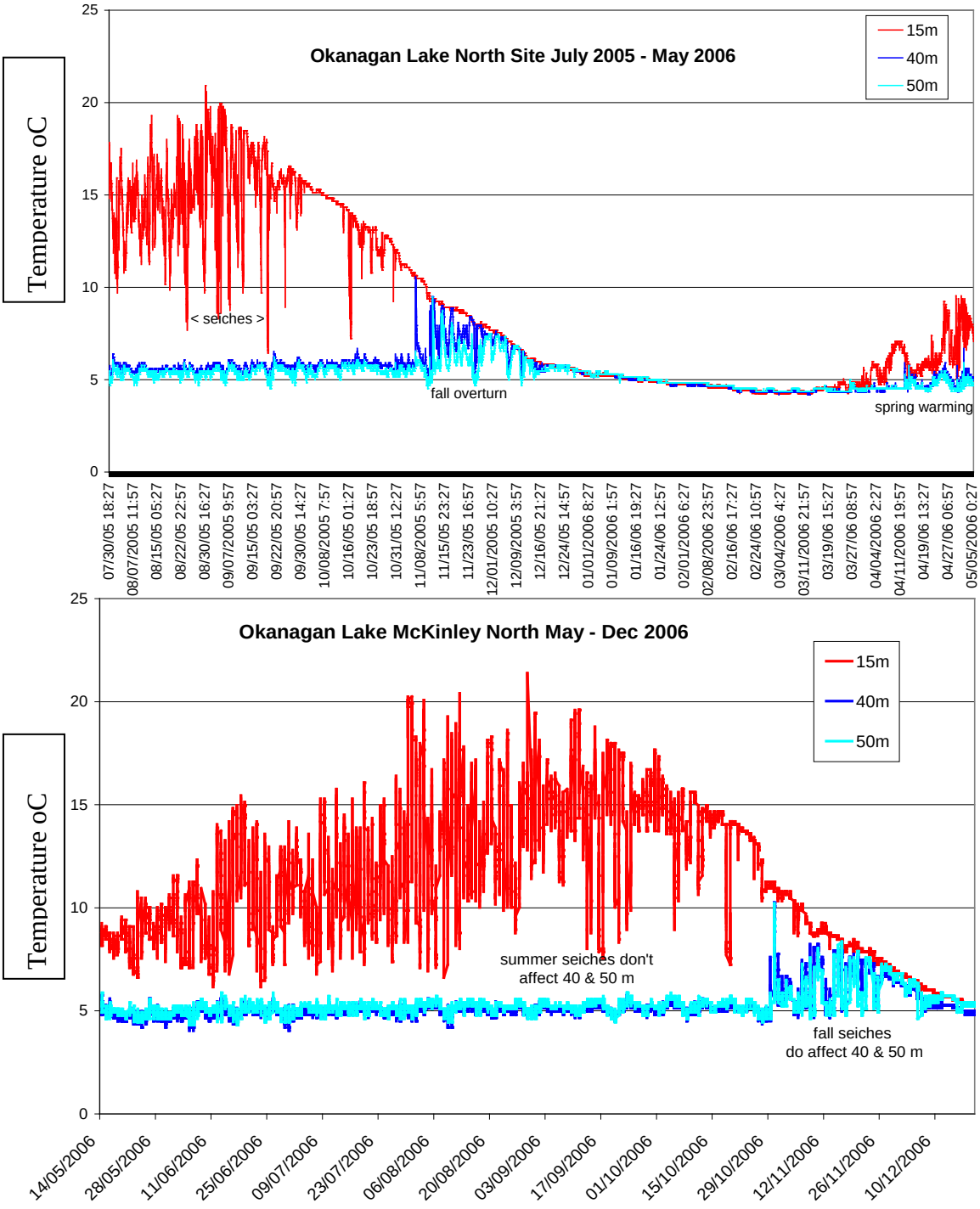


After: *(Andrusak et al., 2000)*

Okanagan Lake is divided into three sub-basins by an underwater sill at Squally Point and another sill at the Bennett (Kelowna) Bridge.

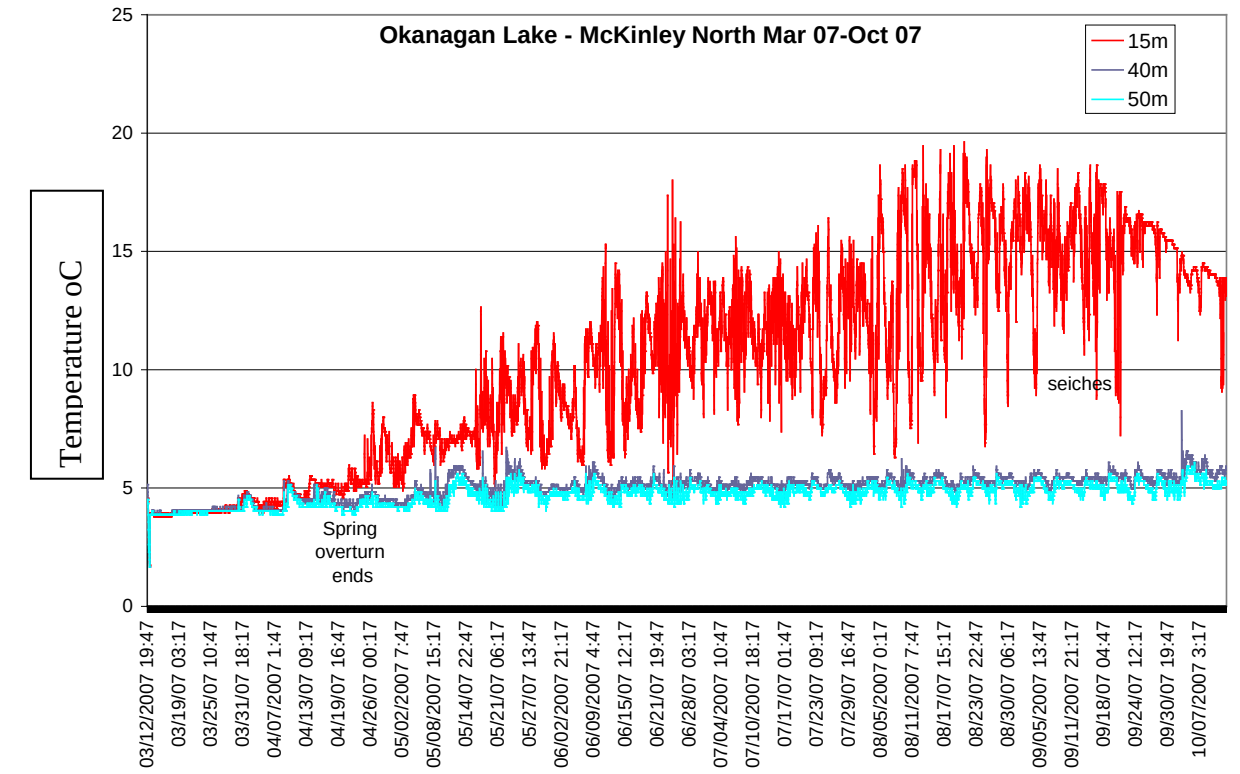
Detailed thermal data from GEID's thermistor lines located near McKinley Landing in the North Basin of Okanagan Lake is presented in Figure 2.2 and 2.3.

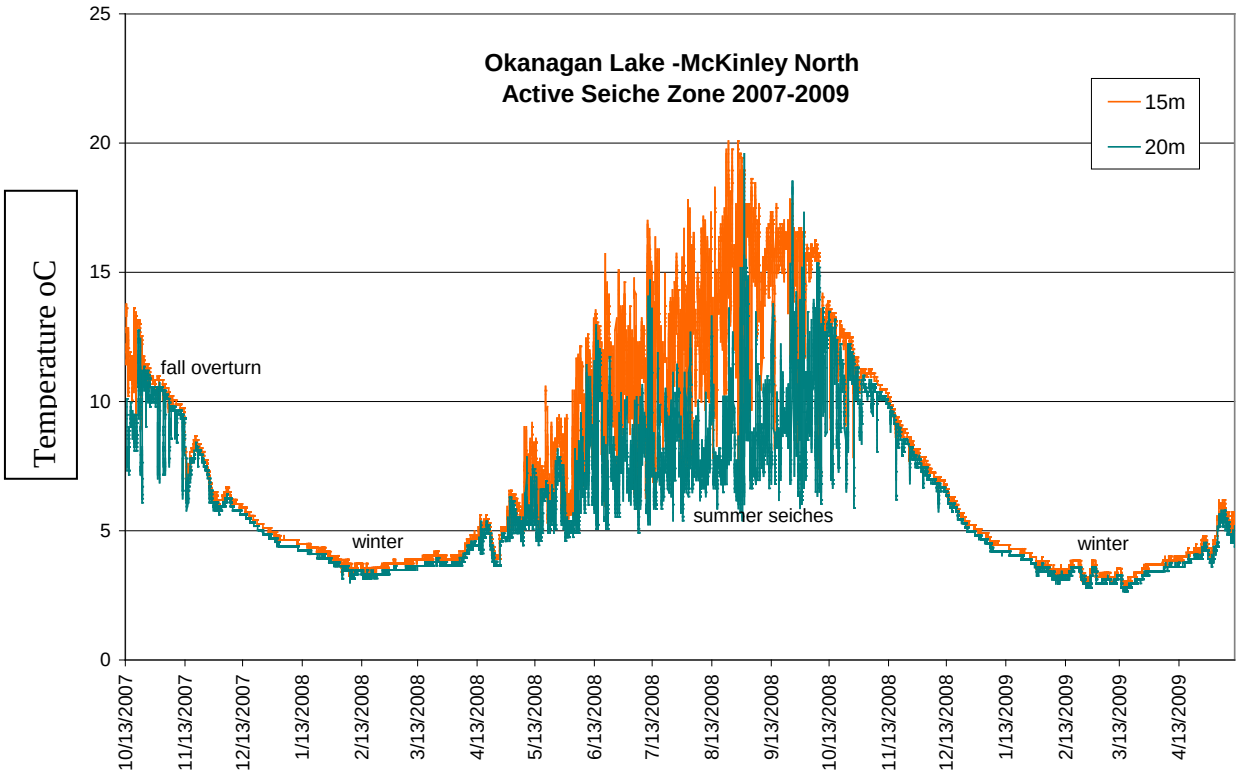
Figure 2.3:
Thermistor Data for Proposed GEID Okanagan Lake Intake, 2006



COMMENTS: Even 40 and 50 m depths show seiche-induced temperature fluctuations of 3-5^{o}C during fall overturn. The 40/50 m depths are not affected by summer seiches.

Figure 2.4: Thermistor Data for Proposed Okanagan Lake Intake 2007-2009





COMMENTS: The exposed GEID McKinley site showed rapid oscillations in water temperature at the 15 m and 20 m thermistor and several seiches per week, particularly in the early and late summer. The Westshore Estates and Killiney Beach areas in Okanagan Lake are expected to behave similarly.

Temperature fluctuations caused by passing seiches in Okanagan Lake decrease with depth according to the following table:

Table 2.1: Maximum Seiche-Induced Temperature Fluctuations at Okanagan Lake Intake Depths

Intake Depth (m)	Modeled: Central Basin Temp. fluctuation °C and (Min – Max temp)	Measured: North Basin Temp. fluctuation °C and (Min - Max temp)
< 20	**13 (5 – 18)**	**13 (5 – 18)**
25	**10 (5 – 13)**	**9 (4 – 13)**
30	**7 (5 – 12)**	**7 (5 – 12)**
40	**5 (5 – 10)**	**5 (5 – 10)**
50	**3 (5 – 8)**	**4 (4 – 8)**
> 60	**< 3 (4 – 6)**	**< 3 (4 – 6)**
	Modeled by Hayco	Measured by LAC

→ Depth of WE and KB intakes

Intakes at less than 20 m are subject to numerous seiches over the growing season. 40 m intakes evade summer seiches but are briefly affected by October/November seiches (Figure 2.2). Diving up to 40 m is air-diving and is less expensive (4000.00/day for diving crew (Diving Dynamics Kelowna 2009 estimate). Diving from 40 to 47 m requires additional equipment and is more expensive (10,000 – 12,000/day for diving crew plus chamber). Diving 47 m to 80 m is theoretically possible but would require mixed gas, specialist crews from Vancouver, and is very expensive due in part to increased risk for the divers.

2.2.2 Temperature, Dissolved Oxygen, pH and TDS Profiles

Through every summer recorded, dissolved oxygen concentrations were excellent (i.e. never oxygen-depleted) throughout the Okanagan Lake water column. Dissolved oxygen at the intake depths did not drop below 91% at either intake, indicating no problems with oxygen-depleted water (Appendix 1). pH remained in the ideal range for chlorination of 7.9 – 8.2. Total dissolved solids was moderate at both intakes, ranging from 116 – 128 mg/L.

2.2.3 Turbidity and Water Clarity

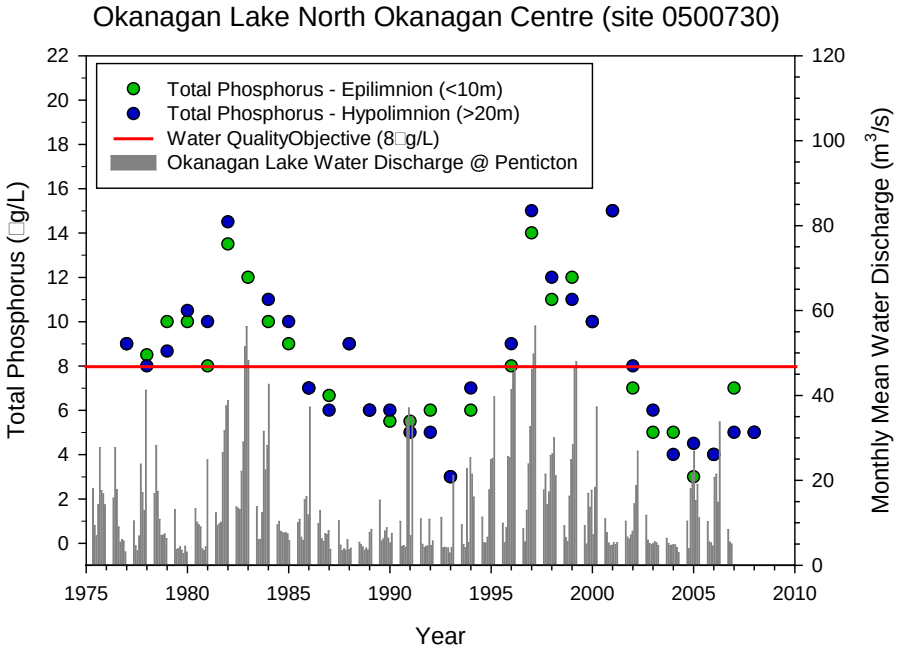
Turbidity increases and water clarity decreases when suspended sediment or microflora growth is high. Okanagan Lake secchi depths averaged 8 m with the greatest clarity in the winter and the lowest clarity (highest productivity) in the late spring/early summer when nutrients fuel algae growth. Years with larger freshets have shorter secchi depths, more turbidity and greater super-saturation zones as photosynthetic bacteria and cyanobacteria take advantage of the greater nutrient concentrations.

2.2.4 Nutrients

Nutrients are important to water quality because they direct microflora production. Within Okanagan Lake, the shallows, bays and arms are more productive than the main body of the lake. There is a general nutrient gradient in Okanagan Lake from moderate nutrient concentrations in the North Arm to more nutrient-poor conditions throughout the balance of the lake, with localized higher nutrient conditions near creeks and urban areas. Overall, Okanagan Lake is classified as oligotrophic or nutrient-poor (Andrusak and Sebastian, 2000). Its typically low nitrogen concentrations give a competitive advantage to cyanobacteria because they can utilize atmospheric nitrogen and they can persist in deep more nutrient-rich water. The spring total phosphorus water quality objective for the north basin of

Okanagan Lake is 8 µg/L. This objective has been met in recent years, but was consistently exceeded in years of high runoff (Figure 2.5).

Figure 2.5: Correlation Between Freshet and Phosphorus Loading to Okanagan Lake



(Sokal, 2011 MoE)

The forms of phosphorus transported to Okanagan Lake in suspended sediments during snowmelt averaged 62% apatite P, 16% non-apatite P and 22% organic phosphorus (Bryan and Jensen; 1996). Total nitrogen concentrations followed a similar trend as total phosphorus levels, with an increase in the late-1970s and early-1980s and a subsequent decrease thereafter.

2.3 Biology of Okanagan Lake with the potential to impact the intakes

2.3.1 Protozoan Pathogens in Water Column

(Oo)cysts are routinely found in Canadian source waters (Health Canada, 2010), however, the internal protozoan parasites *Cryptosporidium* and *Giardia* are rarely detected in Okanagan Lake. Routine methods available for the detection of cysts and oocysts suffer from low recovery rates and do not provide any information on their human infectivity, preventing the development of a maximum acceptable concentration (Health Canada 2010).

Typically, *Giardia* concentrations in surface waters ranged from 2 to 200 cysts/100 L (Health Canada, 2010; USEPA 1998). The RDCO intakes are sampled annually and both systems had non-detectable cyst concentrations of <0.1 cysts/100L on all occasions to date.

2.3.2 Bacteria in Water Column

Total coliforms are a broad category of bacteria that indicate the amount of bacterial loading in the water. *E. coli* (*Escherichia coli*) are found in warm-blooded animal wastes wastes and they serve as an indicator of fecal contamination. Only a few of the thousands of *E. coli* strains are disease-causing, however, if *E. coli* are present, the presence of other bacteria

pathogens can be statistically correlated. The presence of other pathogenic bacteria such as *Campylobacter* may be correlated, while *E. coli* counts do not correlate well with viruses or other pathogens (Carter et al. 1986; Keith et al, 1999).

The majority of the water column bacterial samples from Okanagan Lake contain less than 1 colony forming unit CFU/100 mL (Larratt, 2009). Creek inflow plumes, storm water plumes or turbulence can contribute higher bacteria numbers to the water column.

The criteria set by IHA for source/raw water is (1) No more than 10% of source/raw water *E. coli* samples exceed 20 cfu/100 mL *E. coli* within any 6 month period. (2) No more than 10% of source/raw water total coliform samples exceed 100 cfu/100 mL total coliform within any 6 month period (Health Canada, 2010; IHA, 2008). The highest peaks in *E. coli* counts in the systems were both in May 2010 and were 14 cfu/100 mL at Killiney Beach and 5 cfu/100 mL at Westshore Estates. Norris Creek inflows may affect the Killiney Intake. *E. coli* bacteria and protozoan cysts are very small and can be imported by creek or other inflows.

2.3.3 Bacteria in Sediments

In a lake, 99% of the bacteria population will be associated with the upper few centimeters of sediment. The sediments act as a bacterial reservoir and *E. coli* are capable of persisting, but not reproducing in Okanagan Lake sediments. Despite inputs from agriculture, septic systems and wastewater inputs to the Vernon Arm, this basin had consistently excellent bacteria counts that corroborate well with RDCO results (Appendix 1).

On October 3, 2010 a remote sampler was repeatedly dropped into the sediment near the intake before retrieving a sample 1 m above the substrate. The intent was to mimic seiche turbulence. Sediments retrieved showed significant total coliform bacterial counts (Table 2.2). This data suggests that turbulence that re-suspends these sediments could increase bacterial concentrations in the raw water. However, *E. coli* counts were below detection, indicating that the risk of pathogenic bacterial contamination is currently very low.

3.2.2 Shoreline Wildlife MOVED

Wildlife are less likely to introduce pathogens to a watershed than humans and their domestic animals. Through travel, people and pets are exposed to a far wider range of pathogens than wildlife that live in one locale. Often pathogen and fecal indicator concentrations are higher in domestic animal feces than in wildlife feces (Cox et al, 2005). Wildlife can become infected by introduced pathogens and make the pathogen endemic. The majority of the pathogens detected in watercourses were originally introduced by humans and their pets/domestic animals. Wildlife, particularly rodents, are known carriers of the protozoans *Cryptosporidium* and *Giardia*, and less frequently *Toxoplasma* is encountered. Other infections are possible and every effort should be made to prevent their introduction.

Wildlife that habituate the shoreline, such as muskrat, are a greater concern than animals that do not live near the Okanagan Lake shoreline. In an American study, Bitto and Aldras (2009) found 65.9% of the tested muskrats were positive for *Giardia spp*., 50% were positive for *Cryptosporidium spp*., and 29.3% were infected with both parasites. These findings suggest the muskrat may be an important reservoir host for both *Cryptosporidium spp*. and *Giardia spp*. The prevalence of enteric parasitic infection is rising throughout the world. Wildlife may contribute to *Cryptosporidium* contamination in the water but may not have major public health significance because they are generally infected with non-human-pathogenic species and genotypes (Feng et al., 2007). However, infectivity studies have

demonstrated the potential for cross-transmission exists between rodents and cattle (Donskow et al., 2005). Rodents, because of their close proximity to humans and livestock, pose a potential threat as a maintenance reservoir for *Cryptosporidium* (Zeigler et al., 2007).

Table 2.2: Bacteria in Re-suspended Sediment beneath RDCO North Basin Intakes

October 3, 2010	Killiney Beach	Westshore Estates
Total Coliforms cfu/100 mL	Overgrown	Overgrown
E. coli cfu/100 mL	<1	<1

Sediment traps deployed near each intake captured an entire year of sediment fall near the respective intake depths (Table 2.3). Longshore transport of sediment, local turbulence and settling of algae cells are the major contributors to this material. If large creek plumes or storm water outflows were present in the area, they would increase sediment deposition substantially. The trapped material demonstrated moderate accumulation rates of 9.1 g/m^2/yr, of which 19% was volatile (organic) at Killiney Beach and a higher rate of 17.1 g/m^2/yr, of which 16% was volatile at Westshore Estates. The estimated sediment accumulation rate for the pelagic areas of Okanagan Lake has been estimated at 1 mm/yr or 1 meter in 1000 years (OKBS, 1974). This rate is slower than what we measured near the intakes because their shallow position makes them subject to sediment re-suspension by turbulence.

Table 2.3: Sediment under RDCO North Okanagan Lake Intakes

RDCO Sediment Trap Sept 2010 - Sept 2011 (15 cm dia; 175 cm^2 surface area)	Units	RDL	Killiney Beach 09-Sep-11	Westshore Estates 09-Sep-11
Solids, Total	g	0.005	1.6	3.1
Solids, Total Volatile	g	0.005	0.3	0.5
			19% vol	16% vol
total accumulation rate	g/m^2/yr		9.1	17.7
volatile accumulation rate	g/m^2/yr		1.7	2.9



2.3.4 Sediment Contaminants

At the sedimentation rates measured in Okanagan Lake, it would take three decades for 3 cm of new sediments to "seal over" contaminated sediments, assuming no sediment disturbance. This is fortunate because some pesticides such as DDT and mercury-based materials used in the past are dangerous and persistent. Their contact with the water column today should be minimal under normal circumstances. Wave and seiche turbulence in shallow areas will suspend sediments, while burrowing fish (e.g. carp) and aquatic insects (e.g. *Mysis*) could disturb these sediments. Having re-suspended sediment enter the intake is undesirable. It increases turbidity and possibly introduces small concentrations of sedimented contaminants. Fortunately, the land use in the vicinity of the intakes does not include large-scale agriculture or golf courses that historically have high pesticide use, and as a whole Okanagan Lake concentrations of these materials is declining (MoE; 2011).

2.3.5 Algae and Cyanobacteria in Okanagan Lake

Algae form an important baseline for the food webs in every lake. Algae densities present in Okanagan Lake provide excellent water quality for most of the year. In the surface water, peak diatom algae growth follows the spring overturn, followed by a lull during mid-summer as key nutrients and vitamins are exhausted, and finally a smaller peak in cyanobacteria from late summer to the fall overturn.

Cyanobacteria counts in the RDCO intake samples often include species that inhabit deep water or grow along the substrate. They may be transported to the intakes by seiches, particularly because the Westside intakes are near the sediments.

Okanagan Lake has been dominated by cyanobacteria for at least 70 years (Clemens et al., 1939; Nordin, 1985; Stockner, 2003). Climate change and eutrophication increase the frequency and intensity of cyanobacteria growth (Rantala et al, 2006; H&W Canada, 1992). Enhanced water treatment of the municipal sewage discharged to Okanagan Lake has improved water quality since the 1970's. For example, spring secchi disk depth, a record of water clarity, has gradually increased in Okanagan Lake over the past decade (Sokal, 2011).

Problems caused by cyanobacteria include:

- Toxicity from a variety of cyanotoxins (Table 2.4)
- Taste and odor production
- Increased organic carbon (TOC), thus reduced UV transmissivity
- Contribution of organic material to feed re-growth biofilms within the distribution system (Niquette, et al., 2001; Servais and Savoir, 2001)
- Tri-halomethane (THM) production following chlorination
- Increased cost to treat the water for domestic use

In Okanagan Lake, cyanobacteria occur in three distinct distribution patterns with depth;

1. SURFACE (0-10 m) Maintain position in surface water layer (scum-forming genera, including *Anabaena*, *Aphanizomenon*, *Microcystis* and *Cylindrospermopsis)*. Many of these cyanobacteria require high nutrient concentrations.

2. MIGRANT Move toward the surface at night or in the early morning and downward later in the day. Genera include *Microcystis*, although *Anabaena* and other gas-vacuolate types may also migrate on a daily basis.

3. DEEP (10-80 m) Maintain a position at a particular depth, typically at the thermocline. *Planktothrix* (*Oscillatoria*) and *Planktolyngbya* are examples. Many of these genera are adapted to low nutrient concentrations.

Ingesting cyanotoxins can be fatal, with lethal doses of 50 – 1,000 ug/kg body weight (AWWA, 2001). There have been no reported cyanotoxin human fatalities in the Okanagan, however, there have been cattle, dogs, waterfowl and fish kills due to cyanotoxins in surface water within British Columbia (IHA, pers comm.).

Exposure to an acute and possibly fatal dose of cyanotoxins would require contact with a concentrated surface scum of cyanobacteria and would be very rare on Okanagan Lake. Unfortunately one of the more likely areas is the northern arms of the lake and can affect the shallow RDCO North Basin intakes.

Table 2.4: Toxins Produced by Blue-green Algae (Cyanobacteria)

Cyanobacteria	Lyngbyatoxin , plysia-toxin	Aplysia toxins	lipopoly saccharide	Cylindospermopsin	Microcystin	Nodularins	Anatoxins-a and/or -a(s)	Saxitoxins neosaxi-toxin	BMAA
Type of toxin	Dermal toxin	Dermal	Dernal	Liver toxin	Liver toxin carcinogenic	Liver toxin carcinogenic	Nerve toxin	Nerve toxin	Nerve toxin carcinogen
LD50 (ug/kg)				300	50–1000		20-5000		
Guideline					<1 ug/L		<1 ug/L		
Anabaena			Yes	Yes-?	Yes		Yes	Yes	Yes
Anabaenopsis			Yes		Yes				
Aphanizomenon			Yes	Yes			Yes	Yes	Yes
Aphanocapsa			Yes						
Cylindrospermopsis			Yes	Yes			Yes-?	Yes	Yes
Gloeotrichia					Yes				
Haplosiphon			Yes		Yes				Yes
Lyngbya/ Plectonema	Yes	Yes	Yes	Yes			Yes-?	Yes	Yes
Microcystis			Yes		Yes				Yes
Nostoc			Yes		Yes		Yes-?		Yes
Nodularia			Yes			Yes			Yes
Oscillatoria	Yes	Yes	Yes		Yes		Yes	Yes	Yes
Phormidium	Yes-?		Yes		Yes		Yes		Yes
Planktothrix	Yes	Yes	Yes		Yes		Yes	Yes	Yes
Pseudanabaena			Yes						
Raphidiopsis			Yes	Yes			Yes		
Schizothrix	Yes	Yes	Yes						
Synechococcus			Yes						Yes
Synechocycstis			Yes						Yes
Detection technique				HPLC	ELISA HPLC		HPLC+UV GC/MS		

NOTE: Yes-? = Not all authors list this toxin for the cyanobacteria

-Larratt 2009c

Figure 2.6: Surface Cyanobacteria "Bloom" in Okanagan Lake





For example, in June 1975, an *Anabaena* bloom degraded drinking water quality in the Vernon Arm of Okanagan Lake. A small bloom developed in the north sub-basin in July 2009, detected near McKinley Landing and Ok Center involving *Anabaena* and *Microcystis*. A small bloom was also detected in the Westshore Estates samples during this study in 2011. Small blooms are probably more frequent than current records indicate because they would go unnoticed unless the scum was thick and odorous. There have been two obvious and potentially toxic blue-green algae blooms on Okanagan Lake in the last decade and one on Skaha Lake. The last one on Okanagan Lake occurred in 2004 caused by *Microcystis aeruginosa*.

Results from the deep Okanagan Lake biology study (2009) support the following conclusions relevant to the North Basin:

- Diatoms were most prevalent in all three basins during the spring. They could affect filter runs, and possibly cause musty and/or fishy taste and odor in Apr/May/Jun

- The number of cyanobacteria species tended to decrease with depth, with more of the scum-forming species in the surface water which were gradually replaced by low light-tolerant species at depth.

- There was a greater occurrence of surface scum-forming cyanobacteria in the north sub-basin samples, including *Anabaena, Aphanizomenon and Microcystis (Anacystis)*. These are the species responsible for surface blooms that can accumulate along the shore (3 known occurrences in past 40 years in Okanagan Lake) and present a risk of cyanotoxins including microcystins and anatoxins.

- Deep-dwelling cyanobacteria included the usually toxic *Planktothrix, Oscillatoria, Planktolyngbya and Pseudanabaena.* Their density is nutrient-dependent but they are not likely to form intense blooms in Okanagan Lake. These cyanobacteria present the risk of chronic low doses of cyanotoxins, notably microcystins and anatoxins.

- The bottom samples tended to have greater algae counts than the samples taken 10 m above the bottom, probably due to suspension of sediment-dwelling algae and to viable algae cells raining down from the water column above. Cyanobacteria diversity also increased near the sediments.

- All intakes in this study drew Okanagan Lake water with a range of potentially toxic cyanobacteria but at low densities. 39 out of the 163 intake samples had cyanobacteria counts that exceeded the 2000 cells/mL threshold of concern - alert level II but none of them exceeded the 15,000 cells/mL - alert level III.

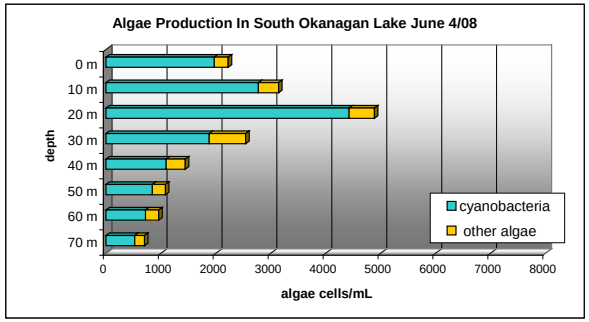
- Cyanobacterial numbers in intake samples were greatest during periods of turbulence where their filaments were readily suspended and nutrients were re-distributed throughout the water column. Intakes near outfalls, creeks or urban areas had higher algae counts than the corresponding profile sample site in that sub-basin

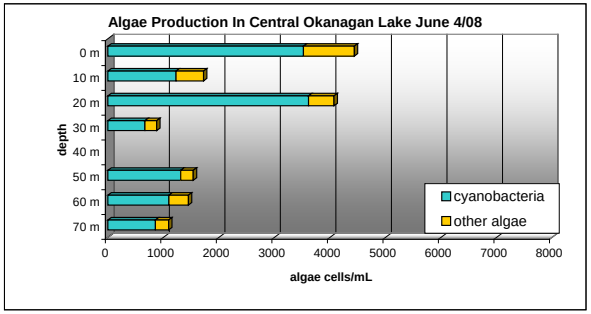
- **Intakes shallower than 12 m** had very low cyanobacterial numbers except in spring 2009 when every shallow intake had an algae cell count exceeding 5000 cell/mL and a cyanobacterial count of >2000-4000 cells/mL. They also had higher detritus and silt concentrations in the samples compared to deeper intakes
- **Intakes in the 14 – 19 m** range in the north sub-basin rarely had cyanobacterial counts exceeding 2000 cells/mL while those in the central sub-basin had frequent high counts, particularly in summer
- **Intakes in the 20 – 30 m** range from the north sub-basin had low cyanobacteria counts with Adventure Bay having the largest counts in this category because of its location in the nutrient-rich North arm
- **Intakes deeper than 30 m** rarely exceeded the 2000 cyanobacterial cell/mL threshold of concern. Winter 2008-2009 (Dec – Mar) intake samples had low cyanobacteria counts with the notable exception of 25 m Poplar Point. At this intake, Dec. and Feb. samples exceeded 2000 cells/mL cyanobacteria of deep-dwelling *Planktothrix*

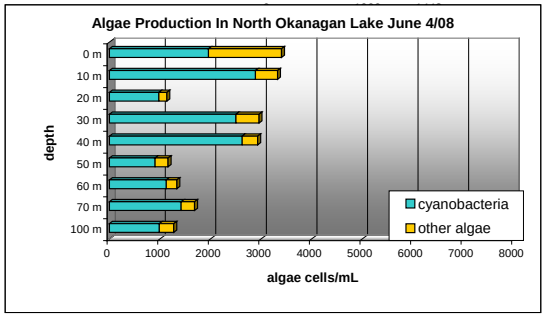
- **Intakes located less than 2 m above the substrates** had more frequent inclusion of sediment algae, detritus and silt than those located 3 m above the substrate or those that had intake structures drawing water diagonally or vertically (not horizontally) (Appendix 3). Okanagan Lake intakes that are in the path of creek plumes carried more silt in the freshet and more detritus throughout the year (e.g. El Dorado). Turbidity >1 NTU occasionally occurs in these intakes, and it was caused more by silt grains than by algae cells (Larratt, 2007).

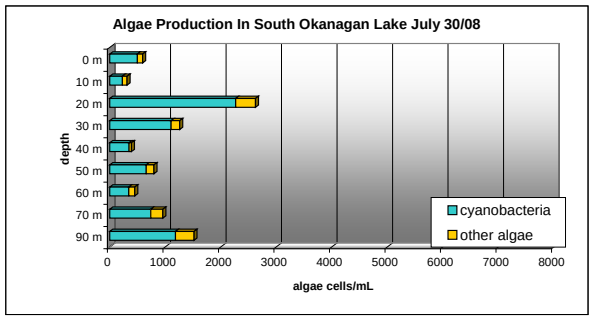
Figure 2.7:
Algae and Cyanobacterial Profiles from the South, Central and North Basins of Okanagan Lake, 2008 - 2009

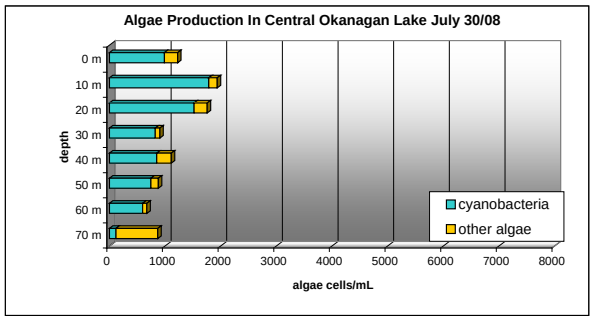
SOUTH | **CENTRAL** | **NORTH**

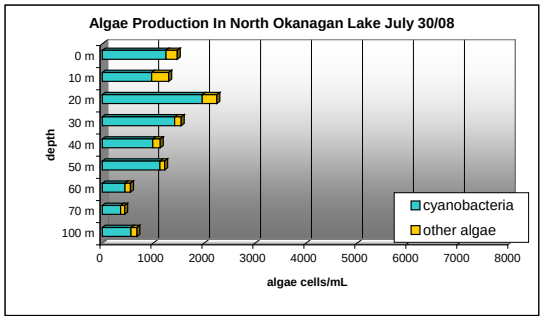


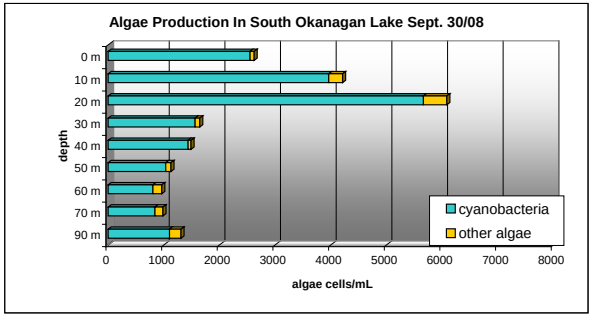


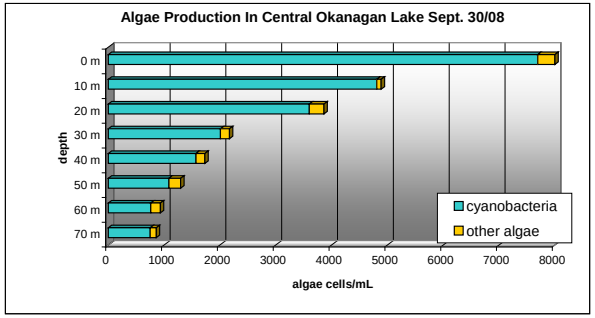


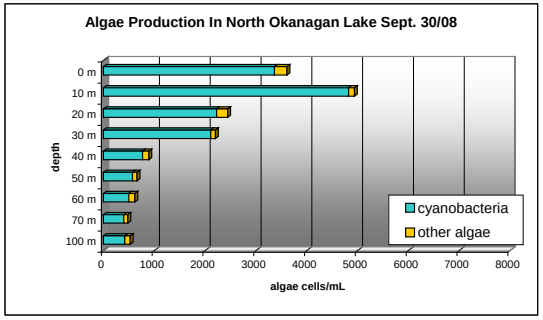


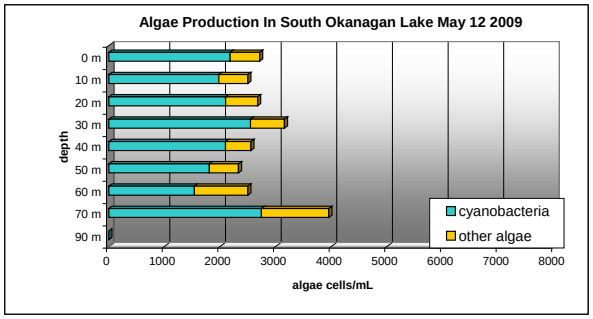


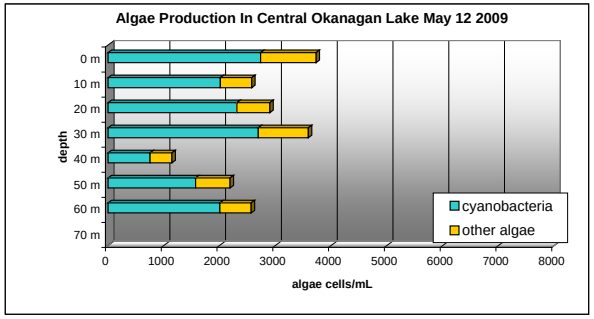












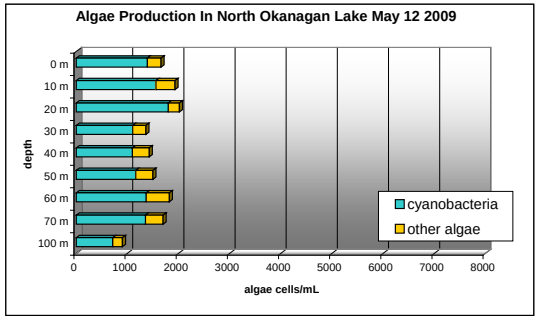
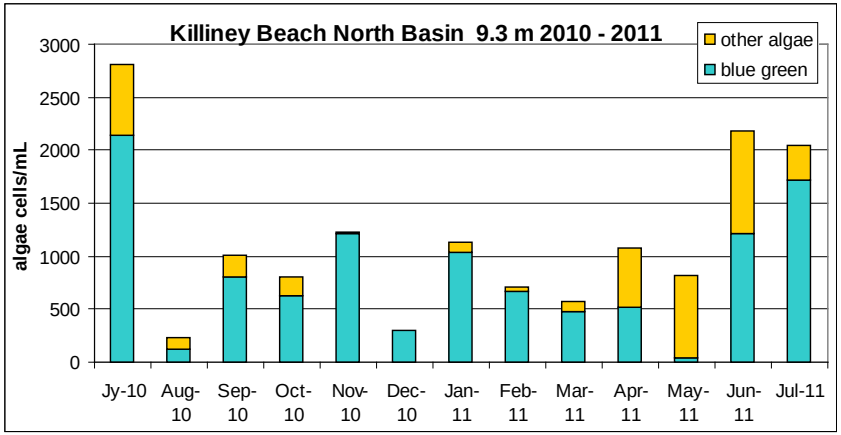
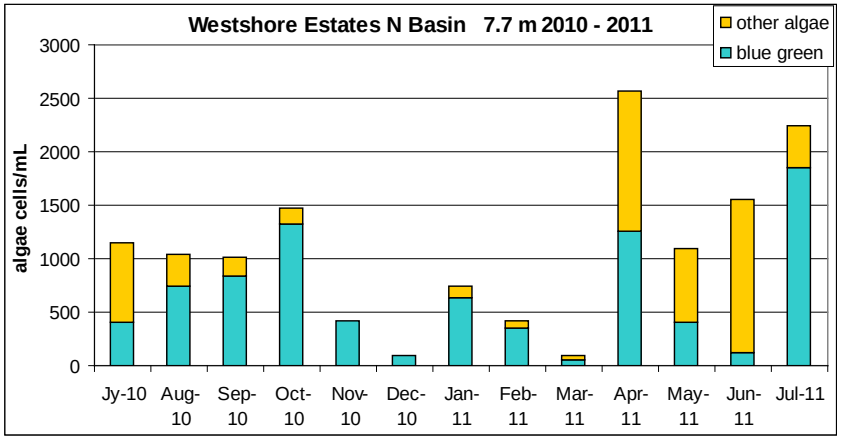
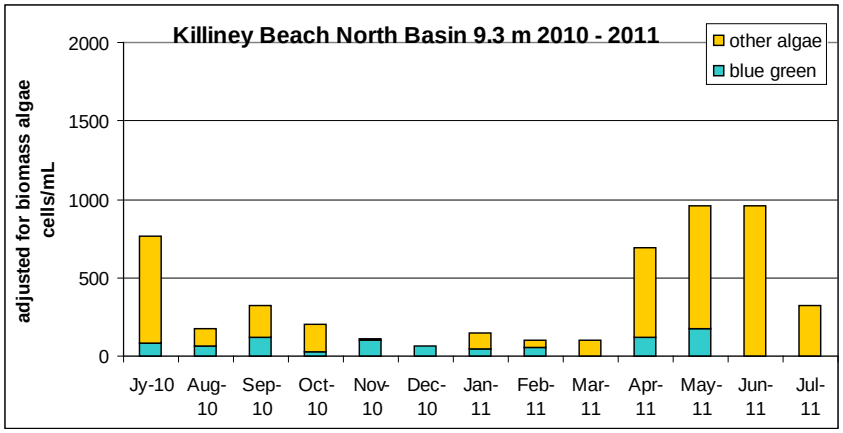
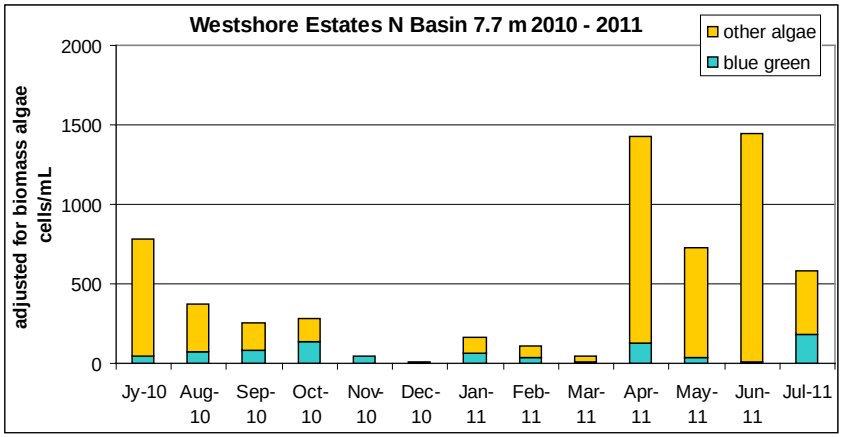


Figure 2.8: Algae and Cyanobacteria from Killiney Beach and Westshore Estates 2010 - 2011









AWWA recommends the following alert system for cyanobacteria:

Alert Level 1 Cyanobacterial biomass >500 but <2000 cells/mL (1 ug/L chlorophyll-a)
Taste and odor problems may occur
Move from weekly to twice weekly algae monitoring (cyanotoxin poisoning risk is low)

Alert Level 2 Cyanobacteria >2000 cells/mL but less than 15,000 cells/mL (about 1-5 ug/L chlorophyll-a)
Perform jar tests with powdered activated carbon and with an oxidant (chlorine etc.)
Develop treatment and monitoring contingency plan (cyanotoxin poisoning risk is low)

Alert Level 3 Cyanobacteria > 15,000 cells/mL (6,500 cells/mL *M. aeriginosa*)
Toxin presence is likely - implement contingency plan
Monitor and analyze for algal toxins through the water treatment process until cell numbers drop below <2000 cells/mL (cyanotoxin poisoning risk is moderate)

Very High Risk Cyanobacteria biomass >100,000 cells/mL of a toxin producing species (> 50 ug/L chlorophyll-a) Toxin presence at levels that impact human health probable (cyanotoxin poisoning risk is high) and may result in acute illness (AWWA, 2001; Westrick, 2008))

2.3.6 Cyanobacteria and Algae in RDCO North Basin Intake Samples

Figure 2.8 contains pairs of charts of the 2010 – 2011 monthly intake samples from Killiney Beach and Westshore Estates. The upper chart of each pair is the standard cell counts; the second chart shows the cyanobacteria count divided by 10 to reflect the far smaller cyanobacterial cell size; this gives the relative biomass of cyanobacteria versus other algae (mostly diatoms and flagellates). Both perspectives are valuable for evaluating water supplies.

Not surprisingly, the results from both intakes were similar in that cyanobacteria dominated numerically except in the spring when diatom numbers were high. Winter algae counts were low at both intakes. Average cyanobacteria densities vary by as much as 50% from 2600 – 5400 cells/mL in Okanagan Lake (Andrusak et al., 2005). In the RDCO intake samples collected in this study, cyanobacteria densities ranged from 35 to 2135 cells/mL at Killiney Beach and 125 – 1855 cells/mL in Westshore Estates.

Overall, the shallower Westshore Estates intake samples had slightly higher algae concentrations than the Killiney Beach intake samples. It also had more surface bloom-forming cyanobacteria (*Anabaena spp*.) than the deeper intake. However, Killiney Beach had more of the deep-dwelling *Planktothrix* than the shallower intake. Both intakes had 2 samples out of 14 with cyanobacteria concentrations exceeding 2000 cells/mL but none exceeded the 15,000 cells/mL threshold of potential toxin threat (AWWA, 2009). i.e.: even if the toxins were being generated at the time of sampling, the dose would be too low to pose a threat to human health, however, the concern of chronic low dose remains

A distinct surface-type cyanobacteria spike occurred at Westshore Estates, detected on July 5, 2011. Because it floats high in the water column, the shallower Westshore Estates intake at 7.6m had 880 cells/mL *Anabaena circinalis* (1855 cells/ml total cyanobacteria) while the deeper 9.3 m Killiney Beach intake had 115 cells/mL *Anabaena circinalis* (1715 cells/mL total cyanobacteria). These densities are not large enough to trigger a notification, but it is possible that the surface water exceeded drinking water guidelines (2000 - 15000 cells/mL) and may affect private shallow intakes in the area, if any. Turbidity readings taken by RDCO staff also increased during the peak (Figure 2).

Deep or bottom-dwelling cyanobacteria in the RDCO intake samples included *Planktothrix, Oscillatoria, Planktolyngbya and Pseudanabaena* during the 2010- 2011 sampling season. These cyanobacteria are uniquely equipped to thrive in very deep water in Okanagan Lake. *Planktothrix* has the highest microcystin concentration of all known cyanobacteria and it occurs specifically in the metalimnion of oligotrophic deep lakes, even in the winter (Hudnell, 2008; WSD Health, 2009).

Overall, the RDCO intake algae counts were moderate to low for Okanagan Lake and met all published criteria for drinking water (AWWA, 2001; HW Canada, 1992; WHO 1999, 2003). When counted as cells per mL, the intake samples were dominated by cyanobacteria (Figure 2).

In summary, deep intakes improve but do not fully resolve the algae/cyanobacteria problem. Deeper intakes reduce the risk of acute surface blooms and increase the risk of chronic low doses of deep-dwelling cyanobacteria. A major toxin produced by deep cyanobacteria is microcystin and it can be degraded by chlorine. An option therefore exists to increase the chlorine dose if large numbers of cyanobacteria are detected at a

deep intake. The other toxins produced by these cyanobacteria do not degrade in chlorine (Table 2.4).

2.3.7 UV Transmissivity

Because UV disinfection produces minimal disinfection by-products, it is often the second treatment of choice for small water systems. UV transmissivity was generally high and ranged from 89.8 to 93.3 % in RDCO intake samples to date. These results agree with samples from other intakes in the North Basin. These systems have suitable transmissivity for UV disinfection. Regular sampling will pinpoint any periods when UV disinfection will be challenged.

2.3.8 Taste and Odor

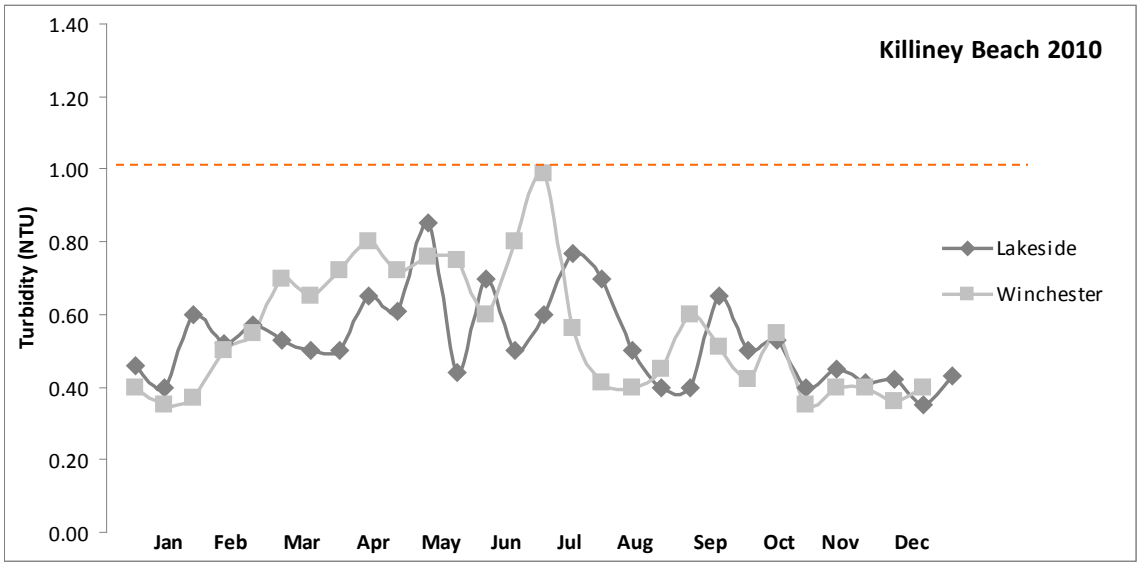
There have been no complaints from the Killiney Beach system, but there has been a recent complaint from the shallower Westshore Estates system. The taste and odor complaint is likely the result of high cyanobacteria concentrations. In fact, a musty/mild septic odor in Okanagan Lake water warns that cyanobacteria concentrations exceed 2000 cells/mL. Many seasonal residents bring in drinking water because they have concerns about the water quality. They may be detecting a difference in flavour between their residence and Killiney Beach or Westshore Estates water.

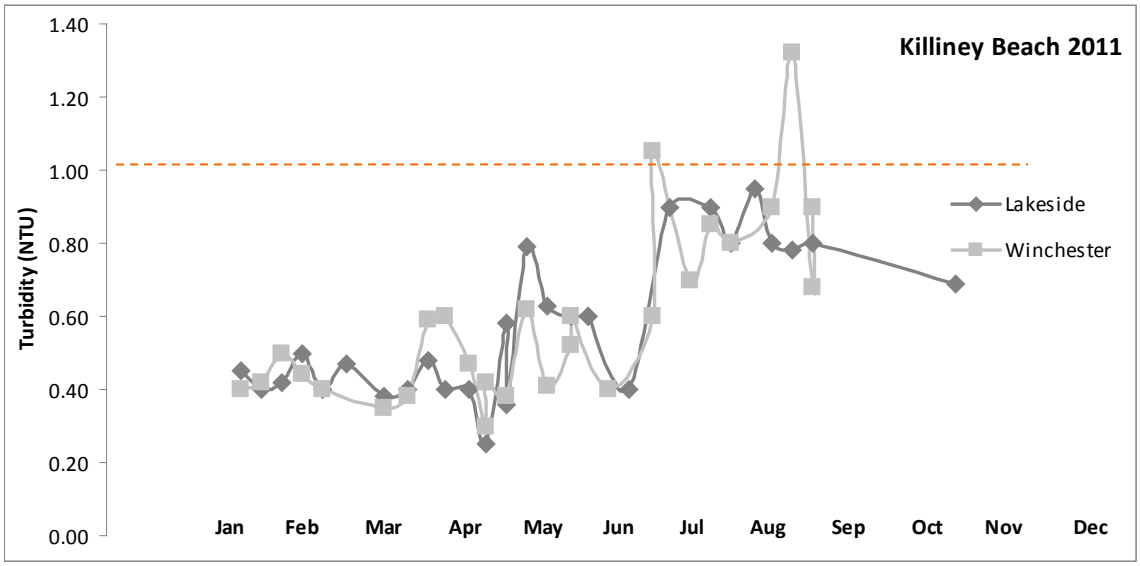
2.3.9 Turbidity

For an oligotrophic lake, turbidity is moderate in Okanagan Lake (Nordin, 1985). Natural sources of turbidity include freshet plumes, seiches, lake overturn and algae blooms. Anthropogenic sources of turbidity include storm water, shoreline modification and vegetation removal along riparian areas.

RDCO measures turbidity at the intake (lakeside) and at a distribution reservoir (Figure 2.9). Intake sample turbidity generally ranged from 0.3 to 0.9 mg/L, with higher readings during the spring and fall (Figure 2.9). IHA currently requires a water quality advisory when daily average turbidity exceeds 1.0 NTU for the North Okanagan intakes because turbidity can interfere with disinfection. While freshet caused turbidity spikes at both intakes, summer turbidity exceeding 1.0 NTU was measured only at Killiney Beach – the deeper intake during a small cyanobacteria bloom (Figure 2.9). These spikes generally correlate to spikes in algae density (Appendix 1). Since the spikes exceeding 1 NTU only occur at the Winchester site, iron from the pipe walls is probably contributing to the higher turbidity measurements at Winchester than at Lakeside (Figure 2.9). RDCO is moving to in-line filters to get rid of the iron and to continuous monitoring. A less likely turbidity source is the Norris/Hope Creek system that extends above the Winchester reservoir to the lake. The creek plume from these drainages could provide a periodic source of sediment that contributes to turbidity.

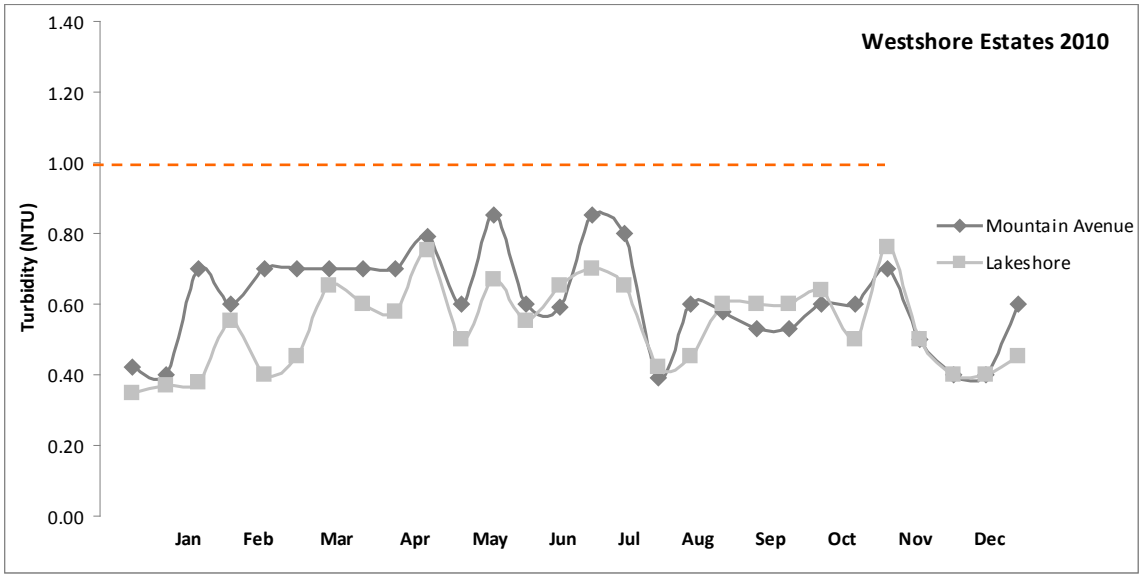
Figure 2.9: Turbidity at RDCO North Okanagan Intakes, 2010 - 2011

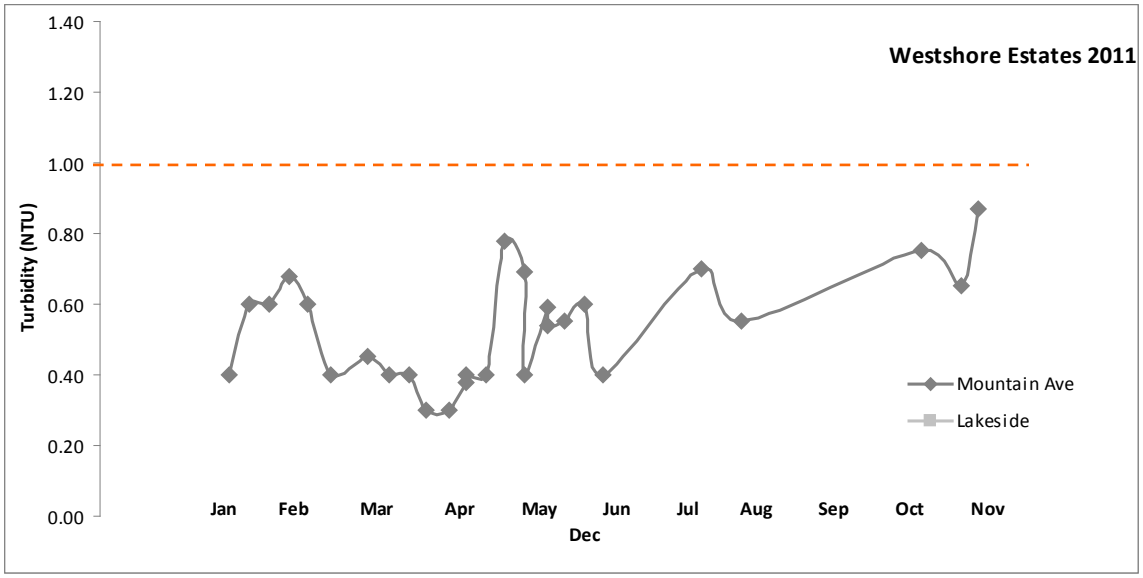




NOTE: The turbidity graphs in Figure 2.9 are based on grab samples

Figure 2.9





Heavier particles like sand and silt settle out rapidly in lake water but finer ones remain suspended, particularly near the substrates. The lighter particles that remain suspended include algae, bacteria and microbes such as *Cryptosporidium parvum* and *Giardia lamblia* cysts. Their slow settling rate was experimentally determined to be 0.27 μm s^{-1} and 0.67 μm s^{-1} for *C. parvum* and *G. lamblia*, respectively (Dia and Boll, 2006). These types of particles will be readily drawn into an intake that is within a meter of the substrate. Based on the Aqua-Bility video, the material they suctioned out of the wet wells was organic, flocculant and contained organic oils. The video also showed layers in the deposited material, suggesting heavier and lighter periods of deposition.

2.4 Calculation of Intake Protection Zone for RDCO North Basin Intakes

An intake protection zone defines the area where the intake should take precedence over every other use or consideration and defines the areas of land and water where special care must be taken in the use and handling of potential contaminants to prevent them from accidentally entering the lake and affecting the intake.

The size of an intake protection zone should be based on the existing and potential hazards, and on the speed with which they can be transported to the intake, both horizontally and vertically. Vertical transport is dominated by fall rates and seiches while horizontal movement in lakes is dominated by wind-driven currents and inflow plumes.

The default intake protection zone defined by IHA is a 100 m radius around the end of the intake. The protection zone should be modified from a circle to reflect consistent influences on water travel near the intake such as stream inflows, water currents and seiche patterns. A second layer of protection zone could be imposed on adjacent land development where subsurface (waste water, irrigation water) and surface (storm water) flows delivered to the intake protection zone would be significantly impacted by the land development.

The minimum intake protection zone safety factor recorded in the Lake Ontario Source Study is 2 hours and 1 km radius (Stantec, 2007). Lake Ontario is a large lake with heavy industrial use, and not analogous to Okanagan Lake. None the less, a decision must be made on the acceptable time-safety factor that would give RDCO a reasonable timeframe to react to an emergency such as a spill. The two hour safety factor was used in the calculations in this report. Because water currents travel faster in shallow water, the intake protection zone will be larger than if the intake was in deep water. The maximum water transport speeds at the surface and at the intake depth were then used to estimate the intake protection zone.

The intake protection zone does not encompass the entire lake area capable of impacting the intake, rather it delineates the “highest risk” area. In a severe storm, a spill anywhere in the North Basin could theoretically impact the RDCO intakes. An intake protection zone based on two hours of water travel under normal wind conditions represents the minimum safety factor recommended in this study. An IPZ should be understood as a critical protection area nested into a larger area of concern (North Basin) and finally into the entire area of concern – Okanagan Lake and its watershed.

2.4.1 Vertical Transport – Fall Velocity

When mixtures of solids and water are introduced to a lake, the dissolved material remains suspended indefinitely and diffuses, while the particulate material settles out according to its fall velocity.

The fall velocity of fine clay is small at 0.0011cm/s (0.04 m/hr or about 1 m/day), and for *E. coli* bacteria it is far smaller at 0.00354 m/day (Hayco, 2009; USGS 2007). For example, it would take several weeks for clay to settle through the water column, unless it clumped with other materials and accelerated. It could take years for bacteria to settle out based strictly on fall velocity. Fortunately, their fall velocity will be accelerated by clumping with other suspended materials. Bacteria can also be consumed by zooplankton and deactivated by sunlight or simply by aging (Wetzel, 2007).

Table 2.5: Size and Fall Velocity Estimates for Lake Particulates

Material	Size	Fall velocity
Inorganic		
Sand	>63 – 100 microns	> 100 m/day
Silt	4 – 63 microns	21 m/day
Clay	0.1 – 4 microns	1 m/day
Biological		
Organic clumps	> 100 microns	>100 m/day
Large algae and diatoms	22 – 70 microns	< 50 m/day
Small algae	6 – 14 microns	<1 m/day
Lrg filament cyanobacteria	5w x 200l microns	0.1 m/day
Sm filament cyanobacteria	1w x 100l microns	>0.007 m/day
Giardia / crypto cysts	4 – 8 microns	0.02 - 0.1 m/day
Bacteria – *E. coli*	0.7 – 10 microns	>0.0035 m/day

(Dia and Boll, 2006; USGS 2007; Hayco, 2009; Larratt 2010)

2.4.2 Vertical Transport - Vertical Currents

Vertical currents generated by a strong wind event can theoretically reach 5 m/sec with a seiche. However, with a typical maximum vertical velocity of 0.08 cm/sec (3 m/hr) for a water current after a strong wind, fine material suspended in the water or disturbed from the sediments could potentially be transported to the surface in 4 hours from a depth of <12 m (Hayco, 2009). There are no persistent vertical currents in a lake; the direction of vertical currents oscillates following the upward and downward water motions in the lake (Hayco, 2009).

2.4.3 Vertical Transport - Seiche Transport and Autumn Overturn Turbulence

Vertical transport of particulates in lakes follows predictable patterns. During the summer stratified period with no seiche activity, sediments that fall in the epilimnion would be in proportion to depth while below the thermocline, sediment fall should keep a constant accumulation rate. In practice, waves erode the shallows and mixing transfers the sediment to deeper water. A storm can increase sediment concentrations at the shallow RDCO intakes by seiche disturbance and by wave turbulence-mixing transfer. Normal wind-driven currents in deep areas of a lake are unlikely to create sufficient turbulence to destroy the boundary water layer near the sediment surface and bring the sediment into suspension. However, rapid current reversals and increased velocity at the thermocline occurs during a seiche or when the wind driving a current suddenly drops. These abrupt changes in water velocity could suspend sediment. Seiche-driven sediment re-suspension decreases linearly with depth (Hilton et al., 1986).

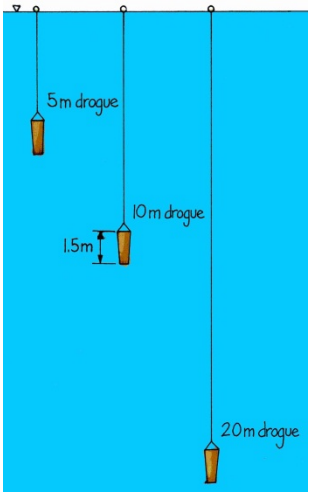
During the autumn overturn, near-bottom sediments traps in lakes catch 2-4 times more material than shallow traps due to re-suspension from all over the lake bed (ref). During spring and fall high seiche periods, over half of the material in traps is re-suspended material. The greatest turbulence is associated with the fall overturn (destratification) (ref).

The height to which the settled materials can be re-suspended depends on their particle size. Because material on the substrate tends to clump, the height of its re-suspension is usually only a few meters and the rate of return to the substrate is rapid – usually a matter of hours (Table 2.5). Unfortunately, this won't help the RDCO intakes that are 1 m from the substrate. Coarser materials settled out in the wet wells while lighter particles were carried further into the distribution systems of Killiney Beach and Westshore Estates.

2.4.4 Water Currents (Horizontal transport)

Like most lakes**,** currents in the North basin of Okanagan Lake show a seasonal variability that is strongly related to wind speed. Horizontal water currents are strongest in the top 5 meters of most lakes, and Okanagan Lake is no exception. A drogue study was undertaken for this report to help define localized water travel patterns near the intakes. Drogues consist of a large surface to intercept and be carried by lake currents, attached by a thin line to a small float. Drogues were released at selected depths near the intakes and tracked by GPS for several hours under a range of moderate wind conditions (Figure 2.23).

Figure 2.10: Schematic Cross Section of Deployed Drogues



Drogues were deployed on October 2, 2010, June 16, 2011 and September 8 2011. The thermocline over these dates ranged from 8-15 m. Wind speeds were moderate, ranging from 0 – 8 km/hr. The relationship between wind speed and water current speed was measured by the drogues and is similar to the standard energy transfer estimate of 1.5 - 2% (Wetzel, 2001).

2.4.5 Drogue Travel in North Okanagan Lake near RDCO Intakes

The shallow 5 m drogues showed water movement at 5 m tends to be in the direction of the wind parallel to shore, with some movement towards shore. Deeper drogues usually travelled slower (Table 2.6). When sustained wind speeds above 10 km/hr occur, turbulence can develop throughout the shallow water column near the intake. Winds exceeding 10 km/hr are common, occurring many times each month, but were not present when the drogues were deployed (Figure 2.11, 2.12).

Table 2.6:
Drogue Results for RDCO North Basin Intakes, 2010 – 2011

Killiney B	Oct 3 /10		Jun 16 /11		Sep 8 /11	
Depth m	m/hr	Wind	m/hr	Wind	m/hr	Wind
3	113.0					
5	145.8	N – NE during drogue run	316.8	NE prior to sampling, switching to S for the drogue run	92.4	S but variable during drogue run
5	143.5		264.3		90.3	
10	81.7		56.0		120.3	
10	106.2		3.9		27.9	

Westshore	Oct 3 /10		Jun 16/11		Sep 8 /11	
Depth m	m/hr	Wind	m/hr	Wind	m/hr	Wind
3	107.6					
5	95.0	N – NE during drogue run	88.4	NE prior to sampling, switching to S for the drogue run	53.8	S - SW but variable during drogue run
5	92.3		168.0		43.0	
10	75.5		137.8		84.4	
10	44.5		144.5		46.4	

The general direction of travel of the drogues was along the lake shore because winds are funneled by the valley (Figures 2.11 2.12). Contradictory travel in different water layers is often observed and is the result of seiches, deflected currents or a change in wind direction. The surface 5 m will change directions and velocity faster than deeper water can following a change in wind direction. This accounts for the higher drogue speed at 20 m than at 10 m on October 3/10 (Table 2.6).

On all three dates, the drogues travelled faster at Killiney Beach than they did at Westshore Estates. The influence of the surrounding mountains or lake bathymetry contributes to this phenomenon. More turbulence was evident at Westshore Estates, with wind and waves striking the intake area at 45^{o} while at Killiney Beach, the drogues predominantly travelled parallel to shore.

On both 2011 dates, the 10 m drogue closest to the Killiney Beach intake did not move more than a few meters. It seems unlikely that the drogue became trapped on the intake because withdrawal layers do not cause an extensive current, however the cause is not known (Figure 2.11).

5 m drogues at Westshore Estates showed significant movement towards shore (Figure 2.12). Similarly, the 10 m drogues also demonstrated movement towards shore on several occasions. As waves and currents hit the shore, they reflect back at an angle and returning water can transport materials away from shore as in June 16's drogue run.

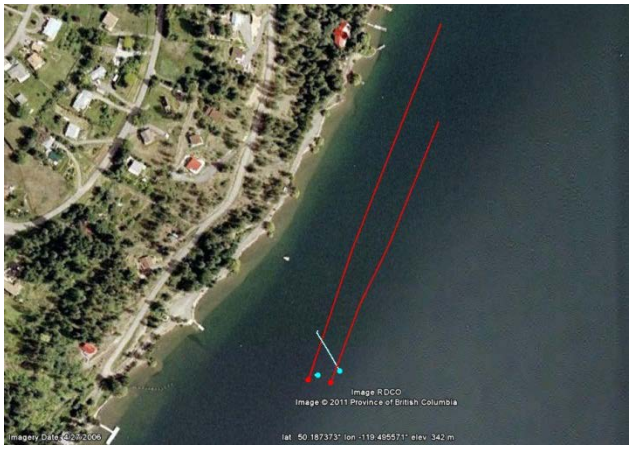
Figure 2.11 North Basin Okanagan Lake Drogue Trials, 2010 - 2011
Killiney Beach

Yellow line = 3 m drogue
Red line = 5 m drogues
Blue line = 10 m drogues
Dot = start point

October 2 2010



June 16 2011



September 8 2011



Figure 2.12: North Basin Okanagan Lake Drogue Trials, 2010 - 2011
Westshore Estates

Yellow line = 3 m drogue
Red line = 5 m drogues
Blue line = 10 m drogues

Dot = start point

October 2 2010



June 16 2011



September 8 2011



2.4.6: Calculation of RDCO Intake Protection Zones (IPZ)

The preceding discussion of vertical and horizontal currents in Okanagan Lakes and their ability to transport contaminants was combined with the drogue behavior, wind patterns and modeled current behavior to define the intake protection zones.

The speed of travel for surface contaminants is important because materials can fall vertically or be transported downward by seiches in the North Basin. Doubling the fastest drogue indicates that a surface contaminant could traverse a 100 m intake protection zone in less than 20 minutes. Conversely, to achieve the two hour guideline, the intake protection zone radius would have to be a minimum of 900 m to match potential travel under 80% of the wind events expected in one year. The white circle on Figures 2.13 and 2.14 represents two hours of travel at 5 m water based on the highest observed water speed or 8 hours of travel at the highest observed speed at 10 m. The shape of the Killiney IPZ is oval because water current travel was directed along the lakeshore (Figure 2.13). At Westshore Estates, the drogues showed that there is more turbulence and influence from the winds funneled by the Vernon Arm. The Westshore IPZ is therefore a truncated circle (Figure 2.14).

There are limited locations for contaminant introduction, thanks to the rural character of the area, the greatest of which are all related to shoreline cottages, homes and camping. If the intakes were re-positioned at 20-40 m or deeper, the IPZ would be progressively smaller because water travels slower at depth than it does near the surface of a lake. There is a substantial reduction of surface contaminant risk resulting from an increase in the depth of the intakes (Hayco, 2000). As it stands, shoreline activities are critically important to the water quality of these shallow intakes.

Long-shore water currents driven by wave action are temporary and they frequently reverse the angle that they strike the shore, making them a weak transport mechanism of potential contaminants over long distances of shoreline (Wetzel, 2001; Hayco, 1999). The RDCO intakes are 198 m KB and 171 m WE in length and those distances partially protect the intakes from particulates transported by wave-generated currents.

The drogues were not used during an intense storm, but currents are estimated to reach surface speeds of up to 9.5 cm/s (342 m/hr) in the open reaches of Okanagan Lake in a storm (Hayco, 2000). The currents slow and deflect as they reach the shallows where the RDCO intakes are. This maximal current speed would dictate very large Intake Protection Zones. Realistically, large spills or discharges anywhere in the North basin have the capacity to affect the RDCO intakes during a storm. The proposed Intake Protection Zone is not the only instrument available to RDCO for the protection of their Okanagan Lake intakes. RDCO also has FIM and a variety of foreshore protection tools. They include:

- Central Okanagan Lake Foreshore Plan (2007) http://www.regionaldistrict.com/docs/planning/env/foreshoreplan2007.pdf
- Rural Westside Official Community Plan (2010) – Development Permit Provisions http://www.regionaldistrict.com/departments/planning/planning_offcomplan.aspx#RuralWestsideOCP
- Zoning Bylaw No 871 – Floodplain Regulations http://www.regionaldistrict.com/departments/planning/planning_bylaw871.aspx
- Foreshore Inventory and Mapping and Aquatic Habitat Index : The Okanagan Lake: A Compilation of the North, South and Central Okanagan Lake report (2011). http://www.regionaldistrict.com/departments/planning/env/env_planning_foreshore.aspx

These tools are intended to assist in the protection of aquatic ecosystems and the Okanagan Lake foreshore. While these protection instruments are not focused on water quality, they can assist in reducing land disturbance close to the lake and other watercourses (M. Bakelaar, pers. comm. 2012).

Water quality protection requires the cooperation of all governments, residents and visitors to Okanagan Lake and its watershed to enact best management practices, particularly along riparian areas and Okanagan Lake shorelines.

Figure 2.13: Proposed Intake Protection Zones for Killiney Beach Intake



A: The white circle encompasses the area that the fastest drogues traveled in two hours with light winds. The shape of the enclosure is defined by the movements of the drogues on three runs.

B: The blue line encompasses the area water currents can travel in two hours with 80 % of the wind events that occur on Okanagan Lake and is the recommended Intake Protection Zone (IPZ).

An Intake Protection Zone that included the area water currents can travel in wind storm events in two hours or in freshet would include the entire North end and Arms of the North basin of Okanagan Lake. The proposed IPZ is within RDCO boundaries.

Figure 2.14: Proposed Intake Protection Zones for Westshore Estates Intake



A: The white circle encompasses the area that the fastest drogues traveled in two hours with light winds. The shape of the enclosure is defined by the movements of the drogues on three runs.

B: The blue line shape encompasses the area water currents can travel in two hours with 80 % of the wind events that occur on Okanagan Lake and is the recommended Intake Protection Zone (IPZ).

An Intake Protection Zone that included the area water currents can travel in wind storm events in two hours or in freshet would include the entire North end and Arms of the North basin of Okanagan Lake. The proposed IPZ is not within the RDCO boundaries. The northern 45% lies within the Okanagan Indian Band jurisdiction.

Table 2.7 MODULE 1: Hazard and Contaminant Table – Killiney Beach Intake

Report section	Drinking Water Hazard/Contaminant	Possible Effects	Existing Preventative Measures/Barriers
	Physical		
2.2.3 2.4.1	Sediment re-suspension from substrates via seiches, currents, on-shore winds	Increased turbidity can compromise disinfection treatment potentially causing illness if pathogens or heavy metals are present	<1 m clearance of intake from substrate (insufficient)
2.2.1 2.4.3	Seiche transport during storms	Intake is affected by surface water intrusions 18+ times/year, increasing the risk of exposure to surface water chemical and biological contaminants	Intake depth at 9.26 m (shallow)
2.4.1 2.4.4 2.4.5	Long-shore current transport	Long-shore currents transport can carry contaminants at speeds up to 364 m/hr at the surface (slower at the intake depth)	Intake location distant from urban centers
2.3.10	Drought low water levels or shoreline flooding	Wet well stranding or flooding of septic fields, yards, causing introduction of contaminants	Drought planning, outlet flow control, emergency lowering of wet well
	Chemical		
2.3.11 2.2.4 2.2.5	Storm water	Transport of nitrogen, pesticides road surface contaminants, pathogens, salt	Infiltration from ditches provides some treatment
2.3.10	Septage from local septic fields, sewage from Vernon, boat and RV disposal	Exposure to: pathogens, organic matter, nitrates, heavy metals, inorganic salts, personal care products, cleaners, paints, medications, auto wastes, PAHs	Health Act's Sewer System Reg. = 30m set-backs from lake. Newer homes with package tmt plants may get reduced setbacks. Yellow shoreline sensitivity zone – min. 15m setback under OCP
2.3.11	Petroleum hydrocarbons	Deliberate or accidental spill or use of gas-powered boats, boat launches,	Dilution and evaporation of spills; rural location of intake
2.3.7 2.3.9 2.4.1	Turbidity	Interferes with disinfection; generally low with occasional spikes	Increased chlorine, public notification
2.5	Taste/odor chemicals	Reduced aesthetic; periodic problem	Increase chlorination
2.3.4 2.2.6	Heavy metals and pesticides	Bioaccumulation through chronic exposure	MoE fish muscle tissue testing shows declining concentrations over 20 yrs
	Biological		
2.3.5 2.3.6	Cyanobacteria	Chronic low-dose exposure to cyanotoxin; health impacts vary with toxin type, can include hepatic cancer	Depth of intake; chlorination provides some protection; minimize nutrient loading
2.3.12	THM precursors (algae, organic material	Organic material (TOC) can react with chlorine to create THMs that are carcinogenic after long-term exposure	TOC load is moderate in Okanagan Lake – rarely exceeded 0.1 mg/L Total THM (IMAC) no excessive chlorine.
2.3.2	Viruses –pathogenic	Acute illness through water-borne exposure	Chlorination
2.3.2	Bacteria (*E. coli*, fecal)	Illness through water-borne exposure	Chlorination
2.3.1	Protozoa -pathogenic	Illness through water-borne exposure	Chlorination
2.3.13	Biofilm	Shields pathogens from disinfection	Cl residual; pipeline flushing

Table 2.8 summarizes the possible drinking water hazards identified in Killiney Beach Module 1 as recommended in the IHA Source Assessment process.

Table 2.8 MODULE 1: Hazard and Contaminant – Westshore Estates Intake

Report section	Drinking Water Hazard/Contaminant	Possible Effects	Existing Preventative Measures/Barriers
	Physical		
2.2.3 2.4.1	Sediment re-suspension from substrates via seiches, currents, on-shore winds	Increased turbidity can compromise disinfection treatment potentially causing illness if pathogens, or heavy metals are present	<1 m clearance of intake from substrate (insufficient)
2.2.1 2.4.3	Seiche transport during storms	Intake is affected by surface water intrusions 20+ times/year, increasing the risk of exposure to surface water chemical and biological contaminants	Intake depth at 7.7 m; shallow
2.4.1 2.4.4 2.4.5	Long-shore current transport	Long-shore currents transport can carry contaminants at speeds up to 364 m/hr at the surface (slower at the intake depth)	Intake location distant from urban centers
2.3.10	Drought low water levels or shoreline flooding	Wet well stranding or flooding of septic fields, yards, causing introduction of contaminants	Drought planning, outlet flow control, emergency lowering of wet well
	Chemical		
2.3.11 2.2.4 2.2.5	Storm water	Transport of nitrogen, pesticides road surface contaminants, pathogens, salt	Infiltration from ditches provides some treatment
2.3.10	Septage from local septic fields, sewage from Vernon, boat and RV disposal, Evely campsite	Exposure to: pathogens, organic matter, nitrates, heavy metals, inorganic salts, personal care products cleaners, paints, medications, auto wastes, PAHs	Health Act's Sewer System Reg. = 30m set-backs from lake. Newer homes with package tmt plants may get reduced setbacks. Orange shoreline sensitivity zone – min. 20m setback under OCP
2.3.11	Petroleum hydrocarbons	Deliberate or accidental spill or use of gas-powered boats, boat launch, marina	Dilution and evaporation of spills; rural location of intake
2.3.7 2.3.9 2.4.1	Turbidity	Interferes with disinfection; generally low with occasional spikes	Increased chlorine, public notification
2.5	Taste/odor chemicals	Reduced aesthetic; periodic problem	Increase chlorination
2.3.4 2.2.6	Heavy metals and pesticides	Bioaccumulation through chronic exposure	Fish muscle tissue testing shows declining conc. in 20yrs
	Biological		
2.3.5 2.3.6	Cyanobacteria	Chronic low-dose exposure to cyanotoxin; health impacts vary with toxin type, can include hepatic cancer	Depth of intake; chlorination provides some protection; minimize nutrient loading
2.3.12	THM precursors (algae, organic material	Organic material (TOC) can react with chlorine to create THMs that are carcinogenic after long-term exposure	TOC load is moderate in Okanagan Lake – never have exceeded 0.1 mg/L Total THM (IMAC) no excessive chlorine.
2.3.2	Viruses –pathogenic	Acute illness through water-borne exposure	Chlorination for disinfection
2.3.2	Bacteria (*E. coli*, fecal)	Illness through water-borne exposure	Chlorination
2.3.1	Protozoa -pathogenic	Illness through water-borne exposure	Chlorination
2.3.13	Biofilm	Shields pathogens from disinfection	Cl residual; pipeline flushing

3.0 North Okanagan Lake Intakes Module 2 Contaminant Inventory

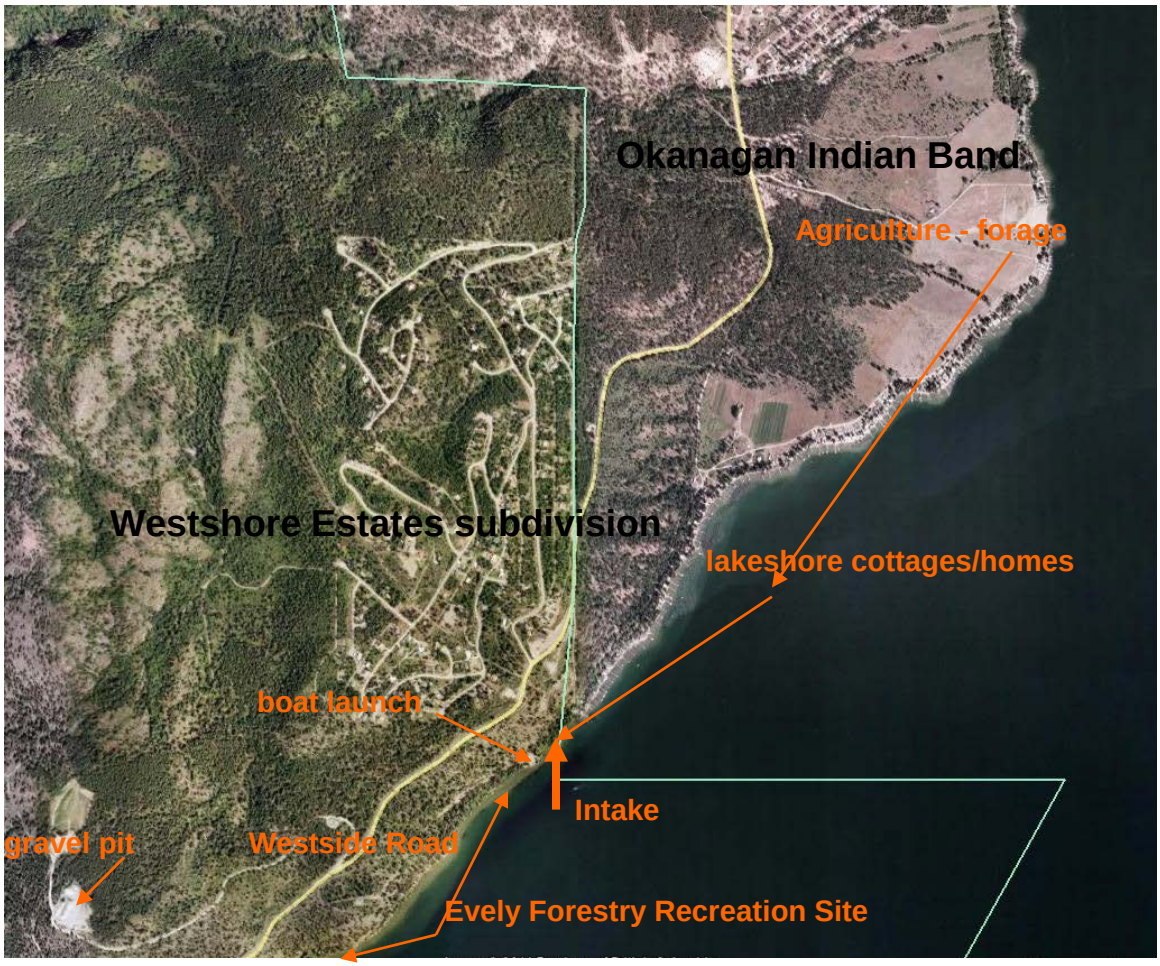
3.1 Anthropogenic Potential Water-Borne Hazards to RDCO North Basin Intakes

A wide range of human activity occurs within the vicinity of the RDCO North Okanagan Intakes, predominated by lakeshore residential, boat-based recreation, roads and agriculture. The degree to which these activities affect the intakes is based on their proximity and their risk. The aerial photos in Figures 3.1 and 3.2 have important features marked. These features are discussed in the following sections 3.1.1 – 3.1.6

Figure 3.1:
Features of the North Basin Okanagan Lake Killiney Beach Intake



Figure 3.2:
Features of the North Basin Okanagan Lake Westshore Estates Intake



3.1.1 Intake Depth

Intake depth defines the exposure to shallow and deep-water contaminants.

Inflows There are no inflows in the immediate vicinity of Westshore Estates but the small and intermittent Norris/Hope Creek discharges to Okanagan Lake near the Killiney Beach intake. The closest major creeks are Shorts, Whiteman, Vernon and Lambly Creeks. Creek inflows can pool as a water parcel and travel as a discrete packet of water, diffusing as it travels. For example, an inflow can pool near the discharge point and be transported by currents. It is therefore not wise to count on dilution with the full volume of the North Basin area to deal with major creek plumes, even creeks that are more than 10 km away from the intake.

Transport for distributed shoreline sources such as local runoff would behave similarly to a creek input (Hayco, 2000). Because the RDCO N basin intakes are shallow and close to shore, shoreline residences have the greatest potential impact on their own drinking water.

Algae Okanagan Lake secchi depths averaged 7 to 10 m during the summer months, yielding a photic depth of approximately 20 m, showing little changed from research conducted in 1939 (Clemens et. al., 1939). Both RDCO intakes are in the photic zone, explaining why the screens foul with algae. This growth may slough off in winter and contribute to the organic material drawn into the intake.

Cyanobacteria Cyanobacteria usually account for about half of the phytoplankton community in summer and they can increase to 60% of both algal density and biomass in the fall (Stockner, in Andrusak et al., 2003). The risk of chronic low dose exposure to cyanotoxins exists at most depths, while the risk of acute toxicity from surface types impacts only shallow intakes.

Mussels The exotic, invasive zebra and quagga mussel populations are rapidly expanding in many neighboring states. It is anticipated that these mussels will invade BC in the next few years. They could dramatically increase intake maintenance costs. Sample screening for zebra and quagga mussels began in 2011 and none were found in the RDCO intake samples, or in the City of Kelowna intake samples. Should these invaders find their way into Okanagan Lake, shallow intakes such as KB and WE will be the most vulnerable to infestation.

3.1.2 Storm Water

One of the most important safety features of the Killiney Beach and Westshore Estates is the absence of storm water outfalls. Storm water in the Okanagan region routinely carries hydrocarbons and materials released from the paving materials, road salt, pathogens as indicated by *E. coli* and landscaping chemicals including fertilizer and pesticides. It may also carry other contaminants when people illegally dispose of materials down the storm drains.

Very little storm water treatment has been developed in the Okanagan to date. Most storm water discharges to the nearest watercourse without treatment. Localized on-site soak-away disposal could be considered for street run-off as well as rainwater gardens for roof drain runoff to lower the total amount of storm water.

Westside Road represents the largest impervious surface in the area and the storm water from it will carry the same contaminants as municipal storm water, with additional salt and turbidity from winter abrasive. It is located within 350 – 660 m of the lakeshore and therefore, contamination from spills is possible. Liquid materials routinely carried along Westside road include fuels, chlorine, septage, and bulk MgCl dust suppressant. Runoff from the highway is managed by unlined ditches that allow infiltration. Seepage to ground from ditches will allow pathogen deactivation and can remove some PAH's but chloride and spilled contaminants may persist and affect drinking water.

Steep impervious driveways may allow overland flow, particularly during thunderstorms. They should be equipped with flow detention / attenuation structures. A review of roads and lanes near the lakeshore and local small creeks should be checked in addition to ditch maintenance.

At the time of subdivision, the RDCO requirements for storm drainage in the Subdivision and Development Servicing Bylaw call for storm water to be attenuated on the subject parcel and for large subdivisions/development, the post-development storm water that flows from the property cannot exceed the pre-development flows (M. Noga, pers comm; RDCO, 2003).

As development continues on the North Westside, storm water outfalls into Okanagan Lake near Westshore Estates and Killiney Beach should be avoided and they should not be placed within the intake protection zone. Alternatives should be encouraged based on BMP's and site-specific conditions, such as soak-away zones (e.g. infiltration basins) and rain water capture. The RDCO Stage 2 Stormwater Quality Management Initiatives for the Westside (2005) identified seven foundational BMP's. They are:

1. Buffer zones/preservation of natural areas and drainage systems
2. Impervious area reduction/restriction/disconnection
3. Education/stewardship
4. Inspection/compliance
5. Street cleaning
6. Catch basin cleaning
7. Maintenance of runoff conveyance systems and hill slopes

Further, the report identified five area-specific BMPS applicable to subdivisions. They are:

1. Water quality inlet
2. Engineered wetlands
3. Vegetated swale/grassed channel
4. Vegetated filter strip
5. Bioretention/dry swale with underdrains

These BMP's are important to reduce the volume and contamination load os Westside storm water. Please refer to Appendix 5 for more information on the Subdivision and Servicing Bylaw (M. Noga, pers. comm. 2011).

A final possible storm water impact to the WE and KB intakes would be a much diluted plume from Vernon Creek that includes substantial storm water from the Vernon area.7

3.1.3 Septic Fields and Package Treatment Plants

Sewage and septage routinely carry pathogens, organic matter, grease, nitrates, ortho-phosphorus, heavy metals, inorganic salts, pharmaceuticals & personal care products (PPCP's), cleaners, paints, auto wastes, petroleum hydrocarbons, PAH's and more, hence the need to prevent it from contaminating drinking water sources.

Sewage The closest source of treated sewage effluent to the North basin is Vernon Creek where City of Vernon's excess effluent can be disposed of, particularly in winter when the opportunity for spary-irrigation is limited. Volumes from their Biological Nutrient Removal (BNR) plant can reach 27 megaliters/day but are generally much lower. The risks are moderated by two factors; the BNR plant produces a very clean effluent and there are fewer water users at Killiney Beach and Westshore Estates during the winter. City of Vernon plans to conduct modelling on the effluent plume travel within Okanagan Lake.

Septage Septage is the mixture of sludge, fatty materials, and wastewater present in septic tanks. It is periodically pumped out by licensed companies. The concentrations of possible pollutants are high in septage and includes disease-causing organisms, nutrients and grease (Crist et al., 1996). Trucking this material along Westside Road presents a risk of spills.

There is currently no sewer service to either Killiney Beach or Westshore Estates. They both have about 300 homes adjacent to the lake. It is unlikely that all residents know how to avoid shocking their septic systems, so effluent quality will be variable. The number of homes on the more advanced package treatment plants is not known. IHA may have records or each building permit could be reviewed by RDCO. As with most jurisdictions, an evaluation of the cumulative impacts has not been attempted. Septic pump-out effluent is trucked to the Lake Country facility.

The volume of water that flows into an average septic tank is on the order of 140 to 150 gallons per day per person and it moves through the soil to the shoreline. Soil adsorption in an effective septic field is typically able to reduce soluble organic carbon, ammonia, but only about 25-50% of the phosphorus load and minimal removal of PPCP's or complex chemicals. Greater septic field efficiencies (80-90%) were observed during the late summer and early fall, when the unsaturated depth of soil was the greatest (Crist et al., 1996). Many of the lakeshore residences are not used in the winter in the North Westside, minimizing the loading during the period where septic treatment is challenged. However, many of these residences are being re-developed as permanent residences.

Further problems with lakeside septic systems occur during high water (June – July), and as many as one-half of all septic tanks in operation do not function correctly (Crist et al., 1996). Although flooding on Okanagan Lake is rare, it can occur in June and July and it could increase the impact from septic fields or informal disposal sites at farms or residences. More modern package treatment plants can produce a cleaner effluent and may be the best choice for properties with septic fields within 30 m of the lakeshore.

The threat from human sewage/septage in the vicinity of the RDCO North Okanagan intakes is not known. There are about 300 septic systems in service at Killiney Beach with an additional 86 lakeshore residences and 336 systems near the Westshore Estates with an additional 92 lakeshore residences within 2 km of the intake. They will almost certainly enrich the subsurface drainage with nutrients and chemicals, but pathogen contamination is less likely. Chlorides are found in high concentrations in wastewaters, so they can be used as a tracer for septic intrusion into the intake areas (Canter & Knox, 1985).

Properly functioning fields should not release pathogens but they will release nutrients and pharmaceuticals / personal care produ*cts* (PPCP's) to the ground water or subsurface flow. Recent research has shown that wastewater treatment plants and septic systems only partially remove pharmaceuticals at best*,* so these chemicals end up in ground water and have been measured in adjacent rivers and lakes (Knox County, ND). Improperly functioning septic systems will allow even greater concentrations of PPCP's to pass as well as microbial contaminants. Septic system contamination can severely impact surface and ground water (USEPA, 2007). The greatest concern is old septic systems located near Okanagan Lake.

Another potential source of septage is improper disposal from houseboats, yachts and cabin cruisers. Numerous complaints of improper houseboat sewage disposal have been reported, including human feces washing up on shore (J. Drought N. basin lakeshore owner, pers. comm.).

The potential human health risks associated with minute levels of PPCP's in drinking water is still being determined, while the impacts on invertebrates and higher trophic levels can be severe (Brett, pers comm 2010). Until more is known, there is much the public health and environmental protection community can do to educate the public about the best practices concerning the use and disposal of PPCP's, thus protecting drinking water sources (Ground Water Foundation N.D.; Reemtsma et al., 2003). For example, in BC, unwanted pharmaceuticals can be returned to any pharmacy for proper disposal. Under no circumstances should these materials be flushed down the toilet. Antibacterial soaps should not be used. They will harm the septic process and can damage beneficial bacteria in Okanagan Lake sediments (Halden, 2008).

2.3.12 Tri-halomethane Formation Potential

Trihalomethanes (THM's) are generated when combinations of total organic carbon, water temperature, contact time and chlorine dose are high (Larratt, 2007). There are many Okanagan water supplies that do not meet the THM criteria. THM's are higher during the summer months with high microflora production than they are in the winter months with low production. Almost all of the THM produced in the distribution system was chloroform ($CHCl_3$) because chlorine reacts with organics in the water.

Total THM's are monitored in March and September annually in the Killiney Beach and Westshore Estates distribution systems. The guideline for Canadian Drinking Water has an Interim Maximum Acceptable Concentration (IMAC) of 100 ug/L (0.100 mg/L). The IMAC has been met in all sampling to date with one exception – a reading of 0.12 mg/L TTHM on September 27, 2011 at Killiney Beach (Appendix 1). The typical readings at both

intakes ranged from 0.017 – 0.046 mg/L TTHM. A cyanobacteria bloom would substantially increase THM's and may account for the one exceedence.

2.3.13 Biofilm Development

Warm lake water rich in organic material will develop biofilm in a distribution system. Biofilms in distribution pipelines contain a build-up of precipitated minerals, organic material and microorganisms (bacteria, fungi, yeasts). Biofilms are dislodged from pipe walls during periods of high flow. Most Okanagan water supplies develop biofilms during the summer when the warmer water accelerates bacterial growth. It is virtually impossible to avoid biofilm entirely, and is one reason why water suppliers maintain chlorine residuals in their pipelines.

Because the RDCO North Okanagan intakes are both shallow, they would be expected to draw warm epilimnion water during the summer, ranging from 13 - 20 ^{o}C while the maximum summer temperatures ranged from 20-24 ^{o}C. The temperatures within the distribution system would be unlikely to meet the 15 ^{o}C CDWG guideline from late May to late September at the Killiney Beach system, and even longer at the shallower Westshore Estates (Table 4.1). Additionally, both systems have high accumulation rates of sediment and organics coming in with the lake water. These materials will "feed" biofilm. Moving to a deep intake would reduce water temperatures and reduce biofilm growth. Currently, twice annual water main flushing reduces the biofilm development within both distribution systems. Additionally, a deeper intake with better clearance should entrain less sediment and organic material.

3.1.4 Moorage, Docks and Powerboat Recreation

Boat traffic on Okanagan Lake increases the contribution of petroleum hydrocarbons including PAH's, motor oil, gasoline and lubricants via exhaust emissions. The boat traffic near both Killiney and Westshore Estates intakes can be intense during July and August. Most shoreline homes have a dock, and one dock per property is allowed in the rural Westside area. The approval process for private docks is not under the jurisdiction of RDCO. Rather, it is through MFLNRO and their Private Moorage Guidelines, found at: http://www.for.gov.bc.ca/Land_Tenures/crown_land_application_information/program_areas.html
Provincial moorage guidelines can be found at:
http://www.env.gov.bc.ca/wld/documents/bmp/BMPSmallBoatMoorage_WorkingDraft.pdf
The Large Lake Protocol "zone(s)" in front of the foreshore in question can be found at:
http://www.env.gov.bc.ca/okanagan/esd/ollp/documents/Foreshore-protocol-May2009.pdf

Operating and mooring power boats can have a significant effect on adjacent areas of Okanagan Lake. A liter of gasoline can contaminate 750,000 to 1,000,000 liters of water (Envi. Canada, 2010). Accidental spills during refueling are a key source of petroleum hydrocarbons to lakes and they can accumulate in the sediments near docks, moorage, boat launches and marinas. Low viscosity fuels such as gasoline can spread rapidly and dispersion is dependent upon water temperature and turbulence. Evaporation is less effective on heavier petroleum hydrocarbons but remains the single most important weathering process in the first few days following a spill that is not cleaned up appropriately (Wang and Stout, 2007).

The potential problem presented by petroleum hydrocarbons to the KB and WE intakes are currently low, with contamination most likely during the power boating season. Currently, a site for the Killiney Beach Fire boat is being sought by RDCO that would keep the moorage out of the intake protection zone.

Another potential source of boat contamination is waste water. Improper "black water" (sewage) disposal from houseboats, yachts and cabin cruisers can occur on Okanagan Lake. In BC, grey water is routinely discharged from these boats. Grey water contains detergents, dyes, personal care products and can contain heavy bacterial loads comparable to domestic sewage (MoE, 2010). A 2008-09 study funded by MOE and Interior Health on Shuswap Lake, "…indicated that the presence of houseboats is correlated to the chance of detecting fecal coliforms that grey water discharges contribute endocrine disruptors to the lake and houseboat discharges are a consistent source of fecal bacteria." These problems led the BC Ministry of Environment to implement a phased-in compliance with the provincial Environmental Management Act Sec. 13 which prohibits the discharge of both black and grey water from any vessel into any inland or coastal marine water.

The concerns presented by a marina on Okanagan Lake must be weighed carefully against the benefits and include:

- Increased introduction of petroleum hydrocarbons during normal motor operation and potentially by accidental spills;
- Increased use of Okanagan Lake with boats equipped with on-board septic holding tanks that do not retain grey water;
- Seasonal pump-out stations at marinas or the collection system that service them can fail. For example, the August 14, 2009 raw sewage from the RDCO system near the Westbank Yacht Club spilled into Gellatly Bay, Okanagan Lake. Storm water deluged a manhole and overflow of storm water and raw sewage flowed into the lake for 45 minutes (Appendix 1).

In addition to posing a potential threat to water quality at the North Okanagan intakes, motorized boating has led to unauthorized camping, dumping of refuse and establishment of "party sites". The remote North Westside location has limited the number of these problem areas.

A final problem presented by vessel traffic is the large wake wave disturbance that can churn up sediments, accelerate shoreline erosion and create sediment plumes that travel along the lake bottom towards deeper water.

3.1.5 Adjacent Land Use

Land use within several hundred meters of the Okanagan Lake shoreline has a greater potential to impact water quality than land use not directly connected to the lake. Fortunately, there is no industrial land use and limited commercial land use on the periphery of the North Basin of Okanagan Lake. Near-shore land use is dominated by: residential/cottage use with large areas of forage behind the cottages on OIB lands (Figure 3.1, 3.2).

RDCO considers the Okanagan Lake shoreline to be environmentally sensitive, and these areas have been identified as Development Permit Areas and restrictions are

placed on the use of land within these areas. The OCP states: “Before development, including subdivision, construction and land alteration can occur within a Development Permit Area (DPA), a Development Permit must first be approved. The Aquatic DPA includes as a minimum a 30 m buffer to Okanagan Lake and watercourses, though a broader area may be identified to recognize other sensitive riparian areas (Figure 3.3). Prior to development occurring within the Aquatic a DPA, a leave-strip is to be identified by a Qualified Environmental Professional (QEP) in an Environmental Impact Assessment. The leave-strip is to be left undisturbed or if previously disturbed, to be restored with native vegetation. Development that would be allowed, subject to the QEP recommendations include: access to the lake, domestic water supply (i.e. water line intakes), and works and plantings to control erosion, protect banks, protect fisheries or waterfowl habitat or otherwise preserve and enhance the watercourse and associated habitats. The Rural Westside OCP Bylaw No 1274 (2010) identifies minimum leave-strips through identification of shoreline sensitivity rating zones. In front of Westshore Estates, there is currently an orange zone with a minimum 20 m leave-strip while there is a minimum 15 m leave-strip in front of Killiney Beach). There are also Sensitive Terrestrial DPAs identified for which an environmental assessment would also be required to identify and mitigate potential impacts on the environment, including water quality (Figure 3.4) (M. Bakelaar, 2012).

The proposed new figures 3.3 and 3.4 would be the Aquatic DPA and Terrestrial DPA. Links provided – though the data can also be provided.
http://www.regionaldistrict.com/docs/planning/RuralWestOCP/RuralWestsideOCP_AquaticDPMaps.pdf

http://www.regionaldistrict.com/docs/planning/RuralWestOCP/RuralWestsideOCP_SenstiveEcoDPMaps.pdf

The OCP future land use designations and Zoning Bylaw zones help define shoreline use. For example, the in front of Westshore Estates, the area is designated in the OCP as Commercial Resort and zoned C5 – Campground, cabin and Motel Commercial. This information can now be found on the public GIS (updated) system.
http://www.rdcogis.com/GIS_App/RDCO_GIS_App.html

Shoreline Properties Shoreline properties have the highest potential to impact the lake. The shoreline near the intakes is extensively developed as shoreline residential. A further 0.7 km is developed as beach (Figure 3.1). The residential properties further back from the water also increase the amount of impervious surface with roads and roofs, generating storm water. Lakeshore owners should be encouraged to preserve a shrub greenbelt between their properties and the lake to intercept drainage. It is illegal to modify the natural shoreline without a permit because of its protective value and fisheries value, but unfortunately, this is a frequent occurrence in the Okanagan. Best practices management of properties within the Intake Protection Zone is more important to the RDCO intakes than management of properties remote from the intake, but all are important.

Overland flow from these properties is the most serious, followed by subsurface drainage which is slower and offers in-situ treatment and attenuation. Both of these routes for contaminant travel are non-point source and are unlikely to measurably impact the intake water quality. However, overland flow and ground water contamination both

contribute incrementally to the contaminant and nutrient loads reaching the lake. Although shoreline flooding is rare on this regulated lake, it is not wise to store toxic or high nutrient materials near or below the high water mark.

Shoreline Disturbance and Land Use - Killiney Beach Killiney Beach Service area is 135 ha. The shoreline impact was deemed moderate or 10-40% during the FIM process (Schleppe, for Ecoscape, 2011), Ecoscape documented 80+ docks and 8+ private boat launches within a few kilometers north of the intake, Killiney Beach Park has a public boat launch immediately adjacent to the pumphouse (15 m north of the intake pipe). To the north, it also has Killiney Beach Park that has been left in a semi-natural state. Norris Creek discharges into Okanagan Lake, 94 m south of the intake.

Shoreline Disturbance and Land Use - Westshore Estates Westshore Estates service area is 128 ha. The shoreline impact was deemed high or >40% during the FIM process (Schleppe, for Ecoscape, 2011), Ecoscape documented numerous docks, 4 private boat launches and 3 groynes along Westshore Estates, as well as 11 launch sites and 3 more groynes in the strip development immediately south of Westshore Estates. The density of cottages and lakeshore homes was high with 80+ cottages densely packed into 2 km immediately north of Westshore Estates. Immediately south of the WE intake, the Evely Forestry Recreation Campsite was recently developed on crown land that is a legally designated recreation site under Section 56 of the Forest and Range Practices Act., with 50 lakeshore campsites with small “private” beaches, accessed by a road within 30 m of the shoreline. Because this is not a Provincial campsite, it is equipped with only two pit toilets both of which are an inadequate 30 m from the shoreline (distances est. from Google Earth).

Although localized shoreline modification has the greatest potential to degrade water quality at the shallow North Basin RDCO intakes, development activities around the North Basin are also important. FIM results indicate that change along the Okanagan shoreline is potentially occurring at rates of 1 to 2% per year and could mean substantial change over the next few decades (Schleppe, 2011).

Much of the remaining 125 km of natural shoreline along Okanagan Lake occur in rural areas such as the North Westside that are prone to future development. It is fortunate that the Rural Westside OCP Bylaw 1274 (Dec 13, 2010) states that …”the North Westside is likely to continue as a rural area with limited community services and infrastructure.” Observing all of the shoreline management guidelines and BMP’s for shoreline development will also help with water quality protection even though that is not their immediate goal. In general, development is to reflect the objectives and guidelines of the Best Management Practices produced by the Province of BC, as well as local government guidelines, including but not limited to the following list:

- Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia, March 2006.
- Standards and Best Practices for Instream Works, March 2004.
- Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia, July 2009.
- Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia, November 2004.
- Best Management Practices for Installation and Maintenance of Water Line Intakes, July 2006.
- Best Management Practices for Lakeshore Stabilization, July 2006

- Best Management Practices for Tree Topping, Limbing and Removal in Riparian Areas.
- Best Management Practices for Small Boat Moorage on Lakes, July 2006.
- Homeowners Firesmart Manual: BC Edition.
- Riparian Factsheet: Agricultural Building Setbacks From Watercourses in Farming Areas, February, 2011, Order No. 823.400-1
- Central Okanagan Lake Foreshore Plan (2007)
- Rural Westside Official Community Plan (2010) – Development Permit Provisions
- Zoning Bylaw No 871 – Floodplain Regulations
- Foreshore Inventory and Mapping and Aquatic Habitat Index: The Okanagan Lake: A Compilation of the North, South and Central Okanagan Lake report (2011).

Parks and Beaches Parks can release fertilizers and pesticides to the lake via storm water or through seepage to ground water (Envi Canada, 2010). The RDCO parks department reports that the Killiney Beach Park and Westshore-Fintry parks have no pesticide use, no geese problems and no milfoil harvesting. No fertilizer is applied to these park properties.

Roadways Westside Road, subdivision roads and private lanes concentrate stormwater with its range of contaminants. Chloride is an urban storm water contaminant that is contributed primarily by winter road salting and salt storage (Baker, 2007). Magnesium chloride may be applied for dust suppression in the summer on dirt roads. Chloride anions and the cations of sodium and magnesium are contributed. Although no sampling results are available for this area, chloride concentrations in Okanagan Lake are climbing (MoE database, 2011).

2.2.5 Sodium and Chloride

Although sodium and chloride occur naturally in lakes, the presence of dissolved sodium and chloride give an indication of animal, human, and storm water impact on a lake system. Road salt is typically the largest human source of chloride to a lake (Wetzel, 2001), followed by sewage and agriculture. In the case of Okanagan Lake, sodium and chloride concentrations are slowly increasing but remain far below the drinking water guidelines (Ashley et al., 1998; Sokal, 2011). For example, the 2010 – 2011 RDCO North basin intake samples ranged from 9.9 to 12.8 mg/L sodium and 5.93 – 6.34 mg/L chloride.

2.2.6 Metals and Pesticide Scans

Annual spring A-to-Z metals scans are completed by RDCO on the north intakes from Okanagan Lake, and to date, no metals exceeded the CDWG maximum acceptable concentration or the aesthetic objective (RDCO records).

MoE conducts pesticide sampling on Okanagan Lake using rainbow trout muscle tissue. Both mercury and DDT have declined sharply from 1974 to 1988, as a direct result of bans on DDT and mercury-bearing pesticides (Bryan and Jensen, 1996).

3.1.6 Vandalism and Accidental Introductions

Deliberate spills into Okanagan lakes through ignorance or spite have occurred in Kelowna (Appendix 1). For example, several 20 gallon pails of hydraulic oil and motor oil were deliberately spilled into Okanagan Lake near the Poplar Point intake in 2009, necessitating an expensive clean-up. While vandalism can be difficult to predict and

control, obvious hazardous targets such as fuel storage or portable outhouses should be protected. The impact of human activity to Okanagan Lake is dependent upon the behavior of all residents and users.

Accidental introductions of invasive aquatic species is increasing in BC with boats on trailers and boating/fishing equipment as the most common transmission vector from region to region (O'Neil, 1993; Larratt, 2011). Of these, the species with the most potential to harm Okanagan Lake source water is the *Dreissena* zebra and quagga mussels. They have rapidly spread throughout North America from the initial infestation in the Great Lakes during 1986-8. Numerous boats infested with these mussels have been detected and turned back at the BC-Washington border in 2011 and 2012. Some authorities feel it is a question of when they arrive in the Okanagan, not if.

In addition to adults that can survive for weeks out of the water, the microscopic mussel larvae or "veligers" are easily transported from infested waters in ballast water and on boats and gear (Mills et al., 1996). These mussels are notorious for their tendency to colonize water intake pipelines, boat hulls and docks in layers up to 15-60 cm thick (O'Neil, 1993). Zebra mussels can attach to intake pipes at water flow velocities of up to 2 m/second (O'Neil, 1993). The *Dreissena* invasion has resulted in drastic changes to the ecology of infested lakes and rivers. In North America, it is causing annual multi-million losses to the economy (USGS, 2002), estimated at 140 million per year in the Great Lakes region during 2007 (Pennsylvania Sea Grant).

Pre-chlorination has been the most common treatment for control, but if this method is used to control both zebra and quagga mussels, the amount of chlorine used may reach hazardous levels to sensitive lake organisms (Grime, 1995). Mussel larvae can be killed in the laboratory after just a few hours using copper exposures of 0.02 mg/L copper ion while killing most of the adults with the algaecide required 96 hours of continuous exposure to 2 mg/L and that copper dose would likely have unintended ecological impacts (Kennedy, 2002). Potassium ions and hot water are two other effective controls in use in North America. Since these mussels have not yet reached Okanagan Lake, no action is currently required, however, intake upgrades should bear *Dreisenna* in mind. Both intakes would have to be extended to 40 m or treatment added at the intake mouth to prevent contamination.

Tables 3.1 through 3.4 summarize Module 2 into Contaminant Source Inventory Tables for the Killiney Beach and Westshore Estates Intakes

Table 3.1 SUMMARY MODULE 2: Contaminant Source Inventory: Killiney Beach

Contaminant Source and Type	Owner/ Jurisdiction	Location	Distance to intake	Possible Contaminants	Contaminant Transport Mechanism	Comments
Inflows						
Creek plumes	n/a	Shorts Whiteman Vernon Lambly	5.2 km 5.8 km 12.2 km 28.2 km	nutrients bacteria pathogens PAHs	currents seiches	plumes diluted at RDCO intakes
Norris Creek	n/a		94 m S	nutrients bacteria pathogens	long shore currents	direct impact in freshet
Flooding	n/a		188 m +	sediment nutrients pesticides	long shore currents	Most likely in June/July
Overland flow	n/a	many locations	diffuse	sediment pathogens fertilizers pesticides	currents	only in storms or freshet
Sewage						
Vernon effluent	GVU	Vernon Arm	12.2 km	sewage*	plume in currents seiches	dilution, de-activation of pathogens
Septic fields active or old, pkg tmt plants	various	Various private properties	200 m+	septage*	subsurface seepage	serious, but new pkg tmt plants may help
Storm Water						
Westside Road	MoH	W of intake	660 m +	PAH salt pathogens accidental spills;	infiltration seepage	Cl-, some PAH travel in seepage
Killiney ditched storm water	RDCO MoH	Entire subdivision	<100 m	Nutrients pesticides PAH salt bacteria	outfall(s) ditch seepage	outfalls should not occur in IPZ
Motorboat						
Motorboats	various		n/a	PAHs	currents	increasing use
Boat launches	RDCO		m	PAHs	currents seiches	many private 1 public launch
Land Use						
Beaches	RDCO	Killiney Beach	190 m+	Garbage, PAHs porta-pottie septage	currents seiches	*E coli* testing would determine potential impact
Shoreline residential	RDCO	nearest hm (55 hm in 2 km S; 31 hm in 2 km N)	280 m+	Pesticides fertilizers	long-shore currents	>32% of shoreline in North Basin
Near-shore subdivisions	RDCO	nearest hm (270 homes)	240 m+	fertilizers pesticides PAHs spills	currents	86 residences on shoreline
Agriculture	OIB RDCO	North Arm orchard	11.3 km+ 1.1 km	Sediment fertilizer pesticides	currents seiches	mostly in North Arm
Natural						
Waterfowl	BC	near shore, docks	n/a	pathogens	Currents, falling vertically	Can be antibiotic resistant
Cyanobacteria	BC	throughout	n/a	Cyanotoxins	seiches	greatest concern in July - Oct
Wildlife	BC	throughout	n/a	wildlife pathogens	currents	Low concern

Table 3.2 Summary MODULE 2: Hazard from Contaminants Identification Table: Killiney Beach

Contaminant Source / Type	**Possible Contaminants**	Existing Preventative Measures and Barriers	Possible Preventative Measures and Barriers
Inflows			
creek plumes	nutrients bacteria pathogens PAHs	riparian restoration studies are available	riparian restoration; storm water treatment and rainwater infiltration
Norris Creek	nutrients bacteria pathogens	Small amt of road run-off discharges to creek	protect, restore riparian vegetation within 85 m of creek where practical
flooding	sediment nutrients metals	Okanagan Lk flood controls	remove hazardous materials from flood-prone areas (paint,fuel,fertilizer)
overland flow	sediment pathogens fertilizers pesticides	Chlorine disinfection, SCADA	restrict pesticide use on near shore properties; discourage over-watering
Sewage			
Vernon effluent	sewage*	Spray irrigation, <27 ML/day discharge to lake	Divert to spray irrigation program
septic fields active or old	septage*	Bigger set-backs control new installations	educate septic field users about contaminants that can reach lake
Storm Water			
Westside Road	PAH salt pathogens accidental spills;	Ditches allowing infiltration	Road-side plantings, rainwater detention structures where appropriate
Killiney ditched storm water	nutrients pesticides petroleum products	Water system has SCADA, chorine	Rainwater harvesting for irrigation to limit ditch flows
Motorboat			
Motorboats	PAHs	None	Encourage non-motorized use; prohibit lake-side re-fuelling
Boat launches	PAHs septage holding tank	Rural location limits launch use	Have spill kit on hand; enforce proper fueling handling; education
Land Use			
Main Beaches	Garbage, PAHs stored septage	Beach garbage clean up as needed by RDCO	Discourage feeding birds with signs; manage garbage septage well
Shoreline residential	Pesticides fertilizers PAHs with docks	none	Limit docks, foreshore alterations; restrict pesticide use or ban
Near-shore Subdivision	fertilizers pesticides PAHs spills	none	Consider pesticide ban on all lakeshore properties and subdivisions
Agriculture – fruit, forage	fertilizer pesticides sediment	none	Shoreline “green belt” between fields and lake, creeks
Natural			
Waterfowl	pathogens	addling program	75+cm high fence to separate grass from shoreline
Cyanobacteria	cyanotoxins	emergency monitoring available as needed	limit nutrient discharges to lake; do riparian restoration on creeks
Wildlife	wildlife pathogens	riparian preservation	continued riparian preservation

Pesticides includes: herbicides, insecticides, fungicides, rodenticides, and avicides; Many pesticides are highly toxic and are mobile in sub-surface flows
PAHs includes: fuels, oil, grease, asphalt (auto wastes also include: transmission fluid, antifreeze, battery acid)
***Septage/sewage** includes: pathogens, organic matter, THM precursors, nitrates, nutrients, heavy metals, inorganic salts, pharmaceuticals, personal care products, cleaners, paints, medications, auto wastes, PAHs
Pathogens includes: bacteria, viruses, fungi, protozoan parasites

Table 3.3 SUMMARY MODULE 2: Contaminant Source Inventory: Westshore Estates

Contaminant Source and Type	Owner/ Jurisdiction	Location	Distance to intake	Possible Contaminants	Contaminant Transport Mechanism	Comments
Inflows						
major creek plumes	n/a	Shorts Whiteman Vernon Lambly	8.2 km 0.65 km 8.7 km 31.2 km	nutrients bacteria pathogens PAHs	currents seiches	plumes diluted at RDCO intakes
Flooding	n/a		160 m +	sediment nutrients pesticides	long shore currents	most likely in June/July
Overland flow	n/a	many locations	diffuse	sediment pathogens fertilizers pesticides	currents	only in storms or freshet
Sewage						
Vernon effluent	GVU	Vernon Arm	8.7 km	sewage*	plume in currents seiches	dilution, de-activation of pathogens
Septic fields active or old, pkg tmt plants	various	Various private properties	180 m+	septage*	subsurface seepage	serious, but new pkg tmt plants may help
Storm Water						
Westside Rd	MoH	W of intake	350 m +	PAH salt pathogens accidental spills;	infiltration seepage	Cl-, some PAH travel in seepage
Westshore road ditches	DoC	Several, see Fig 3.4	<100 m	PAH salt bacteria nutrients pesticides	outfall(s) ditch seepage	Outfalls should not occur in IPZ
Motorboat						
Motorboats	various			PAHs	currents	Increasing use
Boat launches	RDCO		m	PAHs	currents seiches	many private launches
Land Use						
Beaches	RDCO	Westshore-Fintry Beach	m	garbage, PAHs porta-pottie septage	currents seiches	*E coli* testing would determine potential impact
Shoreline residential	RDCO	nearest hm (81 hm in 2km N; 11 hm in 2kmS)	130 m	pesticides fertilizers	Long-shore currents	>32% of shoreline in North Basin
Near-shore subdivisions	RDCO	nearest hm (336 homes)	520 m+	fertilizers pesticides PAHs spills	currents	92 lots on shoreline
Agriculture – forage, fruit	OIB RDCO	North Arm vineyard	7.6 km+ 1.3 km	sediment fertilizer pesticides	currents seiches	mostly in North Arm
Natural						
Waterfowl	BC	near shore, docks	n/a	pathogens	currents, falling vertically	can be antibiotic resistant
Cyanobacteria	BC	throughout	n/a	cyanotoxins	seiches	most concern in spring, summer
Wildlife	BC	throughout	n/a	wildlife pathogens	currents	low concern

Table 3.4 Summary MODULE 2: Hazard from Contaminants Identification Table Westshore Estates

Contaminant Source / Type	**Possible Contaminants**	Existing Preventative Measures and Barriers	Possible Preventative Measures and Barriers
Inflows			
creek plumes	nutrients bacteria pathogens PAHs	riparian restoration studies are available	Riparian restoration; storm water treatment and rainwater infiltration
flooding	sediment nutrients metals	Okanagan Lk flood controls	Remove hazardous materials from flood-prone areas (paint,fuel,fertilizer)
overland flow	sediment pathogens fertilizers pesticides	Chlorine disinfection, SCADA	Restrict pesticide use on near shore properties; discourage over-watering
Sewage			
Vernon effluent	sewage*	Spray irrigation, <27 ML/day discharge to lake	Divert to spray irrigation program
septic fields active or old	septage*	Bigger set-backs control new installations	educate septic field users about contaminants that can reach lake
Storm Water			
Westside Road	PAH salt pathogens accidental spills;	Ditches	Road-side plantings, rainwater detention
Westshore road ditches	nutrients pesticides petroleum products	Water system has SCADA, chorine	Rainwater harvesting for irrigation to limit ditch flow
Motorboat			
Motorboats	PAHs	None	Encourage non-motorized use; prohibit lake-side re-fuelling
Boat launches	PAHs septage holding tank	Rural location limits launch use	Have spill kit on hand; enforce proper fueling handling; education
Land Use			
Beaches	Garbage, PAHs stored septage	Beach garbage clean up as needed by RDCO	Discourage feeding birds with signs; manage garbage septage well
Shoreline residential	Pesticides fertilizers PAHs with docks	none	Limit docks, foreshore alterations; restrict pesticide use or ban
Near-shore Subdivision	fertilizers pesticides PAHs spills	none	Consider pesticide ban on all lakeshore properties and subdivisions
Agriculture	fertilizer pesticides sediment	none	shoreline “green belt” between fields and lake, creeks
Natural			
Waterfowl	pathogens	addling program	75+cm high fence to separate grass from shoreline
Cyanobacteria	cyanotoxins	emergency monitoring available as needed	limit nutrient discharges to lake; do riparian restoration on creeks
Wildlife	wildlife pathogens	riparian preservation	continued riparian preservation

Pesticides includes: herbicides, insecticides, fungicides, rodenticides, and avicides; Many pesticides are highly toxic and are mobile in sub-surface flows
PAHs includes: fuels, oil, grease, asphalt (auto wastes also include: transmission fluid, antifreeze, battery acid)
***Septage/sewage** includes: pathogens, organic matter, THM precursors, nitrates, nutrients, heavy metals, inorganic salts, pharmaceuticals, personal care products, cleaners, paints, medications, auto wastes, PAHs
Pathogens includes: bacteria, viruses, fungi, protozoan parasites

4.0 Okanagan Lake Intake Module 7: Risk Characterization and Analysis

The intent of Module 7 is to connect the contaminant hazards identified in Modules 1 and 2 with an evaluation of the existing source protection and water treatment barriers. The focus of this report is on the Okanagan Lake North Basin water source itself. Module 7 uses the following set of tables to assign risk.

Table 4.1: Module 7 Hazard and Risk Tables

Qualitative Measures of Hazard

Level of Risk	Descriptor	Description	Probability of occurrence within next 10 years
A	Almost certain	Is expected to occur in most circumstances	>90%
B	Likely	Will probably occur in most circumstances	71-90%
C	Possible	Will probably occur at some time	31-70%
D	Unlikely	Could occur at some time	10-30%
E	Rare	May only occur in exceptional circumstances	<10%

Qualitative Measures of Consequence

Level	Descriptor	Description
1	Insignificant	Insignificant impact, no illness, little disruption to normal operation, little or no increase in operating cost
2	Minor	Minor impact for small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs
3	Moderate	Minor impact for large population, mild to moderate illness probable, significant modifications to normal operation but manageable, operating costs increase, increased monitoring
4	Major	Major impact for small populations, severe illness probable, systems significantly compromised and abnormal operation if at all, high level of monitoring required
5	Catastrophic	Major impact for large population, severe illness probable, complete failure of systems

Qualitative Risk Analysis Matrix

Likelihood	**Consequences**				
	1 Insignificant	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
A almost certain	Moderate	High	Very High	Very High	Very High
B likely	Moderate	High	High	Very High	Very High
C possible	Low	Moderate	High	Very High	Very High
D unlikely	Low	Low	Moderate	High	Very High
E rare	Low	Low	Moderate	High	High

Risk Characterization and Analysis The same potential hazard occurring outside the IPZ was given a lower risk rating than the same hazard occurring within the IPZ where there would be less dilution and less time for RDCO to react. Tables 4.2 and 4.3 summarize the hazards and assign a risk level based on likelihood and consequence of each hazard, along with existing and proposed improvements to the barrier(s) guarding the RDCO North Basin Intake systems. For ease of assessment, the hazards have been grouped by typical source.

Seasonal Variation in Hazard and Risk Analysis The largest variation in the risk of hazards presented to the North Basin intakes is affected by the thermal conditions within Okanagan Lake. The possible contaminant distribution will be very different during the stratified portion of the year (May – October) versus the freely mixing portion (Nov – Apr). Please refer to section 2.2 for more information.

If contaminants are suspended in the surface water during the stratified season, the intake is protected because the surface water layer is buoyant and does not mix with the deeper cold water at the depth of the intake. However, even in the summer, a wind event can tip the water layer (a seiche)s and deliver surface water to the intakes, particularly because they are shallow. As intakes increase in depth, they become progressively better protected from seiches. The Killiney Beach at 9.3 m and Westshore Estates intakes at 7.7 m are regularly subject to seiches of varying intensity during the stratified season. They are therefore not immune to a potential contaminant in the surface water layer.

If contaminants are heavier than the density of the surface water layer, they will drop until they reach the depth that matches their density or they settle at a rate determined by their density, particle size, water temperature, etc. If a contaminant enters Okanagan Lake that plunges to the deep water layer during the summer, it will be confined there and the potential dilution of the surface water layer volume is not available.

During the late fall, winter and early spring, Okanagan Lake is freely mixing. No thermal barrier protects the intake from buoyant contaminants, but more dilution is potentially available.

Water currents in the North Basin of Okanagan Lake are primarily wind-driven. Windy weather develops most often in March to June, with average wind speeds of 9 – 13 km/hr (WindFinder, 2011). Average water travel will be fastest during these months, however severe wind storms can develop in most months. Potential transport of surface contaminants via water currents will be fastest in March to April, prior to lake stratification. Faster transport can theoretically minimize dilution. For example, modeling in Okanagan Lake forecasted dilutions as low as 480:1 for a creek plume travelling 8 kilometers in 2 days (Hospital et al., 2011).

Recommendations for mitigation of “high and moderate” risks found in the matrix tables below are presented in Section 5.1

Risk Characterization Table: MODULE 7 Part 1:

Table 4.2: Risks Inside Intake Protection Zone (IPZ) with the Potential to Impact the Killiney Beach Intake

(Recommendations for mitigation of "high and moderate" risks are presented in Section 5.1)

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Comments/ Assumptions
Inflows				
1 Sediment re-suspension	**B**	**1**	Mod	Sediment re-suspension is common but exerts minor impact
2 Long-shore current transport	**A**	**2**	High	Transport contaminants quickly over short distances; IPZ needs vigilance
2b Norris Creek plume	**B**	**2**	High	Sediment transport in creek plume likely reaches intake in freshet
3 Subsurface drainage, groundwater	**A**	**1**	Mod	Subsurface drainage can carry nutrients, metals, salts that report to the IPZ, pathogens are less likely to persist in active form
4 Flood	**D**	**2**	Low	Okanagan Lk controls prevent flooding in most years
Sewage				
5 Septic field seepage	**A**	**2**	High	Some seepage can be expected, most likely from old fields nearest lake
6 Yacht and house boats	**D**	**4**	High	Unlikely event but major impact expected when spill is within the IPZ
Stormwater				
7 Overland flow near intake	**B**	**2**	High	Overland flow may carry contaminants into IPZ
8 Ditched stormwater	**C**	**2**	Mod	Ditch seepage, drainage likely to conduct salt and may carry pathogens
Motorboats				
9 Waste, garbage spill	**E**	**3**	Mod	Depending on spill location and type, emergency response may be needed
10 Refueling chemical spill	**D**	**3**	Mod	Unlikely event with moderate impact expected when spill occurs within IPZ
11 Wake sediment suspension, erosion	**A**	**1**	Mod	Deep wakes near the intake can re-suspend sediment and accelerate shoreline erosion, creating plumes that can affect the shallow intake
Land Use				
12 Shoreline residential	**C**	**2**	Mod	Storing hazardous materials near high water line should not occur
13 Westside Rd	**D**	**3**	High	Chemical spill emergency possible, depends on density, toxicity, currents
14 Adjacent subdivisions	**C**	**2**	Mod	Subsurface drainage can carry pesticides, inappropriately stored chemicals
15 Beaches in front of intake	**C**	**3**	High	Disease-carrier swims at beach or beach-goer releases contaminant
Natural				
16 Geese, gulls, waterfowl	**C**	**1**	Low	These birds can carry pathogens that are difficult to medically treat
17 Cyanobacteria blooms	**B**	**2**	High	Chronic low-dose exposure to cyanotoxins >2000 cells/mL undesirable
18 Algae blooms	**C**	**2**	Mod	Algae increase TOC, THM precursors, odor, chlorine consumption
19 Sediment loading	**A**	**1**	Mod	Sediment loading not prevented because natural vegetation not present

Table 4.3: Risks Outside Intake Protection Zone (IPZ) with the Potential to Impact the Killiney Beach Intake

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Comments/ Assumptions
Inflows				
20 Sediment re-suspension	**C**	**1**	Low	Sediment re-suspension is common but exerts minor impact with dilution
21 Long-shore current transport	**C**	**2**	Mod	Transport contaminants over long distances, can remain concentrated
22 Creek plumes	**A**	**1**	Mod	Whiteman, Shorts Creeks have potential impact; Norris Ck has direct impact during freshet and possibly storms
23 Subsurface flows, groundwater	**A**	**1**	Mod	Subsurface drainage can carry nutrients, metals, salts that can be transported to the IPZ, with dilution
24 Flood	**D**	**2**	Low	Flooding along Okanagan Lake shore can increase contaminant load in plume
Sewage				
25 Septic field seepage	**B**	**1**	Mod	Seepage from cottages, homes probable, will be diluted before reaching IPZ
26 Yachts and houseboats	**C**	**2**	Mod	Unlikely event but impact may occur when spill occurs outside the IPZ
Stormwater				
27 Overland flow outside IPZ	**B**	**1**	Mod	Overland flow may carry contaminants into IPZ but will be diluted
28 Stormwater pathogens	**D**	**2**	Low	Large bacterial introductions possible, may reach IPZ when lake is mixed
Motorboats				
29 Launch hydrocarbon PAH spill	**D**	**2**	Low	Unlikely event with minor impact expected when spill occurs outside IPZ
30 Boat chemical, garbage spill	**E**	**2**	Low	Depending on spill location and type, monitoring may be needed
Land Use				
31 Shoreline residential	**B**	**2**	High	Storing/applying hazardous materials on property should be corrected
32 Westside Road spill	**D**	**3**	Mod	Chemical spill could be serious, depending on density, toxicity, currents
33 Adjacent subdivisions	**C**	**2**	Low	All Okanagan residents must protect the watershed; drainage would dilute
34 Beaches in front of intake	**D**	**2**	Low	Any pathogen introduction would be diluted and have a chance to settle
Natural				
35 Algae blooms	**C**	**1**	Low	Algae blooms can be transported rapidly around North Basin by currents
36 Cyanobacteria blooms	**B**	**2**	Mod	Concentrated cyanobacteria may travel in “water packet” or disperse
37 Geese, gulls, waterfowl	**C**	**1**	Low	Bacteria can be deactivated/consumed in the lake; cysts settle
38 Sediment loading	**C**	**1**	Low	Sedimentation is high in the N Arm with agriculture, creek plumes, currents

(Recommendations for mitigation of “high” risks are presented in Section 5.1)

Characterization Table: MODULE 7 Part 1:

Table 4.4: Risks Inside Intake Protection Zone (IPZ) with the Potential to Impact the Westshore Estates Intake

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Comments/ Assumptions
Inflows				
1 Sediment re-suspension	**B**	**1**	Mod	Sediment re-suspension is common but exerts minor impact
2 Long-shore current transport	**A**	**2**	High	Transport contaminants quickly over short distances; IPZ needs vigilance
3 Subsurface drainage, groundwater	**A**	**1**	Mod	Subsurface drainage can carry nutrients, metals, salts that report to the IPZ, pathogens are less likely to persist in active form
4 Flood	**D**	**2**	Low	Okanagan Lk controls prevent flooding in most years
Sewage				
5 Septic field seepage	**A**	**2**	High	Some seepage can be expected, most likely from old fields nearest lake
6 Yachts and house boats	**C**	**3**	High	Unlikely event but major impact expected when spill is within the IPZ
Stormwater				
7 Overland flow near intake	**B**	**2**	High	Overland flow may carry contaminants into IPZ
8 Stormwater off Westside Rd	**C**	**2**	Mod	Ditch seepage, drainage likely to conduct salt and may carry pathogens
Motorboats				
9 Chemical, garbage spill	**E**	**3**	High	Depending on spill location and type, emergency response may be needed
10 Refueling hydrocarbon spill	**D**	**3**	Mod	Unlikely event with moderate impact expected when spill occurs within IPZ
11 Wake sediment suspension, erosion	**A**	**1**	Mod	Deep wakes near the intake can re-suspend sediment and accelerate shoreline erosion, creating plumes that can affect the shallow intake
Land Use				
12 Shoreline residential	**C**	**2**	Mod	Storing hazardous materials near high water line should not occur
13 Westside Rd	**D**	**3**	High	Chemical spill emergency possible, depends on density, toxicity, currents
14 Adjacent subdivisions	**C**	**2**	Mod	Subsurface drainage can carry pesticides, inappropriately stored chemicals
15 Beaches /campsites	**C**	**3**	High	Disease-carrier swims at beach or beach-goer releases contaminant
Natural				
16 Geese, gulls, waterfowl	**C**	**2**	Mod	These birds can carry pathogens that are difficult to medically treat
17 Cyanobacteria blooms	**B**	**2**	High	Chronic low-dose exposure to cyanotoxins >2000 cells/mL undesirable
18 Algae blooms	**C**	**2**	Mod	Algae increase TOC, THM precursors, odor, chlorine consumption
19 Sediment loading	**A**	**1**	Mod	Sediment loading not prevented because natural vegetation not present

(Recommendations for mitigation of “high and moderate” risks are presented in Section 5.1)

Table 4.5: Risks Outside Intake Protection Zone (IPZ) with the Potential to Impact the Westshore Estates Intake

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Comments/ Assumptions
Inflows				
20 Sediment re-suspension	**C**	**1**	Low	Sediment re-suspension is common but exerts minor impact with dilution
21 Long-shore current transport	**C**	**2**	Mod	Transport contaminants over long distances, can remain concentrated
22 Creek plumes	**A**	**1**	Mod	Whiteman and Shorts Creek plumes have potential impact on WE intake particularly during freshet or summer storms
23 Subsurface flows, groundwater	**A**	**1**	Mod	Subsurface drainage can carry nutrients, metals, salts that can be transported to the IPZ, with dilution
24 Flood	**D**	**2**	Low	Flooding along Okanagan Lake shore can increase contaminant load in plume
Sewage				
25 Septic field seepage	**B**	**1**	Mod	Seepage from cottages, homes probable, will be diluted before reaching IPZ
26 Yachts and houseboats	**C**	**2**	Mod	Unlikely event but impact may occur when spill occurs outside the IPZ
Stormwater				
27 Overland flow outside IPZ	**B**	**1**	Mod	Overland flow may carry contaminants into IPZ but will be diluted
28 Stormwater pathogens	**D**	**2**	Low	Large bacterial introductions possible, may reach IPZ when lake is mixed
Motorboats				
29 Launch hydrocarbon PAH spill	**D**	**2**	Low	Unlikely event with minor impact expected when spill occurs outside IPZ
30 Boat chemical, garbage spill	**E**	**2**	Low	Depending on spill location and type, monitoring may be needed
Land Use				
31 Shoreline residential	**B**	**2**	High	Building/storing materials below high water line should be corrected
32 Westside Road spill	**D**	**3**	Mod	Chemical spill could be serious, depending on density, toxicity, currents
33 Adjacent subdivisions	**C**	**2**	Low	All Okanagan residents must protect the watershed; drainage would dilute
34 Beaches /campsites	**D**	**2**	Low	Any pathogen introduction would be diluted and have a chance to settle
Natural				
35 Algae blooms	**C**	**1**	Low	Algae blooms can be transported rapidly around North Basin by currents
36 Cyanobacteria blooms	**B**	**2**	Mod	Concentrated cyanobacteria may travel in “water packet” or disperse
37 Geese, gulls, waterfowl	**C**	**1**	Low	Bacteria can be deactivated/consumed in the lake; cysts settle
38 Sediment loading	**C**	**1**	Low	Sedimentation is high in the N Arm with agriculture, creek plumes, currents

(Recommendations for mitigation of “high” risks are presented in Section 5.1)

4.1 Condition of Source

Okanagan Lake provides excellent quality drinking water with no color, low hardness, and rare taste and odor events. It currently meets GCDWQ guidelines for raw source water. Okanagan Lake is not under the control of any one jurisdiction. Water quality relies on every resident and user of the resource. Low population densities and the absence of industrial uses help preserve water quality in the North Basin, however residential use including shoreline modification, sewage disposal and agriculture have the potential to degrade the resource. While slow degradation of the resource is far more likely, a sudden water quality disaster could occur. RDCO does not have the option of a back-up water supply, other than trucking in water for emergency use.

4.2 Physical Integrity of Intake, Treatment and Distribution System

Disinfection at the RDCO N- Basin intakes relies on chlorination. Chlorination is achieved with chlorine gas from 150 lb cylinders. It is monitored with on-line analyzers and routine bacterial sample collection. Like any water system, the distribution system is subject to aging, settling of suspended materials, accidental line breaks and cross-connections. On-going maintenance, repairs and monitoring are vital to any water distribution system. Operation and maintenance are scheduled as needed.

Maintenance involves routine reservoir cleaning, twice yearly line flushing and valve exercising. RDCO has two full-time operators with Level I, II, and backflow, chlorine handling certification. Operators must maintain certifications with annual accredited educational units. RDCO also retains a certified instrumentation technologist on staff. Bacterial monitoring is conducted by two trained and experienced water quality technologists.

4.3 Risk Assessment for Healthy and Health-compromised Individuals

On the whole, water quality from Okanagan Lake is excellent and meets the needs of healthy individuals. People with compromised immune systems could profit from another pathogen barrier such as boiling their drinking water. Based on existing monitoring of bacteria, protozoa and THMs, the risk posed by these materials is below the guidelines that usually have a ten-fold safety margin built into them.

4.4 Additional Treatment Options
4.4.1 Intake Extension

Shallow intakes are usually more vulnerable to surface water contamination than deeper intakes. Increased land development, aggregate mining or wildfires can impact water quality from the land, while seiches and the introduction of *Driessena* mussels can foul an intake from the water. Extending the intakes to 20 m or deeper provides protection from most impacts.

Table 4.6 Intake Extension information for Killiney Beach System:

Intake parameter estimates	9.3 m	20 m	30 m	40 m
Intake length (m)*	198	300	500	800
# of seiches over 2°C	40	23	8	4
Peak seiche temperature (°C)	19	18	12	9
Weeks over 15 °C	17-21	4	0	0
Temperature range	4-20.9	4-15	5-12	5-10
Within photic zone?	yes	rarely	no	no
Estimated algae density	1100-4800	1000-2300	1300-2800	800-2800
Susceptibility to mussels	Z & Q	Z & Q	Q	Q

* Actual engineered site and distance may vary Z=zebra mussels Q=quagga mussels

Table 4.7 Intake Extension information for Westshore Estates System:

Intake parameter estimates	6.6 m	20 m	30 m	40 m
Intake length (m)*	171	400	800	900
# of seiches over 2°C	45+	23	8	4
Peak seiche temperature (°C)	20	18	12	9
Weeks over 15 °C	19-22	4	0	0
Temperature range	3.5-23.9	4-15	5-12	5-10
Within photic zone?	yes	rarely	no	no
Estimated algae density	1200-3200	1000-2300	1300-2800	800-2800
Susceptibility to mussels	Z & Q	Z & Q	Q	Q

* Actual engineered site and distance will vary on 20 – 40 m estimates
Z=zebra mussels Q=quagga mussels

The largest disadvantage to extending intakes is their cost of installation. The distance to a >20 m depth is large, particularly at Westshore Estates. The small existing intake pipe diameter of 25.4 cm at Killiney Beach may dictate an entirely new intake pipeline. The current Westshore Estates intake pipe diameter of 45.7 cm may be sufficient to extend to 20 m by bolting onto the existing pipe. Should the need arise, RDCO Engineering staff could prepare a cost-benefit options analysis.

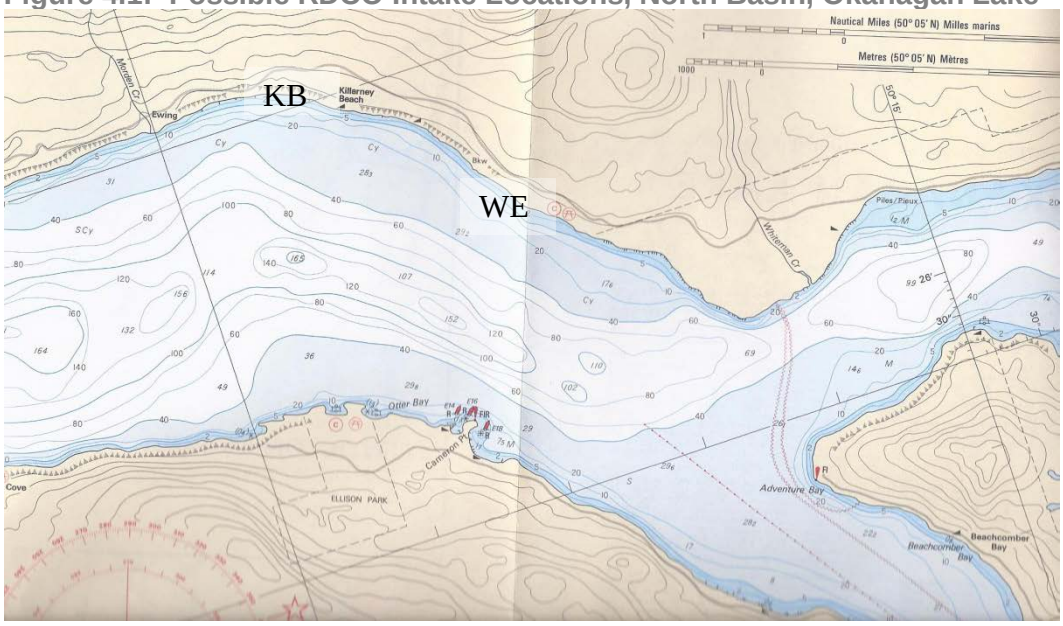
In summary, extending the current intakes to >20 m would allow:

- Theoretically lower risk of contaminants from land-based activities
- Fewer seiches, therefore reduced seiche impact and reduced transport of surface contaminants or contaminants re-suspended by seiche turbulence
- Maximum temperature deviation during a seiche would be lowered to >18°C from the current >20 °C
- Lower overall water temperature (4–15 °C instead of the current 3.5–20°C)

- Lower distribution system water temperatures would exceed 15 °C for >4 weeks instead of the current 17-22 weeks
- Possible lowering of turbidity, possible increased UV transmittance
- Lower algae density
- Lower total coliforms and possibly pathogens
- Opportunity to give intake better clearance from substrate (minimum 3 m vertically above substrate recommended vs current >1 m)

It is the task of water planners to determine the benefits of intake extension versus other capital improvements such as UV disinfection. Extending the intake may support RDCO's deferral of filtration applications. Deferring filtration allows RDCO to take advantage of on-going technological advances while still improving water quality in the interim under IHA's guidance. RDCO may also wish to investigate GUDI wells near the shoreline

Figure 4.1: Possible RDCO Intake Locations, North Basin, Okanagan Lake



Length (m) of Intake	20m Depth	30m Depth	40m Depth
Killiney Beach	300	700	1100
Westshore Estates	600	850	1050

NOTE: actual length will vary with engineering design

4.4.2 UV Disinfection

RDCO has the ability in-house to analyze UV transmissivity samples that can characterize the applicability of UV disinfection as a second disinfection process. Monthly UV transmissivity sampling for several years will capture the frequency of deviations from the typically excellent transmissivity of Okanagan Lake water. Twice monthly sampling would be better but only if that frequency is sustainable for years. If finances dictate the monthly, grabbing storm/wave events would be important. Sampling from proposed intake extension depths should also be monitored for several years.

4.5 Strength/Weakness Opportunities/Threats SWOT Analysis

A SWOT analysis provides a summary overview of the balance between the major positive and negative aspects of the RDCO N-Basin intakes. Only those aspects with the greatest potential to influence RDCO water quality at present and into the future are considered in Table 4.8.

Table 4.8: Strength/Weakness Opportunities/Threats Analysis Summary of the RDCO North Basin Okanagan Lake Intakes

Strengths	Weaknesses
▪ The large size and depth of oligotrophic Okanagan Lake helps maintains constant water quality in the main lake volume ▪ Low concentrations of cyanobacteria most of the year ▪ Dense urban areas are not close to the intakes; land use near IPZ is mainly low-density residential /cottages ▪ SCADA system including temperature, turbidity, chlorine residual, pH, flow with remote monitoring ▪ Chlorination for disinfection ▪ Water operators have appropriate training levels and training is on-going ▪ Appropriate IHA directed water quality monitoring is reported; ▪ 40+ years of water quality and limnology records by MoE and others ▪ FIM and SHIM mapping are completed for the North Basin ▪ RDCO has a WQ deviation response plan and an emergency response plan ▪ DP provisions are in place through OCP to protect the foreshore with leave-strips	▪ Intakes are shallow at 7.7 m and 9.3 m ▪ Intakes are <1 m from substrate, allowing significant sediment accumulation in the system ▪ The <10 m depth of the intakes provide some protection from surface contaminants but seiches regularly deliver surface water to the intake depth ▪ Intakes are shallow enough to be in the photic zone and they foul with algae growing on the screens ▪ Multiple private boat launches, docks, groynes and other shoreline modifications alters sediment transport near intakes ▪ Lack of RDCO control over activities near or in the IPZ ▪ Recreational and shoreline development pressures on North Basin are increasing ▪ No back-up water supply available ▪ Extensive use of septic systems
Opportunities	**Threats**
▪ Apply for License of Occupation or other designation over Intake Protection Zone from ILMB ▪ Encourage shoreline replanting ▪ Extending the RDCO intakes to >20 m + 3 m clearance would provide better water quality and be more remote from sources of contamination, but is expensive ▪ Encourage infiltration and rainwater capture for all residences ▪ Public Education about Okanagan Lk as a water source (get help from NGO's)	▪ Cyanobacteria counts can exceed 2000 cells/mL in the spring and may be increasing with climate change ▪ Increasing population pressures for lake recreation, particularly motorized craft ▪ Impact of septic systems is not known ▪ Impact of new package treatment plants is not known ▪ Inadequate enforcement of recreation polluters (houseboats, yachts) foreshore modification violations

FIM-Foreshore Inventory Mapping
SHIM – Sensitive Habitat Inventory Mapping

5.0 RDCO North Basin Okanagan Lake Intake Module 8: Recommendations

The summation of Modules 1, 2 and 7 lead to the recommendations to protect source water quality at the RDCO North Basin Okanagan Lake Intakes presented here as Module 8. All identified high-risk potential impacts to the RDCO intakes are addressed in these recommendations. The numbered hazards from Table 4.2 - 4.5 addressed by each recommendation are shown in the Risk box attached to each recommendation below.

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5.1 Source Protection Action Plan

The only items worth placing into a source protection action plan are those that can be realistically achieved both from a financial and practical standpoint. Improvements that provide the best cost-benefit for risk reduction are itemized below. Implementation of these recommendations will help support a deferral of filtration application to IHA. Additional protection measures intended to protect unimpaired areas are also provided. All of these recommendations require the co-operation of residents, recreators and developers. Most of the watershed lies outside of the jurisdiction of RDCO, restricting their ability to protect their source water. Similarly, lack of RDCO control over the North Basin Okanagan Lake limits the protection it can provide.

The following recommendations can be prioritized and applied to a timeline by staff and councils using SMART principles (Specific Measurable Achievable Realistic Time-bound). IHA and RDCO will work out the time line as they progress through the intake protection planning process. It is recommended that a stakeholder group be formed to work collaboratively to bring these recommendations forward. Municipal partners could develop terms of reference and invite stake-holders. BCWWA recommends, "Integrated watershed management plans should be implemented in all watersheds where water is taken for human consumption or planned for future human consumption and with urgency given where conflicting priorities exist."

5.2 High Priority Recommendations Based on Risk Rating

The following recommendations address at least one "high" risk rating as identified in Tables 4.2-4.5:

5.2.1 Cost benefit analysis of UV disinfection

Risk	Timeframe	Outcome
1 5 6 7 8 9 12 13	2012 onward	Selection of best possible gain in water quality by providing enhanced water treatment
Action 1	RDCO could complete a cost benefit analysis of UV disinfection. The cost of treatment is dependent upon UV transmissivity.	
Action 2	RDCO could direct staff to commence gathering UV transmissivity samples to be analyzed in-house, during regular sampling trips. Data should be gathered following the Guidelines for Canadian Drinking Water Quality exclusion criteria (e.g. at least 6 months of data for UVT and also: turbidity, cysts, total coliforms, *E. coli*, temperature).	

5.2.2 Install raw water sampling line on Westshore E. and Killiney Beach intakes

Risk	Timeframe	Outcome
1 2 5 6 7 8 9 11 12 16	2012 onward	More accurate water quality and bacterial sampling for raw intake water (currently bacterial samples are taken from a nearby dock)
Action 1	RDCO could direct divers to install a small (1/2") diameter sampling line on the next intake inspection/cleaning; it would be weighted, fed to the shore and buried to the pumphouse	

5.2.3 Cost benefit analysis of extending intakes (Westshore Estates is highest priority)

Risk	Timeframe	Outcome
1 2 5 7 8 9 10 12 17	2011 onward	Selection of best possible gain in water quality for the expenditure between intake extension and providing enhanced water treatment
Action 1	RDCO could complete a cost benefit analysis on intake extension to 20, 30 m or 40 m based on all available studies (with 3 m clearance from substrate); as well as investigating the GUDI (lakeshore well) option.	
Action 2	RDCO request IHA give credit for extending intakes in the bid for filtration deferral.	
Action 3	Begin growing season sampling at the prospective intake extension depths to ensure that water quality is sufficiently better to warrant the extension.	

5.2.4 Investigate options for the Intake Protection Zone (IPZ)

Risk	Timeframe	Outcome
5 6 12 13 14 15	immediate	Increased source protection by pre-empting or placing limits on future developments (e.g. marinas, house boat moorage) and also public education, spill prevention.
Action 1	RDCO could investigate applying to Front Counter BC for either a License of Occupation, or head-lease, or a License for Community Purposes over the Intake Protection Zone. NOTE: Staff at Front Counter BC indicated that, "ILMB would not be prepared to consider issuing tenures over large areas of Crown land foreshore or otherwise, to provide protection to water intakes or water quality" – Bernadette Aura, Natural Resource Officer, July 26, 2010, however, precedents exist for environmental reasons and houseboat exclusion (e.g. Peachland, City of Kelowna, District of West Kelowna, Westbank First Nation)	
Action 2	A letter outlining the IPZ area and its purpose/importance could be submitted to Front Counter BC with a formal request that any application to Front Counter BC within the IPZ be forwarded to RDCO for comment, regardless of the license application outcome.	
Action 3	RDCO consider methods to protect the IPZ in updates to the Rural Westside OCP and the Regional Growth Strategy.	
Action 4	In a future iteration of this report, a next step could include extending the intake protection zone to include land areas with flows that reach the IPZ within two hours (e.g. stormwater outfall; creek plumes).	

5.2.5 Adopt a decision tree for cyanobacteria blooms

Risk	Timeframe	Outcome
17	2012	A decision tree for cyanobacteria blooms would benefit RDCO because this is the most frequently encountered potential toxin source and RDCO has no alternate water source.
Action 1	Note increase in turbidity, or decreased chlorine residuals, or musty taste and odor	
Action 2	Collect 1 liter algae sample if a bloom is suspected.	
Action 3	If bloom is detected >2000 cells/mL of a toxin-producer, increase chlorine dose and take TTHM sample.	
Action 4	Post an advisory if >17,000 cells/mL of a toxin producer occur, take microcystin-LR sample and a more severe warning in the unlikely event that >50,000 cells/mL are detected.	
Action 5	Include a decision tree for cyanobacteria blooms in the emergency response plan for both water systems.	

5.2.6 Assess the impact of septage from lakeside residences and adjacent subdivision

Risk	Timeframe	Outcome
12 14	2011-13	Determine the impact and need for action on upgrading septic systems so appropriate policies can be developed to minimize septage impact on Okanagan Lake, particularly near the intakes.
Action 1	RDCO could implement chloride monitoring using existing wells, observation wells or near shore piezometers	
Action 2	RDCO could request appropriate septic facilities at Evely Forestry campsite to replace the two pit toilets that are within 30 m of lakeshore due to proximity of Westshore Estates intake* (MFLNRO has indicated a willingness to do a field inspection and to discuss options for re-location or replacement.	
Action 3	RDCO could mount an info campaign to educate shoreline property owners and Evely camp host on proper disposal of PPCP's, cleaners, antibiotic soaps in their septic tmt.	
Action 4	RDCO could contact lakeside owners to determine the maintenance, age and use of the septic systems and require pump-out at least every five years	
Action 5	MoE could extend periphyton sampling to the Killiney Beach/Westshore Estates area with an OBWB grant to determine the localized nutrient enrichment from septage by comparing to adjacent natural shoreline.	

5.2.7 Watershed control program

Risk	Timeframe	Outcome
12 13 14 15	Long-term commitment	Preserve and improve water quality entering North Basin; supports deferral of filtration
Action 1	RDCO could continue to work with municipal partners, the Okanagan Collaborative Conservation Program (OCCP) and OBWB to implement the recommendations of Foreshore Inventory and Mapping and Aquatic Habitat Index: "The Okanagan Lake: A Compilation of the North, South and Central Okanagan Lake report (2011)". The report recommendations are aimed at preserving and restoring natural habitats which assists the goal of the IHA-directed watershed control program. RDCO should also work with RDNO, RDOS, Okanagan First Nations and OBWB on the adoption of bylaws and best management practices that will help protect the water quality in Okanagan Lake, i.e., the "one watershed" concept.	
Action 2	RDCO could request assistance from the Drinking Water Officer on watershed issues on Crown land where it has no formal jurisdiction, particularly on the MFLNRO Evely camp site, due to its proximity to the Westshore Estates intake.	
Action 3	A ground water monitoring program using existing wells and perhaps monitoring wells would answer several outstanding questions on nutrient delivery to the lake, particularly seepage from septic fields. An OBWB grant could be applied for to cover this work.	

5.2.8 Bylaw to protect Okanagan Lake foreshore within RDCO jurisdiction

Risk	Timeframe	Outcome
12 15	immediate	Increased source protection
Action 1	RDCO in cooperation with the Province could consider adopting a “water zone” to define the use of foreshore for protection of the RDCO intakes. The RDCO Development Services could use other foreshore policies and BMP’s to draft enforceable (no-build, no-disturb) set-backs from the high water mark, recognizing the limitations of RDCO’s jurisdiction, perhaps modeled after Rural Vernon Bylaw 1708. RDCO may also wish to work with the Water Stewardship Council of OBWB to address local government land use tools for intake protection measures.	
Action 2	RDCO could consider incentives for repair of existing shoreline modifications on private property	
Action 3	RDCO could contact MFLNRO regarding the Evely campsite modification and use of shoreline, and regarding their camp access (within 20 m of lakeshore, within IPZ), road maintenance, boat launch signage encouraging responsible boating/refueling etc.	
Action 4	RDCO to complete the proposed Foreshore Structures bylaw to address the construction, siting, and use of docks and structures within the foreshore This action is in the foreshore plan.	

5.2.9 Public education

Risk	Timeframe	Outcome
9 10 11 5 6	On-going	Better voluntary control of contaminants to Okanagan Lake Prevent contaminants from reaching IPZ
Action 1	RDCO to provide public education through boat launch signage of the IPZ, including encouraging off-water refuelling and providing who-to-call after a spill would be beneficial at boat launches. Some signage is in place.	
Action 2	Public education through open houses, targeted mailings and other initiatives to encourage responsible public behaviour. For example, a directed mailer to shoreline owners could highlight their rights, ownership and responsibility, and explain best practises to protect the lake. It could show where their intake is in relation to their property. Mailer could be based on the information in Appendix 2	
Action 3	RDCO should ensure that dog feces collection bags are provided at their parks, and continue education for dog-owners regarding the costs of not collecting dog feces in RDCO parks (Appendix 3).	
Action 4	RDCO could upload this report to EcoCat for future reference by stakeholders and other interested parties. RDCO could also make this Source Assessment available on their water system webpage.	
Action 5	Also, the public should be educated on decontaminating their boat and equipment when moving from one lake to another. Decontaminating boats is smart maintenance and can be invaluable in protecting Okanagan Lake.	

5.2.10 Clean-up preparedness for a petroleum hydrocarbon or sewage spill into the North Basin

Risk	Timeframe	Outcome
10 2 13 7 8	Long-term commitment	Preventing petroleum or pathogen contamination within IPZ
Action 1	RDCO and other partners co-operate to provide a clean-up kit for a petroleum hydrocarbon (gas/oil etc.) spill into the North Basin. It could be stored at the Fire Hall or Fire Boat and/or at the boat launches and marina. Spills should be reported and cleaned up in accordance with the Spill Reporting Regulation (B.C. Reg.263/90).	
Action 2	RDCO could outline their concerns about risks to drinking water quality identified in this report and ensure that the local PEP team/ fire hall is equipped and trained to handle lake spills from all possible sources, particularly within the IPZ. (refer to RDCO emergency response plan.	
Action 3	RDCO may wish to consider encouraging non-motorized recreation by planning facilities that promote sailing, kayaking, canoeing, all of which have far less potential to impact intake water quality than motorized watercraft.	

5.3 Moderate Priority Recommendations Based on Risk Rating

The following recommendations address predominately "moderate" risk ratings as identified in Table 4.2 to 4.5.

5.3.1 Encourage designation of Shoreline Protected Areas or Aquatic Parks

Risk	Timeframe	Outcome
12 15	2011	Shoreline Protected Areas or Aquatic Parks could have a key role in the preservation of surface and ground water input quality into Okanagan Lake and also protect rare habitat.
Action 1	RDCO could apply to the Province to provide designated (or private) shoreline protected areas or aquatic parks for the dual purpose of protecting source water quality and protecting sensitive aquatic habitat. RDCO should consider a zero-tolerance policy to recreational or land development activities within its boundaries that have the potential to adversely impact water quality.	
Action 2	All regulations pertaining to aquatic protection should be vigorously enforced by RDCO staff.	

5.3.2 Overview of changes to RDCO Okanagan Lake shoreline

Risk	Timeframe	Outcome
12 15	Every 2-3 years	Knowledge of changes to aid planning, processing applications and compliance
Action 1	RDCO and/or a FIM consultant could prepare a date-stamped video survey of the North Basin shoreline within RDCO jurisdiction from a boat to provide a permanent record of shoreline change. A video of the area was done in 2004 and 2010 and they are used to review development applications. Surveys conducted every 2-3 years would capture any modifications made without permits and identify those with the potential to incrementally degrade water quality in the North Basin.	
Action 2	RDCO could also update the ortho photos on a regular basis (last done in 2009). As Google Earth Pro updates become more frequent and resolution improves, this will become an increasingly valuable tool.	

5.3.3 Semi-annual monitoring of septic and package treatment plants

Risk	Timeframe	Outcome
5 25	Every two years	Determine the efficiency of effluent treatment and pinpoint failing systems that could contaminate Okanagan Lake
Action 1	RDCO could require monitoring of effluent quality on package treatment plants beyond the current initial test to ensure stable and acceptable treatment, particularly on the shoreline lots.	
Action 2	RDCO could require submission of septic maintenance records from lakeshore properties and effluent sampling records from package treatment plants.	

5.3.4 Bylaw to prohibit multi-slip new marinas within the IPZ

Risk	Timeframe	Outcome
5 6 9 10 11	2011-12	Increased source protection by pre-empting future marina development and also spill prevention and development community education.
Action 1	RDCO, in cooperation with the province, could draft a Foreshore Structures Bylaw to specifically prohibit multi-slip marinas within the IPZ, particularly those designed for power boats and houseboats.	
Action 2	RDCO could notify the development community so they can devise alternates such as boat storage warehouses and valet service (cheaper insurance for owners).	

5.3.4 Discourage waterfowl and gulls on public beaches

Risk	Timeframe	Outcome
16	Long-term commitment	Preventing pathogen contamination within IPZ
Action 1	RDCO could erect signage discouraging waterfowl feeding. RDCO could contract garbage pick-up from the beach(es) and parking lots to help limit waterfowl feces contamination of the shorelines adjacent to the intake.	
Action 2	Regular garbage pick-up from the beach and parking lots will help limit waterfowl feces contamination of the public beaches adjacent to the intake (Appendix 3).	
Action 3	Encourage residents to provide barriers to prevent walk-on goose access to docks and to dispose of feces, not wash them into the lake.	
Action 4	RDCO continue to support the Okanagan Valley Goose Management Program that successfully implements an addling program.	

5.3.5 GIS mapping of North Basin Okanagan Lake

Risk	Timeframe	Outcome
12 15	Annual updates	Determines intake-land use conflicts; faster emergency responses
Action 1	RDCO could incorporate source water protection objectives into their current GIS systems and continue to update the GIS system as studies and information becomes available. Discussions with GIS staff could be initiated to determine what types of information should be entered into GIS, identify data gaps and enter data relevant to regional emergency response and the IPZ's.	

5.3.6 Information sharing

Risk	Timeframe	Outcome
2 4 17 18	On-going	Faster warning of algae blooms and turbidity spikes
Action 1	Share RDCO intake data with other Okanagan Lake water purveyors and with MoE and utilize the extensive MoE data base for Okanagan Lake water. This information exchange could prevent duplication of effort, and provide faster answers to water quality issues.	

5.3.7 Basin-wide issue partners

Risk	Timeframe	Outcome
12 16 17 18 19	Long-term commitment	Maintaining and improving Okanagan Lk water quality through agency co-ordination
Action 1	Reports and possibly meetings/presentations could be coordinated by the OBWB whose mandate includes facilitating integrated management of the Okanagan Lake watershed. These meetings should improve communication and reduce duplication of effort among water purveyors using Okanagan Lake.	

September 5, 2012.
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Appendix 1: Data Collected for RDCO N Basin Intake Source Assessment Supporting Documentation

Algae Data for Killiney Beach Intake July 2010 – July 2011

Algae samples in cells/mL **Killiney Beach**

2010 chlorinated 2011 Surface

		28-Jul	10-Aug	7-Sep	7-Oct	15-Nov	10-Dec	10-Jan	8-Feb	8-Mar	4-Apr	2-May	9-Jun	4-Jul	6-Sep
importance	**DIATOMS**														
	Amphora ovalis														
	Acnanthes spp.														
	Asterionella formosa									10	70	78	60	**30**	
	Campylodiscus sp.														
	Cyclotella	170	15	20	5	10		5	10		10	20	370	160	10
	Cymbella sp														
	Cymbella cistula.														
	Diploneis sp														
	Epithemia spp.														
	Fragilaria capucina				40							20		10	
	Fragilaria crotonensis			20			P		20		10	35		**20**	
	Gomphonema														
	Gyrosigma sp.														
	Melosira italica							40		**50**	**300**	**310**	**100**	**10**	
	Navicula spp.	70	20	10	10						10	10			
	Pinnularia gibba														
	Rapholodia gibba						P								
	Stauroneis														
	Surirella ovalis														
	Stephanodiscus niagarae	60						5			5	20			
	Synedra acus	20		10	20			10		10	40			20	
	Synedra ulna							5				20	50	10	
	Tabellaria fenestrata								5		30	30	30	10	
	YELLOW-BROWN ALGAE														
	Dinobryon spp.	260	40								30	210	320	40	
	Chromulina sp			10											
	Chrysochromulina sp.			5											
	Cryptomonas ovata			20	20										
	Kephyrion sp.														
	Mallomonas sp														
	Ochromonas sp.														
	Trachelomonas sp.											10			
	micro-flagellates			90	50			25	5		120	20		5	
	Large flagellates			15	20			5	5	30	10				20
	DESMIDS														
	Cosmarium spp.		40												20
	GREEN ALGAE														
	Closteriopsis longissima	20													
	Oocystis sp.	40	20								30		30		10
	Staurastrum	40												10	
toxin	**BLUE-GREEN ALGAE**														
X	Anabaena circinalis			80									15	115	
X	Anabaena planktonica			85	90										
X	Anacystis cyanea														
X	Aphanizomenon sp														
	Dactylococopsis sp							10			20				
	Gloeocapsa punctata		25	50											
	Gomphosphaeria sp	950		**250**									400	100	
X	Planktolyngbya limnetica	**275**			250	940	100	925		200				450	**2125**
	Limnothrix redekeii							13							
X	Oscillatoria sp. smooth/										**250**		**760**	**700**	
X	Planktothrix agardhii			**280**		275	200	75	655	275	**200**	**35**		100	
X	Pseudanabaena	**60**		**65**	195			14			45				
X	Synechocystis sp.														
X	Chroococcus/Synechococ	850	92		95				15				45	250	10
	DINOFLAGELLATES														
	Gyrodinium spp.														
	Peridinium sp. (large)		20												20
	OTHER														
	ciliates		30		5			5							
	bacteria	**L**	**L**	L	VL	VL	VL	**VL**	VL	VL	L	M	L	**L**	VL
	detritus	**M**	**M**	**L**	VL	VL	VL	VL	VL	**VL**	L	VL	L	**C**	VL
	silt	N	**N**	VL	**N**	VL	N	N	VL	**N**	N	N	VL	**VL**	VL
	SUM	2815	302	1010	800	1225	300	1137	715	575	1180	818	2180	2040	2215

N=none L=low C=common M=moderate H=high D=dominant

Significant algae count High algae count Very high algae count

Algae Data for Westshore Estates Intake July 2010 – July 2011

Algae samples in cells/mL **Westshore Estates**

2010 chlorinated 2011 Surface

		28-Jul	*10-Aug*	*7-Sep*	*7-Oct*	*15-Nov*	*10-Dec*	*10-Jan*	*8-Feb*	*8-Mar*	*4-Apr*	*2-May*	*9-Jun*	*4-Jul*	*6-Sep*
importance	**DIATOMS**														
	Amphora ovalis										10				
	Acnanthes spp.														
	Asterionella formosa			25					5	5	110	60	110	80	
	Campylodiscus sp.														
	Cyclotella ocellata	410		10	50			5	10		60	20	470	170	
	Cymbella sp													5	
	Cymbella cistula.	30					P		10		5	5			
	Diatoma spp.										20				
	Diploneis sp												10		
	Epithemia spp.														
	Fragilaria capucina										30				
	Fragilaria crotonensis			20	5			10			120	20	40	40	
	Frustulia sp.												10		
	Gomphonema											10			
	Gyrosigma sp.														
	Melosira italica		200	110				35	20	**30**	**490**	**80**	**360**		
	Navicula spp.							13			30		20		
	Pinnularia gibba														
	Rapholodia gibba														
	Rhizolenia sp.												10		
	Stauroneis				5					5					
	Surirella ovalis														
	Stephanodiscus niagarae	25						5			20	20	20	20	
	Synedra acus	20			15			5	5		110		100	5	
	Synedra ulna							5			60	20		10	
	Tabellaria fenestrata										70	5	60	10	
	YELLOW-BROWN ALGAE														
	Dinobryon spp.	260	40						15	5	30	420	170	30	50
	Chromulina sp				10										
	Chrysochromulina sp.										10			20	10
	Cryptomonas ovata				10										
	Kephyrion sp.														
	Mallomonas sp														
	Ochromonas sp.														
	Treachelomonas sp.											20			
	micro-flagellates			10	20			20	5		120	10			
	Large flagellates										10			5	10
	DESMIDS														
	Cosmarium spp.														
	GREEN ALGAE														
	Closteriopsis longissima														
	Oocystis sp.		60										50		
	Staurastrum														
toxin	**BLUE-GREEN ALGAE**														
X	Anabaena circinalis			115									60	**860**	
X	Anabaena planktonica				75										
X	Anacystis cyanea														
X	Aphanizomenon sp														
	Chroococcus turgida			**20**		20									
	Gomphosphaeria sp		150		90								65	290	**650**
X	Planktolyngbya limnetica	**325**	**550**	**562**	712	250	100	615	275	50	**900**	**400**			**3500**
	Limnothrix redekeii										**50**			250	
X	Oscillatoria sp. smooth/				**250**						**310**			**120**	500
	Merismopedia		16												
X	Planktothrix agardhii			**75**		125		25	75					185	190
X	Pseudanabaena	**85**		**30**	115	10									
X	Synechocystis sp.														
X	Chroococcus/Synechococcus		25	40	85	20								150	80
	DINOFLAGELLATES														
	Gyrodinium spp.														
	Peridinium sp. (large)				10										
	OTHER														
	ciliates				20										
	bacteria				VL	VL	VL	**VL**	VL	VL	C	M	L	**C**	L
	detritus		**L**	**C**	L	VL	VL	VL	VL	**VH***	L	L	L	**L**	L
	silt			L	**L**	L	L	VL	VL	**N**	VL	N	N	**VL**	VL
	SUM	1155	1041	1017	1472	425	100	738	420	95	2565	1090	1555	2250	**4990**

Significant algae count High algae count Very high algae count

Multi-meter Profiles for Killiney Beach and Westshore Estates, 2011

Killiney Beach - 2011

	Temperature oC		Diss Oxygen mg/L		pH		Conductivity us/cm2		TDS mg/L	
Depth (m)	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep
0	16.29	21.71	8.94	8.37	8.19	8.32	239	258	119	129
1	16.26	20.93	8.95	8.65	8.16	8.29	243	260	121	130
2	16.23	20.61	9.02	8.65	8.15	8.28	244	262	122	131
3	16.21	20.31	8.99	8.49	8.12	8.28	245	260	123	130
4	16.17	20.21	9	8.71	8.01	8.27	247	260	123	130
5	16.18	20.16	8.96	8.87	7.98	8.27	248	259	124	130
6	16.17	20.1	9.04	9.06	7.98	8.26	249	259	125	130
7	16.14	20.06	8.98	10.05	7.98	8.27	250	258	125	129
8	15.19	20.02	9.2	10.9	7.94	8.28	253	255	127	127
9	13.82		9.41		7.85		252		126	
10	13.53		9.12		7.85		252		126	
11	13.38		9.19		7.83		253		127	

Westshore Estates

	Temperature oC		Diss Oxygen mg/L		pH		Conductivity us/cm2		TDS mg/L	
Depth (m)	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep	16-Jun	18-Sep
0	15.09	20.51	8.62	8.29	8.07	8.27	261	257	131	128
1	15.1	20.25	8.57	8.42	7.99	8.25	266	259	133	129
2	15.1	20.19	8.52	8.49	7.97	8.22	264	257	132	128
3	15.06	20.16	8.67	8.56	7.95	8.21	263	256	132	128
4	15.04	20.13	8.72	8.64	7.93	8.2	248	258	124	129
5	15	20.1	8.78	8.68	7.92	8.19	230	256	115	128
6	14.94	20.08	8.86	8.87	7.91	8.19	233	256	117	128
7	14.93	19.97	8.9	9.73	7.91	8.19	232	256	116	128
8	14.79		8.94		7.89		231		116	
9										
10										

RDCO Routine Sampling Results, Killiney Beach and Westshore Estates 2010 and 2011

2010 - WESTSHORE RAW WATER DATA

DATE	SAMPLE ID	TIME	Field TURBIDITY *NTU*	TEMP *°C*	Cond	pH	Comments	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
May 26/10	Raw water	12:40	1.06	16.2		8.40	grab sample from shoreline	40	14
July 13/10	Raw water	12:40	1.26				grab sample from shoreline	<1	<1
Aug 10/10	Raw water	9:30	1.90				grab sample from shoreline	30	1
Aug 26/10	Raw water	11:00	1.30				grab sample from shoreline	16	<1
September 2/10	Raw water	11:00	1.20				grab sample from shoreline	32	<1
September 7/10	**Raw water**	**11:10**	**0.72**				**grab sample from shoreline**	**29**	**<1**
September 13/10	Raw water	11:00	0.50				grab sample from shoreline	<1	<1
September 28/10	Raw water	8:50	1.60	17.8		8.30	grab sample from shoreline	90	2
October 3/10	**Raw water**	**16:00**					**grab sample at intake by LAC**	**OG**	**<1**
October 25/10	Raw water	9:15	1.30	14.0	300	8.25	grab sample(van dorn) from dock 30 ft out , 6 ft deep	2	<1
November 8/10	Raw water	11:35	1.43	11.0	312	8.49	grab sample(van dorn) from dock 30 ft out , 6 ft deep	<1	<1
December 2/10	Raw water	11:00	1.19	6.1	294	8.40	grab sample(van dorn) from dock 30 ft out , 6 ft deep	2	<1
December 6/10	Raw water	10:30	1.20	9.1	300	8.40	grab sample(van dorn) from dock 30 ft out , 6 ft deep	<1	<1

Bolded results are from CARO Analytical

2010 - KILLINEY RAW WATER DATA

DATE	SAMPLE ID	TIME	Field TURBIDITY *NTU*	TEMP *°C*	Cond	pH	Comments	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
May 26/10	Raw water	12:00	1.10				grab sample from shoreline	15	5
June 25/10	**Raw water**	**10:15**					**grab sample from shoreline**	**>50**	**3**
July 13/10	Raw water	13:00	1.40				grab sample from shoreline	<1	<1
Aug 10/10	Raw water	9:30	1.90				grab sample from shoreline	56	<1
Aug 26/10	Raw water	9:30	1.90				grab sample from shoreline	16	<1
September 2/10	Raw water	11:00	1.20				grab sample from shoreline	32	<1
September 7/10	**Raw water**	**10:35**					**grab sample from shoreline**	**29**	**<1**
September 13/10	Raw water	9:50	0.50				grab sample from shoreline	38	1
September 28/10	Raw water	8:35	1.50	17.4		8.50	grab sample from shoreline	50	1
October 3/10	**Raw water**	**16:00**					**grab sample at intake by LAC**	**OG**	**<1**
October 25/10	Raw water	9:39	1.30	14.0	293	8.20	grab sample(van dorn) from dock 30 ft out , 6 ft deep	2	<1
November 8/10	Raw water	10:23	1.38	11.1	288	8.66	grab sample(van dorn) from dock 30 ft out , 6 ft deep	<1	<1
December 2/10	Raw water	10:35	1.19	6.4	297	8.44	grab sample(van dorn) from dock 30 ft out , 6 ft deep	1	<1
December 6/10	Raw water	10:00	0.90	6.3	299	8.40	grab sample(van dorn) from dock 30 ft out , 6 ft deep	1	<1

Bolded results are from CARO Analytical

2010 - KILLINEY BEACH WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	CL2 RESIDUAL *mg/L*	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
January 19/10	Lakeside	9:25	1.13	<1	<1
January 19/10	Winchester	9:45	0.66	<1	<1
February 2/10	Lakeside	9:55	1.34	<1	<1
February 2/10	Winchester	10:10	0.51	<1	<1
February 17/10	Lakeside	9:30	1.12	<1	<1
February 17/10	Winchester	9:50	0.39	<1	<1
March 11/10	Lakeside	10:15	0.89	<1	<1
March 11/10	Winchester	10:40	0.52	<1	<1
March 23/10	Winchester	10:15	0.48	<1	<1
March 23/10	Lakeside	10:30	1.20	<1	<1
April 7/10	Lakeside	10:15	1.16	<1	<1
April 7/10	Udell Road	10:35	0.96	<1	<1
April 20/10	Winchester	9:35	0.72	<1	<1
April 20/10	Lakeside	10:10	1.60	<1	<1
May 4/10	Lakeside	10:00	1.47	<1	<1
May 4/10	Winchester	10:20	0.81	<1	<1
May 18/10	Winchester	9:50	0.82	<1	<1
May 18/10	Lakeside	10:15	1.43	<1	<1
June 10/10	Winchester	11:00	0.53	<1	<1
June 10/10	Lakeside	10:45	1.55	<1	<1
June 23/10	Winchester	10:00	0.47	<1	<1
June 23/10	Lakeside	10:10	1.30	<1	<1
July 5/10	Winchester	10:30	0.70	<1	<1
July 5/10	Lakeside	10:45	1.92	<1	<1
July 21/10	Winchester	10:45	1.54	<1	<1
July 21/10	Lakeside	11:00	1.14	<1	<1
August 10/10	Winchester	9:30	0.93	<1	<1
August 10/10	Lakeside	9:45	1.89	<1	<1
August 17/10	Winchester	9:50	0.34	<1	<1
August 17/10	Udell Road	10:10	1.25	<1	<1
August 17/10	Lakeside	10:20	1.46	<1	<1
August 25/10	Lakeside	8:50	1.68	<1	<1
August 25/10	Winchester	9:20	0.68	<1	<1
August 25/10	Udell Road	9:45	1.40	<1	<1
August 30/10	Udell Road	10:30	1.91	<1	<1
August 30/10	Winchester	10:45	1.22	<1	<1
August 30/10	Lakeside	11:00	2.20	<1	<1
September 7/10	Winchester	10:15	0.74	<1	<1
September 7/10	Lakeside	10:30	1.83	<1	<1
September 16/10	Lakeside	14:52	0.71	<1	<1
September 16/10	Killarney	15:00	0.12	**14**	<1
September 16/10	Udell Road	15:13	<0.10	**220**	<1
September 16/10	Winchester	15:23	<0.10	<1	<1
September 17/10	Lakeside	10:23	1.32	<1	<1
September 17/10	Udell Road	10:37	0.83	<1	<1
September 17/10	Winchester	11:31	0.23	<1	<1
September 20/10	Lakeside	7:30	1.41	<1	<1
September 20/10	Killarney	8:00	1.10	<1	<1
September 20/10	Udell Road	8:10	0.93	<1	<1
September 20/10	Winchester	8:23	0.39	<1	<1
October 5/10	Winchester	11:16	0.64	<1	<1
October 5/10	Lakeside	11:31	1.58	<1	<1
October 19/10	Udell Road	10:00	1.27	<1	<1
October 19/10	Winchester	10:07	0.79	<1	<1
October 19/10	Killarney	10:15	1.47	<1	<1
October 19/10	Lakeside	10:26	1.73	<1	<1
November 1/10	Winchester	10:02	0.85	<1	<1
November 1/10	Lakeside	10:19	1.71	<1	<1
November 8/10	Udell Road	9:49	1.38	<1	<1
November 8/10	Winchester	10:00	0.88	<1	<1
November 8/10	Killarney	10:14	1.39	<1	<1
November 8/10	Lakeside	10:30	1.83	<1	<1
November 15/10	Winchester	12:26	1.00	<1	<1
November 15/10	Lakeside	12:45	1.84	<1	<1
December 2/10	Winchester	10:16	1.03	<1	<1
December 2/10	Lakeside	10:27	1.57	<1	<1
December 7/10	Winchester	9:30	1.00	<1	<1
December 7/10	Lakeside	10:00	1.59	<1	<1
December 13/10	Winchester	12:52	0.92	<1	<1
December 13/10	Lakeside	13:09	1.59	<1	<1
December 29/10	Winchester	8:20	0.88	<1	<1
December 29/10	Lakeside	8:45	1.49	<1	<1

2010 - WESTSHORE ESTATES WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	CL2 RESIDUAL *mg/L*	Field TURBIDITY *NTU*	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
January 19/2010	Mountain Avenue	10:00	0.82	0.42	<1	<1
January 19/2010	Lakeshore	10:15	1.44	0.35	<1	<1
February 2/2010	Mountain Avenue	10:33	0.83	0.40	<1	<1
February 2/2010	Lakeshore	10:45	1.14	0.37	<1	<1
February 17/2010	Mountain Avenue	10:10	0.58	0.70	<1	<1
February 17/2010	Lakeshore	10:25	1.03	0.38	<1	<1
March 16/2010	Mountain Avenue	14:20	0.99	0.60	<1	<1
March 16/2010	Lakeshore	14:30	1.49	0.55	<1	<1
March 23/2010	Mountain Avenue	10:55	0.97	0.70	<1	<1
March 23/2010	Lakeshore	11:10	1.38	0.40	<1	<1
April 7/2010	Mountain Avenue	10:30	0.99	0.70	<1	<1
April 7/2010	Lakeshore	10:50	1.37	0.45	<1	<1
April 20/2010	Mountain Avenue	11:10	0.94	0.70	<1	<1
April 20/2010	Lakeshore	10:30	1.52	0.65	<1	<1
May 4/2010	Mountain Avenue	10:40	0.94	0.70	<1	<1
May 4/2010	Lakeshore	10:55	1.59	0.60	<1	<1
May 18/2009	Mountain Avenue	10:40	1.07	0.70	<1	<1
May 18/2009	Lakeshore	10:50	1.47	0.58	<1	<1
June 8/2010	Mountain Avenue	10:00	0.56	0.79	<1	<1
June 8/2010	Lakeshore	10:20	1.20	0.75	<1	<1
June 15/2010	Mountain Avenue	10:00	0.32	0.60	<1	<1
June 15/2010	Lakeshore	9:30	1.24	0.50	<1	<1
June 23/2010	Mountain Avenue	10:40	0.63	0.85	<1	<1
June 23/2010	Lakeshore	10:50	0.67	0.67	<1	<1
June 28/2010	Mountain Avenue	11:45	0.93	0.60	<1	<1
June 28/2010	Lakeshore	12:00	1.69	0.55	<1	<1
July 5/2010	Mountain Avenue	11:00	1.47	0.59	<1	<1
July 5/2010	Lakeshore	11:15	2.00	0.65	<1	<1
July 21/2010	Mountain Avenue	11:20	1.11	0.85	**1**	<1
July 21/2010	Lakeshore	11:30	1.26	0.70	<1	<1
July 23/2010	Mountain Avenue	13:15	1.20	0.80	**<1 retest**	<1
July 26/2010	Mountain Avenue	10:45	0.50	0.80	<1	<1
July 26/2010	Lakeshore	11:00	1.28	0.65	<1	<1
Aug 10/2010	Mountain Avenue	10:15	0.91	0.39	<1	<1
Aug 10/2010	Lakeshore	10:30	1.46	0.42	<1	<1
Aug 17/2010	Mountain Avenue	10:40	1.04	0.60	<1	<1
Aug 17/2010	Lakeshore	10:55	1.42	0.45	<1	<1
Sep 7/2010	Mountain Avenue	11:00	1.18	0.58	<1	<1
Sep 7/2010	Lakeshore	11:15	1.51	0.60	<1	<1
Sep 13/2010	Mountain Avenue	10:15	0.68	0.53	<1	<1
Sep 13/2010	Lakeshore	10:30	0.58	0.60	<1	<1
Sep 20/2010	Mountain Avenue	8:36	0.92	0.53	<1	<1
Sep 20/2010	Lakeshore	8:52	1.28	0.60	<1	<1
Oct 5/2010	Mountain Avenue	12:15	n/a	n/a	<1	<1
Oct 5/2010	Lakeshore	12:10	2.20	0.52	<1	<1
Oct 19/2010	Mountain Avenue	10:57	0.80	0.60	<1	<1
Oct 19/2010	Lakeshore	11:10	1.12	0.64	<1	<1
Oct 25/2010	Mountain Avenue	9:50	1.44	0.60	<1	<1
Oct 25/2010	Lakeshore	10:00	0.78	0.50	<1	<1
Nov 1/2010	Mountain Avenue	10:38	0.81	0.70	<1	<1
Nov 1/2010	Lakeshore	10:51	1.75	0.76	<1	<1
Nov 15/2010	Mountain Avenue	13:00	0.93	0.50	<1	<1
Nov 15/2010	Lakeshore	13:10	1.36	0.50	<1	<1
Dec 2 /2010	Mountain Avenue	10:56	0.68	0.40	<1	<1
Dec 2 /2010	Lakeshore	11:00	1.32	0.40	<1	<1
Dec 7/2010	Mountain Avenue	10:45	0.85	0.40	<1	<1
Dec 7/2010	Lakeshore	10:30	2.01	0.40	<1	<1
Dec 14/2010	Mountain Avenue	12:15	1.02	0.60	<1	<1
Dec 14/2010	Lakeshore	12:32	0.95	0.45	<1	<1

2011 - KILLINEY RAW WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	Field TURBIDITY *NTU*	TEMP *°C*	Cond	pH	Comments	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
January 10/11	raw water	9:40	0.70	2.7	310	8.64		<1	<1
February 8/11	raw water	10:45	1.20	3.2	310	8.55		<1	<1
February 21/11	**raw water**	**10:00**	**1.12**	**1.8**	**320**	**8.54**		**1**	**<1**
March 8/11	raw water	10:25	1.20	3.7	315	8.48		1	<1
April 4/11	raw water	10:00	1.10	5.5	304	8.19		<1	<1
May 2/11	raw water	10:40	0.68	9.6	300	8.26		1	<1
May 24/11	**raw water**	**11:05**	**6.62**	**14.6**	**302**	**8.36**	**visible pollen on the lake**	**17**	**1**
June 6/11	raw water	11:30	1.55	18.0	286	8.40		3	1
July 4/11	raw water	10:35	1.20	17.8	276	8.43		5	1
July 18/11	**raw water**	**10:25**	**0.90**	**19.6**	**278**	**8.50**		**bkd >200**	**<1**
August 15/11	raw water	11:15	1.10	20.8	278	8.25		3	<1
September 6/11	**raw water**	**12:05**	**0.91**	**21.3**	**279**	**8.13**			

2011 - WESTSHORE RAW WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	Field TURBIDITY *NTU*	TEMP *°C*	Cond	pH	Comments	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
January 10/11	raw water	10:45	0.75	2.6	350	8.64		<1	<1
February 8/11	raw water	10:45	1.32	2.6	330	8.60		<1	<1
February 21/11	**raw water**	**10:50**	**1.32**	**2.6**	**330**	**8.60**		**<1**	**<1**
March 8/11	raw water	11:10	1.23	3.2	350	8.42		<1	<1
April 4/11	raw water	11:00	1.25	5.0	308	8.12		<1	<1
May 2/11	raw water	11:30	0.95	9.4	303	8.23		<1	<1
May 24/11	**raw water**	**12:05**	**1.98**	**14.3**	**303**	**8.25**	**visible pollen on the lake**	**1**	**<1**
June 6/11	raw water	12:30	1.33	18.0	293	8.39		<1	<1
July 4/11	raw water	11:30	1.15	18.2	280	8.40		3	<1
July 18/11	**raw water**	**11:10**	**0.90**	**20.2**	**280**	**8.45**		**30 with bkg**	**<1**
August 15/11	raw water	16:00	1.20	22.0	299	8.20		4	<1
September 6/11	**raw water**	**12:40**	**0.95**	**21.2**	**289**	**8.10**			

Bolded results are from Caro Analytical

Note: all samples are grab (van dorn) from dock 30 ft out and 3.5 ft deep

2011 - KILLINEY BEACH WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	CL2 RESIDUAL *mg/L*	Field TURBIDITY *NTU*	Online TURBIDITY *NTU*	Conductivity	TEMP *°C*	pH	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
3-Jan-11	Lakeside	9:00	1.59	0.45	0.57	287	8.0	8.19	<1	<1
3-Jan-11	Winchester	8:30	1.32	0.40	na	286	7.9	8.21	<1	<1
10-Jan-11	Winchester	9:25	0.92	0.40	na	300	6.0	8.05	<1	<1
10-Jan-11	Lakeside	9:30	1.45	0.42	0.57	308	5.7	8.10	<1	<1
17-Jan-11	Winchester	9:30	0.92	0.42	na	316	7.7	8.06	<1	<1
17-Jan-11	Lakeside	9:40	1.42	0.50	0.36	312	6.9	8.01	<1	<1
24-Jan-11	Winchester	9:43	1.06	0.50	na	311	6.5	7.99	<1	<1
24-Jan-11	Lakeside	10:00	1.73	0.44	0.36	311	5.3	7.98	<1	<1
31-Jan-11	Winchester	9:30	1.62	0.40	na	310	5.8	7.99	<1	<1
31-Jan-11	Lakeside	9:41	1.96	0.40	0.32	298	5.6	8.05	<1	<1
8-Feb-11	Winchester	9:45	0.97	0.47	na	340	6.5	8.06	<1	<1
8-Feb-11	Lakeside	10:00	1.60	0.30	0.28	320	5.4	8.15	<1	<1
21-Feb-11	Winchester	9:45	0.99	0.35	na	313	6.4	8.10	<1	<1
21-Feb-11	Lakeside	10:00	1.54	0.38	0.32	308	5.2	8.13	<1	<1
1-Mar-11	Winchester	10:15	0.82	0.40	na	315	9.2	8.12	<1	<1
1-Mar-11	Lakeside	10:25	1.88	0.38	0.38	318	6.8	8.15	<1	<1
8-Mar-11	Winchester	10:00	0.71	0.59	na	312	8.4	8.10	<1	<1
8-Mar-11	Lakeside	10:15	0.85	0.48	0.42	311	5.9	8.19	<1	<1
14-Mar-11	Winchester	9:28	1.20	0.60	na	311	8.4	8.12	<1	<1
14-Mar-11	Lakeside	9:40	1.38	0.40	0.21	308	6.6	8.13	<1	<1
22-Mar-11	Winchester	9:30	0.80	0.47	na	311	8.9	8.12	<1	<1
22-Mar-11	Lakeside	9:43	1.66	0.40	0.25	310	6.8	8.12	<1	<1
28-Mar-11	Winchester	11:15	1.20	0.30	na	312	8.8	8.09	<1	<1
28-Mar-11	Lakeside	11:00	1.60	0.25	0.25	305	6.9	8.12	<1	<1
28-Mar-11	Houghton sample station	11:25	0.50	0.42	na	315	9.1	8.13	<1	<1
4-Apr-11	Winchester	9:37	0.85	0.58	na	297	9.6	7.78	<1	<1
4-Apr-11	Houghton sample station	9:46	0.75	0.38	na	304	5.7	7.87	<1	<1
4-Apr-11	Lakeside	9:55	1.69	0.36	0.19	300	6.0	7.94	<1	<1
11-Apr-11	Winchester	9:57	0.75	0.62	na	299	8.1	7.95	<1	<1
11-Apr-11	Houghton sample station	10:06	0.62	0.54	na	301	6.3	7.98	<1	<1
11-Apr-11	Lakeside	10:20	1.32	0.79	0.41	299	7.7	8.00	<1	<1
18-Apr-11	Udel	9:30	1.35	0.63	na	301	6.6	8.07	<1	<1
18-Apr-11	Houghton sample station	9:50	0.80	0.41	na	300	6.1	8.10	<1	<1
18-Apr-11	Winchester	10:00	0.85	0.41	na	296	9.2	7.95	<1	<1
18-Apr-11	Lakeside	10:10	1.40	0.65	0.40	299	7.5	8.11	<1	<1
26-Apr-11	Houghton sample station	9:43	0.75	0.52	na	298	7.8	8.08	<1	<1
26-Apr-11	Winchester	9:55	0.61	0.60	na	299	9.1	8.04	<1	<1
26-Apr-11	Lakeside	10:15	1.38	0.60	0.38	297	7.9	8.03	<1	<1
2-May-11	Winchester	9:54	0.63	0.60	na	299	9.4	7.99	<1	<1
2-May-11	Houghton sample station	10:00	0.65	0.60	na	296	8.4	8.16	<1	<1
2-May-11	Lakeside	10:30	1.52	0.50	0.44	299	7.8	8.02		<1
9-May-11	Udel	10:00	1.11	0.60	na	300	10.9	8.16		<1
9-May-11	Winchester	10:15	0.7	0.40	na	300	11.0	8.15	<1	<1
9-May-11	Houghton sample station	10:30	0.68	0.45	na	302	10.6	8.20	<1	<1
9-May-11	Lakeside	10:40	1.35	0.40	0.48	301	10.2	8.19	<1	<1
16-May-11	Lakeside	14:38	1.25	0.50	0.44	301	10.3	8.20	<1	<1
16-May-11	Winchester	10:15	0.80	0.40	na	305	10.1	8.10	<1	<1
24-May-11	Udel	10:08	1.06	0.90	na	302	13.0	7.88	<1	<1
24-May-11	Winchester	10:15	0.54	0.82	na	296	11.4	7.87	<1	<1
24-May-11	Houghton sample station	10:30	0.47	0.60	na	295	10.7	7.79	<1	<1
24-May-11	Lakeside	10:55	1.36	1.05	1.20	292	12.8	7.72	<1	<1
30-May-11	Winchester	9:51	0.51	0.90		292	12.5	7.75	<1	<1
30-May-11	Lakeside	10:11	1.56	0.95	1.00	299	11.6	7.86	<1	<1
6-Jun-11	Houghton sample station	11:00	0.39	0.70		289	13.3	7.81	<1	<1
6-Jun-11	Lakeside	11:20	1.59	0.80	0.85	290	17.1	7.86	<1	<1
13-Jun-11	Lakeside	10:24	1.09	0.90	0.80	282	16.0	8.02	<1	<1
13-Jun-11	Winchester	10:35	0.38	0.85		280	14.7	8.02	<1	<1
20-Jun-11	Lakeside	11:00	1.20	0.80	0.80	283	17.3	7.95	<1	<1
20-Jun-11	Winchester	11:17	0.40	0.80		281	16.0	7.98	<1	<1
20-Jun-11	Houghton sample station	11:30	0.37	0.80		277	14.9	7.95	<1	<1
28-Jun-11	Udel	10:05	0.81	0.80		282	17.2	8.10	<1	<1
28-Jun-11	Lakeside	10:55	1.31	0.95	1.20	280	18.4	8.06	<1	<1
4-Jul-11	Houghton sample station	10:16	0.25	0.90		294	14.6	7.81	<1	<1
4-Jul-11	Lakeside	10:30	1.42	0.80	0.60	281	14.2	7.95	<1	<1
11-Jul-11	Winchester	9:00	0.16	1.32		285	17.6	7.89	<1	<1
11-Jul-11	Lakeside	9:20	1.16	0.78	0.48	281	19.1	8.16	<1	<1
18-Jul-11	Houghton sample station	9:50	0.20	0.68		286	14.9	7.98	<1	<1
18-Jul-11	Winchester	10:05	0.24	0.80		282	16.7	7.95	<1	<1
18-Jul-11	Lakeside	10:19	1.30	0.90	0.90	280	17.9	7.98	<1	<1
26-Jul-11	Houghton sample station	9:20	0.20	0.75		286	15.6	7.78	<1	<1
26-Jul-11	Lakeside	9:40	1.30	0.83	0.63	283	17.7	7.81	<1	<1
2-Aug-11	Houghton sample station	9:45	0.44	0.95		285	16.0	7.84	<1	<1
2-Aug-11	Lakeside	10:00	1.56	0.85	0.51	284	19.7	7.94	<1	<1
8-Aug-11	Houghton sample station	10:45	0.25	0.80		308	16.8	7.90	<1	<1
8-Aug-11	Lakeside	11:15	1.59	0.90	0.76	285	18.7	7.86	<1	<1
15-Aug-11	Houghton sample station	10:46	0.28	0.80		289	17.1	7.80	<1	<1
15-Aug-11	Lakeside	11:00	1.59	0.73	0.60	283	19.9	7.84	<1	<1
22-Aug-11	Winchester	11:30	0.20	0.80		294	18.6	7.83	<1	<1
22-Aug-11	Lakeside	11:45	1.38	0.65	0.54	285	18.5	7.68	<1	<1
29-Aug-11	Houghton sample station	10:15	0.35	0.80		287	17.8	7.67	<1	<1
6-Sep-11	killarney	11:45	1.00	0.82		285	20.0	7.80	<1	<1
6-Sep-11	Lakeside	12:00	1.63	0.69	0.55	286	20.9	7.79	<1	<1
12-Sep-11	Houghton sample station	10:00	0.49	0.90		292	17.8	7.70	<1	<1
20-Sep-11	Winchester	11:30	0.54	0.80		287	18.1	7.73	<1	<1
20-Sep-11	Lakeside	12:00	1.41	0.50	0.39	290	18.4	7.80	<1	<1
26-Sep-11	killarney	10:10	1.35	0.75		295	17.4	7.50	<1	<1
26-Sep-11	Lakeside	10:30	2.02	0.50	0.34	287	17.8	7.53	<1	<1
									<1	<1
									<1	<1

2011 - WESTSHORE ESTATES WATER SYSTEM DATA

DATE	SAMPLE ID	TIME	CL2 RESIDUAL *mg/L*	Field TURBIDITY *NTU*	Online TURBIDITY *NTU*	conductivity	TEMP *°C*	pH	TOTAL COLIFORM *CFU/100mL*	E-COLI *CFU/100mL*
3-Jan-11	Mountain Ave	9:30	0.20	0.40	na	305	8.2	8.21	<1	<1
3-Jan-11	Lakeside	9:45	0.20	0.35	0.40	300	7.9	8.19	<1	<1
10-Jan-11	Mountain Ave	10:15	1.28	0.60	na	316	5.4	8.20	<1	<1
10-Jan-11	Lakeside	10:40	1.45	0.60	0.40	310	6.1	8.20	<1	<1
17-Jan-11	Mountain Ave	10:00	0.95	0.60	na	318	9.2	7.98	<1	<1
17-Jan-11	Lakeside	10:10	0.99	0.50	0.30	319	7.9	8.01	<1	<1
24-Jan-11	Mountain Ave	10:22	1.18	0.68	na	308	8.1	7.89	<1	<1
24-Jan-11	Lakeside	10:37	2.01	0.46	0.45	318	5.6	8.06	<1	<1
31-Jan-11	Lakeside	10:00	1.36	0.60	0.48	319	5.8	8.11	<1	<1
31-Jan-11	Mountain Ave	10:15	0.89	0.50	na	315	5.4	8.15	<1	<1
8-Feb-11	Mountain Ave	10:30	0.85	0.40	na	310	7.8	8.20	<1	<1
8-Feb-11	Lakeside	10:40	1.15	0.50	0.12	314	7.9	8.14	<1	<1
21-Feb-11	Mountain Ave	10:40	1.00	0.45	na	315	8.6	8.20	<1	<1
21-Feb-11	Lakeside	10:50	1.15	0.40	0.33	310	7.2	8.19	<1	<1
1-Mar-11	Mountain Ave	10:45	0.80	0.40	na	310	8.5	8.16	<1	<1
1-Mar-11	Lakeside	10:55	1.11	0.30	0.38	312	7.2	8.20	<1	<1
8-Mar-11	Mountain Ave	10:45	0.68	0.40	na	314	6.6	8.09	<1	<1
8-Mar-11	Lakeside	11:00	1.20	0.61	0.38	290	7.0	8.20	<1	<1
14-Mar-11	Lakeside	10:15	1.22	0.30	0.40	320	5.2	8.40	<1	<1
14-Mar-11	Mountain Ave	10:00	0.69	0.40	na	315	7.2	8.07	<1	<1
22-Mar-11	Mountain Ave	10:00	0.50	0.30	na	310	6.8	8.10	<1	<1
22-Mar-11	Lakeside	10:10	1.30	0.39	0.35	311	6.5	8.12	<1	<1
28-Mar-11	Lakeside	11:35	1.20	0.38	0.38	305	6.3	8.12	<1	<1
28-Mar-11	Mountain Ave	11:45	0.98	0.42	na	311	7.2	8.09	<1	<1
28-Mar-11	Hillcrest Sample Station	11:50	0.30	0.40	na	309	7.0	8.05	<1	<1
4-Apr-11	Mountain Ave	10:35	0.65	0.45	na	303	8.0	8.01	<1	<1
4-Apr-11	Hillcrest Sample Station	10:43	0.44	0.40	na	311	5.2	8.13	<1	<1
4-Apr-11	Lakeside	10:55	1.30	0.50	0.39	299	9.0	8.04	<1	<1
11-Apr-11	Mountain Ave	10:40	0.71	0.78	na	302	1.6	8.06	<1	<1
11-Apr-11	Hillcrest Sample Station	10:50	0.38	0.57	na	308	6.5	8.10	<1	<1
11-Apr-11	Lakeside	11:10	0.99	0.60	0.48	300	11.0	8.20	<1	<1
18-Apr-11	Mountain Ave	10:45	0.72	0.69	na	303	1.2	8.30	<1	<1
18-Apr-11	Hillcrest Sample Station	11:00	0.50	0.44	na	310	6.2	8.37	<1	<1
18-Apr-11	Lakeside	11:10	0.91	0.40	0.34	307	11.4	8.10	<1	<1
26-Apr-11	Hillcrest Sample Station	10:40	0.51	0.59	na	306	7.3	8.12	<1	<1
26-Apr-11	Mountain Ave	10:50	0.70	0.61	na	301	9.6	8.02	<1	<1
26-Apr-11	Lakeside	11:10	1.52	0.54	0.40	598	1.2	8.06	<1	<1
May 2, 2011	Mountain Ave	11:10	0.75	0.50	na	303	10.9	8.01	<1	<1
May 2, 2011	Lakeside	11:20	1.54	0.55	0.55	301	12.3	8.12	<1	<1
May 9, 2011	Hillcrest Sample Station	10:54	0.46	0.60	na	307	9.8	8.10	<1	<1
May 9, 2011	Mountain Ave	11:08	0.50	0.40	na	310	11.8	8.04	<1	<1
May 9, 2011	Lakeside	11:15	0.89	0.43	0.51	308	12.5	8.10	<1	<1
16-May-11	Lakeside	13:46	0.67	0.40	0.44	33	11.9	8.10	<1	<1
16-May-11	Mountain Ave	14:18	0.55	0.45	na	340	12.0	7.80	<1	<1
24-May-11	Mountain Ave	11:40	0.65	0.80	na	32	14.9	7.88	<1	<1
24-May-11	Hillcrest Sample Station	11:50	0.60	0.40	na	310	11.9	7.95	<1	<1
24-May-11	Lakeside	11:00	1.27	0.80	0.78	300	15.9	7.95	<1	<1
30-May-11	Mountain Ave	10:30	0.50	1.00	na	300	14.5	7.97	<1	<1
30-May-11	Lakeside	11:00	1.20	0.90	0.90	299	16.0	8.08	<1	<1
6-Jun-11	Mountain Ave	12:15	0.69	0.90	na	291	17.6	8.08	<1	<1
6-Jun-11	Lakeside	12:30	1.48	0.92	0.75	295	19.1	8.10	<1	<1
13-Jun-11	Mountain Ave	9:52	0.54	0.90	na	291	18.0	7.55	<1	<1
13-Jun-11	Lakeside	10:11	0.76	0.70	0.46	286	18.8	7.92	<1	<1
20-Jun-11	Mountain Ave	9:55	0.70	0.90	na	290	17.3	7.83	<1	<1
20-Jun-11	Hillcrest Sample Station	10:10	0.20	0.67	na	293	13.8	7.90	<1	<1
20-Jun-11	Lakeside	10:22	1.16	0.70	0.50	287	18.0	7.91	<1	<1
28-Jun-11	Mountain Ave	11:10	0.68	0.90	na	290	19.5	8.00	<1	<1
28-Jun-11	Lakeside	11:35	1.33	0.60	0.48	290	20.2	8.08	<1	<1
4-Jul-11	Mountain Ave	11:05	0.80	0.80	na	291	18.9	7.99	<1	<1
4-Jul-11	Lakeside	11:20	1.43	0.55	0.40	293	19.7	8.01	<1	<1
11-Jul-11	Mountain Ave	9:55	0.66	0.95	na	291	21.5	8.14	<1	<1
11-Jul-11	Lakeside	10:10	0.94	0.91	0.81	290	22.5	8.20	<1	<1
18-Jul-11	Mountain Ave	10:45	0.43	0.83	na	288	20.6	8.07	<1	<1
18-Jul-11	Hillcrest Sample Station	11:00	0.30	0.80	na	294	16.7	8.17	<1	<1
18-Jul-11	Lakeside	11:20	1.16	0.80	0.88	292	21.0	8.21	<1	<1
26-Jul-11	Mountain Ave	10:10	1.79	0.87	na	292	19.9	7.80	<1	<1
26-Jul-11	Lakeside	10:45	1.25	0.90	1.00	292	19.7	7.92	<1	<1
2-Aug-11	Hillcrest Sample Station	10:25	0.37	0.55	na	293	17.2	8.35	<1	<1
2-Aug-11	Lakeside	11:00	1.46	0.56	0.60	290	21.9	8.07	<1	<1
4-Aug-11	Hillcrest Sample Station	10:25	0.75		na				<1	<1
8-Aug-11	Mountain Ave	11:30	0.90	0.69	na	303	22.5	7.86	<1	<1
8-Aug-11	Lakeside	12:10	1.87	0.77	0.71	293	23.9	8.05	<1	<1
15-Aug-11	Mountain Ave	11:30	1.05	0.75	na	295	20.9	7.87	<1	<1
15-Aug-11	Lakeside	11:50	2.05	0.85	0.81	293	21.6	8.02	<1	<1
22-Aug-11	Mountain Ave	12:00	0.95	0.80	na	286	21.7	7.76	<1	<1
22-Aug-11	Lakeside	12:15	1.75	0.69	0.65	290	20.9	7.82	<1	<1
29-Aug-11	Hillcrest Sample Station	9:45	0.30	0.56	na	305	19.2	7.70	<1	<1
6-Sep-11	391 Lakewood	11:10	0.83		na				<1	<1
6-Sep-11	Mountain Ave	11:20	0.90	0.68	na	306	21.4	7.46	<1	<1
6-Sep-11	Lakeside	12:30	1.48	0.75	0.60	300	22.1	7.88	<1	<1
12-Sep-11	Mountain Ave	10:40	0.74	0.62	na	293	21.0	7.86	<1	<1
20-Sep-11	Mountain Ave	12:15	0.89	0.65	na	295	18.7	7.69	<1	<1
20-Sep-11	Lakeside	12:45	1.64	0.69	0.54	305	20.2	7.85	<1	<1
26-Sep-11	Mountain Ave	11:00	0.77	0.87	na	293	18.6	7.70	<1	<1
26-Sep-11	Hillcrest Sample Station	11:10	0.25	0.80	na	294	16.8	7.80	<1	<1
26-Sep-11	Lakeside	11:25	1.84	0.70	0.56	296	16.2	7.90	<1	<1

Boat launch still closed after heavy rains cause raw sewage overflow into Okanagan Lake

Monday, August 17th, 2009 | 2:10 pm

The Gellatly Bay Boat Launch will remain closed due to water quality concerns after testing revealed a small amount of contaminate entered Okanagan Lake Friday from an overflowing wastewater main. The public is advised not to use the boat launch or enter waters near the launch until the District of West Kelowna advises it is safe to do so.

On August 14, heavy rainfall caused a nearby Regional District of Central Okanagan wastewater main to overflow into Okanagan Lake. Regional District staff are working with Interior Health and the Ministry of Environment. Water samples will be taken near the Gellatly Bay Boat Launch and analyzed daily. Water samples have also been taken from waters near the Marina Park Beach and Willow Beach areas and will be analyzed, but given water currents, proximity of the spill and the small amount of contaminate involved, there are no concerns at this time that these waters are affected.

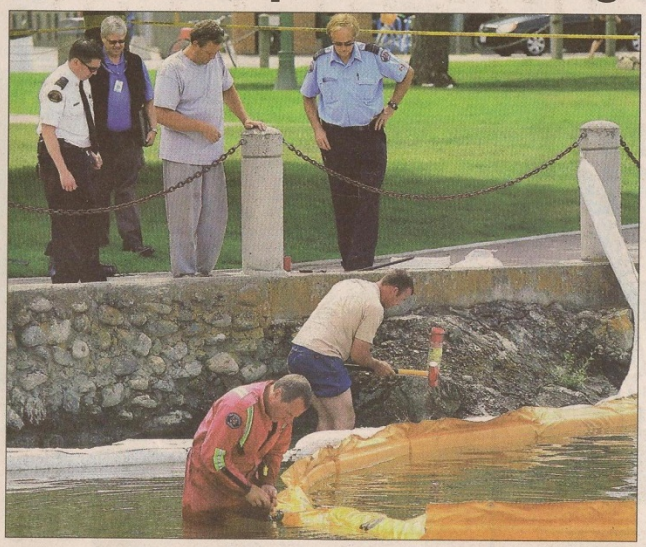
www.kelownacapnews.com

Wednesday, June 23, 2010 capital news A3

NEWS

▼ KELOWNA

Authorities quick to control gasoline leak into lake



SEAN CONNOR/CAPITAL NEWS

KELOWNA FIREFIGHTERS work Monday afternoon at Kerry Park to contain a gasoline fuel tank leak into Okanagan Lake.

JENNIFER SMITH
STAFF REPORTER

A gasoline leak from a land-based tank had the City of Kelowna, the fire department and Petro-Canada staff hopping Monday morning as fuel spilled into Okanagan Lake.

It is not known exactly how much gasoline leaked into the water, but city staff say they believe they caught it early and are hoping the damage is minimal.

"We discovered a very small leak, actually in the wall (along the shore)," said Todd Cashin, City of Kelowna's environment division.

To the point where city officials were called in, Cashin said he believes the spill only contained about a water bottle's worth of gasoline, perhaps 200 milliliters; although, all of the details are still under investigation.

The municipality was contacted by concerned citizens who smelled gas in the downtown area at approximately 8 a.m. and city crews were on scene almost immediately.

The Integrated Land Management Bureau, the provincial Ministry of Environment and the federal Ministry of Environment were all contacted as fire crews set up a boom and absorbent pads to contain the spill.

While the exact source of the leak is under investigation, the city could say the spill's source is around a fuel tank used by Kelowna Marina that is buried under Kerry Park. Details on who is responsible for the tank, its maintenance and so forth have yet to be released, though Cashin confirmed the tank itself is a relatively new one.

The site is complicated because it sits on territory once occupied by ferry docks, so the crews working in the area must go slowly to ensure they don't disrupt live infrastructure lines or hit dormant ones once used to service the docks.

A Petro-Can truck was brought in to siphon off the remains of the gas in the tank Monday morning, leaving the tank empty, but crews are still poking around to ascertain whether more fuel leaked into the ground and exactly what caused the leak.

Fire crews used a silly putty-like sealant to damn the leak spilling into the lake upon arrival.

Unfortunately, gasoline, even in small amounts, does diffuse very quickly, meaning a clean up effort will be required.

Kerry Park sits right beside the brand new Stuart Park where the native riparian shoreline is being restored, but the good news Tuesday was that the lake had been entirely protected.

City officials said more information would be forthcoming Wednesday as the exact source of the leak becomes clear.

jsmith@kelownacapnews.com

Fire-Fighting Stormwater Contaminates Mill Creek and City Beach, 2010

Fire's toxic chemical trail leaves questions

Aug 4, 2010

KATHY MICHAELS
CONTRIBUTOR

When fire crews attacked flames overtaking Stewart Centre Saturday night, their focus wasn't on how local waterways would suffer from the toxic mixture of chemicals they unleashed.

Now, as beaches are cordoned off and images of dead fish rising to the top of local streams make the rounds, the environmental impact is front and centre.

"This might be a wake-up call for everyone to step back and look at our procedures and do the things we need to do to protect fish waterways and ensure safe water for wildlife and people," said Patrick Whittingham, vice-president of the Okeola Fish and Games Club.

"That (dead) fish was a canary in the coal mine. We see the fish that have died off, but we don't know enough about the smaller organisms and what impact this will have on them now, and down the road."

Trouble is, as his club co-hort Rick Simpson put it, you're "damned if you do, damned if you don't."

"What were those guys supposed to do, let the whole block burn down?" he said.

According to Jason Brolund, assistant chief of the Kelowna Fire Department, his crews had a good idea about the chemicals they'd be dealing with and their potential hazard, when they headed into the blaze.

"We knew it was going to take water, and that the water would come out contaminated, but the fire department and province at large follows the B.C. emergency response management system," explained.

That set of principles prioritizes the safety of responders first, then the preservation of life, protecting public life, government infrastructure, property, then the environment comes into play.

"The decisions we made that night were tough," he said.

"It was about keeping people safe and fighting the fire—things were flying left, right and centre and we made decisions about protecting exposures on either side... there were 30 to 40 other businesses that were saved and they could be impacted if we didn't use water to put it out."

With the decision made to deluge flames a call was made to city crews to mitigate the impact of the pesticide, nitrate and glycol mixture that started to trickle into the storm drain system upstream near Lindahl Street, between Springfield Road and Sutherland Avenue.

Their vacuum trucks were on scene, sucking up waste 45 minutes after the first blaze broke.

Unfortunately, they didn't realize they hadn't stopped the flow until the next morning when a resident along Mill Creek noticed the water had changed colour.

Others noticed dead fish on the banks, and as the situation became clear, beaches were closed to swimming.

"In catastrophic situations like that, even the measures the city has in place won't help deal with that volume of water that quickly," said Rick Wagner, environmental emer-

SEE TOXIC A4



WADING UP to his waist in Mill Creek near the entrance to Okanagan lake, an environmental remediation worker inspects and removes debris from the creek after hazardous chemicals from the Stewart Centre fire on Saturday night were washed into the creek through the city's drainage system from the water used to douse the blaze.

SEAN DONNER/CAPITAL NEWS

Marina gas bar flames light up sky by Contributed - Story: 68372
Dec 11, 2011 / 1:11 am

Flames were reaching into the sky as the Kelowna Fire department responded to a fire on the docks of the old Kelowna Marina gas bar. Platoon Captain Tim Light says, "Three engines, a rescue vehicle and a command vehicle responded with 15 personnel." According to Light the first engine extinguished the fire with two hand lines and approximately 1000 gallons of water. Fire investigators will be on scene tomorrow to try and determine the cause and origin of the fire. Light says, "At this time the fire is deemed to be suspicious in nature, but the fire department will know more after a thorough investigation in the morning."



Appendix 3:
Activities Impacting the Intake Protection Zone Checklist

Municipal

- Minimize shoreline clearing for beaches especially with adjacent grassed areas (attracts geese)
- Re-locate storm water outfalls to discharge outside of intake protection zone
- Encourage developers to capture and use storm water on their properties
- Stop or limit the use of fertilizers, pesticides on municipal spaces

Residential Yard Maintenance, Landscaping & Gardening

• Minimize the disturbance of shoreline areas by maintaining natural vegetation cover.
• Minimize high-maintenance grassed areas.
• Replant lakeside grassed areas with native vegetation.
- Do not import fine fill or sand for beaches.

• Use paving stones instead of pavement.
• Stop or limit the use of fertilizers, pesticides.
• Don't use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.

Agriculture

• Locate confined animal facilities away from water bodies and storm water system. Divert incoming water and treat outgoing effluent from these facilities.
• Construct adequate manure storage facilities.
• Do not spread manure during wet weather, on frozen ground, in low-lying areas prone to flooding, within 3 m of ditches, 5 m of streams, 30 m of wells, or on land where runoff is likely to occur.
• Install barrier fencing to prevent livestock from grazing on stream banks.
• If livestock cross streams, provide graveled or hardened access points.
• Provide alternate watering systems, such as troughs, dugouts, or nose pumps for livestock.
• Maintain or create a buffer zone of vegetation along a stream bank, river or lakeshore and avoid planting crops right up to the edge of a water body.
• Limit the use of fertilizers and pesticides

Onsite Sewage Systems

• Inspect your system yearly, and have the septic tank pumped every 2 to 5 years
• Use phosphate-free soaps and detergents.
• Avoid septic additives and house-hold cleaning chemicals
• Don't put toxic chemicals (paints, varnishes, thinners,waste oils, photographic solutions, or pesticides) down the drain because they can kill the bacteria at work in your onsite sewage system and can contaminatewaterbodies.
• Conserve water: run the washing machine and dishwasher only when full and use only low-flow
showerheads and toilets.

Auto Maintenance

• Use a drop cloth if you fix problems yourself.
• Recycle used motor oil, antifreeze, and batteries.
• Use phosphate-free biodegradable products to clean your car. Wash your car over gravel or grassy areas, but not over sewage systems.

Boating

• Do not throw trash overboard or use lakes or other water bodies as toilets.
• Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
• Conduct major maintenance chores on land.
• Use four stroke engines, which are less polluting than two stroke engines, whenever possible. Use an electric motor where practical.
• Keep motors well maintained and tuned to prevent fuel and lubricant leaks.
• Use absorbent bilge pads to soak up minor oil and fuel leaks or spills.
• Recycle used lubricating oil and left over paints.
• Check for and remove all aquatic plant fragments from boats and trailers before entering or leaving a lake.
• Do not use metal drums in dock construction. They rust, sink and become unwanted debris. Use polystyrene (completely contained and sealed in UV-treated material) or washed plastic barrel floats.
• When within 150 m of shore adjust your speed accordingly to prevent waves from eroding banks. Adhere to British Columbia's Universal Shoreline Speed Restriction which limits all power-driven vessels to 10 km/hr within 30 m of shore. Exceptions to this restriction include:• vessels traveling perpendicularly to shore when towing a skier, wakeboard, etc.

-After BC Lake Stewardship Society 2008

Appendix 4: *E. coli* Source Tracking in City of Kelowna Creeks Receiving Storm Water and at Beaches

City of Kelowna Creeks with Storm Water 2006
E. coli Bacterial Source Tracking

Probable Source	Count	Percent
Human	3	13
Canine	6	25
Bovine		0
Horse		0
Song birds		0
Gulls	1	4
Duck	7	29
Canada Goose	1	4
Racoon		0
Deer	4	17
Unknown	2	8
SUM	24	100

City of Kelowna Creeks and Beaches 2006
E. coli Bacterial Source Tracking

Probable Source	Count	Percent
Human	8	8
Canine	15	14
Bovine	1	1
Horse		0
Song birds	14	13
Gulls	18	17
Duck	20	19
Canada Goose	16	15
Racoon	4	4
Deer	5	5
Unknown	4	4
SUM	105	100

City of Kelowna Creeks with Storm Water 2008
E. coli Bacterial Source Tracking

Probable Source	Count	Percent
Human	3	5
Canine	2	3
Bovine	6	9
Horse	2	3
Song birds	14	21
Gulls	5	8
Duck	7	11
Canada Goose	12	18
Racoon	1	1
Deer	6	9
Unknown	8	12
SUM	66	100

City of Kelowna Creeks and Beaches 2008
E. coli Bacterial Source Tracking

Probable Source	Count	Percent
Human	10	5
Canine	13	6
Bovine	21	10
Horse	11	5
Song birds	44	21
Gulls	18	8
Duck	18	8
Canada Goose	26	12
Racoon	6	3
Deer	19	9
Unknown	28	13
SUM	214	100

Courtesy of City of Kelowna, Analyses performed at UVic

Appendix 5: Storm Drainage Requirements for Killiney Beach and Westshore Estates

The following section outlines the Storm Drainage requirements at time of subdivision or development in accordance with the RDCO Subdivision and Development Servicing Bylaw. Typically storm water is attenuated on the subject parcel and for large subdivisions/development the post-development storm water flows from the property cannot exceed the pre-development flows. The infill subdivisions typically do not require offsite works (road and drainage). Parcel drainage requirements are identified in part c, below (M. Noga, Pers comm., 2011).

Storm Drainage Systems

If Schedule C.2 requires a *drainage system*, the *Owner* of the *parcel* being *subdivided* or *developed* must provide the proposed *subdivision*, or the *parcel* being *developed* with a storm *drainage system* constructed and installed in accordance with the standards set out in Schedule C.8.

In addition to the requirements of Schedule C.2, a storm *drainage system* is required where the *subdivision* or *development* is located in an area where drainage studies prepared for the *Regional District* and adopted by the *Regional Board* indicate that drainage work should be constructed.

Where the storm water management plan identifies overland drainage corridors within the *subdivision or development* those corridors must be protected by an easement, and the *Owner* must register a covenant against the title of each parcel to ensure the drainage system is not compromised by future development.

Drainage, Sediment and Erosion Control

The *Owner's Engineer* must prepare plans and documentation outlining the Drainage, Sediment, and Erosion Control Plan that will be used during the *subdivision* or *development* of the *parcel.* The Drainage, Sediment and Erosion Control Plan must address and include any provisions specific to drainage, erosion or watercourse protection from a development permit issued by the *Regional District* in accordance with the Local Government Act of BC and be prepared in accordance with:

- the Ministry of Environment's Best Management Practices document (Develop with Care: Environmental Guidelines for Urban and Rural Land Development);
- the Ministry of Environment's Standards and Best Management Practices for Instream Works;
- the Ministry of Environment's Riparian Area Regulation Implementation Guidebook;
- the Urban Runoff Quality Control Guidelines for British Columbia;
- the Regional District Aquatic Ecosystem Development Permit Guidelines;
- the Regional District Storm Water Quality Management Plan Preparation Guidelines; and
- the City of Kelowna Best Management Practices for Erosion and Sediment Control – Uplands Works and Instream Works.

A copy of the plan must be submitted to the Regional District Engineer for review and must include pre and post *subdivision* or *development* contour plans.

The *Applicant* must ensure that no silt, gravel or debris resulting from construction activity in the *subdivision* or *development* is allowed to discharge in existing drainage systems, natural drainage courses, water courses, or onto *highways*, or adjoining properties.

System Components

Each *drainage system* must consist of the following components:

(a) A Minor System consisting of pipes and ditches which convey flows of a 10-year return frequency.

Driveway culverts that form part of the minor system must be designed to the 10-year return frequency with the design headwater not to exceed half the diameter of the culvert. Minimum culvert size shall be 400 mm.

(b) A Major System consisting of surface flood paths, roadways, and water courses which convey flows of a 100-year return frequency. Major flood path routing is required wherever surface overland flows in excess of 0.01 m^3/s are anticipated. Creeks regulated by the Ministry of Environment may require design to a 1 in 200 year flood.

Roadway crossings must be designed to accommodate the 100-year return frequency. The headwater profile may not exceed half the diameter of the cross culvert. Major overland flow routes are required down-stream of any low-point in a *road* or *cul-de-sac*.

The system must be designed to accommodate the design major flow, should any facility become blocked or restricted. Minimum major system culvert diameter 600 mm.

(c) A *Parcel Drainage System* which identifies individual *parcel* drainage patterns. Where runoff from a *parcel* will cross neighbouring properties, the *Applicant* must:

(i) provide drainage *works* designed and constructed to dispose of the runoff on the *parcel*, **OR;**

(ii) provide a surface or sub-surface conveyance system designed and constructed as part of the overall *drainage system* and where necessary, be protected by easements.

The *Owner's Engineer* shall assess the potential for groundwater problems and a storm drainage service connection shall be required and permitted only in areas where groundwater has been identified as a potential problem by the *Owner's Engineer* or in a drainage plan adopted by the *Regional Board*. Where groundwater is a potential problem, each *parcel* must be provided with a storm drainage service connection.

Appendix 6: Technical Advisory Committee for this report

Invitation to TAC
From: Angela Lambrecht
Sent: May-10-12 11:03 AM
To: Rob Birtles (robert.birtles@interiorhealth.ca); heather@larratt.net; Angela Lambrecht; Margaret Bakelaar; 'Kimm.MagillHofmann@gov.bc.ca'; 'Ken.Cunnigham@gov.bc.ca'; 'danielle.wensauer@tc.gc.ca'; 'Mike.Sokal@gov.bc.ca'; 'okibcouncil@okanagan.org'; 'Wade.Anderson@gov.bc.ca'
Cc: Jim Roe (jim.roe@cord.bc.ca)
Subject: Source Assesment of Okanagan Lake Intakes for Killiney Beach and Westshore Estates - TAC

You are receiving this email as an invitation to participate as a technical advisory committee (TAC) member in a source water assessment for the Regional District of Central Okanagan (RDCO) for the Killiney Beach and Westshore Estates Water Systems. I am the Water Quality Technologist for the RDCO and will be coordinating this effort.

The TAC for the project is intended to include representation from the RDCO (Engineering and Planning), Interior Health, Okanagan Indian Band, Ministry of Natural Resource Operation (Hydrologist and Recreation Officer), Transport Canada, Ministry of Environment (Limnologist) and Integrated Land Management Bureau.

The TAC can expect to meet once or twice in the next 6 months and will review the materials prepared by Larratt Aquatic Consulting and/or the RDCO. The objective of the assessment of the two RDCO North Okanagan Lake intakes is to identify current and forecast future drinking water hazards and vulnerabilities, characterize the risk posed by each hazard, and provide recommendations to reduce impacts on the intake.

Please respond by indicating whether you or someone from your organization will participate, and provide me with availability for a 2 hour meeting June 11, 12 or 13, 2012.

I will send out a confirmation for the meeting date/location/time and provide the names and contact information for the proposed Technical Advisory Committee as well as relevant documents for the project by the week of May 21, 2012.

Respectfully,

Angela Lambrecht, AScT
Water and Wastewater Process Technologist

Regional District of Central Okanagan
1450 KLO Rd, Kelowna BC, V1W 3Z4
Direct Line: (250) 469-6124
Fax: (250) 768-2260
www.regionaldistrict.com

The invitees that were able to attend the June 11, 2012 TAC meeting were:
Margaret Bakelaar RDCO planner
Rob Birtles IHA Drinking water officer
Mike Sokal M of Environment
Heather Larratt Larratt Aquatic Consulting
Angela Lambrecht

Written comments were received from:
Rob Birtles
Wade Anderson NRFLO

Meeting Notes were taken by:
Angela Lambrecht
Heather Larratt

_____end of report_____

Water

Regional District of the Central Okanagan

Killiney Beach Water System Preliminary Design – FINAL

Prepared by:

AECOM
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250 762 3727 tel
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Project Number:

60340265

Date:

April, 2015

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April 27, 2015

Clarke Kruiswyk
Environmental Services Analyst
Regional District of the Central Okanagan
1450 KLO Road
Kelowna, BC V1W 3Z4

Dear Mr. Clarke Kruiswyk:

Project No: 60340265

Regarding: **Killiney Beach Water System Preliminary Design – FINAL**

Please find the attached FINAL Preliminary Design Report for the above reference project. This submission addresses comments submitted by RDCO on April 17th regarding the final draft report.

This report outlines a clear path forward for the RDCO to improve the level of service within the Killiney Beach Water System to meet both local and federal standards for provision of drinking water.

Should you have any questions, please do not hesitate to contact myself.

Sincerely,
AECOM Canada Ltd.

Stephen Horsman, P.Eng.
Project Manager

Encl.
cc:

Distribution List

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	Stephen Horsman	March 17, 2015	90% Draft / Issued for Client Review
1	Stephen Horsman	April 2, 2015	Final Draft / Issued for Client Review
2	Stephen Horsman	April 27, 2015	Final Report

AECOM Signatures

Report Prepared By:

Stephen Horsman, P.Eng, P.E.
Project Manager

Stamp



Report Reviewed By:

April 27/15.

Brett deWynter, P.Eng.

Table of Contents

Statement of Qualifications and Limitations
Letter of Transmittal
Distribution List

page

1. Introduction 1
1.1 Background 1
1.2 Document Organization 1

2. Existing Water System 2
2.1 Overview of Water System 2
2.2 Summary of Existing Infrastructure 3

3. Design Criteria 5
3.1 Water Demand and Population Projections 5
3.2 Water Distribution System and Treated Water Storage 6
3.3 Treated Water Quality Objectives 7

4. Development of Options 9
4.1 Option 1: Treatment Siting at Udell Reservoir 10
4.2 Option 2: Treatment Siting at Okanagan Lake 13
4.2.1 Option 2a: New Treatment Plant at Okanagan Lake and Dedicated Transmission to Killarney 13
4.2.2 Option 2b: New Treatment Plant at Okanagan Lake and No Dedicated Transmission Main 14
4.3 Evaluation of Treatment and Transmission Options 17
4.3.1 Treatment Process and Operational Impacts 17
4.3.2 Compatibility with Existing and Future Infrastructure 17
4.3.3 Environmental Impact 18
4.3.4 Land Use Impacts 18
4.3.5 Cost Comparison of Alternatives 19
4.3.6 The Recommended Alternative 19

5. Analysis of Water System 20
5.1 Distribution System Hydraulic Analysis 20
5.2 Dedicated Transmission Main Assessment 21
5.3 Storage Assessment 21
5.3.1 Storage Capacity 21
5.3.2 Hope Creek Reservoir HGL 22
5.4 Recommended Water System Upgrades 22

6. Preliminary Design of Preferred Alternative 26
6.1 General Description of the Works 26
6.2 Lake Intake 26
6.3 Low and High Lift Pumping 27
6.4 Ultraviolet Disinfection 27
6.5 Chlorine Disinfection 28
6.5.1 Chlorine Dosing and Storage 28

6.5.2 Chlorine Contact Tank 28
6.6 Filtration (Low Pressure Membrane) 29
6.7 Civil Considerations 29
6.8 Offsite Upgrades 30
6.8.1 Killarney PRV Station 30
6.8.2 Dedicated Treated Water Transmission Main 30
6.9 Architectural and Structural Design 30
6.10 Building Mechanical Design 31
6.11 Electrical Design 32
6.11.1 Primary Service 32
6.11.2 Plant Power Distribution 32
6.11.3 Grounding 32
6.11.4 Fire Alarm and Security System 33
6.12 Instrumentation Design 33
6.13 Estimates of Probable Cost 33
6.13.1 Assumptions 33
6.13.2 Estimate of Probable Construction Cost 34

List of Figures

Figure 1 Killiney Beach Water System Schematic 2
Figure 2 Option 1 Treatment Servicing Schematic 11
Figure 3 Treatment Siting Plan Option 1 – Udell Reservoir 12
Figure 4 Option 2a Treatment Servicing Schematic 14
Figure 5 Option 2b: Treatment Servicing Schematic 15
Figure 6 Treatment Siting Plan Option 2 – Lakeshore 16
Figure A-1 Existing Distribution System A1
Figure A-2 Proposed Distribution System Upgrades and Project Numbers A2

List of Tables

Table 1 Okanagan Lake Pump House 3
Table 2 Killarney Reservoir and Pump House 3
Table 3 Udell Reservoir and Pump House 4
Table 4 Winchester Reservoir and Pump House 4
Table 5 Hope Reservoir 4
Table 6 RDCO Bylaw No. 704 – Water Demands 5
Table 7 Current and Projected System Demands 5
Table 8 RDCO Bylaw – Distribution System Pressure and Velocity 6
Table 9 RDCO Bylaw – Treated Water Storage Requirements 6
Table 10 Recommended Long Term Treated Water Quality Goals 7
Table 11 Evaluation Criteria and Relative Weight for Each Criterion 17
Table 12 Capital Cost of Options 19
Table 13 Results of the Option Comparison Model 20
Table 14 Killiney Beach Water System Reservoir Storage Requirements 21
Table 15 Water System Upgrades and Cost 24

Table 16 Design Criteria for Raw and Treated Water Pumps 27
Table 17 Design Criteria for the Ultraviolet Disinfection Reactors 27
Table 18 Pressure Membrane Filtration Parameters 29
Table 19 Structural Design Criteria 31
Table 20 Summary of Electrical Loads 32
Table 21 Capital Cost of Stage 1 Treatment Facility 34
Table 22 Annual Operating Cost of Stage 1 Treatment Facility 35

Appendices

Appendix A. Water System Schematics
Appendix B. Capital Cost Estimates for Siting Options
Appendix C. Hydrant Testing Results
Appendix D. Detailed Breakdown of Preliminary Design Capital and Operating Cost Estimates

1. Introduction

1.1 Background

The Killiney Beach Water System (KBWS) is a small water system maintained and operated by the Regional District of the Central Okanagan (RDCO). Located on the western shore of Okanagan Lake approximately six kilometres north of Fintry, the KBWS serves approximately 280 residential connections with full build-out estimated to be 430 residential connections. Originally the water system relied on Hope Creek and Norris Creek for supply of raw water; however, due to limitations in the quality and quantity of the two creek sources, upgrades were completed in the 1980's to include an intake and pump station to supply Okanagan Lake water throughout the water system.

The configuration of the KBWS presents several challenges for both the users and the utility operations. Previous reports completed by Associated Engineering (AE, 2010) and Kerr Wood Leidal (KWL, 2014) identify several upgrade requirements and review various servicing alternatives to resolve the existing system deficiencies. Building on these recommendations the following key issues are addressed within this report:

1) Relying solely on chlorine disinfection does not meet Interior Health Authority (IHA) guidelines for treatment of surface water sources. RDCO are planning to improve treatment to meet IHA guidelines but have not selected a preferred site for the new treatment infrastructure.
2) The existing reservoirs are undersized and the distribution system is not capable of conveying recommended fire flows throughout the service area. Updated costs estimates and a clear renewal approach are needed to facilitate immediate and long term infrastructure planning.

This report reviews some the options available to address above issues and provides clear recommended solutions. For the recommended treatment option a description of the works are provided complete with an estimate of the capital and operating costs.

1.2 Document Organization

This technical memorandum fulfils the requirements of the Request for Proposals issued by the RDCO and the proposal submitted by AECOM (Canada) Inc. on February 10, 2015.

The remainder of this report is sub-divided into several sections, as follows:

- **Section 2 – Existing System** presents an overview of the existing system infrastructure;
- **Section 3 – Project Design Criteria** presents estimates of the treated water demand, outlines the assumptions regarding the raw water quality and treated water quality requirements, and documents design guidelines and assumptions used for the distribution system analysis;
- **Section 4 – Development of the Options** builds upon the design criteria established in the previous Section, and presents siting options and servicing approaches given the existing service area constraints. Discusses the multi-bottom line evaluation matrix and option rankings and a recommended approach is provided;
- **Section 5 – Hydraulic Assessment** analyzes the build-out distribution network performance based on hydraulic computer modelling, reviews Hope reservoir siting considerations, and recommends upgrades to meet the RDCO bylaw requirements;
- **Section 6 – Preliminary Design of Improvements** provides a preliminary design of the preferred treatment option developed in Section 4 along with capital and operating costs.

2. Existing Water System

2.1 Overview of Water System

The existing KBWS relies on Okanagan Lake as the source of water to service the potable water needs for the Killiney area. Raw water is chlorinated at the Lake Pump House using chlorine gas and then pumped into the distribution network. An overall site plan of the existing distribution system infrastructure is included in **Figure A-1** in **Appendix A**.

Divided into four (4) pressure zones (i.e. low, middle, upper and high), Okanagan Lake water is pumped sequentially from the adjoining lower pressure zone and then balanced in the respective storage reservoir. Two small pressure reducing valves (PRV) are located in the Upper Pressure Zone that service a series of lots along the lower boundary of the pressure zone.

The High and Upper pressure zones consist primarily of 100mm diameter pipe and are unable to meet current fire flow demands. The Middle and Low pressure zones have been upgraded to include predominantly 150mm pipe; however there are locations with 100mm and 50mm piping. As outlined in the AE 2010 report, a series of piping upgrades and additional interconnects between pressure zones are required to meet the current and future fire flow requirements for the area.

The KBWS has a total of 27 hydrants that are adequately spaced to provide fire coverage (i.e. 180 metre radius from hydrant to property line) throughout the service area, with minor exceptions on Moody Crescent and Kilkenny Place.

The hydraulic layout of the existing KBWS is presented in **Figure 1**.

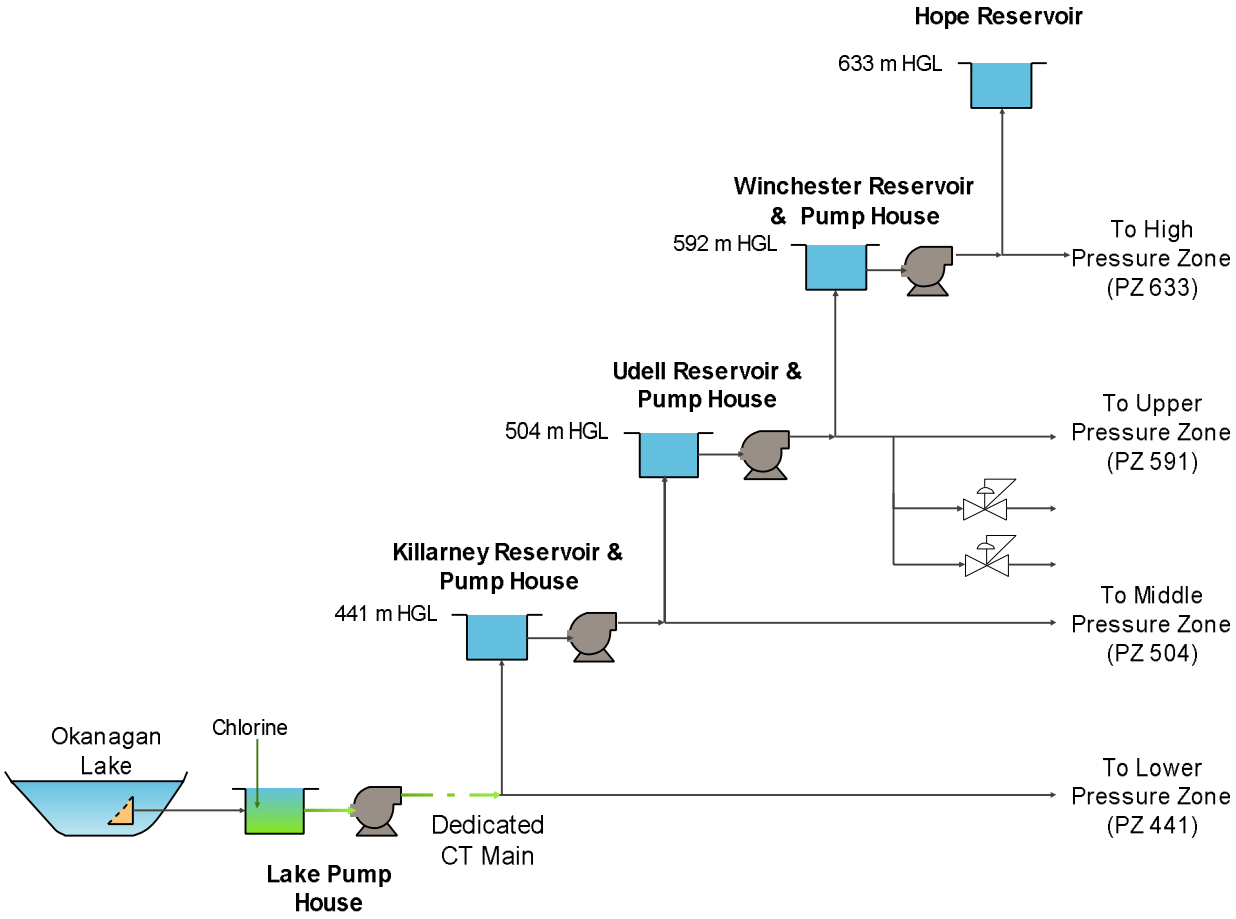


Figure 1 Killiney Beach Water System Schematic

2.2 Summary of Existing Infrastructure

The following tables present an overview of the KBWS infrastructure. Data presented in the tables was obtained from information provided by the RDCO including Killiney Beach Water Distribution Figure[1], record drawings, and the existing WaterCAD computer hydraulic model. Hydraulic Grade Lines (HGL) for each reservoir were verified using contour elevations and hydrant test results provided by RDCO staff.

Table 1 Okanagan Lake Pump House

Infrastructure	Description	Comments
Pumping Capacity		
Number of Pumps:	2 (duty\standby)	None
Pump Size (each):	14 L/s at 105.5 m TDH (30 hp)	
Pump Type:	Dry Mount Vertical turbine	
Storage (Wetwell)		
No of Cells:	1	
Effective Volume:	37 m^3	Based on Lake Low Water Level 340.4m
Tank Type:	Cast-in-place Concrete (Rectangular)	
Dimensions (per cell):	4.9 x 4.9 x 3.7 m (Deep)	
Treatment	Gas Chlorination	Chlorine provided in wetwell and 60 m of 200mm watermain to first customer

Table 2 Killarney Reservoir and Pump House

Infrastructure	Description	Comments
Pumping Capacity		
Number of Pumps:	2 (duty\standby)	None
Pump Size (each):	9.8 L/s at 77.7 m TDH (15 hp)	
Pump Type:	Submersible vertical turbine	
Storage		
No of Cells:	1	None
Effective Volume:	76 m^3	
Tank Type:	Cast-in-place Concrete (Rectangular)	
Dimensions (per cell):	4.9 x 3.7 x 3.7 m (Deep)	
HGL:	441.75 m	
Treatment	None	N/A

[1] *Regional District of the Central Okanagan, Killiney Beach water System, January 23, 2015.*

Table 3 Udell Reservoir and Pump House

Infrastructure	Description	Comments
Pumping Capacity		
Number of Pumps:	2 (duty\standby)	None
Pump Size (each):	7 L/s at 101 m TDH (10 hp)	
Pump Type:	Submersible vertical turbine	
Storage		
No of Cells:	2	
Effective Volume:	340 m^3 (Cell 1), 76 m^3 (Cell 2)	
Tank Type:	Cast-in-place Concrete (Rectangular)	
Dimensions (per cell):	9.7 x 9.7 x 3.7 m (Deep)	Dimensions shown for Cell 1 only. Cell 2 dimensions match Killarney Reservoir.
HGL:	504.75	
Treatment	None	N/A

Table 4 Winchester Reservoir and Pump House

Infrastructure	Description	Comments
Pumping Capacity		
Number of Pumps:	2 (duty\standby)	None
Pump Size (each):	7.5 L/s at 50 m TDH (5 hp)	
Pump Type:	Submersible vertical turbine	
Storage		
No of Cells:	2	
Effective Volume:	340 m^3 (Cell 1), 76 m^3 (Cell 2)	
Tank Type:	Cast-in-place Concrete (Rectangular)	
Dimensions (per cell):	9.7 x 9.7 x 3.7 m (Deep)	Dimensions shown for Cell 1 only. Cell 2 dimensions match Killarney Reservoir.
HGL:	591.4 m	
Treatment	None	N/A

Table 5 Hope Reservoir

Infrastructure	Description	Comments
Pumping Capacity		
Number of Pumps:	None	N/A
Pump Size (each):		
Pump Type:		
Storage		
No of Cells:	1	
Effective Volume:	76 m^3	RDCO noted that the Hope Reservoir volume may be slightly less than shown.
Tank Type:	Rectangular	
Dimensions (per cell):	4.9 x 3.7 x 3.7 m (Deep)	
HGL:	633 m	
Treatment	None	N/A

3. Design Criteria

3.1 Water Demand and Population Projections

For the purposes of municipal infrastructure design, standard practice is to target 20-year and 50-year development horizons to establish logical building and equipment staging scenarios. If a 2% growth rate is applied to Killiney service area the build-out of the community is estimated to occur in 20-25 years. For this reason all proposed infrastructure in the KBWS will be sized for the build-out demands. Provision for servicing outside the current KBWS boundaries is not expected and therefore is not included in the future demand requirements.

As noted in the RFP, revisions to the current RDCO Subdivision and Development Servicing Bylaw No. 704 (RDCO Bylaw) are proposed that reduce the Maximum Daily Demand (MDD) and peak hour demand throughout the water system. A comparison of the current and proposed RDCO Bylaw per capita demands is shown in **Table 6**.

Table 6 RDCO Bylaw No. 704 – Water Demands

Criterion	Proposed Bylaw Demands	Current Bylaw Demands
ADD (L/cap/day)	900	900
MDD (L/cap/day)	2100	2400
PHD (L/cap/day)	3600	4000
Population (cap/lot)	3	3

Using the proposed Bylaw demands, **Table 7** presents the current and future water demands anticipated within the KBWS. Build-out water demands were estimated based on counting the number of lots within each pressure zone and assuming three person per single family dwelling.

Table 7 Current and Projected System Demands

Pressure Zone	Lots	Demand (L/s)	
		MDD	ADD
Current			
Water System	279	20.3	8.7
Build-out			
High Zone	94	6.9	2.9
Upper Zone	170	12.4	5.3
Middle Zone	95	6.9	3.0
Low Zone	70	5.1	2.2
Water System	**429**	**31.3**	**13.4**

***Notes**:*

1. *Data on the current water use per zone was not available at the time of this study and therefore only build-out provided.*

3.2 Water Distribution System and Treated Water Storage

The RDCO Bylaw defines requirements for pressures and velocities for water distribution systems. The RDCO Bylaw states that mains in the water distribution system must be sized to convey whichever is greater of the peak hourly flow rate or the MDD plus the fire flow rate. In a system the size of KBWS the MDD plus fire flow rate typically governs upgrade requirements. In addition to the capacity requirements the minimum allowable pipe diameter is 150 mm diameter with the exception of dead end mains where 100 mm diameter main is permitted. System pressure and velocity requirements outlined in the RDCO Bylaw are shown in **Table 8**.

Table 8 RDCO Bylaw – Distribution System Pressure and Velocity

Criterion	Pressure (kPa)	Pipe Velocity
Maximum Static	1000	
Minimum Static	275	
Minimum Residual during PHD	250	2 m/s
Min Residual during Fire Flow	140	4 m/s

Distribution storage requirements obtained from the RDCO bylaw and used for our assessment are presented in **Table 9**.

Table 9 RDCO Bylaw – Treated Water Storage Requirements

Component	Storage Volume	Purpose
A – Fire Storage	60 L/s for 1.5 hours based on rural single family land use	Fire storage is the volume reserved in the reservoir at all times to fight fires in the service area. The Fire Underwriters Survey establishes guidelines for determination of fire flow and storage requirements under a variety of scenarios.
B – Equalization Storage	25% of the MDD	Equalization storage will allow the treatment facilities, transmission mains and pump stations to be designed to meet or exceed the MDD, as the balancing storage is used to attenuate spikes in demand.
C – Emergency Storage	25% of Equalization and Emergency Storage	Emergency storage is for covering interruptions to the supply due to equipment or distribution failures.

3.3 Treated Water Quality Objectives

For the purposes of assessing any treatment needs it is necessary to identify treated water quality objectives for potable water delivered from surface water sources. Since the life cycle costs of any new facilities would be at least 20 years, it is considered prudent in the identification of these objectives to not only draw upon the present day set of water quality guidelines and regulations in British Columbia, but also to consider the regulatory environment in other jurisdictions. Of these regulations from other jurisdictions, the U.S. Federal Regulations set by the U.S. Environmental Protection Agency (USEPA) are of particular interest, as they have typically pre-dated similar changes in the Guidelines for Canadian Drinking Water Quality by several years, and have proven to be a valuable "barometer" of the future direction in Canada and British Columbia.

- B.C. Interior Health Authority (IHA) 4-3-2-1-0 guidelines[2];
- The Provincial drinking water quality standards of Alberta[3] and Ontario[4], the two Canadian provinces which have been the most proactive in setting more stringent regulations in recent years;
- The Guidelines for Canadian Drinking Water Quality (GCDWQ)[5];
- The following USEPA Regulations[6]:
  - The Surface Water Treatment Rule (SWTR)
  - The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
  - The Stage 2 Disinfectants/Disinfection By-Product (D/DBP) Rule;
  - The Ground Water Rule (GWR);
  - The Filter Backwash Recycling Rule (FBRR);
  - National Primary and Secondary Drinking Water Standards;
- The drinking water regulations imposed by the United Kingdom's Drinking Water Inspectorate[7];
- The World Health Organization Guidelines for Drinking Water Quality, 2004[8].

The RDCO is completing a separate study to assess the viability of filtration deferral and the suitability of the current intake location. Pending the results of this study, we have separated the recommendations for treatment into two stages. The Stage 1 goals are based on implementing two levels of disinfection and deferring filtration until required by raw water quality conditions. Stage 2 goals include the provision of filtration and are considered the long term treatment objectives for the KBWS water system.

The treatment goals for each stage are presented in **Table 10**.

Table 10 Recommended Long Term Treated Water Quality Goals

Parameter	Units	Stage 1 – Intermediate Goal	Stage 2 – Long Term Goal
Total Alkalinity	mg/L as $CaCO_3$	N/A	≥ 25
Aluminum, total	mg/L	≤ 0.1	≤ 0.1
Iron	mg/L	N/A	≤ 0.3

[2] *http://www.interiorhealth.ca/YourEnvironment/DrinkingWater/Documents/construction%20of%20waterworks%20guidelines.pdf*
[3] *Alberta Environment – "**Standards & Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems**", January, 2006*
[4] *Ontario Ministry of the Environment – "**Ontario Regulation 169/03 – Ontario Drinking Water Quality Standards**",*
[5] *http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2012-sum_guide-res_recom/index-eng.php*
[6] *http://www.epa.gov/safewater/standards.html*
[7] *http://www.dwi.gov.uk/*
[8] *http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/*

Manganese	mg/L	N/A	≤ 0.05
Coliform bacteria	organisms/ 100 mL	Zero	Zero
Cryptosporidium parvum (see **Note 1**)	log reduction	≥ 3-log (99.9 %) removal or inactivation	≥ 3-log (99.9 %) removal or inactivation
Giardia Lamblia (see **Note 1**)	log reduction	≥ 3.5-log (99.9 %) removal or inactivation(0.5 log inactivation by chlorine)	≥ 3-log (99.9 %) removal or inactivation
Enteric viruses (see **Note 1**)	log reduction	≥ 4-log (99.99 %) removal or inactivation	≥ 4-log (99.99 %) removal or inactivation
Sulphates	mg/L	N/A	≤ 200
pH		No pH adjustment	6.5 – 8.5
Corrosion Potential (see **Note 2**)		Stable, not aggressive to piping materials	Stable, not aggressive to piping materials
Temperature	^{o}C	≤ 15	≤ 15
Trihalomethanes (see **Note 4**)	µg/L	≤ 80, on a Locational Running Annual Average (see **Note 3**)	≤ 80, on a Locational Running Annual Average (see **Note 3**)
Haloacetic Acids	µg/L	≤ 60, on a Locational Running Annual Average (see **Note 3**)	≤ 60, on a Locational Running Annual Average (see **Note 3**)
True Colour	TCU	N/A	≤ 15
Turbidity	NTU	Average daily < 1 NTU and never to exceed 5 NTU	Granular Media Filtration < 0.3 NTU 95% of the time, never to exceed 1 NTU; Membrane Filtration < 0.1 NTU 95% of the time, never to exceed 1 NTU

Notes:

1. *The source water available to the Killiney Water System and under consideration for this project, is Okanagan Lake. Note that many jurisdictions, including the USEPA mandate higher removal/inactivation efficiency for sources with elevated Giardia and Cryptosporidium. The Okanagan Lake does not exhibit higher levels of either pathogen which would warrant the pursuit of more stringent removal/inactivation goal;*

2. *Most regulatory bodies do not mandate specific, quantitative objectives for corrosion, due to the complexity of corrosion processes occurring in distribution systems. As such, qualitative goals such as rendering the water "stable, and non-aggressive" are commonly used. Health Canada has recently issued guidelines for utilities to conduct sampling of water drawn at the tap to determine the seriousness of corrosion issues[9]. It is recommended that the Regional District review these guidelines, and measure themselves against these criteria to determine whether their water is "Stable, and not aggressive to distribution system piping materials";*

3. *Locational Running Annual Average, or LRAA, is an alternative means of measuring disinfection by-product concentrations in the distribution system. Present Canadian guidelines call for a Running Annual Average of all samples throughout the system, this allowing for samples with lower DBP concentrations to mask higher levels of DBP's measured elsewhere in the system. The LRAA approach requires that the utility show an ability to meet the target at all points in the system individually, so that the LRAA approach is significantly more stringent than the present approach;*

4. *Health Canada[10] has a guideline for Haloacetic acids[11]. Note that both the goals for THM's and HAA's listed above are based upon the USEPA D/DBP Rule, which is more stringent even than the Health Canada guidelines (or draft guidelines) for these parameters.*

[9] *Health Canada - "**Corrosion Control in Drinking Water Distribution Systems**", Issued for Public Comment, April, 2007*
[10] *Health Canada – "**Guidelines for Canadian Drinking Water Quality – Guideline Technical Document – Trihalomethanes**", May, 2006*
[11] *Health Canada – "**Haloacetic Acids in Drinking Water**", July, 2008*

4. Development of Options

This section of the report develops two treatment siting alternatives and two options for dedicated transmission of treated water. Each alternative includes a brief description, summary of required upgrades, capital cost estimate and list of the key benefits and challenges.

Treatment siting considerations and assumptions common to each option include:

General

- All civil and mechanical components designed to meet build-out demands.
- Raw water supply infrastructure designed to convey build-out MDD plus 10% for losses due to filtration.
- Stage 1 treatment includes two levels of disinfection and deferral of filtration. Treatment capacity based on MDD plus 10%.
- Stage 2 treatment provided in the future when filtration deferral is no longer achievable. The capital cost of Stage 2 treatment is assumed to be comparable for all options and therefore was not included the in the cost comparison;
- Land purchase not included in any of the listed options;
- Fire flow distribution upgrades not included in the treatment siting evaluation.
- Reservoir storage upgrades not included in the treatment siting evaluation.
- Minimum mechanical system redundancy of N+1 for all treatment and conveyance equipment except PRVs and piping.
- New raw and treated water pumping facilities to include three pumps to operate in lead\lag\standby configuration.
- Intake extension not included in the option comparison.

Water Treatment Infrastructure

- Stage 1: UV and Chlorine Disinfection Facility
    - UV Disinfection:
        - 3 log inactivation of *Giardia* and *Cryptosporidium*;
        - 1 duty/1 standby 400 mm low pressure UV reactors;
    - Chlorination:
        - Bulk 12% hypochlorite dosing with metering skid (duty\standby pumps)
        - Chlorination room sized for future addition of 7.5 kg/day on-site hypochlorite generation system;
        - Cast-in-place concrete chlorine contact (CT) tank (volume varies depending on extent of dedicated transmission main).
- Stage 2: Future Filtration
    - Filtration
        - Direct filtration using packaged low pressure membranes.
        - Filtration to achieve 3 log removal of *Giardia* and *Cryptosporidium*.
        - Two membrane treatment trains (duty\standby) based on recovery of 95% and 75% spare module space.
    - Residuals Management
        - Gravity storage and clarification of membrane backwash waste using two 85 m^3 cast-in-place concrete storage tanks.
        - Recycle clarified backwash supernatant with raw water supply;
        - On-site storage of backwash waste sludge to be pumped and hauled to WWTP. 95 m^3 cast-in-place concrete tank sized for one week of storage at Build-out MDD.
        - Monthly CIP waste to be neutralized on-site and hauled to WWTP.

Buildings

- UV and Hypochlorite Disinfection Building
  - 95 m^2 building footprint consisting of a split face masonry superstructure.
  - 25 m^2 for electrical and control rooms and small washroom.
- Filtration Building
  - Two-storey building with a footprint of 100 m^2.
  - Ground level to be masonry and house membrane filtration equipment.
  - Substructure to provide backwash waste handling tank and pumping equipment.
- Tankage
  - On-site storage tanks to be cast-in-place concrete with overflow to nearest drainage course.

Civil and Offsite Improvements

- Gravel access road to building entrances.
- 1.8m high chain-link fencing with 3-strand barb surrounding new facilities.
- Killarney reservoir and pump station modified to include PRV station to service the Low pressure zone.
- 3-phase power provided to the Lake Pump House site via extending transmission 930 metres from Westside Road.
- 3-phase power provided to new treatment site.
- Sanitary waste stored in below grade storage tank for pump and haul operations.
- Stormwater drainage managed on-site using drywells with overflow to nearest drainage course.

4.1 Option 1: Treatment Siting at Udell Reservoir

Option 1 consists of locating the future treatment requirements at the Udell Reservoir Site. This site offers adequate area for construction of the new UV and Chlorine Disinfection facility. The Stage 1 treatment facility is constructed on top of the existing reservoir structure and the chlorine contact is located below grade between the existing reservoir and northeast property line. The existing submersible pumps are retained at the Udell Pump House and minor site piping is required to connect the new treatment facility to the existing storage cells.

Locating treatment at Udell requires construction of a dedicated raw water transmission main from the Lake Pump House to Udell site. The existing raw water pumps need to be upgraded to match head requirements to pump from the Lake, through UV disinfection and into the Udell reservoir.

Future filtration could be constructed adjacent to the UV disinfection building and the backwash waste storage and pumping equipment can be located beneath the structure at the same elevation as the reservoir. Site topography presents minor constructability challenges and necessitates site access to be from the neighbouring property. A treatment servicing schematic and siting plan for this option are provided in **Figure 2** and **Figure 3**.

The following is a list of the key considerations for treatment siting at Udell:

- Upgrade raw water pumps to pump from the Lake Pump House to Udell site. Total of 3 pumps (lead\lag\standby) each rated for 15.3 L/s at 102 m TDH;
- 1,025 metres of dedicated raw water transmission main from the Lakeside Pump House to the Udell site (150 metres of 150mm DR14 PVC, 875 metres of 150mm DR18 PVC);
- UV disinfection building sized to house pumps for the Upper Pressure Zone (future consideration);
- Chlorine contact provided in new 60 m^3 below grade tank and remaining CT achieved using Udell Reservoir emergency\fire flow storage;
- Installation of 3-phase power from Westside Road to both the Lake Pump House and 340m to Udell site.

The estimated capital cost for locating treatment at the Udell Site is **$ 4,430,000** including engineering and construction contingency. A more detailed breakdown of the costs is provided in **Section 5**.

A summary of the key benefits and challenges for this option are provided below.

Benefits

- Low impact site development;
- Stage 1 and Stage 2 treatment located in close proximity;
- Utilize Udell Reservoir for portion of chlorine contact time;
- Reduced operational complexity with single stage pumping from Lake to Udell site and elimination of Killarney Pump Station.

Challenges

- Higher capital cost;
- Close proximity to residential properties;
- 3-phase power required at both Udell and Lake Pump House;
- Impact to neighbouring property due to shared site access.

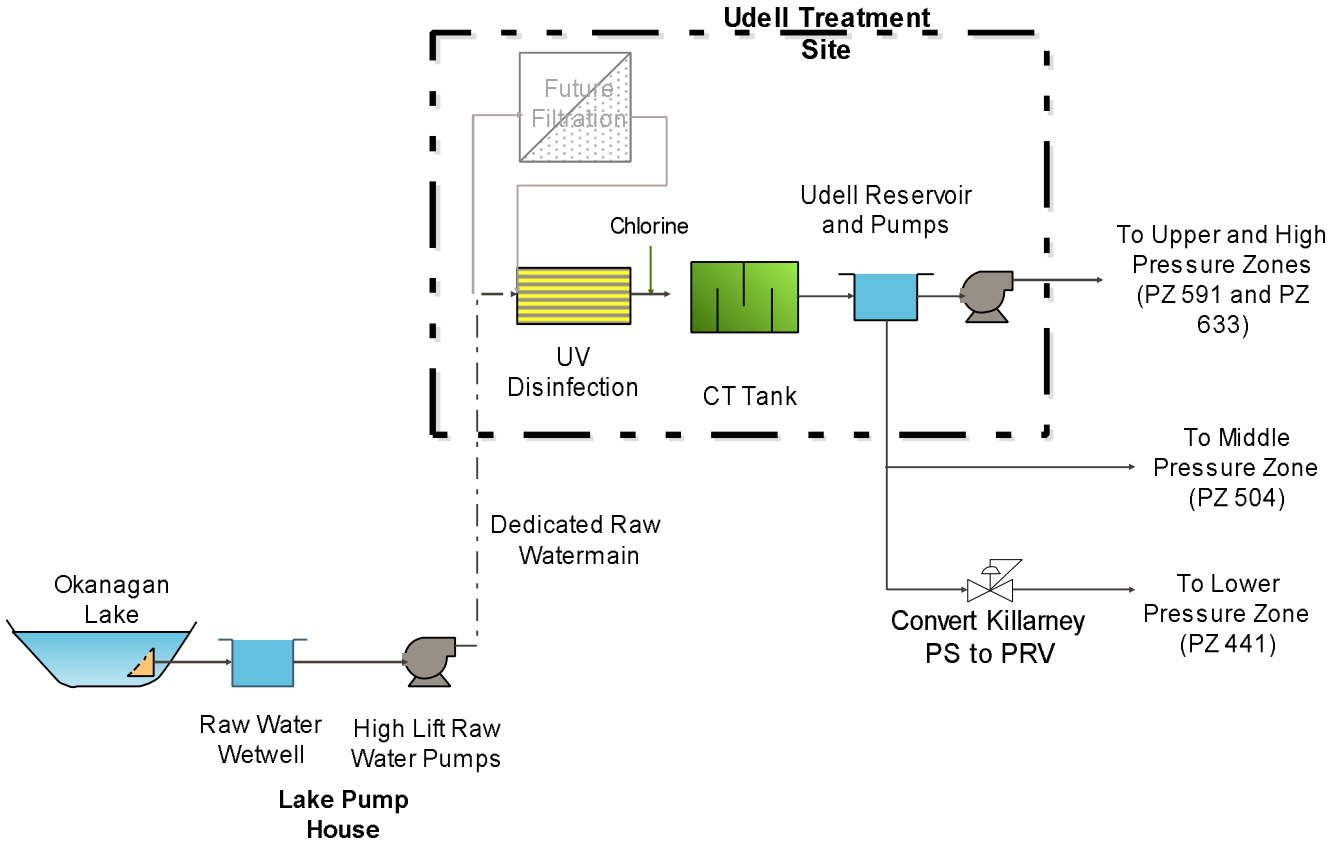
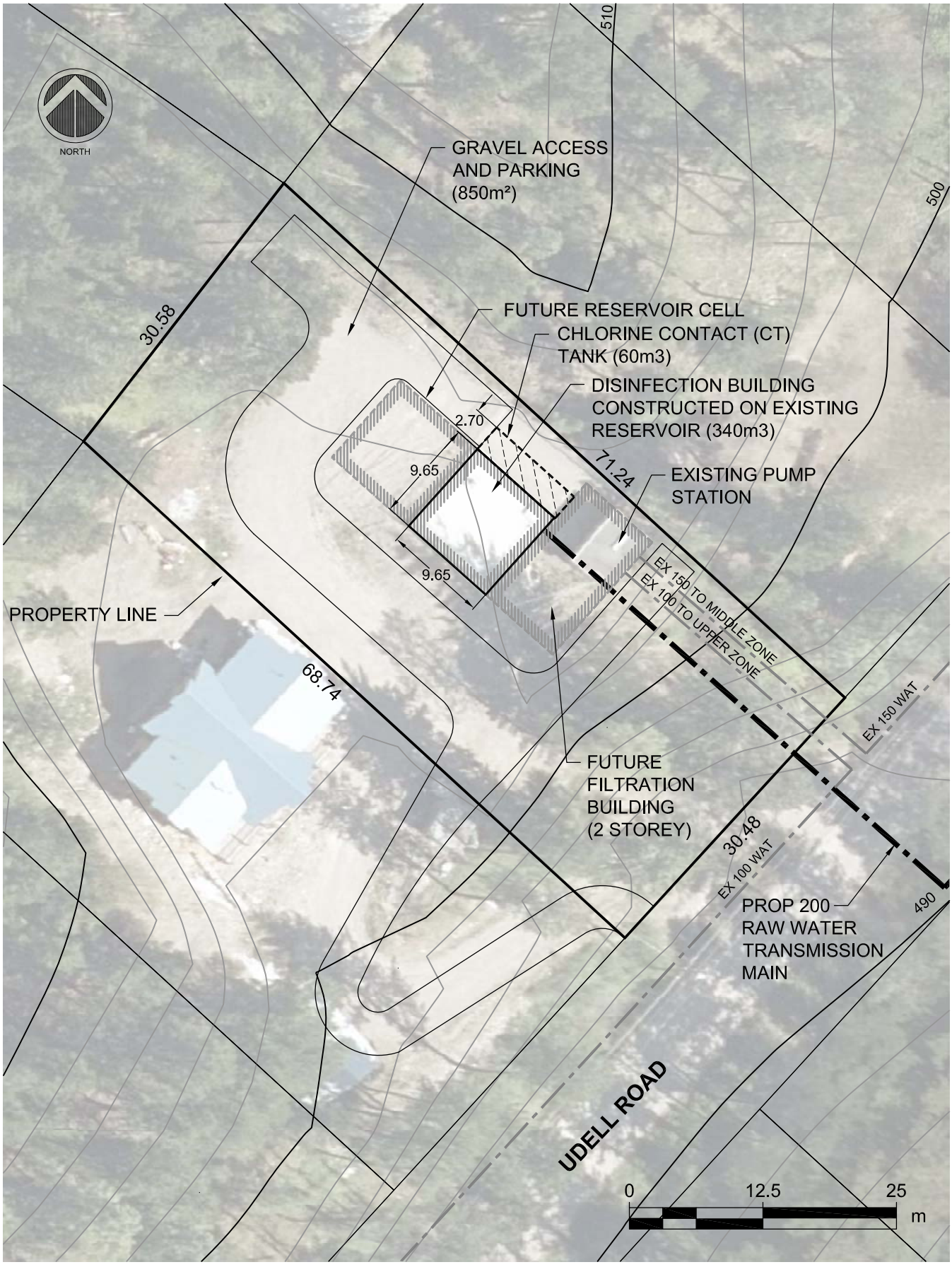


Figure 2 Option 1 Treatment Servicing Schematic



Filename: P:\60340265\900-WORK\910-CAD\1-GENERAL\60340265 FIG 1.DWG

REGIONAL DISTRICT OF THE CENTRAL OKANAGAN

FIGURE-3 TREATMENT SITING OPTION 1
UDEL RESERVOIR

Project No.: 60340265

AECOM

4.2 Option 2: Treatment Siting at Okanagan Lake

Option 2 includes locating treatment at the Lake Pump House site. Siting the new treatment facilities at the Lake Pump House offers multiple options for dedicating the transmission of treated water into the distribution system. We have developed Options 2a and 2b to compare two potential configurations for dedicating the transmission from the new treatment facility. Option 2a consists of dedicated transmission to Killarney and Option 2b includes pumping directly into the Low pressure zone, similar to the current network configuration.

A further variation of Option 2 was considered that included dedicating the treated water transmission main from the Lake Pump House to the Udell Reservoir. This option requires an additional 340 meters of 200 mm diameter transmission main for an addition cost of approximately $65,000. Land or easement acquisition would be required for the section of piping between Killarney and Udell. Dedicated transmission directly to Udell reservoir offers some operational benefits (e.g. reduced pressure spikes in the distribution system due to pump cycling) and the possibility to eliminate or reduce the CT tank sizing. However, the reduced CT requirements and potential operational benefits are not considered to outweigh the increased capital cost of the additional piping. For this reason, this option was not considered further.

A site plan showing the layout of treatment infrastructure for Options 2a and 2b is provided in **Figure 6**.

4.2.1 Option 2a: New Treatment Plant at Okanagan Lake and Dedicated Transmission to Killarney

The existing Pump House building will be converted into a two storey building with pumping, pipe gallery and CT tank located at the ground level. The control room, UV and chlorination equipment, and electrical room are on the second floor with access to the electrical room provided by maintenance access from the upper site access road. The main building entrance will be at the ground level and stairs provided to access the upper level. Rock blasting is expected to be required to expand the existing building footprint to the northwest. Future filtration is sited 45 m from the UV disinfection building near the park washrooms.

The following is a list of the key considerations for treatment siting Option 2a:

- Replace existing Lake Pump House raw water pumps with vertical turbine low lift pumps to pump through UV disinfection and discharge into CT tank.
- 80 m^3 CT tank plus 25 m^3 for balancing storage.
- 700 m of dedicated transmission of 200 mm treated water from Lake Pump house to the Killarney Site.
- 20 m^3 of chlorine contact through the transmission main;
- New 60 hp treated water pumps (2 duty/1 standby) to pump from the CT tank to Middle Pressure Zone HGL. Treated water conveyed through the existing network from Killarney to the Udell;
- Decommission Killarney pumps and convert Killarney Reservoir to PRV;

A summary of the key benefits and challenges for this option are provided below.

Benefits

- Eliminates Middle Pressure Zone pumping;
- Consolidates infrastructure and offers efficient building footprint;
- Dedicated transmission main provides portion of chlorine contact.

Challenges

- Work required within 30 m Riparian setback resulting in increased environmental risks during construction and regulatory permits and approvals;
- Increased operational complexity due to low lift pumps;
- Potential negative impact to park space.

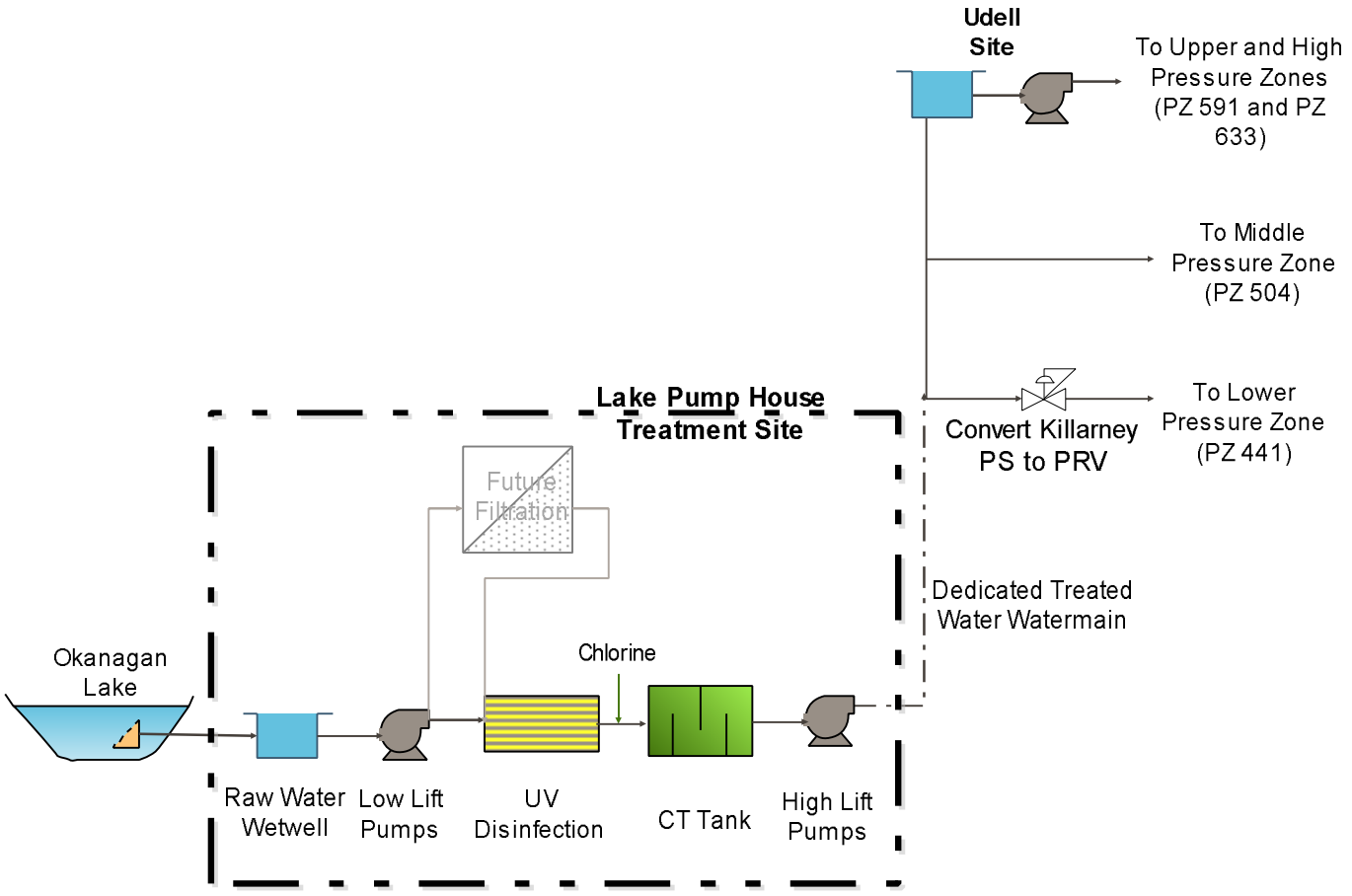


Figure 4 Option 2a Treatment Servicing Schematic

4.2.2 Option 2b: New Treatment Plant at Okanagan Lake and No Dedicated Transmission Main

Treatment siting considerations for Option 2b are similar to those listed in Option 2a. The key difference is that Option 2b provides all chlorine contact at the Lake Pump House Site and then pumps directly into the Low Pressure Zone. For this option, the pumps at Killarney will be upgraded to convey build-out demands to Udell Reservoir.

The following is a list of the key considerations for treatment siting Option 2b:

- Replace existing Lake Pump House raw water pumps with vertical turbine low lift pumps to pump through UV disinfection and discharge into CT tank.
- 100 m^3 Chlorine Contact Tank plus 25 m^3 for balancing storage.
- New 40 hp treated water pumps (2 duty/1 standby) to pump from the CT tank to Low Pressure Zone HGL. Treated water conveyed through the existing network from the Lake Pump House to Killarney;
- Replace Killarney pumps with new 25 hp vertical turbine pumps (2 duty/1 standby) and install PRV to supply fire flows to Low Pressure Zone;

A summary of the key benefits and challenges for this option are provided below.

Benefits

- Lowest capital cost option;
- Consolidates infrastructure and offers efficient building footprint;
- Lowest impact to current system configuration.

Challenges

- Work required within 30m Riparian setback resulting in increased environmental risks during construction and additional regulatory permits and approvals;
- Potential negative impact to park space;
- Increased operational complexity due to low lift pumps;
- Highest long term infrastructure renewal and operating costs due to Killarney Pump Station remaining in-service.

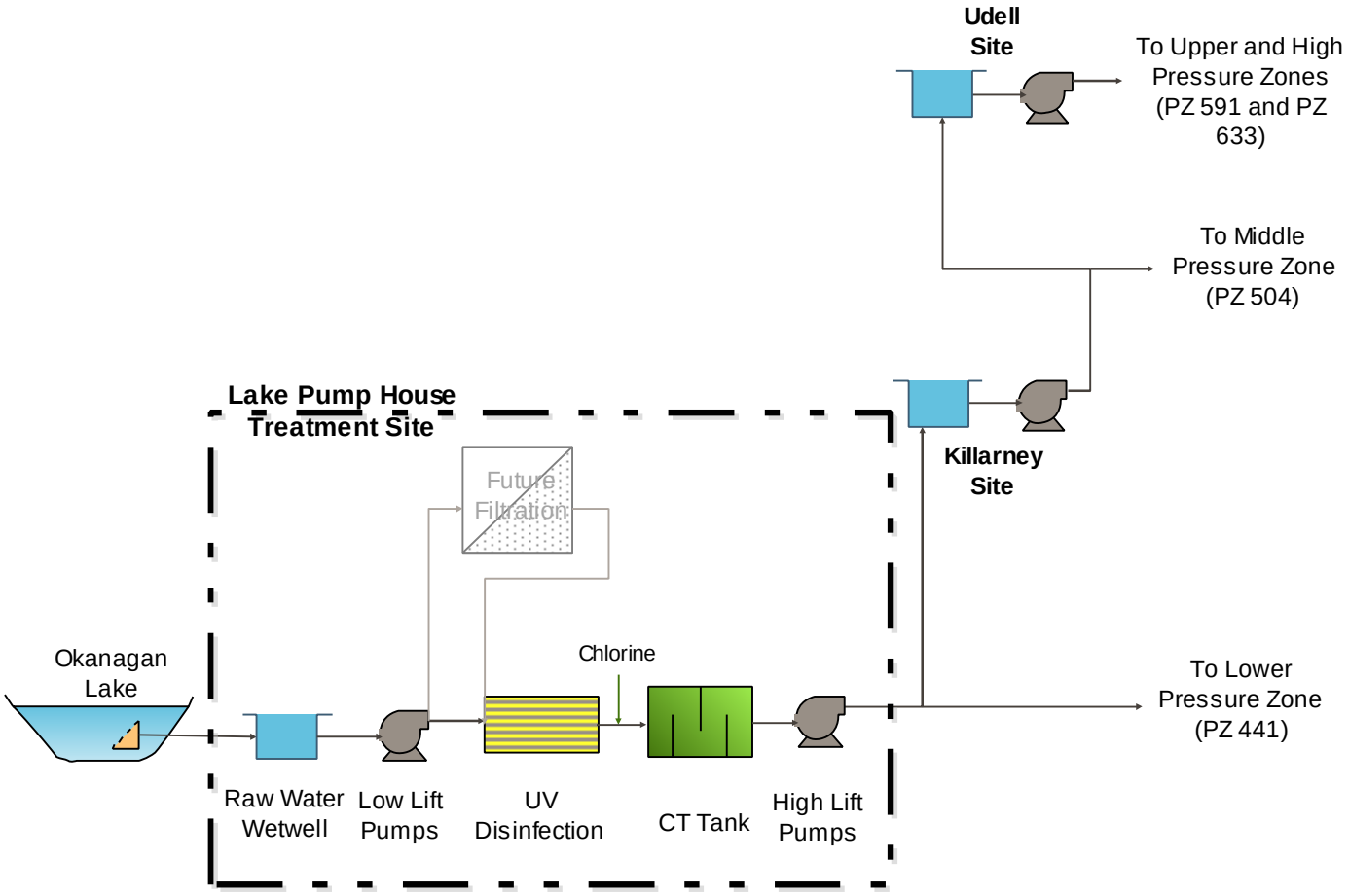
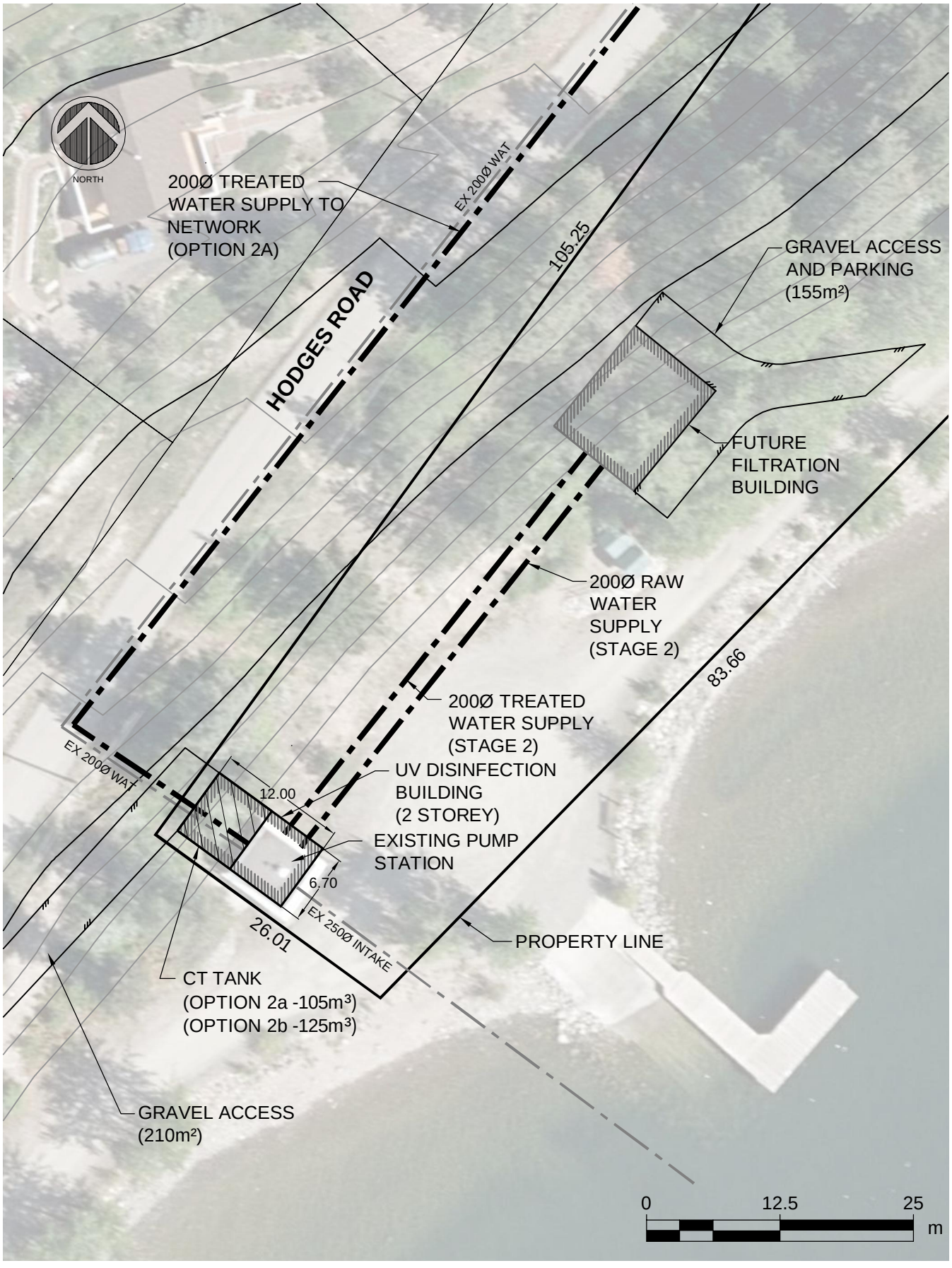


Figure 5 Option 2b: Treatment Servicing Schematic



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REGIONAL DISTRICT OF THE CENTRAL OKANAGAN

FIGURE 6 - TREATMENT SITING OPTION 2 - LAKESHORE

AECOM

Project No.: 60340265

4.3 Evaluation of Treatment and Transmission Options

The above treatment siting and water transmission options provide various advantages and disadvantages. A series of evaluation criteria has been developed to facilitate making a decision on the preferred treatment site for the KBWS. Presented in **Table 11** are the criteria considered in the decision model and the associated weighting.

Table 11 Evaluation Criteria and Relative Weight for Each Criterion

Primary Factor or Secondary Factor	Weighting
Treatment Process and Operational Impacts – The measure of treatment and operational equipment that will be prone to failure or will require frequent checks and servicing.	40%
Compatibility with Existing Infrastructure – A measure of the impact to the offsite infrastructure, including off-site upgrades, retention of previously installed infrastructure, and the long term water servicing scheme.	30%
Environmental Impact – The potential to negatively impact the slope stability, riparian areas and natural water bodies.	15%
Land Use Impacts – The proximity of the site to residential lots, impact to greenspace, truck delivery routing, and visual impact to the surrounding properties.	15%
Total Weighting	**100%**

4.3.1 Treatment Process and Operational Impacts

This criterion compares the scope of new mechanical infrastructure and the overall system operational complexity for each option. Each site has the same requirements for treatment and disinfection, the difference in complexity is therefore primarily based on pumping requirements and relative consolidation of infrastructure. Option 1 includes a single stage of pumping from the Lake Pump House Site to the Udell Site and therefore is given the highest ranking of the three options.

Option 2a and Option 2b require low lift pumps to pump through UV and then high lift pumps to convey treated water into the distribution system. Two stage pumping at the Lake Pump Station will introduce added operational complexity. Further, Option 2b is given the lowest ranking because pumping at Killarney is retained as part of the long term servicing approach.

Option 1: 100 out of 100
Option 2a: 80 out of 100
Option 2b: 40 out of 100

4.3.2 Compatibility with Existing and Future Infrastructure

This category evaluates each option in terms of compatibility with the existing and future infrastructure and off-site upgrade requirements. Options 1 and 2a both require considerable offsite upgrades to provide dedicated transmission of treated water from the Lake Pump House. Option 2b most closely resembles the existing distribution system layout by maintaining the sequential pumping from the Lake. Option 1 requires slightly more piping than Option 2a to dedicate the raw supply directly to Udell Reservoir site. Distribution system upgrades to address existing conveyance and fire flow issues are common to all options and not considered here.

All of the existing pump and storage sites are serviced with single phase power. The treatment siting options include provision of three-phase power from Westside Road. Option 1 requires 3-phase power at the Lake Pump House to accommodate the build-out pumping requirements and at the Udell Site for treatment requirements. Options 2a and 2b require 3-phase power only at the Lake Pump House Site for treatment and pumping.

Future infrastructure considerations are primarily related to the addition of filtration. Option 2a and 2b can accommodate filtration within the current park boundaries. The filtration building could be co-ordinated with the more permanent washroom facilities for the park and offer a shared benefit to the space. Option 1 can accommodate future filtration but the site layout and topography are more limiting than the Lake site option.

Option 1 requires the most offsite improvements and is limited in layout and siting for the future filtration facilities. For these reason Option 1 is given the lowest ranking for this criteria.

Option 1: 50 out of 100
Option 2a: 80 out of 100
Option 2b: 100 out of 100

4.3.3 Environmental Impact

The key environmental factor for the treatment siting options is expanding the building footprint within the Riparian area setback for the Okanagan Lake. While there are no major obstacles to building on the foreshore, Options 2a and 2b will require additional permitting and approvals. Working within the riparian area setback increases environmental risk during construction and presents some operational challenges once filtration is implemented (e.g. management of process upsets, spills and containment, etc.). Special considerations need to be made during the design for standby generator fuel tank, process waste flows, and on-site chemical storage. For these reasons, Options 2a and 2b are given slightly lower rankings than Option 1.

Option 1: 100 out of 100
Option 2a: 70 out of 100
Option 2b: 70 out of 100

4.3.4 Land Use Impacts

Under this criterion, each of the options was rated based on the potential for negative impact to adjacent land uses. Considerations such as noise, aesthetics, site access, opportunity cost of land, and impact to the neighbouring properties are factored into the overall ranking for each option.

Options 2a and 2b require utilization of park space and development of greenspace along the Okanagan Lake foreshore. Increase traffic (delivery and RDCO operations) and expansion of utility building footprint negatively impacts the public space at the Lake Pump House and therefore results in reduced rankings for Option 2a and 2b.

Due to constraints in the existing site topography, Option 1 incudes a shared access road with the neighbouring residential property. This means that access for routine maintenance and chemical deliveries will need to be co-ordinated with the adjacent property owner. The RDCO have an easement for the access road; however the shared access could become increasingly challenging when traffic increases with the Stage 1 and Stage 2 treatment upgrades. For this reason, Option 1 is assigned the lowest score.

Option 1: 80 out of 100

Option 2a: 100 out of 100
Option 2b: 100 out of 100

4.3.5 Cost Comparison of Alternatives

Capital cost estimates for each option are presented in **Table 12**. Detailed breakdown of the capital cost estimates for each option are available in **Appendix B**.

Table 12 Capital Cost of Options

Description	Option 1 - Udell Treatment	Option 2a - Lake Treatment/ Dedicated Main	Option 2b - Lake Treatment w/o Dedicated Main
General Requirements	$ 390,000	$ 350,000	$ 340,000
Civil and Site Works	$ 420,000	$ 360,000	$ 170,000
Architectural and Structural	$ 330,000	$ 340,000	$ 340,000
Process Mechanical	$ 930,000	$ 890,000	$ 920,000
Building Mechanical	$ 90,000	$ 90,000	$ 90,000
Electrical, Instrumentation & Controls	$ 1,080,000	$ 850,000	$ 850,000
Sub-total	***$ 3,240,000***	***$ 2,880,000***	***$ 2,710,000***
Engineering and Contingency (40%)	$ 1,300,000	$ 1,160,000	$ 1,090,000
TOTAL	**$ 4,540,000**	**$ 4,040,000**	**$ 3,800,000**

The estimated capital costs listed in **Table 12** are for comparison of the treatment siting options and do not reflect detailed costs for the options. The absolute cost associated with the preferred site development should be validated with further engineering. The relative difference of the costs between each option is sufficient for the completion of site comparison; however it should not be used for budgetary purposes.

4.3.6 The Recommended Alternative

Table 13 presents the compiled results of the decision modelling effort. As a result of this effort, decision between the preferred treatment sites can be more easily selected.

Table 13 Results of the Option Comparison Model

Criterion	Option 1 - Udell Treatment	Option 2a - Lake Treatment/ Dedicated Main	Option 2b - Lake Treatment w/o Dedicated Main
Treatment and Operation (out of 40%)	40%	32%	16%
Compatibility with Existing (out of 30%)	15%	24%	30%
Environmental Impact (out of 15%)	15%	11%	11%
Land Use (out of 15%)	12%	15%	15%
Total Decision Modelling Score (i.e. Rated "Benefit")	**82%**	**82%**	**72%**
Capital Cost (see Table 12)	$ 4.54	$ 4.04	$ 3.80
Cost-to-Benefit-Ratio	5.5	**5.0**	5.3

Option 1 and Option 2a had the highest benefit rankings, with Option 2a offering the most favourable cost-to-benefit ratio. Option 2b has the second best cost-to-benefit ratio, however, the decision model shows that the benefit of eliminating Killarney pumping in Option 2a outweighs the additional capital cost to provide dedicated transmission from the Lake to the Middle pressure zone. This is consistent with RDCO's preference to reduce the number of facilities in order to reduce the overall operating cost of the system.

Based on the results of the above analysis, we recommend the RDCO proceed with Option 2a and develop treatment at the Lake Pump House site and provide dedicated transmission of treated water to the Middle pressure zone.

5. Analysis of Water System

The existing water system was analyzed to confirm the extent of distribution upgrades required to meet the RDCO Bylaw water servicing requirements. Hydraulic analysis was completed using the existing KBWS WaterCAD computer model provided by the RDCO. Our analysis of the KBWS distribution system focused on confirming the assumptions and recommendations of the previously completed reports[12] and updating the associated capital cost estimates to 2015 dollars.

The following is a summary of the specific objectives of our assessment of the KBWS water system:

1. Determine the distribution system upgrades required to meet the fire flow under build-out demands using the proposed RDCO Bylaw demands;
2. Verify dedicated impacts of transmission options for Option 2a and Option 2b.
3. Confirm reservoir storage requirements including Hope Reservoir current and future HGL;

5.1 Distribution System Hydraulic Analysis

Previous reports (KWL, 2014 and AE, 2010) identified a series of upgrades for the KBWS to meet RDCO Bylaw water service requirements. Since the completion of the AE 2010 report, much of the 100mm diameter watermain in the Low and Middle pressure zones has been replaced with 150mm watermain. The High and Upper pressure zones still have significant lengths of 100mm watermain, which make-up the majority of the existing system deficiencies.

[12] *Killiney Beach Water System Review (AE, 2010), Killiney Beach Water System Review – Rev 2 (KWL, 2014)*

As mentioned previously, we updated the model to reflect the proposed RDCO Bylaw demands. Using the updated hydraulic model, the model results were analysed for MDD, PHD and MDD plus fire flow conditions to determine the extent of upgrades to achieve the minimum level of service outlined in the RDCO Bylaw.

The revised unit rate demands have little impact on the build-out servicing requirements and our recommended upgrades are generally consistent with those identified in the previous reports. Because the domestic demand is relatively small (i.e. only 50% of fire flow), the MDD plus fire flow is the governing scenario driving system improvements for the KBWS. In general, all piping servicing a hydrant needs to be upgraded to a minimum of 150 mm diameter. Short dead-end mains are to be a minimum of 100 mm diameter.

A desktop evaluation of hydrant coverage revealed two minor gaps where properties are more than 180 metres from the nearest hydrant. The following are areas that were identified to not meet the Fire Underwriters Survey fire hydrant coverage guidelines for residential properties:

- Near 562 Moody Crescent; and
- Near 9535 Kilkenny Place.

Provision should be made to add hydrants as part of future piping upgrade or renewal projects.

5.2 Dedicated Transmission Main Assessment

As part of the modelling, we verified the hydraulic transmission requirements for each of the treatment siting options. Model results confirm that the upgraded distribution network in the Middle and Low pressure zone is capable of conveying the build-out pumped flow from the Lake as outlined in Option 2a. A more detailed evaluation of the benefits and challenges related to the extent of dedicated transmission main is provided in **Section 4**.

5.3 Storage Assessment

5.3.1 Storage Capacity

Table 14 presents the build-out storage requirements for each reservoir in the KBWS. As shown in **Table 14**, the existing distribution system does not provide adequate storage to meet the fire flow, balancing and emergency volumes outlined in the RDCO Bylaw. The most significant shortfalls occur in the High and Low pressure zone where there is minimal balancing storage, insufficient fire flow storage and no emergency storage available within the system. In contrast, the Winchester holds a surplus of storage unless it can be used to supplement the Middle pressure zone balancing requirements.

Table 14 Killiney Beach Water System Reservoir Storage Requirements

Reservoir	Pressure Zones	Fire Storage (m^3)	Equalization Storage (m^3)	Emergency Storage (m^3)	Build-out Total (m^3)	Existing (m^3)
Udell + Killarney Reservoirs	Middle\Low	324	260	146	730	492
Winchester Reservoir	Upper	0	268	67	335	416
Hope Reservoir	High	324	148	118	590	76
				Total System Storage Required	**1655**	**908**

The total storage requirement value presented in **Table 14** differs from those identified in previous reports (KWL, 2014 and AE, 2010). The reports identified the requirement to store a single fire flow volume for the entire distribution system. Due to the number of pressure zones, this is not practical or recommended. Good engineering practice is to design for a maximum of two pressure zones for the conveyance of individual fire flows. As such, our storage capacity assessment includes fire flows to be located at the High and Middle pressure zones. This position is supported by the Fire Underwriters Survey (FUS), who assess the impact of mechanical redundancy for fire flow within a system. Systems relying on mechanical components such as PRVs to convey fire flows will receive lower Public Fire Protection Classifications (PFPC).

The following is our recommendation for storage improvements within the KBWS:

- Upgrade Hope Reservoir to provide fire flows to the High and Upper Pressure Zones;
- Hope Reservoir to provide equalization and emergency storage for the High Pressure Zone;
- Winchester Reservoir to provide equalization and emergency storage and supplement for flows for the Upper Pressure Zone;
- Udell Reservoir to provide fire flows, balancing and emergency storage to the Middle and Low Pressure Zones;
- Killarney Reservoir and Pump Station to be converted to a PRV. Relocate storage to Udell site when storage expansion is required.

5.3.2 Hope Creek Reservoir HGL

Further to the storage capacity assessment, the RDCO requested AECOM confirm the benefit of raising the Hope Reservoir elevation as part of the proposed storage capacity upgrades. Given the limited record drawing information for the Hope Reservoir, the actual HGL was confirmed to be 633m using the hydrant test results provided by the RDCO (refer to **Appendix C**).

Using the current HGL, the hydraulic model was analyzed to evaluate the impacts of raising the reservoir top of water level to improve the long term service to the High pressure zone. The following is a summary of the results:

- The HGL in the High pressure zone can be raised as much as 648 m without exceeding the RDCO Bylaw maximum static pressure requirement;
- Recommend relocating the new Hope reservoir to achieve a minimum top of water level of 645.5 metres. Preliminary assessment of the site topography indicates the proposed HGL to be reasonably achievable, however land purchase or easement acquisition would be required from the adjacent Crown land.
- If relocation of the reservoir is not practical or achievable, a new reservoir with a top of water level of 637 metres could be constructed in the current reservoir location. This would require increasing the diameter of 380 metres of watermain to 250 mm from the Hope Reservoir to Winchester.
- Provision for the addition of a re-chlorination facility at Hope Reservoir is recommended.

5.4 Recommended Water System Upgrades

Recommended upgrades presented in **Table** 15 include treatment, storage and distribution pipe upgrades for the KBWS. Each project has been given a priority ranking (low, medium and high) and is presented in the table in order of decreasing priority. Priority rankings are based on the extent of benefit to customers and is intended to guide the RDCO in staging of capital expenditure. The highest priority is given to treatment, followed by fire flow, with lowest priority given to hydraulic improvements where fire flow is not an issue. Interrelation between projects has been noted in the table, where applicable.

The following outlines the key assumptions used in developing the capital costs for each project:

- Stage 1 treatment project cost based on preliminary design estimate included in Section 6.0, which is updated from the options comparison to exclude pumping upgrades at Udell and present refined civil and structural scopes.
- Extending the intake to a depth of 30 m water depth is likely be a component of the Stage 1 treatment objectives and therefore is included as a High priority project next to the Stage 1 treatment upgrades. Actual priority rating of this project will be contingent upon the subsequent filtration deferral assessment being commissioned by the RDCO.
- The Stage 2 treatment upgrades that include filtration are identified as a low priority project on the assumption that Filtration Deferral will be achievable for the foreseeable future.
- Hope Reservoir expansion is identified as a high priority project for provision of fire flows to the High and Upper Pressure Zones. We recommend removal of the existing reservoir and construction of a new reservoir at a higher HGL. For planning purposes we have carried the more conservative cost estimate which includes construction of a bolted steel tank with an HGL of 645.5m. Design approach to be verified at detailed design stage of the project.
- Distribution pump upgrades to include dry mounted vertical turbine pumps in 2-duty and 1-standby configuration. Electrical service upgrades are not included and will need to be reviewed during subsequent design tasks.
- The Udell Reservoir upgrade resolves an existing deficiency, albeit not as significant as the Hope Reservoir storage deficiency. As noted in Section 5.3.1, it is recommended to minimized mechanical components for the conveyance of individual fire flows. Increased storage for the Middle and Lower Pressure Zones will improve the overall FUS classification, which would likely result in reduced insurance premiums in the area. This project is ranked as low priority and we recommend that the RDCO consult the FUS directly to determine the cost benefit of this project (i.e., will the improved classification provide a notable reduction in insurance premiums for customers).
- Distribution piping and PRV upgrades are ranked as high or medium priority depending on the extent of downstream impact.
- Pumping upgrades for the Upper and High pressure zones identified as low priority items to be completed as required to meet demand growth.
- All capital costs include 40% for contingency and professional services (excluding Project 1 - Stage 1 Treatment which includes 35% for contingency and professional services due to definition of scope in).
- The following unit rates were used for distribution system piping upgrades:
    - 200 mm main - $190/m;
    - 150 mm main - $150/m;
    - 100 mm main - $100/m;
    - $125/m for resurfacing (assuming a 4 metre wide trench);
    - $60,000 for PRV stations;
    - $5,000 for hydrants.

Table 15 presents the recommended distribution system improvements for the KBWS. **Figure A-2** in **Appendix A** illustrates the locations of the projects.

Table 15 Water System Upgrades and Cost

#	Priority	Description	Purpose	Pressure Zone	Price
1	H	**Stage 1 Treatment:** two-stage disinfection at Lake Site plus 700 metres dedicated 200 mm transmission main to Killarney and PRV at Killarney.	Health		$ 4,040,000
2	H	**Lake Intake Extension:** extend to water depth of 30 metres, 500 metre length of 400 mm HDPE. Note 4	Health		$ 308,000
3	H	**Hope Creek Reservoir:** install 590 m^3 at HGL 645.5 m. Remove existing reservoir. Price includes provision for re-chlorination. Note 3	Fire Flow	High	$ 728,000
4	H	**Winchester Road - 1:** 920 metres of 200 mm main. To maximize benefit complete with Projects 5 and 6.	Fire Flow	High	$ 406,000
5	H	**Keithly Road - 1:** 190 metres of 150 mm main. Complete with/after Project 4.	Fire Flow	High	$ 73,000
6	H	**High-Upper PRV - 1:** PRV (150 mm) and 20 metres of 150 mm main in Keithly Road connecting High and Upper Pressure Zones. Complete with Project 5. Note 5	Fire Flow	Upper	$ 92,000
7a	H	**Udell Road - 1:** 325 metres of 200 mm main.	Fire Flow	Middle	$ 143,000
7b	H	**Udell Road - 1 Alternate:** 200 metres of 150 mm main from Udell Road Westside Road. Note 1	Fire Flow	Middle	*$ 125,000*
8	H	**Houghton Road - 1:** 380 metres of 200 mm main, 260 metres of 150 mm main. Complete after Projects 4 and 5.	Fire Flow	High	$ 267,000
9	H	**Keithly Road - 2:** 150 metres of 200 mm main and 300 metres of 150 mm main. Complete after Projects 4 and 5.	Fire Flow	Upper	$ 182,000
10	H	**Keithly Road - 3:** 730 metres of 150 mm main. Complete after Projects 4 and 5.	Fire Flow	Upper	$ 281,000
11	H	**Hodges Road:** 390 metres of 150 mm main. Complete after Project 7 and Killarney PRV (Project 1).	Fire Flow	Low	$ 154,000
12	H	**Killarney Place:** 70 metres of 150 mm main. Complete after Project 7 and Killarney PRV (Project 1).	Fire Flow	Low	$ 27,000
13	M	**Winchester Road \ Brant Road:** 365 metres of 200 mm main and 110 metres of 150 mm main. This project includes 20 metres of 150 mm main north of Brandt on Winchester.	Fire Flow	High	$ 203,000
14	M	**High-Upper PRV - 2:** PRV (150 mm) connecting High Pressure Zone and Upper Pressure Zone, 200 metres of 150 mm main.	Fire Flow	Upper	$ 126,000
15	M	**Westside Road:** 60 metres of 150 mm main.	Fire Flow	Middle	$ 24,000
16	M	**Udell Road \ Homer Crescent:** 940 metres of 150 mm main.	Fire Flow	Upper	$ 363,000
17	M	**Middle-Low PRV:** PRV (150 mm) and 50 metres of 150 mm main in Killarney Way connecting Middle and Low Pressure Zones.	Fire Flow	Low	$ 104,000
18	M	**Moody Crescent:** 615 metres of 150 mm main. Hydrant required near 562 Moody Cres. Note 2	Fire Flow	Upper	$ 244,000
19a	M	**Killarney Way to Hodges Road:** 210 metres of 150 mm main. Complete with/after Project 17.	Fire Flow	Low	$ 45,000
19b	M	**Killarney Way to Hodges Road Alternate:** 40 metre 150mm main connection to end of 100 mm main. Complete with/after Project 17. Note 1	Fire Flow	Low	*$ 8,000*
20	L	**Udell Reservoir Storage:** Construct the second storage 340 m^3 cell at Udell Reservoir.	Fire Flow	Middle	$ 294,000
21	L	**Winchester Road - 2:** 55 metres of 100 mm main. Complete in conjunction with Project 13 if budget.	Dead End	High	$ 17,000
22	L	**Udell Road - 2:** 70 metres of 100 mm main.	Dead End	Upper	$ 22,000
23	L	**Keithly Road - 4:** 150 metres of 150 mm main. Complete with Project 10 if budget.	Dead End	Upper	$ 48,000

24	L	**Leah Road:** 55 metres of 100 mm main.	Dead End	Upper	$ 21,000
25	L	**Lester Road:** 430 metres of 150 mm main, 30 metres of 100 mm main and a 150 mm PRV.	Fire Flow	Upper	$ 186,000
26	L	**Udell Road - 3:** 215 metres of 100 mm main. Complete this project in conjunction with Project 7a.	Dead End	Upper	$ 67,000
27	L	**Kilkenny Place:** 320 metres of 150 mm main. Hydrant required near 9535 Kilkenny Pl. (main is 150 mm for proposed hydrant and to allow for extension of system).[Note 2]	Dead End	Low	$ 130,000
28	L	**Blarney Place:** 160 metres of 100 mm main.	Dead End	Low	$ 50,000
29	L	**Udell Pumps:** upgrade Udell pumps and piping header to convey build-out flow rate.	Conveyance	Upper	$ 245,000
30	L	**Winchester Pumps:** Upgrade Winchester pumps to convey build-out flow rate.	Conveyance	High	$ 140,000
31	L	**Stage 2 Treatment:** it is assumed that filtration deferral will be achievable.	Health		$ 5,300,000
Total Cost					**$14,330,000**

Notes:

1. *Costs of alternate projects are not included in the total.*
2. *For these projects a new hydrant is required. Gaps were determined based on a 180 metre radius from each existing hydrant.*
3. *If Hope cannot be located at 645.5m HGL, alternative is to raise HGL to 637 m and install 250 mm main for 380 metres from Hope Site.*
4. *Intake extension length from Larratt Aquatic, Source Assessment of Regional District of Central Okanagan – Killiney Beach and Westshore Estates Water Systems, September 2012.*
5. *Alternative: PRV connecting High and Upper Pressure Zones could be located in Winchester Road. This alternative will eliminate the loop from Winchester Road to Keithly Road, but requires some upgrades to 250 mm diameter between Hope Reservoir and Winchester Reservoir Site.*

6. Preliminary Design of Preferred Alternative

Preliminary design of the preferred treatment approach has been developed to provide the RDCO with a clear definition of the project scope to proceed with adding treatment to the KBWS. Option 2a, as defined in **Section 4**, was selected as the preferred and includes siting treatment at the Lake Pump House and extending dedicated transmission of treated water to the Middle Pressure zone. This approach was determined to be best long term solution for the KBWS to meet the treatment needs of the community. The following outlines the project scope to meet the Stage 1 treatment objectives for the KBWS.

6.1 General Description of the Works

The scope of this predesign includes raw water intake and conveyance, water treatment and treated water pumping. The system will be designed to supply the build-out treated water demand of 2.7 ML/d. Based on the previous analysis completed the general scope of work for the recommended solution is as follows:

- Extend existing Okanagan Lake intake pipe to divert water from a minimum depth of 30 metres (to be determined based on filtration deferral assessment).
- Retrofit the existing Lake Pump House to be a two storey masonry block building that includes the following pumping and treatment infrastructure:
    - Low lift raw water pumps to pump water from the existing wetwell, through the treatment process to a CT Tank. Low lift pumps sized to convey 3.0 ML/d to account for losses through future filtration;
    - Ultraviolet disinfection designed to achieve 3-log inactivation of the *Cryptosporidium* and *Giardia*;
    - Chlorination using bulk hypochlorite;
    - CT Tank sized to provide 4-log virus and 0.5-log *Giardia*;
    - High lift treated water pumps to convey treated water from the CT Tank to the Middle Pressure Zone;
    - Two–storey building super-structure with separate electrical, hypochlorite and process mechanical rooms; and
    - Provision for connection to future membrane filtration facility on the Okanagan foreshore.
- Install 200 mm diameter treated water transmission main between the water treatment plant at Okanagan Lake and the Middle Pressure Zone at the Killiney Site.
- Decommission Killiney Pump Station and convert to a PRV station to supply water to the Low Pressure Zone.

The following sections will provide more description of the proposed works and design criteria for the completion of the detailed design.

6.2 Lake Intake

The existing raw water intake diverts Okanagan Lake water from a depth of 10 metres. Raw water sampling collected to date indicates relatively high quality water being diverted from the intake. The shallow characteristics of the existing intake and the close proximity to the recreational activities from the nearby boat launch and public park space present an increased risk of contaminants from land-based activities, seiches, and potential for increased turbidity, algae density, and coliform bacteria (Larratt, 2012). For these reasons, it is likely that the intake extension will be required as part of a filtration deferral approach and therefore is being identified and discussed in conjunction with the Stage 1 Treatment upgrades.

A depth of 30 m is recommended for intake pipes that use Okanagan Lake for drinking water purposes. While it is not a guarantee, depths of 30m or more in the Okanagan Lake have been shown to exhibit more stable water quality conditions[13] and are expected to increase the KWBS's ability to sustain Filtration Deferral criteria.

The existing intake is 250 mm diameter series 100 PVC. To reach a 30 metre depth, the existing intake needs to be extended approximately 500 metres (Larratt, 2012) along the current intake alignment. The new section of intake pipe will be 400 mm diameter DR26 HDPE pipe complete with concrete anchors and new intake screen.

Should the further investigation confirm that the intake extension is required or warranted, then the cost of Project 2, as shown in **Table 15,** would be added to the overall project costs for the Stage 1 Treatment upgrades.

6.3 Low and High Lift Pumping

Design criteria for the low lift raw water pumps and high lift treated water pumps are presented in **Table 16**. All equipment and infrastructure installed at the Lake Site is expected to meet the build-out needs of the water system.

Table 16 Design Criteria for Raw and Treated Water Pumps

Design Criterion	Value	
Low Lift Raw Water Pumps		
Number of Pumps:	3 total, 2 duty, 1 standby	
Pump Design Criteria	Pump 1:	17.2 L/s at 4 m TDH, VFD, 1.5 kW (2 hp) motor
	Pump 2:	17.2 L/s at 4 m TDH, VFD, 1.5 kW (2 hp) motor
	Pump 3:	17.2 L/s at 4 m TDH, VFD, 1.5 kW (2 hp) motor
High Lift Treated Water Pumps		
Number of Pumps:	3 total, 2 duty, 1 standby	
Pump Design Criteria	Pump 1:	15.6 L/s at 182 m TDH, VFD, 45 kW (60 hp) motor
	Pump 2:	15.6 L/s at 182 m TDH, VFD, 45 kW (60 hp) motor
	Pump 3:	15.6 L/s at 182 m TDH, VFD, 45 kW (60 hp) motor

6.4 Ultraviolet Disinfection

Primary disinfection of Okanagan Lake water will be provided by UV irradiation. The specific UV system will be determined during the design phase of the project, but the basis of preliminary design layout and costing are based on the design criteria presented in **Table 17**.

Table 17 Design Criteria for the Ultraviolet Disinfection Reactors

Design Criterion	Okanagan Lake Water
Ultraviolet disinfection reactor style	Low Pressure, High Output
Treatment Goal	3-log Inactivation *Giardia* and *Cryptosporidium*
Materials of Construction	Stainless Steel
Reactor Configuration	Duty – standby
Accessories	Automatic wiper assembly

[13] *District of Lake Country, Source to Tap Assessment of the Okanagan Lake Intake, Larratt Aquatic, July 2011.*

Control	Flow pace dosing with UV transmittance
Power Requirements	2.0 kW, 1 phase, 575V

6.5 Chlorine Disinfection

6.5.1 Chlorine Dosing and Storage

Chlorine disinfection will be provided to meet the Interior Health guideline of providing two barriers against parasites (i.e. 0.5 log inactivation of *Giardia*), 4-log inactivation of viruses and a free chlorine residual to act as the secondary disinfection within the distribution network.

Chlorination at the WTP will utilize bulk 12% hypochlorite. The key components in the disinfection room within the new WTP building are:

- Chemical dosing provided by peristaltic metering pumps with stroke length adjustment (duty/standby). Pumps to be skid mounted complete with a calibration column, isolation valves, and pressure relief.
- 12 mm PVC or HDPE chemical feed lines to convey hypochlorite from the skid to the chlorine contact tank;
- Hypochlorite stored in 55 gallon drums or 1 m^3 chemical totes. At current flow rate, 5 drums are required or 1 tote, however the floor plan is designed for the required 2 totes to meet the build-out chlorine supply requirements;
- Provision to equip the room with 7.5 kg/day on-site hypochlorite generation system;
- Emergency shower and eye-wash.

6.5.2 Chlorine Contact Tank

The purpose of the CT tank is to provide a minimum contact time for the chlorine inactivate harmful pathogens present in the water. The tank will be cast-in-place concrete and located on grade northwest of the existing Lake Pump House. Blasting and rock removal will be required to accommodate the CT tank. The roof of the CT tank will serve as the floor slab for part of the second storey. Tank sizing is based on providing 0.5 log inactivation of *Giardia* and 4.0 log inactivation of viruses at build-out flow rate.

The governing condition to determine the size of the CT tank is 0.5-log inactivation of Giardia. The chlorine contact time calculation is based on the following assumptions:

1. The water pH is less than 8.0;
2. Temperature is less than 5°C during the peak flow of 2.7 ML/d;
3. Minimum free residual chlorine is 1.5 mg/L; and
4. Effective volume is 70% of the total available reservoir volume.

Based on the above values the effective retention time required in the Treated Water Reservoir is 37 minutes, which translates to a total CT volume of 100 m^3. The dedicated section of treated water transmission main provides approximately 20 m^3 of contact volume. In addition to CT volume, some addition storage capacity is recommended to balance flows between low lift and high lift pumps. The total CT tank volume is calculated as 105 m3, assuming 80 m^3 for CT tank and 25 m^3 for balancing pump operations. Once filtration is provided the additional CT time is only required for 4.0-log inactivation of viruses – meaning the excess volume for 0.5 log *Giardia* inactivation can be used as balancing storage.

6.6 Filtration (Low Pressure Membrane)

Notwithstanding the current immediate plan to defer filtration, Okanagan Lake is a surface water source that is susceptible to contamination. Furthermore, as development continues to occur immediately around Okanagan Lake and within the watershed it is reasonable to assume that the raw water quality will deteriorate resulting in filtration being required at some point in the future. Given this expectation, conceptual planning for future filtration is part of the Stage 1 treatment scope.

Some of the key features associated with the future filtration facility used for the basis of pre-planning are:

1. The future filtration process will be easy to operate and will produce reliable high quality treated water with limited operator input in low pressure membranes.
2. A pressure membrane system will have the smallest building footprint, making this the most constructible option given the space considerations at the project site. The current basis of the design for the future filtration system is a pressure UF membrane skid filtration system. However, the actual selection of the filtration process will probably not be for many years. When filtration is being implemented the actual filtration process should be reconsidered based on the currently available technology.
3. The membrane filtration processes produce waste that needs to be considered during the Stage 1 design process. For the basis of pre-planning it is assumed that the membrane filtration process will generate 10% waste meaning the raw water pumps are designed to convey the ultimate estimated treated water needs plus 10% more raw water.

The basis of the conceptual level design for the filtration facility is the GE Z-Pak Package System. The key parameters are summarized in **Table 18**.

Table 18 Pressure Membrane Filtration Parameters

Parameter	Description
Treated Water Turbidity	< 0.1 NTU
Parasite Removal (Micro/Ultra-Filtration)	> 4.0 log
Number of Trains	2 (n + 1, or 1 redundant train)
Filtered Water Production	2.7 ML/d
Number of Modules per Rack	28
Spare Capacity	25%
Unit Dimensions (Length x Width)	6.4m x 1.9m (x 2 trains)

Based on this equipment the future filtration building footprint reserved at the Lake Pump House site is 15 x 12 m. The building footprint assumes a new electrical room will be located in the filtration building. Once filtration is provided in the future it is assumed that the current planned building footprint will be adequate or a smaller space will be required based on technology improvements.

6.7 Civil Considerations

The area surrounding the main level of the Lake Pump House will remain essentially unchanged, with modifications required to accommodate construction and facilitate ground level access to the building. A utility access will be provided to the second level directly off of Hodges to facilitate ground level access to the electrical and hypochlorite rooms. On-site drainage will be managed through site grading and an on-site drywell well. Blast rock removed for construction of the CT tank will be used structural fill for the access road off of Hodges.

Relocate the existing treated water transmission main to accommodate the new CT tank and reconnect to the high lift pump discharge piping. Provisions to connect the future filtration facility will all be made inside the new building and therefore will not require additional buried valving or piping.

Consistent with the current site characteristics minimal landscaping scope is assumed.

All site servicing work to be completed in accordance with the RDCO Bylaw.

6.8 Offsite Upgrades

6.8.1 Killarney PRV Station

The current configuration of the KBWS provides treated water the Low Pressure Zone from the Lakeside Pump Station. The new transmission main will convey treated water from the Lake Pump House Site directly to the Middle Pressure Zone, bypassing the Low Pressure Zone. A 150 mm PRV will be installed at the existing Killarney Pump House to convey water to the Low Pressure Zone. The PRV will be installed on the ground level of the existing building to avoid confined space issues. The existing pumps at the Killarney Pump Station will no longer be required once the dedicated treated water transmission main is installed.

6.8.2 Dedicated Treated Water Transmission Main

A 200 mm treated water transmission main will be installed to convey treated water from the high lift pumps at the WTP to the Middle Pressure Zone at Killarney Site. The transmission main will be located in Hodges Road, Killarney Way and the existing right-of-way (south of 373 Killarney Way and 9364 Hodges Road). Some specific recommendations for the treated water transmission main are:

- All buried infrastructure work to be completed in accordance with the RDCO Bylaw.
- 200 mm diameter PVC transmission main to convey the build-out treated water flow rate of 2.7 ML/d. Water pressure at the bottom of the transmission approaches 250 psi therefore the first 270 metres of transmission main will be 200 mm PVC DR14 C900 and the upper 430 metres will be 200 mm PVC DR18 C900.

6.9 Architectural and Structural Design

The WTP will be a simple split face masonry structure. To achieve the BC Building Code building insulation requirements the interior of the masonry block will be covered with rigid insulation and metal cladding (gypsum wall board or wood cladding can be reviewed as alternatives during the detailed design phase). Building-off of the existing Pump House footprint the new treatment building will include two storeys, with the second floor extending beyond the current footprint to the northwest. The existing wetwell will be used as the foundation of the southeast half of the structure, the CT tank will form the foundation and main level of the northwest half of the structure. The CT tank walls are estimated to be 300 mm thick and the mat foundation to be 500 mm thick. The exterior walls of the main floor above the existing wetwell and the second floor will be constructed of split-face masonry blocks. All interior walls will be constructed of standard masonry block. The building roof will be a pitched roof with pre-finished standing seam metal roofing on pre-manufactured timber trusses.

A summary of the building layout and accessibility considerations for each room within the facility is provided below:

- Pump Room: on the ground level that contains the high and low lift pumps and wetwell access;
- Process Mechanical Room: on the second level that contains the UV reactors;

- Chlorine Room: on the second level that contains the hypochlorite storage and dosing; and
- Electrical and Control Room: on the second level that contain the electrical equipment.
- The electrical, hypochlorite and pumping rooms will each have access from grade by exterior double doors. Interior single doors and stairs provide access between the pump room, process mechanical and chlorine room. All access points to the building will be insulated metal doors and frames for durability and security.
- Removal of vertical turbine pumps on main level to be accommodated through floor and roof hatches.

The structural design criteria adopted for this project are summarized in **Table 19**.

Table 19 Structural Design Criteria

Description	Design Value
Structural Design Standards	• Building – British Columbia Building Code Latest Edition. • Reservoirs & Aqueous Retaining Structures – ACI 350M-06 and ACI 350.3-06
Earth Pressures	• Soil at rest, k_o = 0.45 • Soil density = 20 kN/m3
Minimum Floor Live Loads	• Equipment Floor - 6.0 kPa or equipment loads plus 2.4 kPa, whichever is greater. • Access, Walkway & Corridor - 4.8 kPa • Other Areas - 3.6 kPa
Roof Snow Load	• Ground Snow Load, 1/50, Ss – 3.5 kPa • Associated Rain Load, 1/50, Sr – 0.1 kPa
Seismic Load	• Sa(0.2)=0.27, Sa(0.5)=0.16, Sa(1.0)=0.082, Sa(2.0)=0.046 • PGA=0.14
Wind Load	• Hourly Wind Pressure - 1/10=0.3 kPa, 1/50=0.39 kPa
Guardrails	• Design to Occupational Health & Safety in areas of industry occupancy
Temperature (ambient)	• Winter: -23 °C • Summer: 33 °C
Footing Allowable Bearing Pressure	• Native loose to dense sand & gravel deposits, and Engineered Fill – 145 kPa • Dense glacial till deposits – 190 kPa
Materials	• Cast-in-place Concrete to CSA A23.1, f'c = 30 MPa. • Reinforcing to CSA G30.18, fy = 400 MPa • Structural Steel to CSA G40.21, Fy = 350 MPa

6.10 Building Mechanical Design

The mechanical systems will be designed in accordance with the current edition of the following codes, standards, and references:

- British Columbia Building Code
- National Energy Code / American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 90.1
- ASHRAE Standards, Handbooks and Periodicals
- American Society of Plumbing Engineers (ASPE) Data Books
- American Society of Mechanical Engineers (ASME) and Sheet Metal and Air-Conditioning Contractors Association (SMACNA) Standards and Guidelines

The building mechanical systems will consist of electrical unit heaters sized to prevent freezing within the buildings meaning the minimum temperature design setpoint is 5°C. To address ventilation mechanical louvers and fans will be provided. These systems will be design to provide 6 air changes per hour while the building is occupied.

6.11 Electrical Design

6.11.1 Primary Service

A new power service will be provided to the Lake Pump House building. Given the size of the facility electrical loads a 3-phase will need to be extended to the site from Westside Road.

The electrical service requirements are based the estimated motor loads presented in **Table 20**. The values provided in the below table are rounded and include a 5 – 10 % allowance for HVAC equipment and domestic power loads (receptacles and lighting).

Table 20 Summary of Electrical Loads

	Stage 1 - Estimated Load[1] [kW]	Stage 2 - Estimated Load[1] [kW]
Raw and Treated Water Pumping	100	115
Process Equipment	5	180
Building Mechanical	10	15
Total Estimated Process Electrical Load	**115**	**310**

Notes:

1. All electrical loads need to be confirmed during the final design process once all the process/HVAC loads are confirmed.

Standby power for the Lake WTP will be provided in the form of a diesel powered generator. The generator system will include an automatic transfer switch to connect the generator and reconnect the utility in the event of a main power failure. For the purposes of the preliminary design report a 250 kW generator is included at the Lake WTP site to energize the Stage 1 water treatment equipment during a power outage. Standby power for the Stage 2 facility will be provided using a second generator or by upgrading the Stage 1 generator to a larger unit.

The generator will be housed externally in acoustic enclosures; they shall have built in storage tanks enough for a minimum of 12hrs running.

6.11.2 Plant Power Distribution

The Lake WTP will be provided with a motor control centre (MCC). The MCC will provide power distribution to packaged equipment such as the UV disinfection, as well as housing motor VFD's and soft starters. The MCC will also provide a feeder to 120/208 VAC transformers as required for HVAC, lighting, smaller motors, control panels etc.

6.11.3 Grounding

The grounding system will have a buried counterpoise grounding wire circling the structure, and connecting to minimum four grounding electrodes, ufer (concrete reinforcing) ground and main grounding bus located in the electrical room. All grounding systems for the distribution MCC's, transfer switch, process equipment and piping, distribution panelboards, emergency generator, dry transformers, and communications bus will be connected to the main grounding bus.

6.11.4 Fire Alarm and Security System

All the new buildings being proposed as part of this project are small and will not be publically occupied. This means there are no Building Code requirements for fire alarm system. As such, no fire alarm system is planned. The site security will consist of intrusion alarms on all the doors of the new facilities that are connected to the RDCO's SCADA network.

6.12 Instrumentation Design

Sufficient instrumentation will be provided to support automated operation of the water treatment and supply system. In addition to the instrumentation provided for the function of the water supply system, instrumentation will also be provided to issue alarms related to faulty operation. Analytical instruments will be provided to monitor and verify the quality of the water conveyed to the distribution network. The key elements of the instrumentation and control system design are:

- Analytical Instruments: All instruments used for measurement of parameters that affect compliance with the water supply criteria will be reliable, easy to calibrate. All instruments / transmitters used in the facility will have local indicators scaled to indicate the process variable as a percentage of the full scale. All instruments will be capable of interfacing and communication with the main plant control system.
- Control Equipment: A programmable logic controller (PLC) will be located in the WTP. At this site a personal computer (PC) based HMI operator interface (OI) workstation will be provided. Some of the principles implemented into the development of the PLC's based control network include:
    - A stand-alone distributed automatic control philosophy at Lake WTP so in the event a SCADA system link is lost, the remainder of the water system continue to operate normally and alarms are generated to advise an operator of the issue.
    - In addition to recording and monitoring process variables, equipment, operational events and alarms at the facility location, and reporting on-screen and historical data archiving in printed format, the plant operator will have control capability at a central remote location(s) can identify current operational status and implement changes remotely from an off-site SCADA node; and
    - The main PLC panel at the Lake WTP, I/O, and essential instruments will be powered from an UPS to maintain data integrity and to monitor the process during power failures and generator start-up.
- Telemetry: the existing Killiney telemetry system will be used to communicate with the RDCO's existing SCADA network.

6.13 Estimates of Probable Cost

6.13.1 Assumptions

The following assumptions were made in the development of capital and operating cost estimates for the new water treatment plant for the KBWS:

- The estimate is based on 2015 construction costs. This project will not be tendered until later in 2015 or 2016. Inflation and escalation to account for actual expected prices at the time of tendering are not included.
- GST and PST in the amount of 5% and 7% respectively are not included.
- Land purchase costs are not included.
- Financing and legal fees are not included.
- A geotechnical investigation was not completed prior to the preparation of the estimate. The actual sub-

surface conditions may dramatically impact the capital cost.

- The building superstructure will be a split face masonry block building complete with rigid insulation on the interior.
- Intake extension cost not included within capital estimate. If determined to be required as part of filtration deferral then the pricing listed in Project 2 of **Table 15** would be added to the overall cost of the Stage 1 Treatment upgrades.
- All instruments used for the measurement of parameters that affect compliance with the water supply criteria will be reliable, easy to calibrate, intelligent type (Fieldbus) and capable of in-line verification;
- Relevant instrument measurements will be compiled in a database by the supervisory and control software to monitor the system performance. It is expected that there is sufficient allowance within the capital estimate for the development of a water system that will function automatically during regular operation;
- Annual average values are assumed for the energy consumption, chemical usage, mechanical repairs and labour estimates based on information from other facilities and the preliminary design;
- The estimated current average daily demand is 8.7 L/s;
- The cost of electrical power is estimated to be $0.10/kW-hr.
- Building heat will be provided with electrical powered unit heaters;
- Average chlorine dosage of 2.0 mg/L.
- The electrical demand of the UV system is assumed to be 2.0 kW per reactor while the unit is functioning. The lamp replacement cost is estimated to be $ 2,700/year.

6.13.2 Estimate of Probable Construction Cost

The estimates of probable costs have been prepared using prices obtained from major suppliers and from data in AECOM's possession from projects similar in nature and scope. However, the actual cost may be significantly affected by a number of factors, the cost implications of which cannot be readily forecast. These include factors such as the volume of work in hand or in prospect for contractors and suppliers at the time of tender calls, future labour contract settlements, inflation and market escalation. For this reason, while the estimate has been carefully prepared by competent personnel, the actual costs may be above or below those outlined. Estimates of probable capital and operations & maintenance costs have been developed for the proposed Stage 1 construction scope, and summary tables of these costs are presented as **Table 21** and **Table 22** respectively. Detailed back-up for these estimates is provided as **Appendix D**.

Table 21 Capital Cost of Stage 1 Treatment Facility

Description	Price
General Requirements	$ 350,000
Civil and Site Works	$ 360,000
Architectural and Structural	$ 340,000
Process Mechanical	$ 890,000
Building Mechanical	$ 90,000
Electrical, Instrumentation & Controls	$ 850,000
Sub-total	***$ 2,880,000***
Contingency (20%)	$ 720,000
Professional Services (15%)	$ 440,000
TOTAL	**$ 4,040,000**

Table 22 Annual Operating Cost of Stage 1 Treatment Facility

Description	Price
Electrical Power Costs	$ 28,000
Chemical Costs	$ 3,000
Maintenance Material Allowance	$ 2,700
Labour Costs	$ 43,800
Residuals Disposal	Not applicable
TOTAL ANNUAL O&M COST	**$ 77,500**

Appendix A

Water System Schematics

NORTH
SCALE 1:75

0 100 300 m
50 200

OKANAGAN LAKE

WINCHESTER RESERVOIR

UDELL RESERVOIR

KILLARNEY RESERVOIR

HOPE CREEK RESERVOIR

LAKESHORE PUMPHOUSE

PRV

PRV

BRANT ROAD

HOUGHTON ROAD

TEAM ROAD

KEITHLEY ROAD

MOODY CRESCENT

WESTSIDE ROAD

BLARNEY PLACE

KILKENNY PLACE

GALWAY PLACE

UDELL ROAD

KILDARE WAY

KILLARNEY WAY

HODGSE ROAD

KILLARNEY PLACE

LESTER ROAD

WINCHESTER ROAD

HOMER CRESCENT

LEGEND

SYSTEM BOUNDARY

EXISTING PIPES

50Ø

100Ø

150Ø

200Ø

PRESSURE ZONES

HIGH

UPPER

MIDDLE

LOW

Filename: P:\60340265\900-WORK\910-CAD\1-GENERAL\60340265 FIGS A1 A2.DWG

REGIONAL DISTRICT OF CENTRAL OKANAGAN

FIGURE A1 - EXISTING DISTRIBUTION SYSTEM

Project No.: 60340265

AECOM

NORTH
SCALE 1:75
0 100 300 m
50 200

OKANAGAN LAKE

WINCHESTER RESERVOIR

UDELL RESERVOIR

HOPE CREEK RESERVOIR

KILLARNEY PRV

LAKESHORE PUMPHOUSE

PRV

KEITHLEY ROAD
BRANT ROAD
HOUGHTON ROAD
TEAM ROAD
WESTSIDE ROAD
MOODY CRESCENT
GALWAY PLACE
UDELL ROAD
BLARNEY PLACE
KILKENNY PLACE
KILDARE WAY
KILLARNEY WAY
HODGES ROAD
KILLARNEY PLACE
LESTER ROAD
WINCHESTER ROAD
HOMER CRESCENT

LEGEND

SYSTEM BOUNDARY
EXISTING PIPES
PROPOSED PIPES
100Ø
150Ø
200Ø

PRESSURE ZONES
HIGH
UPPER
MIDDLE
LOW

REGIONAL DISTRICT OF CENTRAL OKANAGAN

FIGURE A2 - PROPOSED DISTRIBUTION SYSTEM UPGRADES AND PROJECT NUMBERS

Project No.: 60340265

AECOM

P:\60340265\900-WORK\910-CAD\1-GENERAL\60340265 FIGS A1 A2.DWG

Appendix B

Capital Cost Estimates for Siting Options

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**General Requirements**	1	LS	NA	**$ 390,000**
2.0	**Civil and Site Work**	1	LS	NA	**$ 420,000**
3.0	**Architectural and Structural**	1	LS	NA	**$ 330,000**
4.0	**Process Mechanical**	1	LS	NA	**$ 930,000**
5.0	**Building Mechanical**	1	LS	NA	**$ 90,000**
6.0	**Electrical, Instrumentation & Controls**	1	LS	NA	**$ 1,080,000**
	Sub-Total				**$ 3,240,000**
	Construction Contingency (approximately 25%)				$ 810,000
	Professional Services Allowance (approximately 15%)				$ 490,000
	TOTAL ESTIMATED CAPITAL COST				**$ 4,540,000**

Assumptions

1 Raw water transmission main installed from Lakeside Pump House to Udell site. Transmission main sized for build-out demand plus an addition 10% for future filtration.
2 Split-face masonry disinfection building sized for build-out water demand. Cast-in-place concrete floor suspended over existing reservoir roof. Facility includes UV and Pumping Room, Sodium Hypochlorite Disinfection Room, Electrical Room, and Washroom.
3 Future filtration to be two storey building with wood-frame superstructure and cast-in-place substructure. Main floor to include membrane filtration equipment and lower floor to include tankage and pumping room. Filtration building located southeast of the existing Reservoir Cell.
4 Process mechanical infrastructure sized for the build-out water demand.
5 100 m3 chlorine contact volume sized for the 0.5-log Giardia and 4-log Virus inactivation at build-out water demand. Minimum peak demand temperature of less than 5 °C and chlorine residual of 1.5 mg/L. 60 m3 to be provided in a dedicated below grade CT Tank and the remaining 40 m3 to be provided by the Udell Reservoir Emergency Storage Component.
6 Bulk 12% hypochlorite dosing equipment sized for build-out water demands as noted above and a summer chlorine dose of 2.5 mg/L. Hypochlorite room sized to accommodate addition of 7.5 kg/day on-site 0.8% hypochlorite generation system.
7 Low pressure UV reactors selected for the building layout and process cost estimates. Basis of design is the Trojan SwiftSC D12.
8 Existing lake pumps replaced with new raw water pumps sized to pump directly to the new treatment site. Raw water pump station header upgraded to meet the build-out design flows of 34.5 L/s at 176 metres of head pressure.
9 Killarney storage and pumping converted to a PRV to serve the low pressure zone.
10 Upper and high pressure zone pumping requirements located at Udell treatment site. Pumping to remain at existing Udell pump house. Pumps sized to convey the build-out water demand of 17 L/s at 105 metres of head pressure. Upgraded pumping and piping costs are not included in the capital cost. New treatment facility floor plan to accommodate addition of the pumps in the future.
11 Buried piping designed to build-out demand horizon.
12 Septic holding tank installed on-site for sanitary waste storage and pumpout.
13 Existing operations staff to run new facility
14 Work completed over a 5 month construction period.

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**GENERAL REQUIREMENTS**				
1.1	50% Performance Bonds	1	LS	29,000	29,000
1.2	Insurance (General Contractor)	1	LS	29,000	29,000
1.3	Overhead - Indirect Costs (5% of Project value)	1	LS	143,000	143,000
1.4	Profit (5% of Project Value)	1	LS	143,000	143,000
1.5	Site soft costs	5	mth	10,000	50,000
	TOTAL 1.0 - GENERAL REQUIREMENTS				**390,000**

Overhead is based on 5% of the project cost before including the construction contingency and general requirements. The contractor overhead covers office management and support staff, main office costs, etc.

Profit is based on 5% of the total project cost before including the construction contingency and general requirements.
Site soft cost are for construction power, site office, site foreman,
first-aid attendant, telephones, site trailers, crew trucks and other miscellaneous support equipment located on-site.

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
2.0	**CIVIL**				
2.1	**Excavation**				
2.1.1	Excavation and Off-Site Disposal (above groundwater)	150	m3	50	7,500
2.1.2	Excavation and Backfill	50	m3	25	1,250
2.1.3	Imported Fill	15	m3	30	450
2.1.4	Bedrock Removal Allowance		LS		
2.1.5	Dewatering Allowance		LS		
	Total 2.1 - Common Excavation				**9,200**
2.2	**Roadworks and Grading**				
2.2.1	Subgrade Preparation	520	sqm	5	2,600
2.2.2	Gravel Parking Areas	500	sqm	40	20,000
2.2.3	100mm Depth Concrete Door Pads	20	m2	125	2,500
	Total 2.2 - Roadworks and Grading				**25,100**
2.3	**Transmission Mains**				
2.3.1	200mm DR14 PVC Treated Water Main	175	lm	200	35,000
2.3.2	200mm DR18 PVC Treated Water Main	900	lm	190	171,000
2.3.3	Modify Existing 200 Supply Piping	1	LS	20,000	20,000
2.3.4	Asphalt Restoration	560	lm	125	70,000
	Total 2.3 - Transmission Mains				**296,000**
2.4	**Storm and Yard Piping**				
2.4.1	Yard Piping Allowance	1	LS	50,000	50,000
2.4.2	Building Storm Drywells - 1200 mm dia.	2	ea	5,000	10,000
2.4.3	5,000 L Buried Septic Holding Tank	1	ea	6,000	6,000
	Total 2.4 - Storm and Yard Piping				**66,000**
2.5	**Site Improvements**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

2.5.1	Site Landscaping Allowance (incl. hydroseeding, irrigation, fencing)	1	LS	20,000	20,000
	Total 2.5 - Site Improvements				**20,000**
	TOTAL 2.0 - CIVIL				**420,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
3.0	**STRUCTURAL**				
3.1	**Concrete**				
3.1.1	Main Building				
	Main Floor Slab - Reinforce Reservoir	42	m3	1,800	75,600
	Total 3.1.1 - UV Disinfection Facility				**75,600**
3.1.2	Chlorine Contact Tank				
	Base Slab	11	m3	1,300	14,300
	Exterior Walls	27	m3	1,600	43,200
	Roof	10	m3	1,600	16,000
	Total 3.1.2 - Chlorine Contact Tank				**73,500**
	Total 3.1 - Concrete				**149,100**
3.2	**Buildings**				
3.2.1	Metal Clad Roof	113	m2	300	33,900
3.2.2	FRP Grating	14	m2	650	9,100
3.2.3	WTP				
	Split Face Masonry Block				
	East Exterior Wall	30	m2	230	6,900
	North Exterior Wall	30	m2	230	6,900
	South Exterior Wall	30	m2	230	6,900
	West Exterior Wall	30	m2	230	6,900
	Interior Walls	87	m2	190	16,500
	Exterior Wall Cladding and Insulation (inside)	120	m2	100	12,000
	Total 3.2 - Buildings				**99,100**
3.3	**Miscellaneous Metals**				
3.3.1	Facility Metals Allowance	1	LS	25,000	25,000
	Total 3.3 - Miscellaneous Metals				**25,000**
3.4	**Doors, Windows, and Hatches**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

3.4.1	Single Door Allowance	4	ea	4,500	18,000
3.4.2	Double Door Allowance	4	ea	8,000	32,000
3.4.4	Windows Allowance	1	LS	5,000	5,000
3.4.5	Hatches Allowance	2	ea	3,000	6,000
	Total 3.4 - Doors, Windows and Hatches				**61,000**
	TOTAL 3.0 - STRUCTURAL				**330,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
4.0	**PROCESS MECHANICAL**				
	.				
4.1	**Mechanical Equipment**				
4.1.1	<u>UV Reactors</u>				
	UV Disinfection Equipment	2	ea	100,000	200,000
	Piping allowance	2	ea	15,000	30,000
	Installation	2	ea	25,000	50,000
	Total 4.1.1 - UV Reactors				**280,000**
4.1.2	<u>Raw and Treated Water Pumps</u>				
	Raw Water Pumps - Vertical Turbine	3	ea	40,000	120,000
	Installation Allowance	3	ea	10,000	30,000
	Udell Treated Water Pumps - Vertical Turbine	3	ea	25,000	75,000
	Installation Allowance	3	ea	5,000	15,000
	Total 4.1.2 - Raw and Treated Water Pumps				**240,000**
4.1.3	<u>Bulk 12% Hypochlorite Dosing</u>				
	Delta Metering Pump Package	1	ea	22,000	22,000
	Installation @ 20%	1	ea	4,400	4,400
	Total 4.1.2 - Chlorination System				**26,400**
	TOTAL 4.1 - MECHANICAL EQUIPMENT				**546,400**
4.2	**Piping, Fittings, Valves, etc.**				
4.2.1	150 mm Butterfly Valve 250psi	3	ea	5000	15,000
4.2.2	150 mm Butterfly Valve 200psi	7	ea	1000	7,000
4.2.3	100 mm Butterfly Valve 200psi	3	ea	900	2,700
4.2.4	150mm Check Valve 250psi	3	ea	7000	21,000
4.2.5	100mm Check Valve 200psi	3	ea	2500	7,500
4.2.6	Process Piping Installation Allowance	1	LS	125,000	125,000
4.2.7	Small Diameter Piping Allowance	1	LS	30,000	30,000
4.2.8	Installation allowance @ 50%	1	LS	100,000	100,000
	TOTAL 4.2 - PIPING, FITTINGS AND VALVES				**308,200**
4.3	**Convert Killarney Booster to PRV**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

4.3.1	PRV Allowance (Retrofit Killarney Pump Station)	1	LS	75000	75,000
	TOTAL 4.3 - Killarney PRV				**75,000**
	TOTAL 4.0 - PROCESS MECHANICAL				**930,000**

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
5.0	**BUILDING MECHANICAL**				
5.1	**Building HVAC**				
5.1.1	HVAC Allowance	1	LS	70,000	70,000
	Total 5.1 - Building Heating and Ventilation				**70,000**
5.2	**Building Plumbing**				
5.2.1	Domestic Plumbing Allowance	1	LS	20,000	20,000
	Total 5.2 - Plumbing				**20,000**
	TOTAL 5.0 - BUILDING MECHANICAL				**90,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 1 - Treatment at Udell Site

Item	Description	Quantity	Unit	Unit Price	Extension ($)
6.0	**ELECTRICAL AND INSTRUMENTATION**				
6.1	**Electrical**				
6.1.1	Extend 3-phase power to Udell Site (BC Hydro Quote)	1	LS	100,000	100,000
6.1.2	Extend 3-phase power from Lake Site (BC Hydro Quote)	1	LS	200,000	200,000
6.1.3	Building Electrical Cost	1	LS	75,000	75,000
6.1.4	Motor Control Centre	1	LS	200,000	200,000
6.1.5	Standby Power Generation (WTP + Lake Pump House)	1	LS	250,000	250,000
6.1.7	Exterior Duct Banks & Manholes	1	LS	10,000	10,000
6.1.9	Field Misc. Devices, Terminations & Equipment Connectio	1	LS	30,000	30,000
6.1.10	Cable Trays & Grounding	1	LS	15,000	15,000
6.1.11	Start-up, Testing & Commissioning	1	LS	30,000	30,000
	Total 6.1 - Electrical				**910,000**
6.2	**I & C**				
6.2.1	SCADA Control H/W (including Panelboards & PLC)	1	LS	30,000	30,000
6.2.2	SCADA Software & Integration	1	LS	15,000	15,000
6.2.3	Field Instruments	1	LS	30,000	30,000
6.2.4	Field Components RIO & Local Control Panels	1	LS	40,000	40,000
6.2.5	Instrumentation Wiring	1	LS	30,000	30,000
6.2.6	Start-up, Testing & Commissioning	1	LS	25,000	25,000
	Total 6.2 - I & C				**170,000**
	TOTAL 6.0 - ELECTRICAL, INSTRUMENTATION & CONTROL				**1,080,000**

Job No. 60340265
22-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**General Requirements**	1	LS	NA	**$ 350,000**
2.0	**Civil and Site Work**	1	LS	NA	**$ 360,000**
3.0	**Architectural and Structural**	1	LS	NA	**$ 340,000**
4.0	**Process Mechanical**	1	LS	NA	**$ 890,000**
5.0	**Building Mechanical**	1	LS	NA	**$ 90,000**
6.0	**Electrical, Instrumentation & Controls**	1	LS	NA	**$ 850,000**
	Sub-Total				**$ 2,880,000**
	Construction Contingency (approximately 25%)				$ 720,000
	Professional Services Allowance (approximately 15%)				$ 440,000
	TOTAL ESTIMATED CAPITAL COST				**$ 4,040,000**

Assumptions

1 Raw water transmission main installed from Lake Pump House to Middle Pressure Zone at Killarney site. Transmission main sized for build-out demand plus an additional 10% for future filtration
2 Split-face masonry UV disinfection building sized for build-out water demand. Facility includes Pumping Room, Electrical Room, UV Disinfection Room, Sodium Hypochlorite dosing and washroom.
3 Future Filtration to be located in park area near washrooms.
4 Process mechanical infrastructure sized for the build-out water demand.
5 100 m3 chlorine contact volume sized for 0.5-log Giardia and 4-log Virus inactivation at build-out water demand (Minimum peak demand temperature of less than 5 °C and chlorine residual of 1.5 mg/L). 80 m3 will be provided the CT Tank and 20 m3 provided by the dedicated 200 mm transmission main. CT Tank will be oversized to 105 m3 to provide balancing storage for pumping.
6 Bulk 12% hypochlorite dosing equipment sized for build-out water demands as noted above and a summer chlorine dose of 2.5 mg/L. Hypochlorite room sized to accommodate addition of 7.5 kg/day on-site generation system.
7 Low pressure UV reactors selected for the building layout and process cost estimates. Basis of design is the Trojan SwiftSC D12.
8 Replace existing lake pumps with new low lift raw water pumps sized to pump through treatment to the CT tank. New high lift treated water pumps to convey treated water from CT tank to the Middle Pressure Zone. Pumping and piping costs are included in the capital cost.
9 Killarney storage and pumping will be converted to a PRV to serve the low pressure zone.
10 Upper and high pressure zones pumping requirements to remain at Udell site. New pumps sized to convey the build-out water demands for upper and high pressure zones. Pumping and piping costs are not included in the capital cost.
11 Buried piping designed to build-out demand horizon.
12 Septic holding tank installed on-site for sanitary waste storage and pump-out.
13 Existing operations staff to run new facility
14 Work completed over a 5 month construction period.

Job No. 60340265
22-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**GENERAL REQUIREMENTS**				
1.1	50% Performance Bonds	1	LS	25,000	25,000
1.2	Insurance (General Contractor)	1	LS	25,000	25,000
1.3	Overhead - Indirect Costs (5% of Project value)	1	LS	127,000	127,000
1.4	Profit (5% of Project Value)	1	LS	127,000	127,000
1.5	Site soft costs	5	mth	10,000	50,000
	TOTAL 1.0 - GENERAL REQUIREMENTS				**350,000**

Overhead is based on 5% of the project cost before including the construction contingency and general requirements. The contractor overhead covers office management and support staff, main office costs, etc.

Profit is based on 5% of the total project cost before including the construction contingency and general requirements.
Site soft cost are for construction power, site office, site foreman,
first-aid attendant, telephones, site trailers, crew trucks and other miscellaneous support equipment located on-site.

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
2.0	**CIVIL**				
2.1	**Excavation**				
2.1.1	Excavation and Off-Site Disposal (above groundwater)	100	m3	50	5,000
2.1.2	Excavation and Backfill	20	m3	25	500
2.1.3	Imported Fill	50	m3	100	5,000
2.1.4	Bedrock Removal Allowance	200	m3	100	20,000
2.1.5	Dewatering Allowance	1	LS	10,000	10,000
	Total 2.1 - Common Excavation				**40,500**
2.2	**Roadworks and Grading**				
2.2.1	Subgrade Preparation	550	sqm	5	2,750
2.2.2	Gravel Parking Areas	365	sqm	50	18,250
2.2.3	100mm Depth Concrete Door Pads	20	m2	125	2,500
2.2.4	Lock Block Retaining Structure	50	ea	500	25,000
	Total 2.2 - Roadworks and Grading				**48,500**
2.3	**Transmission Mains**				
2.3.1	200mm DR14 PVC Treated Water Main	270	lm	200	54,000
2.3.2	200mm DR18 PVC Treated Water Main	430	lm	190	81,700
2.3.3	Asphalt Restoration	450	lm	125	56,300
	Total 2.3 - Transmission Mains				**192,000**
2.4	**Storm and Yard Piping**				
2.4.4	Yard Piping Allowance	1	LS	30,000	30,000
2.4.6	Building Storm Lead - 200 mm dia. PVC, DR 35	50	lm	100	5,000
2.4.7	Building Storm Drywell - 1200 mm dia.	1	ea	5,000	5,000
2.4.5	5,000 L Buried Septic Holding Tank	1	ea	10,000	10,000
	Total 2.4 - Storm and Yard Piping				**50,000**
2.5	**Site Improvements**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

2.5.1	Site Landscaping Allowance (incl. hydroseeding, irrigation, fencing)	1	LS	20,000	20,000
2.5.2	Clearing and Grubbing	1	LS	10,000	10,000
	Total 2.5 - Site Improvements				**30,000**
	TOTAL 2.0 - CIVIL				**360,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
3.0	**STRUCTURAL**				
3.1	**Concrete**				
3.1.1	Main Building				
	Main Floor Slab - Reinforce Reservoir	12	m3	1,800	21,600
	Total 3.1.1 - UV Disinfection Facility				**21,600**
3.1.2	Chlorine Contact Tank				
	Base Slab	21	m3	1,300	27,300
	Exterior Walls	25	m3	1,600	40,000
	Roof	20	m3	1,600	32,000
	Total 3.1.2 - Chlorine Contact Tank				**99,300**
	Total 3.1 - Concrete				**120,900**
3.2	**Buildings**				
3.2.1	Metal Clad Roof	128	m2	300	38,400
3.2.2	FRP Grating	14	m2	650	9,100
3.2.3	WTP				
	Split Face Masonry Block				
	East Exterior Wall	66	m2	290	19,100
	North Exterior Wall	42	m2	290	12,200
	South Exterior Wall	42	m2	290	12,200
	West Exterior Wall	66	m2	290	19,100
	Interior Walls	42	m2	190	8,000
	Exterior Wall Cladding and insulation (inside)	125	m2	100	12,500
	Total 3.2 - Buildings				**130,600**
3.3	**Miscellaneous Metals**				
3.3.1	Facility Metals Allowance	1	LS	25,000	25,000
	Total 3.3 - Miscellaneous Metals				**25,000**
3.4	**Doors, Windows, and Hatches**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

3.4.1	Single Door Allowance	3	ea	4,500	13,500
3.4.2	Double Door Allowance	4	ea	8,000	32,000
3.4.3	Windows Allowance	1	LS	5,000	5,000
3.4.4	Hatches Allowance	4	ea	3,000	12,000
	Total 3.4 - Doors, Windows and Hatches				**62,500**
	TOTAL 3.0 - STRUCTURAL				**340,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
4.0	**PROCESS MECHANICAL**				
	.				
4.1	**Mechanical Equipment**				
4.1.1	UV Reactors				
	UV Disinfection Equipment	2	ea	100,000	200,000
	Piping allowance	2	ea	15,000	30,000
	Installation	2	ea	25,000	50,000
	Total 4.1.1 - UV Reactors				**280,000**
4.1.2	Raw and Treated Water Pumps				
	Low Lift Raw Water Pumps - Vertical Turbine	3	ea	15,000	45,000
	Installation Allowance	3	ea	5,000	15,000
	Treated Water Pumps - Vertical Turbine	3	ea	40,000	120,000
	Installation Allowance	3	ea	10,000	30,000
	Total 4.1.2 - Raw and Treated Water Pumps				**210,000**
4.1.3	Bulk 12% Hypochlorite Dosing				
	Delta Metering Pump Package	1	ea	22,000	22,000
	Installation @ 20%	1	ea	4,400	4,400
	Total 4.1.2 - Chlorination System				**26,400**
	TOTAL 4.1 - MECHANICAL EQUIPMENT				**516,400**
4.2	**Piping, Fittings, Valves, etc.**				
4.2.1	150 mm Butterfly Valve 250psi	3	ea	5000	15,000
4.2.2	150 mm Butterfly Valve 200psi	10	ea	1000	10,000
4.2.4	150mm Check Valve 250psi	3	ea	7000	21,000
4.2.5	100mm Check Valve 200psi	3	ea	2500	7,500
4.2.6	Process Piping Installation Allowance	1	LS	115,000	115,000
4.2.7	Small Diameter Piping Allowance	1	LS	30,000	30,000
4.2.8	Installation allowance @ 50%	1	LS	100,000	100,000
	TOTAL 4.2 - PIPING, FITTINGS AND VALVES				**298,500**
4.3	**Convert Killarney Booster to PRV**				
4.3.1	PRV Allowance	1	LS	75,000	75,000

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

	TOTAL 4.3 - Killarney PRV				**75,000**
	TOTAL 4.0 - PROCESS MECHANICAL				**890,000**

Job No. 60340265
22-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
5.0	**BUILDING MECHANICAL**				
5.1	**Building HVAC**				
5.1.1	HVAC Allowance	1	LS	70,000	70,000
	Total 5.1 - Building Heating and Ventilation				**70,000**
5.2	**Building Plumbing**				
5.2.1	Domestic Plumbing Allowance	1	LS	20,000	20,000
	Total 5.2 - Plumbing				**20,000**
	TOTAL 5.0 - BUILDING MECHANICAL				**90,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2a - Treatment at Lake Site - Dedicated Main to Killarney

Item	Description	Quantity	Unit	Unit Price	Extension ($)
6.0	**ELECTRICAL AND INSTRUMENTATION**				
6.1	**Electrical**				
6.1.1	Extend 3-phase power from Lake Site	1	LS	200,000	200,000
6.1.2	Building Electrical Cost	1	LS	75,000	75,000
6.1.3	Motor Control Centre	1	LS	200,000	200,000
6.1.4	Standby Power Generation (WTP+Udell Site)	1	LS	125,000	125,000
6.1.5	Exterior Duct Banks & Manholes	1	LS	5,000	5,000
6.1.6	Field Misc. Devices, Terminations & Equipment Connectio	1	LS	25,000	25,000
6.1.7	Cable Trays & Grounding	1	LS	15,000	15,000
6.1.8	Start-up, Testing & Commissioning	1	LS	30,000	30,000
	Total 6.1 - Electrical				**675,000**
6.2	**I & C**				
6.2.1	SCADA Control H/W (including Panelboards & PLC)	1	LS	30,000	30,000
6.2.2	SCADA Software & Integration	1	LS	15,000	15,000
6.2.3	Field Instruments	1	LS	30,000	30,000
6.2.4	Field Components RIO & Local Control Panels	1	LS	40,000	40,000
6.2.5	Instrumentation Wiring	1	LS	30,000	30,000
6.2.6	Start-up, Testing & Commissioning	1	LS	25,000	25,000
	Total 6.2 - I & C				**170,000**
	TOTAL 6.0 - ELECTRICAL, INSTRUMENTATION & CONTROL				**850,000**

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**General Requirements**	1	LS	NA	**$ 340,000**
2.0	**Civil and Site Work**	1	LS	NA	**$ 170,000**
3.0	**Architectural and Structural**	1	LS	NA	**$ 340,000**
4.0	**Process Mechanical**	1	LS	NA	**$ 920,000**
5.0	**Building Mechanical**	1	LS	NA	**$ 90,000**
6.0	**Electrical, Instrumentation & Controls**	1	LS	NA	**$ 850,000**
	Sub-Total				**$ 2,710,000**
	Construction Contingency (approximately 25%)				$ 680,000
	Professional Services Allowance (approximately 15%)				$ 410,000
	TOTAL ESTIMATED CAPITAL COST				**$ 3,800,000**

Assumptions

1 Raw water transmission main installed from Lake Pump House to Middle Pressure Zone at Killarney site. Transmission main sized for build-out demand plus an additional 10% for future filtration
2 Split-face masonry UV disinfection building sized for build-out water demand. Facility includes Pumping Room, Electrical Room, UV Disinfection Room, Sodium Hypochlorite dosing and washroom.
3 Future Filtration to be located in park area near washrooms.
4 Process mechanical infrastructure sized for the build-out water demand.
5 Chlorine contact designed for 0.5-log Giardia and 4-log Virus inactivation at build-out water demand (Minimum peak demand temperature of less than 5 °C and chlorine residual of 1.5 mg/L). 125 m3 of chlorine contact volume is required, 100 m3 for chlorine contact with 25 m3 to provide balancing storage for pumping.
6 Bulk 12% hypochlorite dosing equipment sized for build-out water demands as noted above and a summer chlorine dose of 2.5 mg/L. Hypochlorite room sized to accommodate addition of 7.5 kg/day on-site generation system.
7 Low pressure UV reactors selected for the building layout and process cost estimates. Basis of design is the Trojan SwiftSC D12.
8 Replace existing lake pumps with new low lift raw water pumps sized to pump through treatment to the CT tank. New high lift treated water pumps to convey treated water from CT tank to the Middle Pressure Zone. Pumping and piping costs are included in the capital cost.
9 Killarney storage and pumping will be converted to a PRV to serve the low pressure zone.
10 Upper and high pressure zones pumping requirements to remain at Udell site. Future pumps sized to convey the build-out water demands for upper and high pressure zones. Pumping and piping costs are not included in the capital cost.
11 Buried piping designed to build-out demand horizon.
12 Septic holding tank installed on-site for sanitary waste storage and pump-out.
13 Work completed over a 5 month construction period.

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**GENERAL REQUIREMENTS**				
1.1	50% Performance Bonds	1	LS	24,000	24,000
1.2	Insurance (General Contractor)	1	LS	24,000	24,000
1.3	Overhead - Indirect Costs (5% of Project value)	1	LS	119,000	119,000
1.4	Profit (5% of Project Value)	1	LS	119,000	119,000
1.5	Site soft costs	5	mth	10,000	50,000
	TOTAL 1.0 - GENERAL REQUIREMENTS				**340,000**

Overhead is based on 5% of the project cost before including the construction contingency and general requirements. The contractor overhead covers office management and support staff, main office costs, etc.

Profit is based on 5% of the total project cost before including the construction contingency and general requirements.
Site soft cost are for construction power, site office, site foreman,
first-aid attendant, telephones, site trailers, crew trucks and other miscellaneous support equipment located on-site.

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
2.0	**CIVIL**				
2.1	**Excavation**				
2.1.1	Excavation and Off-Site Disposal (above groundwater)	100	m3	50	5,000
2.1.2	Excavation and Backfill	20	m3	25	500
2.1.3	Imported Fill	50	m3	100	5,000
2.1.4	Bedrock Removal Allowance	200	LS	100	20,000
2.1.5	Dewatering Allowance	1	LS	10,000	10,000
	Total 2.1 - Common Excavation				**40,500**
2.2	**Roadworks and Grading**				
2.2.1	Subgrade Preparation	550	sqm	5	2,750
2.2.2	Gravel Parking Areas	365	sqm	50	18,250
2.2.3	100mm Depth Concrete Door Pads	20	m2	125	2,500
2.2.4	Lock Block Retaining Structure	50	ea	500	25,000
	Total 2.2 - Roadworks and Grading				**48,500**
2.3	**Transmission Mains**				
2.3.1	200mm DR14 PVC Treated Water Main	0	lm	200	0
2.3.2	200mm DR18 PVC Treated Water Main	0	lm	190	0
2.3.3	Asphalt Restoration	0	lm	125	0
	Total 2.3 - Transmission Mains				**0**
2.4	**Storm and Yard Piping**				
2.4.1	Yard Piping Allowance	1	LS	30,000	30,000
2.4.3	Building Storm Leads - 200 mm dia. PVC, DR 35	50	lm	100	5,000
2.4.4	Building Storm Drywells - 1200 mm dia.	1	ea	5,000	5,000
2.4.5	5,000 L Buried Septic Holding Tank	1	ea	10,000	10,000
	Total 2.4 - Storm and Yard Piping				**50,000**
2.5	**Site Improvements**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

2.5.1	Site Landscaping Allowance (incl. hydroseeding, irrigation, fencing)	1	LS	20,000	20,000
2.5.2	Clearing and Grubbing	1	LS	10,000	10,000
	Total 2.5 - Site Improvements				**30,000**
	TOTAL 2.0 - CIVIL				**170,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
3.0	**STRUCTURAL**				
3.1	**Concrete**				
3.1.1	Main Building				
	Suspended Floor Slab	12	m3	1,800	21,600
	Total 3.1.1 - UV Disinfection Facility				**21,600**
3.1.2	Chlorine Contact Tank				
	Base Slab	21	m3	1,300	27,300
	Exterior Walls	25	m3	1,600	40,000
	Roof	20	m3	1,600	32,000
	Total 3.1.2 - Chlorine Contact Tank				**99,300**
	Total 3.1 - Concrete				**120,900**
3.2	**Buildings**				
3.2.1	Metal Clad Roof	128	m2	300	38,400
3.2.2	FRP Grating	14	m2	650	9,100
3.2.3	WTP				
	Split Face Masonry Block				
	East Exterior Wall	66	m2	290	19,100
	North Exterior Wall	42	m2	290	12,200
	South Exterior Wall	42	m2	290	12,200
	West Exterior Wall	66	m2	290	19,100
	Interior Walls	42	m2	190	8,000
	Exterior Wall Cladding and Insulation (inside)	125	m2	100	12,500
	Total 3.2 - Buildings				**130,600**
3.3	**Miscellaneous Metals**				
3.3.1	Facility Metals Allowance	1	LS	25,000	25,000
	Total 3.3 - Miscellaneous Metals				**25,000**
3.4	**Doors, Windows, and Hatches**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

3.4.1	Single Door Allowance	3	ea	4,500	13,500
3.4.2	Double Door Allowance	4	ea	8,000	32,000
3.4.3	Windows Allowance	1	LS	5,000	5,000
3.4.4	Hatches Allowance	4	ea	3,000	12,000
	Total 3.4 - Doors, Windows and Hatches				**62,500**
	TOTAL 3.0 - STRUCTURAL				**340,000**

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
4.0	**PROCESS MECHANICAL**				
	.				
4.1	**Mechanical Equipment**				
4.1.1	<u>UV Reactors</u>				
	UV Disinfection Equipment	2	ea	100,000	200,000
	Piping allowance	2	ea	15,000	30,000
	Installation	2	ea	25,000	50,000
	Total 4.1.1 - UV Reactors				**280,000**
4.1.2	<u>Raw and Treated Water Pumps</u>				
	Low Lift Raw Water Pumps - Vertical Turbine	3	ea	15,000	45,000
	Installation Allowance	3	ea	5,000	15,000
	Lake High Lift Pumps - Vertical Turbine	3	ea	40,000	120,000
	Installation Allowance	3	ea	10,000	30,000
	Killarney Treated Water Pumps - Vertical Turbine	3	ea	25,000	75,000
	Installation Allowance	3	ea	5,000	15,000
	Total 4.1.2 - Raw and Treated Water Pumps				**300,000**
4.1.3	<u>Bulk 12% Hypochlorite Dosing</u>				
	Delta Metering Pump Package	1	ea	22,000	22,000
	Installation @ 20%	1	ea	4,400	4,400
	Total 4.1.2 - Chlorination System				**26,400**
	TOTAL 4.1 - MECHANICAL EQUIPMENT				**606,400**
4.2	**Piping, Fittings, Valves, etc.**				
4.2.1	150 mm Butterfly Valve 250psi	3	ea	5000	15,000
4.2.2	150 mm Butterfly Valve 200psi	10	ea	1000	10,000
4.2.3	100 mm Butterfly Valve 200psi	3	ea	900	2,700
4.2.4	150mm Check Valve 250psi	3	ea	7000	21,000
4.2.5	100mm Check Valve 200psi	6	ea	2500	15,000
4.2.6	Process Piping Installation Allowance	1	LS	115,000	115,000
4.2.7	Small Diameter Piping Allowance	1	LS	30,000	30,000
4.2.8	Installation allowance @ 50%	1	LS	100,000	100,000
	TOTAL 4.2 - PIPING, FITTINGS AND VALVES				**308,700**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

4.3	**Install PRV at Killarney Booster**				
4.3.1	PRV Allowance	1	LS	0	0
	TOTAL 4.3 - Killarney PRV				**0**
	TOTAL 4.0 - PROCESS MECHANICAL				**920,000**

Job No. 60340265
27-Mar-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
5.0	**BUILDING MECHANICAL**				
5.1	**Building HVAC**				
5.1.1	HVAC Allowance	1	LS	70,000	70,000
	Total 5.1 - Building Heating and Ventilation				**70,000**
5.2	**Building Plumbing**				
5.2.1	Domestic Plumbing Allowance	1	LS	20,000	20,000
	Total 5.2 - Plumbing				**20,000**
	TOTAL 5.0 - BUILDING MECHANICAL				**90,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Option 2b - Treatment at Lake Site - No Dedicated Transmission

Item	Description	Quantity	Unit	Unit Price	Extension ($)
6.0	**ELECTRICAL AND INSTRUMENTATION**				
6.1	**Electrical**				
6.1.1	Electrical service and BC Hydro connection fees	1	LS	200,000	200,000
6.1.2	Building Electrical Cost	1	LS	75,000	75,000
6.1.3	Motor Control Centre	1	LS	200,000	200,000
6.1.4	Standby Power Generation (WTP + Killarney + Udell Site)	1	LS	125,000	125,000
6.1.5	Exterior Duct Banks & Manholes	1	LS	5,000	5,000
6.1.6	Field Misc. Devices, Terminations & Equipment Connectio	1	LS	25,000	25,000
6.1.7	Cable Trays & Grounding	1	LS	15,000	15,000
6.1.8	Start-up, Testing & Commissioning	1	LS	30,000	30,000
	Total 6.1 - Electrical				**675,000**
6.2	**I & C**				
6.2.1	SCADA Control H/W (including Panelboards & PLC)	1	LS	30,000	30,000
6.2.2	SCADA Software & Integration	1	LS	15,000	15,000
6.2.3	Field Instruments	1	LS	30,000	30,000
6.2.4	Field Components RIO & Local Control Panels	1	LS	40,000	40,000
6.2.5	Instrumentation Wiring	1	LS	30,000	30,000
6.2.6	Start-up, Testing & Commissioning	1	LS	25,000	25,000
	Total 6.2 - I & C				**170,000**
	TOTAL 6.0 - ELECTRICAL, INSTRUMENTATION & CONTROL				**850,000**

Appendix C

Hydrant Testing Results

RDCO # Assigned	25 28
Date	SEPT 4/14

REGIONAL DISTRICT OF CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	~~9364 HODGES ROAD~~ 9467 KILKENNY			
Location Description*				
UTM Co-ordinates (North)	50.11.240	UTM Co-ordinates (East)	119.29.842	
Shutoff/Valve Location	1 METER	Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4" mm 100			☐ storz
Main Capacity	I GPM			
Static Pressure	~~105~~ 89 PSI	Flow* Modeled		~~IGPM~~
Irrigation District*	KILLINEY BEACH	Actual	402	IGPM
Hydrant Make	TC	Residual Pressure 6		IGPM
Hydrant Model				
Hydrant Type	SLIDE GATE			

Comments:	
ELEV 1292'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	2426
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
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Date Submitted*		Date Submitted*	

Street Address/ Lot #*	~~9467 KILKENNY~~ 9364 HODGES			
Location Description*				
UTM Co-ordinates (North)	~~50.11.426~~	UTM Co-ordinates (East)	~~119.29.742~~	
Shutoff/Valve Location	I METER	Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4" mm 100			☐ storz
Main Capacity	I GPM			
Static Pressure	~~80~~ 120 PSI	Flow* 70 PSI Modeled		IGPM
Irrigation District*	KILLINEY BEACH	Actual	~~360~~ 364	IGPM
Hydrant Make	TC	Residual Pressure	13	~~IGPM~~ PSI
Hydrant Model				
Hydrant Type	SLIDE GATE			

Comments:	
ELEV 1339'	4" ISOLATION VALVE : OKAY ISOLATION VALVE BOX AND HYDRANT NEED RISER

RDCO # Assigned	25 235
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

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Date Submitted*		Date Submitted*	

Street Address/ Lot #*	2 BLARNEY PLACE				
Location Description*					
UTM Co-ordinates (North)	50.11.490		UTM Co-ordinates (East)	119.29.782	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	120	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	493	IGPM
Hydrant Make	~~TERMUELER~~		Residual Pressure	100 PSI	IGPM
Hydrant Model	COMPRESSION				
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1358'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	22/24
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9544 HODGES (NEW HYDRANT)				
Location Description*					
UTM Co-ordinates (North)	50.11.556		UTM Co-ordinates (East)	119.29.803	
Shutoff/Valve Location	7 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	98	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	380	IGPM
Hydrant Make	TC		Residual Pressure	5 PSI	~~IGPM~~
Hydrant Model					
Hydrant Type	COMPRESSION				

Comments:	
ELEV 1377'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	20
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	355 KILLARNEY WAY					
Location Description*						
UTM Co-ordinates (North)	50.11.391		UTM Co-ordinates (East)	119.29.053		
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch	
Main size*	4"	mm 100			☐ storz	
Main Capacity		I GPM				
Static Pressure	45	PSI	Flow* Modeled		IGPM	
Irrigation District*	KILLINEY BEACH		Actual	475	IGPM	
Hydrant Make	TC		Residual Pressure 9.5		IGPM	
Hydrant Model						
Hydrant Type	SLIDE GATE					

Comments:	
ELEV 1324'	4" ISOLATION VALVE : OKAY NELSON BOX NEEDS TO BE RAISED

RDCO # Assigned	1922
Date	

REGIONAL DISTRICT OF CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	19 KILLARNEY PLACE				
Location Description*					
UTM Co-ordinates (North)	50.11.231		UTM Co-ordinates (East)	119.30.029	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	49	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	469	IGPM
Hydrant Make	TC		Residual Pressure	9PS1	IGPM
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1254'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	1821
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	474 KILLARNEY				
Location Description*					
UTM Co-ordinates (North)	50.11.228		UTM Co-ordinates (East)	119.30.167	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	93	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	380	IGPM
Hydrant Make	TC		Residual Pressure 55PSI		IGPM
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1400'	4" ISOLATION VALVE : OKAY ADJUSTED PACKING LEAK AT STEM

RDCO # Assigned	420
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9365 WESTSIDE ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.225		UTM Co-ordinates (East)	119.30.244	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	60	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	362	IGPM
Hydrant Make	TC		Residual Pressure	4 psi	IGPM
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1540'	4" ISOLATION VALVE : SLIGHT LEAK

RDCO # Assigned Date	2719

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	302 KILLARNEY WAY				
Location Description*					
UTM Co-ordinates (North)	50.11.564		UTM Co-ordinates (East)	119.29.907	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	~~60~~ 77	PSI	Flow* 5 psi Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	380	IGPM
Hydrant Make	TC		Residual Pressure	45	~~IGPM~~ psi
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1377'	4" ISOLATION VALVE : OKAY NELSON BOX NEEDS TO BE RAISED

RDCO # Assigned	2518
Date	SEPT 24/14

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	315 KILDARE				
Location Description*					
UTM Co-ordinates (North)	50.11.459		UTM Co-ordinates (East)	119.29.982	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	~~90~~ 89	PSI	Flow* 6psi Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	402	GPM
Hydrant Make	TC		Residual Pressure 6		IGPM
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1427'	4" ISOLATION VALVE : OKAY NELSON BOX AND RISER ARE FULL OF DIRT

RDCO # Assigned	17
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	366 KILDARE				
Location Description*					
UTM Co-ordinates (North)	50.11.333		UTM Co-ordinates (East)	119.30.129	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	80	PSI	Flow* ~~Modeled~~		IGPM
Irrigation District*	KILLINEY BEACH		Actual	402	IGPM
Hydrant Make	TC		Residual Pressure	6	~~IGPM~~ PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1446	4" ISOLATION VALVE : OKAY

RDCO # Assigned	~~15~~ 16
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	410 GALWAY				
Location Description*					
UTM Co-ordinates (North)	50.11.497		UTM Co-ordinates (East)	119.30.079	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	~~60~~ 55	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	540	IGPM
Hydrant Make	TC		Residual Pressure	12	~~IGPM~~ PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1524	4" ISOLATION VALVE : OKAY

RDCO # Assigned	~~16~~ 15
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	~~9485 WESTSIDE ROAD~~ 480 GALWAY PLACE				
Location Description*					
UTM Co-ordinates (North)	50.11.424		UTM Co-ordinates (East)	119.30.199	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	~~60~~ 55	PSI	Flow* Modeled	517	IGPM
Irrigation District*	KILLINEY BEACH		Actual	~~540~~	IGPM
Hydrant Make	TC		Residual Pressure	47	~~IGPM~~
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1519'	~~4" ISOLATION VALVE · NELSON BOX FULL OF DIRT,~~ HEAD LEAKED, ~~ADJUSTED PACKING~~, VAC TRUCK ~~NEEDED FOR~~ SOIL REMOVAL FROM ~~VALVE BOX~~

RDCO # Assigned	13/14
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	604 UDELL				
Location Description*					
UTM Co-ordinates (North)	50.11.289		UTM Co-ordinates (East)	119.30.425	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	75	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	450	IGPM
Hydrant Make	TC		Residual Pressure	7.5	~~IGPM~~
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1717'	4" ISOLATION VALVE : SLIGHT LEAK

RDCO # Assigned	~~14~~ 13
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	60 LESTER				
Location Description*					
UTM Co-ordinates (North)	50.11.210		UTM Co-ordinates (East)	119.30.412	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	~~85~~ 75	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	443	IGPM
Hydrant Make	TC		Residual Pressure	75	~~IGPM~~ PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1635'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	12
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	764 UDELL				
Location Description*					
UTM Co-ordinates (North)	50.10.990		UTM Co-ordinates (East)	119.30.633	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	95	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	540	IGPM
Hydrant Make	TC		Residual Pressure	12	~~IGPM~~ PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1720'	4" ISOLATION VALVE OK OPERATING STEM WORN FROM SOMEONE USING PIPE WRENCH ON IT. NEEDS REPLACING

RDCO # Assigned	11
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	82 HOMER CRESCENT				
Location Description*					
UTM Co-ordinates (North)	50.11.020		UTM Co-ordinates (East)	119.30.748	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	85	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	624	IGPM
Hydrant Make	TC		Residual Pressure	16	~~IGPM~~ PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1688'	4" ISOLATION VALVE OK

RDCO # Assigned	10
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	674 UDELL ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.165		UTM Co-ordinates (East)	119.30.575	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	103	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	624	IGPM
Hydrant Make	TC		Residual Pressure	16	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1782'	4" ISOLATION VALVE : OKAY ATION BROOKS BOX NEEDS RISER

RDCO # Assigned	9
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9409 KEITHLY ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.314		UTM Co-ordinates (East)	119.30.586	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	82	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	624	IGPM
Hydrant Make	TC		Residual Pressure	16	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1731'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	8
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9634 KEITHLY ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.658		UTM Co-ordinates (East)	119.30.334	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	45	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	540	IGPM
Hydrant Make	TC		Residual Pressure	12	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1690'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	7
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9555 KEITHLY ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.525		UTM Co-ordinates (East)	119.30.432	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	70	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	400	IGPM
Hydrant Make	TC		Residual Pressure	6	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1740'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	6
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9432 KEITHLY				
Location Description*					
UTM Co-ordinates (North)			UTM Co-ordinates (East)		
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	70	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	446	IGPM
Hydrant Make	TC		Residual Pressure	85	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1755'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	5
Date	10/2014

REGIONAL DISTRICT OF CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9620 HOUGHTON ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.708		UTM Co-ordinates (East)	119.30.463	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	65	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	342	IGPM
Hydrant Make	TC		Residual Pressure	3	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1933'	4" ISOLATION VALVE : OKAY

RDCO # Assigned	4
Date	

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9406 HOUGHTON ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.581		UTM Co-ordinates (East)	119.30.662	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	60	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	362	IGPM
Hydrant Make	TC		Residual Pressure	4	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1919'	4" ISOLATION VALVE: SLIGHT LEAK

RDCO # Assigned	3
Date	10/2014

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9493 WINCHESTER ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.438		UTM Co-ordinates (East)	119.30.750	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ stortz
Main Capacity		I GPM			
Static Pressure	70	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	402	IGPM
Hydrant Make	TC		Residual Pressure	6	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1925'	4" ISOLATION VALVE

RDCO # Assigned	2
Date	10/2014

REGIONAL DISTRICT of CENTRAL OKANAGAN

ENVIRONMENTAL SERVICES

HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below

Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9368 WINCHESTER ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.267		UTM Co-ordinates (East)	119.30.826	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	64	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual		IGPM
Hydrant Make	TC		Residual Pressure	75	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1936'	4" ISOLATION VALVE

REGIONAL DISTRICT of CENTRAL OKANAGAN

RDCO # Assigned	1
Date	SEPT 2014

ENVIRONMENTAL SERVICES
HYDRANT REPORTS

Please attach a map or sketch showing the location of the hydrant described below
Items marked with a (*) are mandatory – no number can be assigned without them!!

Date Submitted*		Date Submitted*	

Street Address/ Lot #*	9280 WINCHESTER ROAD				
Location Description*					
UTM Co-ordinates (North)	50.11.111		UTM Co-ordinates (East)	119.30.875	
Shutoff/Valve Location	1 METER		Number of Ports	2 - 2.5"	☐ 4 inch
Main size*	4"	mm 100			☐ storz
Main Capacity		I GPM			
Static Pressure	70	PSI	Flow* Modeled		IGPM
Irrigation District*	KILLINEY BEACH		Actual	493	IGPM
Hydrant Make	TC		Residual Pressure	10	PSI
Hydrant Model					
Hydrant Type	SLIDE GATE				

Comments:	
ELEV 1984'	4" ISOLATION VALVE

Appendix D

Detailed Breakdown of Preliminary Design Capital and Operating Cost Estimates

Job No. 60340265
1-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**General Requirements**	1	LS	NA	**$ 350,000**
2.0	**Civil and Site Work**	1	LS	NA	**$ 360,000**
3.0	**Architectural and Structural**	1	LS	NA	**$ 340,000**
4.0	**Process Mechanical**	1	LS	NA	**$ 890,000**
5.0	**Building Mechanical**	1	LS	NA	**$ 90,000**
6.0	**Electrical, Instrumentation & Controls**	1	LS	NA	**$ 850,000**
	Sub-Total				**$ 2,880,000**
	Construction Contingency (approximately 25%)				$ 720,000
	Professional Services Allowance (approximately 15%)				$ 440,000
	TOTAL ESTIMATED CAPITAL COST				**$ 4,040,000**

Assumptions

1 Raw water transmission main installed from Lake Pump House to Middle Pressure Zone at Killarney site. Transmission main sized for build-out demand plus an additional 10% for future filtration
2 Split-face masonry UV disinfection building sized for build-out water demand. Facility includes Pumping Room, Electrical Room, UV Disinfection Room, Sodium Hypochlorite dosing and washroom.
3 Future Filtration to be located in park area near washrooms.
4 Process mechanical infrastructure sized for the build-out water demand.
5 100 m3 chlorine contact volume sized for 0.5-log Giardia and 4-log Virus inactivation at build-out water demand (Minimum peak demand temperature of less than 5 °C and chlorine residual of 1.5 mg/L). 80 m3 will be provided the CT Tank and 20 m3 provided by the dedicated 200 mm transmission main. CT Tank will be oversized to 105 m3 to provide balancing storage for pumping.
6 Bulk 12% hypochlorite dosing equipment sized for build-out water demands as noted above and a summer chlorine dose of 2.5 mg/L. Hypochlorite room sized to accommodate addition of 7.5 kg/day on-site generation system.
7 Low pressure UV reactors selected for the building layout and process cost estimates. Basis of design is the Trojan SwiftSC D12.
8 Replace existing lake pumps with new low lift raw water pumps sized to pump through treatment to the CT tank. New high lift treated water pumps to convey treated water from CT tank to the Middle Pressure Zone. Pumping and piping costs are included in the capital cost.
9 Killarney storage and pumping will be converted to a PRV to serve the low pressure zone.
10 Upper and high pressure zones pumping requirements to remain at Udell site. Pumping and piping costs for Upper and High pressure zones are not included in the capital cost.
11 Buried piping designed to build-out demand horizon.
12 Septic holding tank installed on-site for sanitary waste storage and pump-out.
13 Existing operations staff to run new facility
14 Work completed over a 5 month construction period.

Job No. 60340265
1-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
1.0	**GENERAL REQUIREMENTS**				
1.1	50% Performance Bonds	1	LS	25,000	25,000
1.2	Insurance (General Contractor)	1	LS	25,000	25,000
1.3	Overhead - Indirect Costs (5% of Project value)	1	LS	127,000	127,000
1.4	Profit (5% of Project Value)	1	LS	127,000	127,000
1.5	Site soft costs	5	mth	10,000	50,000
	TOTAL 1.0 - GENERAL REQUIREMENTS				**350,000**

Overhead is based on 5% of the project cost before including the construction contingency and general requirements. The contractor overhead covers office management and support staff, main office costs, etc.

Profit is based on 5% of the total project cost before including the construction contingency and general requirements.
Site soft cost are for construction power, site office, site foreman,
first-aid attendant, telephones, site trailers, crew trucks and other miscellaneous support equipment located on-site.

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
2.0	**CIVIL**				
2.1	**Excavation**				
2.1.1	Excavation and Off-Site Disposal (above groundwater)	100	m3	50	5,000
2.1.2	Excavation and Backfill	20	m3	25	500
2.1.3	Imported Fill	50	m3	100	5,000
2.1.4	Bedrock Removal Allowance	200	m3	100	20,000
2.1.5	Dewatering Allowance	1	LS	10,000	10,000
	Total 2.1 - Common Excavation				**40,500**
2.2	**Roadworks and Grading**				
2.2.1	Subgrade Preparation	550	sqm	5	2,750
2.2.2	Gravel Parking Areas	365	sqm	50	18,250
2.2.3	100mm Depth Concrete Door Pads	20	m2	125	2,500
2.2.4	Lock Block Retaining Structure	50	ea	500	25,000
	Total 2.2 - Roadworks and Grading				**48,500**
2.3	**Transmission Mains**				
2.3.1	200mm DR14 PVC Treated Water Main	270	lm	200	54,000
2.3.2	200mm DR18 PVC Treated Water Main	430	lm	190	81,700
2.3.2	Asphalt Restoration	450	lm	125	56,300
	Total 2.3 - Transmission Mains				**192,000**
2.4	**Storm and Yard Piping**				
2.4.1	Yard Piping Allowance	1	LS	30,000	30,000
2.4.2	Building Storm Lead - 200 mm dia. PVC, DR 35	50	lm	100	5,000
2.4.3	Building Storm Drywell - 1200 mm dia.	1	ea	5,000	5,000
2.4.4	5,000 L Buried Septic Holding Tank	1	ea	10,000	10,000
	Total 2.4 - Storm and Yard Piping				**50,000**
2.5	**Site Improvements**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

2.5.1	Site Landscaping Allowance (incl. hydroseeding, irrigation, fencing)	1	LS	20,000	20,000
2.5.2	Clearing and Grubbing	1	LS	10,000	10,000
	Total 2.5 - Site Improvements				**30,000**
	TOTAL 2.0 - CIVIL				**360,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
3.0	**STRUCTURAL**				
3.1	**Concrete**				
3.1.1	Main Building				
	Main Floor Slab - Reinforce Reservoir	12	m3	1,800	21,600
	Total 3.1.1 - UV Disinfection Facility				**21,600**
3.1.2	Chlorine Contact Tank				
	Base Slab	21	m3	1,300	27,300
	Exterior Walls	25	m3	1,600	40,000
	Roof	20	m3	1,600	32,000
	Total 3.1.2 - Chlorine Contact Tank				**99,300**
	Total 3.1 - Concrete				**120,900**
3.2	**Buildings**				
3.2.1	Metal Clad Roof	128	m2	300	38,400
3.2.2	FRP Grating	14	m2	650	9,100
3.2.3	WTP				
	Split Face Masonry Block				
	East Exterior Wall	66	m2	290	19,100
	North Exterior Wall	42	m2	290	12,200
	South Exterior Wall	42	m2	290	12,200
	West Exterior Wall	66	m2	290	19,100
	Interior Walls	42	m2	190	8,000
	Exterior Wall Cladding and insulation (inside)	125	m2	100	12,500
	Total 3.2 - Buildings				**130,600**
3.3	**Miscellaneous Metals**				
3.3.1	Facility Metals Allowance	1	LS	25,000	25,000
	Total 3.3 - Miscellaneous Metals				**25,000**
3.4	**Doors, Windows, and Hatches**				

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

3.4.1	Single Door Allowance	3	ea	4,500	13,500
3.4.2	Double Door Allowance	4	ea	8,000	32,000
3.4.3	Windows Allowance	1	LS	5,000	5,000
3.4.4	Hatches Allowance	4	ea	3,000	12,000
	Total 3.4 - Doors, Windows and Hatches				**62,500**
	TOTAL 3.0 - STRUCTURAL				**340,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
4.0	**PROCESS MECHANICAL**				
	.				
4.1	**Mechanical Equipment**				
4.1.1	UV Reactors				
	UV Disinfection Equipment	2	ea	100,000	200,000
	Piping allowance	2	ea	15,000	30,000
	Installation	2	ea	25,000	50,000
	Total 4.1.1 - UV Reactors				**280,000**
4.1.2	Raw and Treated Water Pumps				
	Low Lift Raw Water Pumps - Vertical Turbine	3	ea	15,000	45,000
	Installation Allowance	3	ea	5,000	15,000
	Treated Water Pumps - Multi-stage Vertical Turbine	3	ea	40,000	120,000
	Installation Allowance	3	ea	10,000	30,000
	Total 4.1.2 - Raw and Treated Water Pumps				**210,000**
4.1.3	Bulk 12% Hypochlorite Dosing				
	Delta Metering Pump Package	1	ea	22,000	22,000
	Installation @ 20%	1	ea	4,400	4,400
	Total 4.1.2 - Chlorination System				**26,400**
	TOTAL 4.1 - MECHANICAL EQUIPMENT				**516,400**
4.2	**Piping, Fittings, Valves, etc.**				
4.2.1	150 mm Butterfly Valve 250psi	3	ea	5000	15,000
4.2.2	150 mm Butterfly Valve 200psi	10	ea	1000	10,000
4.2.3	150mm Check Valve 250psi	3	ea	7000	21,000
4.2.4	100mm Check Valve 200psi	3	ea	2500	7,500
4.2.5	Process Piping Installation Allowance	1	LS	115,000	115,000
4.2.6	Small Diameter Piping Allowance	1	LS	30,000	30,000
4.2.7	Installation allowance @ 50%	1	LS	100,000	100,000
	TOTAL 4.2 - PIPING, FITTINGS AND VALVES				**298,500**
4.3	**Convert Killarney Booster to PRV**				
4.3.1	PRV Allowance	1	LS	75,000	75,000

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

	TOTAL 4.3 - Killarney PRV				**75,000**
	TOTAL 4.0 - PROCESS MECHANICAL				**890,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
5.0	**BUILDING MECHANICAL**				
5.1	**Building HVAC**				
5.1.1	HVAC Allowance	1	LS	70,000	70,000
	Total 5.1 - Building Heating and Ventilation				**70,000**
5.2	**Building Plumbing**				
5.2.1	Domestic Plumbing Allowance	1	LS	20,000	20,000
	Total 5.2 - Plumbing				**20,000**
	TOTAL 5.0 - BUILDING MECHANICAL				**90,000**

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design Estimate

Item	Description	Quantity	Unit	Unit Price	Extension ($)
6.0	**ELECTRICAL AND INSTRUMENTATION**				
6.1	**Electrical**				
6.1.1	Extend 3-phase power to Lake WTP Site	1	LS	200,000	200,000
6.1.2	Building Electrical Cost	1	LS	75,000	75,000
6.1.3	Motor Control Centre	1	LS	200,000	200,000
6.1.4	Standby Power Generation	1	LS	125,000	125,000
6.1.5	Exterior Duct Banks & Manholes	1	LS	5,000	5,000
6.1.6	Field Misc. Devices, Terminations & Equipment Connectio	1	LS	25,000	25,000
6.1.7	Cable Trays & Grounding	1	LS	15,000	15,000
6.1.8	Start-up, Testing & Commissioning	1	LS	30,000	30,000
	Total 6.1 - Electrical				**675,000**
6.2	**I & C**				
6.2.1	SCADA Control H/W (including Panelboards & PLC)	1	LS	30,000	30,000
6.2.2	SCADA Software & Integration	1	LS	15,000	15,000
6.2.3	Field Instruments	1	LS	30,000	30,000
6.2.4	Field Components RIO & Local Control Panels	1	LS	40,000	40,000
6.2.5	Instrumentation Wiring	1	LS	30,000	30,000
6.2.6	Start-up, Testing & Commissioning	1	LS	25,000	25,000
	Total 6.2 - I & C				**170,000**
	TOTAL 6.0 - ELECTRICAL, INSTRUMENTATION & CONTROL				**850,000**

Job No. 60340265
1-Apr-15

Regional District of the Central Okanagan
Killiney Beach Water System Predesign

Stage 1 Water Treatment Plant - Preliminary Design O&M Estimate

Item		Description	Quantity	Unit	Unit Price	Extension ($)
7.0		**ANNUAL OPERATION AND MAINTENANCE COSTS**				
7.1		**Electrical Costs**				
	7.1.1	Raw Water Pumping	6500	kw-hr	0.10	650
	7.1.2	Treated Water Pumping	160000	kw-hr	0.10	16,000
	7.1.3	Building Energy Consumption	110000	kw-hr	0.10	11,000
	7.1.4	UV Power Cost	3500	kw-hr	0.10	350
		Total 7.1 Electrical Costs				**28,000**
7.2		**Treatment Chemicals**				
	7.2.1	Sodium Hypochlorite	750	kg Cl	4.00	3,000
		Total 7.2 - Treatment Costs				**3,000**
7.3		**Equipment Cost**				
	7.3.1	Lamp Replacement	9.0	lamps	300	2,700
		Total 7.3 - Equipment Costs				**2,700**
7.4		**Operations and Maintenance**				
	7.4.1	Labour Costs	730	hrs	60	43,800
		Total 7.4 - Operations and Maintenance Costs				**43,800**
		TOTAL 7.0 - ANNUAL OPERATION AND MAINTENANCE COSTS				**77,500**

Assumptions:
1 Cost of bulk 12% hypochlorite purchased as 200 L drums.
2 UV power consumption and lamp replacement costs based on Trojan SwiftSC D12.
3 Equipment replacement cost based on 2.0% of the capital cost of the mechanical and electrical
4 Existing operations staff run the new treatment facility. Estimated 2 hours of additional labour per day to run the facility.

Water

Regional District of Central Okanagan

Source Water Investigations: Killiney Beach & Westshore Estates Water Systems – Final Report

Prepared by:

AECOM
201 – 3275 Lakeshore Road 250 762 3727 tel
Kelowna, BC, Canada V1W 3S9 250 762 7789 fax
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Project Number:

60439416

Date:

December 2015

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

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- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
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December 7, 2015

Delphine Maja
Regional District of the Central Okanagan
1450 KLO Road
Kelowna, BC V1W 3Z4

Dear Delphine:

Project No: **60439416**

Regarding: **Source Water Investigations: Killiney Beach & Westshore Estates Water Systems – Final Report**

Please see the attached Final Report for the above referenced project for your use. This report outlines the available options to supply water for potable use to the Killiney Beach & Westshore Estates Water Systems to meet both local and federal standards for the provision of drinking water.

Should you have any questions, please do not hesitate to contact the undersigned.

Sincerely,
AECOM Canada Ltd.

Stephen Horsman, P.Eng.
Project Manager

SH:vl
Encl.
cc:

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
1	Yes	Regional District of Central Okanagan

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Stephen Horsman	2015/12/07	Final / Issued for Client Use

AECOM Signatures

Report Prepared By:

Stephen Horsman, P.Eng, P.E.
Project Manager

Stamp

DEC 7 2015
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
S. C. H. HORSMAN
36256

Report Reviewed By:

Brett deWynter, P.Eng.

Executive Summary

The Killiney Beach Water System (KBWS) and the Westshore Estates Water System (WEWS) are small independent water systems that serve rural residential communities located on the west side of Okanagan Lake. Owned and operated by the Regional District of Central Okanagan (RDCO), both systems rely on Okanagan Lake for water and require additional treatment to meet the Drinking Water Treatment Objectives (Microbial) for Surface Water Supplies in British Columbia. Prior to investing further resources in the existing surface water sources, it is prudent to investigate alternate source water supply options to ensure the RDCO directs resources toward the preferred long term solution.

Source water screening identified the potential to develop two groundwater sources to supply drinking water to the KBWS and WEWS. The first and most viable groundwater source identified is the Fintry/Shorts Creek aquifer. Located on the Fintry delta, the Fintry/Shorts Creek aquifer offers access to a high quality and high yielding groundwater source. RDCO currently own and operate a groundwater facility in the Fintry/Shorts Creek aquifer that includes two 200mm diameter groundwater wells each with a rated capacity of 31.5 L/s. To meet the build-out demands of the KBWS and WEWS the existing Fintry wells would need to be upgrade or two new wells drilled on a nearby property.

The other potential groundwater source identified is the Whiteman Creek aquifer located on the Okanagan First Nation land just north of WEWS. Having similar characteristics to the Fintry/Shorts Creek aquifer, the Whiteman Creek aquifer offers access to a high yielding and high quality groundwater source. Development of this source would only be viable if the groundwater could be accessed from a well located outside of the First Nation Reserve boundaries. Further hydrogeological investigation between KBWS and the Whiteman Creek is needed to confirm whether this would be possible.

Okanagan Lake is the only potential or easily available surface water source available to the two service areas. Offering access to abundant and high quality surface water, Okanagan Lake is relied on by several utilities to supply drinking water throughout the Okanagan. Both KBWS and WEWS utilize shallow (i.e. <10m deep) intakes to divert Okanagan water to the systems. Historical data from Okanagan Lake indicates that intakes at depths less than 20m are subject to surface contamination due to Lake turn-over, seiches, runoff and other events. In order to continue to use the Okanagan Lake, RDCO need to enter into a Filtration Deferral Agreement for both water systems, which will likely require the addition of treatment with two-stage disinfection prior to the water entering the distribution system.

Based on the source water evaluation, the following options were develop to supply water to the KBWS and WEWS:

Option 1: Developing a common groundwater well and pump station at Fintry and delivering the water to the KBWS and WEWS via transmission mains

Option 2: Constructing independent Okanagan Lake intakes and filtration plants for each of the KBWS and WEWS

Option 3: Constructing a common Okanagan Lake intake and filtration plant at the KBWS and delivering the water to the WEWS via transmission main

Each of the above options was evaluated using a combination of financial and non-financial factors. A summary of the financial and non-financial comparison is presented in the following **Table E.1**.

Table E.1 KBWS and WEWS Source Water Options Evaluation Summary

Criterion	Option 1 Fintry Groundwater for KBWS and WEWS	Option 2 Independent Okanagan Lake Treatment Facilities at KBWS and WEWS	Option 3 Common Okanagan Lake Treatment Facility at KBWS
Source Integrity (out of 40%)	32%	36%	40%
Treatment and Operation (out of 30%)	30%	15%	21%
Compatibility with Existing (out of 15%)	15%	10%	12%
Environmental Impact (out of 15%)	8%	15%	12%
Total Decision Modelling Score (i.e. Rated "Benefit")	**85%**	**76%**	**85%**
Net Present Value Cost (see Table 12)	**$ 14.1M**	**$ 18.2M**	**$ 14.9M**
NPV Total Capital (Initial)	$ 12.8M ($ 12.8M)	$13.3M ($ 7.0M)	$ 11.4M ($ 7.8M)
NPV of Operating Costs	$ 1.3M	$ 4.9M	$ 3.5M
Cost-to-Benefit-Ratio	**16.7**	23.9	17.5

Having comparable life cycle costs and equal benefit scoring, Option 1 and Option 3 receive similar overall cost-to benefit rankings. To differentiate these options further, an evaluation of the implementation and staging opportunities was considered. Option 3 is significantly more flexibility from an implementation and staging perspective and requires a much lower initial capital investment than Option 1. Initial implementation of Options 3 includes obtaining a filtration deferral agreement with IHA to extend the intake and provide two-stage disinfection on the Okanagan Lake source. The source water can then be monitored for compliance to the filtration deferral conditions and additional treatment would only be considered, as and when, required based on the Okanagan Lake water quality. Given the staging and implementation benefits, Option 3 is the preferred long term source water supply solution for the KBWS and WEWS.

Based on our assessment of the source water supply options we recommend the following, listed in order of implementation:

1) Proceed with Option 3, which includes extending the intake at KBWS, obtaining filtration deferral agreement from IHA, adding two-stages of disinfection at KBWS, and monitoring water quality at the new intake depth and location. This serves as a proof of concept to access stable and high quality water from greater depths within Okanagan Lake. Following successful demonstration, install conveyance infrastructure to supply treated water to WEWS.
2) If the water quality in Okanagan Lake declines and the KBWS intake is no longer capable of satisfying the filtration deferral conditions, then the RDCO should conduct a preliminary hydrogeological screening of the Whiteman Creek aquifer to confirm the viability to access sufficient groundwater to meet the needs of the KBWS and the WEWS. If sufficient groundwater is accessible from the Whiteman Creek aquifer outside of First Nation reserve boundaries, then development of this option offers a lower capital and comparable operating cost solution to Option 1. Alternatively, reconsider provision of Fintry/Short Creek groundwater to supply drinking water to the KBWS and WEWS.

Table of Contents

Executive Summary
Statement of Qualifications and Limitations
Letter of Transmittal
Distribution List
Executive Summary

page

1. Introduction 1
1.1 Background 1
1.2 Objective 1
1.3 Document Organization 1

2. Water System Overview 2
2.1 Killiney Beach Water System 2
2.2 Westshore Estates Water System 3

3. Design Criteria 4
3.1 Water Demand and Population Projections 4
3.2 Treated Water Quality Objectives 5

4. Source Water Evaluation 7
4.1 Surface Water Sources 7
4.1.1 Okanagan Lake 7
4.1.2 Upland Creek Source Water 9
4.1.2.1 Whiteman Creek 9
4.1.3 Norris Creek and Hope Creek 10
4.1.4 Summary 11
4.2 Groundwater Sources 11
4.2.1 Whiteman Creek Fan Aquifer 12
4.2.2 Sugarloaf Mountain Bedrock Aquifer 12
4.2.3 Fintry/Shorts Creek Fan Aquifer 14
4.3 Summary of Source Water Screening 16

5. Development of Options 17
5.1 Option 1: Fintry Groundwater Source for KBWS and WEWS 17
5.1.1 Source Water Development 17
5.1.2 Conveyance 18
5.1.3 Summary 19
5.2 Option 2: Independent Okanagan Lake Intakes and Filtration Plants for each of the KBWS and WEWS 21
5.3 Option 3: Common Okanagan Lake Intake and Filtration Plant at the KBWS with Transmission Main to the WEWS 23

6. Evaluation of Source Water Supply Options 25
6.1 Non-cost Evaluation Criteria 25
6.1.1 Source Water Integrity 25
6.1.2 Treatment Process and Operational Impacts 26

6.1.3 Compatibility with Existing and Future Infrastructure 26
6.1.4 Environmental Impact 27
6.2 Financial Comparison 28
6.2.1 Net Present Value Costs 28
6.3 The Recommended Alternative 29

List of Figures

Figure 1 Killiney Beach Water System Schematic 2
Figure 2 Westshore Estates Water System Schematic 3
Figure 3 Flow Data for Whiteman Creek 10
Figure 4 Aquifer and Water Well Locations 13
Figure 5 Fintry to KBWS Westside Road Transmission Main Alignment 18
Figure 6 Option 1 Fintry Groundwater Source Schematic 20
Figure 7 Option 2 Independent Okanagan Lake Sources at KBWS and WEWS 22
Figure 8 Option 3: Common Okanagan Lake Source for KBWS and WEWS 24

List of Tables

Table 1 RDCO Bylaw No. 704 – Water Demands 4
Table 2 Current and Projected System Demands for the KBWS 4
Table 3 Current and Projected System Demands for the WEWS 4
Table 4 Recommended Long Term Treated Water Quality Goals 6
Table 5 Raw Water Quality for Okanagan Lake (courtesy of AE 2010 report) 8
Table 6 Hydrometric Station Information for Whiteman Creek 9
Table 7 Summary of Surface Water Sources 11
Table 8 Aquifer Characteristics 12
Table 9 High Yield Wells 14
Table 10 Water Quality for Fintry Wells (Well Tag #104531 and #106933) 15
Table 11 Evaluation Criteria and Relative Weight for Each Criterion 25
Table 12 Comparison of Net Present Value for Each Option 28
Table 13 Results of the Option Comparison Model 29

Appendices

Appendix A. Groundwater Well Information
Appendix B. Capital and Operating and Maintenance Costs Breakdown
Appendix C. Net Present Value Cost Breakdown

1. Introduction

1.1 Background

The Killiney Beach Water System (KBWS) and the Westshore Estates Water System (WEWS) serve rural residential areas north of Kelowna, on the western shore of Okanagan Lake, and are owned and operated by the Regional District of Central Okanagan (RDCO). The source water for both water systems is Okanagan Lake, with treatment consisting solely of chlorine disinfection. Original construction of the water systems occurred in the 1960s and 1970s. The current level of treatment is not compliant with drinking water regulations for surface water sources. Prior to investing further treatment for the two water systems, the RDCO is interested in investigating the viability of alternate source water servicing options available to the two water systems with the goal of developing the lowest cost long term water source for residents that is compliant with local and provincial health guidelines.

1.2 Objective

The purpose of this report is to identify potential source water options for the KBWS and the WEWS, develop long term servicing strategies for those that are the most viable, and evaluate each option in terms of quality, long term (i.e. 40 years) capacity and capital and operating costs. From the options evaluation, a recommendation for the preferred long term source water option will be provided for each service area.

1.3 Document Organization

This report fulfils the requirements of the Request for Proposals issued by the RDCO and the proposal submitted by AECOM (Canada) Inc. on July 27, 2015.

The remainder of this report is sub-divided into several sections, as follows:

- **Section 2 – Water System Review** presents a brief overview of the existing infrastructure for the KBWS and the WEWS;
- **Section 3 – Design Criteria** presents the treated water demand projections, raw and treated water quality requirements, and documents design guidelines and assumptions used for the water supply infrastructure;
- **Section 4 – Source Water Evaluation** examines available water sources and develops a preliminary screening of sources for further evaluation;
- **Section 5 – Development of Options** builds upon the design criteria and source water evaluations established in the previous sections, and present servicing approaches for three source water supply options;
- **Section 6 – Evaluation of Source Water Options** presents a multi-bottom line evaluation matrix and option ranking and provides a recommended approach.

2. Water System Overview

2.1 Killiney Beach Water System

The KBWS is a small water system serving approximately 280 residential connections, with full build-out estimated to be 430 residential connections. Originally, the water system relied on Hope Creek and Norris Creek for supply of raw water. Due to limitations in the quality and capacity of the two creek sources, upgrades were completed in the 1980s that included an intake and a series of pump houses to supply Okanagan Lake water throughout the KBWS.

The lake intake pipe is 250 mm diameter PVC and extends 198 m offshore. The end of the pipe includes a mesh screen and is positioned 11.3 m deep and 1 m above the lake bottom. The service area is located on a hillside, and the KBWS is divided into four pressure zones (i.e. low, middle, upper and high). Chlorine disinfection is achieved using 12% sodium hypochlorite injected in the submerged intake. The chlorinated Okanagan Lake water is then pumped into the KBWS distribution system.

A schematic of the showing the hydraulic layout of the existing KBWS is presented in **Figure 1**.

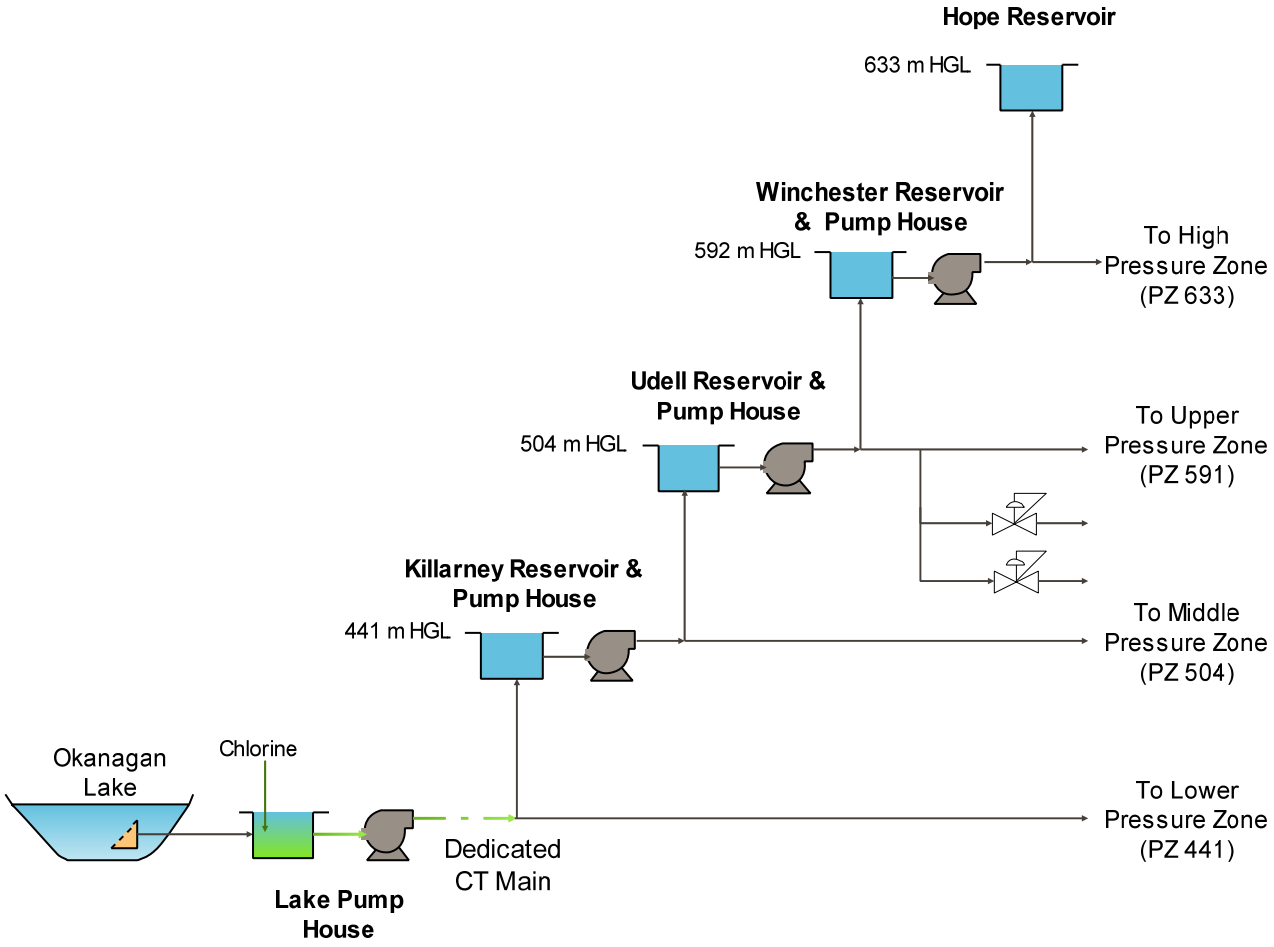


Figure 1 Killiney Beach Water System Schematic

2.2 Westshore Estates Water System

Located approximately 7 km north of Killiney Beach, the Westshore Estates is a similar rural residential subdivision. The WEWS serves approximately 250 residential connections, and has a full build-out potential of 520 residential connections. Okanagan Lake functions as the source water and the water system includes an intake and two pump stations.

The lake intake is a 450 mm diameter corrugated steel pipe and extends 170 m offshore. The pipe is positioned 7 m deep and 1 m above the lake bottom. A series of three screened standpipes at a height of 1 m above the lake bottom feed the intake pipe. The WEWS service area is situated on the hillside adjacent to the Lake and is divided into two pressure zones (lower and upper). Water treatment is limited to disinfection using chlorine gas injected at the pipe intake in the lake, after which Okanagan Lake water is delivered from the lake level pump house to the Mountain Reservoir. From this zone, the water can be pumped to the Upper Reservoir at the upper pressure zone or drain by gravity to the lower pressure zone. The WEWS includes two pressure reducing valves (PRV) to control flow to two small pressure zones.

The hydraulic layout of the existing WEWS is presented in **Figure 2.**

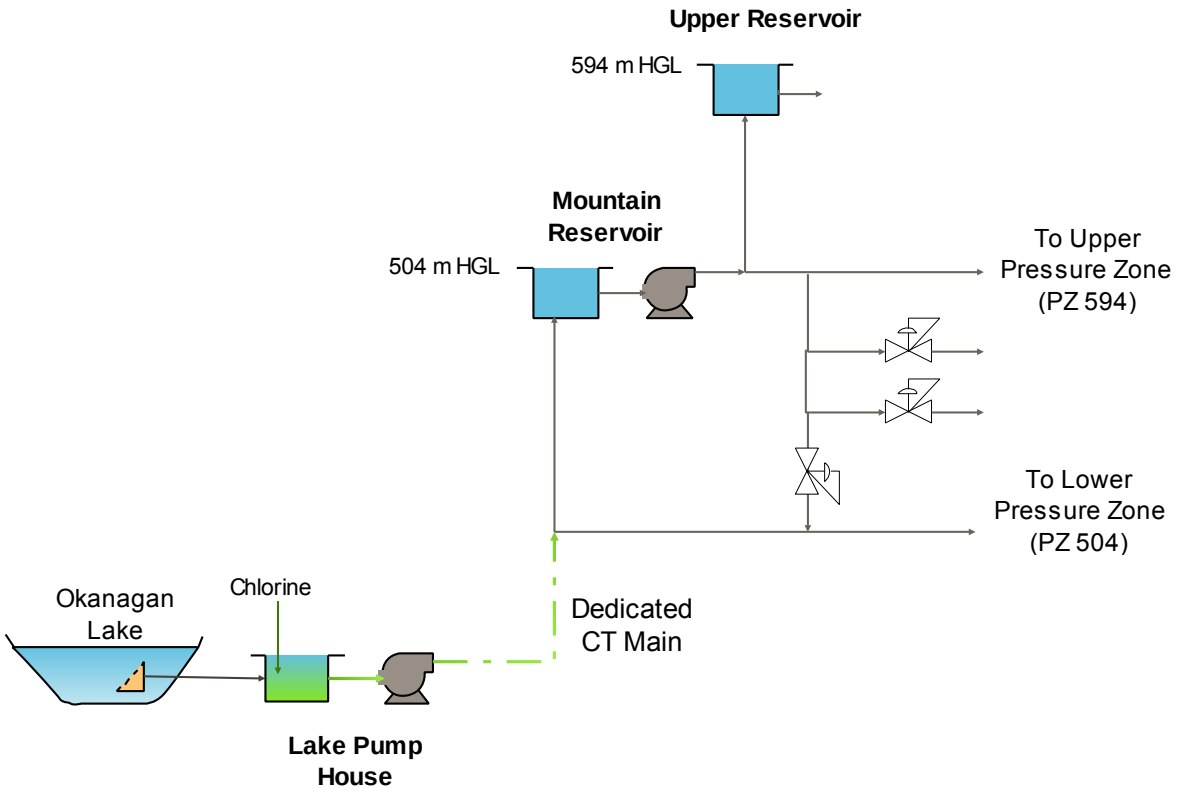


Figure 2 Westshore Estates Water System Schematic

3. Design Criteria

3.1 Water Demand and Population Projections

In order to estimate the build-out capacity of each service area, Maximum Daily Demand (MDD) and Average Daily Demand (ADD) unit rates from the RDCO Subdivision and Development Servicing Bylaw No. 704 (RDCO Bylaw) are used. Revisions to the RDCO Bylaw are currently being proposed that reduce the MDD and Peak Hour Demand (PHD) throughout the water system. A comparison of the proposed and current RDCO Bylaw per capita demands is shown in **Table 1**. Provision for servicing outside the current KBWS and WEWS boundaries is not expected and therefore not included in the future demand requirements.

Table 1 RDCO Bylaw No. 704 – Water Demands

Criterion	Proposed Bylaw Demands	Current Bylaw Demands
ADD (L/cap/day)	900	900
MDD (L/cap/day)	2100	2400
PHD (L/cap/day)	3600	4000
Population (cap/lot)	3	3

Using the proposed Bylaw demands, **Table 2** and **Table 3** below present the current and future water demands anticipated within the KBWS and WEWS, respectively. Build-out water demands are estimated based on the population projections by assigning a three-person single family dwelling per development lot.

Table 2 Current and Projected System Demands for the KBWS

Pressure Zone	Lots	Demand (L/s)	
		MDD	ADD
Current Water System	284	20.7	8.9
Build-out Water System	**427**	**31.1**	**13.3**

Table 3 Current and Projected System Demands for the WEWS

Pressure Zone	Lots	Demand (L/s)	
		MDD	ADD
Current Water System	252	18.4	7.9
Build-out Water System	**522**	**38.1**	**16.3**

3.2 Treated Water Quality Objectives

In evaluating the viability of different water sources for potable use, it is necessary to consider the associated treatment needs to meet federal and provincial health regulations. For the purposes of assessing any treatment needs, it is important to first identify treated water quality objectives for potable water delivered from surface water and groundwater sources. Since the life cycle costs of any source water supply or treatment facility would be at least 20 years, it is considered prudent in the identification of these objectives to not only draw upon the present day set of water quality guidelines and regulations in British Columbia, but also to consider the regulatory environment in other jurisdictions. A short list of these is below. The U.S. Federal Regulations set by the U.S. Environmental Protection Agency (USEPA) are of particular interest, as they typically pre-date similar changes in the Guidelines for Canadian Drinking Water Quality by several years, and are a valuable "barometer" of how similar policies in Canada and British Columbia develop and become effectively implemented.

- Drinking Water Treatment Objectives (Microbial) for Surface Water Supplies in BC[1];
- Interior Health Authority filtration deferral Issue Paper: Planning for Drinking Water Filtration Recommendation, February 2008.
- The Provincial drinking water quality standards of Alberta[2] and Ontario[3], the two Canadian provinces which have been the most proactive in setting more stringent regulations in recent years;
- The Guidelines for Canadian Drinking Water Quality (GCDWQ)[4];
- The following USEPA Regulations[5]:
    - The Surface Water Treatment Rule (SWTR)
    - The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
    - The Stage 2 Disinfectants/Disinfection By-Product (D/DBP) Rule;
    - The Ground Water Rule (GWR);
    - The Filter Backwash Recycling Rule (FBRR);
    - National Primary and Secondary Drinking Water Standards;
- The drinking water regulations imposed by the United Kingdom's Drinking Water Inspectorate[6];
- The World Health Organization Guidelines for Drinking Water Quality, 2004[7].

In reviewing the above health guidelines we have developed a set of long term treated water quality objectives, as presented in **Table 4**, that apply to the use of both groundwater and surface water sources. These objectives form the basis for determining treatment requirements for each water source assessed for future use to supply potable water to the KBWS and WEWS. For all surface water sources, we have assumed that filtration deferral will not be sustainable over the study period of 40 years.

[1] *http://www2.gov.bc.ca/assets/gov/environment/air-land-water/dwog-part-b.pdf*
[2] *Alberta Environment – http://esrd.alberta.ca/water/programs-and-services/drinking-water/legislation/standards-and-guidelines.asp, April 2012.*
[3] *Ontario Ministry of the Environment – "**Ontario Regulation 169/03 – Ontario Drinking Water Quality Standards**",*
[4] *http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc*
[5] *http://www.epa.gov/safewater/standards.html*
[6] *http://www.dwi.gov.uk/*
[7] *http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/*

Table 4 Recommended Long Term Treated Water Quality Goals

Parameter	Units	Goal
Total Alkalinity	mg/L as $CaCO_3$	≥ 25
Aluminum, total	mg/L	≤ 0.1
Iron	mg/L	≤ 0.3
Manganese	mg/L	≤ 0.05
Coliform bacteria	organisms/ 100 mL	Zero
Cryptosporidium parvum (see **Note 1**)	log reduction	≥ 3-log (99.9 %) removal or inactivation for surface waters or groundwater at risk of containing pathogens (GARP). No removal/inactivation required for non-GARP.
Giardia Lamblia (see **Note 1**)	log reduction	≥ 3-log (99.9 %) removal or inactivation for surface waters or groundwater at risk of containing pathogens (GARP). No removal/inactivation required for non-GARP.
Enteric viruses (see **Note 1**)	log reduction	≥ 4-log (99.99 %) removal or inactivation for surface waters or groundwater at risk of containing pathogens (GARP). No removal/ inactivation required for non-GARP groundwaters. ≥ 4-log (99.99 %) removal/inactivation required for non-GARP groundwaters.
Sulphates	mg/L	≤ 200
pH		6.5 – 8.5
Corrosion Potential (see **Note 2**)		Stable, not aggressive to piping materials
Temperature	^{o}C	≤ 15
Trihalomethanes (THM) (see **Note 4**)	µg/L	≤ 80, on a Locational Running Annual Average (see **Note 3**)
Haloacetic Acids (HAA) (see **Note 4**)	µg/L	≤ 60, on a Locational Running Annual Average (see **Note 3**)
True Colour	TCU	≤ 15
Turbidity	NTU	Granular Media Filtration < 0.3 NTU 95% of the time, never to exceed 1 NTU; Membrane Filtration < 0.1 NTU 95% of the time, never to exceed 1 NTU

Notes:

1. *The surface water source available to the KBWS and WEWS under consideration for this project is Okanagan Lake. Note that many regulatory bodies, including the USEPA, mandate higher removal/inactivation efficiency for sources with elevated Giardia and Cryptosporidium. Okanagan Lake water does not exhibit higher levels of either pathogen which would warrant the pursuit of a more stringent removal/inactivation goal;*
2. *Most regulatory bodies do not mandate specific quantitative objectives for corrosion due to the complexity of corrosion processes occurring in distribution systems. As such, qualitative goals such as rendering the water "stable and non-aggressive" are commonly used. Health Canada has recently issued guidelines for utilities to conduct sampling of water drawn at the tap to determine the seriousness of corrosion issues[8]. It is recommended that the RDCO review these guidelines and measure themselves against these criteria to determine whether their water is "Stable, and not aggressive to distribution system piping materials";*
3. *Locational Running Annual Average, or LRAA, is an alternative means of measuring disinfection by-product (DBP) concentrations in a distribution system. Present Canadian guidelines call for a Running Annual Average of all samples throughout the system. This allows samples with lower DBP concentrations to mask higher levels of DBPs measured elsewhere in the system. The LRAA approach requires that a utility show an ability to meet the target at all points in the system individually, making the LRAA approach significantly more stringent than the current approach;*
4. *Health Canada[9] has a guideline for Haloacetic acids[10] (HAAs). Note that both the goals for trihalomethanes (THMs) and HAAs listed above are based upon the USEPA D/DBP Rule, which is more stringent than the Health Canada guidelines (or draft guidelines) for these parameters.*

*[8] Health Canada - "**Corrosion Control in Drinking Water Distribution Systems**", Issued for Public Comment, April, 2007*
*[9] Health Canada – "**Guidelines for Canadian Drinking Water Quality – Guideline Technical Document – Trihalomethanes**", May, 2006*
*[10] Health Canada – "**Haloacetic Acids in Drinking Water**", July, 2008*

4. Source Water Evaluation

4.1 Surface Water Sources

In order to assess the viability of a surface water source for drinking water, a number of factors are considered. These include the characterization of the source water, such as the hydrology and water quality; contaminant survey results identifying any potential hazards that could impact water quality; risk characterization that would impact the drinking water; and source protection methods that should and can be implemented. Ideally, a surface water source would have minimal potential of contamination from activities in the watershed. Routine monitoring is also required of the source once treatment facilities are operating and in service.

This section discusses the surface water sources available to the Killiney Beach and Westshore Estates areas and their viability as drinking water sources for both quantity and quality. Screening of surface waters within the vicinity of the KBWS and WEWS service areas identified both upland surface water sources from smaller tributaries and Okanagan Lake. Each source is described further in the following sections.

4.1.1 Okanagan Lake

Okanagan Lake is the current surface water source used by the KBWS and WEWS. Being a large surface water body, Okanagan Lake is known to consistently produce high quality water. Several of the small water utilities in the Okanagan, as well as many of the larger utilities including Kelowna, Penticton, and Lake Country rely on the Okanagan Lake for provision of drinking water. The level of treatment implemented by these utilities varies from single-stage disinfection (WFN) and two-stage disinfection (Naramata, Lake Country, Kelowna) to conventional treatment (Penticton).

The stability of the water quality obtained from Okanagan Lake is highly dependent on the depth and location of the point of diversion (i.e. intake). Intakes used by Kelowna and Penticton are deeper than 20 m. At such depths, water quality is seasonally more consistent. In general, greater intake depths and lengths provide fewer seiche events (wind-driven disturbance of water layers), lower temperatures, and less favourable photosynthetic conditions (photic zones) for algae growth[11]. Conversely, intakes at shallow depths (i.e. > 20m) are prone to larger seasonal variations in turbidity and temperature and the presence of harmful pathogens.

Table 5 lists data obtained from the AE 2010 reports[12,13] for raw water quality parameters in Okanagan Lake at the KBWS and WEWS intakes and compares this to data from the City of Kelowna and the City of Penticton from 1990 to 2009. The data for the KBWS and WEWS collected in June 2009 is generally within range of the Kelowna and Penticton values for the same parameters; however the data represents only a limited sample period when compared to the Penticton and Kelowna datasets. Data from Penticton and Kelowna demonstrate the long term stability of the water quality at depths greater than 20m.

[11] *Regional District of Central Okanagan, Source Assessment of the Regional District of Central Okanagan – Killiney Beach and Westshore Estates Water Systems, Larratt Aquatic, September 2012*

[12] *Regional District of Central Okanagan, Westshore Estates Water System Review, Associated Engineering, November 2012.*

[13] *Regional District of Central Okanagan, Killiney Beach Water System Review, Associated Engineering, November 2012.*

Table 5 Raw Water Quality for Okanagan Lake (courtesy of AE 2010 report)

Parameter	Units	Penticton and Kelowna			KBWS (June 2009)	WEWS (June 2009)
		Minimum	Maximum	Normal		
Alkalinity	mg/L	101	102	109	106	111
Colour	TCU	0	5	2	<5	<5
Hardness	mg/L	105	130	117	128	139
pH		7.5	9.1	8.0	7.9	7.9
Turbidity	NTU	0.1	4	0.5	0.7	0.7
Calcium	mg/L	30	38	34	34.8	35.4
Iron	mg/L	0.01	0.11	0.02	<0.1	<0.1
UV Transmittance	%	83	94	87	90.5	89.8

The intakes employed by the KBWS and WEWS are at depths of approximately 11 m and 7 m, respectively. Water at these depths is more susceptible to surface contamination, such as elevated turbidity spikes. Larratt Aquatic conducted source water assessments for both the KBWS and WEWS in 2012, which confirmed the need to extend the intakes to increase the protection against contaminants entering the water system intakes. As a minimum, further use of Okanagan Lake at these locations would require an intake extension, the addition of two-stage disinfection, and an approval for filtration deferral by IHA. Long term, it is anticipated that filtration will be required for all single point diversion systems on Okanagan Lake. Therefore, within the scope of this study, it has been assumed that the long term use of Okanagan Lake will include filtration.

To date, the RDCO has not formally applied for filtration deferral. Continued use of the Okanagan Lake source for both water systems will require that the RDCO sign a filtration deferral agreement with IHA that outlines the specific conditions and requirements for each water system. Filtration deferral agreements allow the water purveyors to operate using a two-staged disinfection approach until such time as the source intake can no longer satisfy the filtration deferral conditions or requirements (i.e. turbidity, coliform counts, oocysts, source water protection\monitoring, etc.).

4.1.2 Upland Creek Source Water

Other surface water sources for consideration include upland creeks within the vicinity of the services areas. Upland creek sources typically demonstrate stable water quality the majority of the year with seasonal flashes in turbidity and organics with the spring freshet. In general, creek sources experience significantly more variability than water obtained from Okanagan Lake. Key considerations when assessing upland creek sources include seasonal variability in flow and quality, watershed activity, fish bearing requirements, and licence availability.

4.1.2.1 Whiteman Creek

Whiteman Creek flows north of Westshore Estates. Some data for Whiteman Creek is available as hydrometric station data via the Government of Canada database. **Table 6** lists some details of this station.

Table 6 Hydrometric Station Information for Whiteman Creek

Station Name	Whiteman Creek above Bouleau Creek
Station #	08NM174
Latitude	50° 12' 44" N
Longitude	119° 32' 19" W
Gross Drainage Area	114 km^2

Figure 3 displays flow information from the station for 2011. Maximum and minimum flows based on historical data from 1971 to 2011 are also shown. The minimum and maximum values tend to increase between March and September due to freshet and increased precipitation events. Outside of these months, flows tend to be less than 1 m^3/s, or 1,000 L/s. According to **Table 3**, the average daily demand listed for the WEWS at build-out conditions is 16.3 L/s. Considering the historical minimum trend in **Figure 3**, the flow rate is equal to or greater than 16.3 L/s for most of the calendar year. On 37 occasions, however, the minimum flow falls below 16.3 L/s, and thus would not be sufficient for the average daily demand at build-out conditions for the WEWS.

Use of Whiteman Creek would require a storage reservoir and pump station to convey flows to the WEWS Upper Reservoir at 600m elevation. In addition, the RDCO does not presently have storage or water use licencing on Whiteman Creek.

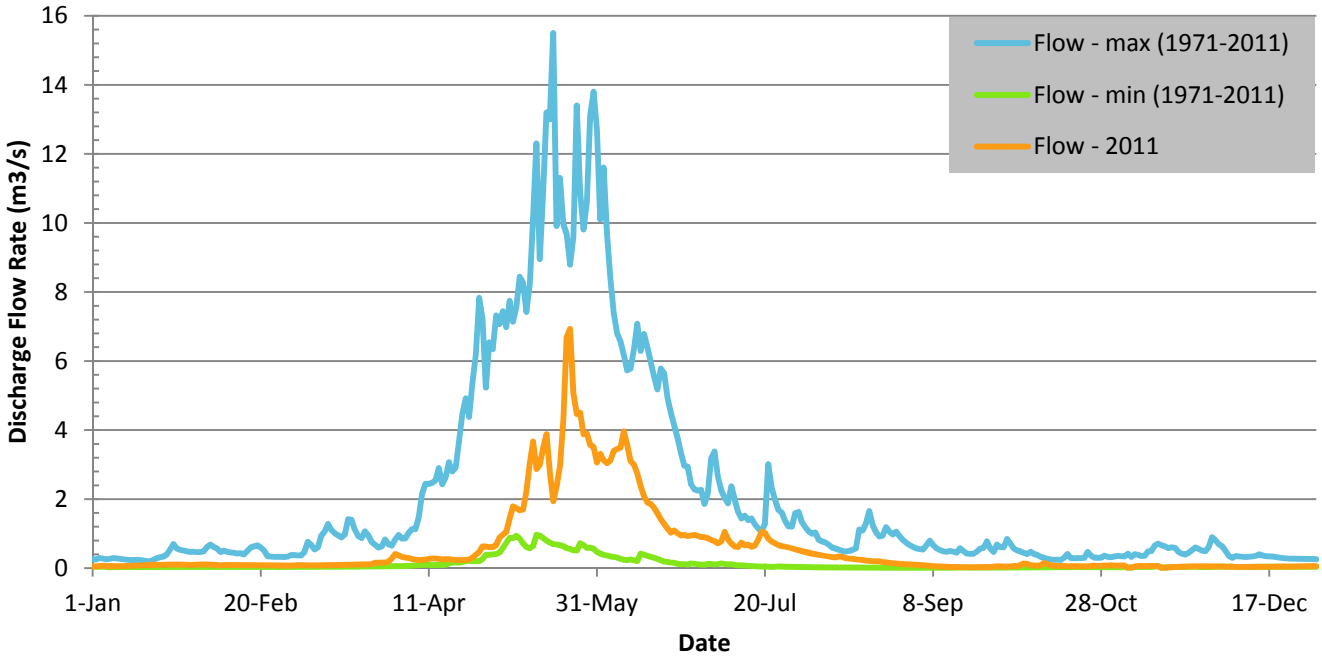


Figure 3 Flow Data for Whiteman Creek

In a report by Dobson Engineering[14], a turbid flow period was noted and found to coincide with the spring freshet period from April 1 to June 30. Mean turbidity values for Whiteman Creek for this period between 2001 and 2008 ranged from 1.9 NTU to 18.8 NTU. Significant precipitation events also occurred during these years that caused large turbidity spikes. These included an event on June 30, 2008 that caused a maximum turbidity reading of 5.7 NTU lasting for 10 hours, and an event on November 8, 2008 which resulted in a maximum turbidity value of 867 NTU lasting for 11 hours. In addition to turbidity, concern with water quality regarding temperature is also an issue. Temperatures greater than 15°C were reported on several occasions between 2001 and 2008, and this is considered to affect the quality of drinking water (**Table 4**).

Based on the water quality information, filtration would be required as one of the barriers in order to use this creek as a drinking water source. Given the spike in turbidity observed during the spring freshet, treatment requirements for Whiteman Creek would likely involve conventional treatment consisting of clarification followed by filtration and two-stage disinfection.

4.1.3 Norris Creek and Hope Creek

Norris Creek flows through the Killiney Beach area towards Okanagan Lake, while Hope Creek runs just south of Killiney Beach. These creeks were originally used as the primary source of potable water for the KBWS but were abandoned due to challenges with quality and quantity. As with Whiteman Creek, both of these creeks may be subject to freshet events, along with spikes in turbidity levels. Thus, conventional treatment (i.e. clarification, filtration, and disinfection) would be required to use either of these sources for potable water.

Very little information is available for either creek, however, based on the gross drainage area for the Whiteman Creek hydrometric station from **Table 6** and the reported watershed areas for each creek from **Table 7**, area ratios were

[14] *Water Quality Monitoring for Lambly and Whiteman Creeks (TFL49) 2008 Annual Report, March 2009*

calculated and used to estimate maximum and minimum flows. The estimated minimum creek flows in Norris and Hope creeks are lower than the average daily demand for KBWS of 13.3 L/s.

Based on limitations in the available water quantity, neither Hope Creek nor Norris Creek are considered to be suitable as a long term source for potable water.

4.1.4 Summary

Table 7 provides a comparison of the surface water sources discussed in the preceding sections. Also included in the table are current water license capacities.

Table 7 Summary of Surface Water Sources

Surface Water Source	Okanagan Lake	Whiteman Creek	Norris Creek/Hope Creek
Service Area	KBWS, WEWS	WEWS	KBWS
Watershed	8000 km^2	114 km^2	1.7 km^2 (Norris Creek) 1.5 km^2 (Hope Creek)
Water License Capacity	442,210 m^3/year (at WEWS intake) 364,221 m^3/year (at KBWS intake)	n/a	112,934 m^3/year (Norris Creek) [2] 76,993 m^3/year (Hope Creek) [3]
Flow	Low flow from August to February represents 14% of total annual flow, or an average of 18,200 ML/month (mostly groundwater); Flow from March to July represents 86% of the total annual flow, or an average of 156,520 ML/month (59,500 L/s) [1]	Less than 16.3 L/s (the average daily demand of the WEWS at build-out conditions) on 37 days of the year	Less than 13.3 L/s (the average daily demand of the KBWS at build-out conditions) on 362 days of the year (Norris Creek) [2] Less than 13.3 L/s (the average daily demand of the KBWS at build-out conditions) on 365 days of the year (Hope Creek) [3]
Quality	High	Moderate	Moderate
Minimum Treatment	2-stage disinfection	Conventional	Conventional
Viability as Drinking Water Source	High	Low	Low

Notes:

1. *From the Okanagan Water Supply and Demand Project: Phase 2 Summary Report (July 2010)*
2. *From the Interior Watershed Assessment for the Norris Creek Watershed, Dobson Engineering (December 1998)*
3. *From the Interior Watershed Assessment for the Hope Creek Watershed, Dobson Engineering (December 1998)*

4.2 Groundwater Sources

As with surface water sources, groundwater sources must also be analyzed for quantity and quality considerations to determine if they are suitable to use in drinking water. Issues to consider are the characterization of the aquifer, such as site selection and vulnerability; contaminant survey results identifying any available hazards or potential impacts to water quality; risk characterization that would impact the drinking water; and source protection methods that should and can be implemented. Contamination of the source from activities within the aquifer recharge zone should be minimized, and routine monitoring should be conducted after a site has been selected and treatment facilities have been put in place. In addition, wells should generally be in accordance with the AWWA Standard for Water Wells (A100-97) and the Water Act, Ground Water Protection Regulation.

This section provides a comparison of the potential groundwater sources for the KBWS and WEWS. Two alluvial fan aquifers (Whiteman Creek and Fintry/Shorts Creek) and one bedrock aquifer (Sugarloaf Mountain) are located within the area of interest. Aquifer boundaries are presented in **Figure 4** and the aquifer characteristics are listed in **Table 8**. Water well data for existing wells taken from the publically available Ministry of Environment (MOE) water well database are presented in **Table 8** and shown in **Figure 4**. Water wells located within these aquifers with reported yield values equal to or greater than 100 US gallons per minute (GPM) are referred to as "high yield" wells. Wells producing less than 100 GPM are referred to as low yield wells. High yield well logs are presented in **Appendix A**. Due to the limitations of the MOE database and well logs, well completion information and well yield values should be verified with well owners or confirmed through additional testing.

Table 8 Aquifer Characteristics

MOE Aquifer #	Aquifer ID	Stratographic Unit	Size (km^2)	Productivity	Vulnerability	Demand
357	Whiteman Creek Fan	Alluvial fan deposits	2.2	High	High	Low
1020	East face of Sugarloaf Mountain	Intrusive rock; granite & alkali feldspar granite	52.4	Low	Moderate	Low
1019	Fintry/Shorts Creek Fan	Ice contact deposits	2.1	Moderate	High	Moderate

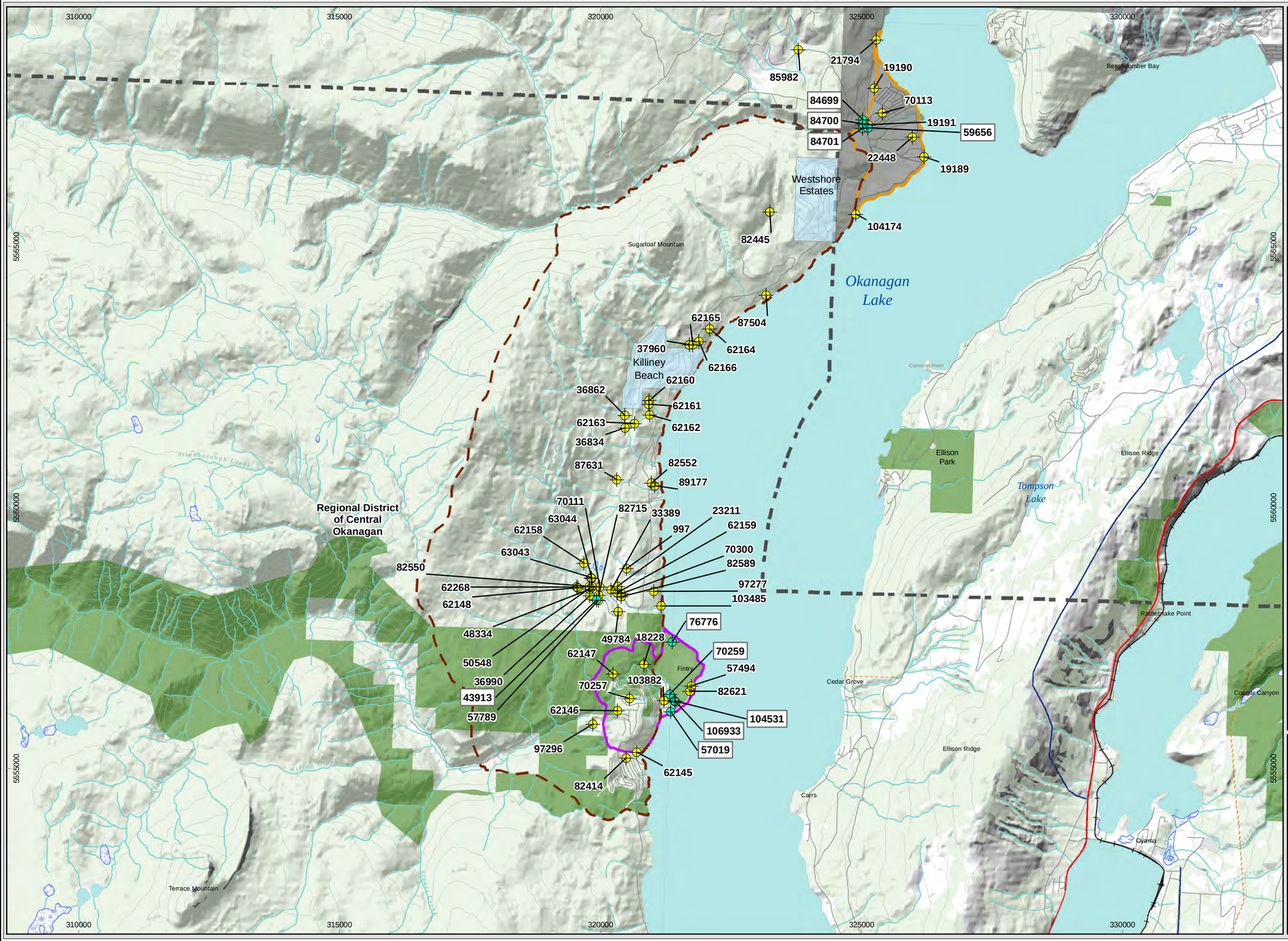
Note: *Data obtained from the MOE aquifer mapping database*

4.2.1 Whiteman Creek Fan Aquifer

The Whiteman Creek Fan Aquifer is characterized as a sand and gravel aquifer that is highly productive and highly vulnerable, and experiences low demand. The MOE water well database indicates four high yield wells are located within this aquifer. All four high yield wells are within 200 m of each other near the intersection of Westside Road and Whiteman Creek. One of these wells (MOE Well Tag #59656) is owned by the Parker Cove Resort and has a reported yield of 1,423 GPM. This value should be verified because even optimal 6 inch diameter wells are only capable of producing less than 200 GPM (Sterrett, 2007). The other three wells (MOE Well Tags #84699, #84700 and #84701) are owned by First Nations, but the well yields are not documented on the well logs. Because these wells are part of a water supply system, it is inferred that each well is capable of producing 100 GPM or more. This aquifer appears to be capable of providing significant quantities of groundwater to existing users and is worth considering for future development.

4.2.2 Sugarloaf Mountain Bedrock Aquifer

The Sugarloaf Mountain Bedrock Aquifer is characterized as a bedrock aquifer that exhibits low productivity and moderate vulnerability, and experiences low demand. The MOE water well database indicates that one high yield well is located within this aquifer. This well (MOE Well Tag #43913) is owned privately and is located near the intersection of Alpine Road and Briarwood Road, and apparently produces 100 GPM. Minimal details regarding well construction are recorded on the well log. The well was drilled 116 m (381 feet) deep; however, the borehole was advanced through 6 m (20 feet) of unconsolidated sediments prior to encountering bedrock. This well was completed as an open borehole and it is not clear if the groundwater is derived from the bedrock aquifer or the overlying unconsolidated sediments. Within a 450 m radius of this well, 15 other wells are identified with reported yields of less than 23 GPM. This wide range of well yields within a short distance is typical of fractured bedrock aquifers, where well productivity is often governed by the bedrock fractures intersected by a given well. It is difficult to reliably target highly fractured bedrock and develop highly productive water supply wells.



Legend

6251 Well Tag ID

- High Yield Water Well (>= 100 GPM)
- Low Yield Water Well (< 100 GPM)
- East face of Sugarloaf Mountain Aquifer Boundary
- Fintry/Shorts Creek Fan Aquifer Boundary
- Whiteman Creek Fan Aquifer Boundary
- Water Purveyor Area
- Road
- Highway
- Lake
- River
- Topology (100 m interval)
- Park and Protected Area
- First Nation Reserve
- Regional District

Overview Map



Base Mapping from Government of BC, ESRI and,AECOM 2015.

N W E S

0 500 1,000 1,500 2,000

Metres

1:70,000

NAD 1983 UTM Zone 11N

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Killiney Beach & Westshore Estates Water Systems
Location: Okanagan Lake

Aquifer and Water Well Locations

November 2015
Project: 60439416

AECOM

Figure 4

File Location: Y:\60439416\900-Work\920-929 (GIS-Graphics)\Maps\Fig3-2015-09-21-AquiferFigure-60439416-001.mxd Date Revised: November 04, 2015 Prepared by: yuf3 Project:

4.2.3 Fintry/Shorts Creek Fan Aquifer

The Fintry/Shorts Creek Fan Aquifer is characterized as a sand and gravel aquifer that is moderately productive and highly vulnerable, and experiences moderate demand. Data from the MOE water well database indicates that five high yield wells are located within this aquifer. All five wells (MOE Well Tag #57019, #70259, #76776, #104531 and #106933) are located less than 325 m from Okanagan Lake. Four of the wells are located near the intersection of Fintry Delta Road and Morden Road, while the fifth well is near the northerly end of Fintry Delta Road. The two wells (MOE Well Tag #104531 and #106933) service the Upper Fintry/Shalal Rd/Valley of the Sun Water System. Detailed information, including well yield information and water quality data can be found in the well protection plan prepared for the RDCO (WWA, 2011). Well #70259 has a reported yield of 525 GPM from a six inch diameter well. As discussed above, a well yield greater than 200 GPM from a 6 inch diameter well is considered rare and should be verified. This aquifer appears to be capable of providing significant quantities of groundwater to existing users and is worth considering for future development.

A summary of the high yield wells is provided in **Table 9**.

Table 9 High Yield Wells

Well Tag #	Location	Aquifer Name	Aquifer Type	Yield (GPM)	Well Depth (FT)	Diameter (IN)	Well Use	Bedrock Depth (FT)	Water Depth (FT)
43913	North of Fintry	Sugarloaf Mountain Bedrock Aquifer	Unconsolidated	100	381	6	Unknown	20	0
57019	Fintry	Fintry/Shorts Creek Fan	Unconsolidated	150	40	6	Irrigation	0	6
59656	Westshore	Whiteman Creek Fan	Unconsolidated	1423*	118.5	6	Water Supply System	0	62
70259	Fintry	Fintry/Shorts Creek Fan	Unconsolidated	525*	71	6	Other	0	21
76776	Fintry	Fintry/Shorts Creek Fan	Unconsolidated	100	76	6	Water Supply System	0	17
84699	Westshore	Whiteman Creek Fan	Unconsolidated	100**	95	-	Water Supply System	-	-
84700	Westshore	Whiteman Creek Fan	Unconsolidated	100**	-	-	Water Supply System	-	-
84701	Westshore	Whiteman Creek Fan	Unconsolidated	100**	-	-	Water Supply System	-	-
104531	Fintry	Fintry/Shorts Creek Fan	Unconsolidated	100***	144	8	Water Supply System	0	12
106933	Fintry	Fintry/Shorts Creek Fan	Unconsolidated	500***	157	8	Water Supply System	0	0

Notes:

Data obtained from the MOE water well database on September 22, 2015. Data should be verified with well owner or confirmed through additional testing.

** Data requires confirmation.*

*** Assumed value based on reported well use.*

**** Data obtained from Western Water Associates (2011).*

Table 10 provides water quality data for two of the existing wells (well tag #104531 and #106933), taken from the Final Report[15] by WWA. Compared with the water quality guidelines in **Table 4**, the water quality of these wells is generally good. It is assumed that a new groundwater well developed in the vicinity of these two existing wells would produce groundwater of similar quality.

Table 10 Water Quality for Fintry Wells (Well Tag #104531 and #106933)

Parameter	Units	Well Tag #104531	Well Tag #106933
pH		8.00	8.08
Temperature	°C	7.6	7.9
Conductivity	µS/cm	285	282
Turbidity	NTU	0.1	0.1
Total Dissolved Solids	mg/L	162	167
Total Hardness	mg/L	143	146
Fluoride	mg/L	0.15	0.12
Nitrate	mg/L	<0.01	<0.01
Sodium	mg/L	5.37	6.81
Chloride	mg/L	0.74	0.80
Sulfate	mg/L	7.2	7.3
UV Transmittance	% @254 nm	93.9	96.3
Total Organic Carbon	mg/L	3.6	7.8
Arsenic	mg/L	0.0016	<0.0005
Iron	mg/L	0.05	0.07
Manganese	mg/L	0.016	0.013
Uranium	mg/L	0.0030	0.00305
Total Coliform	CFU/100 ml	<1	<1
E. Coli	CFU/100 ml	<1	<1
Iron Related Bacteria	Present/Not Present	Detected	Not Detected
Sulphate Reducing Bacteria	Present/Not Present	Not Detected	Not Detected

[15] *Regional District of the Central Okanagan, Source Water Assessment and Protection Plan, Upper Fintry/Shalal Road/Valley of the Sun Water System, Groundwater Supply at Fintry, BC, Western Water Associates, November 2011*

4.3 Summary of Source Water Screening

As seen in **Table 7**, Okanagan Lake is the most viable surface water source, as the watershed, flow, and general water quality are all high, and can sufficiently provide the KBWS and WEWS with water. For Whiteman Creek, although the watershed is a large area, the number of days in which the historical minimum flow falls below the average daily demand of the WEWS at build-out conditions is significant. If the inclusion of tributaries can increase the flow to the WEWS, a pumping station would be required, adding to the capital and operating and maintenance costs. With respect to Norris Creek and other minor creeks in the Killiney Beach area, the potential for low flow is enough to eliminate these creeks as source waters for further consideration. All surface water options will require, at a minimum, two-stage disinfection and long term some form of filtration.

Groundwater in Fintry/Shorts Creek alluvial fan aquifers exhibit relatively dilute concentrations of dissolved constituents. The aquifer is classified, however, as highly vulnerable by the BC MOE due to the lack of protective confining layer overlying the aquifer and highly conductive geology. In addition, the aquifer is located very close to surface streams and Okanagan Lake, and the influence of surface water on the groundwater supply should be further evaluated to determine treatment requirements (i.e., GARP vs. Non-GARP). Groundwater samples have been collected from the wells that are part of the Upper Fintry/Shalal Rd/Valley of the Sun Water System (#104531 and #106933). Groundwater quality in these wells is slightly alkaline pH (7.5-8), is moderately conductive (250- 310 µS/cm), exhibited low concentrations of total metals (arsenic, iron, manganese and uranium) and anions (fluoride, nitrate, sodium, chloride and sulphate), has moderate hardness concentrations (140 - 150 mg/L), and has low to non-detectable concentrations of bacteria, including coliforms, iron-related bacteria and sulphate-reducing bacteria. Investigations by Western Water Associates concluded that these wells are not under the influence of surface water and were not at risk of containing pathogens.

Similar to the Fintry/Shorts Creek aquifer, groundwater in the Whiteman Creek alluvial fan aquifer exhibits relatively dilute concentrations of dissolved constituents. The aquifer limits are entirely within First Nation reserve lands. The Whiteman Creek aquifer is classified as highly vulnerable by the BC MOE due to the lack of protective confining layer overlying the aquifer and highly conductive geology. This is mitigated in the existing Fintry wells by using a deep well screen that extends the time of travel. The aquifer is located very close to surface streams and Okanagan Lake, and the influence of surface water on the groundwater supply should be further evaluated to determine treatment requirements (i.e., GARP vs. Non-GARP). Accessing the aquifer without trespassing on First Nations land may present a challenge to develop this source further. There is potential to conduct hydrogeological exploration immediately north of the WEWS service area in an attempt to tap into the aquifer outside of the defined aquifer boundary and outside of First Nation land. If well exploration in this location proved to be unproductive then this source would be deemed not to be viable for future consideration.

The Sugarloaf Mountain Bedrock Aquifer is classified as moderately vulnerable. Groundwater obtained from deep bedrock aquifers often contain higher concentrations of dissolved constituents, including iron, manganese, and sulphur, and may require additional treatment to address aesthetic concerns.

For the purposes of this report, Okanagan Lake and the high yield wells of the Whiteman Creek and Fintry/Shorts Creek alluvial fan aquifers will continue to be considered as potential source water for the KBWS and WEWS. Options for delivering the source water to each service area are developed in the next section.

5. Development of Options

This section of the report develops three options for delivering potable water to both of the KBWS and WEWS. Each option includes a brief description, a summary of required changes, a capital cost estimate, and a list of the key benefits and challenges. The options include:

- **Option 1:** Developing a common groundwater well and pump station at Fintry and delivering the water to the KBWS and WEWS via transmission mains
- **Option 2:** Constructing independent Okanagan Lake intakes and filtration plants for each of the KBWS and WEWS
- **Option 3:** Constructing a common Okanagan Lake intake and filtration plant at the KBWS and delivering the water to the WEWS via transmission main

5.1 Option 1: Fintry Groundwater Source for KBWS and WEWS

Option 1 consists of developing a new groundwater well and pump station near the existing high yield wells in the Fintry/Shorts Creek fan aquifer and pumping the groundwater to the KBWS and WEWS service areas. The groundwater would be conveyed from Fintry to the KBWS and connect into the existing distribution network. A new pump station would then convey groundwater from the KBWS to the WEWS. Once connected to the existing distribution systems the groundwater can be disinfected and conveyed using the existing infrastructure.

5.1.1 Source Water Development

Water quality from the proposed groundwater well is expected to be similar to the existing Fintry water system groundwater wells. While the aquifer is identified as highly vulnerable, investigation by WWA concluded the drilled wells are not at risk (WWA 2011) due to the depth of the screens and the limited activity within the Fintry area. While the minimum level of treatment would be chlorine disinfection, a second level of disinfection, such as UV radiation, would further protect against potential intrusion of contaminants within the well capture zone. Treatment could be provided at the Fintry source with re-chlorination at each water system or treatment each system prior to entering the distribution system. Given the length of the transmission mains, treatment at each water system is assumed to be the most effective and forms the basis of the capital cost estimates. The existing Okanagan Lake intakes would be isolated from the pump station wetwells and decommissioned or abandoned.

A variant of Option 1 includes retrofitting the existing Fintry wells to increase the capacity of the existing Fintry wells using a larger casing and screen. The existing Fintry groundwater wells each have a rated capacity of 31.5 L/s[16]. The build-out MDD for KBWS and WEWS is approximately 70 L/s, meaning additional well capacity would be required to add these water systems to the Fintry water supply. In order to maintain back-up well capacity, both wells would need to be retrofitted with approximately 300mm diameter well screen (current screens are 180mm diameter). Upsizing the existing groundwater wells eliminates the need to purchase additional land but would require similar hydrogeological assessment and drilling requirements as the development of two new wells. Redevelopment would need to be explored further during subsequent planning and design tasks if this option determined to be the preferred source water approach.

[16] *Regional District Central Okanagan, Upper Fintry/Shalal Rd/Valley of the Sun Water System Source Protection Report, November 2011.*

5.1.2 Conveyance

Two pipeline routing options were considered to convey groundwater from Fintry to the KBWS and WEWS. One potential alignment is to follow Westside Road, as shown in **Figure 5**. Being regulated by the Ministry of Transportation, it is our experience that the proposed watermain would need to be installed outside of the actual roadway, either within the ditch or along the shoulder to limit the impact to traffic during construction. Traffic management during construction of the 12 kilometres of transmission would be a significant consideration for any alignment following Westside Road. Additionally, Westside Road presents several constructability challenges including potential for rock removal and multiple changes in elevation (i.e. multiple high and low points).

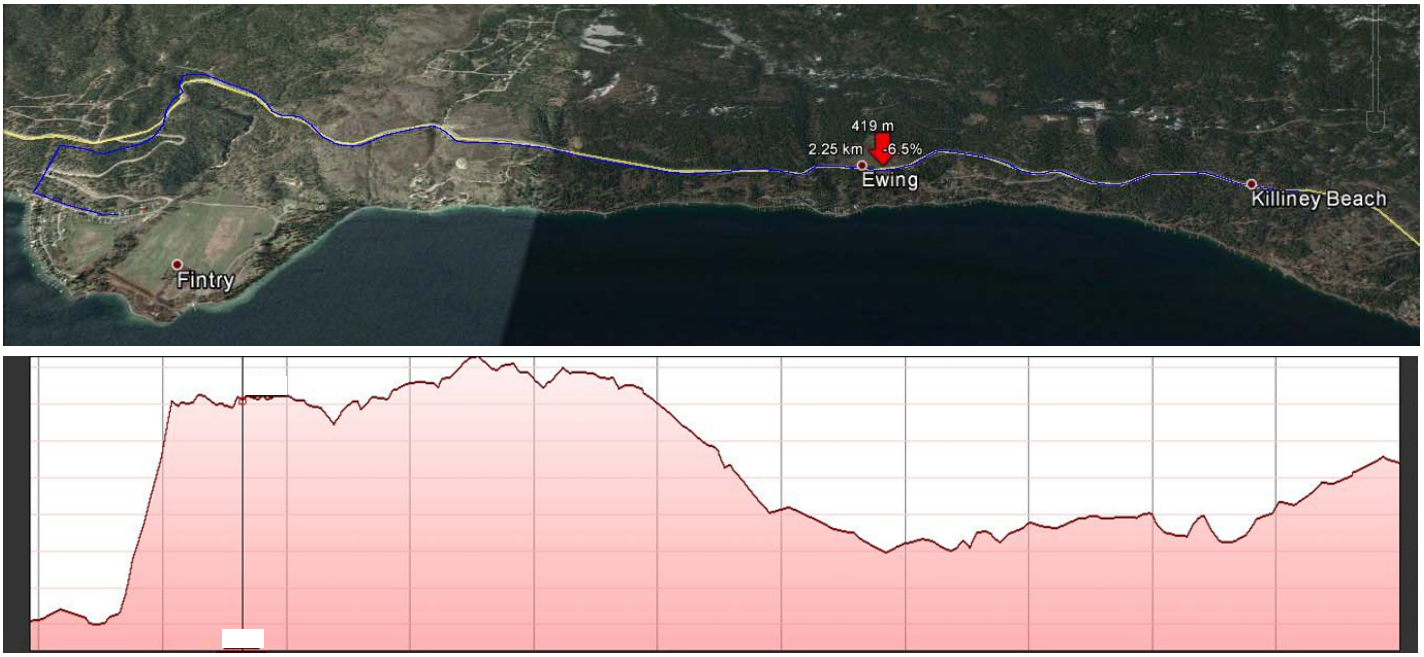


Figure 5 Fintry to KBWS Westside Road Transmission Main Alignment

The other alignment considered is to install a continuous transmission main within Okanagan Lake and connect to each water system at the existing pump stations located on the Okanagan Lake foreshore. Use of fused HDPE piping is common for submerged pipeline applications and allows for easy installation that follows a pre-defined bathymetric contour at a10 and 20 metre water depth. Changes in grade can easily be minimized and long sections of piping can be fused together, floated into the lake and then installed on the lake bottom. One disadvantage of installing the piping along the lake bottom is the inability to service individual lots from the pipeline. If needed, branch connections could be provided to allow future connection in specific locations were future development is anticipated.

Installing the proposed transmission mains within Okanagan Lake does involve additional environmental monitoring and mitigation measures; however, these are expected to incur less cost than the potential traffic management and constructability challenges related to the Westside Road alignment. Based on the above assessment, the lower cost approach is estimated to involve installing the transmission mains along the Okanagan Lake bottom and connecting to the existing Lake pump stations.

5.1.3 Summary

A water schematic showing the proposed modifications for Option 1 is presented in **Figure 6**. The following is a summary of the capital improvements associated with this option:

- Develop a new groundwater well in the Fintry/Shorts Creek aquifer and complete associated hydrogeological testing.
- Purchase land and construct a new 40 m^2 pump station at the new well site with provision for chlorine disinfection equipment and future (year 20) UV disinfection. The facility will include a separate electrical room, standby power and two 60 Hp vertical turbine pumps (standby/duty) capable of producing 70 L/s at a total dynamic head of 60 metres.
- New 15 m^2 pump station at the KBWS to convey water to the existing WEWS pump station. The basis of design includes two 15 Hp vertical turbine pumps installed within pump cans and connected to the existing wetwell. A simple, slab on grade facility with standby power to be constructed adjacent to the existing building.
- Transmission main from Fintry to the KBWS is a 350 mm diameter HDPE DR 11 pipe (approximately 8 km long), and from the KBWS to the WEWS is 250 mm diameter HDPE DR 11 pipe (approximately 4 km long). Transmission mains to be submerged in Okanagan Lake using concrete ballasts and located at a bathymetric contour elevation between 10 and 20m of depth.[17]
- Existing pump stations at each of the KBWS and WEWS to be used to re-chlorinate and convey water into the existing distribution network of each water system.

The estimated 40 year life cycle cost for developing a groundwater well and pump station at Fintry and delivering the water to the KBWS and WEWS is **$ 14,104,000,** including engineering and construction contingency. A more detailed breakdown of the costs is provided in **Section 6**.

Key benefits and challenges for this option are listed below:

Benefits

- Potential for high yield well with good water quality
- Minimal impact to the existing KBWS and WEWS distribution systems
- Lowest operating cost
- Lowest life cycle cost

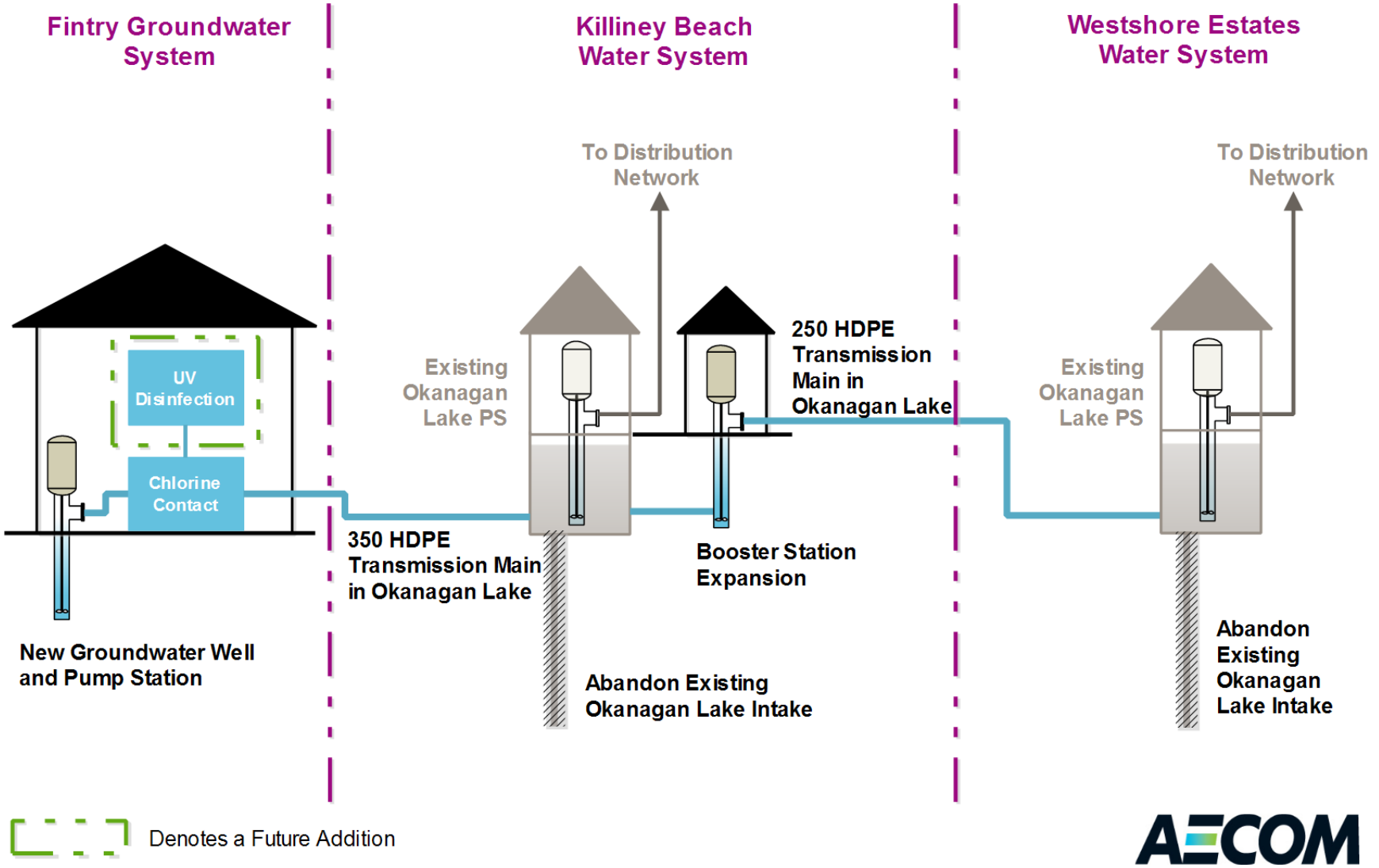
Challenges

- Highest initial capital cost
- Environmental permitting and approvals associate with the transmission mains
- Potential loss of service due to failure of the well
- Increased groundwater use in the area could negatively impact the available withdrawal capacity
- Potential for influence of surface water in the future
- Difficult to repair or maintain submerged transmission mains

[17] *Transmission main between KBWS and WEWS could be installed along Westside Road at a comparable cost to the submerged piping costs. The preferred transmission main alignment should be reviewed further during detailed design once the preliminary environmental screening process has been completed.*

Figure 6 Option 1: Fintry Groundwater Source for KBWS and WEWS

Killiney Beach & Westshore Estates Water Systems: Source Water Assessment



5.2 Option 2: Independent Okanagan Lake Intakes and Filtration Plants for each of the KBWS and WEWS

Option 2 involves developing independent Okanagan Lake treatment facilities at each of the KBWS and WEWS. The existing intakes would be extended and submerged deeper in Okanagan Lake to access water of better quality, and each existing pump station would be modified into a treatment facility, complete with two-stage disinfection and membrane filtration. Following treatment the existing distribution system would be relied on to convey potable water throughout the network. Following a similar approach as outlined in the AECOM 2014 report, each water system needs to obtain a filtration deferral agreement with IHA and implement two-stage disinfection as soon as possible. For the purposes of long range planning, it has been assumed that filtration will be required within the 40 year study period and therefore the costs of filtration are included within the capital and operating cost comparisons.

A water schematic showing the proposed modifications for Option 2 is presented in **Figure 7**. Infrastructure modifications associated with this option include:

- Extend intake 500 metres to achieve a minimum depth of 20 metres at each of the KBWS and WEWS.
- Replace the existing lake pump station at each site with a two-storey building. Building to include low lift raw water pumps (duty/standby), pipe gallery, UV disinfection reactors (duty/standby), chlorine contact (CT) tank, standby power generator, and control and electrical rooms. Note that the treated water pump has been excluded from the description as this is common to all options and therefore is not included in the cost evaluation.
- Two storey membrane filtration building (200 m^2 per floor including tankage) at each site consisting of:
    - Two 72 module membrane treatment trains (duty\standby). Assumes 95% recovery and 25% spare capacity for each train.
    - Backwash waste storage, clarification, and recycle. Backwash waste stream not recycled will be stored and hauled to the WWTP. Waste storage tank sized to provide one week of on-site storage.
    - Clean-in-Place (CIP) system to prevent permanent fouling of the membranes. CIP's to be completed monthly with the waste stream being neutralized and hauled to the WWTP.

The estimated 40 year life cycle cost for developing independent Okanagan Lake treatment facilities at each of the KBWS and WEWS is **$ 18,242,000,** including engineering and construction contingency. A more detailed breakdown of the costs is provided in **Section 6.**

Key benefits and challenges for this option are listed below:

Benefits

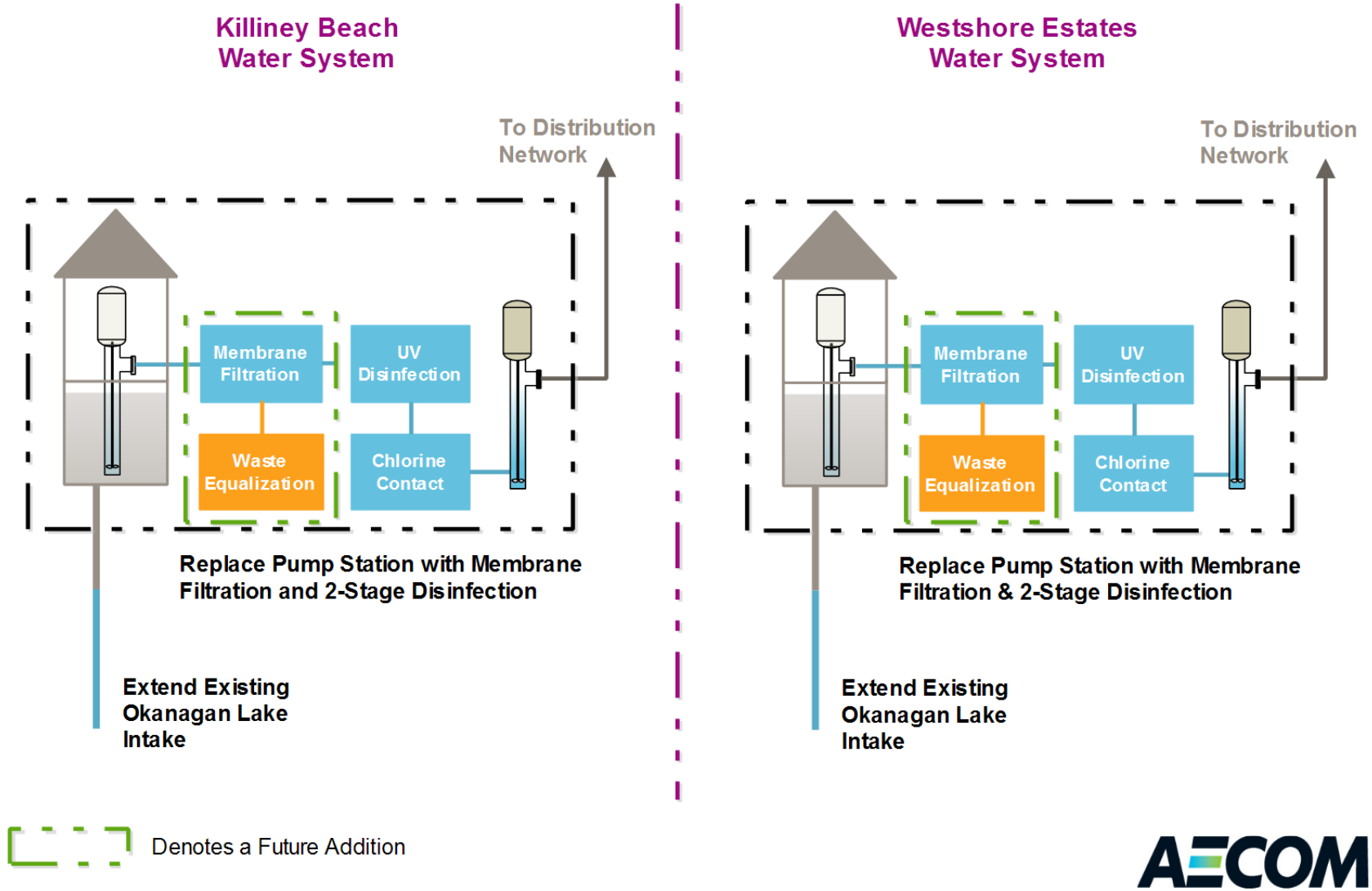
- Autonomy maintained between water systems
- Maximizes use of existing infrastructure
- Limits construction impacts to Okanagan Lake
- Robust level of treatment providing a high level of protection against pathogens

Challenges

- Highest capital and operating cost
- Duplication of infrastructure and staff resources

Figure 7 Option 2: Independent Okanagan Lake Sources at KBWS and WEWS

Killiney Beach & Westshore Estates Water Systems: Source Water Assessment



5.3 Option 3: Common Okanagan Lake Intake and Filtration Plant at the KBWS with Transmission Main to the WEWS

Option 3 consists of developing a common Okanagan Lake intake and filtration plant at the KBWS to supply both KBWS and WEWS. The existing lake intake at the KBWS would be extended and submerged deeper in Okanagan Lake to access water of better quality and the existing KWBS lake pump station would be retrofit to serve as a two-stage disinfection facility. Similar to Option 2, provision for a separate membrane filtration facility is included, when filtration deferral is no longer permitted. Treated water would be pumped into the KBWS using the existing infrastructure. Pumping infrastructure will be provided at the two-stage disinfection building to convey treated water to the WEWS via a HDPE transmission main submerged in Okanagan Lake or installed along Westside Road. Once delivered, the existing pump station at the WEWS will convey the treated water into the distribution network.

A water schematic showing the proposed modifications for Option 3 is presented in **Figure 8**. Infrastructure modifications associated with this option include:

- Extend the existing 400mm intake to achieve a minimum depth of 20 metres.
- Replace the existing lake pump station at the KWBS with a two-storey building. Building to house low lift raw water pumps (duty/standby), pipe gallery, UV disinfection reactors (duty/standby), chlorine contact (CT) tank, standby power generator, and control and electrical rooms. Note that the treated water pump has been excluded from the description as this is common to all options and therefore is not included the cost evaluation.
- Two storey membrane filtration buildings (300 m^2 per floor) at each site to include:
    - Two 96 module membrane treatment trains (duty/standby). Assumes 95% recovery and 25% spare capacity for each train.
    - Backwash waste storage, clarification, and recycle. Backwash waste stream not recycled will be stored and hauled to the WWTP. Waste storage tank to be sized to provide one week of on-site storage.
    - CIP system to prevent permanent fouling of the membranes. CIP's to be completed monthly with the waste stream being neutralized and hauled to the WWTP.
- Two 15 Hp pumps (standby\duty) to deliver 38.1 L/s to the WEWS via 250 mm diameter HDPE DR 11 (approximately 4.5 km long) transmission main. Transmission main to be submerged in Okanagan Lake using concrete ballasts and located at a bathymetric contour elevation between 10 and 20m of water depth. [18]

The estimated 40 year life cycle cost for upgrading the Okanagan Lake intake and developing a common treatment facility at the KBWS with a transmission main to the WEWS is **$ 14,916,000,** including engineering and construction contingency. A more detailed breakdown of the costs is provided in **Section 6**.

Key benefits and challenges for this option are listed below:

Benefits

- Robust level of treatment providing a high level of protection against pathogens
- Consolidates infrastructure between KBWS and WEWS
- Potential to utilize both KBWS and WEWS intake diversion points in the future

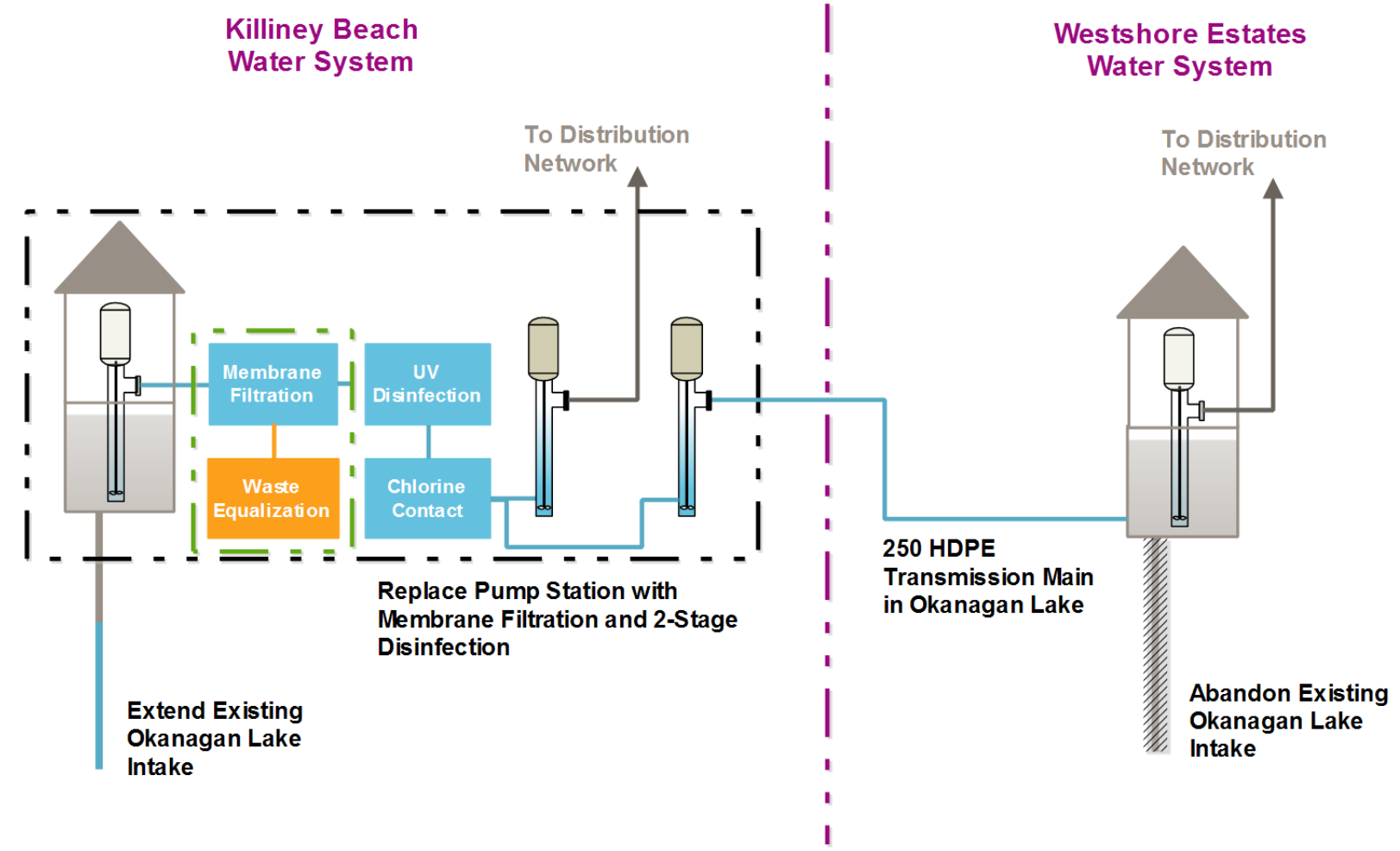
Challenges

- Higher operational cost than the Fintry groundwater system
- Environmental permitting and approvals required for submerged transmission main
- Larger building footprint required at the KBWS park site

[18] *Transmission main between KBWS and WEWS could be installed along Westside Road at a comparable cost to the submerged piping costs. The preferred transmission main alignment should be reviewed further during detailed design once the preliminary environmental screening process has been completed.*

Figure 8 Option 3: Common Okanagan Lake Source for KBWS and WEWS

Killiney Beach & Westshore Estates Water Systems: Source Water Assessment



6. Evaluation of Source Water Supply Options

6.1 Non-cost Evaluation Criteria

The above source water supply options provide various advantages and disadvantages. A series of evaluation criteria has been developed to facilitate making a decision on the preferred source water supply approach for the KBWS and WEWS. Presented in **Table 11** are the criteria considered in the decision model and the associated weighting.

Table 11 Evaluation Criteria and Relative Weight for Each Criterion

Primary Factor or Secondary Factor	Weighting
Source Water Integrity – The susceptibility of the source to be negatively impacted, either in quality or quantity, due to neighbouring water use or landuse and overall robustness of the source water protection planning requirements.	40%
Treatment Process and Operational Impacts – The measure of treatment and operational equipment that will be prone to failure or will require frequent checks and servicing.	30%
Compatibility with Existing Infrastructure – A measure of the impact to the offsite infrastructure, including off-site upgrades, retention of previously installed infrastructure, and the long term water servicing scheme.	15%
Environmental Impact – The potential to negatively impact the slope stability, riparian areas and natural water bodies.	15%
Total Weighting	**100%**

6.1.1 Source Water Integrity

Under this criterion, each of the options was rated based on the potential for negative impacts to the quality or quantity of the source water. Considerations to impacts from adjacent landuse, climate change, recreational activity, etc. are factored into the overall ranking for each option.

The Fintry groundwater source is characterized as an unconfined aquifer that could be impacted by septic systems or hazardous spills within the capture zone at the Fintry delta. Activity in this area is considered low; however, development impacts of the neighbouring properties and the BC Parks space would need to be considered. Compared to Okanagan Lake, the Fintry/Shorts Creek aquifer offers a lower risk of contamination from surface activities. Having a moderate well yield capability, additional groundwater withdrawals in the Fintry/Shorts Creek Aquifer would not be expected to impact the short term availability. Long term development of the area and reduction in precipitation could reduce the long term capacity of the groundwater source. In addition, long term operation of high volume groundwater wells carries a risk of well failure and loss of service. This would result in the need to drill additional wells, which is currently accounted for under well refurbishment costs in the life cycle costing analysis.

Okanagan Lake is considered a high quality surface water source that is capable of sustaining stable water quality conditions at depths below 20 m. Extending the existing intake(s) allows for the KBWS and WEWS to access higher and more stable water quality; however, high recreation use and practical limitations to manage activity within the watershed present a longer term risk to using this source. Once membrane filtration is added, Okanagan Lake would arguably improve the level of protection to comparable or better than that of the Fintry groundwater source. For this reason, implications of quality degradation can be effectively mitigated through filtration, when required. Given the volume and inflow rates associated with Okanagan Lake, water availability for the KBWS and WEWS is not expected to be a concern within the study period.

Comparing the three options, Option 1 is the least susceptible to quality impacts but could experience reduced quantity and potentially failure of the well, over time. Future development on the Fintry delta would increase the risk of negative impacts, both quality and quantity, to the Fintry/Shorts Creek aquifer.

Options 2 and 3 are more likely to be negatively impacted by recreational use and land development within the Okanagan area, but offer access to a large surface water source with sufficient capacity for the foreseeable future. By accounting for filtration in the future, the robustness of the Okanagan Lake sources results in Option 2 and 3 being rated slightly higher than Option 1. A variant of Option 3 includes retaining the intakes at both sites and including provision to divert water from either intake. This would increase the capital cost for the option but offers a potential future measure to further increase the robustness of this option. For this reason, Option 3 is given a slightly higher ranking than Option 2.

Option 1: 80 out of 100
Option 2: 90 out of 100
Option 3: 100 out of 100

6.1.2 Treatment Process and Operational Impacts

This criterion compares the scope of new mechanical infrastructure and the overall system operational complexity for each option. Considerations to the number of facilities, type and complexity of the treatment process, facility classification, and requirements for operator involvement are evaluated to determine the option ranking under this criterion.

Option 1 requires the least amount of treatment, even with UV disinfection added in the future, and therefore scores the highest for this criterion. Two-stage disinfection is very common and would be considered to be one of the simplest and least complex methods of treatment. Options 2 and 3 both involve the eventual addition of filtration, which will add considerable complexity to the operation of the water systems. Package membrane systems require daily system checks and routine monitoring of equipment and process performance and are typically classified as Level III facilities by the Environmental Operators Certification Program (EOCP). Operating two separate facilities will require additional staffing resources and increases the overall complexity of the system option. For this reason, Option 2 is given the lowest overall ranking of the three options.

Option 1: 100 out of 100
Option 2: 50 out of 100
Option 3: 70 out of 100

6.1.3 Compatibility with Existing and Future Infrastructure

This category evaluates each option in terms of compatibility with the existing and future infrastructure and upgrade requirements. Factors such as changing the configuration of the service areas, abandonment of existing infrastructure or future upgrade requirements result in lower rankings for this criterion.

Modifications to the existing KBWS and WEWS for Option 1 are limited to the connection details at the existing Okanagan Lake pump stations and the addition of a booster station at the KBWS. Beyond that the KBWS and WEWS's operation will remain essentially unchanged resulting in Option 1 having the highest ranking in this category. Both Option 2 and Option 3 involve the addition of a two-stage disinfection and ultimately filtration to treat the existing surface water sources. Option 2 is given a slightly lower ranking due to the compounding effect of add two-stage disinfection and filtration at both water systems.

Option 1: 100 out of 100
Option 2: 70 out of 100
Option 3: 80 out of 100

6.1.4 Environmental Impact

Environmental impacts evaluate the potential for each option to adversely impact the natural environment as a result of construction and ongoing operation of the proposed improvements. Factors considered include working within the riparian area, impacts to wildlife habitat such as removal of vegetation, disturbance to spawning habitat, or chemical or oil spills are evaluated when assigning the ranking for this criterion. The key environmental factor associated with these options is the impact to Okanagan Lake.

Option 1 involves the installation of over 12 kilometres of watermain in Okanagan Lake and therefore presents the highest risk of negatively impacting the Lake during construction. From an environmental regulatory and permitting perspective, Option 1 presents the highest risk of encountering unforeseen delays or costs related to installing the submerged pipeline. After the submerged transmission mains are installed, Option 1 and Option 3, both present a risk of introducing chlorinated water into Okanagan Lake through a leak in the submerged transmission mains.

Options 2 and 3 include expanding the existing building footprint within the riparian area setback along the Okanagan Lake foreshore. This will likely involve clearing of vegetated area within the Riparian area setback and potential to negatively impact the Lake through ground disturbances during construction. Once constructed, the treatment plants along the foreshore present a risk of leaking backwash and neutralized waste into the Lake. Option 1 is given the lowest ranking due to the magnitude of in-Lake work required to install the roughly 12 kilometres of submerged pipeline. Option 3 is given a slightly lower ranking than Option 2 because it also includes the installation of a submerged pipeline.

Option 1: 50 out of 100
Option 2: 100 out of 100
Option 3: 80 out of 100

6.2 Financial Comparison

6.2.1 Net Present Value Costs

The estimated of life cycle costs for each option are presented in **Table 12**. Detailed breakdown of the capital and operating costs estimates are provided in **Appendix B**.

Table 12 Comparison of Life Cycle Costs for Each Option

Description	Option 1 Fintry Groundwater for KBWS and WEWS	Option 2 Independent Okanagan Lake Treatment Facilities at KBWS and WEWS	Option 3 Common Okanagan Lake Treatment Facility at KBWS
1.0 NPV of Capital Costs			
1. Fintry Pump Station	$2,050,000	n/a	
2. KBWS Pump Station	$363,000	n/a	$218,000
3. KBWS Disinfection Building	n/a	$3,074,000	$3,553,000
4. KBWS Membrane Building	n/a	$2,890,000	$3,781,000
5. WEWS Disinfection Building	n/a	$3,466,000	n/a
6. WEWS Membrane Building	n/a	$3,147,000	n/a
7. KBWS Intake	n/a	$363,000	$363,000
8. WEWS Intake	n/a	$363,000	n/a
9. Fintry to KBWS Transmission Main	$6,960,000		
8. KBWS to WEWS Transmission Main Intake	$3,480,000		$3,480,000
1.0 NPV of Capital Costs	***$12,853,000***	***$13,303,000***	***$11,395,000***
2.0 NPV of Operating Costs			
1. Base Costs	$1,084,000	$1,901,000	$1,128,000
2. Future Treatment	$153,000	$3,038,000	$2,393,000
3. Well Refurbishment	$288,000	n/a	n/a
2.0 NPV of Operating NPV	***$1,251,000***	***$4,939,000***	***$3,521,000***
TOTAL 40 YEAR LIFE CYCLE	**$14,104,000**	**$18,242,000**	**$14,916,000**

The following assumptions have been made in the development of capital costs for the recommended facility upgrades:

- The estimate is based on 2015 construction costs. Inflation and escalation to account for actual expected prices at the time of tendering are not included.
- The impact of the PST in the amount of 7% is included within the estimate, but the GST in the amount of 5% is not included.
- All estimates of capital cost include the assumed general contractor mark-up and profit of 10%. The estimates are intended to reflect the complete cost of construction.
- Financing and legal fees are not included.
- All capital costs include a 15% allowance for engineering and 30% construction contingency.
- Detailed geotechnical, topography, or bathymetry data was not used in the development of the options.

- Fintry pump station capital cost incudes well development, building, chlorination and future (year 20) UV disinfection.
- Fintry pump station and WEWS treatment facility each include $ 200,000 land acquisition costs.
- Submerged transmission main costs include mob and demob costs for drilling at three sites, environmental monitoring and permitting, 12 weeks of divers, specialty flexible connection fittings, and HDPE DR 11 pipe complete with concrete ballasts.
- Groundwater wells to be refurbished every 20 years.
- Membrane filtration provided at year 20 on all Okanagan Lake sources.
- Membrane O&M include energy costs, membrane replacement (10 year replacement frequency), and chemical usage.
- Mechanical equipment replacement costs not accounted for in the life cycle cost beyond the annual building maintenance budget.
- Distribution system upgrades for KBWS and WEWS are not included in the capital cost comparison as they are the same for all options. Where distribution infrastructure would be located within the treatment buildings then the associated costs have been omitted from the overall capital cost estimate.
- All pump station facilities include a standby generator sized to energize one duty pump and the building critical system requirements.
- Pump station at KBWS for Option 3 to be located within treatment building, therefore costs are less than the stand alone pump station required for Option 1.
- Unit electricity cost of $0.10/kW-hr
- Discount rate of 3% applied for net present value calculations
- Provision of three phase power to KWBS and WEWS pump station sites not included as it is considered a requirement of the distribution system upgrades.

The estimated capital costs listed in **Table 12** are for comparison of the options and do not reflect detailed costs for the options. The absolute cost associated with the preferred solution should be validated with further engineering. The relative difference of the costs between each option is sufficient for the completion of option comparison; however it should not be used for budgetary purposes.

6.3 The Recommended Alternative

Table 13 presents the compiled results of the decision modelling effort. As a result of this effort, decision between the preferred source water supply options can be more easily selected.

Table 13 Results of the Option Comparison Model

Criterion	Option 1 Fintry Groundwater for KBWS and WEWS	Option 2 Okanagan Lake Treatment at KBWS and WEWS	Option 3 Common Okanagan Lake Treatment at KBWS
Source Integrity	32%	36%	40%
Treatment and Operation	30%	15%	21%
Compatibility with Existing	15%	10%	12%
Environmental Impact	8%	15%	12%
Total Decision Modelling Score (i.e. Rated "Benefit")	**85%**	**76%**	**85%**
Net Present Value Cost (see Table 12)	$ 14.1	$ 18.2	$ 14.9
NPV Total Capital (Initial)	$ 12.8M ($ 12.8M)	$13.3M ($ 7.0M)	$ 11.4M ($ 7.8M)
NPV of Operating Costs	$ 1.3M	$ 4.9M	$ 3.5M
Cost-to-Benefit-Ratio	**16.7**	23.9	17.5

Option 1 and Option 3 both offer robust long term source water supply options at a comparable life cycle cost. Development of a groundwater well in the Fintry/Shorts Creek aquifer results in the highest benefit ranking and lowest capital and operational cost solution to meet the drinking water needs for the KBWS and the WEWS. Potential for future degradation of the groundwater source quality in the Fintry/Shorts Creek aquifer can be mitigated with the addition of UV disinfection, if required. A source integrity challenge with development of the Fintry source is potential of reduced water availability through increased demand and reduction in inflows to the aquifer. Given the proximity of the well to multiple surface water bodies it is expected that the recharge of aquifer can sustain the demands for the KBWS and WEWS for the foreseeable future. The key disadvantage of Option 1 is the significant initial capital cost required to proceed with the option.

Option 3 receives an equal benefit ranking to Option 1 and a slightly higher NPV. The key advantage of Option 3 is the lower initial capital cost than required by Option 1. Furthermore, Option 3 provides access to an abundant source of water in the Okanagan Lake. Having a marginally higher life cycle cost and lower initial capital cost, Option 3 is worth further consideration as the one of the preferred long term solutions. It is unknown how long the Okanagan Lake source water can maintain the filtration deferral criteria. The longer filtration can be deferred the more favourable Option 3 becomes when compared to Option 1. Due the significant operational costs associated with the addition of membrane filtration, the current life cycle cost evaluation is quite sensitive to variation in timing of when filtration is trigger.

Having comparable life cycle costs and equal benefit scoring, Option 1 and Option 3 receive similar overall cost-to benefit rankings. To differentiate these options further, an evaluation of the implementation and staging opportunities was considered. Option 3 is significantly more flexibility from an implementation and staging perspective and requires a much lower initial capital investment than Option 1. Initial implementation of Options 3 includes obtaining a filtration deferral agreement with IHA to extend the intake and provide two-stage disinfection on the Okanagan Lake source. The source water can then be monitored for compliance to the filtration deferral conditions and additional treatment would only be considered, as and when, required based on the Okanagan Lake water quality. Given the staging and implementation benefits, Option 3 is the preferred long term source water supply solution for the KBWS and WEWS.

Based on our assessment of the source water supply options we recommend the following, listed in order of implementation:

1) Proceed with Option 3, which includes extending the intake at KBWS, obtaining filtration deferral agreement from IHA, adding two-stages of disinfection at KBWS, and monitoring water quality at the new intake depth and location. This serves as a proof of concept to access stable and high quality water from greater depths within Okanagan Lake. Following successful demonstration, install conveyance infrastructure to supply treated water to WEWS.
2) If the water quality in Okanagan Lake declines and the KBWS intake is no longer capable of satisfying the filtration deferral conditions, then the RDCO should conduct a preliminary hydrogeological screening of the Whiteman Creek aquifer to confirm the viability to access sufficient groundwater to meet the needs of the KBWS and the WEWS. If sufficient groundwater is accessible from the Whiteman Creek aquifer outside of First Nation reserve boundaries, then development of this option offers a lower capital and comparable operating cost solution to Option 1. Alternatively, reconsider provision of Fintry/Short Creek groundwater to supply drinking water to the KBWS and WEWS.

Appendix A

Aquifer and Well Data

Table X - Summary of Wells in MOE Aquifers 357, 1020 and 1019

WHITEMAN CREEK FAN AQUIFER (MOE # 357)							
WELL TAG #	AQUIFER TYPE	YIELD (GPM)	WELL USE NAME	WELL DEPTH (FT)	DIAMETER (IN)	BEDROCK DEPTH (FT)	WATER DEPTH (FT)
19189	UNCONSOLIDATED	12	Unknown Well Use	31	6.0	0	11
19190	UNCONSOLIDATED	0	Unknown Well Use	110	6.0	103	0
19191	UNCONSOLIDATED	0	Unknown Well Use	75	6.0	0	0
21794	UNCONSOLIDATED	8	Unknown Well Use	30	6.0	0	10
22448	UNCONSOLIDATED	10	Unknown Well Use	36	6.0	0	10
59656	**UNCONSOLIDATED**	**1423***	**Water Supply System**	**118.5**	**6.0**	**0**	**62**
70113	-	60	Private Domestic	78	6.0	0	26
84699	**UNCONSOLIDATED**	**100****	**Water Supply System**	**95**	**-**	**0**	**0**
84700	**UNCONSOLIDATED**	**100****	**Water Supply System**	**0**	**-**	**0**	**0**
84701	**UNCONSOLIDATED**	**100****	**Water Supply System**	**0**	**-**	**0**	**0**
104174	-	20	Private Domestic	57	-	0	0
SUGARLOAF MOUNTAIN BEDROCK AQUIFER (MOE # 1020)							
WELL TAG #	AQUIFER TYPE	YIELD (GPM)	WELL USE NAME	WELL DEPTH (FT)	DIAMETER (IN)	BEDROCK DEPTH (FT)	WATER DEPTH (FT)
997	UNCONSOLIDATED	3	Unknown Well Use	48	6.0	0	17
23211	UNCONSOLIDATED	23	Unknown Well Use	60	8.0	58	11
33389	-	0	Unknown Well Use	340	5.0	29	0
36834	BEDROCK	10	Private Domestic	220	5.0	20	60
36862	BEDROCK	50	Private Domestic	180	5.0	20	0
36990	UNCONSOLIDATED	0	Private Domestic	1080	-	48	20
37960	BEDROCK	3	Unknown Well Use	340	5.0	16	67
43913	**UNCONSOLIDATED**	**100**	**Unknown Well Use**	**381**	**6.0**	**20**	**0**
48334	BEDROCK	1	Unknown Well Use	218	5.5	55	29
49784	BEDROCK	0.1	Unknown Well Use	300	7.0	3	0
50548	BEDROCK	2.5	Unknown Well Use	40	5.5	34	16
57789	BEDROCK	0	Private Domestic	240	-	33	0
62145	BEDROCK	30	Private Domestic	32	6.0	1	0
62148	UNCONSOLIDATED	0	Private Domestic	0	-	0	0
62158	BEDROCK	2	Private Domestic	320	6.0	156	122
62159	BEDROCK	1.5	Private Domestic	322	6.0	0	80
62160	BEDROCK	2.5	Private Domestic	480	5.3	422	73
62161	BEDROCK	8	Private Domestic	300	5.3	240	30
62162	BEDROCK	8	Private Domestic	260	5.3	160	90
62163	UNCONSOLIDATED	0	Private Domestic	90	0.0	0	0
62164	BEDROCK	10	Private Domestic	160	6.0	155	65
62165	BEDROCK	10	Private Domestic	240	5.3	220	110
62166	BEDROCK	7	Private Domestic	320	5.3	290	215
62268	BEDROCK	0.4	Private Domestic	350	6.0	319	5
63043	-	0.1	Private Domestic	138	6.0	13	0
63044	-	4	Private Domestic	38	6.0	0	0
70111	BEDROCK	3	Private Domestic	440	6.0	0	23
70300	BEDROCK	0.5	Private Domestic	420	6.0	58	100
82414	BEDROCK	0.2	Private Domestic	300	6.0	0	200
82445	-	0	Unknown Well Use	280	6.0	112	0
82550	BEDROCK	0.125	Private Domestic	660	6.0	0	445
82552	-	2.5	Private Domestic	400	6.0	0	39
82589	BEDROCK	0.75	-	440	6.0	0	0
82715	BEDROCK	0.5	Private Domestic	260	6.0	0	190
87504	-	8	Private Domestic	641	-	46	178
87631	-	15	Private Domestic	480	-	66	0
89177	-	1.75	Private Domestic	280	-	76	61.5
97277	BEDROCK	3	Private Domestic	340	-	8	90
97296	BEDROCK	0	-	700	-	194.5	0
103485	BEDROCK	2.5	Private Domestic	500	-	0	38
FINTRY/SHORTS CREEK FAN AQUIFER (MOE # 1019)							
WELL TAG #	AQUIFER TYPE	YIELD (GPM)	WELL USE NAME	WELL DEPTH (FT)	DIAMETER (IN)	BEDROCK DEPTH (FT)	WATER DEPTH (FT)
18228	UNCONSOLIDATED	0	Unknown Well Use	45	6.0	0	26
57019	**UNCONSOLIDATED**	**150**	**Irrigation**	**40**	**6.0**	**0**	**6**
57494	UNCONSOLIDATED	20	Private Domestic	18	7.0	0	6
62146	UNCONSOLIDATED	0	Private Domestic	150	6.0	0	0
62147	UNCONSOLIDATED	5	Private Domestic	320	6.0	0	260
70257	UNCONSOLIDATED	6	-	40	6.0	0	6
70259	**UNCONSOLIDATED**	**525***	**Other**	**71**	**6.0**	**0**	**21**
76776	**UNCONSOLIDATED**	**100**	**Water Supply System**	**76**	**6.0**	**0**	**17**
82621	-	0	-	0	-	0	0
103882	-	0	-	0	-	0	0
104531	**-**	**100*****	**Water Supply System**	**144**	**8.0**	**0**	**12**
106933	**-**	**500*****	**Water Supply System**	**157**	**8.0**	**0**	**0**

Notes:

BOLD text indicates high yield well (reported/assumed well yield is≥ 100 GPM)

Data obtained from the MOE water well database on September 22, 2015. Data should be verified with well owner or confirmed through additional testing.

* Data requires confirmation.

** Assumed value based on reported well use.

*** Data obtained from Western Water Associates (2011).

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 59656

Owner: PARKER COVE RESORT

Address: WESTSIDE ROAD

Area: VERNON

WELL LOCATION:

OSOYOOS (ODYD) Land District

District Lot: Plan: 68978 Lot: 39

Township: Section: Range:

Indian Reserve: 1 Meridian: Block: 5

Quarter:

Island:

BCGS Number (NAD 83): 082L023232 Well: 2

Class of Well:

Subclass of Well:

Orientation of Well: Vertical

Status of Well: New

Licence General Status: UNLICENSED

Well Use: Water Supply System

Observation Well Number:

Observation Well Status:

Construction Method: Drilled

Diameter: 6 inches

Casing drive shoe:

Well Depth: 118.5 feet

Elevation: feet (ASL)

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: feet

Lithology Info Flag: Y

File Info Flag: N

Sieve Info Flag: N

Screen Info Flag: Y

Site Info Details:

Other Info Flag:

Other Info Details:

Construction Date: 1991-05-04 00:00:00

Driller: Capri Drilling

Well Identification Plate Number:

Plate Attached By:

Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: 1423 (Driller's Estimate) U.S. Gallons per Minute

Development Method:

Pump Test Info Flag: Y

Artesian Flow:

Artesian Pressure (ft):

Static Level: 62 feet

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag: Y

Field Chemistry Info Flag:

Site Info (SEAM): N

Water Utility: N

Water Supply System Name: PARKER COVE RESORT

Water Supply System Well Name:

SURFACE SEAL:

Flag: Y

Material: Other

Method:

Depth (ft):

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size
118.5	114.5		80
114.5	110.5		60
110.5	106.5		40

Casing from	to feet	Diameter	Material	Drive Shoe
0	106.5	null	null	null

GENERAL REMARKS:
 PUMP TEST & CHEMISTRY DONE.

LITHOLOGY INFORMATION:

From 0 to 4 Ft. TOPSOIL WITH SAND & GRAVEL 0 nothing entered

From 4 to 71.5 Ft. MOIST,TIGHT ,SHARP SAND WITH GRAVEL -- 0 nothing entered

From to Ft. COBBLES & SOME BOULDERS. 0 nothing entered

From	71.5 to 95 Ft.	WATER-BEARING SAND & GRAVEL,LOOSER WITH	0	nothing entered
From	95 to 118.5 Ft.	WATERBEARING SAND & GRAVEL (LOOSER) WITH MORE WATER	0	nothing entered
From	to Ft.	DUE TO SCREEN LENGTH & LOW STATIC LEVEL UNABLE TO GET ACURATE FLOW RATE WITH AIRLIFT.	0	nothing entered
From	to Ft.	PUMP TEST SHOULD BE DONE FOR MAX FLOW RATE ON WELL.	0	nothing entered

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 84699	Construction Date:
Owner: OKANAGAN FIRST NATION	Driller:
Address: WESTSIDE ROAD	Well Identification Plate Number:
	Plate Attached By:
Area: VERNON	Where Plate Attached:
WELL LOCATION:	PRODUCTION DATA AT TIME OF DRILLING:
KAMLOOPS (KDYD) Land District	Well Yield: (Driller's Estimate)
District Lot: Plan: Lot:	Development Method:
Township: Section: Range:	Pump Test Info Flag: N
Indian Reserve: 1 Meridian: Block:	Artesian Flow: UNKNOWN YIELD
Quarter:	Artesian Pressure (ft):
Island:	Static Level:
BCGS Number (NAD 83): 082L023232 Well: 3	WATER QUALITY:
Class of Well:	Character:
Subclass of Well:	Colour:
Orientation of Well:	Odour:
Status of Well:	Well Disinfected: N
Licence General Status: UNLICENSED	EMS ID:
Well Use: Water Supply System	Water Chemistry Info Flag: N
Observation Well Number:	Field Chemistry Info Flag:
Observation Well Status:	Site Info (SEAM): N
Construction Method:	Water Utility: N
Diameter: inches	Water Supply System Name: WHITEMAN CREEK WATER SYSTEM
Casing drive shoe:	Water Supply System Well Name: WELL NO. 1
Well Depth: 95 feet	SURFACE SEAL:
Elevation: 1200.8 feet (ASL)	Flag: N
Final Casing Stick Up: inches	Material:
Well Cap Type:	Method:
Bedrock Depth: feet	Depth (ft):
Lithology Info Flag: N	Thickness (in):
File Info Flag: N	

Sieve Info Flag: N Screen Info Flag: N Site Info Details: Other Info Flag: Other Info Details:	WELL CLOSURE INFORMATION: Reason For Closure: Method of Closure: Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 84700	Construction Date:
Owner: OKANAGAN FIRST NATION	Driller:
Address:	Well Identification Plate Number:
	Plate Attached By:
Area:	Where Plate Attached:
WELL LOCATION:	PRODUCTION DATA AT TIME OF DRILLING:
KAMLOOPS (KDYD) Land District	Well Yield: (Driller's Estimate)
District Lot: Plan: Lot:	Development Method:
Township: Section: Range:	Pump Test Info Flag: N
Indian Reserve: 1 Meridian: Block:	Artesian Flow: UNKNOWN YIELD
Quarter:	Artesian Pressure (ft):
Island:	Static Level:
BCGS Number (NAD 83): 082L023232 Well: 4	WATER QUALITY:
Class of Well:	Character:
Subclass of Well:	Colour:
Orientation of Well:	Odour:
Status of Well:	Well Disinfected: N
Licence General Status: UNLICENSED	EMS ID:
Well Use: Water Supply System	Water Chemistry Info Flag: N
Observation Well Number:	Field Chemistry Info Flag:
Observation Well Status:	Site Info (SEAM): N
Construction Method:	Water Utility: N
Diameter: inches	Water Supply System Name: WHITEMAN CREEK WATER SYSTEM
Casing drive shoe:	Water Supply System Well Name: WELL NO. 2
Well Depth: feet	SURFACE SEAL:
Elevation: 1213.9 feet (ASL)	Flag: N
Final Casing Stick Up: inches	Material:
Well Cap Type:	Method:
Bedrock Depth: feet	Depth (ft):
Lithology Info Flag: N	Thickness (in):
File Info Flag: N	

Sieve Info Flag: N Screen Info Flag: N Site Info Details: Other Info Flag: Other Info Details:	WELL CLOSURE INFORMATION: Reason For Closure: Method of Closure: Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 84701

Owner: OKANAGAN FIRST NATION

Address: WESTSIDE ROAD

Area: VERNON

WELL LOCATION:

KAMLOOPS (KDYD) Land District

District Lot: Plan: Lot:

Township: Section: Range:

Indian Reserve: 1 Meridian: Block:

Quarter:

Island:

BCGS Number (NAD 83): 082L023232 Well: 5

Class of Well:

Subclass of Well:

Orientation of Well:

Status of Well:

Licence General Status: UNLICENSED

Well Use: Water Supply System

Observation Well Number:

Observation Well Status:

Construction Method:

Diameter: inches

Casing drive shoe:

Well Depth: feet

Elevation: 1217.2 feet (ASL)

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: feet

Lithology Info Flag: N

File Info Flag: N

Construction Date:

Driller:

Well Identification Plate Number:

Plate Attached By:

Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: (Driller's Estimate)

Development Method:

Pump Test Info Flag: N

Artesian Flow: UNKNOWN YIELD

Artesian Pressure (ft):

Static Level:

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag: N

Field Chemistry Info Flag:

Site Info (SEAM): N

Water Utility: N

Water Supply System Name: WHITEMAN CREEK WATER SYSTEM

Water Supply System Well Name: WELL NO. 3

SURFACE SEAL:

Flag: N

Material:

Method:

Depth (ft):

Thickness (in):

Sieve Info Flag: N Screen Info Flag: N Site Info Details: Other Info Flag: Other Info Details:	WELL CLOSURE INFORMATION: Reason For Closure: Method of Closure: Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 43913	Construction Date: 1979-12-01 00:00:00
Owner: PAUL STICKNEY	Driller: M. Schibli Drilling
Address: WEST SIDE RD	Well Identification Plate Number:
Area:	Plate Attached By:
WELL LOCATION:	Where Plate Attached:
OSOYOOS (ODYD) Land District	PRODUCTION DATA AT TIME OF DRILLING:
District Lot: 2922 Plan: 20608 Lot: 17	Well Yield: 100 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Township: Section: Range:	Development Method:
Indian Reserve: Meridian: Block:	Pump Test Info Flag:
Quarter:	Artesian Flow:
Island:	Artesian Pressure (ft):
BCGS Number (NAD 83): 082L013144 Well: 1	Static Level:
Class of Well:	WATER QUALITY:
Subclass of Well:	Character:
Orientation of Well:	Colour:
Status of Well: New	Odour:
Licence General Status: UNLICENSED	Well Disinfected: N
Well Use: Unknown Well Use	EMS ID:
Observation Well Number:	Water Chemistry Info Flag:
Observation Well Status:	Field Chemistry Info Flag:
Construction Method: Drilled	Site Info (SEAM):
Diameter: 6.0 inches	Water Utility:
Casing drive shoe:	Water Supply System Name:
Well Depth: 381 feet	Water Supply System Well Name:
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag:
Well Cap Type:	Material:
Bedrock Depth: 20 feet	Method:
Lithology Info Flag:	Depth (ft):
File Info Flag:	Thickness (in):
Sieve Info Flag:	WELL CLOSURE INFORMATION:
Screen Info Flag:	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
OPEN HOLE

LITHOLOGY INFORMATION:

From	0	to	20 Ft.	CLAY & ROCKS,SMALL AMOUNT OF WATER @ 12'
From	20	to	75 Ft.	HARD BLACK ROCK
From	75	to	127 Ft.	SOFT GRAY ROCK
From	127	to	182 Ft.	SOFT PALE GREEN ROCK
From	182	to	211 Ft.	SANDSTONE
From	211	to	224 Ft.	LIMESTONE
From	224	to	301 Ft.	GRANITE
From	301	to	355 Ft.	HARDER GRANITE
From	355	to	370 Ft.	LIMESTONE
From	370	to	381 Ft.	GRANITE

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 76776	Construction Date: 1999-07-21 00:00:00
Owner: FINTRY PROVINCIAL PARK	Driller: Cyclone Drilling Ltd.
Address: WESTSIDE RD	Well Identification Plate Number: 19013
Area: FINTRY	Plate Attached By: JAMES HUBER
WELL LOCATION:	Where Plate Attached:
OSOYOOS (ODYD) Land District	PRODUCTION DATA AT TIME OF DRILLING:
District Lot: 686 Plan: Lot:	Well Yield: 100 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Township: Section: Range:	Development Method:
Indian Reserve: Meridian: Block:	Pump Test Info Flag: Y
Quarter:	Artesian Flow:
Island:	Artesian Pressure (ft):
BCGS Number (NAD 83): 082L013233 Well: 1	Static Level: 17 feet
Class of Well:	WATER QUALITY:
Subclass of Well:	Character:
Orientation of Well:	Colour:
Status of Well: New	Odour:
Licence General Status: UNLICENSED	Well Disinfected: N
Well Use: Water Supply System	EMS ID:
Observation Well Number:	Water Chemistry Info Flag: Y
Observation Well Status:	Field Chemistry Info Flag:
Construction Method: Drilled	Site Info (SEAM): N
Diameter: 6 inches	Water Utility: N
Casing drive shoe:	Water Supply System Name: DINTRY PROVINCIAL PARK WATER SYSTEM
Well Depth: 76 feet	Water Supply System Well Name: FINTRY 1
Elevation: 1141.7 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: Y
Well Cap Type: BOLTED CAP	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: Y	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: Y	WELL CLOSURE INFORMATION:
Screen Info Flag: Y	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
67.5	76		80
0	0		0

0	0		0	

Casing from	to feet	Diameter	Material	Drive Shoe
0	67.5	6.63	Other	null

GENERAL REMARKS:
STEEL CAP BOLTED TO CASING

LITHOLOGY INFORMATION:

From	0 to	3 Ft.	TOP SOIL WITH GRAVEL
From	3 to	10 Ft.	SHARP MED BROWN SAND & GRAVEL
From	10 to	17 Ft.	MED SHARP BROWN SAND WITH SOME GRAVEL
From	17 to	21 Ft.	WATER BEARING SHARP BROWN SAND WITH SOME
From	17 to	21 Ft.	GRAVEL
From	21 to	26 Ft.	WET SILTY BROWN CLAY
From	26 to	34 Ft.	(DIRTY) WATER BEARING BROWN SAND &
From	26 to	34 Ft.	GRAVEL WITH SOME SILTY SAND
From	34 to	46 Ft.	CLEANER WATER BEARING BROWN SAND &
From	34 to	46 Ft.	GRAVEL
From	46 to	54 Ft.	WATER BEARING MED BROWN SAND WITH SOME
From	46 to	54 Ft.	GRAVEL
From	54 to	77 Ft.	WATER BEARING MED COARSE BROWN SAND &
From	54 to	77 Ft.	GRAVEL
From	77 to	78 Ft.	WATER BEARING FINE BROAN SAND WITH
From	77 to	78 Ft.	GRAVEL (DIRTY)

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 70259	Construction Date: 1996-03-25 00:00:00
Owner: BC PARKS OKANAGAN REGION	Driller: Capri Drilling
Address: FINTRY DELTA RD	Well Identification Plate Number:
Area: FINTRY PROVINCAL PAR	Plate Attached By:
WELL LOCATION:	Where Plate Attached:
OSOYOOS (ODYD) Land District	PRODUCTION DATA AT TIME OF DRILLING:
District Lot: 686 Plan: Lot:	Well Yield: 525 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Township: Section: Range:	Development Method:
Indian Reserve: Meridian: Block:	Pump Test Info Flag: N
Quarter:	Artesian Flow:
Island:	Artesian Pressure (ft):
BCGS Number (NAD 83): 082L013142 Well: 4	Static Level: 21 feet
Class of Well:	WATER QUALITY:
Subclass of Well:	Character:
Orientation of Well:	Colour:
Status of Well: New	Odour:
Licence General Status: UNLICENSED	Well Disinfected: N
Well Use: Other	EMS ID:
Observation Well Number:	Water Chemistry Info Flag: N
Observation Well Status:	Field Chemistry Info Flag:
Construction Method: Drilled	Site Info (SEAM): N
Diameter: 6 inches	Water Utility: N
Casing drive shoe:	Water Supply System Name:
Well Depth: 71 feet	Water Supply System Well Name:
Elevation: feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: Y
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: Y	Depth (ft): 21 feet
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	WELL CLOSURE INFORMATION:
Screen Info Flag: Y	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
56	71		60

Casing from	to feet	Diameter	Material	Drive Shoe
0	21	12	null	null
0	56	8	Other	null

GENERAL REMARKS:
STEEL CASING 0 TO 56 DRILLER: CLEAR

LITHOLOGY INFORMATION:

From 0 to 75 Ft. SAND & GRAVEL

From to Ft.

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 104531	Construction Date:
Owner: REGIONAL DISTRICT OF CENTRAL OKANAGAN	Driller:
Address: MORDEN ROAD	Well Identification Plate Number: 29316
Area: FINTRY	Plate Attached By:
WELL LOCATION:	Where Plate Attached:
Land District	PRODUCTION DATA AT TIME OF DRILLING:
District Lot: 686 Plan: Lot: 19	Well Yield: (Driller's Estimate)
Township: Section: Range:	Development Method:
Indian Reserve: Meridian: Block:	Pump Test Info Flag: N
Quarter:	Artesian Flow:
Island:	Artesian Pressure (ft):
BCGS Number (NAD 83): 082L013231 Well:	Static Level: 12 feet
Class of Well: Water supply	WATER QUALITY:
Subclass of Well: Domestic	Character:
Orientation of Well: Vertical	Colour:
Status of Well: New	Odour:
Licence General Status: UNLICENSED	Well Disinfected: N
Well Use: Water Supply System	EMS ID:
Observation Well Number:	Water Chemistry Info Flag:
Observation Well Status:	Field Chemistry Info Flag:
Construction Method:	Site Info (SEAM):
Diameter: 8 inches	Water Utility:
Casing drive shoe:	Water Supply System Name:
Well Depth: 144 feet	Water Supply System Well Name:
Elevation: feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: 14 inches	Flag: N

Well Cap Type: WATERTIGHT Bedrock Depth: feet Lithology Info Flag: N File Info Flag: N Sieve Info Flag: N Screen Info Flag: N Site Info Details: Other Info Flag: Other Info Details:	Material: Method: Depth (ft): Thickness (in): WELL CLOSURE INFORMATION: Reason For Closure: Method of Closure: Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
INFORMATION PROVIDED FROM WELL PUMP INSTALLATION REPORT.

LITHOLOGY INFORMATION:

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

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 106933

Owner: REGIONAL DISTRICT OF CENTRAL OKANAGAN

Address: MORDEN ROAD

Area: FINTRY

WELL LOCATION:

Land District

District Lot: 686 Plan: Lot: 19

Township: Section: Range:

Indian Reserve: Meridian: Block:

Quarter:

Island:

BCGS Number (NAD 83): 082L013231 Well:

Class of Well: Water supply

Subclass of Well: Domestic

Orientation of Well: Vertical

Status of Well: Alteration

Licence General Status: UNLICENSED

Well Use: Water Supply System

Observation Well Number:

Observation Well Status:

Construction Method:

Diameter: 8 inches

Casing drive shoe: N N

Well Depth: 157 feet

Elevation: feet (ASL)

Final Casing Stick Up: 14 inches

Well Cap Type: PITLESS WATERTIGHT

Bedrock Depth: feet

Lithology Info Flag: N

File Info Flag: N

Sieve Info Flag: N

Screen Info Flag: Y

Site Info Details:

Other Info Flag:

Other Info Details:

Construction Date: 2010-04-06 00:00:00

Driller: Robbins Water Wells & Pump Service

Well Identification Plate Number: 17864

Plate Attached By: GREG ANDERSON

Where Plate Attached: JUST UNDER PITLESS CAP

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: (Driller's Estimate)

Development Method:

Pump Test Info Flag: N

Artesian Flow:

Artesian Pressure (ft):

Static Level:

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag: N

Field Chemistry Info Flag:

Site Info (SEAM):

Water Utility:

Water Supply System Name:

Water Supply System Well Name:

SURFACE SEAL:

Flag: N

Material: Bentonite clay

Method: Poured

Depth (ft): 8.5 feet

Thickness (in):

Liner from To: feet

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size
115	118		null
118	128		100
128	134		null
134	144		80
144	148		null

Casing from	to feet	Diameter	Material	Drive Shoe
0	6	10	null	N
6	null	8	Steel	N

GENERAL REMARKS:
INSTALL PITLESS ADAPTER ON EXISTING WELL TO ALLOW FOR INSTALL OF PUMP EQUIPMENT. REATTACHED ORIGINAL WELL ID PLATE TO PITLESS. ALTERATION DONE BY GREG ANDERSON FROM MEARL'S MACHINE WORKS 2011-01-11. WELL PUMI

LITHOLOGY INFORMATION:

From 0 to 3 Ft. Loose TILL brown

From 3 to 70 Ft. Loose GRAVEL & COARSE SAND WB brown

From 70 to 125 Ft. CLEAN COARSE GRAVEL 300 U.S. Gallons per Minute

From 125 to 131 Ft. TIGHT SAND & GRAVEL brown

From 131 to 132 Ft. CEMENTED SAND, GRAVEL & CLAY

From 132 to 148 Ft. Loose COARSE SAND & GRAVEL 400 U.S. Gallons per Minute brown

From 148 to 149 Ft. Loose COARSE SAND 500 U.S. Gallons per Minute BLOW IN brown

From 149 to 157 Ft. Medium SAND 100 U.S. Gallons per Minute grey

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

Information Disclaimer
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 57019

Owner: BEN SCHMIDT

Address: FINTRY

Area: KELOWNA

WELL LOCATION:

OSOYOOS (ODYD) Land District

District Lot: 686 Plan: 15329 Lot: 7

Township: Section: Range:

Indian Reserve: Meridian: Block:

Quarter:

Island:

BCGS Number (NAD 83): 082L013231 Well: 2

Class of Well:

Subclass of Well:

Orientation of Well:

Status of Well: New

Licence General Status: UNLICENSED

Well Use: Irrigation

Observation Well Number:

Observation Well Status:

Construction Method: Drilled

Diameter: 6.0 inches

Casing drive shoe:

Well Depth: 40 feet

Elevation: 0 feet (ASL)

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: feet

Lithology Info Flag:

File Info Flag:

Sieve Info Flag:

Screen Info Flag:

Site Info Details:

Other Info Flag:

Other Info Details:

Construction Date: 1987-04-22 00:00:00

Driller: McHarg Drilling

Well Identification Plate Number:

Plate Attached By:

Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: 150 (Driller's Estimate) Gallons per Minute (U.S./Imperial)

Development Method:

Pump Test Info Flag:

Artesian Flow:

Artesian Pressure (ft):

Static Level: 6 feet

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag:

Field Chemistry Info Flag:

Site Info (SEAM):

Water Utility:

Water Supply System Name:

Water Supply System Well Name:

SURFACE SEAL:

Flag:

Material:

Method:

Depth (ft):

Thickness (in):

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

```
GENERAL REMARKS:
 NO DATA


LITHOLOGY INFORMATION:

From      0 to      0 Ft.    NO LOG
```

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

Information Disclaimer
The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

Appendix B

Capital Operating and Maintenance Cost Brekdown

Regional District of Central Okanagan
Killiney & Westshore Water Systems Source Water Assessment

Capital Cost Estimate - Detailed Cost Breakdown

Description	Option 1 Fintry Groundwater for KBWS and WEWS	Option 2 Independent Okanagan Lake Treatment Facilities at KBWS and WEWS	Option 3 Common Okanagan Lake Treatment Facility at KBWS
Fintry Pump Station			
Building (40 m2)	$290,000	n/a	n/a
Mechanical (60 Hp)	$218,000	n/a	n/a
Standby Power (100 kW)	$109,000	n/a	n/a
Electrical and Controls	$73,000	n/a	n/a
Land Purchase	$435,000	n/a	n/a
Future UV Disinfection	$363,000	n/a	n/a
Well Development	$363,000		
Sub-total Fintry Pump Station	***$1,851,000***	***$0***	***$0***
KWBS Pump Station			
Building (20 m^2)	$252,000	n/a	$102,000
Mechanical (15 Hp)	$105,000	n/a	$73,000
Standby Power (40 kW)	$84,000	n/a	$15,000
Electrical and Controls	$84,000		$29,000
Sub-total KWBS Pump Station	***$525,000***	***$0***	***$219,000***
UV Disinfection Building (KBWS)			
Building (100 m2 Independent, 120m2 Common)	n/a	$1,146,000	$1,320,000
Mechanical (UV+Chlorine)	n/a	$1,146,000	$1,233,000
Electrical and Controls	n/a	$914,000	$1,001,000
Sub-total UV Disinfection	***$0***	***$3,206,000***	***$3,554,000***
Membrane Filtration Building (KBWS)			
Building (200 m2 Independent, 300 m2 Common)	n/a	$1,668,000	$2,509,000
Mechanical (Membrane Package+Pumps)	n/a	$2,320,000	$2,900,000
Electrical and Controls	n/a	$1,233,000	$1,421,000
Sub-total Membrane Filtration	***$0***	***$5,221,000***	***$6,830,000***
UV Disinfection Building (WEWS)			
Building (100 m2)	n/a	$1,146,000	n/a
Mechanical (UV+Chlorine)	n/a	$1,204,000	n/a
Electrical and Controls	n/a	$1,117,000	n/a
Sub-total WEWS UV Disinfection	***$0***	***$3,467,000***	***$0***
Membrane Filtration Building (WEWS)			
Building (220 m2)	n/a	$1,842,000	n/a
Mechanical (Membrane Package+Pumps)	n/a	$2,610,000	n/a
Electrical and Controls	n/a	$1,233,000	n/a
Sub-total WEWS UV Disinfection	***$0***	***$5,685,000***	***$0***
Pipelines			
Intake Extension (500m of 400mm DR 26 HDPE)		$363,000	$363,000
Fintry to KBWS (8 km 350mm HDPE DR 11)	$6,960,000	n/a	n/a
KBWS to WEWS (4 km 250mm HDPE DR 11)	$3,480,000	n/a	$3,480,000
Sub-total WEWS UV Disinfection	***$10,440,000***	***$363,000***	***$3,843,000***
TOTAL	**$12,816,000**	**$17,942,000**	**$14,446,000**

Regional District of Central Okanagan
Killiney & Westshore Water Systems Source Water Assessment

Operation and Maintenance Cost Estimate - Option 1: Fintry Groundwater for KBWS and WEWS

Item		Description	Quantity	Unit	Unit Price		Extension ($)
7.0		**OPERTING AND MAINTENANCE COST ESTIMATE AT YEAR 20**					
7.1		**Electricity Charges**					
	7.1.1	Groundwater pumping from Fintry to KBWS	127,000	kW-hr	0.10	$	12,700
	7.1.2	Pumping from KBWS to WEWS	50,000	kW-hr	0.10	$	5,000
	7.1.3	Building Energy Costs	110000	LS	0.10	$	11,000
	7.1.4	UV Disinfection Fintry	51,000	kW-hr	0.10	$	5,100
		Total 7.1 - Electricity Charges				**$**	**33,800**
7.2		**Maintenance and Repair Costs**					
	7.2.1	Raw Water Pump Station Building (incl. Mechanical, Electrical, General	1	LS	10,000	$	10,000
	7.2.2	Groundwater Well Refurbishment	1	LS	10,000	$	10,000
	7.2.3	Lamp Replacement Cost (total of 20 Lamps with 1.4 year life)	15	each	300	$	4,500
		Total 7.2 - Maintenance and Repair Costs				**$**	**24,500**
7.3		**Chemical Supply**					
	7.3.1	12% Sodium Hypochlorite	1900	kg	4.00	$	7,600
		Total 7.3 - Chemical Supply				**$**	**7,600**
7.4		**Labour**					
	7.4.1	Operating Staff Premium	1	LS	0	$	-
		Total 7.4 - Labour				**$**	**-**
		TOTAL 7.0 - OPERATION & MAINTENANCE AT YEAR 20				**$**	**65,900**

Assumptions:

1 Operating costs based on Build-out Maximum Daily Demands for KBWS and WEWS at year 20
2 Average cost of electricity 0.10 $/kW-hr.
3 Labour costs for KBWS and WEWS remain the same as the current system
4 Average chlorine dose of 2.0 mg/L
5 Average motor efficiency is 75%

Regional District of Central Okanagan
Killiney & Westshore Water Systems Source Water Assessment

Operation and Maintenance Cost Estimate - Option 2: Independent Okanagan Lake Treatment Facilities at KBWS and WEWS

Item		Description	Quantity	Unit	Unit Price		Extension ($)
7.0		**OPERTING AND MAINTENANCE COST ESTIMATE AT YEAR 20**					
7.1		**Electricity Charges**					
	7.1.1	KBWS Disinfection Facility					
		UV Disinfection KBWS	29,000	kW-hr	0.10	$	2,900
		Building Energy Cost	110,000	kW-hr	0.10	$	11,000
	7.1.2	KBWS Membrane Facility					
		Raw Water Pumping to Membranes	129,000	kW-hr	0.10	$	12,900
		Membrane Intermittent Loads Energy Costs	73,000	kW-hr	0.10	$	7,300
		Building Energy Cost	190,000	kW-hr	0.10	$	19,000
	7.1.3	WEWS Disinfection Facility					
		UV Disinfection WEWS	33,000	kW-hr	0.10	$	3,300
		Building Energy Cost	110,000	kW-hr	0.10	$	11,000
	7.1.4	WEWS Membrane Facility					
		Raw Water Pumping to Membranes	158,000	kW-hr	0.10	$	15,800
		Membrane Intermittent Loads Energy Costs	80,000	kW-hr	0.10	$	8,000
		Building Energy Cost	190,000	kW-hr	0.10	$	19,000
		Total 7.1 - Electricity Charges				**$**	**110,200**
7.2		**Maintenance and Repair**					
	7.2.1	Disinfection Building					
	7.2.2	KWBS Disinfection Building (incl. Mechanical, Electrical, General)	1	LS	20,000.00	$	20,000
	7.2.2	KBWS Water Treatment Building (incl. Mechanical, Electrical, General)	1	LS	40,000.00	$	40,000
	7.2.1	WEWS Disinfection Building (incl. Mechanical, Electrical, General)	1	LS	20,000.00	$	20,000
	7.2.1	WEWS Membrane Buildings (incl. Mechanical, Electrical, General)	1	LS	40,000.00	$	40,000
	7.2.3	Lamp Replacement Cost (total of 24 Lamps with 1.4 year life)	18	each	300	$	5,400
	7.2.4	Membrane Replacement Cost (based on 2 trains of 72 modules and 2 trains of 68 Modules)	1	LS	45,000	$	45,000
		Total 7.2 - Maintenance and Repair				**$**	**170,400**
7.3		**Chemical Usage**					
	7.3.1	12% Sodium Hypochlorite (Disinfection)	1900	kg	4.00	$	7,600
	7.3.2	Membrane Cleaning Chemicals	1	LS	15,000.00	$	15,000
		Total 7.3 - Chemical Usage				**$**	**7,600**
7.4		**Labour**					
	7.4.1	Operating Staff Premium	1	LS	80,000	$	80,000
		Total 7.4 - Labour				**$**	**80,000**
7.5		**Residuals Disposal**					
	7.5.1	Backwash Waste Hauling (<1% Solids)	360	trips	150	$	54,000
		Total 7.5 - Residual Disposal				**$**	**54,000**

Regional District of Central Okanagan
Killiney & Westshore Water Systems Source Water Assessment

Operation and Maintenance Cost Estimate - Option 2: Independent Okanagan Lake Treatment Facilities at KBWS and WEWS

TOTAL 7.0 - OPERATION & MAINTENANCE AT YEAR 20	**$**	**422,200**

Assumptions:

1 Operating costs based on Build-out Maximum Daily Demands for KBWS and WEWS at year 20
2 Average cost of electricity 0.10 $/kW-hr.
3 Labour costs for KBWS and WEWS remain the same as the current system
4 Average chlorine dose of 2.0 mg/L
5 Average motor efficiency is 75%
6 Membrane replacement costs based on a 10 year service life and replacement of all membranes at year 10.
7 Intermittent membrane operating load includes backwash, air pulse, and CIP heating operations.
8 Premium labour costs based on a additional a $75/hr labour rate and 4 hours per day to operate the two facilities

Regional District of Central Okanagan
Killiney & Westshore Water Systems Source Water Assessment

Operation and Maintenance Cost Estimate - Option 3: Common Okanagan Lake Treatment Facility at KBWS

Item		Description	Quantity	Unit	Unit Price		Extension ($)
7.0		**OPERTING AND MAINTENANCE COST ESTIMATE AT YEAR 20**					
7.1		**Electricity Charges**					
	7.1.1	KBWS UV Disinfection Facility					
		UV Disinfection KBWS	51,000	kW-hr	0.10	$	5,100
		Building Energy Cost	110,000	kW-hr	0.10	$	11,000
	7.1.1	KBWS Membrane Filtration Facility					
		Raw Water Pumping to Membranes	287,000	kW-hr	0.10	$	28,700
		Membrane Intermittent Loads Energy Costs	105,000	kW-hr	0.10	$	10,500
		Building Energy Cost	220,000	kW-hr	0.10	$	22,000
		Total 7.1 - Electricity Charges				**$**	**77,300**
7.2		**Maintenance and Repair**					
	7.2.1	KWBS Disinfection Building (incl. Mechanical, Electrical, General)	1	LS	20,000.00	$	20,000
	7.2.1	KWBS Membrane Buildings (incl. Mechanical, Electrical, General)	1	LS	40,000.00	$	40,000
	7.2.2	Lamp Replacement Cost (total of 20 Lamps with 1.4 year life)	15	each	300	$	4,500
	7.2.3	Membrane Replacement Cost (based on 2 trains of 96 modules)	1	LS	30,000	$	30,000
		Total 7.2 - Maintenance and Repair				**$**	**94,500**
7.3		**Chemical Usage**					
	7.3.1	12% Sodium Hypochlorite (Disinfection)	1900	kg	4.00	$	7,600
	7.3.1	Membrane Cleaning Chemicals	1	LS	15,000.00	$	15,000
		Total 7.3 - Chemical Usage				**$**	**22,600**
7.4		**Labour**					
	7.4.1	Operating Staff Premium	1	LS	80,000	$	80,000
		Total 7.4 - Labour				**$**	**80,000**
7.5		**Residuals Disposal**					
	7.5.1	Backwash Waste Hauling (<1% Solids)	360	trips	150	$	54,000
		Total 7.5 - Residual Disposal				**$**	**54,000**
		TOTAL 7.0 - OPERATION & MAINTENANCE				**$**	**328,400**

Assumptions:
1 Operating costs based on Build-out Maximum Daily Demands for KBWS and WEWS at year 20
2 Average cost of electricity 0.10 $/kW-hr.
3 Labour costs for KBWS and WEWS remain the same as the current system
4 Average chlorine dose of 2.0 mg/L
5 Average motor efficiency is 75%
6 Membrane replacement costs based on a 10 year service life and replacement of all membranes at year 10.
7 Intermittent membrane operating load includes backwash, air pulse, and CIP heating operations.
8 Premium labour costs based on a additional a $75/hr labour rate and 4 hours per day to operate the two facilities

Appendix C

Net Present Value Cost Breakdown

60439416
10-Dec-15

Rev 1

Killiney & Westshore Water Systems Source Water Assessment
Net Present Value Comparison

Summary Table - 40 Year Net Present Value Comparison

	Option 1: Fintry Groundwater to KWBS and WEWS	Option 2: Treatment at KWBS and WEWS	Option 3: Treatment at KWBS
1.0 NPV of Capital Costs			
1. Fintry Pump Station	$2,050,000		
2. KBWS Pump Station	$363,000		$218,000
3. KBWS Disinfection Building		$3,074,000	$3,553,000
4. KBWS Membrane Building		$2,890,000	$3,781,000
5. WEWS Disinfection Building		$3,466,000	
6. WEWS Membrane Building		$3,147,000	
7. KBWS Intake		$363,000	$363,000
8. WEWS Intake		$363,000	
9. Fintry to KBWS Transmission Main	$6,960,000		
8. KBWS to WEWS Transmission Main	$3,480,000		$3,480,000
1.0 NPV of Capital Costs	**$12,853,000**	**$13,303,000**	**$11,395,000**
2.0 NPV of Operating Costs			
1. Base Costs	$1,084,000	$1,901,000	$1,128,000
2. Future Treatment	$82,000	$3,038,000	$2,393,000
3. Well Refurbishment	$85,000		
2.0 NPV of Operating NPV	**$1,251,000**	**$4,939,000**	**$3,521,000**
TOTAL 40 YEAR NPV	**$14,104,000**	**$18,242,000**	**$14,916,000**

60439416

10-Dec-15

Rev 1

Killiney & Westshore Water Systems Source Water Assessment

Net Present Value Comparison

Option 1: Fintry Groundwater to KWBS and WEWS

	Present Value (2015)	2015	2035	2056
1.0 Capital Costs				
1. Fintry Pump Station	$1,849,000	$1,848,750		
2. KBWS Pump Station	$363,000	$362,500		
3. Future UV	$201,000		$362,500	
4. Fintry to KBWS Transmission Main	$6,960,000	$6,960,000		
5. KBWS to WEWS Transmission Main	$3,480,000	$3,480,000		
Capital NPV	**$12,853,000**			
2.0 Operating Costs				
1. Base Operating Costs	$1,084,000	$46,300	$46,300	$46,300
2. UV Disinfection	$82,000		$9,600	$9,600
3. Groundwater Well Refurbishment	$85,000		$100,000	$100,000
Operational NPV	**$1,166,000**			
TOTAL 25 Year NVP	**$14,019,000**			
Discount Rate	3.0%			

Assumptions:

1. Fintry pump station costs include the building and well development
2. UV to be added to the Fintry source at year 20
3. Base operating costs include building energy requirements, pump energy, chemical usage and building maintenance

60439416

10-Dec-15

Rev 1

Killiney & Westshore Water Systems Source Water Assessment

Net Present Value Comparison

Option 2: Treatment at KWBS and WEWS

	Present Value (2015)	2015	2035	2056
1.0 Capital Costs				
1. KBWS Disinfection Building	$3,074,000	$3,074,000		
2. KBWS Membrane Filtration	$2,890,000		$5,220,000	
3. KBWS Intake Extension	$363,000	$362,500		
4. WEWS Disinfeciton Building	$3,466,000	$3,465,500		
5. WEWS Membrane Filtration	$3,147,000		$5,684,000	
6. WEWS Intake Extension	$363,000	$362,500		
Capital NPV	**$13,303,000**			
2.0 Operating Costs				
1. Base Operating Costs	$1,901,000	$81,200	$81,200	$81,200
2. Membrane Operation	$3,038,000		$356,000	$356,000
Operational NPV	**$4,939,000**			
TOTAL 25 Year NVP	**$18,242,000**			
Discount Rate	3.0%			

Assumptions:

1. Membrane filtration to be added at year 20 to KBWS and WEWS source
2. Base operating costs include disinfection buildings' energy requirements, chemical usage and building maintenance

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10-Dec-15

Rev 1

Killiney & Westshore Water Systems Source Water Assessment

Net Present Value Comparison

Option 3: Treatment at KWBS

	Present Value (2015)	2015	2035	2056
1.0 Capital Costs				
1. KBWS Disinfection Building	$3,553,000	$3,552,500		
2. KBWS Membrane Filtration	$3,781,000		$6,829,500	
3. KBWS Intake Extension	$363,000	$362,500		
5. KBWS Pump Station	$218,000	$217,500		
5. KBWS to WEWS Transmission Main	$3,480,000	$3,480,000		
Capital NPV	**$11,395,000**			
2.0 Operating Costs				
1. Base Operating Costs	$1,128,000	$48,200	$48,200	$48,200
2. Membrane Operation	$2,393,000		$280,400	$280,400
Operational NPV	**$3,521,000**			
TOTAL 25 Year NVP	**$14,916,000**			
Discount Rate	3.0%			

Assumptions:

1. Membrane filtration to be added at year 20 to KBWS and WEWS source
2. Base operating costs include disinfection buildings' energy requirements, chemical usage and building maintenance

Agua Consulting Inc.
"Engineered Water Solutions"
Agua file: 030-11.402

September 12, 2016

Regional District of Central Okanagan
1450 KLO Road
Kelowna, BC
V1W 3Z4

Attention: Mr. Clarke Kruiswyk, Environmental Services Analyst

RE: CHLORINE CONTACT TIME REPORT - KILLINEY BEACH WATER SYSTEM

1.0 INTRODUCTION

We are pleased to present herein our report on chlorine contact time for Killiney Beach Water System.

2.0 KILLINEY BEACH WATER UTILITY

Killiney Beach Water System is a public water utility owned and operated by the Regional District of Central Okanagan (RDCO). The system has approximately 279 Single Family residences connected with a total build-out of 429 Single Family lots.

The critical Killiney Beach Water Utility infrastructure is described below:

Intake: The water source for this utility is Okanagan Lake. The water intake into Okanagan Lake extends out a distance of approximately 200 metres from the pump station to a depth of 26.0 metres below low water level. The intake pipe is a 250mm diameter solvent welded Series 100 PVC water main. There is a box screen at the end of the pipe.

Wet Well / Pump Station: From the intake, the water enters a rectangular concrete pump station wet well with inside dimensions of 4.88m x 3.96m. Water is disinfected by means of chlorination as it enters the wet well from the lake intake pipe. The pump station consists of two vertical turbine style pumps that lift the water to Killarney Pump Station and Reservoir at elevation 440m. The pumping rate from the lake for each pump is 14.0 L/s at 106m TDH.

Transmission Main: From the lake pump station, water is conveyed by the station through a supply line to Killarney Reservoir. The water main is not dedicated with connections off of the water main to local services.

Killarney Reservoir: Killarney Reservoir is a small 76m^3 concrete staging reservoir.

Maximum Daily Water Demand (MDD)

The best estimate MDD number is required for the CT analysis as this is the actual time water is estimated to be within the water mains before the first user. For this analysis, it is based on one pump supplying the system i.e. 14 L/s.

3.0 REGULATOR'S CRITERIA

Interior Health is the regulator for water utilities in the BC Southern Interior.
Interior Health's 4-3-2-1-0 Drinking Water Objectives includes:

- 4 log inactivation of viruses and bacteria
- 3 log removal or inactivation of Giardia Lamblia and Cryptosporidium
- 2 refers to two treatment processes for all surface drinking water systems
- 1 for less than 1 NTU of turbidity with a target of 0.1 NTU
- 0 total and fecal coliforms and E. Coli.

4.0 CT CALCULATION

A CT calculation to the first customer is provided to assess the relative risk of the utility from viruses, bacteria and protozoa (specifically *Giardia*).

Lake Intake pipe: 250mm diameter, approximately 200m long, solvent joint PVC

Volume = 9.8 m^3

Note: This volume is not included as chlorination currently occurs after leaving the lake intake pipe

Wet Well: Water levels in Okanagan Lake affect the depth of water within the wet well

Okanagan Lake HWL	= 343.08
Normal High Water Level	= 342.50
Average Water Level	= 341.80
Normal Low Water Level	= 341.30
Bottom of Wet Well	= 338.82
Effective Depth of Wet Well	= 2.48 m
Wet Well Area	= 19.32 m^2

Volume = 47.9 m

Note: All water is chlorinated at the point where it enters the wet well; however, the volume is adjusted by a short circuiting factor (F_{SC}) of 0.5.

Adjusted Volume = Volume x F_{SC} = 24.0 m^3

Water main to First Connection:

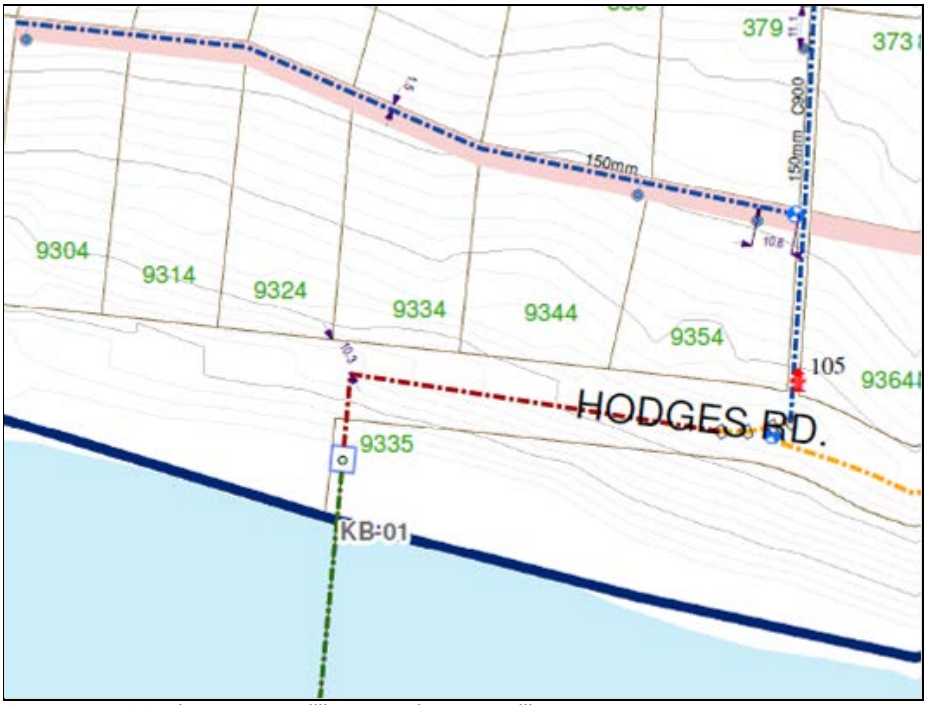
Volume calculation based on the following length of pipes and sizes to first connection shown on Figure 4.1.

Pipe Size	Length	Factor	Volume
200 mm	117 m	0.0314 m^3/m	3.7 m^3
150 mm	67 m	0.0177 m^3/m	1.2 m^3
100 mm	19 m	0.0079 m^3/m	0.1 m^3

Volume = 5.0 m^3

TOTAL EFFECTIVE CONTACT VOLUME **Volume = 29.0 m^3**

Figure 4.1 - Route to First User - 9354 Hodges Road



Source: RDCO Plate maps – Killiney Beach Water Utility

Total Volume for Chlorine Contact: **29.0 m^3**

Pumped Rate: **14.0 L/s**

Contact Time: = Total Volume / Pumped Rate
= 29.0 m^3 / (14.0 L/s x 1 m^3/1,000 L x 60 s/minute) = **34.5 minutes**

Residual chlorine level at the first user:

Cl Residual leaving Wet Well:	1.8 mg/L
Cl Residual leaving Mountain Reservoir:	1.2 mg/L
Estimated Cl residual at first user:	**1.6 mg/L**

$CT_{Achieved}$: = Contact Time x Chlorine Concentration
= 34.5 minutes x 1.6 mg/L
= 55.2 min-mg/L

5.0 INACTIVATION OF BACTERIA, VIRUSES, AND GIARDIA

CT tables from the USEPA inactivation profiling manual for chlorine disinfection effectiveness for bacteria, viruses, and *Giardia* inactivation were utilized in this analysis and are included as an Appendix for reference.

Assumptions for pH and temperature are provided. Intake sampling conducted this year has indicated a pH of approximately 8.25 and that the temperature generally follows measured Okanagan Lake temperatures. The lake generally has a high of approximately 20°C in mid-summer and a low temperature of between 6°C and 10°C. Chlorine is more effective at higher temperatures, therefore a conservative low temperature of 7.5°C is used for this analysis.

Based on a Chlorine residual of 1.6 mg/L as outlined above, pH of 8.25, and temperature of 7.5 C, the required CT value was interpolated from the US EPA tables for *Giardia* inactivation:

	Bacteria and Viruses	***Giardia***
$CT_{Required}$	**8 min-mg/L**	**225 min-mg/L**

Given the $CT_{Achieved}$ at the first connection is CT = 55.2 min-mg/L, the inactivation of bacteria and viruses is achieved. The inactivation of *Giardia* however is not achieved. As the water system does not have a dedicated main to Killarney Reservoir many residents serviced from the Killarney and Udell Reservoirs may receive water with insufficient contact time for *Giardia* inactivation. Only those customers located in the upper two pressure zones, supplied for Winchester or Hope Creek Reservoirs have sufficient chlorine contact time for *Giardia* inactivation.

6.0 COMPLIANCE WITH INTERIOR HEALTH'S OBJECTIVES

The following table outlines the water system's current status of meeting Interior Health's Drinking Water Objectives outlined above:

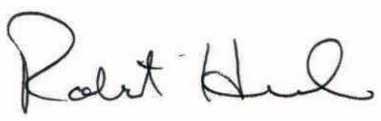
Objective	**Status**
Inactivation of viruses and bacteria	Compliant
Inactivation of *Giardia Lamblia*	Partial Compliance
Inactivation of *Cryptosporidium*	Non-Compliant
2 treatment processes	Non-Compliant
Less than 1 NTU	Compliant
Coliforms and E. Coli	Compliant

The Killiney Beach Water System, as currently set up, has sufficient contact time for bacteria and virus inactivation but insufficient contact time to provide 3 log inactivation of *Giardia* to all connections. Interior Health also requires 3 log inactivation of *Cryptosporidium*, which cannot be achieved through chlorination alone.

We trust that the content of this report is clear. We are available to meet with you to discuss its contents and to meet with Interior Health staff if required. Please call me directly at (250) 212-3266 if you have any questions.

Yours truly,

Agua Consulting Inc.



Bob Hrasko, P.Eng.
Principal

Agua Consulting Inc.
"Engineered Water Solutions"
Agua file: 030-11.401

September 12, 2016

Regional District of Central Okanagan
1450 KLO Road
Kelowna, BC
V1W 3Z4

Attention: Mr. Michael Noga, AScT, Project Manager

Dear Michael,

RE: DISINFECTION UPGRADE REPORT - WESTSHORE WATER UTILITY

1.0 INTRODUCTION

We are pleased to present herein our report on chlorine contact time for the Westshore Water System.

2.0 WESTSHORE WATER UTILITY

The Westshore Water Utility is a public water utility, owned and operated by the Regional District of Central Okanagan (RDCO). The utility has approximately 235 single family residences connected with a total build-out of 522 Single family lots. The utility is located on the northwest shores of Okanagan Lake approximately 22 kilometers south of the Highway 97 – Westside road intersection.

A listing of the critical Westshore Utility water supply infrastructure is described below.

Intake: The water source for this utility is Okanagan Lake. The water intake into Okanagan Lake extends out a distance of 209 metres from the pump station to a depth of 7.0 metres below the annual low water level for Okanagan Lake. The intake pipe is a 450mm diameter welded corrugated steel pipe. There is screening at the end of the pipe.

Wet Well / Pump Station: From the intake, the water enters a 2.44m diameter circular wet well where the water is disinfected by means of chlorination. The pump station operates with one pump running, pumping at a rate of 17.0 L/s for one pump.

Transmission Main: From the lake pump station, water is conveyed by the station through a dedicated 200mm diameter supply line to Mountain Reservoir. The flow rate through this transmission main is the same as the lake pump station pumping rate of 17.0 L/s.

Mountain Reservoir: A new 510m^3 two-celled concrete reservoir is to be constructed at the Mountain Avenue site. The reservoir will have a high water level of 503.95m. The water from the lake station enters Mountain Reservoir directly. The water runs into the reservoir cells and exits via a different pipe to the local distribution system and to the Mountain Pump Station building.

Mountain Pump Station This station lifts the water to Upper Reservoir at a flow rate of 25.4 L/s. Upper Reservoir is being upgraded to a two-celled concrete reservoir. It will have a storage volume of 1106 m^3 and a high water level of 595.60m;

Maximum Daily Water Demand (MDD)

The water flow rates that were considered for the calculation of CT values include:

1. The pumped flow rate at the lake of 17.0 L/s, which as applied to the wet well and dedicated main to Mountain Reservoir;

2. With upper pumps off, the maximum daily demand estimate for the utility for the lower pressure zones is 102 residences x 3.0 persons/residence = 306 persons at 1,600 L/ca/day, the flow rate for the utility is 5.67 L/s;

3. With the upper pumps on, the flow rate through the reservoir would increase to 25.4 L/s which is the critical design scenario. With mixing the short circuiting factor was set as $F_{sc} = 0.70$;

3.0 REGULATOR'S CRITERIA

Interior Health is the regulator for water utilities in the BC Southern Interior.
Interior Health's 4-3-2-1-0 Drinking Water Objective is as follows:

- 4 log (99.99%) inactivation of bacteria and viruses;
- 3 log (99.9%) inactivation of protozoa which includes *Cryptosporidium* and *Giardia*;
- 2 types of treatment which can include two types of disinfection or filtration and disinfection;
- 1 refers to water with < 1.0 NTU turbidity units supplied to the customers at all times;
- 0 Total Coliforms and *E.Coli* bacteria in the treated water supply at all times.

4.0 CT CALCULATION

A CT calculation is provided to assess the relative risk of the utility from viruses, bacteria and protozoa (*Giardia*). CT tables from the USEPA Disinfection profiling manual for chlorine disinfection effectiveness for *Giardia* inactivation were utilized in this analysis.

Infrastructure component volumes are summarized below:

Lake Intake pipe 450mm diameter, 208m long, welded CSP 33.08 m^3
Chlorination occurs within the intake pipe, however the exact distance down the intake is not known For the purposes of this calculation, the travel time in the intake pipe is <u>not</u> included in the calculations for contact time.

Wet Well: Water levels in Okanagan Lake affect the depth of water within the wet well

Okanagan Lake HWL	= 343.08		
Normal High Water Level	= 342.50		
Average Water Level	= 341.80		
Normal Low Water Level	= 341.30		
Bottom of wet well	= 338.94		
Depth of Wet Well	= 2.86 m		
Wet well diameter	= 2.44 m	Volume	= 13.35 m^3

Multiplying factor for short circuiting is set at 0.50 x Volume
A short circuiting factor of 0.50 was applied to the effective wet well volume.

Adjusted Volume = 6.67m^3

200mm Dedicated Transmission main
With no connections between the Okanagan Lake pump station and new Mountain Reservoir
670 m x 0.03148 m^3/m **Volume = 21.05 m^3**

Mountain Reservoir
Two cells, separated inlet and outlet lines for each cell. Dedicated inlet and outlet lines for each. Long retention time with nozzle mixing system. Mixing factor is set at 0.70 x Time
Volume = 510 m3 x 0.70 MF = **Volume = 357 m^3**

The travel-time through the water infrastructure components is summarized below:

Intake Wet Well - TIME = 6.67 m^3 /0.017 m^3/s (MDD flowrate) / 60 sec./min. = 6.53 minutes

Pipeline - TIME = 21.05 m^3 /0.017 m^3/s (MDD flowrate) / 60 sec./min. = 20.64 minutes

For the reservoir, the maximum outflow from the reservoir would represent the shortest chlorine contact time. This would be at MDD with the pumps on, therefore the sum of lower pressure zone demand plus the flow volume from one pump on.
Reservoir - TIME = 357 m^3 / 0.03107 m^3/s (MDD flowrate) / 60 sec./min. = 191.50 minutes

TOTAL TIME = 218.67 minutes

Residual chlorine level leaving Mountain Reservoir = 1.00 mg/L / chlorine.
Existing Conc. X Time = CT = 218 min. x 1.00 mg/L
CT $_{Achieved}$ = 218 min-mg/L.

5.0 INACTIVATION OF BACTERIA, VIRUSES, AND GIARDIA

CT tables from the USEPA inactivation profiling manual for chlorine disinfection effectiveness for bacteria, viruses, and *Giardia* inactivation were utilized in this analysis and are included as an Appendix for reference.

Assumptions for pH and temperature are provided. Nearby intake water sampling conducted this year has indicated a typical pH of approximately 8.25 and Okanagan Lake temperatures generally within the normal levels dependent on sample depth. The lake generally has a high of approximately 20^{o}C and a low of approximately 5^{o}C. As Chlorine is more effective at higher temperatures, a conservative low temperature of 7.5^{o}C is used for this analysis.

Based on a Chlorine residual of 1.0 mg/L as outlined above, pH of 8.25, and temperature of 7.5 C, the required CT value was interpolated from the US EPA tables for *Giardia* inactivation:

	Bacteria and Viruses	***Giardia***
CT $_{Required}$	**8 min-mg/L**	**208 min-mg/L**

Given for the water leaving Mountain Reservoir, $CT_{Acheived}$ = 218 min-mg/L which is adequate for 3 log inactivation of bacteria and viruses, and *Giardia.*

6.0 COMPLIANCE WITH INTERIOR HEALTH'S OBJECTIVES

The following table outlines the water system's current status of meeting Interior Health's Drinking Water Objectives outlined above:

Objective	Status
Inactivation of viruses and bacteria	Compliant
Inactivation of *Giardia Lamblia*	Compliance
Inactivation of *Cryptosporidium*	Non-Compliant
2 treatment processes	Non-Compliant
Less than 1 NTU	Compliant
Coliforms and E. Coli	Compliant

The Westshore Water System, as currently set up, has sufficient contact time for bacteria and virus inactivation and 3 log inactivation of *Giardia* to all connections. Interior Health also requires 3 log inactivation of *Cryptosporidium*, which cannot be achieved through chlorination alone.

We trust that the content of this report is clear. We are available to meet with you to discuss its contents and to meet with Interior Health staff if required. Please call me directly at (250) 212-3266 if you have any questions.

Yours truly,

Agua Consulting Inc.



Bob Hrasko, P.Eng.
Principal

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September 18, 2017
File: 20172085.00.A.01.02

Clarke Kruiswyk
Environmental Services Analyst
Regional District of Central Okanagan, Environmental Services
1450 KLO Road
Kelowna, BC V1W 3Z4

Re: KILLINEY BEACH AND WESTSHORE ESTATES WATER SYSTEM REPORT REVIEW

Dear Mr. Kruiswyk:

1 INTRODUCTION

The **Regional District of Central Okanagan** (RDCO) requested that Associated Engineering (AE) undertake a contextual review of the Killiney Beach and Westshore Estates Water System report by AECOM[1]. This review takes into consideration the recent high turbidity event in Okanagan Lake, updated water quality data, and the most recent documentation on drinking water provided by Interior Health.

As this is a review of a technical report, we have assumed that the reader is familiar with the content of the original report as well as the BC regulatory framework, background data on the water systems and the proposed works within the AECOM report. This review has been prepared for the technical staff at the RDCO.

2 WATER SOURCE ASSESSMENT

2.1 SURFACE WATER SOURCES

2.1.1 Okanagan Lake

Water quality data from the RDCO was provided for several dates from 2016 up to May 9, 2017. The data was collected by grab samples from Okanagan Lake near the existing intakes, as well as Sites A, B and C which represent possible future intake locations at 20m and 30m depths. The RDCO was not able to obtain water quality sampling beyond May 9, 2017 due to the increasing flood levels of Okanagan Lake. The RDCO also has online turbidimeters at both Killiney Beach and Westshore Estates Water System (WEWS) intakes. Readings from the online turbidimeters were compared to the hand samples taken. The online turbidity reading on May 9, 2017 coincided with the highest turbidity recording through the spring of 2017 for the WEWS area, and close to the highest turbidity value recorded at the Killiney Beach intake. The online turbidity readings dropped after they spiked around May 9th. It is therefore assumed that the grab samples represent close to the peak annual turbidity reading.

[1] Source Water Investigations: Killiney Beach & Westshore Estates Water Systems – Final Report, December 2015

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Online turbidity readings for both the WEWS and Killiney Beach systems exceeded 1.0 NTU for much of the month of May and early June 2017. This would likely not meet the IHA filtration deferral requirement of 'around 1 NTU' given the duration and the number of readings above 2.0 NTU. The WEWS water system experienced one day above 5.0 NTU and Killiney Beach had 2 days above 5.0 NTU. Technically this falls under the allowable maximum of 2 days exceeding 5.0 NTU, but may not be reliable to constantly remain below 5 NTU on a yearly basis.

It is difficult to determine a meaningful statistical trend of turbidity levels based on the few grab samples collected since 2016. From the samples taken, turbidity levels improve slightly for the deeper samples taken at sites A, B and C compared to the existing intake locations, especially during the extreme flood event that occurred around May 9, 2017. This is consistent with other municipalities that generally draw lower turbidity water from deeper intakes within Okanagan Lake. However, the deeper intake locations still occasionally peak above 1.0 NTU at the deeper depths, with the highest reading showing 2.17 NTU on May 9, 2017 and another reading of 1.16 NTU on June 9, 2016. It is expected that even with an extended intake at a depth of 20 to 30 meters that occasional turbidity spikes above 1.0 NTU will likely still occur, resulting in a Water Quality Advisory to be issued by RDCO. Continued data collection at these proposed intake locations could help to build confidence that a case for filtration deferral could be met at these locations. If the trend, however, is toward more extreme runoff events (i.e. climate change impacts), the turbidity could exceed the existing filtration deferral criteria in the future. Going forward, this a risk the RDCO should evaluate and consider.

2.1.2 Other Surface Water Sources

Upon review of the upland creek source water and previous recommendations from the AE 2010 Master Water Plans[2,3], we confirm that none of the Whiteman, Norris or Hope Creek offer suitable year-round water supply to these communities given the inconsistent flow regimes. Each would fail to provide the maximum day demand (MDD) throughout the year.

2.2 GROUNDWATER SOURCES

i. Upon review of the groundwater source information provided, we note the following:

1. Whiteman Creek Aquifer: The high yield wells are centered in one location at the start of the alluvial fan which is located inside First Nations land. We estimate that it would be difficult to obtain the flows required from a new well drilled to service north of Westshore Estates. In addition, the terrain would require a difficult and expensive pipeline installation to service the WEWS area. This would also require extending a pipeline, or at least increasing the capacity of several sections of the distribution system through WEWS and to service the Killiney Beach area. It is recommended to not consider this option further.

[2] Regional District of Central Okanagan, Westshore Estates Water Systems Review, Associated Engineering, November 2010.
[3] Regional District of Central Okanagan, Killiney Beach Water Systems Review, Associated Engineering, November 2010.

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2. Sugar Mountain Bedrock Aquifer: It is agreed with the report conclusions that it would be difficult to develop high yield wells from this area, and therefore no further exploration is recommended.
3. Fintry/Shorts Creek Aquifer: From our assessment, we consider this location as the most suitable for developing a groundwater supply for the water systems. This a high yielding aquifer with a confined layer is not considered "groundwater under the influence of surface water" and not at risk of containing pathogens as reported by Western Water Associates[4]. We note that AECOM reported that the aquifer was classified as "highly vulnerable" and that further evaluation would be required to determine the treatment requirements. AECOM noted that water quality reported from wells drawing from this aquifer reported generally high quality and suitable for further development. This note should be tempered with the understanding that there is a risk that if the water extraction is increased from this aquifer, surrounding wells may see their yield rates drop due to the increased withdrawal near those wells.

   To increase the water supply from the Fintry/Shorts Creek Aquifer, additional groundwater licensing would be required. Under the *Water Sustainability Act*, an assessment of groundwater – surface water (GW/SW) interaction is required to support licensing applications. Specifically, the quantification of the connectivity between groundwater and surface water is required to assess potential impacts to water supplies and aquatic environments. In addition, the Okanagan Basin Water Board is also in the process of establishing Environmental Flow Needs for Shorts Creek, which are to be reviewed and eventually accepted by the BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development. As such, additional groundwater licensing within the Fintry/Shorts Creek Aquifer will require additional technical investigations to prove the sustainability of the aquifer and creek under both average day and peak day water demand requirements. This is consistent AECOM's recommendation that a hydrogeological assessment would be required for the well redevelopment.

3 WATER SUPPLY AND TREATMENT PLAN

3.1 REGULATORY REVIEW

The spring of 2017 provided challenging water quality conditions with higher than normal turbidity in Okanagan lake. There were numerous Water Quality advisories issued by municipalities and Districts in accordance with IHA policy who source water from Okanagan Lake; including the City of Kelowna and the Killiney Beach and Westshore water systems. These water utilities experienced extended periods where source turbidity exceeded 1.0 NTU.

As directed by the RDCO, Associated Engineering did not engage in discussions with the IHA specifically for this project. We can however comment on the perceived direction of the IHA based on other

[4] Regional District of Central Okanagan, Source Water Assessment and Protection Plan, Upper Fintry/Shalal Road/Valley of the Sun Water System, Groundwater Supply at Fintry, BC, Western Water Associates, November 2011.

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discussions we have had with the IHA for unrelated projects. With respect to filtration deferral, directives have not changed since the release of the 2012 Drinking Water Treatment Objectives (Microbial) for Surface Water Supplies in BC. The IHA continues to take an outcome based approach to filtration deferral requirements and does not dictate a hard target of 1 NTU. They continue to use the wording 'around 1 NTU' in line with their objectives. What constitutes compliance with this criterion is at the discretion of the Drinking Water Officer who may determine that the filtration deferral has not been met. However, the IHA do use a hard target where the average daily turbidity levels must not exceed 5 NTU for more than two days in a 12-month period. We recommend that the RDCO confirm this approach with IHA before proceeding with the recommended system upgrade options.

4 CONSTRUCTABILITY AND ENVIRONMENTAL REVIEW

We have reviewed the proposed infrastructure presented in the AECOM report; specifically, the proposed buildings at both Killiney Beach and Westshore Estates intake locations as well as the proposed interconnecting pipelines. Based on a review of the legal lot lines on the RDCO cadastral mapping, there appears to be adequate land available to build the proposed works within the existing RDCO's legal boundary, easements and right of ways (ROWs).

The issue of installing an interconnecting pipeline along the foreshore location has precedent in the Okanagan, and therefore does not pose a high environmental risk to the project. A key example where a similar pipeline was installed within Okanagan Lake for the RDCO's own sewage transmission system to the Peachland wastewater system. On the proposed project, the lake foreshore would be the most reasonable location to place an interconnecting pipeline. The alternative alignment along Westside road is narrow with many hills making installation costly and more difficult to construct. During the design phase, this additional complexity and cost would need to be weighed against the opportunity to expand the service area to surrounding users.

AE's Environmental group reviewed the proposed works, and suggested that any RDCO proposed works within the lake or within the 30m riparian setback would trigger a full Environmental Assessment (EA) process. The timeline for an EA is typically 120 days with the province, and likely resulting in habitat enhancements and construction work windows being designated. An environmental monitor would be required during construction and the anticipated total costs of an EA would be around $50,000.

It was noted that one risk to consider is the effect of the proposed work on the Kokanee habitat zones (See attachment 1 – CDC Occurrence Map). The areas in red and black are of the most concern. The black area represents the locations where no permanent infrastructure is allowed (e.g. piers or docks). This would affect the pipeline routing in Option 1 of the AECOM report as the pipeline would have to be routed outside the spawning area; likely deeper into the lake. Additional discussion is required with the Province to review this option to see if there are options available.

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Climate change is also something that needs to be considered for future planning. Based on the available information, the climate in the RDCO is predicted to warm, and annual precipitation is predicted to increase. Snowpacks are projected to be increased at higher elevations but be reduced at lower elevations, creating uncertainty. In addition, snowmelt is projected to occur earlier with meltwater runoff expected to decrease due to more rain generated runoff throughout the winter. The magnitude of extreme events (e.g., floods and droughts) is also projected to increase and become more variable. Thus, potential risks to RDCO water supplies and infrastructure are as follows:

- Air temperature increases during the late summer and fall low streamflow and lake level periods, could result in increased water temperatures. Water temperature affects many of the biological and chemical processes that take place in water, for example, dissolved oxygen becomes less soluble as water temperature increases. Studies have shown that climate change and reduced streamflows may result in increased biological oxygen demand, lower levels of dissolved oxygen, and higher concentrations of phosphorus, all of which may promote the growth of harmful algae. Also, nitrification rates may increase, resulting in higher levels of nitrate in surface water. Thus, potential water quality changes should be considered for future planning of water treatment.
- More frequent and intense storms and associated runoff and flooding may cause levels of suspended sediment to become higher, less predictable, and more difficult to manage from a water treatment perspective. Runoff events can contribute several types of specific contaminants to water (e.g., nutrients, pesticides, bacteria), depending on nearby land use. These runoff events may become more prevalent in spring, when streamflow is projected to increase.
- More frequent droughts can result in reduction of available water supplies and additional water conservation requirements. Currently, the Okanagan Basin Water Board is developing drought stage triggers for Okanagan Lake to help provide water suppliers (using the lake for supply) an understanding of their risk to water availability during times of drought. Once the triggers have been implemented, the RDCO should ensure that any water supply limitations are known for each of their systems.

5 WATER TREATMENT STRATEGY

AE supports the recommendation to provide filtration at the Killiney Beach site. As proposed by AECOM, chlorine would be added post-filtration and a clearwell would be required for virus CT. The current system meets the virus CT requirements per the Aqua letter dated September 22, 2016[5]. This letter assumes that only one pump operates, providing the existing wetwell a short circuit (baffle) factor of 0.5. If two pumps were operating to meet MDD and a baffle factor of 0.1 (typical for unbaffled reservoirs), then satisfying the required future virus CT is questionable depending on the lowest temperature expected for the new intakes, the flow rates, wetwell water level and the chlorine residual provided. We note that from the data taken at the new sites A, B and C, the pH is always between 6 and 9 and the minimum temperature found in April

[5] Chlorine Contact Time Report – Killiney Beach Water System, Agua Consulting Inc., September 2016.

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2016 was 5.2 degrees. No winter temperatures were taken. It is recommended that a combination of these factors be analyzed further as part of the upgrade to the intake facility. If necessary, the wetwell will need to be sized and designed to accommodate the future virus CT requirement.

5.1 ALTERNATIVE OPTION

An alternative option would be to further stage the works for each of the WEWS and Killiney Beach systems. The requirement for 3-log disinfection of Giardia and Cryptosporidium can be met with new UV disinfection units installed at each site. The UV unit in the WEWS could be installed at the Mountain Reservoir site. That system already has a dedicated main from the intake to the Mountain Reservoir, therefore UV treatment can be achieved along this pipeline prior to discharge into the reservoir. The UV unit could be retrofitted or installed separately in a small building near the existing building at the Mountain Reservoir site. It would be placed on the incoming line to the reservoir where the pressure is low.

For the Killiney Beach site, there is a requirement for increased virus CT based on the buildout MDD and lower lake temperatures at the deeper intake location. The preliminary design for this system (Killiney Beach Water System Preliminary Design, April 2015[6]) proposes a dedicated main from the lakeside pump house to the middle pressure zone. AE has determined that adequate CT would be achieved for virus inactivation within the new dedicated 700m long pipeline from Lakeside Pump house to the Killarney site. If the dedicated main was installed today, the UV system could be installed in the existing Killarney pump station or an adjacent building. As part of the preliminary design, referenced above, the existing Killarney reservoir and pumps could be replaced by a PRV that would feed the lower pressure zone. This upgrade is not necessary for the installation of the UV, but would have an advantage of freeing up the existing building space for the UV equipment. This PRV would be placed downstream of the UV system, and would be reviewed in greater detail during the design phase. Adding a dedicated main would delay the need for adding new low lift pumps at the Lakeside location until the membranes are installed. It would also eliminate the need for a CT tank in the future and the current high lift pump station structure could remain intact with chlorine being injected upstream of the existing wetwell. The existing high lift pumps would need to be replaced with higher head pumps capable of pumping to Udell reservoir if a PRV replaced the pumps and reservoir at the Killarney site.

As part of this option, the lake intakes should be extended to reach at least a 20m depth as proposed.

This alternative option would allow for the delay of the Okanagan Lake transmission main between the Killiney Beach and WEWS systems until the filtration system is installed. At this point, the membrane filtration treatment and transmission mainline, as outlined in Option 3 of the report, would be installed. This alternative option requires adding the cost of installing UV and extending the intake at the WEWS area, but would reduce the overall Net Present Value of Option 3 by delaying the $3.5M transmission main until

[6] Killiney Beach Water System Preliminary Design, AECOM, April 2015.

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approximately 2035. This would result in a Net Present Value savings of an estimated $1.6M on the pipeline portion of the project alone.

5.2 FINTRY PIPELINE CONNECTION

For Option 1 outlined in the AECOM report, AE would suggest a lower weighting for the water security portion than what was assigned in the AECOM report as there is a risk that increasing withdrawal could negatively impact other wells in the area. Additionally, this option cannot be staged and relies on groundwater continuing to meet the non-GUDI status that eliminates the need for filtration. With the additional risk weighting and the potential cost savings for Option 3, we do not recommend going forward with Option 1.

5.3 MEMBRANE TREATMENT REVIEW

If filtration is required, then we agree with the use of membranes. The water supply would need to be piloted during the preliminary design stage to confirm this requirement. Currently, no other municipality or district currently uses membranes to treat water drawn from Okanagan Lake.

As shown in Table 5 of the AECOM report, Okanagan Lake water is a source of excellent quality, normally only requiring dual disinfection. The main purpose of membrane filtration would therefore be to filter out any protozoa in the water that might not be adequately disinfected during an elevated turbidity event. As chlorine is very effective against bacteria and viruses, Cryptosporidium oocysts are the smallest particles of concern and are 3-5 µm in size. Thus, a microfiltration system would be adequate. Typically, microfilters have a pore size of about 0.1 µm so they form a physical barrier to the oocysts. Some vendors offer ultrafiltration systems with a pore size an order of magnitude smaller. Either type system would be expected to be adequate for this application and other factors such as integration with the hydraulics, recovery, footprint, availability of service, capital and lifecycle costs, cleaning method and frequency would drive the final selection. As membrane filters present a physical barrier to particles, they do not depend on chemical pre-treatment of the water as do granular media filters. Therefore, it is likely that no pre-treatment will be necessary, unless seasonal algae is an issue which is covered below.

The greatest risk to operation is membrane fouling. This can be caused by chemical precipitates, biofilm growth or an unusual presence of particulates such as might be caused by an algae bloom. The impact of fouling is that production capacity is impeded rather than water quality being compromised. Pilot testing can help to establish suitable design criteria and reduce the risk that excessive fouling will be a concern. However, pilot testing is dependent on the raw water conditions present during the piloting period unless artificially induced challenge testing is undertaken, the value of which is limited.

During design, decisions can be made regarding strategies to minimize negative fouling effects such as provision of shock chlorination and various clean-in-place (CIP) facilities. The report assumes monthly CIP. This is a reasonable assumption at this stage, but pilot testing can be useful in refining that frequency.

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The report also assumes a 95% recovery which means that 5% of the water drawn into the facility will be rejected as wastewater. We concur that this is a reasonable assumption at this stage. However, during design, this can also be refined. If the rejected water can be discharged back to the lake, then this may be the most economical approach. If no chemical pre-treatment is required, it can be argued that the material going back to the lake is only what was already in the lake water. If this is not acceptable, then alternative waste management strategies can be considered during pre-design such as provision of a small secondary membrane filtration system to reduce the volume of the reject water. The filtered water from this system can be discharged to the lake, recycled to the head of the plant or be directed to production depending on the regulations, quality assurance and operation and cost considerations. The concentrated reject from the secondary system can either be processed on-site or hauled to the WWTP as suggested for the spent CIP waste.

The algae data provided (as summarized in Table 5-1) shows that there is an average of 1,117,000 cells/L and maximum of 6,650,000 cells/L in the source water (excludes diatoms, includes yellow/brown algae, green algae, cyanobacteria, other flagellates). These concentrations would likely lead to operational issues for direct membrane treatment (with strainers upstream). At these algae concentrations, strainers would need to be removed and pressure washed daily and would required additional cleans of membranes (thus reducing the service life of membranes) as algae would accumulate in the membrane itself.

Table 5-1
Algae counts at future intake locations

Site		Total Algae Cells (#/L)				Filter Clogging Algae Cells (#/L)			
	Depth, m	Average	Max	Stdev.	# data	Average	Max	Stdev.	# data
A	20	1,797,143	6,790,000	1,846,638	14	139,000	560,000	166,768	15
	30	918,333	2,595,000	892,558	15	115,333	430,000	133,877	15
B	20	1,669,000	7,530,000	1,893,763	15	271,000	1,690,000	474,470	15
	30	3,435,000	3,435,000		1	585,000	585,000		1
C	20	1,376,333	3,915,000	1,231,914	15	241,667	1,490,000	400,538	15
	30	1,266,000	4,690,000	1,433,627	15	186,667	1,390,000	351,526	15

AE recently completed a side-by-side comparison of direct membrane vs clarifier-membrane piloting with a water source with approximately 1 million algae cells/L. While both trains met the treated water quality requirements, the direct membranes required frequent cleaning of strainers and demonstrated increased levels of membrane fouling.

In a recent project for another client in, BC, AE found that a DAF pre-treatment ensured proper membrane operations. A pre-treatment clarifier (plate or tube settlers or DAF) may reduce the lifecycle costs (capital

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costs may be higher). Side-by-side piloting is recommended to demonstrate effects of algae and treatment requirements followed by a life-cycle cost comparison.

6 PROJECT COSTS

The costs were reviewed for the three options presented in the report.

AE compared facility costs with rough water treatment costs provided by AE in the RDCO Killiney Beach Water System Review as well as recent cost estimates obtained another plant in BC that AE is currently designing which includes membrane treatment as one of the stages of treatment. Membrane treatment costs for Option 2 and 3 appear to be higher than expected. The costs presented in the AECOM report include 30% contingency, 15% engineering, 7% PST, and a 10% contractor markup. Generally, when evaluating capital costs, PST and contractor markups are included in the capital cost estimate, with engineering and contingency added at the end to complete the total construction capital cost. A comparative cost for membranes and UV for 70 L/s or 6.0 MLD is $7.7M, based on updated 2010 costs from AE's Water System Review, with 3% annual inflation added. This compares reasonably to AECOM's $10.4M. The elevated costs may be due to the site restraints and blasting requirements at the Killiney Beach site as well as the two-story building requirement. There are likely opportunities to reduce this capital cost during preliminary and detailed design. It is noted that if pre-treatment is required for membranes such as DAF are required, then the cost estimate increases to close to the $10.4M estimate by AECOM.

Generally, the costs for the pipeline installation within Okanagan lake look reasonable when compared to AE's cost estimate from 2010 and when factored for inflation and additional contingency.

One item to flag is the trucking costs assumed for a membrane plant. As noted earlier, single stage membrane plants treating high quality source water result in approximately 5% of waste water. The AECOM report assumes that all waste would be sent to a tank and trucked away regularly. The following table shows ADD volumes at 5% waste and for 1% waste which could be attained with a secondary stage membrane recycle or lamella plate settlers.

Table 5-2
Membrane Residual Waste

	ADD Existing	ADD Buildout	
Plant Flow	16.8	29.3	l/s
5% Waste	72.6	126.6	m3/d
1% Waste	14.5	25.3	m3/d

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The AECOM report includes backwash waste storage, clarification and recycling, but later states the waste stream is not recycled but stored and hauled to the WWTP. Assume that this refers to the waste stream from the clarifier not being recycled as so the plant would see only 1% waste being trucked away. Based on a hauling capacity of 13m^3 per truck, this results in over 400 truck runs year plus any CIP trucking requirements

There may be an opportunity to send primary stage backwash waste back into Okanagan lake if no pre-treatment chemicals are needed. This would be determined during the piloting stage of the membrane design, in consultation with the appropriate environmental regulator, but could have significant cost saving opportunities.

7 CONCLUSIONS AND RECOMMENDATIONS

1. Present the findings and recommended option in this report to IHA to confirm direction.
2. Continue grab sampling to determine the optimal location to place the intake extensions.
3. Extend the intake at both the Killiney Beach and WEWS locations to at least 20m depths.
4. Add UV at both Killiney Beach and WEWS locations, with future filtration allocated at Killiney Beach per Option 3. This delays the need for a pipeline now and would be added when filtration is required.
5. UV can be added at the Mountain site in the WEWS area.
6. UV and CT tank should be added at the Killiney Beach intake location as recommended in Option 3. An alternative is to install these components at the Killarney Reservoir location if a dedicated main is installed from the Lakeside Pumphouse to the Reservoir site.
7. New intake locations appear promising to meet current IHA filtration deferral guidelines.
8. The RDCO should apply for filtration deferral once the works have been completed.

Yours truly,

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
M. S. LOZIE
34791
Sept 18, 2017

Matthew Lozie, P.Eng.
Project Manager

Reviewed by:

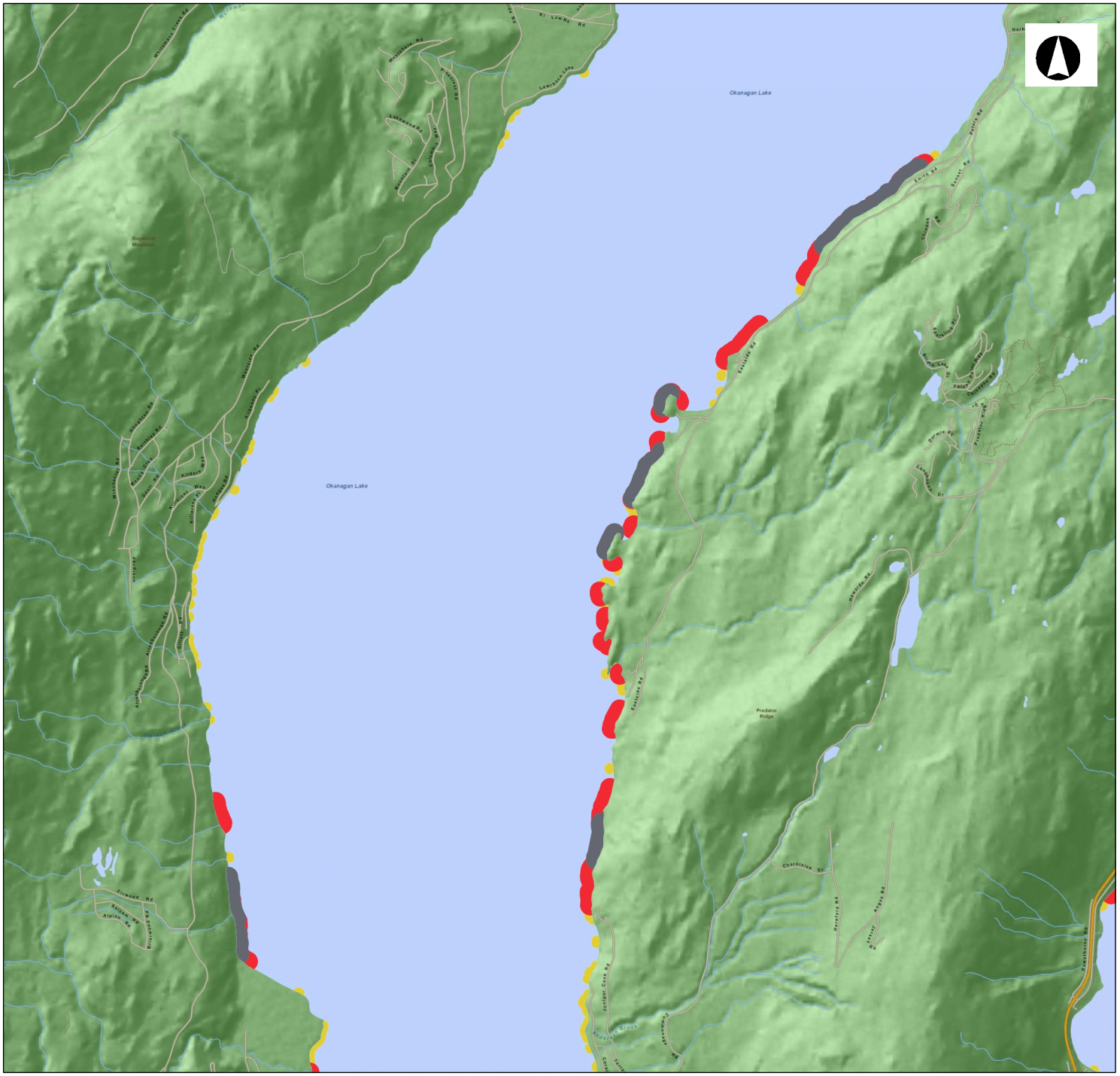
Ian Wright, P.Eng.
Water Treatment Specialist

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Senior Engineer

ML/IW/RTM/lw

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ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF
Signature:
Date: Sept 21/2017



BRITISH COLUMBIA

CDC Occurrence Map

Legend

Kokanee Habitat Zones - Ok
Colour Themed

HABITAT_ZONE

- Black Zone
- Red Zone
- Yellow Zone

0 1.17 2.34 km

1: 57,674

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Datum: NAD83
Projection: NAD_1983_BC_Environment_Albers

Key Map of British Columbia



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Issue Date:	August 30, 2018	**File:**	20182363.00.E.03.02
Previous Issue Date			
To:	Clarke Kruiswyk, Environmental Services Analyst		
From:	Matt Lozie, P.Eng.		
Client:	Regional District of Central Okanagan		
Project Name	Killiney Beach and Westshore Estates Water Systems Report Review		
Project No.	20182363		
Subject:	DRAFT - Killiney Beach and Westshore Estates Water Systems Report Review		

TECHNICAL MEMORANDUM

1 INTRODUCTION

The Regional District of Central Okanagan (RDCO) requested that Associated Engineering (AE) review and confirm the findings from AE's previously submitted contextual review of the Source Water Investigations: Killiney Beach and Westshore Estates Water Systems – Final Report prepared by AECOM. This memo will review the findings in AE's review and confirm the recommendations in light of more recent turbidity sampling data in the past year.

2 WATER SOURCE ASSESSMENT

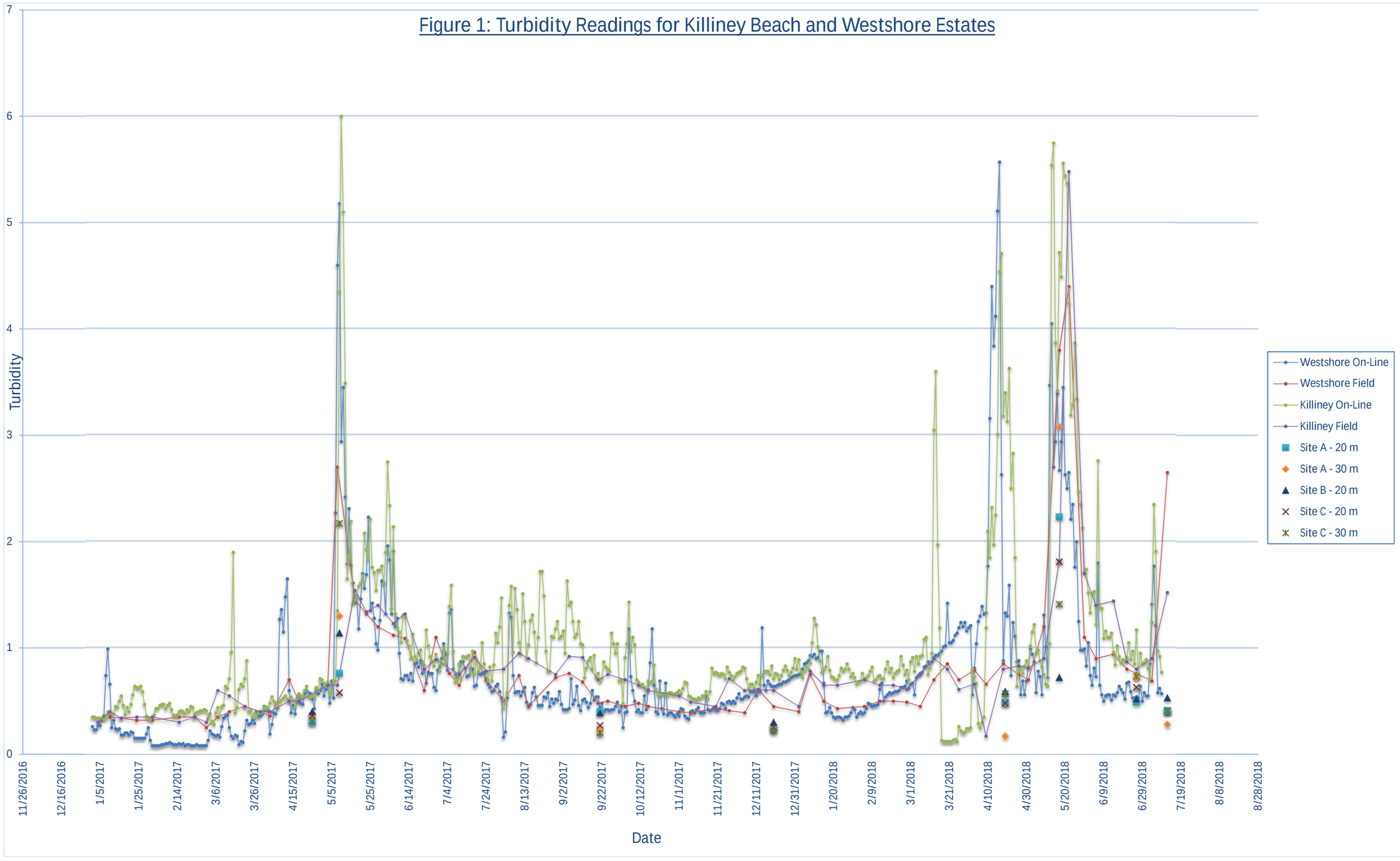
Updated water quality data from the RDCO was provided for the period from September 2017 up to June 2018. The data was collected by grab samples from Okanagan Lake near the existing intakes as well as Sites A, B and C which represent possible future intake locations at 20m and 30m depths. Site A is located near Killiney Beach intake, Site C is near the Westshore intake and Site B is between the sites. Online turbidity readings along with field samples from the existing Killiney Beach and Westshore water intakes were also provided for the past year. The turbidity of each sample from each site was plotted together for comparison purposes and is shown in Figure 1.

Several observations were made from the turbidity readings:

1. The 2018 freshet caused a longer elevated turbidity excursion than the previous year. There was an initial short duration turbidity spike in April 2018 followed by a longer duration turbidity spike in May 2018.
2. The field turbidity readings were taken weekly so they do not capture the same level of detail as the online turbidity sampling but do serve to verify that the online turbidity readings are accurate. Generally, the field data matches closely to the online turbidity readings and therefore the online turbidity readings are assumed to be accurate. One notable exception is the online readings on the first turbidity spike in April of 2018, which the field data did not pick up. This can be attributed to the turbidity spike occurring between weekly field readings for the Westshore system The field reading for Killiney Beach on April 18, 2018 is lower than expected. This may be due to the timing of the sampling or a single sampling inaccuracy. Generally, the field data does follow the online trend data and therefore the online data can be assumed as representative of the turbidity at each existing intake.
3. In 2018 there were 2 days in the Westshore system where turbidly exceeded 5 NTU. Technically, this just remains within the Interior Health Authority (IHA)'s filtration exclusion criteria of maximum 5.0 NTU for 2 days.

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Figure 1: Turbidity Readings for Killiney Beach and Westshore Estates



4. In 2018 there were 5 days in the Killiney Beach system where turbidity exceeded 5 NTU. This does not fall within the IHA's filtration exclusion criteria.
5. The field data from the samples at site A, B and C show improved turbidity readings over the existing intakes with a maximum observed turbidity at Site A of 3.08 NTU on May 17, 2018 at 30m and at 2.23 NTU at 20m depth. The online turbidity reading at the existing Killiney Beach intake on the same day was 4.72 NTU.

3 DISCUSSION

The additional grab samples have provided valuable data that helps to establish the criteria for the water systems. The RDCO should continue to take field samples as this will help to further refine the criteria and also to track any changes. From the samples taken it is observed that the deeper intakes had lower turbidity levels than at the existing intakes. This is consistent with other municipalities that draw water from Okanagan Lake at deeper intake levels such as the City of Kelowna. The City observed elevated turbidities during the 2018 spring freshet in the range of 1.0 to 2.0 NTU at their intakes. This is higher than previous years and represents a very challenging year for water quality in the lake. The City attributed this to an earlier than normal spring runoff where large creek inflows entered the lake before the lake had a chance to stratify, thus higher turbidities were seen at greater depths in the lake. This was coupled with a fast snowmelt that saw high flows in the creeks which resulted in high turbidities. It has now been two years in a row where fast snowmelt has caused flooding and erosion of creeks resulting in elevated creek turbidities. These, in turn, have elevated Okanagan Lake turbidity. It is difficult to predict if this trend will continue, but with the affects of climate change, earlier and faster spring freshets are anticipated to become more common and will likely cause challenging water quality conditions in the future. It would be prudent for the RDCO to plan accordingly by anticipating the recent elevated turbidities may become increasingly more common.

The current Westshore system was barely able to comply with the 5.0 NTU turbidity maximum duration and the current Killiney Beach system failed to stay within that maximum allowance,

In the previous report, AE recommended to extend the existing intakes at Killiney Beach and Westshore Estates to a depth of 20m. The updated field data shows that the deeper intake locations continue to have lower turbidity than the existing intakes, but there is not a marked difference between the 30m depth and the 20m depth turbidities. This strengthens the case for extending the intakes to 20m initially with the plan to continue monitoring the intake location at 30m depth.

The deeper intakes still show turbidites over 1 NTU during the spring freshet for short durations, so the RDCO would still require issuing Water Quality Advisories in these cases, but the length and frequency of the advisories would be expected to decrease with the extended intake locations in comparison to the current intakes. The field testing at the 20 m depth has not shown any readings over 5 NTU during the past two years. This is a promising indicator that the extended intakes would continue to meet the IHA's filtration exclusion criteria for turbidity which require the turbidity levels to be 'around 1 NTU' but do not exceed 5 NTU for more than two days in a 12-month period. The IHA continues to take an outcome-based approach to filtration exclusion requirements and do not dictate a hard target of 1 NTU but do use a hard target where the turbidity levels must not exceed 5 NTU for more than two days in a 12-month period. The filtration exclusion is at the discretion of the Drinking Water Officer who may determine that the filtration exclusion has not been met, so we recommend that the RDCO confirm with the IHA the approach of extending the intakes and the approach to add UV without filtration at this time.

4 GRANT FUNDING RECOMMENDATION

The Green Infrastructure – Environmental Quality Sub-stream application requires that the proposed project meets the Provincial Water Treatment Objectives. Currently the existing Killiney Beach system does not meet the 4-3-2-1-0 protocol used by the IHA in BC as stated in the 2012 Drinking Water Treatment Objectives (microbial) for Surface Water Supplies in BC. The Westshore system technically has met the protocol's turbidity criteria but there is a demonstrated plausible risk of falling outside the criteria of a maximum of 2 days exceeding 5 NTU. The proposed staged project in AE's 2017 report review involves adding UV to each system, increasing the CT and extending the water intakes. Based on the available data, these projects would bring the systems into compliance with the current 4-3-2-1-0 protocol in the Provincial Water Treatment Objectives. The UV system would provide a dual barrier approach and the deeper intakes would provide a source water that has a turbidity that has been shown to be consistently less than 5 NTU.

5 SUMMARY

The additional turbidity data has shown that the current Westshore system was barely able to comply with the IHA's filtration exclusion turbidity criteria and the current Killiney Beach system failed to stay within the criteria. However, the field samples taken at the alternative intake extension sites showed that the turbidity there remained within the filtration exclusion criteria. Therefore, the previous recommendations to add UV disinfection, increase CT and extend the intakes remain valid.

The inherent risks to this approach are that the water source quality could further deteriorate due to climate change effects as outlined in the previous AE report or other external factors such as increased algae, forest fires, spills or other contaminants entering the source water. Another risk is that the IHA could tighten the turbidity requirements for filtration exclusion. For these reasons we recommend the RDCO continue with filtration exclusion but should make plans to install future filtration if it becomes required. Our other recommendations made in the previous 2017 report review remain unchanged.

Prepared by:	**Reviewed by:**
Matt Lozie, P.Eng.	Ian Wright, P.Eng.
Project Manager	Senior Water Treatment Engineer

ML/IW/lw

Interior Health
Every matters

February 1, 2019

Regional District of Central Okanagan
1450 K.L.O. Road
Kelowna, BC V1W 3Z4

Attention: David Komaike, Director of Engineering

Re: Killiney Beach Water Supply System

This letter is a follow up to the Compliance Status Letter issued on May 30, 2016 and outlines the status of the water supplier's compliance with the Drinking Water Protection Act and Regulation, previous conditions placed on the operating permit, and the Drinking Water Treatment Objectives for Surface Water Supplies in British Columbia, for the Killiney Beach Water Supply System.

Water Treatment
Status: *Not Compliant*

The Killiney Beach Water Supply System is not in compliance with Section 6 of the Drinking Water Protection Act as there is inadequate treatment of the surface water source. The Killiney Beach Water Supply System does not meet the treatment objectives set out in Section 4 of the Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia (SWTO).

Currently, the sole form of treatment for water from Okanagan Lake is chlorine disinfection.
As operated, this treatment process:

- Does not provide a 3 log reduction or inactivation of *Giardia* and *Cryptosporidium.*
- Does not reduce turbidity below 1 NTU, and
- Does not provide a second form of treatment.

Bacteria, viruses and protozoa are present in Okanagan Lake. Under the right conditions chlorine disinfection will reduce bacteria, viruses and *Giardia* cysts. Water temperature, pH, chlorine dose and contact time influence chlorine effectiveness. Chlorine is not effective against cryptosporidium oocysts.

- Reports completed by AECOM in 2015 on the source water and treatment options for the Killiney Beach and Westshore water systems concluded that the most cost effective approach would be to share an intake and water treatment facility for the two water systems.
- In 2016, the RDCO requested additional time to explore the feasibility of constructing a single water treatment plant located in the Killiney Beach area that would distribute treated water to the Westshore water system.
- The 2017 Associated Engineering (AE) completed a contextual reviewed of the Killiney Beach and Westshore Estates Water System reports taking into consideration the 2017 flooding and high turbidity events in Okanagan Lake.
- In September 2018 AE provided a Technical Memo to update their 2017 report, taking into consideration the additional sampling data from the 2018 freshet into Okanagan Lake.

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HEALTH PROTECTION
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Kelowna, BC, V1Y 0C5

From 2012 to 2018, the RDCO has focussed on upgrading the storage and distribution infrastructure, and improving fire flows.

- The water main replacement project completed in January 2018 replaced approximately 3 km of old water mains in the upper zone including Winchester, Brant, Houghton, Keithly roads and Moody Cres.
- A 590 m^3 storage reservoir and control building were completed at the Winchester Rd reservoir site.
- These infrastructure improvements were funded in part through a $1.9-million grant from the Canada-BC Gas Tax Small Communities Fund.
- Explored options for relocation of the Killiney Beach Intake and the feasibility of a joint water treatment plant for both Killiney Beach and Westshore Estates Water Systems.

These infrastructure works did not include improvements to treatment and have not addressed risks associated with the surface water source.

Condition 1 Provide treatment for the Killiney Beach Water System that meets the Drinking Water Treatment Objectives for Surface Water Supplies in B.C. by December 31, 2021

	Intermediate Actions Required:	Timeline
1.	Provide Interior Health with an updated **treatment improvement plan** and **implementation schedule** for bringing the Killiney Beach Water System into compliance with the Provincial Drinking Water Treatment Objectives.	June 28, 2019
2.	Update the Water Quality Information provided on the RDCO website. Ensure messaging is clear to make water users aware that current treatment does not reduce the risk of *Cryptosporidium* in the source water.	Ongoing until treatment provided

Source Assessment and Protection Plan

Status: *In Progress*

- A Source Assessment was conducted by Larratt Aquatic in February 2012 for the Killiney Beach and Westshore Estates Water Systems.
- The Source Water Protection Plan has not been submitted.

Source assessment is an important first step towards the development of a source protection plan. The next step is to use this information in the development of a protection plan. Creating and implementing a source water protection plan is best practice for all water supply systems and one of the criteria for meeting filtration exemption criteria.

The Source Protection and Water Quality Monitoring Plans include activities to reduce threats to water quality, provides an additional barrier for drinking water protection, can be used to support and influence planning, and to measure impacts on water quality. *DWP Act Section 18 (2).*

Condition 2 Provide a Source Protection Plan for the Killiney Water System Intake

	Required Actions	Timeline
1.	Provide a written report of the activities undertaken to create a Source Protection Plan for the Killiney Beach Water System including trends identified and information gaps.	June 28, 2019
2.	Develop a **Source Protection Plan** and implement protection measures to prevent contamination.	December 2020
3.	Provide a copy of the completed Source Protection Plan to Interior Health and make the Plan available to the public.	December 2020
4.	Report out on monitoring of source protection activities in the Annual Drinking Water Report.	June 30, 2021

Operator Training
Status: Compliant

Killiney Beach Water System is classified by the Environmental Operators Certification Program (EOCP) as:

EOCP Facility #	Facility Name	EOCP Classification		
		Type	Level	Date Classified
1850	Killiney Beach Water Distribution System	Distribution System	II	2012-03-24
2306	Killiney Beach Water Treatment Facility	Treatment Facility	II	2015-12-10

According to section 12(2) of the DWPR, "a person is qualified to operate, maintain or repair a water supply system if the person is certified by the EOCP for that class of system as classified under the EOCP".

EOCP #	Operators	Treatment Level (WT)	Distribution Level (WD)	Relevant Courses	
4607	Kevin Trottier	2	3	CH	
5654	Gary Evans		2	CH	
6468	Angela Lambrecht	1	1	CH	
7787	Greg Beloin			CH	
8244	Peter Meersma		1	Plumber	
9216	Shane Dorey		1		
	Jim Kornelson			Electrician/Instrumentation Technician	

Certified operators are shared between the six RDCO water systems. Currently there is one operator certified to the Water Treatment Facility level classification and two operators certified to the Water Distribution level classification.

It is recommended that additional staff be certified to the facility treatment level to ensure that qualified staff are available to compensate for vacation, employee illness, emergency situations, knowledge translation and succession planning.

Required Action:	Timeline
Develop an operator training and succession plan that ensures there are adequately certified operators for the EOCP Water Treatment Facility and Distribution System classifications. Provide a copy to Interior Health.	March 29, 2019

Emergency Response and Contingency Plan
Status: *In Progress*

The RDCO has an Emergency Response and Contingency Plan for the Killiney Beach Water System. Consider the challenges in 2017 and 2018 with flooding and wildfires. Review and update the ERCP with any new information or procedures established after dealing with these incidents.

Required Action:	Timeline
Update the Emergency Response and Contingency Plan annually and provide a copy to Interior Health	March 29, 2019

Water Quality Monitoring Program and Monthly Reports
Status: *Requires Updating*

Section 11 of the Drinking Water Protection Act requires a water supplier to monitor the drinking water source, treatment and the water supplied in the distribution system. The information submitted in the monthly reports helps to demonstrate that the water supplier is complying with monitoring requirements under the Drinking Water Protection Regulation.

1. Monthly reports for the Killiney Beach Water System are submitted in a timely manner.
2. Bacterial analysis of samples collected in 2018 met the water quality standards set out in Schedule A and frequency set out in Schedule B of the Drinking Water Protection Regulation.
3. Source turbidity in 2018:

Exceeded 1 NTU	85 days, possibly fewer as problems with turbidity meter in Mar/Apr
Exceeded 5 NTU	2 days, likely more as turbidity meter upper limit is 6 NTU

4. The maximum upper limit of the online turbidity monitor is 6 NTU. This low upper limit results in under reporting of the average daily turbidity during critical times such as freshet and lake turnover and does not conform to best practice.
5. Turbidity is not currently monitored in the distribution system. Monitoring turbidity within the distribution system can help identify areas where there may be changes to the water quality, such as biofilm growth or resuspension, release of corrosion products and/or disturbance of sediments. Incorporate routine turbidity monitoring in the distribution system to identify baseline levels and deviations from normal conditions.
6. Full chemical analysis results are submitted bi-annually for the Killiney Beach Water System source. The last full chemical analysis was submitted in March 2018. No parameters exceeded the maximum acceptable concentrations set out by Health Canada.

   Chemical analysis is being conducted on source water samples. Sampling at points in the distribution system will help to demonstrate the quality of water reaching consumers at the tap and identifies problems which may arise due to issues in the distribution system.
7. Monitoring for disinfection by-products is conducted twice per year. Identification of the appropriate location for sampling of disinfection by-products will help to gather information to support future treatment plans.
   a. Identify and include the rationale for sampling location and scheduling for Trihalomethanes (THMs) and Haloacetic acids (HAAs) in the update to the WQM Plan.
   b. Include sampling for HAAs in bi-annual sampling.
8. The Water Quality Monitoring (WQM) Plan will need to be updated if a new intake is installed.
   a. Bacteriological samples from the intake will be required to assess the water quality at the new location. Initially these should be collected weekly during freshet and lake turnover, monthly during the periods when the lake stratification has stabilized.
   b. On-line turbidimeter must be capable of measurements beyond 6 NTU. The turbidimeter must be located such that pump starts do not interfere with measurements, or that data will need to be reviewed and verified on a routine basis.
   c. Water quality monitoring for parameters to assess the suitability of UV disinfection will be required if the Regional District is proposing to employ UV as part of the treatment process.

Data collection and management is a key component for effective operation of any water supply system. This is a critical time period for collection of water quality monitoring data that will support water treatment plant design. Sample parameters, location, scheduling and frequency must be considered to ensure that the WQM Plan accurately represents water quality throughout the treatment process, storage and distribution system.

Condition 3 Update the Killiney Beach Water Quality Monitoring Plan

Required Action:	Timeline
Update the Water Quality Monitoring Plan to provide additional information on source, treatment and distribution aspects of the water supply system (DWP Act Section 11 & DWP Regulation Section 8 & Schedule A & B) and provide a copy to Interior Health.	March 29, 2019

Annual Reports

Status: Compliant

The RDCO uses a variety of methods to keep its residents aware of issues relevant to their drinking water systems. This includes:

- media releases during emergency events,
- bi-annual newsletters,
- posting water rate, conservation and system maintenance information on the website,
- annual drinking water reports and
- Email notification of water system alerts and advisories for those residents that subscribe.

While the Annual Report and website includes Information for the public about the risk of bacteria, viruses and protozoa in the surface water source, it is written in a manner that may not clearly identify (undermine) this risk. The statement that "protozoa testing has been done and all results were negative for Cryptosporidium and/or Giardia" may lead to a false sense of security.

The RDCO does not routinely test for protozoa. Very few source samples have been analyzed for Cryptosporidium and Giardia over the years, representing such a small portion of the water. Fifty samples, negative for the presence of Giardia and Cryptosporidium, would yield a 68% confidence that there is low occurrence of these organisms in the source water (NHMRC, 2011).

In June 24, 2008, a filtered sample of 5,064 litres of treated water from a drinking water system in Northamptonshire UK was found to have 418 oocysts or 0.08 oocysts per litre. Despite a Boil Water advisory being issued by 6:00 am the next morning, this resulted in an outbreak Cryptosporidiosis in the community resulting in approximately 422 cases. Had the Boil Water advisory not been put in place, more individuals would likely have become infected (Puleston et al, 2014).

The purpose of the Annual Report and for posting advisories is to let the public know the risks associated with their water supply, be aware of increased risks and what actions they can take to avoid those risks. It is the responsibility of the water supplier to ensure that water system users are made aware of the risks associated with their drinking water supply. This will help them make an informed decision whether they need to take additional steps to protect themselves, family members and visitors against these risks until there is appropriate treatment in place.

Required Action:	Timeline
Update the Killiney Beach Annual Drinking Water Report and the RDCO website to include clear statements about the microbiological risks associated with the source and current treatment process.	June 2019

Cross Connection Control Program

Status: In Progress

Killiney Beach Water System currently supplies water to 284 residential connections. Each connection is metered using meters that are able to detect backflow events.

Required Action:	Timeline
Provide a written summary of any backflow events identified and actions taken to address the issue.	Annually June 2019

In summary, the following conditions have been added to the Operating Permit for the Killiney Beach Water Supply System.

Conditions on Permit		**Timeline**
1.	**a)** Provide treatment for the Killiney Beach Water System that meets the Drinking Water Treatment Objectives for Surface Water Supplies in B.C.	December 31, 2021
	b) Provide Interior Health with an updated Water Treatment Improvements implementation schedule.	June 28, 2019
2.	Provide a Source Protection Plan for the Killiney Beach Water System Intake and report out on source protection activities in the annual report.	December 31, 2020 Annually by June 30th
3.	Update the Water Quality Monitoring Plan for Killiney Beach Water System.	March 29, 2019

Thank you for your efforts towards improving the Killiney Beach Water System and taking the necessary steps to create a sustainable water supply network.

If you have any questions please call me directly at (250) 469-7070 ext. 12274.

Sincerely,

Judi Ekkert, B.Sc., CPHI(C)
Specialist Environmental Health Officer

cc: Dan Byron, Team Leader, Interior Health Drinking Water Program
Wayne Radomske, Public Health Engineer, Interior Health

Interior Health
Every person matters

February 15, 2019

Regional District of Central Okanagan
1450 K.L.O. Road
Kelowna, BC V1W 3Z4

Attention: David Komaike, Director of Engineering

Re: Westshore Estates Water Supply System

This letter is a follow up to the Compliance Status Letter issued on June 1, 2016 and outlines the status of the water supplier's compliance with the Drinking Water Protection Act and Regulation, previous conditions placed on the operating permit, and the Drinking Water Treatment Objectives for Surface Water Supplies in British Columbia, for the Westshore Estates Water Supply System.

The Westshore Water System currently serves 265 domestic connections with a potential build out of 527 connections. The intake line extends out 171 metres into Okanagan Lake to a depth of 7.71 metres below average lake level. The current water treatment consists of chlorination at the lake pumphouse. A dedicated main from the lake pumphouse to the Mountain Reservoir provides chlorine contact time.

Water Treatment
Status*: Not Compliant*

The Westshore Estates Water Supply System is not in compliance with Section 6 of the Drinking Water Protection Act as there is inadequate treatment of the surface water source. The Westshore Estates Water Supply System does not meet the treatment objectives set out in Section 4 of the Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia (SWTO).

Currently, the sole form of treatment for the Westshore Water Supply System is chlorine disinfection of the Okanagan Lake source. As operated, this treatment process:

- Does not provide a 3 log reduction or inactivation of *Cryptosporidium.*
- Does not reduce turbidity below 1 NTU, and
- Does not provide a second form of treatment.

Bacteria, viruses and protozoa are present in Okanagan Lake. Water temperature, pH, chlorine dose and contact time influence chlorine effectiveness. Turbidity decreases the effectiveness of disinfectants by shielding microorganisms. Chlorine is not effective against cryptosporidium oocysts.

- The 2015 AECOM report on the treatment options for the Westshore and Killiney water systems concluded that the most cost effective approach would be to share an intake and water treatment facility for the two water systems. In 2016, the RDCO requested time to explore the feasibility of constructing a water treatment plant located in the Killiney Beach area that would distribute treated water to the Westshore water system.
- In 2017 Associated Engineering (AE) completed a contextual reviewed of the Westshore Estates and Killiney Beach Water System reports taking into consideration the 2017 flooding and high turbidity events in Okanagan Lake and provided an update in September 2018 that considered the additional sampling data from the 2018 freshet into Okanagan Lake.

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From 2012 to 2018, the RDCO focussed on upgrading the storage and distribution infrastructure, and improving fire flows.

- A 1,100 m^3 dual cell concrete storage reservoir was completed at the Upper Reservoir site.
- A new dual cell 510 m^3 in ground concrete reservoir is located at the Mountain Drive site.
- These infrastructure improvements were funded in part through an $870,000 grant from the Canada-BC Gas Tax Small Communities Fund.

Having completed these infrastructure works, it is time to provide improvements to the treatment process to reduce risks associated with the surface water source.

Condition 1 Provide treatment for the Westshore Estates Water System that meets the Drinking Water Treatment Objectives for Surface Water Supplies in B.C.

	Required Actions	Timeline
1.	Provide Interior Health with an updated **treatment improvement plan** and **implementation schedule** for bringing the Westshore Estates Water System into compliance with the Provincial Drinking Water Treatment Objectives.	June 28, 2019
2.	Update the Water Quality Information provided on the RDCO website. Ensure water users are aware that current treatment does not reduce the risk of *Cryptosporidium* in the source water.	Ongoing until treatment provided

Source Assessment and Protection Plan

Status: *In Progress*

- A Source Assessment was conducted by Larratt Aquatic in February 2012 for the Westshore Estates and Killiney Beach Water Systems.
- The Source Water Protection Plan has not been submitted.

Source assessment is an important first step towards the development of a source protection plan. Creating and implementing a source water protection plan is best practice for all water supply systems and one of the criteria for meeting filtration exemption criteria. A Source Protection and Water Quality Monitoring Plan includes activities to reduce threats to water quality, provides an additional barrier for drinking water protection, can be used to support and influence planning, and to measure impacts on water quality. *DWP Act Section 18 (2).*

Should the RDCO proceed with a separate intake and water treatment facility for the Westshore Water System, then a Source Protection Plan will be required for each intake location. If an intake will be shared by these water systems, then a single Source Protection Plan will be required.

Condition 2 Provide a Source Protection Plan for the Westshore Estates Water System Intake

	Required Actions	Timeline
1.	Provide a written report of the activities undertaken to create a Source Protection Plan for the Westshore Water System.	June 28, 2019
2.	Develop a **Source Protection Plan** and implement protection measures to prevent contamination. Provide a copy of the Plan to Interior Health and make the Plan available to the public.	December 2020
3.	Monitor, evaluate and report out on source protection activities in the Annual Drinking Water Report.	June 30, 2021

Operator Training

Status: Compliant

Westshore Estates Water System is classified by the Environmental Operators Certification Program (EOCP) as:

EOCP Facility #	Facility Name	EOCP Classification		
		Type	Level	Date Classified
1852	Westshore Estates Water Distribution System	Distribution System	II	2012-03-24
2307	Westshore Estates Water Treatment Facility	Treatment Facility	II	2015-12-10

According to section 12(2) of the DWPR, "a person is qualified to operate, maintain or repair a water supply system if the person is certified by the EOCP for that class of system as classified under the EOCP".

EOCP #	Operators	Treatment Level (WT)	Distribution Level (WD)	Relevant Courses	
4607	Kevin Trottier	2	3	CH	
5654	Gary Evans		2	CH	
6468	Angela Lambrecht	1	1	CH	
7787	Gary Beloin			CH	
8244	Peter Meersma		1	Plumber	
9216	Shane Dorey		1		
	Jim Kornelson			Electrician/Instrumentation Technician	

Certified operators are shared between the six RDCO water systems. Currently there is one operator certified to the Water Treatment Facility level classification and two operators certified to the Water Distribution level classification. It is recommended that additional staff be certified to the facility treatment level to ensure that qualified staff are available to compensate for vacation, employee illness, emergency situations, knowledge translation and succession planning.

Required Action:	Timeline
Develop an operator training and succession plan that ensures there are adequately certified operators for the EOCP Water Treatment Facility and Distribution System classifications, and provide a copy to Interior Health.	March 29, 2019

Emergency Response and Contingency Plan

Status: *In Progress*

The RDCO has an Emergency Response and Contingency Plan for the Westshore Estates Water System. Review and update the ERCP with any new information or procedures established after dealing with the 2017/18 flooding and fire incidents.

Required Action:	Timeline
Update the Emergency Response and Contingency Plan annually and provide a copy to Interior Health	March 29, 2019

Water Quality Monitoring Program and Monthly Reports

Status: *Requires Updating*

Section 11 of the Drinking Water Protection Act requires a water supplier to monitor the drinking water source, treatment and the water supplied in the distribution system. The information submitted in the monthly reports helps to demonstrate that the water supplier is complying with monitoring requirements under the Drinking Water Protection Regulation.

1. Monthly reports for the Westshore Estates Water System are submitted in a timely manner.
2. Bacterial analysis of samples collected in 2018 met the water quality standards set out in Schedule A and frequency set out in Schedule B of the Drinking Water Protection Regulation.
3. Source turbidity in 2018:

Exceeded 1 NTU	58 days, possibly fewer as problems with turbidity meter in Mar/Apr, or potentially some of the early high turbidity levels may be related to the lowering of Okanagan Lake level in preparation for the anticipated melt of the above average snow pack. The lower Okanagan Lake level combined with the relatively shallow intake may have resulted in increased turbidity levels throughout Mar/April 2018.
Exceeded 5 NTU	2 days, possibly more as turbidity meter upper limit is 6 NTU

4. The maximum limit of the online turbidity monitor is 6 NTU. This low upper limit results in under reporting of the average daily turbidity during critical times such as freshet and lake turnover and does not conform to best practice.
5. Turbidity is not currently monitored in the distribution system. Monitoring turbidity within the distribution system can help identify areas where there may be changes to the water quality, such as biofilm growth or resuspension, release of corrosion products and/or disturbance of sediments.

   Incorporate routine turbidity monitoring in the distribution system to identify baseline levels and deviations from normal conditions.
6. Full chemical analysis results were submitted in 2018. No parameters exceeded the maximum acceptable concentrations (MACs) set out by Health Canada.

   Chemical analysis is being conducted on source water samples. Sampling at points in the distribution system will help to demonstrate the quality of water reaching consumers at the tap and identifies problems which may arise due to issues in the distribution system.
7. Monitoring for disinfection by-products is conducted twice per year. Current locations and schedule of monitoring likely underrepresent the extent of THMs in the distribution system. Identification of the appropriate location for sampling of disinfection by-products will help to gather information to support future treatment plans.

   If the RDCO makes the decision to have a joint intake and treatment plant for both water systems, it may be more challenging to maintain disinfection by-products below the maximum acceptable concentrations set out by Health Canada.

   Additional information is required to understand the extent of disinfection by-product precursors in the source and concentration levels in the Westshore distribution system.
8. Update monitoring for disinfection by-products in the Westshore Water System to identify appropriate sampling locations and scheduling for Trihalomethanes (THMs) and Haloacetic acids (HAAs).
9. The Water Quality Monitoring (WQM) Plan will need to be updated if a new intake is installed.
   a. Bacteriological samples from the intake will be required to assess the water quality at the new location without any chlorine.

b. On-line turbidimeter must be capable of measurements beyond 6 NTU. The turbidimeter must be located such that pump starts do not interfere with measurements, or that data will need to be reviewed and verified on a daily/monthly basis.
c. Water quality monitoring for parameters to assess the suitability of UV disinfection will be required if the Regional District is proposing to employ UV as part of the treatment process.

Data collection and management is a key component for effective operation of any water supply system. This is a critical time period for collection of water quality monitoring data that will support water treatment plant design. Sample parameters, location, scheduling and frequency must be considered to ensure that the WQM Plan accurately represents water quality throughout the treatment process, storage and distribution system.

Condition 3 Update the Westshore Estates Water Quality Monitoring Plan

Required Action:	Timeline
Update the Water Quality Monitoring Plan to provide additional information on source, treatment and distribution aspects of the water supply system (DWP Act Section 11 & DWP Regulation Section 8 & Schedule A & B) and provide a copy to Interior Health.	March 29, 2019

Annual Reports
Status: Compliant

The RDCO uses a variety of methods to keep its residents aware of issues relevant to their drinking water systems. This includes:

- media releases during emergency events,
- bi-annual newsletters,
- posting water rate, conservation and system maintenance information on the website,
- annual drinking water reports and
- Email notification of water system alerts and advisories for those residents that subscribe.

While the Drinking Water Annual Report and RDCO website includes Information for the public about the risk of bacteria, viruses and protozoa in the surface water source, it is written in a manner that may not clearly identify this risk. The statement that "protozoa testing has been done and all results were negative for Cryptosporidium and/or Giardia" may lead to a false sense of security. Very few samples for Cryptosporidium and Giardia have been analysed over the years representing such a small portion of the water used in the community. The purpose of the Annual Report and for posting advisories is to let the public know the risks associated with their water supply, be aware of increased risks and what actions they can take to avoid those risks.

It is the responsibility of the water supplier to ensure that water system users are made aware of the risks associated with their drinking water supply. This will help them make an informed decision whether they need to take additional steps to protect themselves, family members and visitors against these risks until there is appropriate treatment in place.

Required Action:	Timeline
Update the Westshore Annual Drinking Water Report and the RDCO website to include clear statements about the microbiological risks associated with the source and current treatment process.	June 2019

Cross Connection Control Program
Status: In Progress

Westshore Estates Water System currently supplies water to 265 residential connections. Each connection is metered using meters that are able to detect backflow events.

Required Action:	Timeline
Provide a written summary of any backflow events identified and actions taken to address the issue.	Annually June 2019

In summary, the following conditions have been added to the Operating Permit for the Westshore Estates Water Supply System.

Conditions on Permit		**Timeline**
1a	Provide treatment for the Westshore Estates Water System that meets the Drinking Water Treatment Objectives for Surface Water Supplies in B.C.	December 31, 2021
1b	Provide Interior Health with an updated Water Treatment Improvement Plan and implementation schedule.	June 28, 2019
2.	Provide a Source Protection Plan for the Westshore Water System Intake and report out on Source Protection Activities in annual report.	December 31, 2020 Annually by June 30th
3.	Update the Water Quality Monitoring Plan for the Westshore Water System.	June 30, 2019

Thank you for your continuing efforts towards improving the Westshore Estates Water System and taking the necessary steps to create a sustainable water supply network.

If you have any questions please call me directly at (250) 469-7070 ext. 12274.

Sincerely,

Judi Ekkert, B.Sc., CPHI(C)
Specialist Environmental Health Officer

cc: Dan Byron, Team Leader, Large Water Systems Program, Interior Health
Wayne Radomske, Public Health Engineer, Interior Health

Near-Shore Water Quality and Periphyton Production in Okanagan Lake at Killiney Beach and Westshore Estates Area



Prepared for: Regional District of Central Okanagan

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Executive Summary

Regional District of Central Okanagan (RDCO) has jurisdiction over Killiney Beach and Westshore Estates, two adjacent communities located along the western shore of the north basin of Okanagan Lake. All properties within these communities rely on private septic fields including numerous fields immediately adjacent to the foreshore. The BC ENV Okanagan Collaborative study demonstrates that dissolved nitrogen does not meet North Basin Objectives and there is an increasing trend in nitrate, total phosphorus, and chlorophyll-a. This study was undertaken to determine if septic fields were having a measurable impact on their immediate foreshore and on the north basin as a whole.

The focus of this study was on water chemistry and periphyton growth using a test-control framework. Samples were collected during two deployments from June – August and August – October 2020. Parameters included field data (temperature, conductivity, dissolved oxygen), markers for septage (chloride), nutrients (TN, TKN, TP, TDP, NO_2, NO_3, NH_3), and biological parameters (fecal bacteria, chlorophyll-a, periphyton abundance and biovolume). Composite water-chemistry samples provide instantaneous measurements while periphyton react to nutrients over a period of weeks, providing a longer-term record of nutrient exposure.

This study was able to confirm the following:

The main body of the Lake beyond the study area remains oligotrophic. The near-shore littoral area was between the oligotrophic and mesotrophic classifications and phosphorus was significantly higher than the main, pelagic area due to typical near-shore effects including sediment resuspension, creek plumes and shoreline residential development.

Fall water temperatures were higher than the summer which encouraged significantly greater periphyton growth, particularly of the cyanobacteria. Model averaging was able to identify total nitrogen (TN), total dissolved phosphorus (TDP) and to a lesser extent, light as the critical drivers of periphyton growth. This confirms the importance of nutrients to foreshore periphyton productivity. The ratio of DIN : TP was lower than <1:1, indicating strong limitation to periphyton growth from bioavailable nitrogen.

Differences between the control and shoreline residence zones for water chemistry and periphyton were subtle and not statistically significant. There was slightly more growth at the shoreline residential zone and more nitrogen fixers in the control periphyton, both suggesting nutrient enrichment of the residential zone. Zone A was the most apparently impacted of the residential zones – it had higher chloride, conductivity, total phosphorus, and E. coli than any other zone, and it is the most developed of the study areas.

No statistically significant differences were detected between the developed and control areas in any of the parameters that were assessed. This finding is likely caused by powerful longshore currents that rapidly distribute nutrients along the foreshore. Most parameters measured in the foreshore samples were statistically similar to those from the Okanagan Lake north basin long-term monitoring location at Okanagan Centre (ENV site 0500730) indicating that there is mixing between the littoral and pelagic areas of the north basin of Okanagan Lake.

The absence of statistically detectable differences in the near-shore periphyton does not mean that further development or increased use of this foreshore area would have no adverse effects, nor does it mean that current septic loading is benign.

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Suggested Citation: Self, J. and H. Larratt, 2021. Near-Shore Water Quality and Periphyton Production in Okanagan Lake at Killiney Beach and Westshore Estates. Prepared for: Regional District of Central Okanagan.

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Table of Contents

Executive Summary 2
Table of Contents 5
Definitions 8
1.0 Introduction 9
1.1 Okanagan Lake Overview 9
1.2 Study Background 9
1.3 Study Purpose 9
1.4 Study Design 10
2.0 Methods 13
2.1 Water Quality 13
2.2 Periphyton 13
2.2.1 Sampler Retrieval 14
2.2.2 Processing of Periphyton Samples 15
2.3 Analytical and Statistical Methods 15
2.3.1 Determination of Substrate Position 15
2.3.2 Variables and Statistical Analyses 15
3.0 Results 17
3.1 Lake Conditions 17
3.2 Water Temperature 17
3.3 Light on Substrates 18
3.4 Water Chemistry 19
3.4.1 Electrochemistry Parameters - Conductance 19
3.4.2 Chloride 20
3.4.3 Inorganic Nitrogen and Total Nitrogen 21
3.4.4 Inorganic Phosphorus and Total Phosphorus 23
3.4.5 Chlorophyll-a 25
3.4.6 E. coli 25
3.4.7 Parameters with Non-significant Differences 26
3.4.8 Interactions Between Water Quality Parameters 27
3.5 Periphyton 28
3.5.1 Periphyton Abundance and Biovolume 29
3.5.2 Periphyton Community Structure 32
3.5.3 Periphyton Growth Modeling 37
3.6 Incidental Observations 38
4.0 Discussion 39
4.1 Water Chemistry 39
4.2 Periphyton 40
5.0 Conclusions 41
Water chemistry 41
Periphyton 41
Overall 42

6.0 Recommendations....42
Literature Cited....43
Appendices....45
Appendix 1: Water Quality Data....46
Appendix 2: Thermistor Data for all Sites....47
Appendix 3: Master Taxonomy Table....50
Appendix 4: Model Averaging Detailed Results....53
Appendix 5: Okanagan Lake Water Quality Objectives....54
Okanagan Lake Collaborative Summary Results – 2019....55
Appendix 6: Periphyton Tests of Difference....56
Appendix 7: Periphyton Results Graphs....58
Appendix 8: 2016-2019 Phytoplankton Results and Comparison....62

Figures

Figure 1: Map of Killiney-Westshore sampling program with locations of sampling zones....12
Figure 2: Photograph of recently submerged periphyton sampler at Killiney Beach....13
Figure 3: Periphyton sampler A3 found out of water on shoreline....14
Figure 4: Boxplot Explanation Diagram....16
Figure 5: Example dendrogram plot....16
Figure 6: Water temperature at Site B1 over the course of the two sampling deployments....17
Figure 7: Temperature comparison for the summer vs fall deployment at each site....18
Figure 8: Comparison of light during first 3 days of deployment compared to last 3 days of deployment....19
Figure 9: Field conductivity in sampling zones compared to Okanagan Lake North Basin, 2020 .20
Figure 10: Chloride at sample zones compared to Okanagan Lake N. basin, 2020....21
Figure 11: Nitrate + nitrite in north basin of Okanagan Lake over past 10 years by month....21
Figure 12: Nitrate and nitrite in Okanagan Lake compared to the test zones during 2020....22
Figure 13: TN in Okanagan Lake compared to sample zones during 2020....23
Figure 14: Total phosphorus and total dissolved phosphorus at sample zones compared to Okanagan Lake N Basin....24
Figure 15: Comparison of chlorophyll-a concentration between the open water of the north basin and the sampling zones at Killiney Beach....25
Figure 16: *E.coli* at sample locations compared by site during 2020....26
Figure 17: Correlation of chemical parameters dendrogram....27
Figure 18: Microscope image of periphyton community at site A1 after fall deployment with example cells marked....28
Figure 19: Example of retrieved sampler at the end of the fall deployment (Site A5)....29
Figure 20: Periphyton abundance comparison between control and shoreline residential during summer and fall deployment periods....30
Figure 21: Periphyton biovolume comparison between control and shoreline residential during summer and fall deployments....30
Figure 22: Comparison of total abundance and total biovolume for each sampler during summer and fall deployments....31
Figure 23: Community composition of periphyton compared between control and shoreline residential zones....33

Figure 24: Comparison of Shannon Weaver Index between control and shoreline residential zones during summer and fall deployment periods 35
Figure 25: Model average results for periphyton total abundance and total biovolume 37
Figure 26: Kokanee spawning in north basin of Okanagan Lake during 2020 at a high (black) spawning zone 38
Figure 27: Mean coefficients and their 95% confidence limits of standardized explanatory variables of periphyton production 53

Tables

Table 1: Water chemistry parameters 10
Table 2: Schedule of Sampling 11
Table 3: Number of samples 11
Table 4: Status of periphyton samplers after summer and fall deployments 14
Table 5: Ions Contributing to Electrochemistry Parameters 20
Table 6: Parameters with non-significant differences in T-Tests 27
Table 7: Periphyton abundance and biovolume summary statistics and comparison of shoreline residential vs control during summer and fall deployments 31
Table 8: Top 10 taxa for abundance and biovolume at control and residential zones, ranked by percentage 34
Table 9: Diversity measures in periphyton samples 35
Table 10: Taxa that were significantly different between the shoreline residential and control zones during each deployment 36

Definitions

The following terms are briefly defined as they are used in this report.

Term	Definition
Algae	Photosynthetic one-celled or multi-celled plants that are suspended in water (phytoplankton) or attached to substrates (periphyton)
Bioavailable	Available for use or uptake by plants or animals
Colinearity	Correlation between predictor variables that explains some of the same variance in the dependent variable - a problem in regression analysis
Cyanobacteria	Bacteria-like algae with cyanochrome as the main photosynthetic pigment, often associated with problem blooms that can produce toxins (also blue-green algae)
Diatoms	Algae that have hard, silica-based "shells" frustules
Effluents	liquid waste or sewage discharged into a river or lake
Eutrophic	Nutrient-rich, biologically productive water body, may produce excessive algae or rooted aquatic plants (TP >0.03-0.05 µg/L)
Light attenuation	Reduction of sunlight strength during transmission through water. It is even higher when light passes through turbid water
Limiting nutrient	The nutrient in lowest supply relative to algae needs that controls or limits algae production
Littoral	The shallow shoreline area of a lake
Microflora	The sum of algae, bacteria, fungi, Actinomycetes, etc., in water or biofilms
Peak biomass	The highest density, biovolume or chl-a attained in a set period on a substrate
Pelagic	The upper layers of the deeper open water area of a lake
Periphyton	Microflora that are attached to aquatic plants or solid substrates
Periphyton production	Periphyton productivity measures include chl-a, biovolume, and abundance
Phytoplankton	Algae that float, drift or swim in water columns of reservoirs, lakes and slow-moving rivers
Stratification, stratified	Layering in lakes by thermal density in which the surface warm layer (epilimnion) is separated from the deep cold layer (hypolimnion) by a discrete zone of greatest temperature change (thermocline)
Substrates	The surface of water-covered sediments that are colonized by periphyton
Taxa	A classification of organisms; taxa can mean species or genera, for example
Zooplankton	Minute animals that graze algae, bacteria and detritus in water bodies

1.0 Introduction

1.1 Okanagan Lake Overview

Okanagan Lake is a large, deep lake with low nutrient levels. It is approximately 135 km long, 1-5 km wide and has a surface area of 350 km². The theoretical residency time is 52.8 years. Its maximum depth is 230 m with a mean depth of 76 m and it is divided into three sub-basins by underwater ridges. Okanagan Lake receives water from 19 major tributaries of Bear Creek and Shorts Creek are the largest in the North Basin. Treated wastewater is discharged into Okanagan Lake from Kelowna, West Kelowna, Summerland, and occasionally from Vernon (may become more common in the future). Every year, the single greatest impact on water quality in Okanagan Lake is the size of the freshet, with its variable imports of nitrogen, phosphorus, pH, calcium, sulphate and organic/inorganic particulates (MoE data, Larratt 2009). Generally, years of increased runoff correspond with increased concentrations of spring total phosphorus and in drier years, spring phosphorus levels are lower (Sokal, 2011). The impact of freshet is affected by the scale and type of watershed disturbance, as well as natural watershed conditions.

Each year the Ministry of Environment commissions the Okanagan Lake Collaborative Study to assess nutrient conditions and trends in Okanagan Lake. The 2019 report found that the north basin of Okanagan Lake did not meet the total nitrogen objective, had an increasing trend in nitrate, TP, and chlorophyll-a (Self and Larratt, 2020; Appendix 5).

1.2 Study Background

Killiney Beach and Westshore Estates are two lakeshore communities within the North Basin of Okanagan Lake that are currently serviced by private septic systems. Regional District of Central Okanagan (RDCO) is interested in determining if there are detectable impacts from septic leachate on the chemistry and biology of Okanagan Lake and contracted Larratt Aquatic Consulting (LAC) to perform a study at Killiney Beach and Westshore Estates using periphyton and water chemistry during 2020.

1.3 Study Purpose

The proposed study involved a water quality sampling program and a periphyton monitoring program in Okanagan Lake from Killiney Beach to Westshore Estates to determine if there was any influence or impact from septic systems in this area (Figure 1).

When effluents enter lakes, they mix rapidly and can be difficult to detect. Water quality samples alone would only tell part of the story. Periphyton communities (algae attached to rocks near shore) are sensitive to subtle changes in nutrient status. Their growth can provide a record of recent conditions as opposed to instantaneous water chemistry measurements. They are commonly used to identify changes in water quality that are difficult to detect using water chemistry.

This study assessed periphyton growth during the summer and fall periods (two deployments) and water chemistry collected three times during each deployment to enable statistical assessment of the data. Periphyton studies were used to assess generalized cumulative nutrient impacts over weeks, while water samples measure instantaneous concentrations of selected septic-influenced parameters.

The specific questions that this study set out to answer are:
Water chemistry:

Q1. Was there a difference between the developed and control areas in terms of water chemistry markers of septic influence and were those differences, if any, more prevalent during the high-use summer period?

Q2. Does shoreline residential development influence the water quality of North Basin Okanagan Lake?

Periphyton:

Q3. Was there a difference between the developed and control areas in terms of periphyton growth, and were those differences, if any, more prevalent during the high-use summer period?

Q4. What parameters drove periphyton growth and were they related to septic leachate?

Overall:

Q5. How did this study compare to a similar study of Cosens Bay, Kalamalka Lake?

1.4 Study Design

This study design was modeled after the successful 2014-2015 Cosens Bay study for RDNO (report can be requested). Chemistry samples were sent to Caro Labs, Kelowna and water chemistry parameters are listed in Table 1. Periphyton samples were identified to species by LAC, along with cell density and biovolume calculations.

Table 1: Water chemistry parameters

Parameter	Units	Detection Limit
Chloride	mg/L	0.1
Nitrate (as N)	mg/L	0.01
Nitrite (as N)	mg/L	0.01
Nitrate+Nitrite (as N)	mg/L	0.01
Nitrogen, Total	mg/L	0.05
Ammonia, Total (as N)	mg/L	0.05
Nitrogen, Total Kjeldahl	mg/L	0.05
Phosphorus, Total (as P)	mg/L	0.005
Phosphorus, Total Dissolved	mg/L	0.005
Chlorophyll a	ug/L	0.1
Coliforms, Total	MPN/100 mL	1
Coliforms, Fecal	MPN/100 mL	1
E. coli	MPN/100 mL	1

Sampling focused on four zones between Killiney Beach and Westshore Estates. Three of the zones are along developed stretches of shoreline with one control zone along a stretch of undeveloped shoreline (Figure 1). Within each zone, five periphyton samplers (Figure 2) were deployed as close to shore as possible. Permission of homeowners was sought to ensure samplers were not disturbed. Each sampler was equipped with two honed stone tiles as a uniform substrate for periphyton samples, and with temperature + light sensors. The temperature and light data allowed statistical control for these drivers and confirm there were no significant differences

between the samplers for these parameters. Composite water chemistry samples consisting of 10 subsamples were be collected within each zone three times during the summer and three times during the fall deployment to measure septic impacts.

The summer deployment began in June and ended in August to span the active cottage/high use season while the fall deployment began in August and ended in October to span the low-use season while Okanagan Lake is still stratified.

Table 2: Schedule of Sampling

Time	Periphyton Samples	Chemistry Samples
Early-June	Deploy	Summer 1
Early-July		Summer 2
Early-August	Collect	Summer 3*
Late August	Deploy	Fall 1
Mid-September		Fall 2
Mid-October	Collect	Fall 3

*This set of chemistry samples were not collected because a storm forced field staff to abort and return to land

Table 3: Number of samples

Time	Periphyton Samples	Chemistry Samples
Summer Deployment	5 x 4 = 20	4 x 2 = 8
Fall Deployment	5 x 4 = 20	4 x 3 = 12
Total Samples	40	20

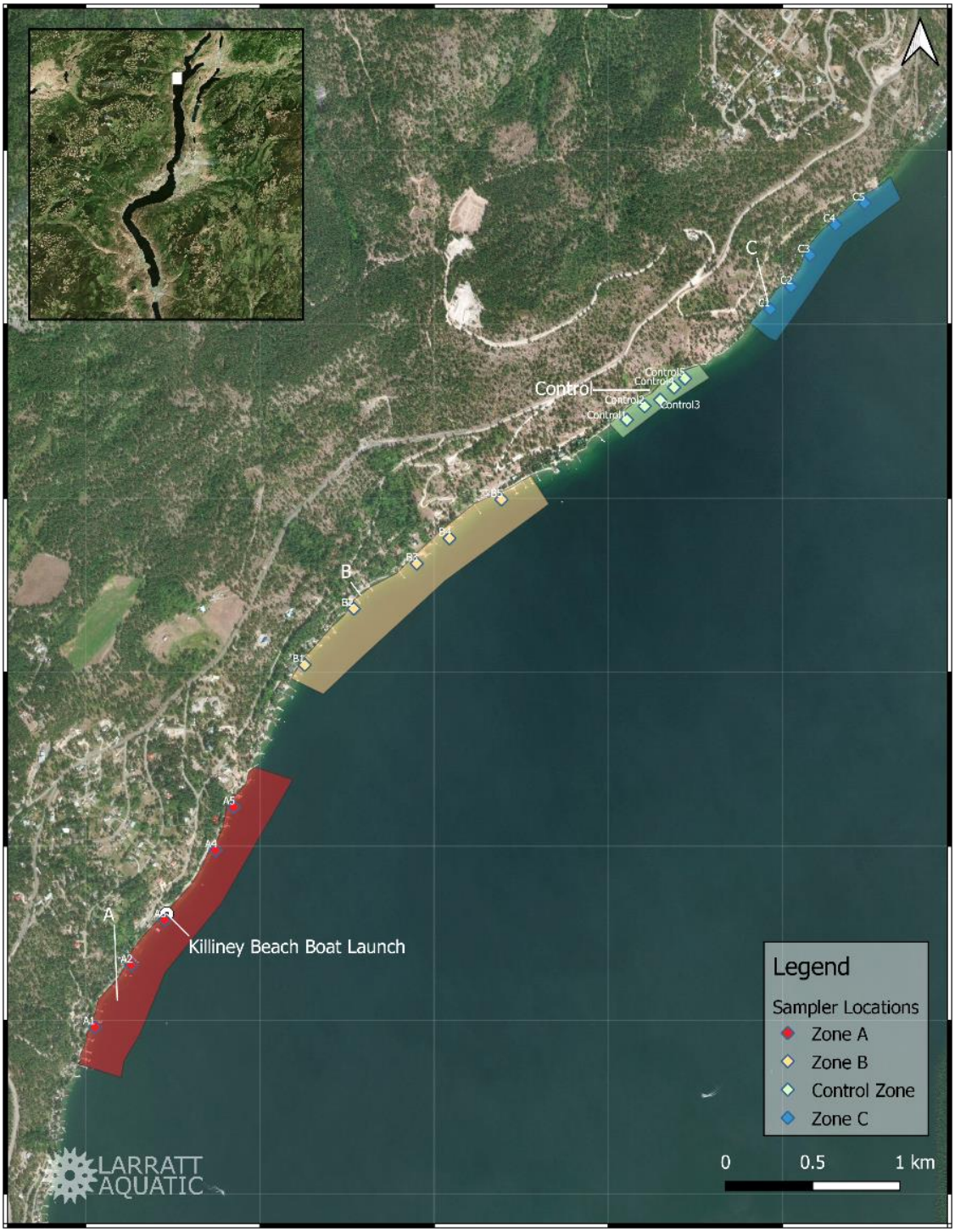


Figure 1: Map of Killiney-Westshore sampling program with locations of sampling zones

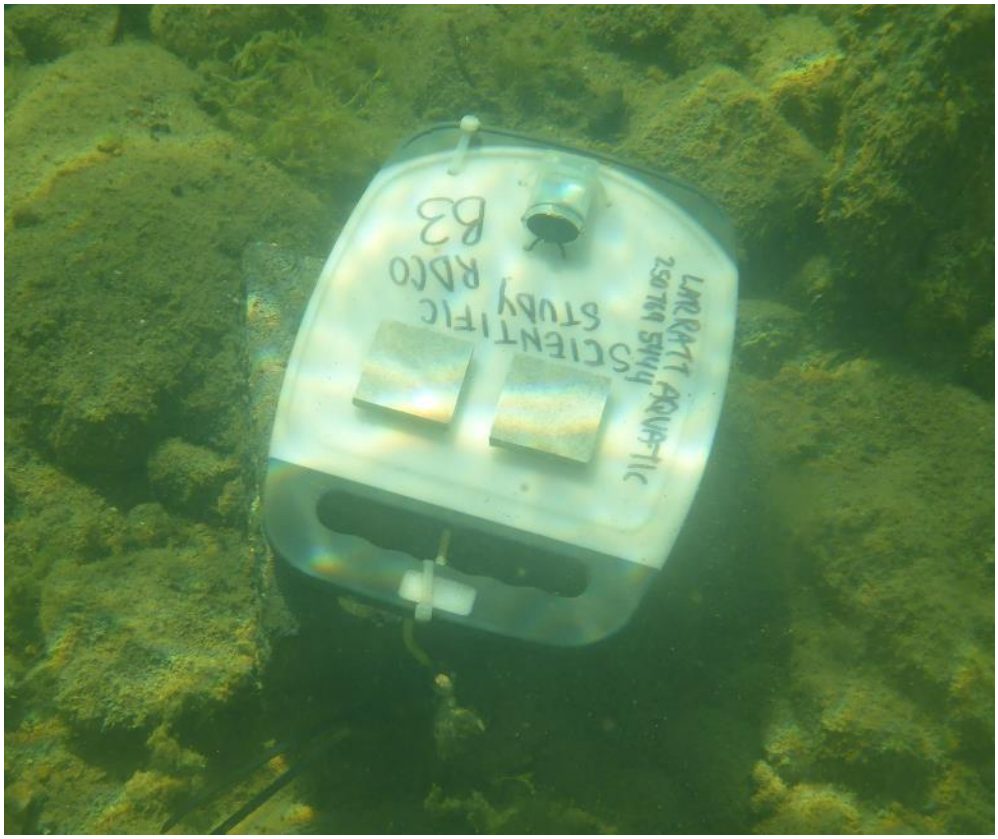


Figure 2: Photograph of recently submerged periphyton sampler at Killiney Beach
Note the extensive periphyton growth on adjacent rocks

2.0 Methods

2.1 Water Quality

Water quality samples were collected in a low-metals Van Dorn bottle-sampler. Every sample was a composite of 10 subsamples collected throughout each zone at 50 cm depth in water that was 1-2 m deep (Figure 1). These subsamples were mixed in a triple-rinsed 4L container before decanting into the sample bottles. The sample bottles were provided by Caro Environmental Laboratories (Caro Labs) with the appropriate preservatives pre-measured into the bottles. The filled sample bottles were placed on chipped ice and delivered to Caro Labs in Kelowna, B.C. within 8 hours of collection. Samples were analysed according to current Standard Methods.

2.2 Periphyton

Honed stone tiles were used as artificial substrates for periphyton growth. A Tidbit light and temperature logger was mounted on each sampler to detect variations of light or water temperature between the samplers (Figure 2). The light loggers also recorded any event where the sampler became dislodged. At the time of deployment, the elevation and location of each sampler was recorded using a hand-held GPS.

We deployed 20 samplers for July/August (61-day deployment) and 20 samplers for Sept/Oct (41-day deployment) along the foreshore of Okanagan Lake to provide statistically workable data. These samplers were all deployed at 1-2 m depth in non-shaded areas; five samplers per zone (Figure 1).

A known surface area was sampled from the tiles at the end of each deployment. Two samples were collected from the samplers. Each sample set was analyzed by LAC for taxonomy, cells counts, and biovolume, to give an accurate estimate of live and dead standing crop (Wetzel and Likens, 1991).

2.2.1 Sampler Retrieval

Samplers remained in Okanagan Lake for each deployment and were retrieved by boat. The stone tiles were detached and placed into marked ziplock bags for analyses. Substrate samples were placed in pre-labeled containers and refrigerated in the dark until further processing. Back-up sample material was frozen in case a sample was damaged during taxonomic review.

During the summer and fall deployments, several samplers went missing and could not be retrieved while others were moved or flipped over (Table 4). The sample area is prone to strong winds and large waves that are believed to be responsible for moving most of the samplers. A few were moved and damaged by recreators.

Table 4: Status of periphyton samplers after summer and fall deployments

Site	Summer	Fall
A1	√	√
A2	√	√ (Flipped over)
A3	√	Washed ashore
A4	√	Missing
A5	√	√
B1	√	√
B2	√	√
B3	√	√
B4	√	√
B5	√	Missing tile
CTL 1	√	√
CTL 2	√	√
CTL 3	√	√
CTL 4	√	√ (Flipped over)
CTL 5	Lost	Lost
C1	Lost	√
C2	Lost	√
C3	√	√
C4	√	√
C5	√ (repositioned)	Missing



Figure 3: Periphyton sampler A3 found out of water on shoreline

2.2.2 Processing of Periphyton Samples

Periphyton was carefully removed from each tile and placed into a known volume of deionized water. Prior to lab sampling, this mixture was blended to break up clumps and distribute periphyton cells evenly throughout the water. A known volume of the blended mixture was placed on a 1 mL Sedgewick-Rafter counting slide. Species cell density and total biovolume were recorded for each sample. A photograph archive was compiled from the samples. Detailed protocols on periphyton laboratory processing are available from Larratt Aquatic.

2.3 Analytical and Statistical Methods

2.3.1 Determination of Substrate Position

Water and air temperature data obtained from the HOBO light/temperature loggers were used to determine whether an artificial sampler was in the correct position and to give an indication of periphyton accrual using the decline in measured light. Further, differences in the light received by each logger could vary, since the angle of incidence at each sample site was not identical. The average of the first three days the samplers were deployed was used to determine the amount of light received by each sampler. The light loggers functioned as substrates and were gradually covered in periphyton over deployment window. The first three days were used because this would give an estimate of light reaching the sampler before the effects of periphyton growth could interfere with the data.

2.3.2 Variables and Statistical Analyses

Water quality data was compiled into a database that was compatible with the Okanagan Water Quality Database (www.obwb.ca/wqdb). Non-detect values were converted to ½ detection level for use in this report. Nitrate, nitrite, NO_3+NO_2, and ammonia results were mostly or entirely below detection limits. For this reason, water quality statistical analyses focused on the parameters that did not have a majority of non-detectable values.

Statistical tests of difference were frequently used to assess potential differences between the control and cottage sites. The non-parametric Kruskal-Wallis test (KW Test) was preferred because water quality data frequently violates the assumption of normal distribution used in other tests. The Kruskal-Wallis test is a non-parametric equivalent of the Students T-Test that was also used in this report.

All descriptive statistics and statistical tests used the R statistical programming language (R Development Core Team 2008) and Microsoft Excel. Model averaging was completed using the R package “MuMIn” (Barton 2014). In all analyses, we assumed that each sampler was independent from every other sampler because growth on one sampler did not affect growth on another sampler.

We used model-averaging to determine which sampled parameters most accurately predicted periphyton production in Okanagan Lake at Killiney Beach and Westshore Estates. Model averaging compares multiple explanatory variables simultaneously and generates a series of numerical values describing the strength of a variable’s explanatory power. The model averaged coefficient indicates whether the parameter positively or negatively relates to periphyton growth. The 95% confidence interval around the average is used to determine statistical significance. If

the upper and lower confidence intervals were on the same side of zero as the model average coefficient then the results were statistically significant.

To compare variables with values that ranged several orders of magnitude, we standardized the data by subtracting the mean and dividing by two times the standard deviation for each parameter. This process is known as centering and scaling. Data was further reduced by using the mean of each deployment period to align with the periphyton growth data.

Boxplots of water quality parameters were generated using R to illustrate the variation between season and location. A generalized boxplot is provided in Figure 4. The horizontal line in the center of the box depicts the median, with the inter-quartile range (box) representing the 25th and 75th percentiles, the whiskers extend to the highest value that is within 1.5 times the inter-quartile range, and outliers are represented by dots.

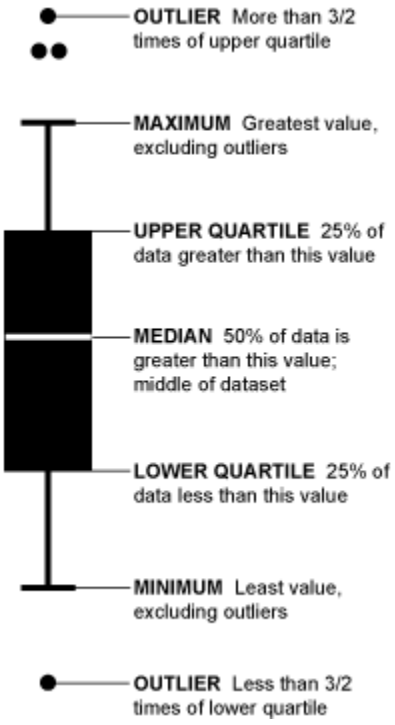


Figure 4: Boxplot Explanation Diagram

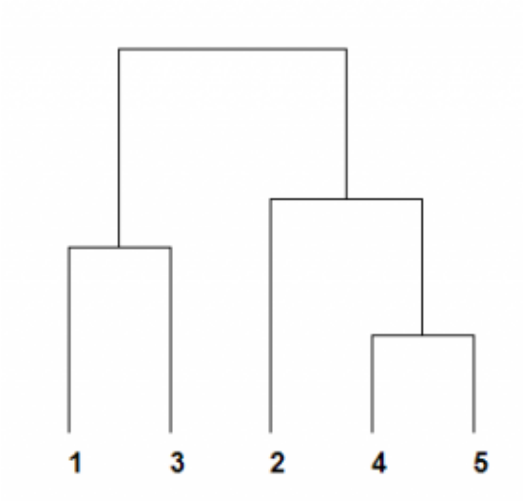


Figure 5: Example dendrogram plot

Dendrograms were generated using R Pearson's correlation coefficient and/or Euclidian distance. It clusters parameters by how closely they correlate to each other in a cluster analysis. The level at which branches merge is related to their similarity. In the example below, 4 and 5 are more similar to each other than the other data points (Figure 5).

3.0 Results

3.1 Lake Conditions

Lake conditions during the summer deployment were stable and 17 of 20 plates were successfully recovered. An intense windstorm occurred in during the last week of the fall deployment that caused damage. Of the 20 fall plates, 6 were lost, 1 washed ashore, and 4 more plates were flipped over. The effect of this event on data quality was carefully considered with additional analyses performed to determine if there was an effect on periphyton growth.

3.2 Water Temperature

Water temperature followed a seasonal pattern, where they increased during the first deployment and decreased during the second deployment (Figure 6). The range of water temperatures each day was greatest in the summer and tapered as fall approached. All loggers[1] recorded virtually identical water temperatures in both the control and community areas as long as they were submerged (Appendix 2).

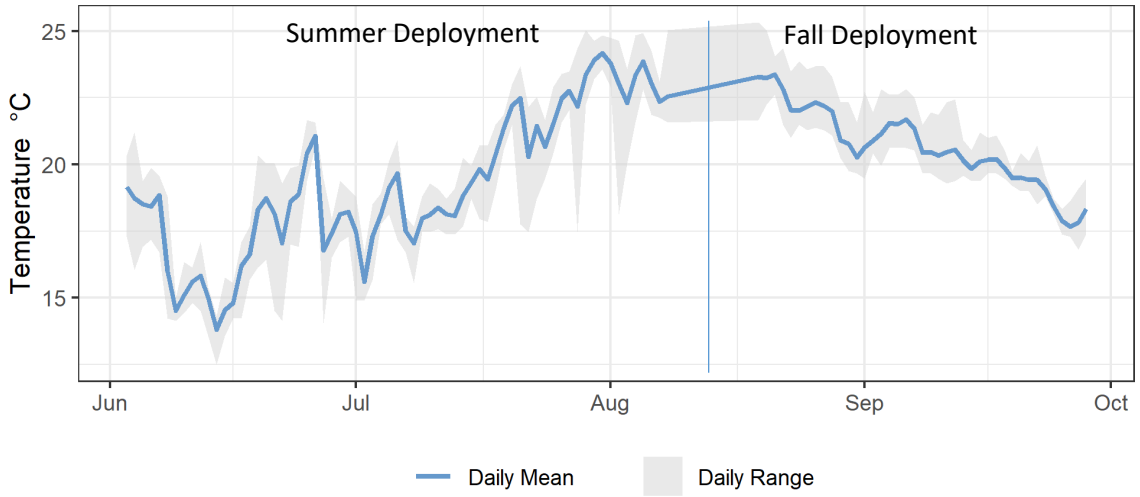


Figure 6: Water temperature at Site B1 over the course of the two sampling deployments

The mean temperature of the summer deployment was 19.3 ± 2.9 °C and was significantly cooler than the fall deployment that averaged 20.5 ± 1.6 °C although the difference was small (KW-Tests, $p<0.001$; Figure 7). Both ranges exceeded the 15 °C threshold above which microflora growth is rapid.

[1] The temperature results from Logger Control4 were consistently 7-8 °C warmer than other loggers while maintaining a similar daily variation. It is likely that this logger was mis-calibrated and the data obtained from it was not included in further analyses

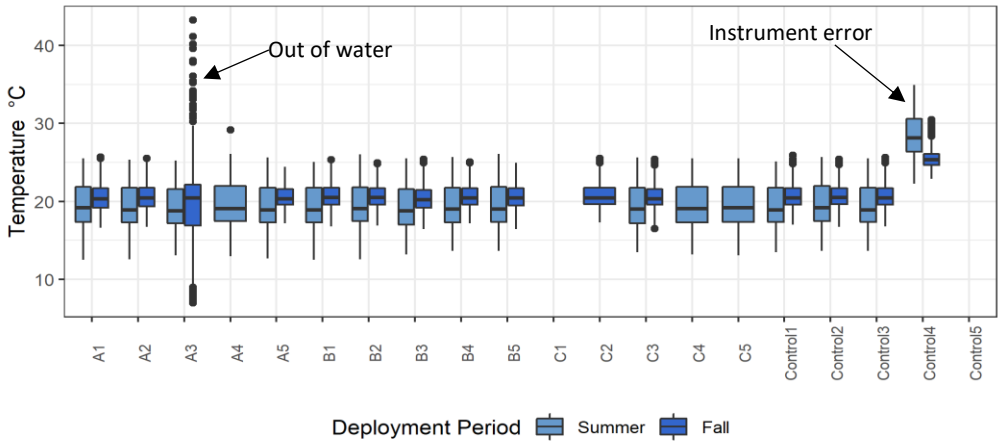


Figure 7: Temperature comparison for the summer vs fall deployment at each site

3.3 Light on Substrates

During the light logger deployments in the lake, periphyton growth coated the light sensors causing a progressive decrease in light readings (Figure 8). For 30 of the 32 loggers, the first three days recorded higher light than the last three days of each deployment and this pattern was statistically significant for many of the loggers (KW-Tests). For the other two loggers, the difference was not statistically significant.

The rate of light decrease between the loggers in the control and the shoreline residential zones was not statistically significant for the summer or fall sampling sessions (KW-tests) indicating that light attenuation by periphyton growth was not significantly different between the control and residential non-control zones.

Some samplers were recovered in an inverted position but this likely happened late in the deployment window resulting in no significant difference between the flipped and non-flipped samplers for overall light availability during the summer or fall deployments (Appendix 2).

The absence of light variation between sites means that this important driver of periphyton production did not influence the results. This means comparison of results from the control zone with the shoreline residential zones and the investigation of nutrients from septage could proceed unhindered.

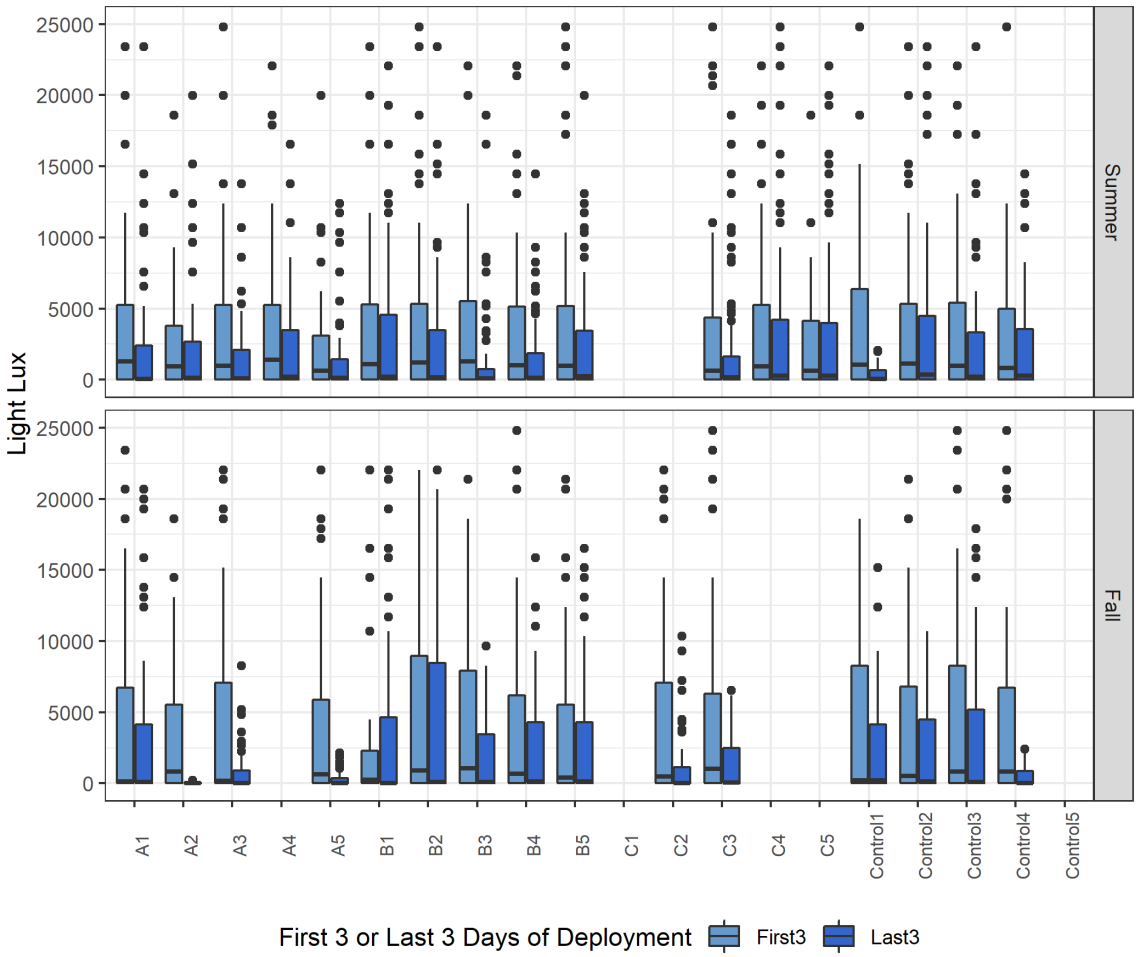


Figure 8: Comparison of light during first 3 days of deployment compared to last 3 days of deployment
Note: Scale is cropped to max of 25000 lux to reduce vertical compression of y-axis caused by outliers

3.4 Water Chemistry

A total of five composite near-shore water quality samples collected from each site (2 in summer set, 3 in fall set) during the study period. Sample collection occurred at the beginning, middle, and end of the periphyton sampling periods (Table 2).

3.4.1 Electrochemistry Parameters - Conductance

Specific conductance, total dissolved solids (TDS), alkalinity and hardness all measure the concentrations of ionized constituents in water and for this reason, they frequently trend together (Table 1). Statistically significant differences between the average conductivity in the control zone (293 ± 3 µS/cm) and along the developed shoreline zones (294 ± 4 µS/cm) was not detected (T-Test, p=0.48; Figure 9). None the less, Figure 9 demonstrates that Zone A had the highest conductivity of the tested sites. All foreshore zones (including the control) had higher conductivity than the main body of Okanagan Lake during 2020 (286 ± 5 µS/cm ENV site at Okanagan Centre, T-Test p=0.002) indicating

that the difference is likely a shoreline effect and not necessarily caused by shoreline residential development. Conductivity data did not indicate a localized effect from shoreline septic leachate.

Table 5: Ions Contributing to Electrochemistry Parameters

Parameter	Equation or Principle Ions Measured
Alkalinity	Alkalinity = $[HCO_3^-]_T + 2[CO_3^{-2}]_T + [B(OH)_4^-]_T + [OH^-]_T + 2[PO_4^{-3}]_T + [HPO_4^{-2}]_T + [SiO(OH)_3^-]_T - [H^+]_{sws} - [HSO_4^-]$
Hardness	Mainly contributed by Ca^{+2} Mg^{+2}, and also Sr Fe Ba Mn
TDS	Soluble salts that yield ions such as: Na^{+2} Ca^{+2} Mg^{+2} HCO^{3-} SO_4^{-2} Cl- NO_3- PO_4-
Conductivity	Mainly contributed by $CaCO_3$; also (H^+ Ca^{+2} Mg^{+2} K^+ Na^{+2} CI- $S0_4^{-2}$ $N0^{3-}$ HCO-, OH-

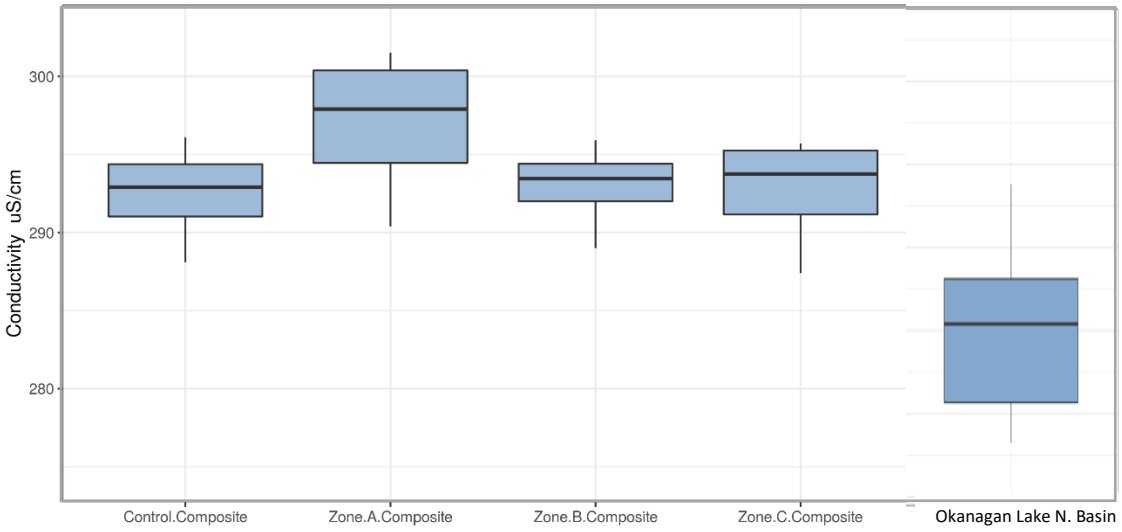


Figure 9: Field conductivity in sampling zones compared to Okanagan Lake North Basin, 2020
Note: Okanagan Lake N. Basin = ENV Site 0500730

3.4.2 Chloride

Elevation of chloride (Cl^-) above naturally occurring levels can indicate septic system impact. Chloride values of 50 to 100 mg/L are common in septic tank effluent.

Chloride concentrations were similar between the control and shoreline residential zones and the Okanagan Lake north basin sample location (Figure 10). Chloride averaged 5.47 ± 0.21 mg/L in the combined zones A-C, 5.39 ± 0.16 mg/L in the control zone, and 5.45 ± 0.12 mg/L at the north basin long term monitoring location (ENV 0500730). None the less, Figure 9 demonstrates that Zone A had slightly higher chloride. There was a small (non-significant) difference between the summer and fall deployments for chloride within the residential zones (T-Test, p=0.05) with the fall period (5.6 ± 0.2 mg/L) having slightly higher chloride than summer (5.3 ± 0.2). Chloride data did not indicate a localized, statistically significant impact from septic leachate.

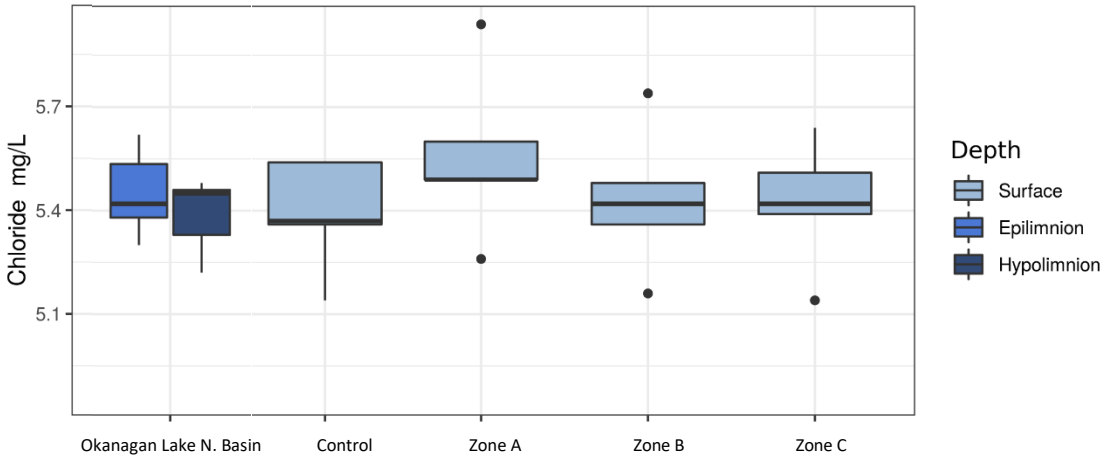


Figure 10: Chloride at sample zones compared to Okanagan Lake N. basin, 2020
Note: Okanagan Lake N. Basin = ENV Site 0500730

3.4.3 Inorganic Nitrogen and Total Nitrogen

The common forms of inorganic nitrogen (DIN) include nitrate, nitrite, and ammonia. These are key nutrients that are repeatedly consumed, transformed, and released in shoreline areas. Research suggests that septic loading to shallow groundwater is between 5.7 and 10.7 kg/household/year (Reay, 2004), a small fraction of the input from a large creek into Okanagan Lake[2]. Inorganic nitrogen is rapidly consumed by algae and periphyton and is usually below detection during the stratified period in Okanagan Lake (Figure 11). This indicates rapid DIN consumption by the periphyton and also suggests that periphyton growth may be limited by DIN availability.

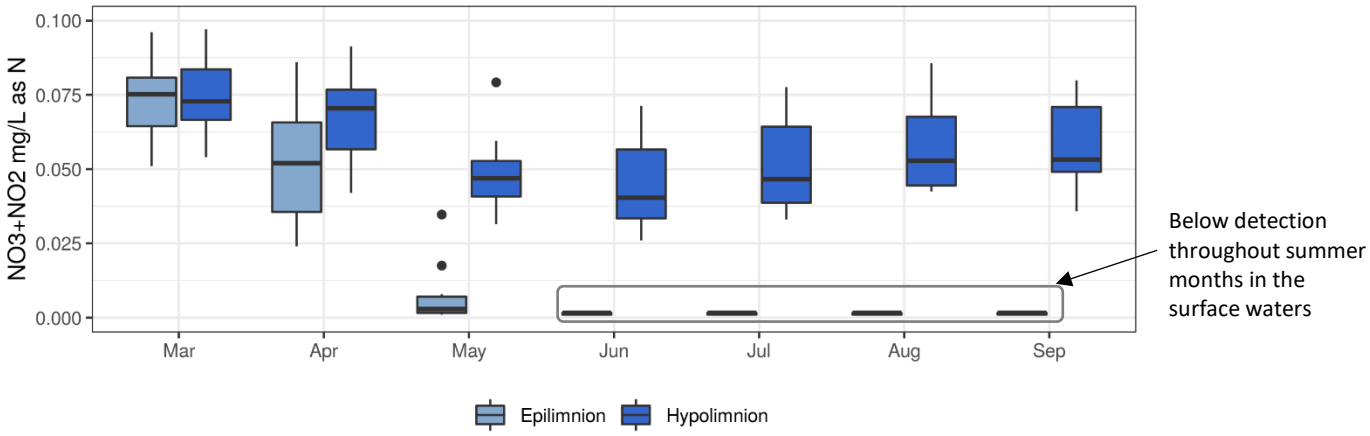


Figure 11: Nitrate + nitrite in north basin of Okanagan Lake over past 10 years by month
Note: Sample location = ENV 0500730

[2] Using the 2018 annual average concentration from Vernon Creek at Okanagan Lake (0.316 mg/L as N) multiplied by the average annual discharge of Vernon Creek (49,500 dam³/year) from Nordin, 2005 generates a value of approximately 15,000 kg/yr. This is considered a substantial underestimation because the 2018 data did not include freshet.

Throughout Okanagan Lake, DIN is dominated by nitrate, yet nitrate was non-detectable in all samples from the four test zones, as would be expected based on Okanagan Lake concentrations at the same time (Figure 12). Okanagan Lake experiences a seasonal nitrate decline commencing in late spring and into early summer every year caused by algal uptake. If inorganic N was detected in foreshore samples, it would have been a potential indicator of septic leachate, but this was not the case. Ammonia and nitrite were non-detectable, as is expected in aerobic environments.

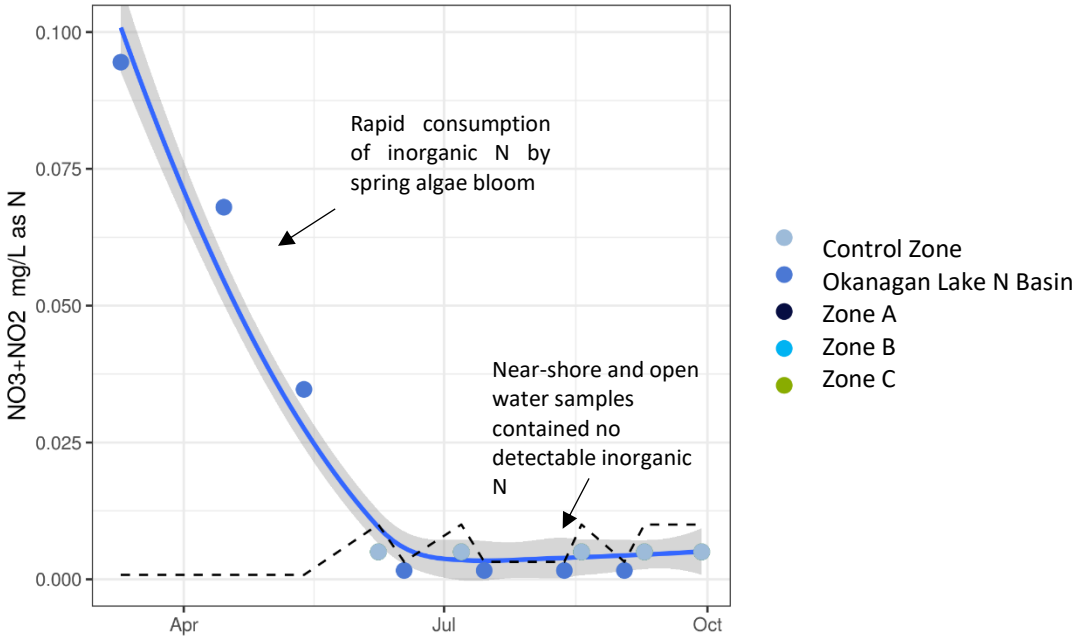


Figure 12: Nitrate and nitrite in Okanagan Lake compared to the test zones during 2020

Notes: black dashed line indicates lab detection limit, data point for zones A-C overlap and are not all visible in the above plot

Virtually all sampled nitrogen occurred in organic forms such as algae and bacterial proteins (100% for near-shore sample zones during 2020; Figure 13). As a result, Total Kjeldahl nitrogen (TKN) and total nitrogen (TN) concentrations were the same in all sampled zones. Total nitrogen averaged 0.230 ± 0.076 mg/L as N in the control zone and a higher 0.249 ± 0.060 mg/L as N across zones A-C during 2020, however the difference was not statistically significant (T-Test, p=0.6). No significant difference between the spring and fall deployments occurred for any nitrogen species (T-Tests p>0.05). For reference, in the open water of Okanagan Lake, TN averaged 0.250 ± 0.028 mg/L as N during 2020 (ENV site 0500730). These nitrogen results put Okanagan Lake in the mesotrophic category (Appendix 5). Nitrogen data from this study did not detect a statistically significant localized impact of septic leachate.

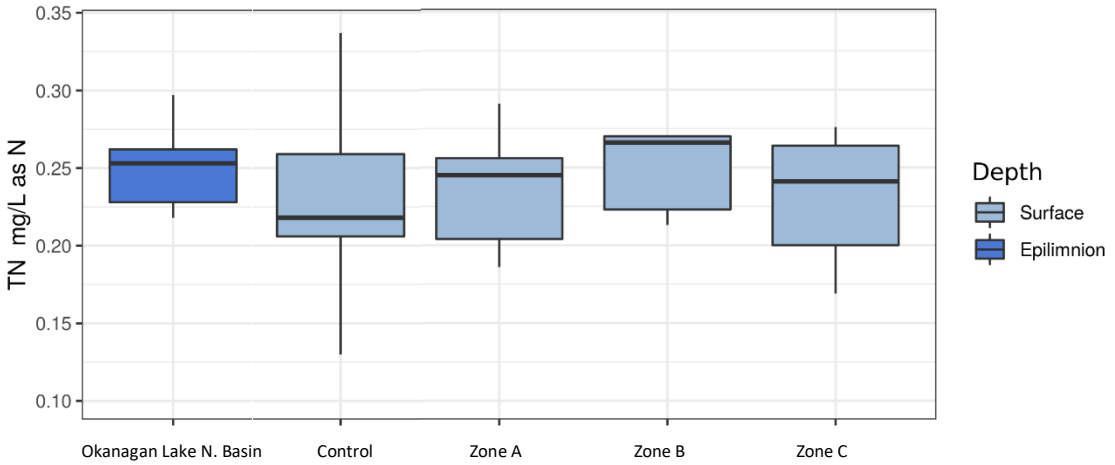


Figure 13: TN in Okanagan Lake compared to sample zones during 2020

3.4.4 Inorganic Phosphorus and Total Phosphorus

Phosphorus is an important nutrient and it often limits or controls lake productivity. Major sources of phosphorus to Okanagan Lake include soil erosion (particularly during freshet), human and animal wastes, detergents, septic systems and runoff from farmland or lawns. Total phosphorus (TP) represents the sum of dissolved and particulate phosphorus in a water sample. Total dissolved phosphorus (TDP) represents the biologically available portion.

With all study data combined, total phosphorus (TP) averaged 0.009 ± 0.001 mg/L as P in the control zone and 0.010 ± 0.003 mg/L as P across shoreline residential zones A-C. This slight increase was not statistically significant during 2020 (Figure 14). Similarly, no significant differences occurred between summer and fall sample sessions for TP or TDP. These nutrient results place the foreshore in the oligo-mesotrophic category, where Zone A Killiney Beach had the highest (mesotrophic) nutrient concentrations (Appendix 5).

However, the foreshore zones had significantly higher TP than the open water of Okanagan Lake (ENV Site 0500730) which averaged 0.006 ± 0.002 mg/L as P during 2020 (T-Test, p=0.009). The large difference between the foreshore samples and the oligotrophic ENV site samples likely reflects the difference in water chemistry between littoral and pelagic areas of a lake. Foreshore nutrient concentrations are enhanced by nutrient loading from the watershed both as surface and groundwater (i.e. creeks, stormwater, overland flow, subsurface drainage), recycling from the shallow substrates, and sediment resuspension. Higher TP was also noted in the foreshore samples of the Cosens Bay Study from Kalamalka Lake (Larratt and Self, 2015).

Comparison of study TP data between the control and foreshore residential zones did not detect a localized impact from septic leachate.

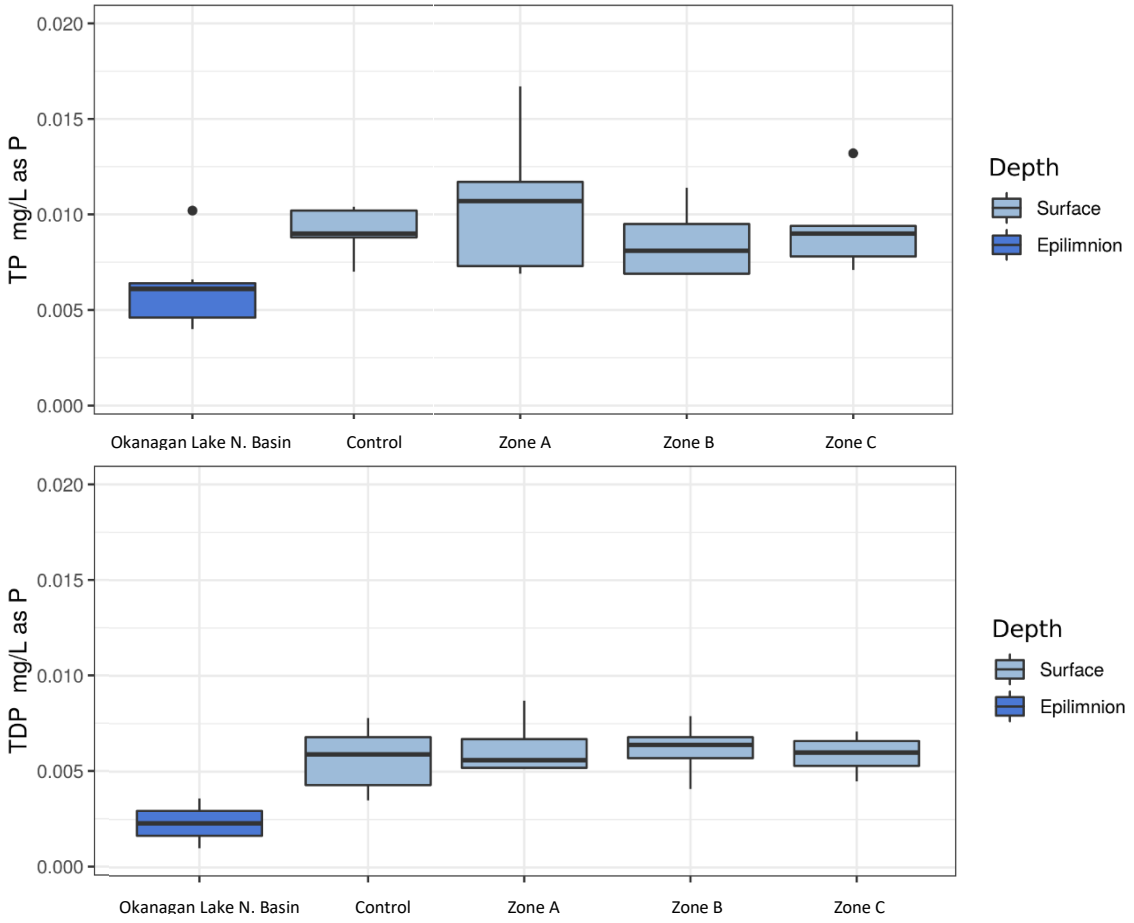


Figure 14: Total phosphorus and total dissolved phosphorus at sample zones compared to Okanagan Lake N Basin

Total dissolved phosphorus (TDP) was very similar between the control (averaged 0.006 ± 0.002 mg/L as P) and the shoreline residential zones (averaged 0.006 ± 0.001 mg/L as P across zones A-C) during 2020 (Figure 14). TDP represented only 65% of TP in the foreshore samples during 2020 indicating significant particulate P, likely in the form of fine sediment. TDP in the main body of Okanagan Lake was significantly lower than the foreshore samples[3]. TDP data did not indicate a localized impact from septic leachate on the residential foreshore zones.

The ratio of available nitrogen (DIN) to phosphorus (TDP) in a lake plays an important role in the types of phytoplankton and periphyton that will be dominant (Appendix 5). A ratio of less than 5 : 1 indicates nitrogen limitation, that is productivity is being restricted by nitrogen while phosphorus

[3] TDP was sampled only twice annually by ENV, preventing statistical comparison with 2020 data only. 10 years of data were combined to run this test.

is relatively abundant. Conversely, a ratio of greater than 15 : 1 means that phosphorus is limiting productivity while a ratio between 5 : 1 and 15 : 1 means that both nutrients are likely limiting production (Appendix 5). Because DIN was below detection in all foreshore samples, the DIN:TDP ratio was <1 : 1 indicating strong nitrogen limitation.

3.4.5 Chlorophyll-a

Chlorophyll-a is a major photosynthetic pigment found in many types of algae and is used as a measure of phytoplankton production. Phytoplankton chlorophyll-a was similar between the control (2.1 ± 1.0 µg/L) and shoreline residential zones (1.8 ± 0.9 µg/L) while the north basin of Okanagan Lake epilimnion was higher than the foreshore samples (2.7 ± 1.3 µg/L) during 2020 (T-Test, p=0.05; Figure 15). This difference is likely related to the different sampling methodologies between this study (surface grab composites) and the ENV monitoring (1,5,10 m composites) with the ENV sampling better capturing the entire photic zone[4] and the timing of sample collection (ENV samples collected Mar-Sept). Chlorophyll-a was significantly higher in the summer foreshore samples (2.6 ± 0.3 µg/L) compared to the fall (1.2 ± 0.6 µg/L; T-Test, p<0.001), likely this relates to those samples being collected closer to the peak growing season for phytoplankton (typically the spring bloom in Okanagan Lake). The ranges of near-shore phytoplankton were indicative of low nutrient conditions. The sample sites showed the same results because of water movement with shoreline currents.

The phytoplankton chlorophyll-a data from this study did not indicate an effect of septic leachate on the foreshore zones during 2020.

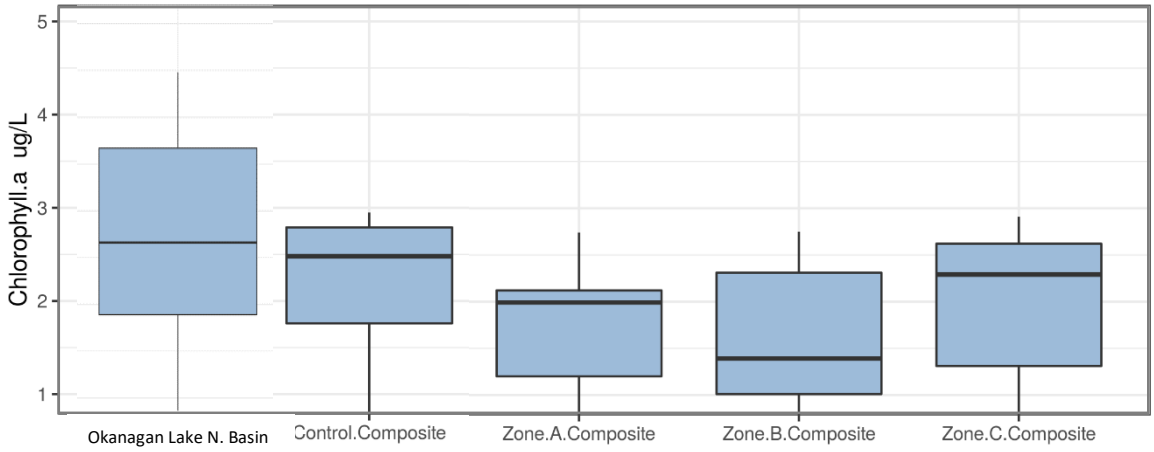


Figure 15: Comparison of chlorophyll-a concentration between the open water of the north basin and the sampling zones at Killiney Beach

Note: Okanagan Lake N. Basin represents vertical composite of 1,5,10 m depths while other zones are horizontal composites from 0.5 m depth.

3.4.6 E. coli

Escherichia coli (*E. coli*) bacteria normally live in the lower intestines of warm-blooded animals. Their presence in water can indicate fecal contamination. Of the 20 samples collected, 25% contained non-detectable *E. coli*. Although more *E. coli* was detected in the residential zones

[4] Phytoplankton often prefer to be several meters below the surface to avoid the harshest sunlight.

where there appeared to be a northward decline with A > B > C, the differences were not statistically significant (Figure 16). The range of detected *E. coli* was non-detectable to 7 CFU/100 mL.

A significant decline from the high use period would be a marker for impact from residential and associated activities (e.g. recreation). A small decline in *E. coli* occurred over the deployment periods, particularly at Zone A but the decline was not quite statistically significant. The decline in the other zones was less distinct (T-Test, p=0.05).

E. coli data from this study did not indicate a statistically significant effect of septic leachate on the Okanagan Lake foreshore during 2020.

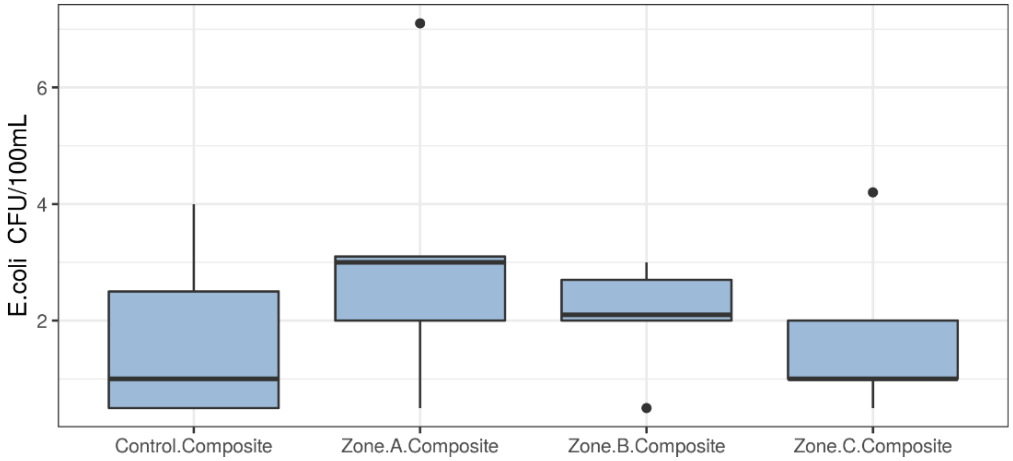


Figure 16: *E.coli* at sample locations compared by site during 2020

3.4.7 Parameters with Non-significant Differences

Several parameters exhibited apparent differences either between control and residential zones or between the summer (heavy use period) and fall (lower use period); none of these differences were statistically significant (Table 6). Some parameters appeared higher in summer and some in fall, suggesting the observed differences may be statistical anomalies related to the small number of samples. There were also several instances where Zone A, the most impacted of the residential zones) had the poorest water quality, although all differences were not statistically significant and may be anomalous. Further study would be required to provide clarity.

Table 6: Parameters with non-significant differences in T-Tests

Parameter	Difference	Significance (p-value)	Figure in Report
Conductivity	-Fall higher than Summer	0.10	-
	-Zone A appeared highest	0.48	Figure 9
Chloride	-Fall higher than Summer	0.05	-
	-Zone A appeared highest	0.25	Figure 10
TN	-Fall higher than Summer	0.10	-
TP	-Summer higher than Fall	0.20	-
	-Zone A appeared highest	0.42	Figure 14
Chlorophyll-a	-Zone A appeared lowest	0.55	Figure 15
E. coli	-Summer higher than Fall	0.05	-
	-Zone A appeared to be highest with northward decline	0.30	Figure 16

3.4.8 Interactions Between Water Quality Parameters

The collinearity of water quality parameters can be shown visually in a dendrogram (Figure 17). This dendrogram is based on the Pearson's correlation coefficient and it clusters parameters by how closely they correlate to each other.

Total nitrogen to TKN formed the most correlated group because 100% of available nitrogen was organic in the collected samples (Figure 13). The parameters that compose dissolved inorganic nitrogen (NO_2, NO_3, NH_3) were below detection in all samples and were therefore excluded from the correlation analysis. Interestingly, TP and TDP were poorly correlated forming a loose group with *E. coli*, possibly indicating sediment resuspension as their source. Nitrogen did not correlate to phosphorus, suggesting independent sources or consumption mechanics. Chlorophyll-a correlated to TN (R=-0.53) possibly because, like chl-a, nitrogen was bound up in algal cells. Chloride did not correlate to any of the other parameters in a meaningful way.

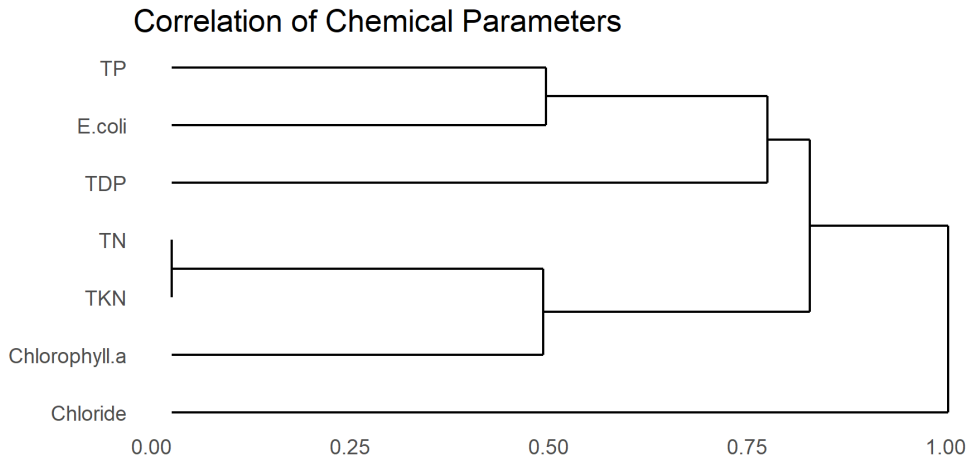


Figure 17: Correlation of chemical parameters dendrogram

Note: x-axis values represent the distance from perfect collinearity. The smaller the x-axis value of the connection point, the tighter the correlation with 0 being perfect collinearity.

3.5 Periphyton

Periphyton consists of two broad groups of micro-organisms:

- photosynthetic bacteria and algae, and
- heterotrophic (non-photosynthetic) bacteria and fungi.

Algal periphyton production can only occur while substrates are submerged *and* exposed to light, while the bacterial biofilm component also grows in the dark (Lear et al. 2009). Bacteria and fungi (moulds, yeasts) are pioneering organisms that can dominate the periphyton initially and again after the periphyton mat (biofilm) is well established (Fernandes and Esteves 2003). Drift pushed along the shore by lake currents helps supply cells to populate new or disturbed substrates.

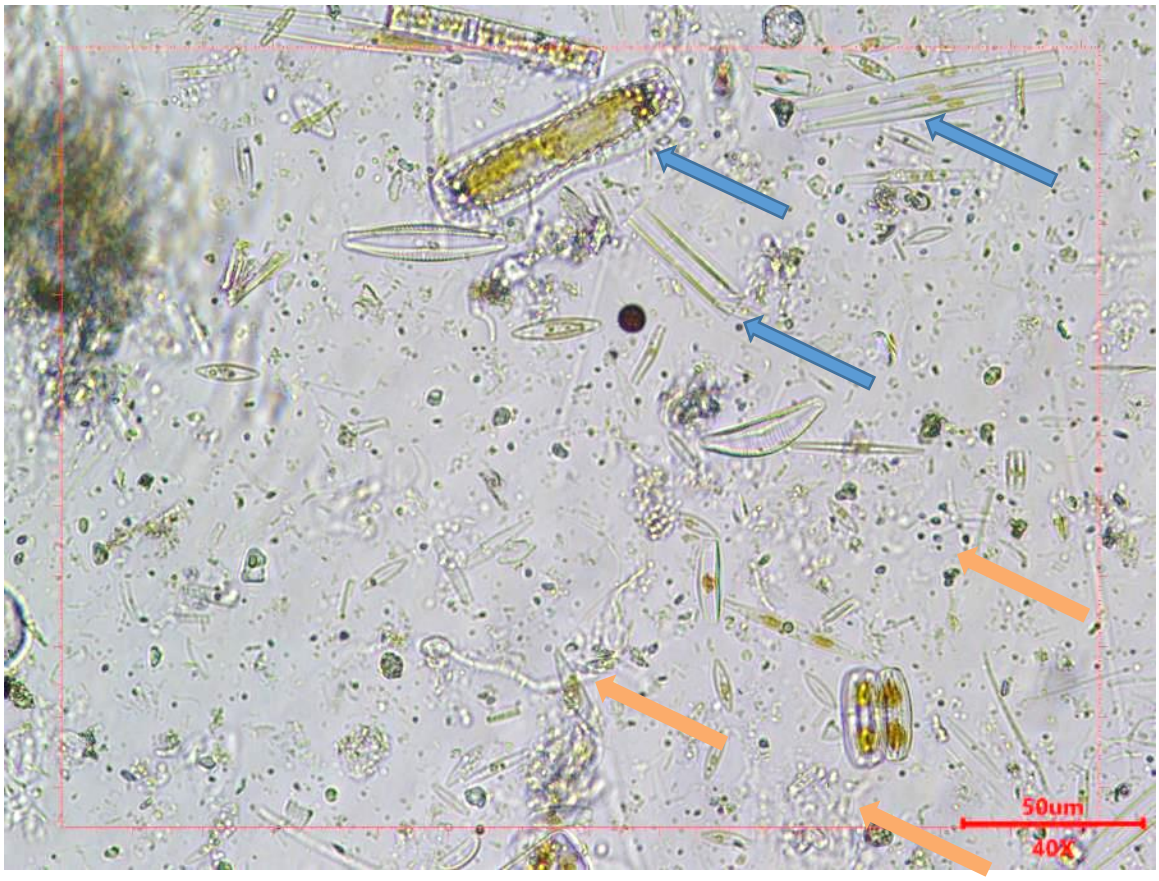


Figure 18: Microscope image of periphyton community at site A1 after fall deployment with example cells marked

Diatoms ← Cyanobacteria ←



Figure 19: Example of retrieved sampler at the end of the fall deployment (Site A5)

Some of the samplers were not found while others were flipped so the sampler was not facing up towards the sun (Table 4). A sampler that was inverted for an extended length of time would have artificially low growth and this was accounted for in the analyses of periphyton data. Fortunately in this case, it appears that the samplers that were flipped did so near the end of the deployments and this did not affect either light (Appendix 2), or periphyton growth (Figure 22, KW-Tests).

3.5.1 Periphyton Abundance and Biovolume

Periphyton was assessed by abundance as number of cells/cm² and as biovolume as µm³/cm². These two results are intrinsically linked but the results can be quite different because of the large variation in cell size from very small cyanobacteria to large diatoms.

Summer samplers were very similar between the control and residential zones but abundance was significantly higher during the fall deployment at both control and residential zones (Table 7, Figure 20, KW-Test, $p<0.001$), likely because of warmer water temperatures (Figure 7). The difference between the control and residential zones during the fall was not statistically significant (KW-Test, $p=0.06$; Figure 20) and a large fraction of this apparent difference was driven by significantly higher flagellated algae densities in the control samples compared to the residential samples during the fall period ($1.0 \pm 1.1 \times 10^6$ cells/cm²; KW-Test, $p=0.02$).

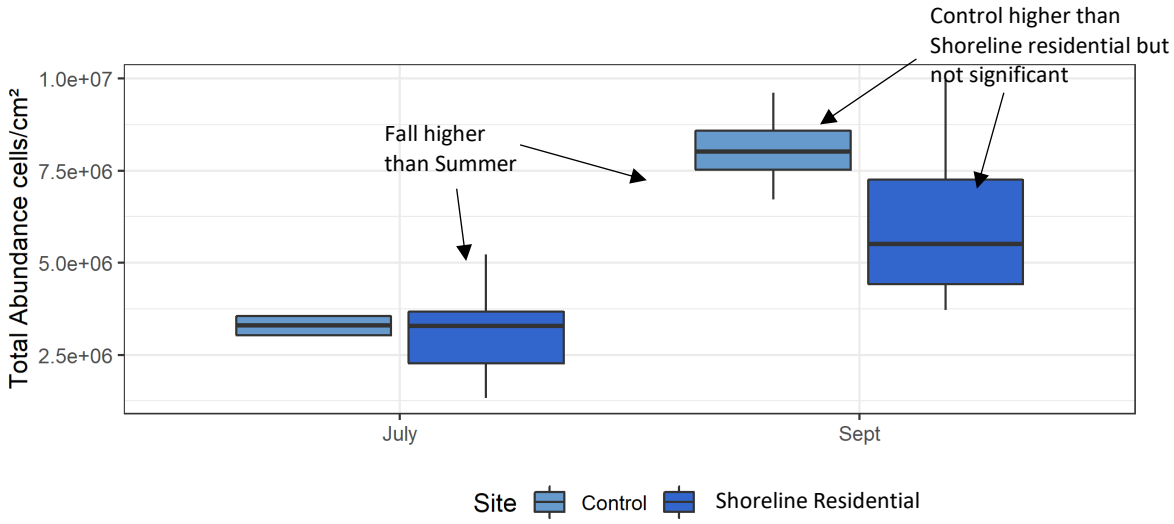


Figure 20: Periphyton abundance comparison between control and shoreline residential during summer and fall deployment periods

Biovolume is calculated by multiplying the abundance for each taxa by the specific cellular volume of that taxa as measured in these samples and is reported in the units cubic micrometers per square centimeter. Biovolume was not significantly different between the residential and control zones or between the summer and fall deployment periods (Figure 21, Table 7, KW-Tests).

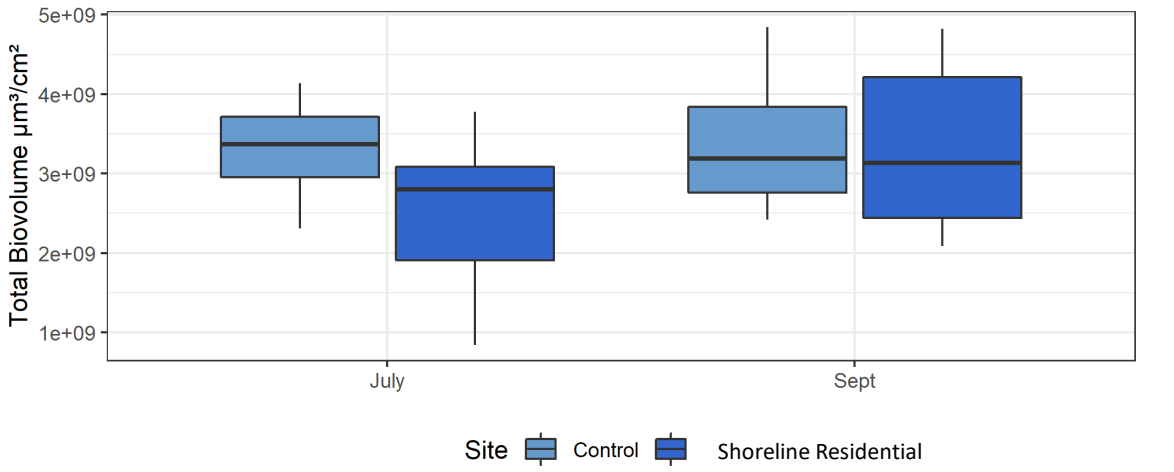


Figure 21: Periphyton biovolume comparison between control and shoreline residential during summer and fall deployments

Table 7: Periphyton abundance and biovolume summary statistics and comparison of shoreline residential vs control during summer and fall deployments

Measure		Site	p-value	Control	Shoreline residential
Periphyton Abundance	Million cells/cm²	Summer	0.650	3.30 ± 0.31	3.02 ± 1.07
		Fall	0.064	8.09 ± 1.20	5.95 ± 1.96
Periphyton Biovolume	Billion µm³/cm²	Summer	0.174	1.65 ± 0.38	1.26 ± 0.48
		Fall	0.877	1.72 ± 0.53	1.66 ± 0.52

Note: p-value <0.05 indicates significant difference between control and shoreline residential means for a given season from series of KW-Tests

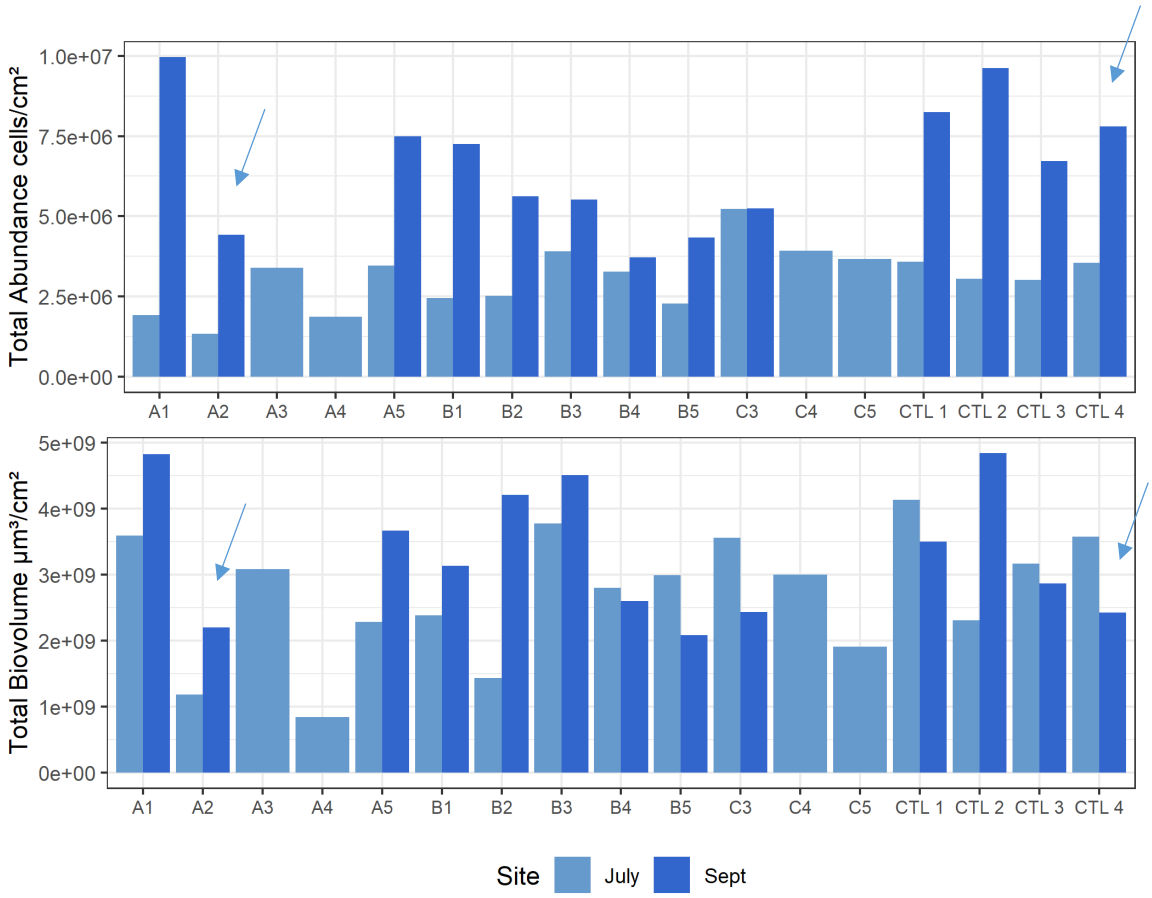


Figure 22: Comparison of total abundance and total biovolume for each sampler during summer and fall deployments

Note: Blue arrows indicate sampler samplers that were recovered in inverted position

Overall, no significant difference between control and shoreline residential samples occurred for periphyton total abundance or biovolume during the summer deployment but cyanobacteria and flagellates were higher in the fall (Figure 20, Figure 21, Table 7). Periphyton total abundance and biovolume data did not indicate a statistically significant localized impact from septic leachate on Okanagan Lake during 2020.

3.5.2 Periphyton Community Structure

Periphyton community structure can be subdivided into the major categories: diatoms, green algae, cyanobacteria, and flagellates. Overall periphyton community structure was very similar between the shoreline residential and the controls (Figure 23). There were more flagellates at the control sites than the residential sites during fall deployment although the cause is not clear (KW-Test; p=0.025, Appendix 7). This increased flagellate density in the control was not large enough to cause a significant increase in total abundance at the control compared to the shoreline residential zones (Table 7). Figure 23 shows that the small-celled cyanobacteria may be numerous, but they are very small relative to other algae cells so they account for far less biovolume than the diatoms and filamentous green algae on a per cell or total biovolume basis (Figure 23, Table 8).

As expected based on warmer fall water temperature (Figure 7), periphyton growth was slightly higher in fall than summer, driven by elevated cyanobacteria (blue-green algae) abundance (KW-Tests, p<0.001; Figure 20, Figure 21, Figure 22). As mentioned previously, there were also more flagellates in the control zone samples than in the residential zones (KW-Test, p=0.03, Figure 23, Appendix 7).

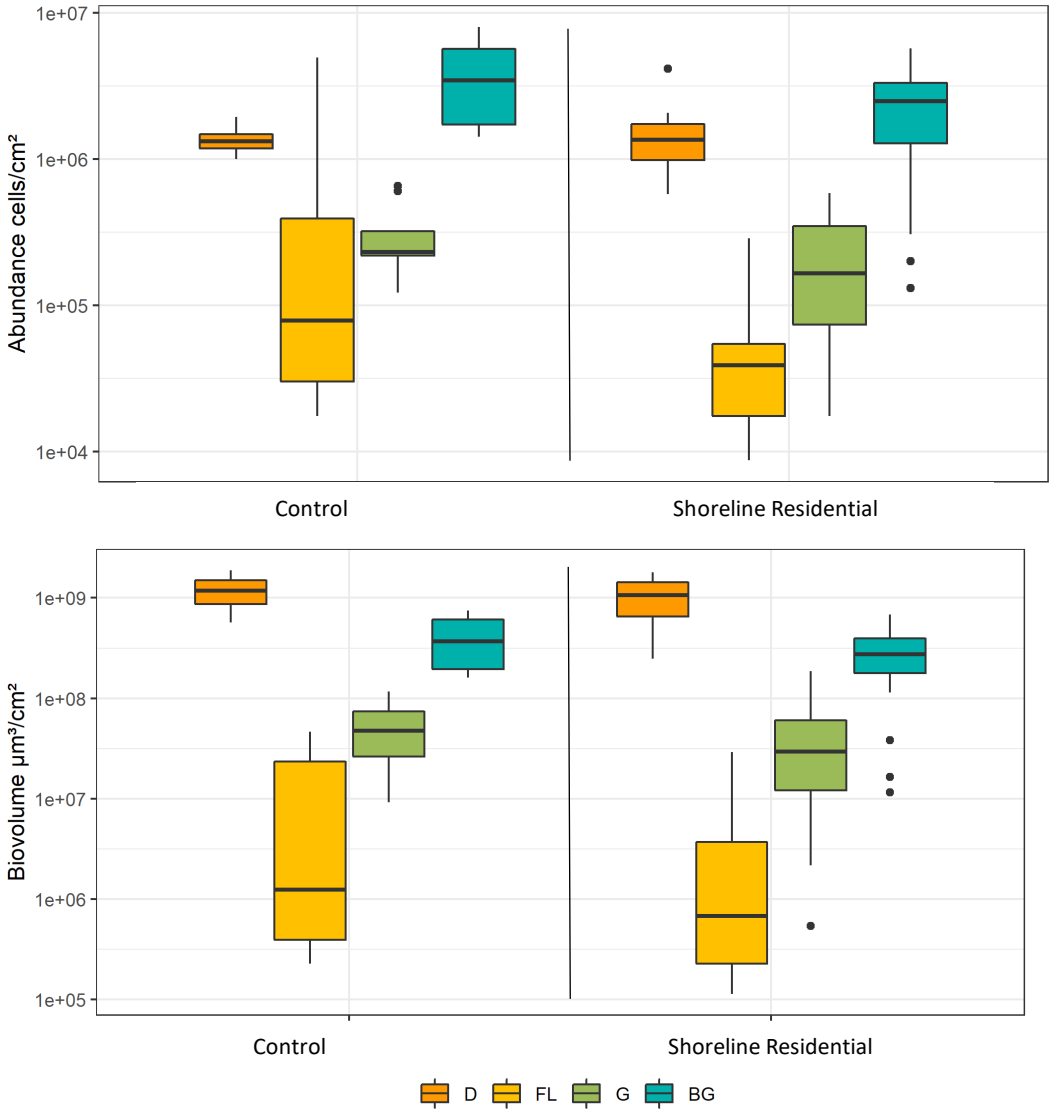


Figure 23: Community composition of periphyton compared between control and shoreline residential zones

Note: Log scale used in this figure to increase visual spread of data; D = diatoms, FL = flagellates, G = green algae, BG = cyanobacteria

Table 8: Top 10 taxa for abundance and biovolume at control and residential zones, ranked by percentage

Control			
Relative abundance - dominant species	Relative Abundance (%)	Relative biovolume - dominant species	Relative Biovolume (%)
Leptolyngbya sp.	56.8%	Leptolyngbya sp.	24.0%
nano and pico-flagellates	9.0%	Epithemia turgida	19.7%
Staurosira construens	3.2%	Rhopalodia gibba	16.1%
Achnanthidium minutissimum	2.7%	Mastogloia sp.	3.9%
Aphanothece sp.	2.3%	Eucocconeis flexella	3.7%
Gloeothece sp.	2.3%	Cyclotella bodanica	3.2%
Anacystis cyanea	1.9%	Pennate diatoms	3.0%
Colonial Cyanobacteria	1.8%	Staurosira construens	2.3%
Achnanthidium minutissimum var linearis	1.7%	Tabellaria fenestrata	2.1%
Navicula sp. small	1.5%	Caloneis sp.	1.7%

Foreshore residential			
Relative abundance - dominant species	Relative Abundance (%)	Relative biovolume - dominant species	Relative Biovolume (%)
Leptolyngbya sp.	52.8%	Epithemia turgida	20.5%
Achnanthidium minutissimum	5.4%	Leptolyngbya sp.	19.5%
Staurosira construens	5.4%	Rhopalodia gibba	15.4%
Achnanthidium minutissimum var linearis	2.6%	Pennate diatoms	4.8%
Anacystis cyanea	2.3%	Staurosira construens	3.4%
Navicula sp. small	2.1%	Cymbella cistula	3.0%
Fragilaria crotonensis	2.1%	Cyclotella bodanica	2.9%
Gloeothece sp.	2.0%	Mastogloia sp.	2.9%
Aphanothece sp.	2.0%	Eucocconeis flexella	2.3%
Botryococcus	1.6%	Tabellaria fenestrata	1.3%

Note: See Appendix 3 for Master Taxonomy Table

Periphyton species diversity indices demonstrated stable species richness between the shoreline residential and control sites in both season (KW-Tests, $p \geq 0.3$). The average number of taxa per site ranged from 39 – 44 and was not significantly different between shoreline residential or control zones, or between the seasons. However, there was a significant reduction in the Shannon Weaver diversity index between summer and fall (Figure 24, Table 9), indicating that a small number of taxa were responsible for a greater fraction of the abundance, in particular the cyanobacteria *Leptolyngbya sp.* increased by >10% on average in the fall samples compared to the summer samples. An increase in cyanobacteria abundance is common at this time of year because they prefer warmer water (Figure 7).

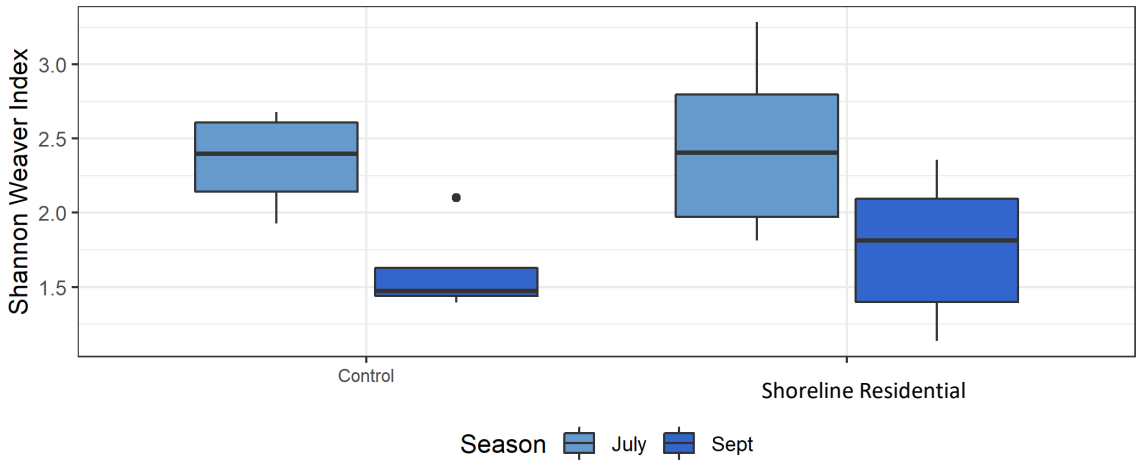


Figure 24: Comparison of Shannon Weaver Index between control and shoreline residential zones during summer and fall deployment periods

Table 9: Diversity measures in periphyton samples

Diversity measure	Site type	Control	Residential	p-value
Species.Richness.Index	Summer	41.3 ± 2.6	38.0 ± 5.7	0.28
Shannon.Weaver.Index		2.4 ± 0.3	2.4 ± 0.5	1.0
Species.Richness.Index	Fall	44.5 ± 7.1	41.6 ± 8.5	0.49
Shannon.Weaver.Index		1.6 ± 0.3	1.8 ± 0.4	0.76

Note: Blue p-value indicates statistically significant difference; analysis based upon series of KW-Tests

While there was little change in the distribution of the entire periphyton communities on the periphyton samplers, individual taxa did show unique changes. Periphyton taxa that were statistically different between the control and shoreline residential sites are listed in Table 10. Interestingly, all of them were higher at the control site in both seasons. Of the diatoms, *Eunotia* species are most abundant at lower pH and are highly sensitive to water chemistry. *Diploneis* and *Tabellaria* are most abundant at low to moderate nutrient conditions and also sensitive to water chemistry. Their preference for the control site may relate to its subtle differences in water chemistry (Table 6). The other diatom taxa – *Nitzschia palea*, *Caloneis sp*. and *Amphora ovalis* are generalist diatoms that are indiscriminate.

Periphyton taxa that fix atmospheric nitrogen should do best in lower nitrogen periphyton habitats, that is areas not exposed to inputs of external DIN. There were several taxa that can nitrogen fix that demonstrated different distributions from the shoreline residential to the control zone. These include cyanobacteria and the diatoms that have symbiotic cyanobacteria, specifically *Epithemia, Rhopalodia* (Stancheva et al, 2013). The control zone appeared to have higher abundance of nitrogen-fixing periphyton compared to the residential zones during the fall deployment but the difference was not significant (KW-Tests, p=0.12). There were no significant differences in biovolume between the shoreline residential and control during either deployment. Further study would be required to clarify if the apparent difference was meaningful.

Periphyton community structure did not indicate a localized impact from septic leachate on Okanagan Lake during 2020.

Table 10: Taxa that were significantly different between the shoreline residential and control zones during each deployment

	Deployment Period	Algae Class	Taxa Name	Residential	Residential-n	Control	Control-n	p-value
Abundance (1000 cells/cm²)	July	Diatom	Nitzschia palea	2.7 ± 5.54	13	26.2 ± 12.4	4	0.041
		Diatom	Eunotia sp.	4.7 ± 8.5	13	21.9 ± 8.7	4	0.027
		Diatom	Caloneis sp.	13.5 ± 18.4	13	35.0 ± 16.0	4	0.013
		Green	Gloeothece sp.	55.9 ± 58.9	13	142.2 ± 63.2	4	0.040
		Diatom	Amphora ovalis	0.7 ± 2.4	13	8.7 ± 10.1	4	0.002
	Sept	Flagellates	nano and pico-flagellates	51.5 ± 81.2	9	1008.3 ± 1105.9	4	0.027
		Diatom	Diploneis sp.	ND	9	8.7 ± 10.1	4	0.027
		Green	coccoid colonial	ND	9	6.6 ± 8.4	4	0.013
		Diatom	Tabellaria fenestrata	1.9 ± 5.8	9	8.7 ± 7.1	4	0.047
Biovolume (million µm³/cm²)	July	Diatom	Nitzschia palea	0.8 ± 1.6	13	7.5 ± 3.5	4	0.041
		Diatom	Eunotia sp.	6.7 ± 12.1	13	31.3 ± 12.5	4	0.027
		Diatom	Caloneis sp.	8.1 ± 11.1	13	21.0 ± 9.6	4	0.013
		Green	Gloeothece sp.	1.7 ± 1.8	13	4.4 ± 2.0	4	0.040
		Diatom	Amphora ovalis	0.5 ± 1.7	13	6.2 ± 7.2	4	0.002
	Sept	Flagellates	nano and pico-flagellates	0.7 ± 1.1	9	13.1 ± 14.4	4	0.027
		Diatom	Diploneis sp.	ND	9	5.2 ± 6.1	4	0.027
		Green	coccoid colonial	ND	9	0.3 ± 0.3	4	0.013
		Diatom	Tabellaria fenestrata	3.8 ± 11.5	9	17.3 ± 14.1	4	0.047

Note: Analysis based upon series of KW-Tests with p-values listed | ND = not detected

3.5.3 Periphyton Growth Modeling

Model averaging is a statistical regression process that allows us to statistically assess the relative importance of water chemistry, temperature, and light data to the measured periphyton growth. Model averaging involves the creation of hundreds or thousands of individual linear models and averages the results from those to identify the parameters that most significantly affected the variable(s) in question, periphyton growth in this case. Figure 25 presents model average estimates for the descriptive predictors of periphyton growth split by abundance and biovolume with 95% confidence intervals. Based on the collinearity results (Figure 17), the following parameters were selected for inclusion in the models: TP, TDP, TN, temperature, luminosity (light), and chloride. Parameters not included were: TKN (collinear with TN), dissolved inorganic nitrogen species (all data below detection), and chlorophyll-a (not a predictive variable).

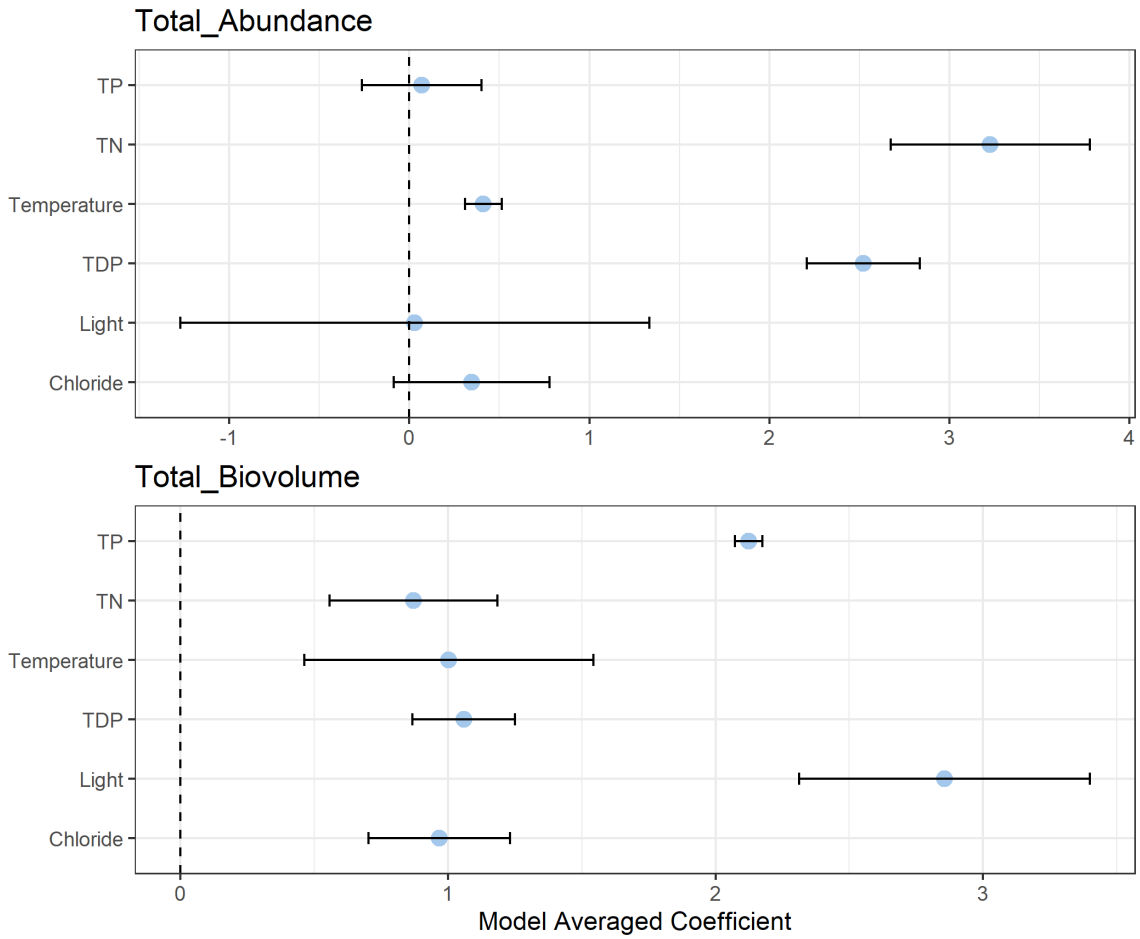


Figure 25: Model average results for periphyton total abundance and total biovolume

Positive averaged coefficients indicate that the parameter relates to periphyton growth while negative values relate to periphyton loss. All samplers began with zero growth, so all coefficients were positive. Parameters with a 95% confidence interval that cross 0 are not statistically significant. Results for parameters with wide confidence intervals were less reliable than those with tight confidence intervals.

The strongest predictive variables for total abundance were TN and TDP while temperature was less important. For total biovolume however, all parameters were identified as significant but TP and light were most important. Nitrogen and phosphorus are the primary nutrients to periphyton while temperature and light are well known to affect growth rates.

Periphyton classes respond differently to environmental stimuli, as would be expected based on their preferred environmental niches. For example, cyanobacteria prefer warmer water and were therefore the only periphyton class to have a significant response to water temperature (Appendix 4).

3.6 Incidental Observations

Residents expressed to LAC field staff that slime on rocks has noticeably increased over many years (no timeframe given), but this study cannot address this question with data collection over one growing season.

LAC observed cyanobacteria blooms in the north basin during summer and fall 2020. The cyanobacteria *Anabaena sp*. formed a light bloom in shallow water during August. This was followed by a *Planktothrix sp.* bloom in deeper water during the fall. The later was likely triggered by nutrients from the decomposing shore-spawning Kokanee. The *Planktothrix* bloom caused severe taste and odor problems for raw water intakes downslope from kokanee spawning zones (Figure 26). Both blooms indicate abundant phosphorus.



Figure 26: Kokanee spawning in north basin of Okanagan Lake during 2020 at a high (black) spawning zone
Source: LAC ROV photo

4.0 Discussion

Eutrophication remains one of the foremost impacts of industrialization and population expansion on aquatic ecosystems worldwide (Nelson et al. 2013). Urban stormwater, treated effluent, agriculture, and septic systems are important direct anthropogenic contributors of phosphorus to Okanagan Lake. Although at present most of Okanagan Lake would be classified as oligotrophic, it deserves an extra margin of safety to protect it from deterioration because of its use as a primary drinking water supply for over 100,000 people. Foreshore = xxxx; trends=xxxx This study involved a water quality and periphyton sampling program in Okanagan Lake near Killiney Beach and Westshore Estates to determine if there is any detectable impact from shoreline septic systems.

4.1 Water Chemistry

Water quality parameters of interest in areas serviced by septic systems were monitored at along the foreshore of Okanagan Lake from Killiney Beach to Westshore Estates and in an adjacent control area. These samples did not detect any statistically significant differences in chemistry parameters between residential and control sites in summer (Jun-Aug) or in fall (Aug-Oct) samples either separately or combined. Strong longshore currents move along the Okanagan Lake foreshore that would transport septic leachate, diluting as they travel. This likely reduced the differences between the shoreline residential and control areas.

Total nitrogen was not significantly different between the control site samples and the residential samples, and dissolved nitrate/nitrite/ammonia concentrations were never above detection limits in any samples during 2020. These findings indicate that the effect of septic effluents on nitrogen was too low to detect using water chemistry. Similarly, there was virtually no difference in total and dissolved phosphorus concentrations between the control and residential zones.

Some parameters such as TP were significantly higher in the foreshore samples than the pelagic areas of Okanagan Lake. This was attributed to the combined effects of groundwater inflow, sediment interaction with the water column, and sediment resuspension that together elevate nutrient conditions in the foreshore zone.

Other findings from the water chemistry sampling did not indicate strong correlations between nitrogen and phosphorus or with *E. coli* as could be expected if septic influence was severe.

Although the potential existed for water quality influence from shoreline residential, influences from were not detected in the water chemistry analyses. Because the water quality results did not show significant differences between residential foreshore and the control foreshore where water quality differences should have been greatest, we can assume that the impact of the Killiney-Westshore residential areas on the North Basin would be below statistical significance and likely below analytic detection limits.

4.2 Periphyton

Periphyton are especially useful as biological indicators of nutrient sources into lakes. Localized nutrient inputs such as streams or septic fields can cause identifiable changes in periphyton attached to nearby substrates (Stevenson and Stoermer 1982). The periphyton communities of the shoreline residential zone and the control zone had similar species compositions, indicating that the two areas were legitimately comparable, whereas completely dissimilar periphyton communities would not allow statistical comparison. It also means that any detected impacts at the residential area were not disruptive of typical community structure in the 2020 results.

No significant differences in periphyton abundance, biovolume, or species diversity occurred between the control and shoreline residential areas. There was significantly greater periphyton abundance in the fall samples compared to the summer but this was also true of the control samples, likely because of warmer water during the fall period.

Light intensity was a significant driver of periphyton growth in this study but no significant differences between the control or residential areas occurred for light intensity that could have affected periphyton responses and prejudiced study results.

Because the overall community response to nutrient addition may be dependent upon the increased growth of a small number of species, an understanding of indicator species can be critical (Fairchild et al. 1985). There were several taxa that were significantly different between the control and residential areas and in all cases, the control site had higher abundance and biovolume than the residential areas. There were three taxa of diatom that are considered sensitive to changes in water chemistry and may indicate a subtle reduction in water quality in the residential zones. Nitrogen-fixing periphyton can be used as a marker for subtle nitrogen loading and were elevated in the control compared to the residential zones during the fall deployment although the difference was too subtle to be statistically significant.

The observed cyanobacteria blooms in the N basin in 2020 suggest that nutrient tipping point may be approaching and that in the future, small increases nutrient loading may lead to disproportionate increases in productivity. Productivity in the nearby Armstrong Arm is always elevated relative to the balance of Okanagan Lake due to its shallower depth and agricultural/shoreline development in its watershed (Okanagan Lake Collaborative Study, 2019). For this reason, the water quality objectives are less stringent in this part of the lake than the deeper areas of Okanagan Lake further south (Appendix 5); despite the less stringent objectives, the Armstrong Arm consistently fails to meet the objectives and nitrogen and phosphorus were both trending up according to the 2019 collaborative study (Self and Larratt, 2020).

5.0 Conclusions

Water chemistry

Q1. Was there a difference between the developed and control areas in terms of water chemistry markers of septic influence and were those differences, if any, more prevalent during the high-use summer period?

No statistically significant differences were detected between the control and residential areas for water chemistry parameters selected during this study; several subtle but non-significant differences were noted that would require greater study to clarify. The highest concentrations of parameters that are septage constituents were seen in Zone A – the most developed zone. Chlorophyll-a was the only parameter significantly higher during the summer than the fall but this is likely related to time of year, preponderance of cyanobacteria during the fall, and not a result of septic leachate.

The lack of statistically significant differences between the control and residential areas may relate to strong longshore currents spreading out the effects of shoreline residential such that a true control area may not exist in the north basin.

Q2. Does shoreline residential development influence the water quality of North Basin Okanagan Lake?

It is not a question of if. Septic fields leak nutrients into the surrounding groundwater and this inevitably flows towards Okanagan Lake. Rather, it is a question of quantifying the scale of the impact of septic fields on Okanagan Lake relative to other inputs. This study did not detect statistically significant differences between the shoreline residential and control zones and was therefore unable to quantify the nutrient load contributed to Okanagan Lake by septic leachate but estimates from literature place it far below the contributions from the watershed creeks.

Periphyton

Q3. Was there a difference between the developed and control areas in terms of periphyton growth, and were those differences, if any, more prevalent during the high-use summer period?

No statistically significant differences between the control and developed areas emerged from periphyton abundance, biovolume, or species diversity. Cyanobacterial abundance across all sites was higher in the fall deployment compared to the summer deployment likely because their growth can benefit from the warmer fall water temperatures as demonstrate by the results from model averaging (see Appendix 4). However, there were increased representation by nitrogen-fixing algae at the control zone relative to the shoreline residential zones.

Q4. What parameters drove periphyton growth and were they related to septic leachate?

Based on the results from this study, the dominant drivers of periphyton abundance were TN and TDP while periphyton biovolume was most affected by TP. These parameters would be contributed by septic leachate but there were no significant differences between the areas with and those without nearshore septic fields for the parameters assessed in this study.

Overall

Q5. How did this study compare to a similar study of Cosens Bay, Kalamalka Lake?

While Cosens Bay is a sheltered bay on a smaller lake and not a perfect comparison to the Killiney foreshore of Okanagan Lake, the results from this study shared similarities to the Cosens Bay Study (Larratt and Self, 2015) such as higher phosphorus in the foreshore samples than those from the pelagic areas of both lakes. However, the two years of data collected for the Cosens Bay Study improved statistical confidence and allowed the detection of subtle effects on periphyton growth and community composition from the shoreline residential zones that were not detected in this study. Detecting septic influence in Cosens Bay is likely to be easier than detecting septic influence along N/S sides of Okanagan Lake that experience stronger wind-driven water currents.

In summary, impacts from the developed shoreline area of Killiney Beach, Evely Campsite and Westshore Estates are probable but were not statistically significant in the water quality or periphyton data from this 2020 study. The absence of statistically detectable differences in the near-shore periphyton does not mean that further development or increased use of this foreshore area would have no adverse effects.

6.0 Recommendations

This study could be repeated at regular intervals to watch for long-term change in water quality and periphyton growth. A program interval such as:

- every 5 years to follow trends
- the year following shoreline change such as new shoreline development, or removal of failing septic/pit toilets from a community
- the year of a dramatic event such as widespread algae blooms, extreme flooding, or a watershed failure (landslides, etc.)

The methodology employed in 2020 is appropriate and gave good results at a reasonable cost.

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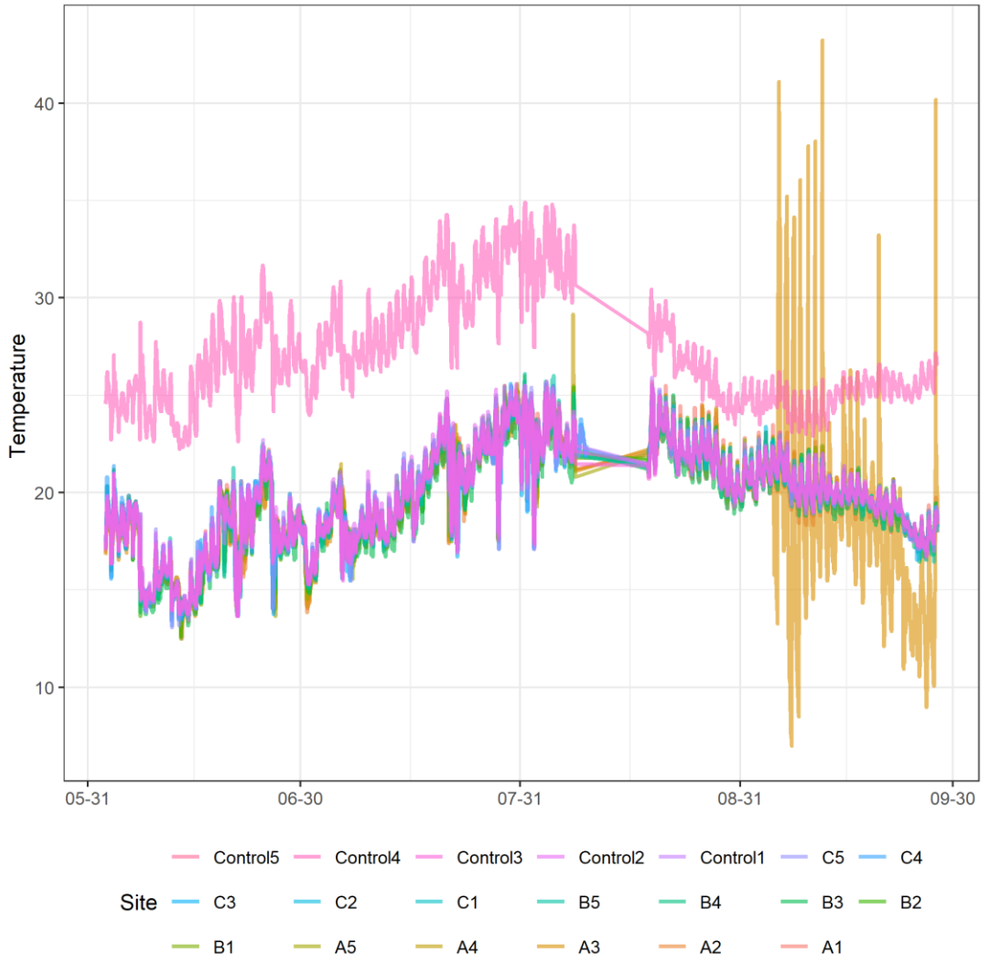
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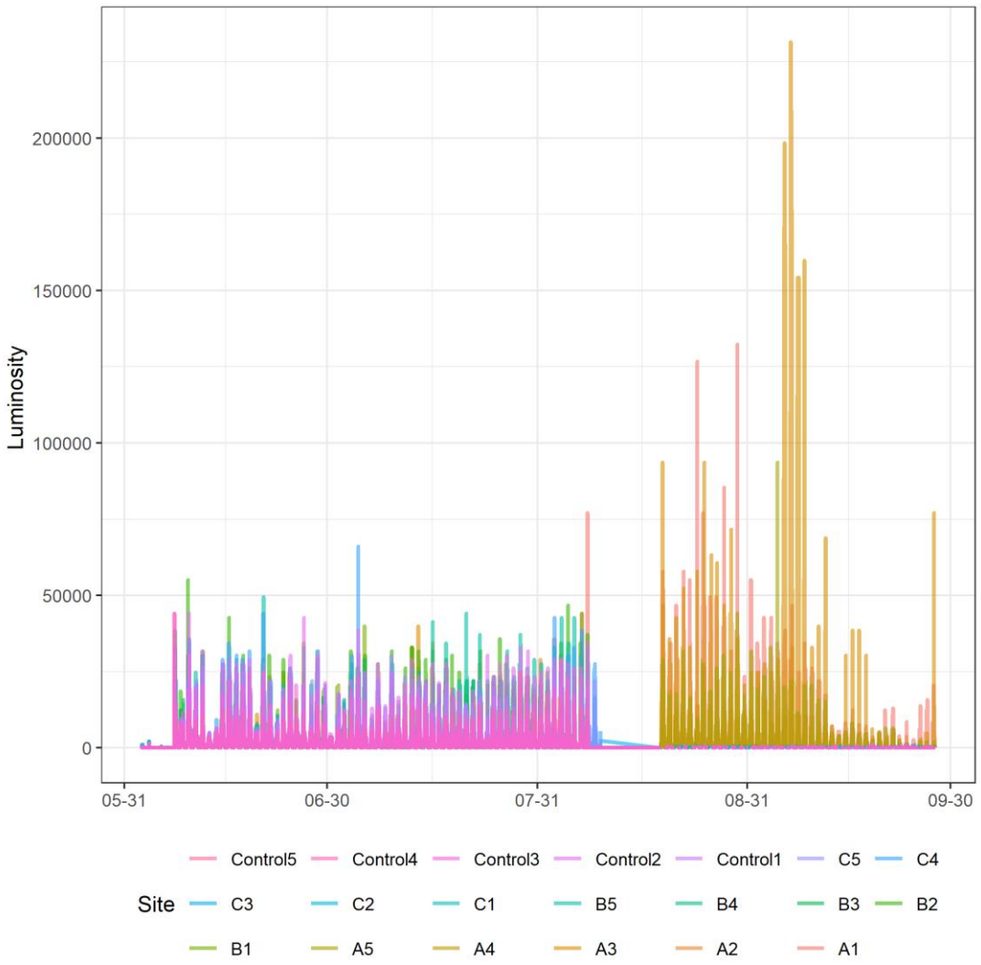
Appendices

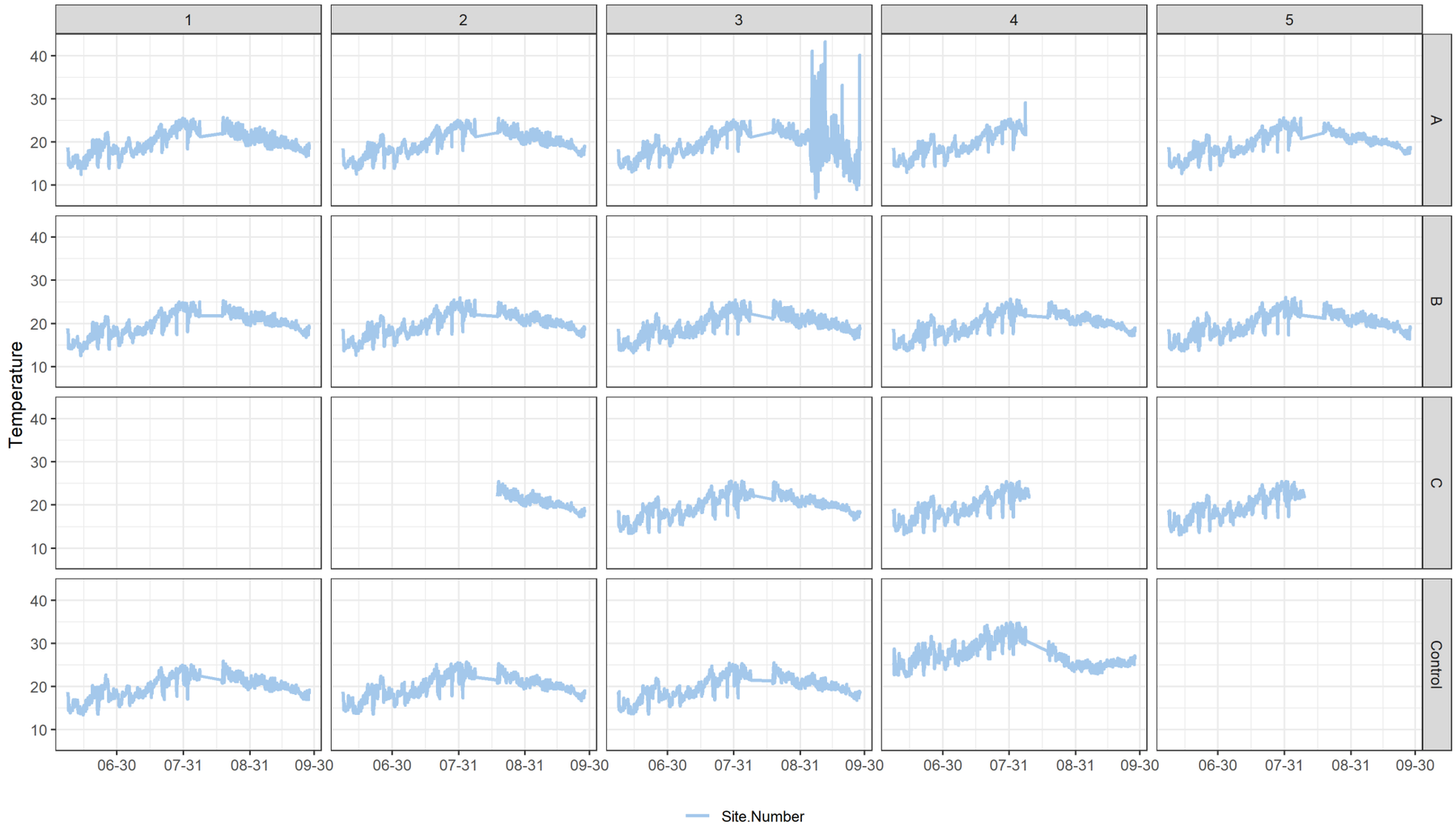
Appendix 1: Water Quality Data

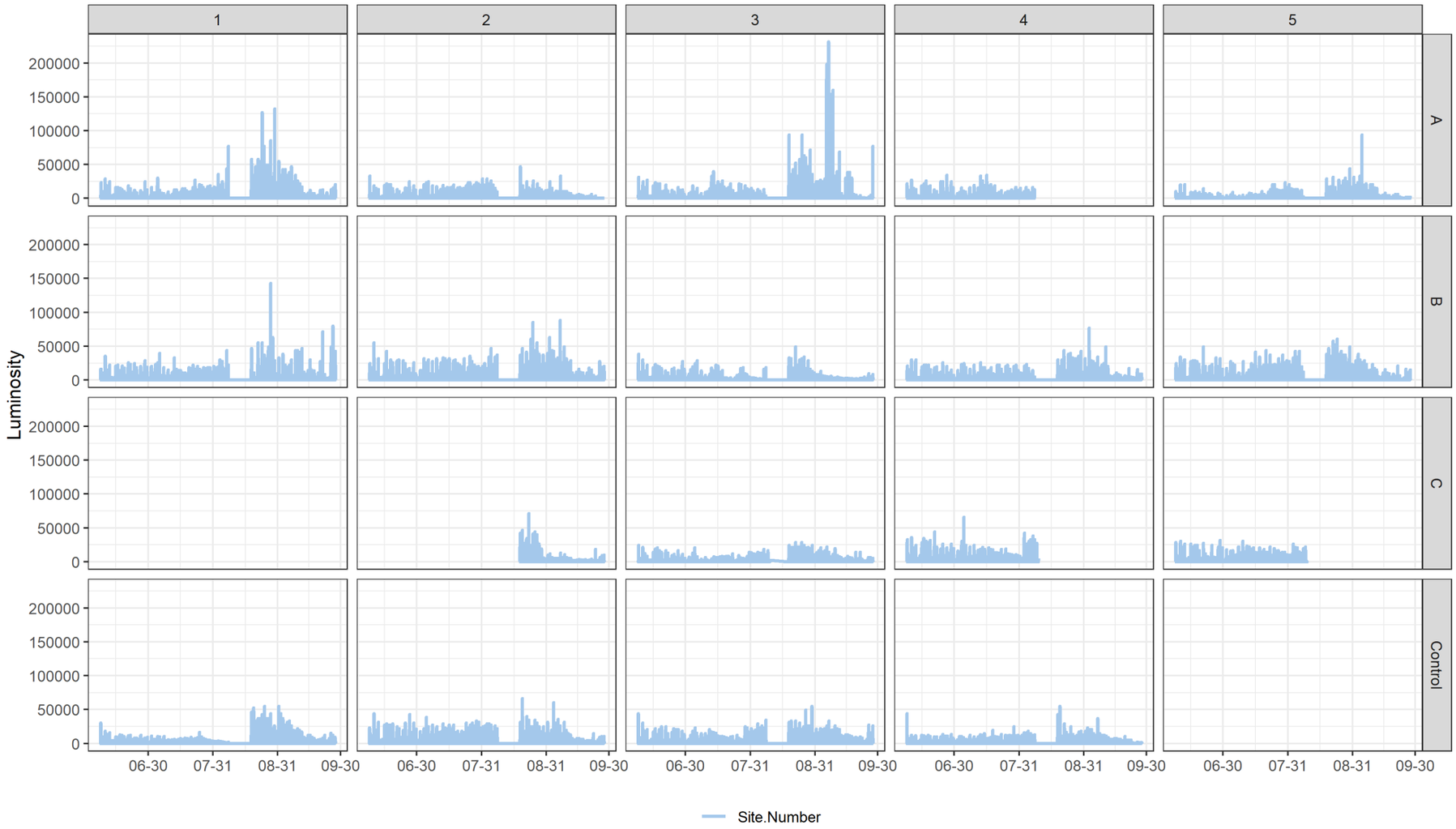
Site	Date	Chloride	NO3	NO2	NO3+NO2	TN	NH3	TKN	TP	TDP	Chl-a	Total.Coliforms	Fecal.Coliforms	E.coli
Zone A Composite	2020-09-29	5.49	<0.010	<0.010	<0.0100	0.256	<0.050	0.256	7.30E-03	5.60E-03	1.2	144	<1	<1
Zone B Composite	2020-09-29	5.42	<0.010	<0.010	<0.0100	0.223	<0.050	0.223	6.90E-03	5.70E-03	1.01	150	<1	<1
Zone C Composite	2020-09-29	5.51	<0.010	<0.010	<0.0100	0.276	<0.050	0.276	1.32E-02	6.00E-03	1.31	727	2	1
Control Composite	2020-09-29	5.54	<0.010	<0.010	<0.0100	0.259	<0.050	0.259	1.02E-02	7.80E-03	2.79	225	<1	<1
Zone A Composite	2020-09-09	5.49	<0.010	<0.010	<0.0100	0.291	<0.050	0.291	0.0069	0.0067	0.66	921	2	2
Zone B Composite	2020-09-09	5.36	<0.010	<0.010	<0.0100	0.424	<0.050	0.424	0.0069	0.0064	0.51	579	4	3
Zone C Composite	2020-09-09	5.39	<0.010	<0.010	<0.0100	0.2	<0.050	0.2	0.0071	0.0053	0.56	1200	1	1
Control Composite	2020-09-09	5.36	<0.010	<0.010	<0.0100	0.337	<0.050	0.337	0.007	0.0059	0.51	14100	<1	<1
Zone A Composite	2020-08-18	5.94	<0.010	<0.010	<0.0100	0.245	<0.050	0.245	0.0117	0.0052	2.12	1120	3	3
Zone B Composite	2020-08-18	5.74	<0.010	<0.010	<0.0100	0.27	<0.050	0.27	0.0095	0.0068	1.39	579	2	2
Zone C Composite	2020-08-18	5.64	<0.010	<0.010	<0.0100	0.241	<0.050	0.241	0.009	0.0071	2.29	461	4	2
Control Composite	2020-08-18	5.54	<0.010	<0.010	<0.0100	0.13	<0.050	0.13	0.009	0.0068	1.76	238	4	4
Zone A Composite	2020-07-07	5.6	<0.010	<0.010	<0.0100	0.186	<0.050	0.186	0.0107	0.0052	2.74	153	3.1	3.1
Zone B Composite	2020-07-07	5.48	<0.010	<0.010	<0.0100	0.213	<0.050	0.213	0.0081	0.0041	2.75	172	2.1	2.1
Zone C Composite	2020-07-07	5.42	<0.010	<0.010	<0.0100	0.169	<0.050	0.169	0.0078	0.0045	2.91	517	4.2	4.2
Control Composite	2020-07-07	5.37	<0.010	<0.010	<0.0100	0.206	<0.050	0.206	0.0088	0.0035	2.95	105	3	2.5
Zone A Composite	2020-06-08	5.26	<0.010	<0.010	<0.0100	0.204	<0.050	0.204	0.0167	0.0087	1.99			7.1
Zone B Composite	2020-06-08	5.16	<0.010	<0.010	<0.0100	0.266	<0.050	0.266	0.0114	0.0079	2.31			2.7
Zone C Composite	2020-06-08	5.14	<0.010	<0.010	<0.0100	0.264	<0.050	0.264	0.0094	0.0066	2.62			<1.0
Control Composite	2020-06-08	5.14	<0.010	<0.010	<0.0100	0.218	<0.050	0.218	0.0104	0.0043	2.48			1

Appendix 2: Thermistor Data for all Sites






1
2
3
4
5
A
B
C
Control
Temperature
40
30
20
10
06-30
07-31
08-31
09-30
Site.Number


1
2
3
4
5
A
B
C
Control
Luminosity
200000
150000
100000
50000
0
06-30
07-31
08-31
09-30
Site.Number

Appendix 3: Master Taxonomy Table

Raw taxonomic data is available upon request.

The following taxa were noted during this study.

Categorical Groupings	Taxa Name
D	Achnanthidium gracillimum
D	Achnanthidium minutissimum
D	Achnanthidium minutissimum var linearis
D	Amphipleura pellucida
D	Amphora bicapitata
D	Amphora ovalis
D	Amphora sp. (pediculus)
BG	Anacystis cyanea
D	Anomoeoneis sp.
BG	Aphanothece sp.
D	Asterionella formosa
D	Aulacoseira sp.
G	Botryococcus
G	Bulbochaete sp.
D	Caloneis sp.
FL	Chlamydomonas sp.
G	Chlorella vulgaris
FL	Chromulina sp.
BG	Chroococcus sp.
FL	Chroomonas
G	coccoid colonial
D	Cocconeis placentula
D	Cocconeis pseudothumensis
BG	Colonial Cyanobacteria
G	Cosmarium large
G	Cosmarium sp.
D	Cyclotella bodanica
D	Cyclotella comta
D	Cyclotella sp. small (rossi?)
D	Cymbella cistula
D	Cymbella sp.
D	Cymbella sp. sm (parva?)
D	Cymbella turgida
D	Denticula spp.
D	Diatoma hiemale
D	Diatoma vulgaris
D	Diploneis sp.
D	Encyonema caespitosum
D	Encyonema reichardtii

D	Encyonema sp.
D	Encyonema ventricosum
D	Epithemia sp. small
D	Epithemia turgida
D	Eucocconeis flexella
FL	Euglena sp.
D	Eunotia sp.
D	Eunotia tenella
FL	Flagellate Cyst
D	Fragilaria capucina
D	Fragilaria crotonensis
D	Fragilaria sp.
D	Fragilariforma virescens
D	Frustulia rhomboides
D	Frustulia sp.
G	Gloeothece sp.
D	Gomphonema minutum
D	Gomphonema sp. Sm
D	Hannaea arcus
G	Hyalotheca sp.
D	large pennate
BG	Leptolyngbya sp.
D	Melosira varians
D	Meridion anceps
G	Mougeotia sp.
FL	nano and pico-flagellates
D	Navicula gastrum
D	Navicula radiosa
D	Navicula sp.
D	Navicula sp. small
D	Nitzschia paleacea
D	Nitzschia sigma
D	Nitzschia sp. large
D	Nitzschia spp. small
FL	Not identified flagellates
FL	Ochromonas sp.
G	Oedogonium sp.
G	Oocystis sp.
BG	Oscillatoria spp.
G	Pandorina
D	Pennate
FL	Peranema sp.
D	Pinnularia brebisonii
D	Pinnularia sp.
BG	Planktosphaeria sp.

D	Rhopalodia gibba
G	Scenedesmus sp.
G	Scenedesmus sp. Large
G	Spirogyra sp.
G	Staurastrum sp.
D	Staurosira construens
D	Surirella ovalis (ovilaceum)
D	Surirella sp.
BG	Synechocystis sp.
D	Synedra acus
D	Synedra acus sm variety
D	Synedra nana
D	Synedra ulna
D	Synedra ulna, sm variety
D	Tabellaria fenestrata
D	Tabellaria flocculosa
G	Tetraedron
BG	Tolypothrix sp.
D	Ulnaria capitata

Appendix 4: Model Averaging Detailed Results

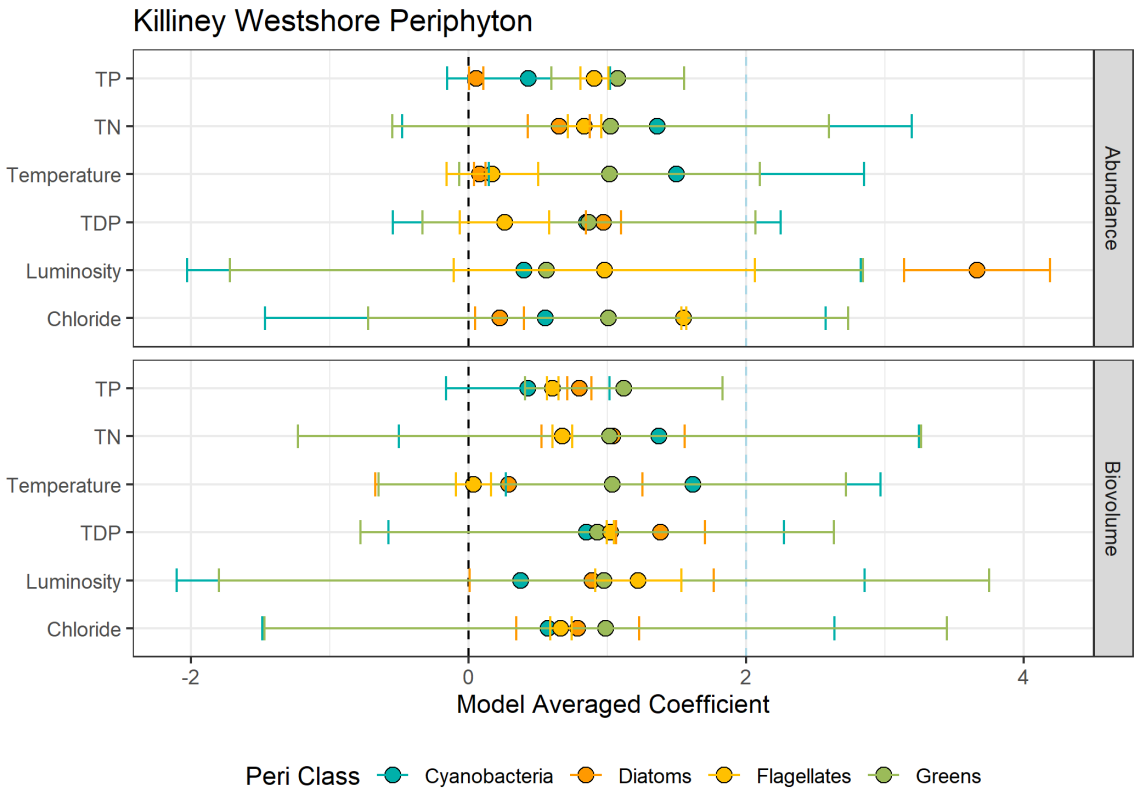


Figure 27: Mean coefficients and their 95% confidence limits of standardized explanatory variables of periphyton production

Appendix 5: Okanagan Lake Water Quality Objectives

Parameter (Nordin, 2005)	**Summerland**	**Kelowna**	**Ok Centre**	**Armstrong Arm**
Secchi Depth (growing season average: Apr-Sep)	>7m	>6m	>6m	>5m
Dissolved Oxygen (minimum in bottom waters)	-	-	-	>5 mg/L
TP (mg/L as P) (maximum at spring overturn)	<0.008	<0.008	<0.007	<0.01
Chlorophyll-a (µg/L) (maximum seasonal average)	<4.5	<4.5	<4	<5
TN (mg/L as N) (maximum at spring overturn)	<0.230	<0.230	<0.230	<0.250
N:P Ratio (spring weighted ratio)	>25:1	>25:1	>25:1	>25:1
Algae Taxonomy (% heterocystous cyanobacteria)	<5%	<5%	<5%	<5%
Algae Biomass (µL/L) (growing season average)	<0.75	<0.75	<0.75	<0.75
Zooplankton Biomass (µg/L) (growing season average)	>50	>50	>50	>50
Zooplankton Taxonomy (% cladocerans)	>5%	>5%	>5%	>5%

The following tables present information that supports the concepts used in this report.

Lake Classification by Trophic (Nutrient) Status Indicators

Trophic Status	chlorophyll-a ug/L chl-a	Total phosphorus ug/L as P	Total Nitrogen ug/L as N	Secchi disc m	Primary production mg Carbon/m^2/day	TSI Index
Ultra-oligotrophic	<0.95	<4	< 75	>10	> 50	<30
Oligotrophic (low nutrients)	1 – 2	4 – 10	<100	6 -12	50 - 300	30 - 40
Mesotrophic (moderate)	2 – 5	10 – 20	100 – 500	3 – 6	250 – 1 000	40 - 50
Meso-eutrophic	5 - 7	20 - 35	500 - 900	2 - 3		50 - 60
Eutrophic (high nutrients)	7 - 25	35 - 100	900-1500	1 - 2.5	>1 000	60 - 70
Hyper-eutrophic	>25	>100	>1500	<1		70 - 80+

(after Ashley 1996, Carlson 1983, Wetzel 2001, Carlson and Simpson 1996,Vollenweider and Kerekes, 1982, Kasprzac et al. 2008)

Nutrient Balance Definitions for Microflora Growth (Dissolved Inorganic N : Dissolved Inorganic P)

Phosphorus Limitation	Co-Limitation of N and P	Nitrogen Limitation
>15 : 1	<15 : 1 – 5 : 1	5 : 1 or less

After Nordin,1985

Okanagan Lake Collaborative Summary Results – 2019

Summary water quality results and attainment of objectives

Parameter		Summerland	Kelowna	Ok Centre	Armstrong Arm
Secchi Depth		8.9	8.1	8.0	4.0
Dissolved Oxygen		10.00	10.11	10.69	2.70
TP (mg/L)	0:10m:	0.004	0.007	0.007	0.010
	20-45m:	0.004	0.004	0.005	0.018
Chlorophyll-a (µg/L)		1.68	2.51	2.37	4.95
TN (mg/L)	0-10m:	0.231	0.229	0.231	0.248
	20-45m:	0.278	0.267	0.256	0.296
N:P Ratio	0-10m:	53:1	41:1	37:1	30:1
	20-45m:	64:1	62:1	51:1	18:1
Algae Taxonomy (% heterocystous cyanobacteria)		2%	3%		
Algae Biomass (µg/L)		0.295	0.822		
Zooplankton Biomass (µg/L)		34.9	51.6		
Zooplankton Taxonomy (% cladocerans)		7.0%	6.0%		

Legend:

Met objective in 2019	Did not meet objective in 2019	No Data/ No Objective

Okanagan Lake water quality trends (2011-2019)

Parameter	Summerland	Kelowna	Ok Centre	Armstrong Arm
Secchi Depth	-	-	-	-
Dissolved Oxygen	-	-	-	-
TP (mg/L)	-	-	↑	↑
Chlorophyll-a (µg/L)	-	↑	↑	↑
TN (mg/L)	-	-	-	↑
N:P Ratio	-	-	↓	↓
Algae Taxonomy (% heterocystous cyanobacteria)	-	-		
Algae Biomass (µL/L)	↑	↑		
Zooplankton Biomass (µg/L)	-	-		
Zooplankton Taxonomy (% cladocerans)	-	-		

Legend:

Met objective in 2019	Did not meet objective in 2019	No Data/ No Objective

↑ = Increasing Trend ↓ = Decreasing Trend - = No Trend

Appendix 6: Periphyton Tests of Difference

Comparison between housing and control zones for each categorical grouping during summer (July) and fall (Sept) deployments using KW-Test

Abun Biovol	Deployment Period	Peri Type	Shoreline residential-x	Shore. Res sd	Shore. Res.n	Control-x	Control-sd	Control-n	p-value
Abundance	July	BG	1,412,627	884,000	13	1,784,796	416,413	4	0.496906
Abundance	July	D	1,358,114	444,913	13	1,301,414	356,345	4	0.734095
Abundance	July	FL	37,688	26,581	13	26,247	8,749	3	0.683403
Abundance	July	G	208,630	164,605	13	196,853	49,749	4	1
Abundance	July	Total	3,017,059	1,071,820	13	3,302,748	313,543	4	0.650613
Abundance	Sept	BG	4,078,978	1,145,574	9	5,413,444	927,239	4	0.122823
Abundance	Sept	D	1,576,764	1,052,481	9	1,283,916	515,690	4	0.877371
Abundance	Sept	FL	73,742	96,087	7	1,028,008	1,124,839	4	**0.02179**
Abundance	Sept	G	241,084	211,208	9	367,458	195,242	4	0.164915
Abundance	Sept	Total	5,954,181	1,962,791	9	8,092,825	1,199,283	4	0.064078
Biovolume	July	BG	165,386,789	96,475,773	13	202,513,103	54,384,678	4	0.734095
Biovolume	July	D	1,060,979,116	466,392,237	13	1,407,908,765	403,198,424	4	0.212946
Biovolume	July	FL	3,246,552	4,731,015	13	341,211	113,737	3	0.634729
Biovolume	July	G	34,413,855	28,111,596	13	40,002,615	26,489,000	4	0.5713
Biovolume	July	Total	1,264,026,312	476,444,577	13	1,650,680,392	382,577,051	4	0.141032
Biovolume	Sept	BG	475,441,074	122,399,835	9	617,539,416	106,392,283	4	0.122823
Biovolume	Sept	D	1,115,671,508	482,670,063	9	1,005,647,243	480,107,799	4	0.643429
Biovolume	Sept	FL	5,083,169	10,641,876	7	25,477,088	21,610,120	4	0.058207
Biovolume	Sept	G	65,380,305	69,024,206	9	71,264,980	46,429,411	4	0.440401
Biovolume	Sept	Total	1,660,446,463	524,337,471	9	1,719,928,727	531,625,781	4	0.757621

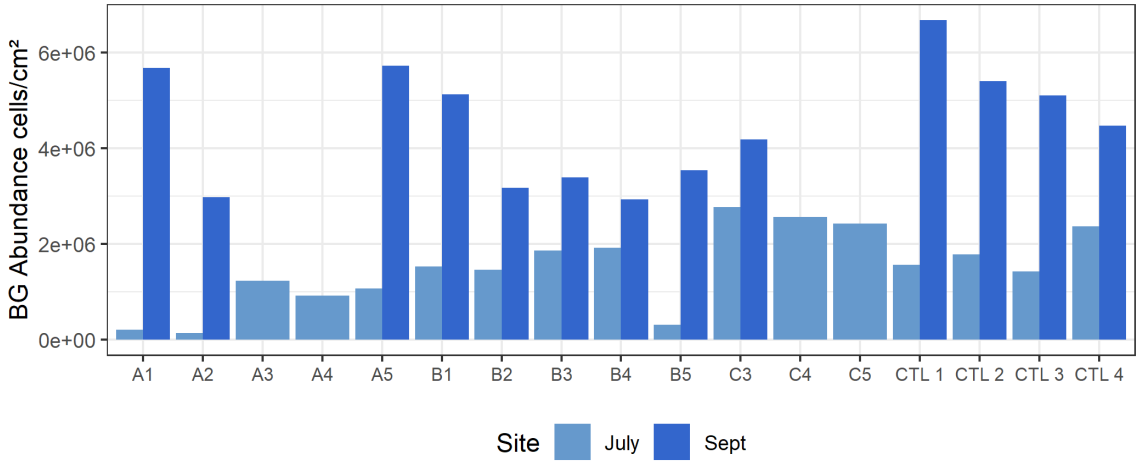
Note: Abundance units = cells/cm^2, biovolume units = µm^3/cm^2

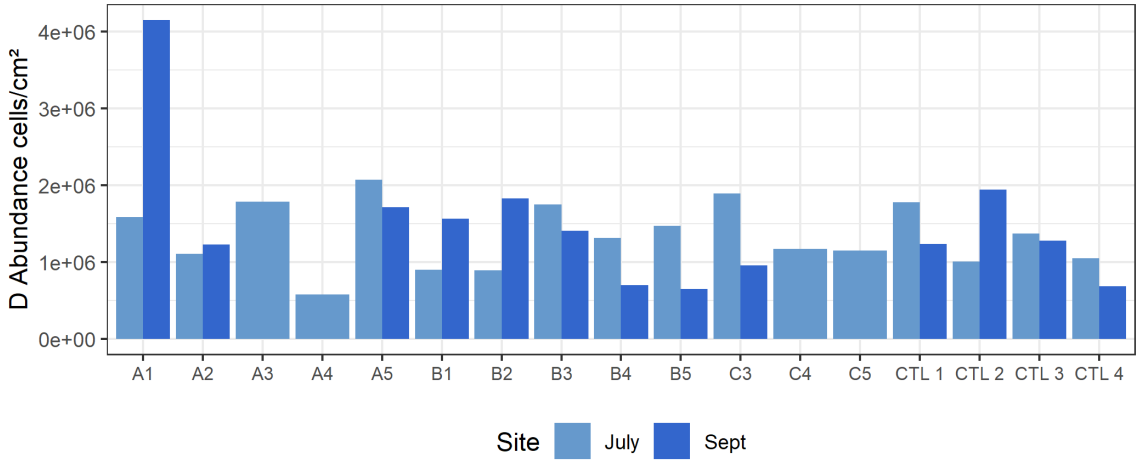
Comparison between summer (July) and fall (Sept) deployments for each major categorical grouping using KW-Test

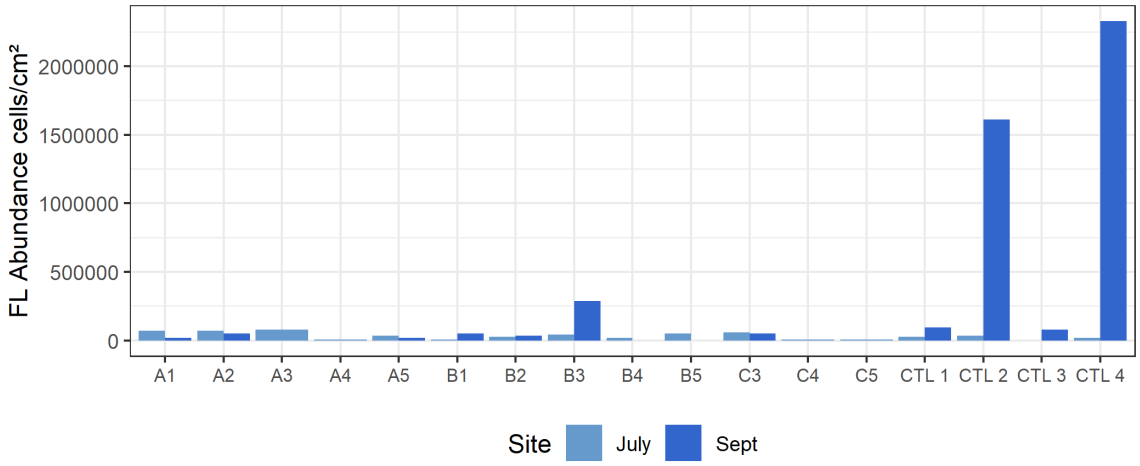
Abun Biovol	Peri Type	July-x	July-sd	July-n	Sept-x	Sept-sd	Sept-n	p-value
Abundance	BG	1,500,196	803,171	17	4,489,583	1,225,067	13	**3.75E-06**
Abundance	D	1,344,773	415,793	17	1,486,657	908,159	13	0.983305
Abundance	FL	35,543	24,428	16	420,747	785,439	11	**0.025534**
Abundance	G	205,859	144,263	17	279,968	207,255	13	0.36806
Abundance	Total	3,084,280	946,380	17	6,612,225	1,995,853	13	**1.01E-05**
Biovolume	BG	174,122,392	88,310,583	17	519,163,641	132,201,818	13	**3.75E-06**
Biovolume	D	1,142,609,622	465,438,509	17	1,081,817,888	464,470,675	13	0.66034
Biovolume	FL	2,701,801	4,390,830	16	12,499,140	17,717,714	11	0.066913
Biovolume	G	35,728,857	27,022,772	17	67,190,974	61,017,549	13	0.160905
Biovolume	Total	1,355,003,742	475,682,874	17	1,678,748,698	504,737,069	13	0.173772

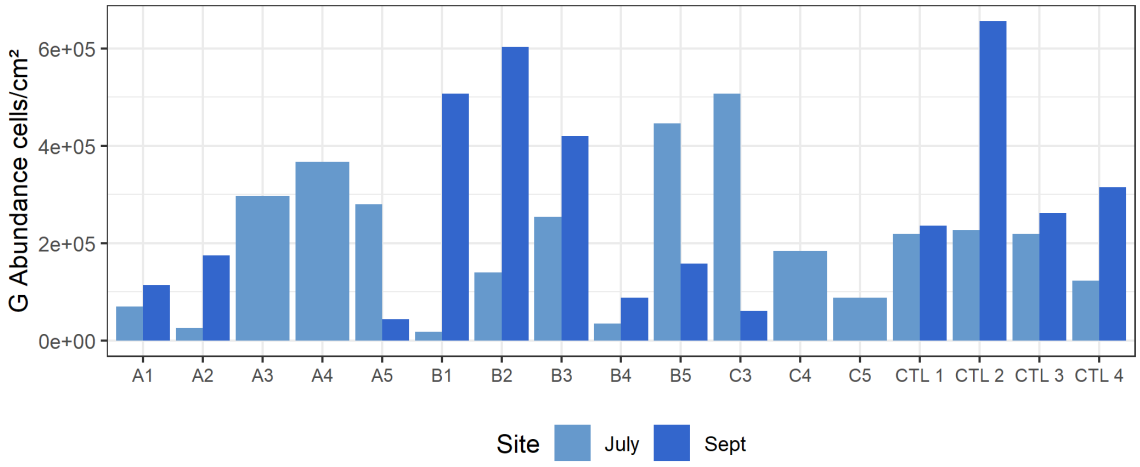
Note: Abundance units = cells/cm^2, biovolume units = µm^3/cm^2

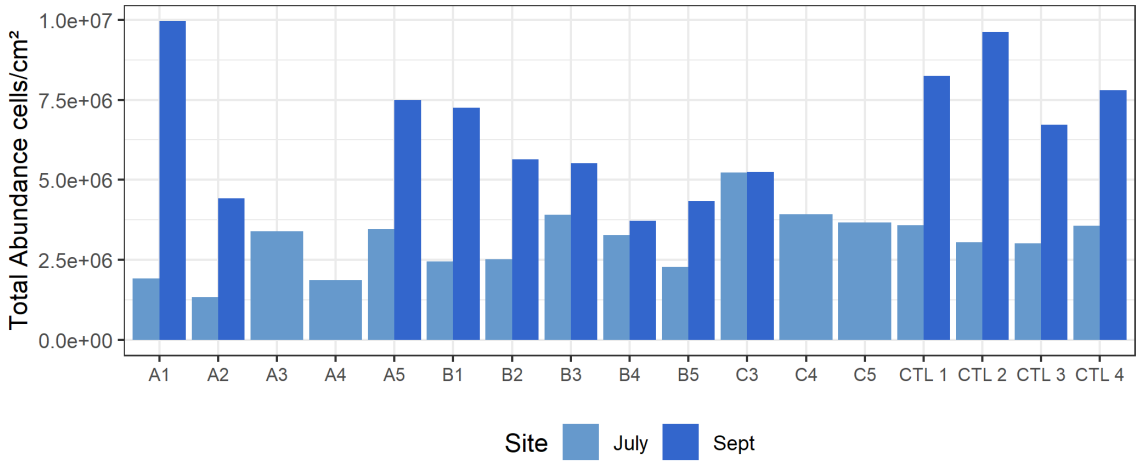
Appendix 7: Periphyton Results Graphs

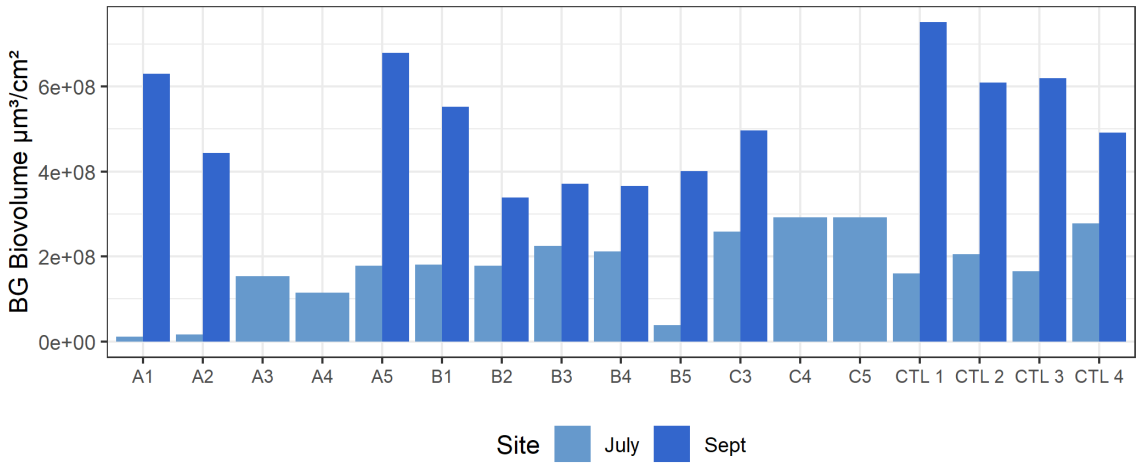


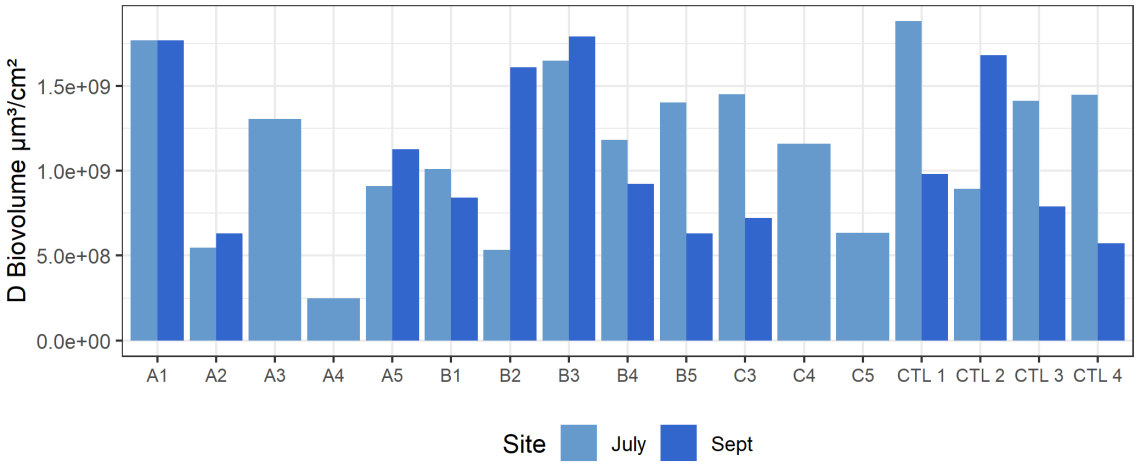


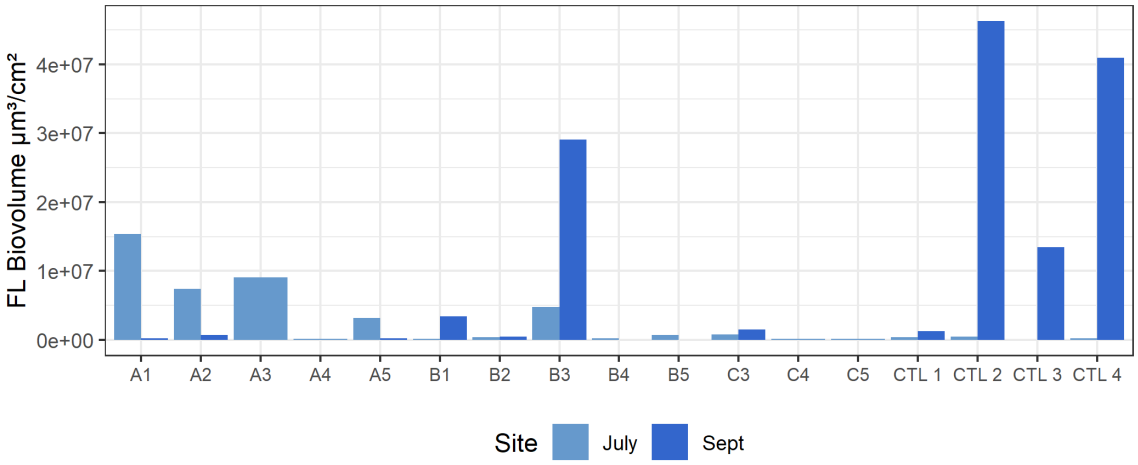


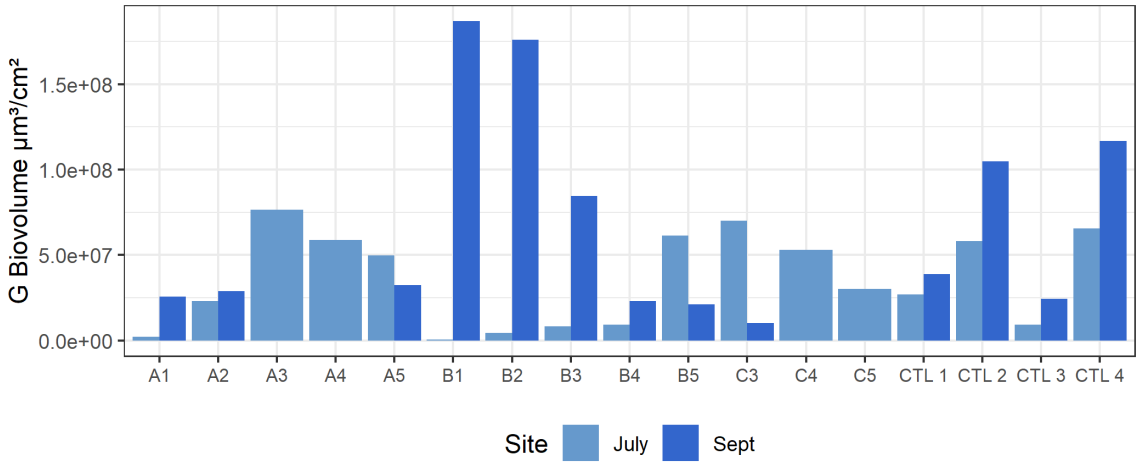

G Abundance cells/cm²
6e+05
4e+05
2e+05
0e+00
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 C3 C4 C5 CTL 1 CTL 2 CTL 3 CTL 4
Site July Sept

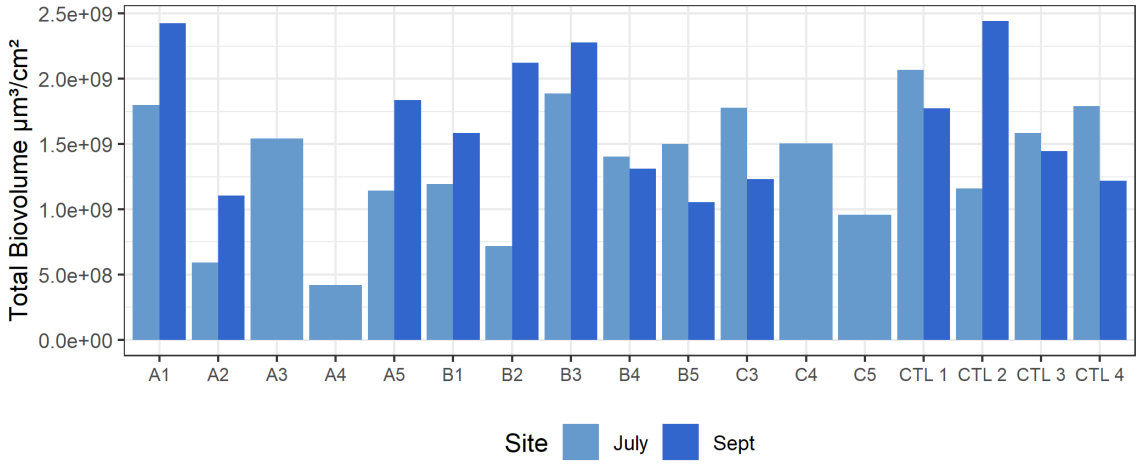

Total Abundance cells/cm²
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7.5e+06
5.0e+06
2.5e+06
0.0e+00
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 C3 C4 C5 CTL 1 CTL 2 CTL 3 CTL 4
Site July Sept


BG Biovolume µm³/cm²
6e+08
4e+08
2e+08
0e+00
A1 A2 A3 A4 A5 B1 B2 B3 B4 B5 C3 C4 C5 CTL 1 CTL 2 CTL 3 CTL 4
Site July Sept


D Biovolume µm³/cm²
1.5e+09
1.0e+09
5.0e+08
0.0e+00
A1
A2
A3
A4
A5
B1
B2
B3
B4
B5
C3
C4
C5
CTL 1
CTL 2
CTL 3
CTL 4
Site
July
Sept


FL Biovolume µm³/cm²
4e+07
3e+07
2e+07
1e+07
0e+00
A1
A2
A3
A4
A5
B1
B2
B3
B4
B5
C3
C4
C5
CTL 1
CTL 2
CTL 3
CTL 4
Site
July
Sept


G Biovolume µm³/cm²
1.5e+08
1.0e+08
5.0e+07
0.0e+00
A1
A2
A3
A4
A5
B1
B2
B3
B4
B5
C3
C4
C5
CTL 1
CTL 2
CTL 3
CTL 4
Site
July
Sept


Total Biovolume µm³/cm²
2.5e+09
2.0e+09
1.5e+09
1.0e+09
5.0e+08
0.0e+00
A1
A2
A3
A4
A5
B1
B2
B3
B4
B5
C3
C4
C5
CTL 1
CTL 2
CTL 3
CTL 4
Site
July
Sept

Appendix 8: 2016-2019 Phytoplankton Results and Comparison

Phytoplankton samples were collected at sites along the shoreline of Okanagan Lake between Killiney Beach and Westshore Estates from 2016-2019 as part of a study by RDCO to determine the ideal location for a new drinking water intake (Figure 28). The site and zone letters between that study and this study are comparable, that is Zone A and Site A are close etc. As part of this study, these results were re-analyzed to compare for a significant difference between the phytoplankton. While the total number of cells counted was highest at Site A and decreased towards Site C (at 20 m), the results did not show a statistically significant difference in phytoplankton densities between the three sampling locations (ANOVA, p=0.84).

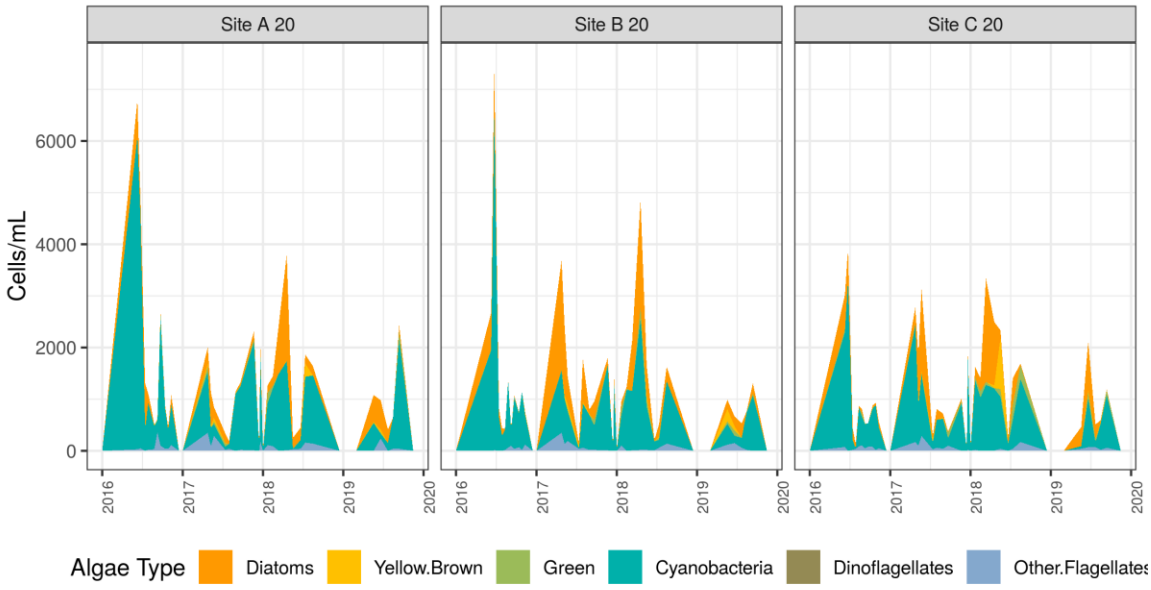


Figure 28: Phytoplankton results from samples along Killiney-Westshore area of Okanagan Lake, 2016-2019

----------End of Report----------

APPENDIX C

WESTERN WATER GROUNDWATER EXPANSION FEASIBILITY REPORT

February 28, 2021 WWAL Project 21-132-01VR

Regional District of Central Okanagan
1450 KLO Road
Kelowna, BC,
V1W 3Z4

Attn: Clarke Kruiswyk

Re: Feasibility Assessment of Increasing Capacity of the Fintry RDCO Community Water System Wells and Aquifer 358

Western Water Associates Ltd. (WWAL) is pleased to provide the following report for the above-noted project. The scope of work for the project was outlined in our proposal dated October 25, 2021.

1.0 PROJECT BACKGROUND

In 2010, the Regional District of Central Okanagan (RDCO) commissioned the drilling of two 200 mm diameter supply wells in Lower Fintry, on the alluvial fan created by Shorts Creek. The wells are 35 m and 45 m deep, and were completed in unconfined Aquifer No. 358 IIA. Testing found the wells to be highly productive, and in 2012 after the new pump house and water distribution system were built to serve Upper Fintry, Salal Rd and Valley of the Sun, the wells were commissioned. The Lower Fintry community (i.e. the neighbourhood where the wells are located) is not connected to the system and obtains water from Okanagan Lake.

1.1 Existing water system at Fintry

The water system design by TRUE Consulting called for an estimated average day demand (ADD) of 918 m^3/day and a peak day demand of 2,448 m^3/day, and we understand key components of the water system were designed and built to accommodate this capacity. WWAL hydrogeologists Ryan Rhodes and Douglas Geller oversaw the drilling and testing of those wells (Summit 2010), and in 2011 completed a Source Water Protection Plan on behalf of RDCO for the water supply wells (WWAL 2011). In order to develop the groundwater supply, RDCO purchased a vacant lot on Morden Road in Lower Fintry where the existing two-well system and pump house were subsequently built in 2011 and commissioned in early 2012. RDCO holds a Conditional Water Licence issued in 2017 that allows extraction of only 30,000 m3/year (far below the ADD of 918 m^3/day or 355,000 m^3/year), but allowing for a maximum daily well flow rate of 2,448 m^3/day that meets the system design criteria for MDD. The licence allows the water to be used in accordance with RDCO Water Services Bylaw 1254. Bylaw 1370 governs how the RDCO will provide water to properties within a water service area and how residents can use water.

1.2 System Expansion Options

It is our understanding that the RDCO is evaluating options to supply water to other areas of the Westside, specifically the Killiney Beach and Westshore Estates communities located north of Fintry. Two water supply options are being considered: a new deep intake on Okanagan Lake and groundwater from Aquifer 358. For the groundwater option, water could be provided by the existing community supply wells in Lower Fintry if spare

capacity exists and a water licence amendment is feasible, or from newly drilled wells (which would also require a licence or licence amendment). The RDCO also wished to understand whether additional groundwater extraction would affect existing well users, and to understand the effects of and sensitivity to climate change on groundwater supplies.

2.0 SCOPE OF SERVICES

WWAL completed the following for this project:

1. Developed an understanding of the additional water demand being sought, both average and maximum day demands. This included consideration of how many undeveloped lots existed within the current and contemplated expanded water system service area.
2. Reviewed available background information including the well completion report, driller's logs for wells in the area, historical water quality data, environmental studies of Shorts Creek, aquifer and geological mapping, hydrometric and climate data. Reviewed pertinent groundwater and surface water licenses.
3. Obtained and analyzed historical data from the existing Lower Fintry supply wells, including water consumption, water quality and water level data from the SCADA system. Assessed current well efficiency for comparison to original 2010 testing data.
4. Visited the Lower Fintry Well Site, assessed land use in the area and determined whether and where vacant land may be available for future well drilling if needed. Attempted to confirm other groundwater uses in Aquifer 358. Assessed potential impact of additional groundwater extraction from the aquifer on other wells using aquifer parameters derived from previous pumping tests and a distance-drawdown analysis.
5. Assessed the potential for climate change to affect groundwater availability. Using groundwater elevation data from the wells and Okanagan Lake, assessed the level of influence lake levels have on groundwater levels and developed a conceptual model of aquifer recharge to Aquifer 358. Assessed the relationship of Shorts Creek to the aquifer system.
6. Prepared this report with findings and recommendations.

3.0 HYDROGEOLOGICAL SETTING

In depth information regarding the hydrogeologic setting of the current water system supply wells is presented in the well completion report (Summit 2010) and the water system source water protection plan report (WWAL 2011). What follows is a brief summary of key information.

The current water system water supply wells are located on the alluvial fan created by Shorts Creek. The alluvial fan hosts an aquifer, mapped by the Province as Aquifer 358. The aquifer is unconfined and very productive. The principal form of aquifer recharge is from infiltrative losses from Shorts Creek. Losses from the creek near the apex of the fan just below the prominent set of waterfalls and along its channel to the lake creates a groundwater mounding effect. The direction of groundwater flow radiates from the apex of the fan; north of Shorts Creek

groundwater generally flows northwestward (WWAL 2018), while south of the creek groundwater flow is generally to the southeast. An additional and less significant component of aquifer recharge results from the direct infiltration of rainfall and snowmelt over the footprint of the aquifer.

Okanagan Lake exerts a strong influence on the water level in the aquifer, and during high and low water events, it may also influence creek water levels. As detailed in a later section of the report, water levels in the aquifer and lake rise and fall in unison with little or no lag time. Under pumping conditions, induced recharge from the lake could become a meaningful source of aquifer recharge.

The groundwater study completed by Golder and Summit (2009) for the Okanagan Basin Water Board Water Supply and Demand Project characterized the aquifer. For that study, the aquifer was identified as No. 259, and assigned a hydraulic gradient and hydraulic conductivity of 0.01 and 9.0 x 10^{-4} m/s, respectively. The estimated average groundwater discharge through the aquifer under ambient conditions was estimated at 7.62 x 10^{6} m^3/year. Averaged throughout the year, this equals a flow of approximately 242 L/s (3,800 US gpm).

Select construction details for the wells are provided in Table 3.1.

Table 3.1: Summary of Fintry Production Well Construction Details

Well ID	Diameter (mm / inch)	Finished Depth (m / ft)	Static Water level (m / ft)	Well screen details	Screen transmitting capacity
Well 1 (WPID29316)	200 / 8	34.5/113	4.1 / 13.5	• Top of screen assembly at 28.2 m (92.5 ft) • Screened interval 28.2 m to 34.5 m (92.5 ft to 113 ft) • 0.080" (80 slot) and 0.060" (60 slot) screens	420 US gpm (26.5 L/s)
Well2 (WPID17864)	200 / 8	44.1 / 144.7	3.7 / 12.0	• Top of screen assembly at 35.1 m(115ft) • Screened interval 35.1 m to 45.1 m (115 ft to 148 ft) • 0.100" (100 slot) and 0.080" (80 slot) screens used, separated by a blanked interval.	640 US gpm (40.3 L/s)

4.0 PROJECTED WATER DEMANDS FOR EXPANDED WATER SYSTEM

Projected water demands for the expanded system were estimated based on data provided by the RDCO and Urban Systems, as summarized in Table 4.1.

Table 4.1: Projected Water System Demands

Area	Current # connections	Full Build out # connections	Actual MDD (2021) L/s	Full Build-out MDD L/s	Full Build-out ADD[1] L/s
Upper Fintry / Shahal RD / Valley of the Sun (Current Service Area)	153	325	17.1[2]	20.3	8.1
Westshore Estates	290	526	15.2	32.9	13.2
Killiney Beach	296	427	17.3	26.7	10.7
			Total	**79.9**	**32.0**

Notes:

1) Full build-out MDD assumed to be 2.5 times ADD.

2) 2021 MDD for the current service area was higher than expected. See next section.

4.1 Analysis of SCADA Data for Existing System

The RDCO provided 2019 through 2021 water system SCADA data which included pumping rates, pump run hours, water levels and total volumes pumped. The pumps currently installed in the wells each have a typical operating rate of ~26 L/s, which is less than the rated capacity of the wells (31.5 L/s) provided in the well completion report (Summit 2010).

Figure 4.1 shows water consumption for the existing service area for the past three years and illustrates the significant increase in water use in July and August of 2021. Actual 2021 MDD for the existing water system service area was significantly higher than typical (more than three times higher than 2020) due to the prolonged drought and forest fires which impacted the Westside of Okanagan Lake.

Figure 4.1: Upper Fintry Water System Recent Water Consumption by Month

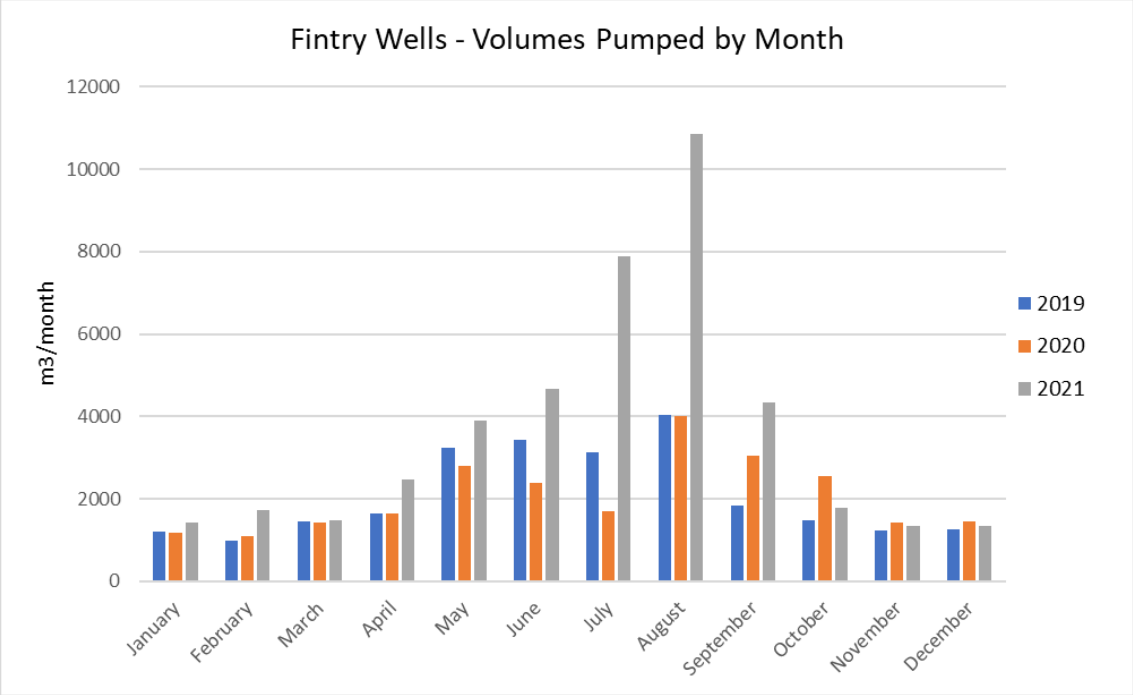


Figure 4.2 depicts monthly water consumption (expressed in m^3/month) in recent years along with source capacity for three scenarios:

1. Current source capacity with one well running at its current operating rate 24 hours per day.
2. Current source capacity with both wells running at current operating rates 24 hours per day.
3. Source capacity with both wells running 24 hours per day at their rated capacity of 31.5 L/s.

The data indicate that there is significant excess source capacity compared to current usage. Estimated ADD for the contemplated expanded service area could easily be met by the two wells with the existing pumps.

Figure 4.3 presents the same scenarios in units of m^3/day along with projected ADD and MDD. Again, this figure illustrates that ADD can easily be met by the two existing wells, but the two wells cannot meet projected MDD.

Figure 4.2: Recent Water Consumption by Month Compared to Source Capacity

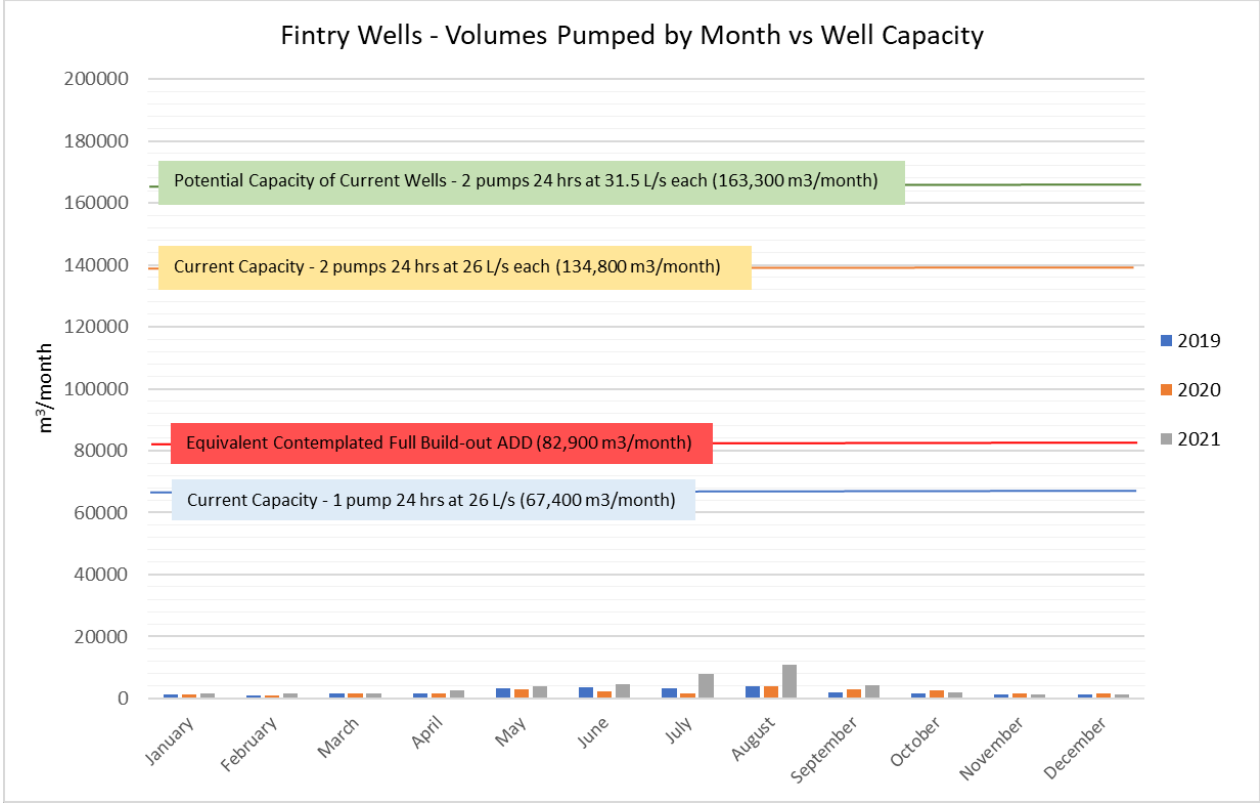
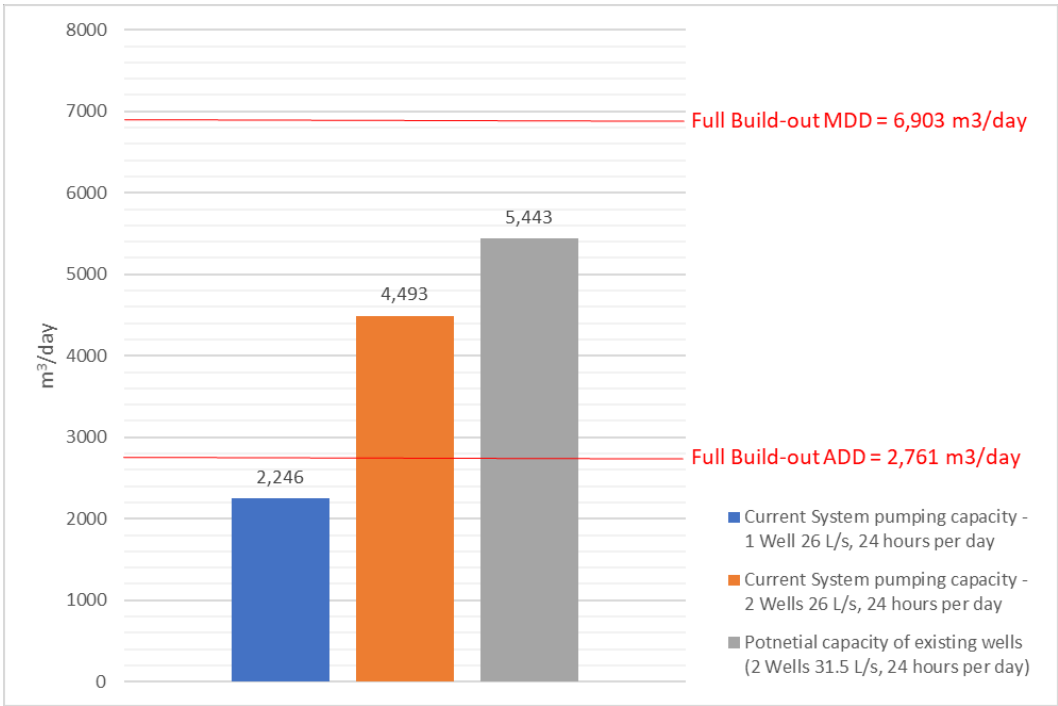


Figure 4.3: Source Capacity (m^3/day) Compared to Projected Demands for Expanded Water System



5.0 ASSESSMENT OF WELL SPECIFIC CAPACITY

Specific capacity (determined by dividing pumping rate by drawdown in a well) is an indicator of aquifer productivity and well efficiency. While the physical properties affecting an unconsolidated aquifer's productivity are typically stable over time, wells may become less efficient (require more drawdown to produce a given amount of water) over time due to chemical and mechanical changes on and around the well screen. These changes may include mechanical plugging by fine grained sediments around the well screen, geochemical reactions that result in chemical encrustation of the well screen or biological growth on and around the well screen. More than one of these factors can occur in a given well, and all contribute to a decrease in specific capacity. Periodic rehabilitation of wells can be required to maintain or restore specific capacity, and redevelopment can consist of both mechanical and chemical methods. The need for and frequency of rehabilitation varies, dependent on groundwater chemistry, well pumping rates and aquifer properties.

The Fintry wells have been in operation for over 10 years. As a check on well efficiency over time, specific capacity from the original testing was compared to specific capacity values derived from the SCADA data provided. In order to make a useful comparison, data from similar pumping rates, similar durations and similar water levels was compared, with results shown in Table 5.1. The data indicate that there has been a relatively minor decrease in specific capacity at both wells, on the order of 9% at Well #1 and 3-4% at Well #2.

Well #1 was completed first, at a shallower depth and was developed primarily with compressed air, while Well #2 was developed with the surge and bail method with a cable tool drilling rig. After initial testing of both wells in 2010, it was clear that Well #2 was much more efficient, and some additional development using the surge and

bail method was completed on Well #1 which was effective at increasing the specific capacity. It is possible that additional development at Well #1 could have been warranted.

In conclusion, both wells display relatively small declines in specific capacity over the last 10 years, and well re-development is not warranted at this time. A good rule of thumb is to schedule well rehabilitation works when specific capacity declines reach 15%. It appears Well #1 may reach this threshold first, perhaps in another five years time.

Table 5.1 Summary of 2010 and 2021 Specific Capacity

Well	Original Specific Capacity (April 2010)	April 2021 Specific Capacity
Well 1	8.9 L/s/m (pumping at 25.2 L/s)	8.0 to 8.2 L/s/m (pumping at 26 L/s)
Well 2	11.4 L/s/m (pumping at 25.2 L/s)	10.6 - 11.2 L/s/m (pumping at 26 L/s)

6.0 ASSESSMENT OF THE POTENTIAL FOR WELL INTERFERENCE

There are few wells in Lower Fintry with which the Fintry wells could interfere. On the south side of the Shorts Creek, there are only three other wells reported, one of which is abandoned (Figure 1). WWAL attempted to contact both property owners while at Fintry in early January 2021 but no one was home at either property. It is not clear whether either of these wells are in use, as the lower Fintry community is serviced by a water utility sourcing water from Okanagan Lake.

North of Shorts Creek, four wells are reported, one of which is abandoned. There is a shallow domestic well just north of Shorts Creek near the lake that is likely the domestic supply well for a Manor in the Provincial Park. Fintry Provincial Park obtains water from dedicated potable and irrigation wells, both of which are located more than 1.1 km to the north. These wells, which operate only seasonally, are not at risk of well interference from the RDCO wells.

Table 6.1 Summary of Reported Wells in Lower Fintry

Well Tag Number	Depth	Purpose	Driller Estimated Well Yield	Distance from Closest Fintry Water System Well
South of Shorts Creek				
82621		unknown		340 m
57019	12.2 m	irrigation	9.4 L/s	205 m
103882	abandoned			
North of Shorts Creek				
57494	6 m	Manor within Fintry PP, domestic supply	1.3 L/s	435 m
18228	abandoned			
70259	21.6	Fintry PP Domestic Supply Well	33.1 L/s	1,130 m
76776	23.2	Fintry PP Irrigation Well	6.3 L/s	1,130 m

Well interference was assessed during initial testing of the wells. After pumping Well #2 for 11 hours at 31.5 L.s, 0.23 m of interference was induced at Well #1 located 30 m away (Summit 2010). Pumping water levels had stabilized for several hours at this point. To assess the potential for water level interference at greater distances, we modelled the distance-drawdown relationship using Aqtesolv, a commercial hydrogeological analysis software, and data from the 2010 pumping tests. The analysis indicates that when pumping at 31.5 L/s (essentially the ADD of the contemplated water system), drawdown at a distance of 100 m from the pumping well is approximately 0.1 m. Drawdown declines to near zero at a distance of 220 m. Higher pumping rates, like those contemplated by the water system expansion, would result in larger drawdowns that reach farther, but not significantly so. Considering the small number of wells in the area (if present and actively used south of Shorts Creek), their distance from the supply wells and small modelled drawdown, its is our opinion well interference would not be an issue at the contemplated pumping rates. It is unlikely well interference effects would be measurable north of Shorts Creek.

7.0 WATER QUALITY

The RDCO provided WWAL with the results of comprehensive water quality sampling for recent years. That data, along with the data collected during original testing of the wells is summarized in Table 7.1. The data indicates water quality has remained stable over time and continues to meet all Guidelines for Canadian Drinking Water Quality. The only exception is one result for lead in 2013 which exceeded the MAC, but this is an isolated occurrence. Parameters associated with impacts from septic systems such as chloride, sodium and nitrate have been stable and all remain at very low concentrations.

Table 7.1: Fintry Raw Groundwater Quality

General Parameters	Date	2010-03-25	2010-04-20	2013-03-04	2014-03-17	2016-03-02	2018-03-06	2020-03-25	GCDWQ
	Sample ID	Well 1	Well 2	Morden	Booster Station	Booster Station	Booster Station	Booster Station	
	Units								
pH	--	8	8.08	7.84	8.01	7.98	7.92	8.07	7.0 - 10.5
Conductivity	us/cm	285	282	295	297	290	277	272	n/a
Turbidity (lab)	NTU	0.1	0.1	0.1	0.1	0.2	0.2	0.14	varies
TDS	mg/L	162	167	160	157	167	166	167	AO ≤ 500
Hardness, Total	mg/L	143	146	143	140	149	144	143	n/a
Alkalinity, Total	mg/L	143	149	149	144	151	157	164	n/a
Select Ions									
Fluoride	mg/L	0.15	0.12	0.11	0.12	0.12	0.11	<0.10	MAC = 1.5
Chloride	mg/L	0.74	0.8	0.97	2.94	3.07	2.45	0.62	AO ≤ 250
Nitrate, N	mg/L	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	MAC = 10
Nitrite, N	mg/L	<0.01	<0.01	<0.011	<0.010	<0.010	<0.010	<0.011	MAC = 1
Sulfate	mg/L	7.2	7.3	8.8	7.5	7.9	7.4	7.4	AO ≤ 500
Selected Total Ions and Metals									
Aluminum	mg/L	0.008	0.014	<0.05	<0.05	<0.05	<0.0050	<0.0050	AO < 1.0
Antimony	mg/L	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.00020	<0.00020	MAC = 0.006
Arsenic	mg/L	0.0016	<0.0005	<0.005	<0.005	<0.005	<0.00050	<0.00050	MAC = 0.01
Barium	mg/L	0.0125	0.0138	0.07	<0.05	<0.05	0.0103	0.0126	MAC = 2
Boron	mg/L	0.008	0.006	<0.04	<0.04	<0.04	0.0095	0.0105	MAC = 5
Cadmium	mg/L	<0.00001	<0.00001	<0.0001	0.0001	<0.0001	<0.000010	<0.000010	MAC = 0.005
Calcium	mg/L	44.4	42.9	43	42	45.4	43.6	42.8	n/a
Chromium	mg/L	0.0014	0.0015	<0.005	<0.005	<0.005	<0.00050	<0.00050	MAC = 0.05
Copper	mg/L	0.0012	0.001	<0.002	0.025	0.036	0.0209	0.00152	MAC = 2, AO ≤ 1
Iron	mg/L	0.05	0.07	<0.1	<0.10	<0.1	0.03	0.038	AO ≤ 0.3
Lead	mg/L	0.0001	<0.0001	0.012	<0.001	0.001	<0.00020	0.00174	MAC = 0.01
Manganese	mg/L	0.0016	0.0013	0.003	<0.002	<0.002	0.00065	0.00106	MAC = 0.12, AO ≤ 0.02
Selenium	mg/L	<0.0003	<0.0003	<0.005	<0.005	<0.005	<0.00050	<0.00050	MAC = 0.05
Sodium	mg/L	5.37	6.81	6.3	8.1	9.2	7.47	5.65	AO ≤ 200
Uranium	mg/L	0.003	0.00305	0.0024	0.0026	0.0029	0.00279	0.00295	MAC = 0.02
Zinc	mg/L	0.007	0.019	<0.04	<0.04	<0.04	<0.0040	<0.0040	AO ≤ 5
Microbiological Parameters									
Total Coliforms	CFU/100mL	<1	<1	--	--	--	<1	--	MAC = non-detect
E.Coli	CFU/100mL	<1	<1	--	--	--	<1	--	MAC = non-detect

7.0 ASSESSMENT OF CLIMATE CHANGE IMPACTS ON GROUNDWATER AVAILABILITY

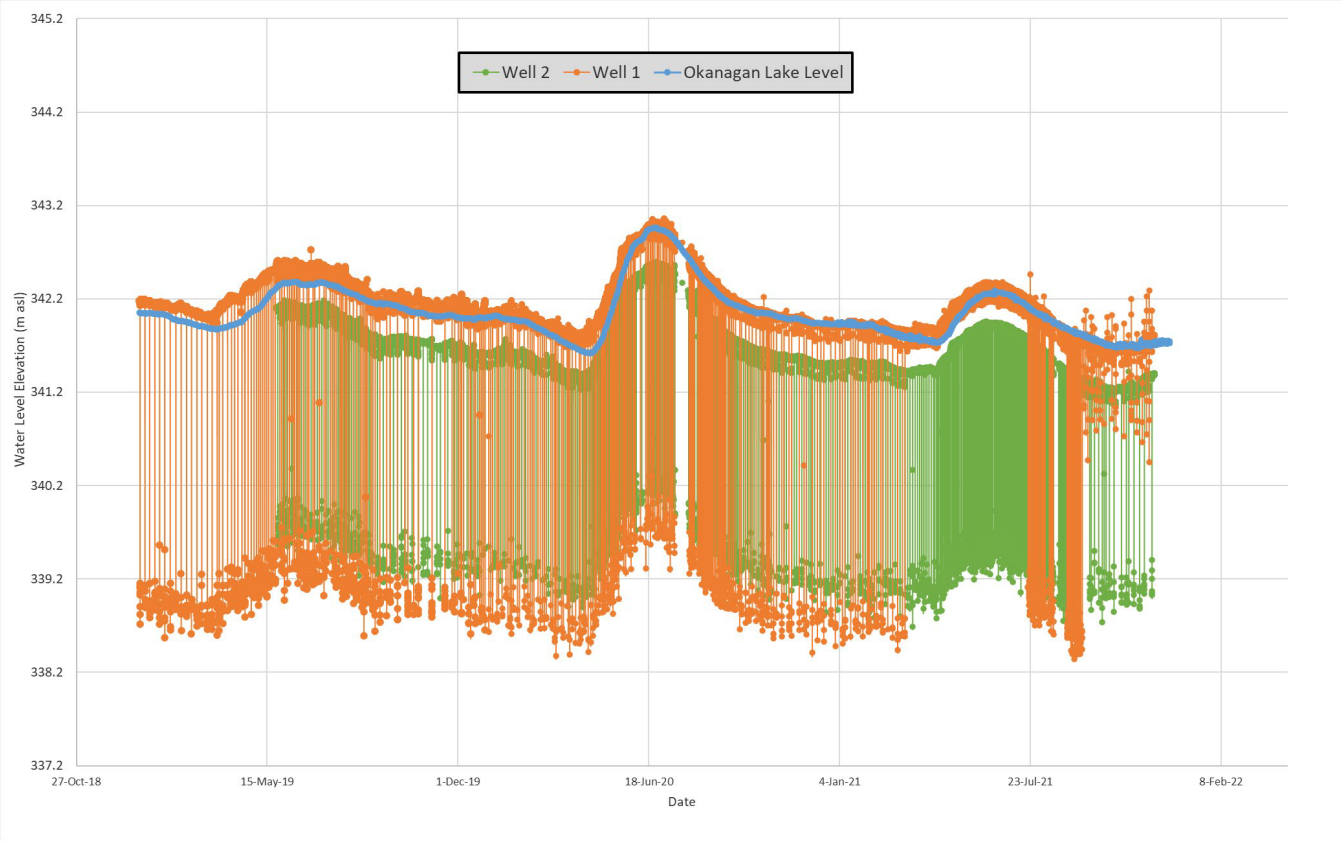
The Pacific Climate Impacts Consortium (PCIC) climate change summary for the Thompson-Okanagan Region (PCIC 2013) forecasts warming in all seasons, with the largest projected increase in the summer. The average prediction of multiple climate change models predicts that average summer temperatures will increase by 2.2°C over the 1961-1990 average summer temperature by 2050. Precipitation is expected to increase in the autumn through spring and decrease in the summer months. Coupled with rising temperatures, this could mean more precipitation falling as rain at low and mid-elevations and decreased mid-elevation snowpacks. At higher elevations, the projected increase in precipitation could result in increased snowpacks and a higher potential for spring flooding. The climate change summary acknowledges that the topography in the Thompson-Okanagan region is highly variable and that climate change effects may therefore vary significantly over short distances. Climate change projections for the Okanagan Regions were updated in a 2020 document commissioned by the Okanagan Basin Water Board and the three Regional Districts in the Okanagan Valley (Pinna Sustainability 2020). Climate projections were based on an ensemble of climate models developed by the PCIC and are largely the same as the 2013 document. The main expectations remain warmer temperatures year round particularly in the summer, with increased precipitation in the fall through spring (17% increase) and drier summers than in the past.

As mentioned previously, the main source of recharge to the Lower Fintry aquifer is losses from Shorts Creek. There is no current hydrometric station on Shorts Creek, but one was present from 1969 to 1982 located near the mouth of the creek. The hydrograph of the creek is typical of Okanagan streams, with a freshet dominated peak in runoff lasting approximately two months in the April to June range. A report on Shorts Creek prepared by the Ministry of Environment indicated that in some years no flow was observed at the mouth of the creek while flows were still present in the highlands to the west (Summit 2010). This is due to the permeable nature of the fan materials, when seepage losses are greater than streamflows reaching the fan. In the absence of visible streamflow across the fan, the aquifer is likely still being recharged by subsurface flows down the Shorts Creek drainage.

While Shorts Creek is the primary aquifer recharge source under ambient conditions, Okanagan Lake is inferred to be the primary control on aquifer water levels and the rate of groundwater flow through the system, and under high-rate and extended pumping conditions, the lake may become a significant or the dominant recharge source. As a check on the relationship between groundwater levels and lake levels, we determined groundwater elevations based on survey data contained on the Morden Road pump house as built and a spot water level measurement made on January 11, 2022. We then used this measurement to convert the SCADA water level data (which reads water level above the transducer) to geodetic, and compared the groundwater levels to Okanagan Lake water levels as recorded at Water Survey of Canada hydrometric station 08NM083 (Water Survey Canada 2022). The results of this comparison are shown on Figure 8.1 and indicate that lake levels and groundwater levels rise and fall in unison with little or no time lag. The lake elevation matched very well with the groundwater elevation calculated for Well #1. We caution that there may be some error in our conversion of groundwater levels to geodetic, as the conversion was based on a surveyed ground surface elevation next to each well head which may have changed slightly over time, and because the water level SCADA data was adjusted based on one spot measurements in January 2022. For example, the groundwater elevation at Well 2 should not be lower than the lake level as indicated on Figure 8.1. We expect that on a long-term average basis, groundwater levels at both

Wells #1 and #2 would typically trend slightly higher than the lake, resulting from a groundwater mounding effect caused by infiltration under Shorts Creek and owing to the fact that groundwater flow is toward the ultimate discharge point of Okanagan Lake. For relatively short periods during high lake level events, the groundwater gradient could flatten or locally be reversed with water moving from the lake into the aquifer.

Figure 7.1: Comparison of Groundwater Levels in Aquifer 358 to Okanagan Lake Levels



With the strong relationship between aquifer and lake levels confirmed, the level of Okanagan Lake is the primary factor affecting the availability of groundwater for the supply wells. Okanagan Lake levels are controlled in a fairly tight target range by the Province, with the dam in Penticton. Lake level targets were set in 1974, and reaffirmed in 1982 (OBWB 2019). The 1982 Okanagan Basin Implementation Board set the target lake levels that remain in place today. That document states that Okanagan Lake is managed within a range of 341.3 m asl to 342.5 m asl in all but anticipated extreme flood years and successive drought years. Under prolonged drought conditions, the lake may be drawn down by up to 0.9 m below the target low, to an elevation of 340.4 m asl (ENV 2000), a level not reached in the 2021 drought (Water Survey Canada 2022). The lake level exceeded 343.2 m asl in the 2017 flood event (Associated Environmental 2017).

Recent flood hazard assessment work in the Okanagan Valley that considers climate change has led the OBWB to call for a review of how Okanagan Lake is managed (OBWB 2021). Presumably, in order to account for increased freshet flows or rain on snow events, Okanagan Lake could be pre-emptively drawn down in the late winter to accommodate those inflows.

While the changing climate could eventually lead to a change in the way water levels in the lake are managed, it appears unlikely that regulation of the lake will be dramatically altered such that the available drawdown in the aquifer and by extension the productivity of the Fintry production wells will be impaired. A one metre decrease to the lake low level target would be significant and unlikely. Based on the performance parameters of the wells, a one metre decrease in lake levels will not affect the yield or total volumes available from the wells.

In completing our research on the control of lake levels, we briefly reviewed a document prepared by the OBWB outlining proposed drought stage trigger guidelines for Okanagan Mainstem Lakes and River (OBWB 2019). This document suggests using lake levels as the main factor in determining drought level and decision-making related implementation of drought management plans and water restrictions. This same framework could potentially be applied to the Fintry production wells given the strong control on groundwater water levels the lake exerts.

8.0 REGULATORY CONSIDERATIONS

In this section, we review the pertinent legislation and regulations that would govern the increase in capacity of the lower Fintry groundwater supply system, which are water licensing under the *Water Sustainability Act* and environmental assessment under the *Environmental Assessment Act*. Both of these pieces of legislation have regulations that result in timelines that can be lengthy, on the order of many months to years depending on the project. It will be important to engage the respective ministry staff responsible early in the project in order to plan properly for meeting these regulations while keeping to a timeline to build the project.

8.1 Water Licensing under the *Water Sustainability Act*

WWAL was provided with and reviewed the groundwater licence issued to the RDCO for the Upper Fintry water system, as well as the surface water licences associated with the existing Killiney Beach and Westshore Estates water systems. Select details of these licences are summarized in Table 8.1. All licences indicate water can be used year-round.

First, with regards to the water licence associated with the current Upper Fintry Water System, we note that the annual licensed volume was sufficient for 2019 and 2020 where consumption was in the 25,000 m^3/year range. In 2021, water usage increased significantly (43,208 m^3) due to the drought and fires that occurred on the Westside, both of which could be considered exceptional events. As already noted, the maximum daily withdrawal limit on the licence meets the original design criteria and would be adequate to meet current and full build-out MDD for the Upper Fintry system. The RDCO should apply for expanded licence capacity for the existing wells to match the current water system ADD. This application, if submitted, could trigger additional technical information requirements. One of the technical issues could potentially involve an assessment on whether increased groundwater withdrawal could have an impact on low flows of Shorts Creek, particularly near its mouth. The 2020 Environmental Flow Needs (EFN) assessment of Shorts Creek (ONA 2020) suggested that based on the existing situation, meeting EFNs on Shorts Creek is “problematic.” This suggests that the Ministry water officer reviewing a licence amendment application would need to consider EFNs in making a licence decision.

Table 8.1: Summary of Water System Water Licences

	Licence Number	Licence Type	Licence Status	Annual Volume (m^3)	Daily Max (m^3)
Upper Fintry Water System	500183	Groundwater	Current	30,000[1]	2,448
Killiney Beach					
Okanagan Lake	60438	Surface Water	Current	364,221	2,998
Norris Creek	61569	Surface Water	Current	112,834	773
Hope Creek	61570	Surface Water	Current	76,993	526
Westshore					
Okanagan Lake	41569	Surface Water	Current	142,702	391
Okanagan Lake	43787	Surface Water	Current	299,508	819
			Total	**1,026,258**	**7,955**
Contemplated Water System ADD				1,009,152	2,765
Contemplated Water System MDD				N/A	6,903

Second, should the RDCO proceed with amalgamating the water systems, in theory (and on paper) there is enough licensed capacity on the whole to cover the projected ADD of the combined water system at full build out. There is also enough daily maximum capacity associated with the licence to cover the projected combined MDD. It would have to be confirmed with the MFLNRORD, but we believe it is feasible for an amalgamation of water licences to occur. The surface water licences associated with Killiney Beach and Westshore Estates are either on Okanagan Lake or tributaries to the lake, and the aquifer in which the Upper Fintry wells are completed is hydraulically connected to and ultimately discharges to Okanagan Lake. As such it reasonable to propose abandoning licences associated with surface water in exchange for an equivalent expansion to the Upper Fintry groundwater licence. The Province would likely look favourably on this exchange, as it would reduce potential low flow issues with Hope and Norris Creeks and potentially increase habitat values along those drainages.

8.2 Environmental Assessment under *Environmental Assessment Act*

Under the B.C. *Environmental Assessment Act*, a groundwater extraction project is reviewable if the design capacity of the system exceeds 75 L/s or for an existing system greater than 75 L/s if a 35% expansion in capacity is proposed. We note that the full build-out MDD of the combined water systems of 79.9 L/s exceeds the 75 L/s groundwater extraction threshold. In addition, there has been a recent amendment to this Act which requires large groundwater users within 15% of the threshold (64 L/s) to consult with the Environmental Assessment Office (EAO). The Environmental Assessment process can be lengthy and expensive. The fact that the system ADD would be much less than the threshold and that the proposed extraction would be a replacement and amalgamation of

[1] The Fintry groundwater supply system is designed for ADD of 918 m^3/day which is 335,000 m^3/year. It is not known why the licence was issued for less than the design ADD but adequate for the design MDD. This apparent discrepancy will need to be addressed.

several direct withdrawals from the lake would be supportive of a potential application to the EAO for an EA exemption. The exemption process itself is fairly involved and if successful, would result in a Ministerial Order with conditions (e.g. monitoring, limits on withdrawal, etc). More investigation and preliminary discussions with the EAO would be required to confirm whether an environmental assessment would be required for the contemplated project. It is our understanding that MFLNRORD prefers that the EAO requirements be met prior to making a water licence decision on an integrated application submitted under the B.C. *Environmental Assessment* and *Water Sustainability Acts*.

9.0 CONCLUSIONS

Based on our assessment we offer the following conclusions:

C1 Our comparison of projected combined water system demands to existing source capacity indicates that the two existing wells, as they currently operate, can meet projected build-out ADD but not MDD. The existing wells could be equipped with higher capacity pumps such that they both operate at their rated capacity (31.5 L/s), which would increase combined output, but would still not be capable of meeting MDD. A question for the engineering team would be whether the difference between MDD and current source capacity can be met with storage.

C2 In order to meet the project MDD, additional source capacity would be required. Our recommendation would be to complete a larger diameter well (10 or 12-inch) in the vicinity of Well #1, and that the well be completed at the depth of Well #2. A larger diameter well would likely be capable of producing 63 L/s or more and could operate along with Well #2 to meet the full build-out MDD. A larger diameter well could be completed on the same property as the current water infrastructure; acquiring additional land does not seem necessary. The addition of a third high capacity well would result in a very resilient water system in terms of source capacity.

The estimated costs to construct, test, and licence application under the well under the *Water Sustainability Act*, including hydrogeological oversight and reporting are summarized in the table below. These costs do not include equipping the well with a permanent pump and controls. A detailed environmental flow needs assessment is not included in the provided hydrogeology estimate. The costs associated with obtaining an environmental certificate for the groundwater withdrawal under the *Environmental Assessment Act*, or a formal exemption, are less certain (See Conclusion C6), but could be significant.

Well Drilling and Development (12-inch diameter, 150 ft deep, 15 ft of well screen).	$65,000
Pumping Test Program	$15,000
Hydrogeology (tendering, oversight, reporting, permitting)	$25,000
Total	**$105,000**

C3 The potential for well interference between wells supplying the contemplated water system and other wells in the area was assessed and is considered to be low. There are only two other wells reported south of Shorts Creek, both located over 200 m from the Morden Road well site. We were not able to confirm whether these wells are still in use. Distance drawdown projections were used to estimate well interference at the contemplated water system ADD and is found to be negligible at the potential well locations. Higher pumping rates (MDD demands) would result in slightly more drawdown, but would not impair the use of other wells south of Shorts Creek, if present. Drawdown interference with wells north of Shorts Creek would likely not be measurable.

C4 Water quality from the original testing of the wells in 2010 was compared to more recent sampling completed by the RDCO. The data indicate stable water quality over time. Operating the wells at current pumping rates does not appear to have resulted in a change in water quality.

Pumping the wells at higher rates could result in a change in water quality. It is possible that at higher pumping rates, the influence of septic systems in Lower Fintry could result in higher chloride, sodium and nitrate concentrations in the water supply. Higher pumping rates may also result in more recharge to wells coming from Okanagan Lake. We do not anticipate major changes to water quality, but additional monitoring and characterization of water quality in light of higher extractions rates would be prudent and should be planned for. Turbidity is expected to remain consistently below 1 NTU.

C5 We assessed the effects of climate change on the availability of groundwater in lower Fintry. Water levels in Aquifer 358 are strongly linked with and controlled by the Okanagan Lake level. As the Okanagan Lake level is regulated within a set range that would not result in the wells being unable to produce the desired volumes of groundwater, we find that Aquifer 358 would be resilient to climate change. We understand that there have been recent calls for changes to how lake levels are managed, but do not believe those changes would affect the above conclusion.

C6 The current licence for the Fintry system appears to be inconsistent with system design in that it allows for a maximum flow rate of 2,448 m^3/day (450 US gpm) but only 30,000 m^3/year, which is about 15 US gpm. The annual volume has already been exceeded once (in 2021), which means the licence needs to be reviewed and amended, regardless of whether the contemplated expansion occurs.

Should the proposed water system expansion proceed, two applications/amendments need to be planned and proposed:

- Increase the annual volume to meet the new system requirements to build-out ADD of 1,009,150 m^3/year. In exchange, propose relinquishing existing surface water licences associated with the Killiney Beach and Westshore Estates water systems.
- Change the appurtenance from existing (Water Services Bylaw 1254) to proposed (Bylaw to be determined).

Factors supporting a licence amendment to increase the annual extraction volume from Aquifer 358 would include lack of well interference concerns, low susceptibility to drought, and the potential abandonment of surface water licences on Okanagan Lake and tributaries currently held for operation of

the Killiney Beach and Westshore Estates water systems. The technical issue that may require assessment would be whether or not increased extraction from Aquifer 358 would impact EFNs in lower Shorts Creek.

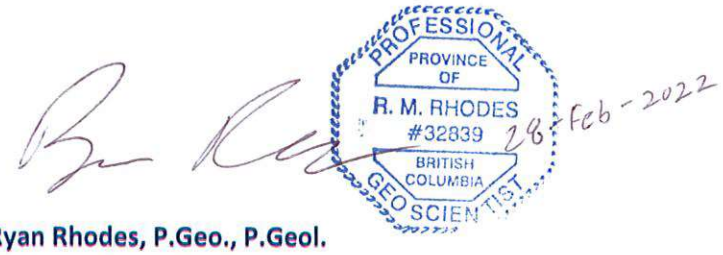
C7 We note that the proposed MDD of the combined system of 79.9 L/s exceeds the threshold for the completion of a groundwater Environmental Certificate under the *Reviewable Projects Regulation* under the BC *Environmental Assessment Act*. As the design capacity of the contemplated groundwater system exceeds 75 L/s, an environmental assessment or exemption certificate would likely be required. To further investigate whether an Environmental Certificate would be needed for the project, we would recommend preparing a conceptual project design brief and providing that to the EAO for comment. Then the next steps can be identified (pursue EA, EA exemption, or other alternative).

C8 Regulatory timelines for water licensing and EA processes are typically lengthy (years) and these timelines will need to be built into the overall project plan.

CLOSURE

We trust this report provides the information you require at this tie. If you have any questions on the information provided, do not hesitate to contact the undersigned.

Western Water Associates Ltd.
(EGBC Permit to Practice #1001419)



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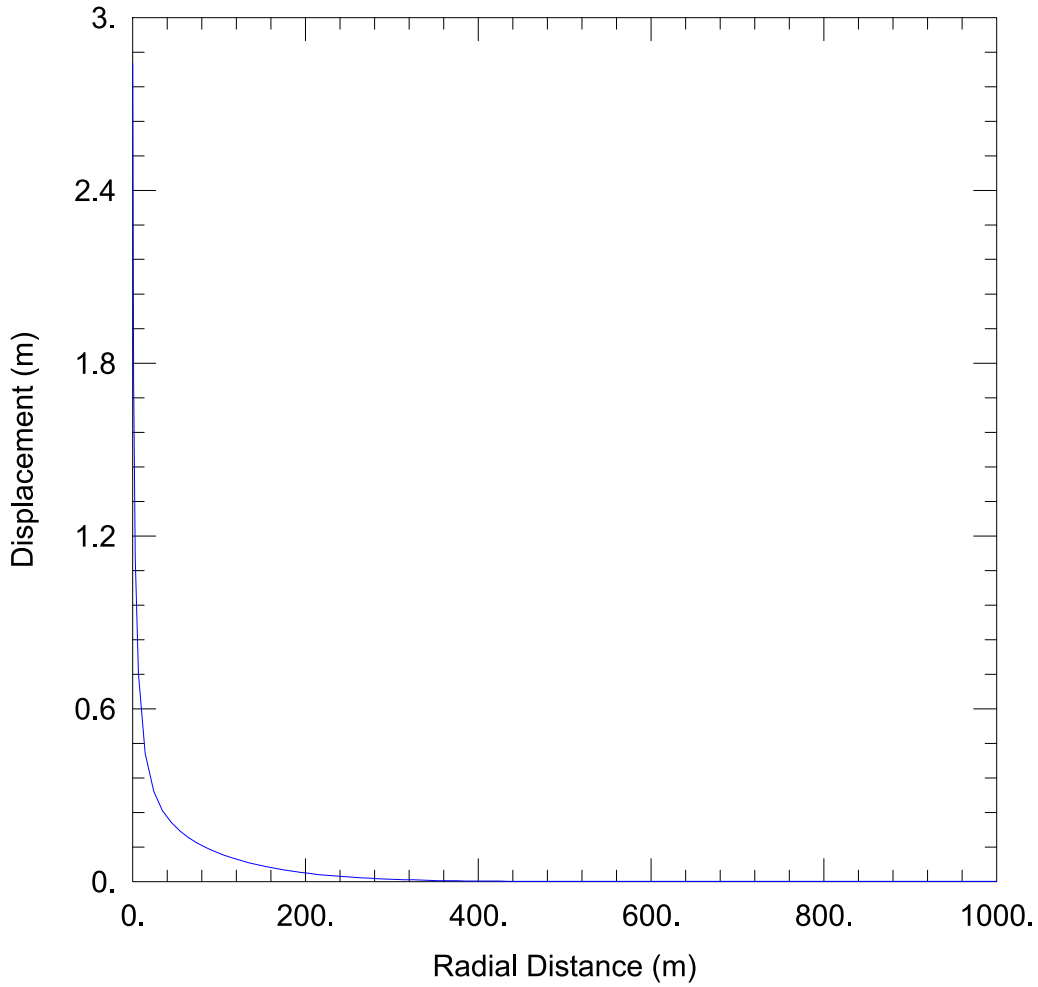
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Figure 1 - Wells and Aquifer Mapping at Lower Fintry

Date: January 2022	Image Source: BC Water Resources Atlas		WWAL Project: 21-132-01VR
Drawn by: RR	Checked by: RR	Client: RDCO	Client Project:

western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management



WELL TEST ANALYSIS

Data Set: D:\...\fintry forward solution.aqt
Date: 01/31/22 Time: 20:18:51

PROJECT INFORMATION

Company: WWAL
Client: RDCO
Project: 21-132-01VR
Location: Lower Fintry
Test Well: Fintry Well 2
Test Date: April 2010

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Fintry Well 2	0	0

Observation Wells

Well Name	X (m)	Y (m)
▫ Fintry Well 2	0	0

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 3162.3 m^2/day
S = 0.1
Kz/Kr = 1.
b = 40. m