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REPORT

Regional District Okanagan-Similkameen

Source Evaluation and Conceptual Design, Missezula Lake Water System Upgrades



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2023-8374



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EXECUTIVE SUMMARY

As part of upgrading the existing drinking water system for the Missezula Lake water system (MLWS), owned and operated by Regional District Okanagan-Similkameen (RDOS), Associated Environmental Consultants Inc. (Associated) evaluated whether the MLWS should continue using their surface water source for water supply or switch to groundwater supply. As part of this evaluation, Associated conducted the following analysis:

- Oversaw the drilling of a new water supply well (WIPN 52992) and characterized aquifer properties, including potential capacity, water quality, and aquifer vulnerability; and
- Analyzed raw water quality from the surface and groundwater sources to identify treatment requirements to meet current BC standards for drinking water and develop treatment option budgetary-level opinions of probable cost.

Associated concluded the following regarding the groundwater source:

- WIPN 52992 is completed in a sand and gravel, provincially unmapped aquifer and has a long-term sustainable yield of 5.14 L/s versus the MLWS's 2021 maximum daily demand (MDD) of 11 L/s observed in July 2021.
- In terms of water quality, the groundwater source contains elevated concentrations of total organic carbon, aluminum (total), manganese (total), total dissolved solids, and hardness. The well has not been assessed for its vulnerability to microbiological contamination (groundwater at risk of containing pathogens [GARP]). For the purposes of this study, Associated assumed that the groundwater source would be classified as GARP-viruses only.
- Two treatment scenarios were considered: One that provides treatment for all of the aforementioned water quality parameters that do not meet current BC drinking water standards, and the other that proposes a simplified treatment schematic that did not include treatment for hardness and total dissolved solids.

Associated concluded the following regarding the surface water source:

- Treatment objectives for the surface water would involve algae removal and organics reduction, as well as filtration with disinfection to reduce the presence of microbiological parameters. Note that a capacity assessment of the surface water source has not been conducted, nor has Associated conducted an inspection of the existing intake infrastructure.

The capital Opinion of Probable Cost for the three scenarios were as follows:

- Option 1 – surface water: \$2,990,000
- Option 2 – groundwater: \$4,647,500
- Option 3 – groundwater (simplified): \$2,470,000

Based on a multi-criterion decision-making process, the surface water option ranked the highest, and one of the main factors was that the groundwater source can only meet half the MDD. Therefore, Associated recommends that RDOS pursue upgrading the MLWS using surface water.

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1 INTRODUCTION

The Regional District of Okanagan-Similkameen (RDOS) owns and operates the Missezula Lake water system (MLWS). RDOS retained Associated Environmental Consultants Inc. (Associated) to support the MLWS upgrade project. The goals of the project were to assess a possible new groundwater source, refine the treatment options for the existing source (Missezula Lake) considering the newly identified risk posed by the presence of algae in the lake, and help RDOS select a water source and treatment scenario to move forward with. This report presents the methods and results of the drilling, aquifer testing, and conceptual design.

1.1 Background

The MLWS provides drinking water to 190 residential and seasonal recreational lots of the Missezula Lake community. It is located 45 km north of Princeton (Figure 1-1). The MLWS currently sources its water from a lake intake built in 2002, and only a single barrier of treatment is provided via a chlorination building and chlorine contact chamber. Other infrastructure added in 2002 includes a dam, a high lift pump station, an emergency power supply generator building, and a distribution system. In 2018, True Engineering (True) estimated a maximum water demand of 9.02 L/s (143 U.S. gallons per minute [USgpm]). In July 2021, the maximum daily consumption was 11 L/s (174 USgpm).

When RDOS took over the ownership, operation, and maintenance of the system in January 2020, a filtration plant was envisioned, at a cost of \$2,676,000 (in 2018 dollars) (True Engineering 2018). After RDOS took over ownership, they commissioned a study by Larratt Aquatics (2021) that concluded that:

- (1) Blue-green algae (potential toxin-producers) are present, but not in concerning numbers.
- (2) High algal density in late summer and early fall are increasing the raw water turbidity above 1 nephelometric turbidity unit (NTU).
- (3) Diatom algae can significantly reduce filtration efficiency, particularly during the spring bloom in June and July. Larratt recommended that replacing the lake intake with a well adjacent to the pumphouse would alleviate the concerns regarding algae and cyanotoxicology in the raw water.

During July and August 2021, water levels in Missezula Lake were lower than normal. During this period, Ministry of Forests identified the need to release more water from the lake. The community expressed concern with the ministry's plan, as additional releases could cause the water system infrastructure to become non-functional, which would result in a state of emergency for the community. RDOS proactively imposed water conservation measures. Understanding RDOS's concern, the ministry reduced the water releases.

Knowing that Missezula Lake may require additional management and possibly other studies, assessments, or enhancements to manage water levels during drought, and knowing that groundwater would alleviate algae concerns, RDOS started looking at groundwater as an alternative water source.

In July 2022, RDOS retained a driller to complete an exploratory drilling program to gain an understanding of the groundwater table and the general geology in the area. Well identification plate number (WIPN) 43254, completed by Value Contracting and overseen directly by RDOS, revealed an aquifer that has the potential to provide the water system with a more reliable and treatable water source. While screens were installed, no well development occurred. At this point, RDOS retained Associated to answer several fundamental questions before deciding whether to make significant investments, such as drilling and testing larger-diameter wells that can be used for production, or continuing to use a lake source with filtration and additional pre-treatment for algae. Associated was awarded the groundwater investigation and conceptual design water supply upgrade project.

Figure 1-1 Site Overview

1.2 Regulatory Framework

Interior Health regulates community water systems in this region. The MLWS is considered a small water system, with 15–300 connections under Interior Health’s permit to operate (Facility Number 15-105-00021). The Ministry of Health provides various guidance documents to support the design of treatment systems under the *Drinking Water Protection Regulation*; these documents are introduced as needed in this report. The Province regulates surface water and groundwater diversion; the Missezula Lake Waterworks District has a water licence for Missezula Lake.

Discharges of waste to the environment in BC are regulated by the *Waste Discharge Regulation* (BC Reg. 320/2004) of the *Environmental Management Act* (SBC 2003). Residuals from water treatment plants are not specifically listed in either Schedule 1 or 2 of the Regulation but are captured under the definition of “effluent,” which are substances introduced to water or land that can damage the environment. Therefore, any potential discharge of residuals to the environment from the MLWS would be regulated. Once the water treatment option for the MLWS is selected and the characteristics of the residuals are known, RDOS will need to apply to the Ministry of Environment and Climate Change Strategy for an authorization to discharge. To support evaluating treatment options that are the scope of this report, Associated assessed the potential impact to receiving waters from residuals anticipated for each option and thereby the likelihood of obtaining authorization to discharge from the Province. A discharge with water quality guideline exceedances may also be considered a “deleterious substance” under the federal *Fisheries Act*. To address this Act, “deleterious substance” is typically interpreted as the requirement for the effluent to not be acutely toxic to fish in the receiving waters.

1.3 Objectives

The objective of the groundwater investigation and conceptual design water supply upgrade project was to support RDOS in deciding whether to continue using surface water as a community water source or consider using groundwater.

The questions to be answered related to the groundwater source were:

- Can the aquifer support the 2018 water demand estimated by True?
- What level of treatment is required for the physical and chemical water quality parameters?
- What is the classification of the new well with respect to presence of micro-organisms (i.e., groundwater at risk of containing pathogens [GARP] determination)? Can the groundwater source act as a viable candidate for filtration exemption to significantly reduce capital and annual costs of treatment?
- Will RDOS need a new groundwater licence, or can they amend their current licence to switch from the lake source to groundwater, and what additional technical studies are needed to support either of these applications? How long will it take for the Province to review either application?
- What is the cost of capital improvements and the life cycle of a groundwater source?
- What other information is required for RDOS to make an informed decision?

While the initial scope for this project focused on assessing the groundwater supply from the existing well (WIPN 43254), during the initial site visit, it appeared that the well was not constructed with the intent of being used for a water supply well, and a new well needed to be drilled. Additional questions related to using a groundwater source now were: Is one well sufficient to meet the demand? Where should the well (or wells) be located to meet the setbacks from septic fields and other drinking water hazards?

The questions to be answered related to lake source were:

- What additional treatment processes are needed to make the lake water potable, now considering the risk of algal blooms?
- Can the receiving environment (Summers Creek) handle the residuals from the treatment process?

1.4 Scope of Work and Structure of Report

To answer the questions in Section 1.3, Associated completed the following tasks, which are based on the work plan in the proposal and in scope changes 1 and 2. The scope changes have been approved by RDOS.

- **Task 1: Background review of physical setting.** Associated reviewed available information on the physical setting, including climate, hydrology, soils, geology, and aquifers and wells in the area. This task is summarized in Section 2.
- **Task 2: Drilling, water sampling, and aquifer testing.** Associated oversaw drilling and a 48-hour aquifer test, and collected a water sample for analysis of Interior Health's list of parameters for new sources. This task also included pre-drilling activities, as follows: visiting the site and collecting a water sample from WIPN 43254, logging soil samples (including sieving) from WIPN 43254 to support an understanding of the hydrogeology, and preparing an environmental management plan to ensure the pumping test discharge water from a new well will not cause harm to aquatic habitat and fish. This task is summarized in Sections 3 to 6.
- **Task 3: Liaison with RDOS, regulatory agencies, and third-party utilities.** Associated worked with Eric Hegerat, fisheries biologist at the Ministry of Forests, to confirm the dam and environmental flow needs information before the pumping test, and met with Judi Ekkert, of Interior Health, on August 7, 2024. This task is summarized in Sections 5.1.1 and 8.2.
- **Task 4: Conceptual design.** Associated completed a preliminary review of drinking water hazards and a GARP screening to support disinfection treatment objectives; compared water quality results to drinking water guidelines; and developed design concepts with respect to connecting the water to the existing MLWS, including treatment and storage. To answer questions related to Missezula Lake and residuals management, Associated also completed a conceptual design for a lake intake and additional residuals management. This task is summarized in Section 7.
- **Task 5: Opinion of probable costs and options evaluation.** Associated developed a conceptual-level opinion of probable costs for the capital works needed for the production well(s) and any further aquifer testing and technical assessments in support of a water licence amendment, and any infrastructure tie-ins required. The costs for operations and maintenance of three treatment scenarios are also provided. Lastly, Associated completed a multi-criterion evaluation to support RDOS in selecting a water supply option to move forward with. This task is summarized in Sections 7.4 and 8.3.
- **Task 6: Open houses and/or meet with residents.** Associated prepared for and presented at a virtual community meeting on August 8, 2024. The recording was uploaded to RDOS's communication platform, at <https://rdosregionalconnections.ca/missezula-lake-water-system-upgrade>. This task is summarized in Section 8.2.

2 PHYSICAL SETTING

2.1 Physiographic Setting

The site is situated on the lake shore at the south terminus of Missezula Lake in Missezula Lake, BC, at coordinates Zone 10U, 680192 m E and 5515766 m N, approximately 35 km north of the City of Princeton. The site is in the

Southern Interior of BC as part of the Thompson Plateau physiographic region (Church and Ryder 2010) and sits in a generally north–south trending valley. The immediate topography of the lakeshore site slopes gently westward down 1–2 m toward the lake. However, hills with more than 300 m of relief wrap around the site’s eastern flank; at their closest, the relevant hills’ toes are approximately 0.14 km to the northeast and 0.28 km to the east-southeast. To the southwest, approximately 0.08 km across the south end of the lake is a large (likely) bedrock hill of 30–40 m relief. Further west across the lake is a large hill of >400 m; its toe is approximately 0.35 km west-southwest of the site.

2.2 Climate

Climate normal data are available for 1981–2010 (most recent available) from the Princeton A station (station ID 1126510), located at 680223 m E and 5482433 m N in Zone 10, at an elevation of 702 m above sea level (m asl) and roughly 33.3 km south of the property. Daily average temperatures range from –5.6°C in December to 17.9°C in July and August, with an average annual temperature of 6.6°C (ECCC 2024). The average annual precipitation is 346.9 mm; the highest amount of precipitation occurs in November, at 44.5 mm, and the lowest occurs in March, at 16.5 mm. The 3-month period with the highest amount of precipitation is November to January (120.6 mm, falling mostly as snow), and the lowest amount of precipitation occurs February to April (55.4 mm, falling mostly as rain) (ECCC 2024).

The climate has been changing due to anthropogenic release of carbon into the atmosphere, and looking forward, it will likely continue to change. To understand to what extent the climate may change in the future, Associated uses ClimateData (2024) to amalgamate the most relevant climate models into a single projection. ClimateData (2024) uses the normals period 1971–2000 as its base point and then projects into the future. Because ClimateData uses a different normals period (1971–2000) than the ECCC (2024) data in the previous paragraph, and because ClimateData’s data and projections are for the 10 km by 6 km grid covering Missezula Lake (rather than using ECCC’s Princeton A station, 300 m lower than Missezula Lake), the resulting average temperature and precipitation data are different. Using ClimateData’s (2024) data, the average temperature is 3.7°C and the average annual precipitation is 531 mm. Under a high-emissions (conservative, or worst-case) scenario, the average annual temperatures are projected to rise to 5.8°C for the 2021–2050 period, 7.3°C for 2051–2080, and 11.2°C for 2081–2100 (ClimateData 2024). Under a high-emissions scenario, the average annual precipitation is projected to be 7% higher for the 2051–2080 period and 10% higher for 2081–2100 (ClimateData 2024). Overall, climate change is expected to result in increased temperatures and precipitation at the general site area. Connecting these climate projections to groundwater recharge, however, is challenging because despite the warmer but wetter winters, the timing of recharge may be impacted by the predicted longer and drier summers.

2.3 Hydrology

The site’s new well, WIPN 52992, sits approximately 15 m from the southern end of Missezula Lake on its eastern shore and is approximately 70 m north of the lake’s outflow, Summers Creek. Missezula Lake is a managed lake and is used for recreational activities such as (power) boating, fishing, and other water sports. The main creeks around the site are Summers Creek and Dillard Creek. Summers Creek is a managed creek and is fish bearing (bull trout [*Salvelinus confluentus*] and rainbow trout [*Salvelinus confluentus*]), with mean annual discharge of 125 L/s (Fisheries Management Section n.d.). During site visits in September and October 2023, Associated observed Summers Creek flowing. However, in images dated September 2020 and 2022, Google Earth shows Summers Creek running dry. It is possible that Summers Creek is fed by a spring south of 680143 m E and 5513845m N, as below this point, Summers Creek appears to be flowing in the same satellite images. This suggests that the confined aquifer in which WIPN 52992 is screened could be discharging to Summers Creek down the valley at this location. The operator of the water treatment system at Missezula Lake has observed debris (branches, leaves, etc.) clogging the spill way of the lake into Summers Creek, which can choke off flow to the creek (A. Cunningham, personal communication, 2023). Dillard Creek

is south of the site and flows northeast–southwest, joining Summers Creek about 137 m from Summers Creek’s head. Dillard Creek is ephemeral and was not observed flowing during the drilling of WIPN 52992 in September 2023.

2.4 Significant Aquatic Values

Missezula Lake is a full-length lake (reservoir) whose volume is managed to meet ecological flow and downstream water rights (Larratt 2022). The lake is valuable to recreational fishers, stocked with rainbow trout (*Oncorhynchus mykiss*), eastern brook trout (*Salvelinus fontinalis*), and kokanee (*Oncorhynchus nerka*), and it contains squawfish (Northern Pikeminnow [*Ptychocheilus oregonensis*]) (Fisheries Management Section n.d.). It is also valuable to the community and users for recreational activities such as (power) boating, fishing, and other water sports. The lake’s outflow, Summers Creek, is a managed creek and is fish bearing for bull and rainbow trout (Fisheries Management Section n.d.). The lake is also the current drinking water source for the community of Missezula Lake. However, as noted in Section 1, there are concerns over the lake’s viability as a drinking water source due to the newly discovered concentrations of cyanobacteria-based algal blooms that are considered potentially toxic through prolonged low-dose exposure and the algae’s negative impacts on drinking water filtration systems (Larratt 2022). Additionally, decreasing water levels in Missezula Lake are a concern with respect to the community’s water intake as lower water levels could threaten the quality and quantity of water available to the community. Missezula Lake is also a valuable source of water for irrigation for users further down the Summers Creek valley; irrigation is licensed for a volume up to the equivalent of 0.3 m of the total surface area of the lake (Larratt 2022).

2.5 Geology

The bedrock geology at the site is composed of basaltic volcanic rocks from the Nicola Group formed during the Upper Triassic Period on the Quesnellia terrane (Schiarizza and Church 1996). The bedrock is also described as mafic breccia and tuff, with augite and hornblende-pyric clasts; local intercalated argillite can also be present (Schiarizza and Church 1996).

The surficial geology for the site or Missezula Lake in general has not been well characterized by any public studies. The only data for the area that Associated could access are the drill logs from drilling WIPNs 52992 and 43254. These deposits showed sand and gravel varying degrees of fines, from trace silt and clay to 30% silt and clay. Given the location of the lake and Summers and Dillard Creeks, the poor sorting of the sediment, the presence of fines, the sub-angular to sub-round grains and clasts, it would be reasonable to interpret the surficial deposits as glacio-alluvial-lacustrine deposits.

2.6 Aquifers and Wells

Associated reviewed the Groundwater Wells and Aquifers (GWELLS) provincial database (2024) and found no mapped aquifers in the area. Furthermore, GWELLS showed no wells within 500 m of WIPN 52992 (other than WIPN 43254). The nearest well to WIPN 52992 is WTN 129980, which is 1.4 km south and down the Summers Creek valley from WIPN 52992. The well log for WTN 129980 states it is screened from 22.4 to 23.6 m bgs (GWELLS 2024). Using Google Earth’s elevation for WTN 129980 (995 m asl), its screen would be at an elevation of approximately 973 m asl, which is a similar elevation to the top of the aquifer at WIPN 52992 (984 m asl).

3 PRE-DRILLING TASKS

3.1 Site Visit

Marta Green, P.Geo., visited the site on April 18, 2023, to collect a water quality sample of the lake and the existing WIPN 43254 in preparation for developing an environmental management plan for the pumping test. The well became turbid, and the pump stopped at a pumping rate of 2.5 USgpm due to turbidity in the well jamming the pump. Later that day, after letting the well sit for 2 hours and restarting the pump at 0.5 USgpm, Associated collected another groundwater sample. On the same day, Associated also collected water samples at the lake and creek. Water quality results from the April sampling are provided in a summary table in Appendix A. The full laboratory reports are provided in Appendix B.

3.2 Logging of WIPN 43254

WIPN 43254 was drilled by Value Contracting and completed in July 2022, overseen directly by RDOS. Associated understands that a well screen was installed without sieving the samples. Based on the driller's log (Appendix C), a screen 2.74 m (9 ft.) long composed of 25- and 30-slot was installed from 27.74 m bgs to 30.48 m bgs (91 ft. bgs to 100 ft. bgs). Value Contracting developed the well for 8 hours via pumping and bailing and then performed a yield test for 2 hours, estimating the well yield at >0.6 L/s (10 USgpm). WIPN 43254's sediment cuttings were stored at RDOS's OK Falls warehouse, which Associated picked up on April 19, 2023. Associated then logged these drill cutting samples and sieved selected samples.

Based on the soil logging, the lithology for WIPN 43254 consists of the following main units relevant to the aquifer:

- Unit A – Aquitard/confining layer. The lithology is two thin layers of silt-rich sands and gravels separated by a poorly graded sand with trace gravel (26.2 to 27.4 m bgs). The silt-rich layers are silty sand and gravel from 25.0 to 25.6 m bgs and silt gravel from 27.4 to 28.0 m bgs.
- Unit B – Aquifer (from 28.0 m bgs to bottom of hole at 30.5 m bgs). The lithology is predominantly sand gravel.

The well log for WIPN 43254 is in Appendix C. The exact location of each lithologic unit was uncertain, and because the drilling did not continue to bedrock, a thicker, more coarse layer could be encountered. For this reason, Associated, after discussions with RDOS, recommended drilling a new well and converting the existing well into a monitoring well. A monitoring well can be useful to support development of aquifer properties, which are needed to understand the aquifer potential.

4 DRILLING WIPN 52992

4.1 Methods

Associated's target was to drill a well that can exceed the 9.02 L/s (143 USgpm) maximum daily demand (MDD) (value from True's 2018 report). However, Associated understands that the community used 11 L/s (174 USgpm) in 1 day in July 2021 (July 31, 2021) (R. Palmer, personal communication, 2023). To allow the community some flexibility with the MDD value possibly changing over time, Associate aimed for a target of 13.5 L/s (213 USgpm), which is 1.5 times the MDD.

Associated retained Cyclone Drilling Ltd. to drill and install WIPN 52992 at the predetermined general location. Associated's field hydrogeologist, Dylan Riley, geoscientist-in-training, met with Adam Cunningham, the RDOS water

treatment plant (WTP) operator. They used the as-built drawings for the WTP to site the well in the ideal location to have sufficient setback from the nearest private property line (to ensure >30 m from a septic system), the lake, the WTP infrastructure, and the existing WIPN 43254, and cause the least obstruction to recreational beach users. The well was drilled and constructed by Qualified Well Driller Jim Genereux (WD 05062302). Drilling began on September 19, 2023, was completed and developed on September 26, 2023. During construction of the well, Associated's Dylan Riley was on site to supervise the drilling, collect samples, record lithology, sieve samples, and design the well construction. Associated's senior hydrogeologist Marta Green, P.Geo., oversaw the well drilling field programs, including the well design.

For the well, Cyclone used a truck-mounted air rotary rig to advance 152.4 mm (6 in.) diameter steel casing through the unconsolidated overburden. Air rotary drilling installs a well casing as drilling advances. A casing drive-shoe is welded to the bottom of the casing to help cut through the material as the casing advances. Inside the casing, a drill string with a hammer bit is used to drill and remove the materials encountered. The casing and drill rods were each 6.1 m (20 ft.) in length.

A temporary 254 mm (10 in.) casing was advanced for the first 5.5 m (18 ft.) of drilling, and 152.4 mm (6 in.) steel casing was then lowered into the hole; bentonite chips were poured into the annulus between the 152.4 mm and 254 mm casing and wetted. The 254 mm casing was then removed, to leave a 50 mm (2 in.) thick surface seal between the 152.4 mm casing and the ground material to meet the requirements of the *Groundwater Protection Regulation* for water wells (Government of British Columbia 2022b).

Drilling with production casing (152.4 mm diameter) was then advanced to a depth of 39.62 m bgs (130 ft. bgs), at which bedrock was encountered. Compressed air was used to remove the cuttings, and clean water was added from the surface as necessary to help remove the cuttings while the well was still being drilled into unsaturated material. Samples were collected at 1.5 m (5 ft.) intervals in unsaturated material and at 0.6 m (2 ft.) intervals within the aquifer, or whenever the lithology changed. Associated determined the depth at which drill casing should be pulled back on encountering bedrock, based on the quantity of water that was returned during drilling via airlifting. This depth ensured sufficient available drawdown in the well and avoided a fines layer at 37.79 to 38.40 m bgs (124 to 126 ft. bgs).

After reaching the agreed-on target well depth, Associated's field hydrogeologist conducted dry-sieve analysis of nine samples from 28.19 m bgs (92.5 ft. bgs) to 37.79 m bgs (124 ft. bgs) to determine the screen slot size. A screen 3.66 m (12 ft.) long was selected and installed from 34.5 m bgs to 38.4 m bgs. The screen was made up of various sized slot screens, as follows (from top to bottom): 30-slot, 40-slot, and 35-slot. The screens were 6-inch diameter, 1.22 m (4 ft.) long telescopic stainless steel screen (Johnson's screen) with a 0.05 m (2 in.) long stainless steel end cap and a 0.46 m (1.5 ft.) long stainless steel riser and K-Packer at the top. The installed screen has a theoretical screen-transmitting capacity of 14.45 L/s (229 USgpm), which is higher than that required by the community (MDD is 9.02 L/s and observed maximum daily consumption is 11 L/s).

After the screens were installed, the well was developed for 13.5 hours by surging and air lifting to ensure a good filter pack around the screen and remove any material from within the well's screened section. Development continued until the well was producing virtually no fine sediment and its water was clear. Associated and the driller noted a mild sulphur smell from the well water during development.

The well was completed with a 0.76 m above ground surface stick-up and capped by a vermin-proof and locked well cap, and a well identification plate (WIPN 52992) was attached to the casing stick-up, meeting the *Groundwater*

Protection Regulation requirements. Well construction details for the well (and WIPN 43254, for comparison purposes) are provided in Table 4-1, and the well log is provided in Appendix C.

Table 4-1 Well Construction Details for WIPN 52992 (New Well) and WIPN 43254 (Old Well)

Specification	WIPN 52992 (New Well)	WIPN 43254 (Old Well)
Date constructed	2023-09-26	2022-07-04
Coordinates (Zone 10)	680192 m E 5515766 m N	680198 m E 5515761 m N
Approximate ground elevation (m asl) ¹	1,013	1,013 ²
Surface seal depth (m bgs)	5.5	4.6
Completed well depth (m bgs)	38.4	30.5
Steel casing diameter (mm)	152.4	152.4
Static water level (m bgs)	20.73 ³	20.38 ⁴
Casing stick-up (m)	0.762 ³	0.671
Base of screen (m bgs)	38.4	30.5
Top of screen (m bgs)	34.5	27.7
Top of K-Packer (m bgs)	34.4	Data not available
Screen design (from top to bottom)	1.22 m of 30-slot 1.22 m of 40-slot 1.22 m of 35-slot	Individual screen length unknown ⁵ 25-slot 30-slot
Theoretical screen-transmitting capacity (L/s)	14.45 (229 USgpm)	Unknown due to unknown screen length (likely >170 USgpm)
Driller's estimated yield (L/s)	>4.73 (>75 USgpm)	>0.63 (>10 USgpm)
Aquifer type	Confined sand and gravel	Confined sand with gravel

¹ Google Earth. ² At ground level, WIPN 43254 appeared to be 0.25–0.5 m higher in elevation than WIPN 52992.

³ Measured by Jim Genereux (Cyclone) on September 26, 2023. ⁴ Measured by Associated on September 19, 2023.

⁵ The driller's log states two lengths of telescopic screens used a 25-slot and 30-slot from 27.7 to 30.5 m bgs. The length of each screen and their order are unknown.

m asl – metres above sea level; m bgs – metres below ground surface; USgpm – U.S. gallons per minute

4.2 Results

WIPN 52992 was drilled to 39.62 m bgs (130 ft. bgs), at which point bedrock was encountered. The sand aquifer is from 28.19 to 39.62 m bgs (92.5 to 130 ft. bgs), and the water table is about 21.5 m bgs (70.5 ft. bgs), making the aquifer confined. The well was screened from 34.5 to 38.4 m bgs (113 to 124 ft. bgs). The screen's theoretical capacity is about 220–230 USgpm (assumes 4 ft. of 30-slot, 4 ft. of 40-slot and 4 ft. of 35-slot). This does not mean the well is expected to produce this volume; rather, it is what the screens will allow into the well if the aquifer can supply it. The lithology is as follows:

- Unit A – Aquitard/confining layer (from 26.82 m bgs to 28.19 m bgs). The lithology ranges from sand with silt and clay to silty sand with clay and gravel.
- Unit B – Aquifer (from 28.19 m bgs to 39.62 m bgs). The lithology ranges from sand and gravel with trace silt and clay to sand and gravel.
- Unit C – Bedrock (top of bedrock is 39.62 m bgs).

5 AQUIFER TESTING

5.1 Methods

5.1.1 Environmental Management Plan

Associated prepared an environmental management plan to outline the management strategies to minimize potential adverse effects on the environment during the pumping test on WIPN 52992 (Appendix D); primarily, the plan discusses how to manage the discharged groundwater. The main highlight is that previous groundwater quality results indicated concentrations of total selenium, dissolved selenium, and dissolved oxygen did not meet the provincial chronic water quality guidelines for aquatic life and wildlife (ENV 2023). Associated determined that groundwater discharged to Summers Creek would be diluted by the creek water enough to decrease the concentration of selenium to meet the guidelines. If there was any concern with not meeting the concentration, the dam controlling Summers Creek (water licence 111484) could be opened to convey Missezula Lake water into Summers Creek.

5.1.2 Step Test

Initially, Associated planned to run a 4-hour step test to determine the appropriate pumping rate for the constant rate test (CRT). However, during the first step, at 5.68 L/s [90 USgpm], the drawdown was greater than anticipated; through consultation with the senior hydrogeologist, the field hydrogeologist converted the step rate test into a CRT, holding at a rate of 5.68 L/s (90 USgpm) for 48 hours. Therefore, the methods and results of the step test are not discussed further.

5.1.3 Constant Rate Test and Long-Term Sustainable Well Yield Estimate

A CRT was conducted on WIPN 52992, at a pumping rate of 5.68 L/s (90 USgpm) for 48 hours. Water level measurements were recorded at the pumping well (WIPN 52992) and the observation well (WIPN 43254), manually using an electronic water level measuring tape and using a pressure transducer data logger. WIPN 43254 is 8 m southeast of WIPN 52992, and its screen sits approximately 7–8 m higher vertically than that of WIPN 52992, and in likely the same aquifer (Table 4-1). However, it is possible that a thin fines layer separating the two wells was not observed while logging the drill cuttings for WIPN 52992 (discussed further later in this section).

Measurements were taken during the pumping phase at the following schedule:

- 1-minute intervals for the first 10 minutes;
- 2-minute intervals for the next 10 minutes;
- 5-minute intervals for the remainder of the first hour;
- 10-minute intervals for the second hour;
- 20-minute intervals for the third hour;
- 50-minute intervals until minute 500;
- 100-minute intervals until minute 1,000; and

- 200-minute intervals until the test was complete.

The water level data loggers were paired with a pressure transducer that measured barometric pressure to compensate for changes in barometric pressure that may affect the water levels in the well.

After 48 hours of pumping, Associated's senior hydrogeologist reviewed the data for the presence of any new trends in drawdown rates toward the end of the test and approved ending the test to start monitoring groundwater recovery. Recovery water level measurements were taken manually at the same intervals as the pumping portion of the test but ceased regular measurements at 200 minutes into recovery as the well was 96% recovered. Recovery measurements were still recorded at varying frequencies until 2,803 minutes into recovery, when the data loggers were pulled.

Data from the CRT were analyzed following the Guidelines for Evaluating Long term Well Capacity for a Certificate of Public Convenience and Necessity (CPCN method) (ENV 2007), which uses the following equation to calculate the sustainable pumping rate:

$$Q = \text{specific capacity at 100 days} \times \text{available drawdown in the well} \times 0.7$$

where:

- Specific capacity at 100 days is the pumping rate divided by the drawdown extrapolated on a straight line on a lin-log plot after pumping for 100 days.
- Available drawdown is the distance between the top of the future pump and the top of the aquifer, or water level, depending on the aquifer type. We used the water level to determine the available drawdown; we note that this would allow the water level to fall below the top of the aquifer temporarily due to the typical well inefficiencies associated with a pumping well; however, the water level temporarily lower than the top of the aquifer would likely occur only in the immediate vicinity of the well.
- 0.7 is a safety factor of 30% to account for changes in water levels over the seasons and over longer periods in cases where water level fluctuation is unknown.

5.1.4 Well Interference

Associated used HydroSOLVE Inc.'s AQTESOLV software to interpret the pumping test results and perform a derivative analysis to understand the aquifer's characteristics, such as its confining layer or lateral extent, and to determine its transmissivity, which is needed to estimate a minimum distance to a second production well, if needed. Associated first used the Theis (1935) solution and its derivative to identify the type of boundary conditions present in that part of the aquifer and then used the Hantush-Jacob (1955)/Hantush (1964) solution (H-J) for leaky aquifers without aquitard storage to determine the transmissivity. Storativity could not be calculated as the observation well (WIPN 43254) is in a vertically different part of the aquifer, is potentially even separated by a thin lower-permeability layer.

The derivative curve from the Theis solution indicated a leaky aquitard through which the overlying aquifer recharged the well. Curve matching to the H-J solution for leaky aquifers confirmed that the aquifer is drawing recharge from an overlying aquifer.

Associated used the Cooper-Jacobs (1946) solution (C-J) to estimate the radius of influence of the pumping well (WIPN 52992). There are numerous assumptions in the C-J solution pertaining to the aquifer, its confining layers, and the pumping conditions. The most pertinent assumption for this aquifer and pumping test setting is that the aquifer is

perfectly confined (i.e., no recharge through a leaky aquitard(s), is of infinite areal extent, is homogenous, is isotropic, is uniform in thickness, and has a small well function value [i.e., <0.05]). In reality, no aquifer/aquitard setting fully meets these requirements, though some adhere more closely to these assumptions than others. This aquifer setting has a leaky aquitard, allowing recharge to the pumped aquifer from an overlying aquifer; this causes the C-J solution to overestimate the amount of drawdown at a given distance from the pumping well. The aquifer is not of infinite areal extent, nor is it homogenous or isotropic. This causes the C-J solution to overestimate the amount of drawdown at a given distance from the pumping well. However, Associated used the derivative analysis to identify the part of the curve that was behaving as a confined aquifer of infinite areal extent and performed its curve matching on that portion of the drawdown curve. Lastly, the well function value is small, at 0.0001. Given this information, while the well function value is not perfectly ideal, the C-J method is still reasonable to use.

5.2 Results

5.2.1 Environmental Management Plan

The environmental management plan was followed. This subsection describes the new developments that occurred during field activities. As the well was developed, Associated collected a water quality sample from the new well on September 26, 2023, to further support the plan for the pumping test. Water quality results from the drilling are provided in Appendix A. To prevent the water produced from well development from entering the lake, Glen Willesen of Wescan Excavating (local to Missezula) excavated a small sump and built a berm to corral the water. Throughout well development, Associated and the driller observed the sump and berm performing as planned, and no water ran off into the lake. Additionally, to prevent spills from the rig during drilling, spill trays were placed under the drilling truck, and all vehicles were regularly checked throughout the day for leaks. Lastly, spill kits were on site to mop up any spills, though no spills occurred during drilling.

5.2.2 Constant Rate Test and Long-Term Sustainable Well Yield Estimate

Associated completed a 48-hour CRT on WIPN 52992 at a constant rate of 5.68 L/s (90 USgpm) from 9 a.m. on October 17, 2023, to 9 a.m. on October 19. Table E-1, in Appendix E, contains the manual water level measurements for the pumping well (WIPN 52992), and Table E-2 contains the manual water level measurements for the observation well (WIPN 43254). The data logger data is available to RDOS on request.

Just before the CRT began, the water level in WIPN 52992 and WIPN 43254 was 20.63 m below ground surface (m bgs) and 20.70 m bgs, respectively. During pumping, the water level in WIPN 52992 declined linearly on a linear-logarithmic plot for the first 90–100 minutes of the test, and the drawdown rate began decreasing steadily until it reached zero, at about 1,600 minutes into the test. The water levels then started to recover and rose by up to 0.1 m during the test. The decrease in drawdown rate to zero and then slightly negative is indicative of the drawdown cone hitting a positive recharge boundary. The observation well showed a nearly identical drawdown curve, albeit substantially delayed, to that of the pumping well. After pumping stopped, the water level recharged quickly to 90% within 120 minutes of recovery and to 96% within 180 minutes of recovery.

During the pumping test, the maximum recorded drawdown was 8.35 m in WIPN 52992 and was 4.39 m in WIPN 43254. The available drawdown calculated for WIPN 52992 was 10.7 m, based on the difference between the static water level (20.63 m bgs) and the top of the pump assembly (31.35 m bgs). The 100-day extrapolated drawdown is 8.3 m (Figure 5-1). With a 30% factor of safety, the long-term sustainable yield is 5.14 L/s (81.4 USgpm) (Table 5-1), which does not meet the 2018 maximum water demand of 9.02 L/s (143 USgpm).

Table 5-1 WIPN 52992 Long-Term Sustainable Yield Calculation

Test Parameter	Value
Pumping rate (L/s)	5.68
Test duration (hours)	48
Depth of pump intake (m bgs)	33.38
Static water level (m bgs)	20.63
Depth of well (m bgs)	38.40
CPCN Inputs	
Pumping rate (L/s)	5.68
Available drawdown (m) ¹	10.72
Drawdown at 100 days (m) ²	8.30
CPCN Outputs	
Volume of water removed (L)	981,178
100-day specific capacity (L/s/m of drawdown) ³	0.684
Calculated sustainable well yield <i>before</i> applying a 30% sustainable factor and other factors (L/s) ⁴	7.34
Calculated sustainable well yield (L/s) <i>after</i> applying a 30% safety factor ⁴	5.14

¹ Available drawdown is calculated as the difference between the static water level (20.63 m bgs) and the top of the pump assembly (31.35 m bgs). ² This is the extrapolation of the drawdown time-series plot to 100 days. ³ 100-day specific capacity is calculated as the pumping rate divided by the drawdown at 100 days. ⁴ Sustainable well yield is calculated as the available drawdown multiplied by the 100-day specific capacity. CPCN – certificate of public convenience and necessity; m bgs – metres below ground surface.

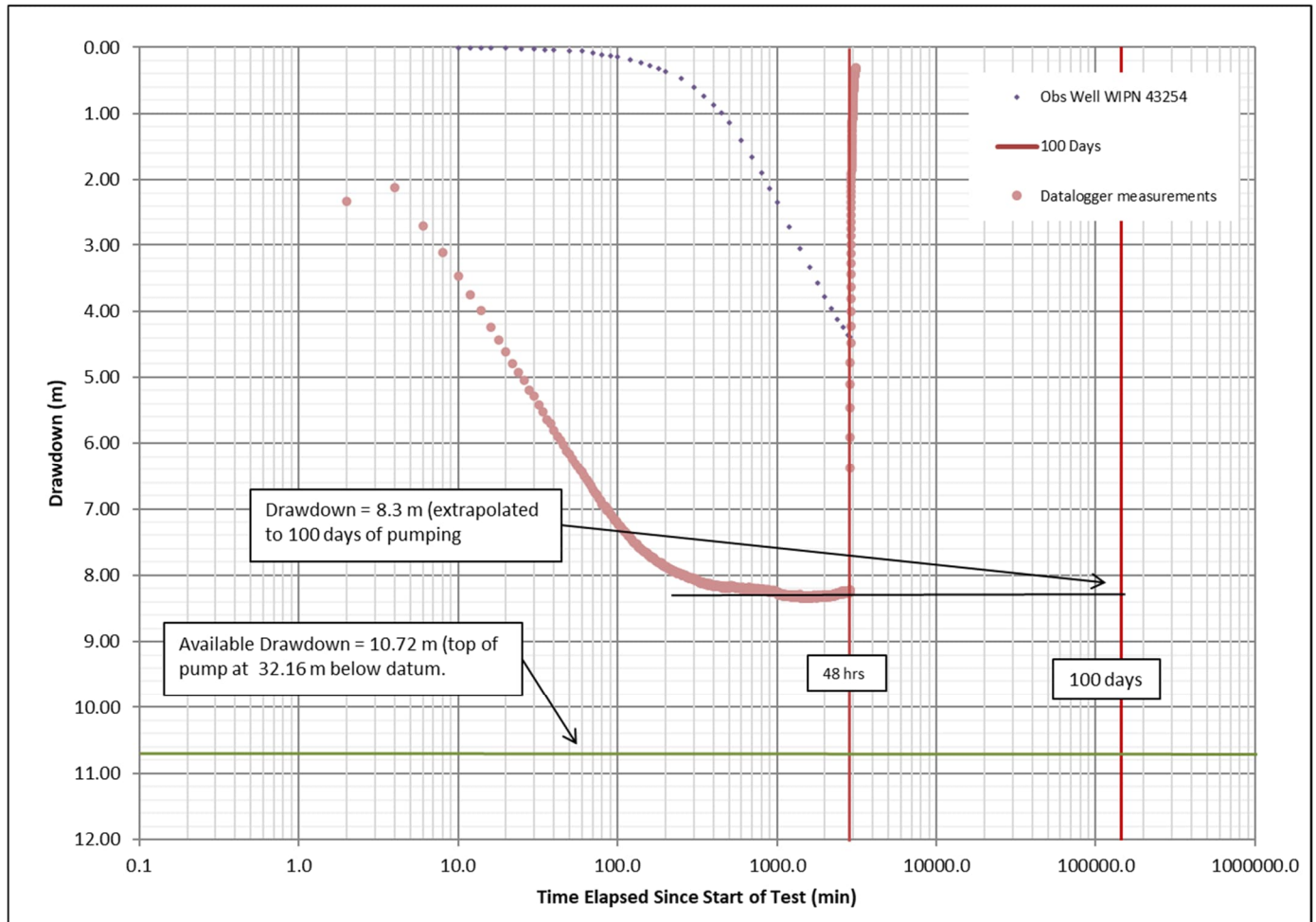


Figure 5-1 Pumping Test Results Showing Drawdown in Pumping Well, WIPN 52992

5.2.3 Well Interference and Distance Needed for a Second Well

To determine how far away a second production well would need to be located from WIPN 52992, transmissivity and storativity values are needed.

The H-J solution determined that the transmissivity at the well was $63 \text{ m}^2/\text{day}$. However, as noted in Section 5.1.4, the analysis did not yield a valid storativity value. As a result, Associated used literature values for storativity (which ranges typically from 10^{-3} to 10^{-5} [unitless]) for radius of influence calculations in this subsection. AQTESOLV curve matching graphs and the solutions reports are presented in Appendix E.

To estimate the radius of influence of the pumping well (WIPN 52992), Associated ran three scenarios of the C-J solution, one each using the typical maximum storativity value (10^{-3}) and typical minimum storativity value (10^{-5}) for a confined aquifer, and one using a value halfway between (10^{-4}). The t value (time since pumping began) used was 1 day, as the well began receiving recharge from the leaky aquifer in less than 1 day. Table 5-2 shows the results for the three storativity values for different radial distances from the well.

Table 5-2 Estimated Drawdown at a Given Distance from Pumping Well, WIPN 52992

Distance from WIPN 52992 (m)	Estimated Drawdown		
	$S = 10^{-3}$	$S = 10^{-4}$	$S = 10^{-5}$
20	3.6	5.1	6.5
50	2.5	3.9	5.4
100	1.6	3.1	4.5
150	1.1	2.6	4.0
200	0.8	2.2	3.6
250	0.5	1.9	3.4
500	0.0	1.1	2.5

The modelled drawdown with an S value of 10^{-3} best fits the observed drawdown data; at 0.5 m from the well, the calculated drawdown is 8.2 m and the observed drawdown in the pumping well was 8.3 m after 1 day of pumping. The calculated drawdown is 9.6 m for $S = 10^{-4}$ and 11.1 m for $S = 10^{-5}$. Thus, it is more likely that the true S value is closer to 10^{-3} than 10^{-4} and it therefore follows that the true drawdown at a given distance from the pumping well is likely more similar to the values presented in the Estimated Drawdown $S = 10^{-3}$ column than to those calculated using the S values of 10^{-4} or 10^{-5} . S – storativity

To meet the MDD of 9.02 L/s (143 USgpm), an additional well needs to produce at least 3.89 L/s (61.6 USgpm) to support the contribution from WIPN 52992 (the new well). Recall from Section 5.2.2, WIPN 52992's long-term sustainable yield as calculated using the CPCN method, was 5.14 L/s (81.4 USgpm) (Table 5-1). To produce 61.6 USgpm, including a 30% factor of safety, well interference cannot be greater than 2.6 m. This assumes the additional water supply well is in a part of the aquifer that has the same properties (i.e., same transmissivity, storativity, aquifer thickness, areal extent, and recharge from overlying aquifers) as WIPN 52992 and that the additional well behaves the same. The value of 2.6 m was back-calculated using the same CPCN calculation and input parameters as those in Table 5-1, but with the long-term sustainable yield (including a 30% factor of safety) of 61.6 USgpm. This means the additional well would likely need to be placed >50 m from WIPN 52992 if $S = 10^{-3}$, or about 150 m if $S = 10^{-4}$. Because the calculated drawdown at a given radial distance to WIPN 52992 is partly based on literature values, and because the aquifer does not fully follow the assumptions of the C-J solution, and to provide a factor of safety, **Associated recommends that if a second well is considered, the more conservative S value of 10^{-4} should be used and the well should be placed at least 150 m from WIPN 52992.**

Associated then reviewed contour maps, and aerial photographs, and completed hydrogeological mapping of the inferred edge of the alluvial fan (Figure 5-2). This assessment indicates that there is not enough space within the boundary of the inferred aquifer north of WIPN52992 to place a second well 150 m away. Associated does not recommend placing a well south of WIPN52992 because an amendment to the water licence to convert to groundwater is not likely to be granted: groundwater near Summer Creek will be considered to be intercepting groundwater that will otherwise flow as baseflow to Summer Creek. This assessment indicates that due to well interference and the small size and narrow shape of the aquifer, a second well is not likely to be successful. Therefore, groundwater is likely not a viable option.



Figure 5-2 Inferred Edge of Aquifer

5.3 Assessment of Impacts on Other Users

5.3.1 Hydraulic Connection

The well is 15 m east of Misesezula Lake. At its deepest, the lake is 74 m deep (243 ft.); however, the lake is 6 km long, and the deepest portion of the bay area west and within 150 m of the well is 23 m deep (Larratt 2022). The new well (WIPN 52992) is screened from 34.5 m bgs to 38.4 m bgs, and the old well (WIPN 43254) is screened from 27.7 m bgs to 30.5 m bgs. The pumping test (Section 5.2.3) determined the old well is in the same aquifer as the new well; however, there is likely a thin layer of lower-permeability material between the screens of the two wells. The driller's logs for the two wells suggest that the top of the aquifer is approximately 28.2 m bgs (base of the silty sand with clay layer) (Appendix C). Therefore, the top of the aquifer is approximately 985 m asl, while the base of the lake west of the wells is approximately 989 m asl.¹ Based on these measurements, the top of the aquifer is at a lower elevation than the lake by 4 m. Additionally, the water level in the new and old wells is approximately 20 m bgs, or 992 m asl. This is approximately 20 m below the lake surface.

¹ This value is based on Google Earth elevations for the lake surface at 1,012 m asl and the old and new wells at 1,013 m asl.

Despite these differences in water level height between the two wells and the lake, a Piper plot analysis² of the water quality data from a lake water sample, and from the new and old wells shows that the old well has very similar water chemistry to the lake, but the new well does not (Figure 5-3) (water quality for WIPN 52992 is discussed in detail in Sections 6 and 7). The Piper plot suggests that the upper part of the aquifer (in which WIPN 43254 is completed) is likely hydraulically connected to the lake. It also provides further evidence of a thin lower-permeability layer between the screens of the two wells. Nevertheless, the pumping test showed a direct connection between the old and new wells (Section 5.2.3). Additionally, the pumping test derivative analysis showed a positive boundary condition via a leaky aquitard from an overlying aquifer (Section 5.2.3). This implies the new well is recharged through a leaky aquitard from an overlying aquifer and that this overlying aquifer is likely hydraulically connected to the lake. Therefore, WIPN 52992 is likely inducing flow from the lake through an overlying unconfined aquifer, a leaky aquitard and into the confined aquifer that contains the old and the new well.

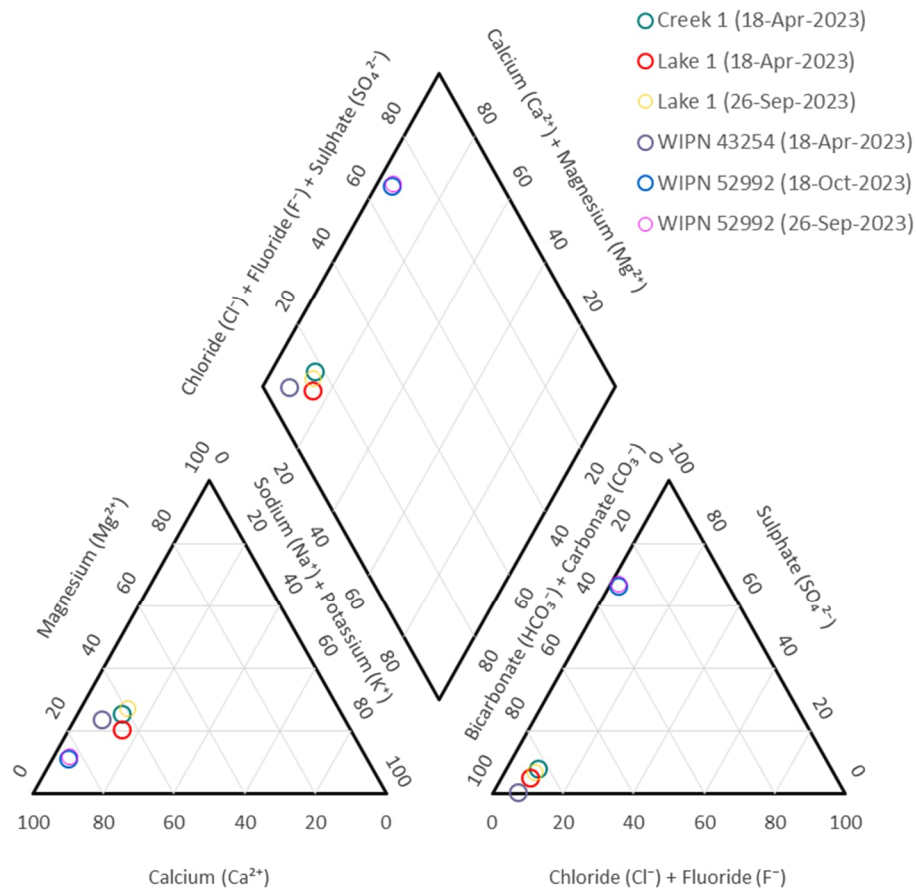


Figure 5-3 Piper Plot of Water Quality Samples from Lake Water, WIPN 52992, and WIPN 43254

² The ion balance (sum of cation and anions) in the April 18 samples taken at WIPN 43254, the lake, and Summers Creek is greater than 5%, at 13.4 %, -12.8%, and 14.1%, respectively. This potentially means the sampling, preservation, and shipping methods used during sampling were potentially of poor quality. However, the lake sample from the September 26, 2023, plots similarly to that from the April 18, 2023, sample, so it is likely that both samples are reasonable representations of the lake. However, there are no other samples from WIPN 43254 to confirm the quality of sampling and analysis. It is reasonable to assume that because the lake samples were shown to be representative, the WIPN 43254 sample is likely also representative of the well's general water chemistry.

A potential reason for the difference in observed water levels between the lake and the new well is the fine-grained lithology observed in the new well during drilling. Associated observed clay- and silt-rich layers at about 6.1–7.3 m bgs (1.2 m thick: sand and gravel with silt and clay) and 13–21.3 m bgs (7.6 m thick: silty SAND with clay, and sand and gravel with clay and silt). The later clay- and silt-rich layers would provide a degree of confining between the aquifer and the lake bottom that could account for different water levels between the lake and the new well, but could still allow for a leaky connection between the lake and the new well when pumped as indicated by the above water chemistry and pumping test data.

Overall, based on the evidence of the water chemistry between the lake and WIPN 43254, and the pumping test analysis, Associated concludes that WIPN 52992 induces infiltration of lake water via the lake bottom, and is, thus, hydraulically connected to Missezula Lake.

5.3.2 Impacts on Nearby Groundwater Users

No other provincially registered groundwater wells are registered within 1,000 m.

5.3.3 Issues Related to Proposed Works, Land, and Public Safety

RDOS has a licence of occupancy of Crown land for the infrastructure that exists. RDOS is working with crown land representatives and the Ministry of Transportation and Infrastructure to learn more about how to move forward with the recommended option.

Associated understands that Missezula Lake floods in some wet years. This will need to be further studied in the design phases of the project, if applicable, once the preferred option is confirmed.

5.3.4 Missezula Lake Water Licences

RDOS already has two water licences for withdrawing from Missezula Lake and storage at the dam (Table 5-3). A detailed review of the exact comparison of the amount of water used by the community in a given year compared to their licensed volume is out of scope for this report. RDOS can apply for a licence amendment (see Section 7.3 for an opinion on the cost to complete a technical assessment in support of a licence amendment).

Table 5-3 RDOS Licence Details

Detail	Conditional Water Licence 132100	Conditional Water Licence 116426	Conditional Water Licence 111484
Date of priority	29-Sep-10	29-Sep-87	29-Sep-87
Issued date	06-May-15		01-Oct-96
Volume on licence	93,166 m ³ /year	50,000 gal./day	500 ac.-ft.
Volume	255 m ³ /d (47 USgpm)	191 m ³ /d (35 USgpm)	616,740 m ³ per year storage (162,925,714 U.S. gallons per year storage)
Purpose	Waterworks	Waterworks	Storage

Detail	Conditional Water Licence 132100	Conditional Water Licence 116426	Conditional Water Licence 111484
Conditions and other notes	Shall install a flow measuring device. Must be taken from storage provided in the reservoir authorized under CWL 111484 or any licence issued in substitution thereof.	This licence is issued in substitution to 111490.	The reservoir may be filled from April 1 to June 15th and the water may be released from storage at any time of the year.

6 DRINKING WATER QUALITY ASSESSMENT

6.1 Water Quality Sampling Methods

During the pumping test, groundwater samples were collected following the procedures outlined in the British Columbia Field Sampling Manual (MWLAP 2013). Field parameters (pH, temperature, conductivity, oxidation–reduction potential, dissolved oxygen, and turbidity) were measured before sampling, using calibrated equipment. The September 26, 2023, samples were collected numerous hours into the well development stage, after field parameters had stabilized and turbidity was relatively low (<10 NTU). The October 17 and 18, 2023, samples were collected numerous hours into the pumping test, after field parameters had stabilized and turbidity was low (≤ 1.21 NTU). The samples were collected in laboratory-supplied containers. Samples for dissolved-phase constituents were passed through a 0.45-micron filter before collection.

All water samples were transported under chain-of-custody protocol in cool boxes with ice to CARO Analytical Services in Richmond, BC, for analysis of the following parameters:

- General water quality parameters (alkalinity, chloride, true colour, conductivity, cyanide, fluoride, hardness, nitrilotriacetic acid, pH, sulphate, total dissolved solids [TDS], total suspended solids, total organic carbon, dissolved organic carbon, turbidity, and UV transmittance at 254 nm);
- Nutrients (ammonia, nitrate, nitrite, total Kjeldahl nitrogen, organic nitrogen, total phosphorus, and dissolved phosphorus);
- Bacteriological parameters (total coliforms, *Escherichia coli*, iron bacteria, and sulphate-reducing bacteria);
- Dissolved and total metals;
- Radiological parameters (gross alpha and gross beta activity);
- Volatile organic compounds;
- BC Ministry of Environment aggregate hydrocarbons (miscellaneous organic substances);
- Monocyclic aromatic hydrocarbons;
- Polycyclic aromatic hydrocarbons;
- Chlorinated hydrocarbons; and
- Halogenated methanes.

Water quality results were compared with the Guidelines for Canadian Drinking Water Quality (GCDWQ) maximum acceptable concentration (MAC) and aesthetic objective (AO) (Health Canada 2023) and the BC Source Drinking Water Quality Guideline (BC SDWQG) MAC and AO (ENV 2020).

6.2 Water Quality Results

The water quality samples for WIPN 52992 were compared with the GCDWQ MAC and AO. The water quality results are shown in their entirety in Appendix A. Overall, the water quality met the guidelines for all parameters, with the following exceedances: total organic carbon, TDS, aluminum (total), and manganese (total). These exceedances and their respective MAC and/or AO are listed in Table 6-1. Note however, the Health Canada technical support document for hardness states that hardness in excess of 500 mg/L is considered unacceptable for most domestic purposes. Thus the well's hardness concentration of 564 mg/L on October 18, 2023, should be considered as an exceedance. Only the results of the October 18, 2023, samples are presented in the table, as those are the results from sampling after the well was developed and pumped for a substantial time (i.e., more than 24 hours) and are therefore the most representative of the true aquifer and well conditions.

Table 6-1 Concentration of Parameters that Exceeded the GCDWQ or BC SDWQG MAC or AO at WIPN 52992

Exceeding Parameter	Concentration (mg/L)	MAC (mg/L)	AO (mg/L)	Most Stringent Guideline
Total organic carbon	4.8	4	NG	BC SDWQG
Total dissolved solids	708	NG	500	GCDWQ
Aluminum	0.115	2.9	0.100	GCDWQ
Manganese (total)	0.155	0.12	0.02	GCDWQ & BC SDWQG

Values in bold exceed a MAC. AO – aesthetic objective; BC SDWQG – BC Source Drinking Water Quality Guideline; GCDWQ – Guidelines for Canadian Drinking Water Quality; MAC – maximum allowable concentration; NG – no guideline value stated

6.3 Preliminary Source Protection Review

For the preliminary source protection review, Associated visited the site, reviewed air photos, and interviewed the WTP operator (Mr. Adam Cunningham) to look for potential land uses that could be a considered a drinking water hazard. A drinking water hazard is defined as an agent of harm (events, conditions, actions, inactions) that has the potential to impact the safety or availability of the water supply (MHLS 2010).

Associated noted the following drinking water hazards:

- Missezula Lake Road is within 30 m of WIPN 52992 and could present a potential source of contamination to the well; however, the road is travelled infrequently and generally only by passenger vehicles, so its risk as a potential source of contamination is considered low.
- No known septic fields are known to exist within 30 m, and the well was placed more than 30 m from any private property boundary to avoid being too close to a private septic system.
- There are outhouses approximately 50 m north and 88 m south of the well, but because they are farther than 30 m away from the well, the a potential source of contamination for all contaminants except viral pathogens is considered low.
- WIPN 43254 has a surface seal that does not meet the *Groundwater Protection Regulation* (BC 253/2022); its drilling log states that its surface seal extends only 4.57 m bgs (15 ft. bgs), while 5 m bgs is required by the

Regulation. Therefore, this well could potentially present a risk to contaminating the aquifer in which WIPN 52992 and 43254 are completed as well as their water quality.

- No other potential sources of contamination, such as underground or aboveground storage tanks, manure piles, or septic tanks or fields exist within 30 m any of the wells.

6.4 GARP Determination

The *Drinking Water Protection Act* regulates all water systems other than single-family dwellings (and related systems). The *Drinking Water Protection Regulation*, enacted from the Act, states that groundwater sources determined to be GARP must be disinfected. Section 1.3 of the Guidance Document for Determining Groundwater at Risk of Containing Pathogens (version 3) (2017) states that a GARP assessment should be considered part of the siting of a new well to help select a location that minimizes exposure to hazards and to anticipate hazards that may require mitigation. Associated did not perform a GARP assessment on WIPN 52992; depending on the outcome of the options of the evaluation, if groundwater is pursued, a GARP assessment is recommended as part of the next phase of the work.

7 ASSESSMENT OF INFRASTRUCTURE AND OPERATIONS REQUIREMENTS

7.1 Treatment Requirements

This subsection compares the anticipated treatment requirements for a new groundwater source, such as from WIPN 52992, and the existing surface water source.

7.1.1 Microbiological Considerations

The minimum level of treatment to address microbiological parameters, as mandated by the BC Ministry of Health, depends on the type of water source. For surface water, the Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia list the following minimum treatment requirements:

- Achieve at least 4-log reduction or inactivation of viruses;
- Achieve at least 3-log reduction or inactivation of *Giardia* and *Cryptosporidium*;
- At least two treatment processes, typically a combination of filtration and disinfection;
- Less than or equal to 1 NTU turbidity in the water entering the distribution system;
- No detectable *E. coli*, fecal coliform, or total coliform in treated water.

For groundwater, a source's potential vulnerability to contamination, assessed and classified according to the ministry's Guidance Document for Determining Groundwater at Risk of Containing Pathogens (GARP), dictates the level of treatment required, as detailed in the Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia:

- GARP – treat to the same level as surface water:
 - Achieve at least 4-log reduction or inactivation of viruses;
 - Achieve at least 3-log reduction or inactivation of *Giardia* and *Cryptosporidium*;
 - Minimum of two treatment processes, typically a combination of filtration and disinfection;
 - Less than or equal to 1 NTU turbidity in the water entering the distribution system; and
 - No detectable *E. coli*, fecal coliform, or total coliform in treated water.
- GARP-viruses only – low risk that *Giardia* or *Cryptosporidium* will be present in the groundwater:

- Achieve at least 4-log reduction or inactivation of viruses;
 - At least one form of treatment, typically disinfection;
 - Around 1 NTU or less turbidity in the water entering the distribution system; and
 - No detectable *E. coli*, fecal coliform, or total coliform in treated water.
- Not GARP – low risk of microbiological contamination:
 - No detectable *E. coli*, fecal coliform, or total coliform.

For the purposes of this assessment, Associated assumes that WIPN 52992 would be classified as GARP-viruses only.

7.1.2 Physical and Chemical Considerations

In addition to containing criteria for microbiological parameters, BC drinking water standards include criteria for physical and chemical parameters as detailed in the BC Drinking Water Officers Guide and Health Canada's GCDWQ. A comparison of key water quality parameters and the GCDWQ objectives are provided in Table 7-1. The full water quality data from the collected surface and groundwater sources are provided in Appendix A.

Table 7-1 Physical and Chemical Water Quality Parameters

Parameter	Surface Water Samples ¹	Groundwater Samples ²	GCDWQ Objective
Turbidity	0.61–1.07 (Avg. 0.84)	0.88–6.86 (Avg. 3.0)	<1.0
True colour	NS	< 5	≤15
pH	7.6–8.3 (Avg. 8.0)	8.0–8.2 (Avg. 8.1)	7.0–10.0
Hardness (mg/L as CaCO ₃)	133–146 (Avg. 140)	464–583 (Avg. 529)	NS ³
Alkalinity (mg/L as CaCO ₃)	125–164 (Avg. 145)	205–225 (Avg. 216)	NS
Total organic carbon (mg/L)	5.0–6.5 (Avg. 5.8)	4.1–4.8 (Avg. 4.5)	NS
Total iron (mg/L)	<0.01	0.19–0.59 (Avg. 0.27)	≤0.3
Total manganese (mg/L)	0.01–0.002 (Avg. 0.002)	0.129–0.163 (Avg. 0.148)	≤0.02 (AO) ≤0.12 (MAC)
Total dissolved solids (mg/L)	165–187 (Avg. 176)	708–756 (Avg. 732)	≤500

¹ Surface water samples were taken from Summers Creek on April 18, 2023, and Missezula Lake on September 26, 2023. ² Groundwater was sampled on September 26 and October 17, 18, and 19, 2023. ³ Aesthetic or health-based criteria are not mandated in the GCDWQ. However, the Health Canada technical support document for hardness states that hardness in excess of 500 mg/L is considered unacceptable for most domestic purposes. AO – aesthetic objective; GCDWQ – Guidelines for Canadian Drinking Water Quality; MAC – maximum acceptable concentration; NS – no sample data

7.1.2.1 Surface Water

The physical and chemical water quality parameters in the creek and lake samples meet the objectives of the GCDWQ. However, Associated recommends that the following additional physical and chemical characteristics of the surface water source be considered:

Algae

RDOS has reported that significant algal blooms develop in the lake in the summer. Aesthetically, algae can impact the visual appearance, taste, and odour of water, and can clog fixtures and mechanical equipment. Some forms of algae also contain cyanobacterial toxins that can be released if the algal cells are damaged. These toxins have been associated with liver toxicity in tests involving rats.

Treatment processes used for particulate removal are generally effective at removing algae. Processes such as dissolved air flotation (DAF) can remove algae with minimal risk of algae damage and cyanotoxin release.

Organics

The GCDWQ do not have a standard for organics concentrations in drinking water as they do not directly pose a health risk or impact water aesthetics. However, organics can be used as an indicator of the potential presence of precursors that can react with chlorine during disinfection to form disinfection byproducts, which can have detrimental health impacts after long-term, regular consumption in elevated concentrations.

Without a Canadian objective for organics removal, the US Disinfectants and Disinfection Byproducts Rule is commonly used as a guide. The Rule provides removal targets for total organic carbon treatment that depend on raw water total organic carbon concentrations, alkalinity, and pH (Table 7-2). However, if disinfection byproducts are not detected at significant levels in the distribution system downstream of treatment, organics removal is typically not required.

Table 7-2 TOC Removal Objectives During Treatment

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as CaCO ₃)		
	0–60	>60–120	>120
>2.0–4.0	35%	25%	15%
>4.0–8.0	45%	35%	25%
>8.0	50%	40%	30%

Source: US Disinfectants and Disinfection Byproducts Rule (US EPA 1998). TOC – total organic carbon

Treatment processes that can effectively remove organics include ion exchange, coagulation (chemical addition) combined with sedimentation or DAF followed by filtration, and direct filtration.

7.1.2.2 Groundwater

The sampled groundwater does not satisfy the GCDWQ for the following physical and chemical parameters:

Turbidity – Turbidity is a measurement of cloudiness and is caused by the presence of organic and/or inorganic particulates in the water. The guidelines for turbidity are largely based on their impact on the visual aesthetics of drinking water and the potential for turbidity to interfere with certain treatment processes. Turbidity is also used as a surrogate to gauge the effectiveness of filtration technologies for removing micro-organisms. Turbidity can be removed by various particulate removal treatment technologies, including filtration, pre-treatment with settling, and pre-treatment with DAF.

Iron – The GCDWQ list a non-health-based AO for iron as 0.3 mg/L, based on the tendency of iron in greater concentrations to cause water to turn red and give it a metallic taste or odour. A lower AO of 0.1 mg/L is currently being considered by Health Canada. Treatment for iron typically consists of oxidation or filtration: Oxidation involves exposing the water to an oxidant (such as sodium hypochlorite or potassium permanganate) to render iron into a form that is easier to remove. Filtration involves passing the water through a coated medium while the oxidized iron sorbs to the surface of the medium's grains.

Manganese – The GCDWQ provide an AO for manganese of 0.02 mg/L, based on the ability of manganese in greater concentrations to cause water to turn dark and give it an unappealing taste and odour. A health-based MAC of

0.12 mg/L has been established in the GCDWQ, based on the potential for elevated manganese concentrations to lead to cognitive impairment in children. Treatment options for manganese include the following:

- Oxidation and filtration;
- Ion exchange;
- Membrane filtration; and
- Biological filtration.

The most suitable form of treatment depends on how manganese reacts to the form of treatment, and on other constituents in the water that might interfere or hinder treatment.

TDS – TDS is the measure of dissolved ions, including sodium, magnesium, and chloride in water. The GCDWQ have established an AO of 500 mg/L for TDS, based on TDS in greater concentrations causing water to have an unpalatable taste. Because of the highly soluble nature of the ions that contribute to TDS, TDS removal is difficult to achieve. Typically, reverse osmosis (RO)—filtration of water through finely pored membranes—is required to reduce TDS. RO often requires pre-treatment, usually in the form of filtration that targets larger particles, to delay the buildup of materials that can clog the fine pores of the RO membranes, thereby prolonging the life of the membranes.

Because of the capital costs, operation and maintenance requirements, and high volume of waste generated when removing TDS, it is common for small water systems in BC to not treat for TDS if the serviced community does not find the presence of TDS in their water objectionable.

Hardness – Hardness is the measurement of hardness ions, such as calcium and magnesium, that can lead to scaling in piping, plumbing fixtures, and hot water tanks. The GCDWQ do not stipulate a MAC or an AO for hardness. The GCDWQ technical support document for hardness indicates that hardness greater than 500 mg/L (as CaCO_3) is generally considered unacceptable for most domestic purposes. In contrast, the Drinking Water Quality Standards and Objectives in Saskatchewan stipulate a hardness AO of 800 mg/L (as CaCO_3). For small water systems, the acceptable upper threshold for hardness in drinking water depends on the tolerance level of their consumers; it is therefore common for small water systems to not treat for hardness even when levels exceed 500 mg/L (as CaCO_3).

Treatment for hardness typically involves an ion exchange system or a water softener, though RO is also commonly used to reduce hardness when an RO system is used to simultaneously treat for other water parameters.

Organics

Organics, expressed in the groundwater data as total organic carbon, do not have a GCDWQ MAC or AO, but they are sometimes used as a surrogate for predicting the potential formation of disinfection byproducts during treatment. The suggested objective for organics removal is discussed in Section 7.2.1.

7.1.3 Summary of Treatment Objectives

Based on the data presented, the recommended treatment objectives for the surface water source are as follows (Option 1):

- Algae removal;
- Organics reduction; and
- Filtration and disinfection to achieve the following:
 - 4-log virus removal or inactivation

- 3-log removal or inactivation of *Cryptosporidium* and *Giardia*

The recommended treatment objectives for groundwater have been presented as two cases: If the economic, operational, and residual management resources are available, the ideal treatment objectives for the groundwater source are as follows (Option 2):

- Iron reduction;
- Manganese reduction;
- Disinfection to achieve 4-log virus removal or inactivation;
- TDS reduction;
- Hardness reduction; and
- Organics reduction.

If the serviced community finds the groundwater hardness and TDS levels palatable, the simplified treatment for groundwater would be as follows (Option 3):

- Iron reduction;
- Manganese reduction;
- Disinfection to achieve 4-log virus removal or inactivation; and
- Organics reduction if disinfection byproducts are detected in the distribution system.

7.2 Treatment Options

7.2.1 Option 1 – Surface Water Treatment

The following treatment objectives are commonly used to meet the surface water treatment objectives proposed in Section 7.1.1:

- Coagulation (chemical addition): Coagulation is the addition of chemicals to encourage particulates to agglomerate and form a larger floc, which is easier to remove by other stages of treatment. Chemicals to raise the pH or alkalinity of the water may also be added to facilitate the coagulation process.
- Pre-treatment: Pre-treatment is the process of encouraging further floc agglomeration and removal of large floc before filtration. Pre-treatment involves a water mixing stage called flocculation, followed by either sedimentation (when a heavier floc settles out of the water) or DAF (when a larger floc floats to the water surface and is removed by automated skimmers).
- Algae and organics tend to form a light floc, which is easier to remove by flotation than by sedimentation. Therefore, Associated has assumed that DAF would be used for this surface water source.
- Filtration: Filtration is the process of physically straining out the remaining floc in the water. The filter can consist of either of media made of anthracite, sand, and/or diatomaceous earth, or a membrane. Of the different types of membranes available, low-pressure membranes such as ultrafiltration are typically used when targeting microbiological parameters.
- Disinfection: Disinfection is the process of destroying or inactivating microbiological parameters using chemicals or UV light. At a minimum, surface water sources use chlorination to ensure viruses are destroyed and to produce a chlorine residual to protect water quality integrity as the treated water travels from the treatment facility to consumer taps.

See Figure 7-1 for a sample process flow diagram for Option 1 – Surface Water.

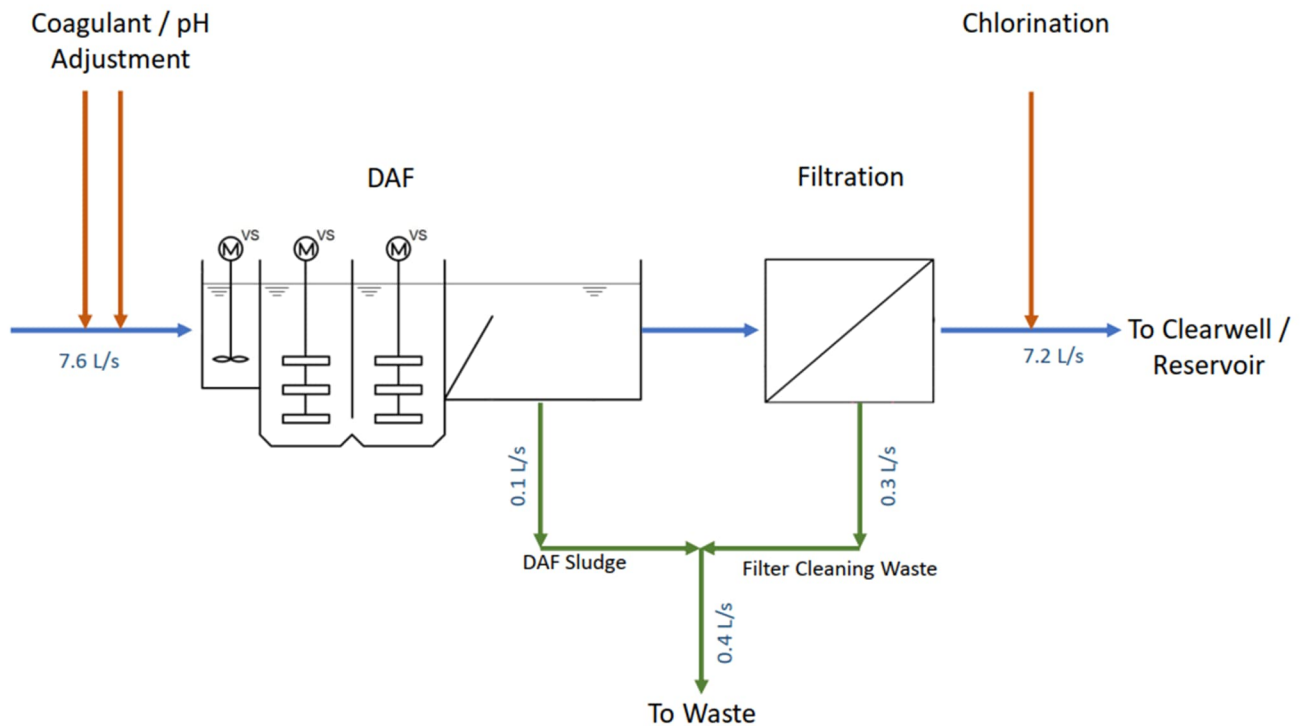


Figure 7-1 Process Flow Diagram for Option 1 – Surface Water

7.2.2 Option 2 – Groundwater Treatment

The following treatment objectives are commonly used to meet the groundwater treatment objectives listed in Section 7.1.3:

- **Oxidation:** Oxidation is the chemical process that energizes metals in the water to render them into a more readily removable form. Typical oxidants include sodium hypochlorite, potassium permanganate, and oxygen.
- **Filtration using a sorbent media:** After oxidation, metals are removed by passing water through a coated medium that sorbs the metals to the surface of the medium's grains. GreensandPlus and pyrolusite are two media commonly used for iron and manganese removal, protected by a layer of anthracite if iron concentrations are high, although other sorbent media can be used.
- **Pre-RO filtration:** This stage involves filtering or straining the water using a large-pored filter to remove larger particles that could damage or clog the RO membranes.
- **RO filtration:** RO membranes, or high-pressure membranes, are finely pored membranes used to remove dissolved solids and other parameters that are difficult to remove. The process involves pumping water at a high pressure through the membranes. The membrane pores prevent materials from passing through the membrane and rejects them in a waste stream. The RO process removes most ions in treated water, leaving the filtered water chemically unbalanced and prone to large oscillations in pH. To mitigate this effect, a portion of the incoming water to the RO system can be diverted to bypass the membranes and blend with the filtered water downstream. In addition to creating a more chemically stable blended water, subjecting only a portion of the treated water to RO filtration reduces the amount of water rejected by the RO process that

must be treated as waste. The level of pre-treatment required to protect the RO units and extend their service life depends on upstream water conditions and on vendor design. Some RO units may not require pre-filtration or the removal of iron and manganese. The vendors that were contacted as part of this assessment recommended pre-filtration and treatment for iron and manganese upstream of the RO systems; therefore, at this stage of design, it has been assumed that iron and manganese removal and pre-filtration would be part of the groundwater treatment system.

- Disinfection: Disinfection is the process of destroying or inactivating microbiological parameters. At a minimum, chlorination is recommended to ensure that viruses are destroyed.

See Figure 7-2 for a sample process flow diagram for Option 2 - groundwater.

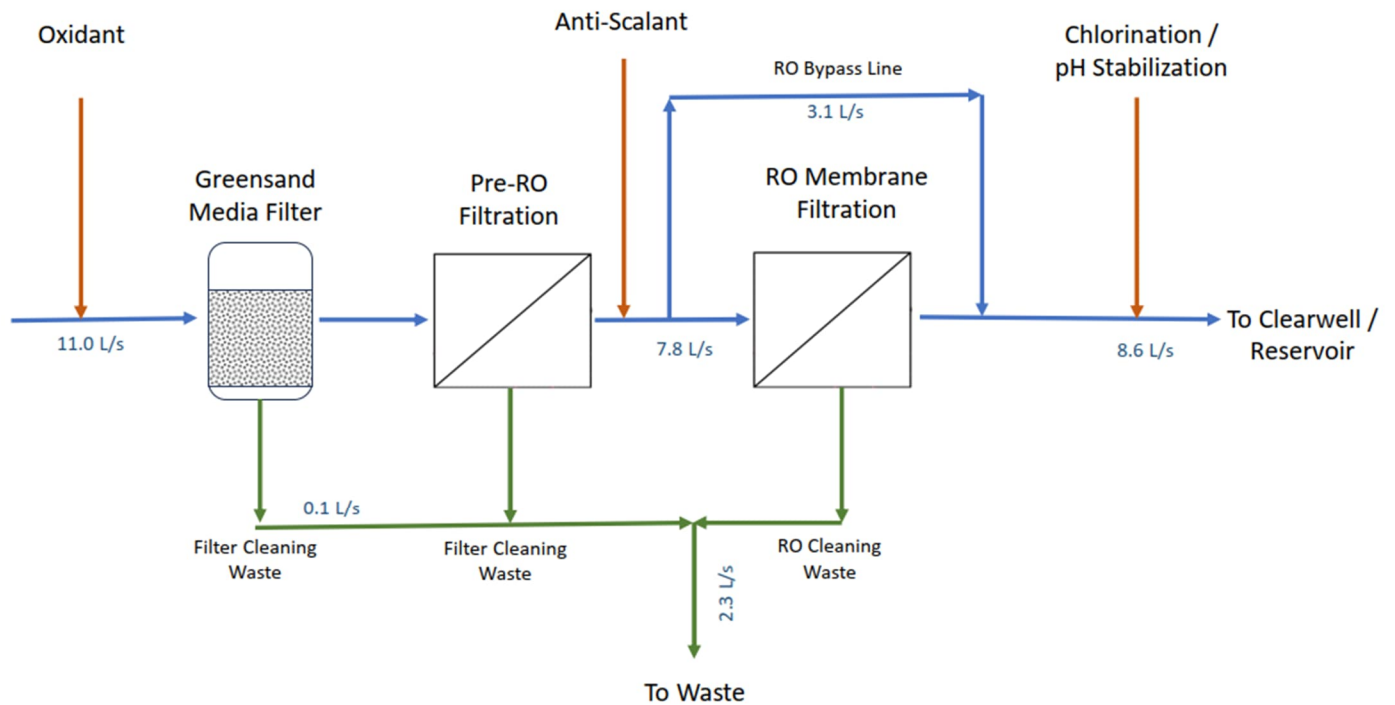


Figure 7-2 Process Flow Diagram for Option 2 – Groundwater

7.2.3 Option 3 – Groundwater Treatment (Simplified)

If the serviced community finds the groundwater hardness and TDS levels palatable, the simplified treatment for groundwater would be as follows (Option 3):

- Iron reduction;
- Manganese reduction;
- Disinfection to achieve 4-log virus removal or inactivation; and
- Organics reduction if disinfection byproducts are detected in the distribution system.

See Figure 7-3 for a sample process flow diagram for Option 3 – groundwater (simplified). The greyed-out text shows the processes removed from Option 2.

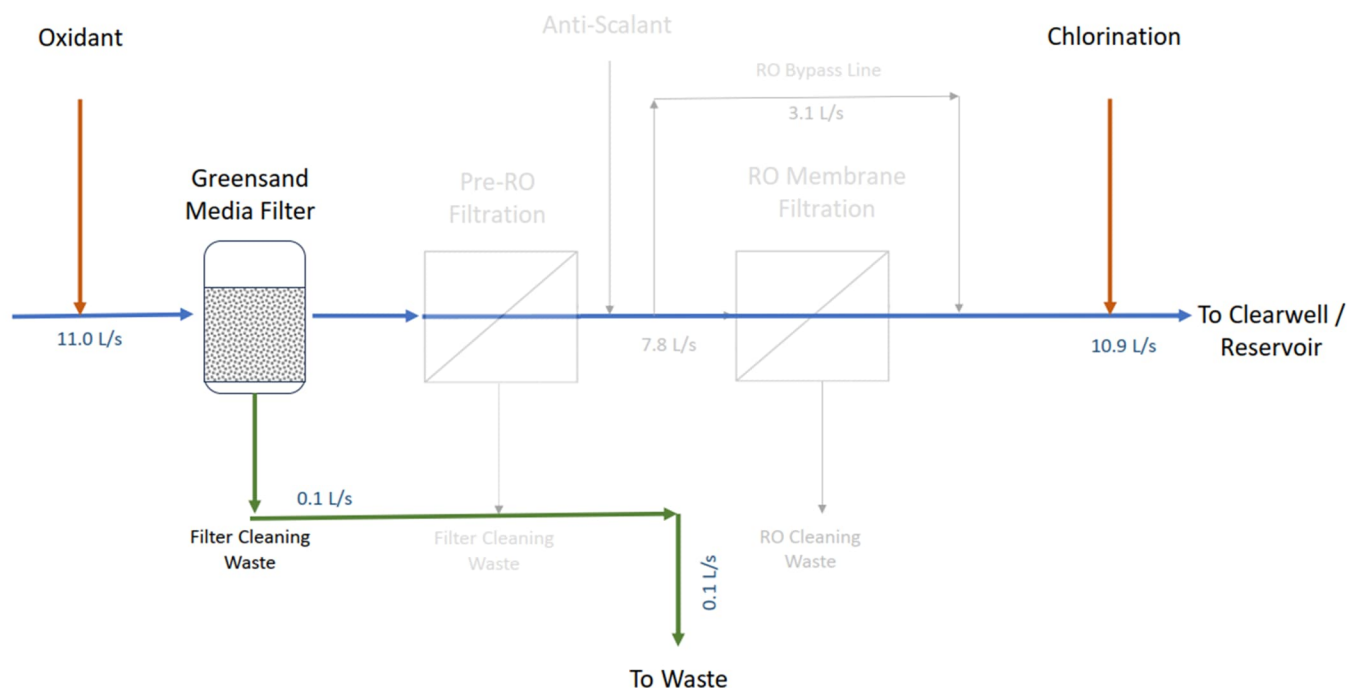


Figure 7-3 Process Flow Diagram for Option 3 – Groundwater (Simplified)

7.2.4 Cost Control Measures

Opinions of probable cost for the Options 1, 2, and 3 treatment facilities were developed based on a design flow of 11 L/s. The costs for Options 1 and 2 for the treatment equipment and housing exceeded RDOS's budget for this capital project. Therefore, the capital estimates for Options 1 and 2 were revised for treatment facilities of a lower capacity, specifically to 7.6 L/s for Option 1 and 8.6 L/s for Option 2. The resulting differences in probable costs for the WTP equipment and building are shown in Table 7-3. Note that these estimates do not include costs for site work outside of the building, which is addressed in Section 7.4.

Table 7-3 Capital Costs for WTP and Housing

Description	Capital Costs for Option 1 - Surface Water	Capital Costs for Option 2 - Groundwater
11 L/s design flow - Housing built on-site - n+1 redundancy in all treatment processes	\$3.4 m	\$1.6 m
- Reduced design flow - Prefabricated building - No redundancy in pre-treatment or filtration processes	\$3.7 m	\$1.6 m

Two additional revisions to the design criteria were applied as part of cost control:

- **Pre-fabricated structure.** For all three options, the WTP equipment and housing would be fabricated at the supplier shop and arrive pre-assembled at site, as opposed to constructing the WTP structure on site. A pre-fabricated enclosure reduces the control that RDOS has on the layout and appearance of the building, but it can significantly reduce the construction and installation costs.
- **Removal of redundant treatment units.** For Option 1, the design revision deleted the standby DAF train and filtration vessel, meaning that all DAF and membrane units must be in operation in order to meet the maximum flow demand. For Option 2, the design revision deleted the standby filtration vessel and standby RO membrane unit. For Option 3, the standby filtration vessel did not need to be removed in order to meet RDOS's budgetary constraints; therefore, this option still includes a standby filtration vessel, or N+1 redundancy, in its configuration. All three options still include standby chemical pumps.

While these design revisions significantly reduced the quoted capital costs of the treatment facility, it also removes the ability for Options 1 and 2 to treat water at the maximum design flow if one treatment unit is offline. This impacts the design and operation of the treatment facilities in the following ways:

- **Regular routine maintenance.** All three options will require periods in which the filtration equipment will need to be brought offline for backwashing or cleaning. This downtime period can typically be set by the operators to occur at a specific time during the day to avoid periods of high demand in the water system. For this assessment, it has been assumed that the treatment units will go offline for 1 hour each day. To improve RDOS's ability to continue to supply treated water to the rest of the distribution system while the WTP is offline, the design for Options 1 and 2 include an additional clearwell for treated water, sized to meet the maximum design flow demand for 1 hour.
- **Unexpected maintenance.** During operation of the WTP, equipment will periodically fault or go offline. In those situations, the duty treatment equipment will then typically come online to ensure that the WTP can continue operating at full capacity. Without redundancy, Options 1 and 2 will have significantly reduced treatment capacity in this scenario and will require immediate response from the operations team to bring the system back online as soon as possible.

In general, it is best practice in the design of drinking water treatment facilities to include at least N+1 redundancy for all significant process equipment. RDOS must carefully consider the cost versus risk of removing the redundant treatment equipment when they budget for the upgraded water treatment infrastructure.

The development of the opinion of probable costs is discussed in Section 7.4. The revised flow rates for Options 1 and 2 were used in the assessment of residual production and management, discussed in Section 7.3.

7.3 Residuals Management

The proposed treatment options for the MLWS generate residuals during treatment that should be discharged as waste. Table 7-4 summarizes the sources of waste residuals generated during treatment.

Table 7-4 Waste Residuals Generated During Treatment

Description	Option 1 – Surface Water	Option 2 – Groundwater	Option 3 – Groundwater (Simplified)
Design flow (L/s)	7.6	8.6	11.0
Average daily waste production at design flow (L/s)			
• DAF sludge	0.1	–	–
• Filter backwash	0.3	–	–
• Greensand medium backwash waste	–	0.1	0.1
• RO hydraulic and (neutralized) chemical cleaning waste	–	2.2	–
Total	0.4	2.3	0.1
Waste description	The coagulant, which is alumina-based, will be concentrated in the waste streams. The waste stream will therefore contain elevated levels of aluminum.	- Iron and manganese will be concentrated in the backwash waste. - Almost all other physical and chemical parameters will be concentrated in the RO waste stream. - RO chemical cleanings involve concentrated hypochlorite and acid solutions. The cleaning waste will be neutralized in the WTP before discharge.	Iron and manganese will be concentrated in the backwash waste.

DAF – dissolved air flotation; RO – reverse osmosis; WTP – water treatment plant

7.3.1 Residuals Characterization

Table 7-4 presents the discharge flow and concentrations of select parameters for the three treatment options. The selected parameters were chosen based on their potential to exceed the BC Approved and Working Water Quality Guidelines for freshwater aquatic life and wildlife (ENV 2021, 2023a) in the receiving environment. For some parameters, the BC aquatic life guidelines include two maximum levels: chronic (or long-term average) and acute (or short-term maximum). Compliance with chronic guidelines is typically assessed by calculating the average concentration over a specified period (i.e., five samples in 30 days). The chronic guidelines are more stringent than the acute guidelines because they are designed to protect from repeated or ongoing exposure.

The lake scenario option has a low flow (0.4 L/s), but high total aluminum concentrations (119 mg/L) in the effluent, based on a coagulant dosage of 40 mg/L of alum for the treatment process. The groundwater option with RO has the highest flow of the three options (2.3 L/s), and the parameters of concern for this treatment option include total iron, total manganese, ammonia-N, sulphate, total arsenic, and total selenium. The groundwater option without RO has the lowest flow of the three options (0.1 L/s) and only two parameters of concern: total iron, and total manganese. However, the concentrations of these two parameters are considerably high (16.3 mg/L and 29.7 mg/L, respectively).

Table 7-5 Select Effluent Parameters for the Three Treatment Options

Parameter	BC Aquatic Life Guideline		BC Wildlife Guideline	Option 1 - Lake	Option 2 - Groundwater (with Reverse Osmosis)	Option 3 - Groundwater (Simplified - Without Reverse Osmosis)
	Chronic	Acute				
Discharge (L/s)	N/A	N/A	N/A	0.4	2.3	0.1
Total aluminum (mg/L)	Calculated ¹	N/A	5	119	N/A	N/A
Total iron (mg/L)	N/A	1	N/A	N/A	0.87	16.3
Total manganese (mg/L)	Calculated ²	Calculated ²	N/A	N/A	0.48	29.7
Total ammonia-N (mg/L)	Calculated ³	Calculated ³	N/A	N/A	0.89	N/A
Sulphate (mg/L)	Calculated ²	N/A	N/A	N/A	1,245	N/A
Total arsenic (mg/L)	0.005	N/A	0.025	N/A	0.006	N/A
Total selenium (mg/L)	0.002	N/A	0.002	N/A	0.01	N/A

¹ The BC aquatic life chronic guideline for total aluminum is calculated based on dissolved organic carbon, pH, and hardness. The guideline ranges from 0.009 mg/L at 1 mg/L dissolved organic carbon, 6 pH, and 10 mg/L hardness to 1.8 mg/L at ≥12.3 mg/L dissolved organic carbon, 8.7 pH, and 10 mg/L hardness (WLRs 2023). The guidelines for the creek and lake samples collected in 2023 are 0.288 mg/L and 0.442 mg/L, respectively. ² The BC aquatic life chronic and acute guidelines for total manganese and the chronic guideline for sulphate are calculated based on hardness. ³ The BC aquatic life chronic and acute guidelines for ammonia-N are calculated based on pH and temperature. N/A – not available.

7.3.2 Receiving Water Characterization

The nearest suitable receiving water for discharging residuals from the WTP is Summers Creek. Summers Creek is regulated by a dam at the outlet of Missezula Lake. Seasonal streamflow records (April to September) for Summers Creek at the lake outlet are available for 1970 to 1980, which was before flow was regulated at the outlet. The mean streamflow at that time ranged from 0.028 m³/s in April to 0.297 m³/s in June (True Consulting 2018). The Ministry of Environment and Climate Change Strategy Fisheries Management Section completed an assessment of the environmental flow needs for Summers Creek in 2017 (ENV 2017). The environmental flow needs were determined to be 62 L/s for December to July and 125 L/s for August to November. While the goal of regulating water at the lake outlet is to meet these flow needs, it has been reported that flow is occasionally lower in the creek during drought conditions.

No drinking water licences exist for Summers Creek within 5 km downstream of Missezula Lake, but there are 23 active water licences for other uses (Table 7-5) (BC 2024). Of these licences, nine are used for irrigation, 12 are used for non-power stream storage or conservation storage, and two are used for construct works.

Table 7-6 Water Licences on Summers Creek Within 5 km Downstream of Missezula Lake

Number	Purpose	Quantity	Licensee
502387	Stream storage: Non-power	8,740 (m ³ /year) ¹	Private individual
502387	Irrigation: Private	8,740 (m ³ /year) ¹	Private individual
C038180	Stream storage: Non-power	215,859 (m ³ /year) ²	Copper Creek Ranch Ltd. (80039)
C048280	Stream storage: Non-power	138,150 (m ³ /year) ²	Private individual
C048281	03B – Irrigation: Private	138,150 (m ³ /year) ¹	Private individual
C048281	03B – Irrigation: Private	138,150 (m ³ /year) ¹	Private individual
C064167	Stream storage: Non-power	229,427 (m ³ /year) ²	Starlight Farms Ltd. (151009)
C111483	Conservation: Construct works	0 (total flow) ²	Fish and Wildlife Section, Penticton (33811)
C111483	Conservation: Storage	616,740 (m ³ /year) ²	Ministry of Environment and Climate Change Strategy (14475)
C111483	Conservation: Construct works	0 (total flow) ²	Ministry of Environment and Climate Change Strategy (14475)
C111483	Conservation: Storage	616,740 (m ³ /year) ²	Fish and Wildlife Section, Penticton (33811)
C111484	Stream storage: Non-power	616,740 (m ³ /year) ²	Regional District of Okanagan-Similkameen (35505)
C128712	Irrigation: Private	24,670 (m ³ /year) ²	Private individual
C128713	Irrigation: Private	6,167 (m ³ /year) ²	Private individual
C131822	Stream storage: Non-power	24,670 (m ³ /year) ²	Private individual

Number	Purpose	Quantity	Licensee
C131823	Stream storage: Non-power	6,167 (m ³ /year) ²	Private individual
F006469	Irrigation: Private	30,220 (m ³ /year) ¹	Private individual
F006469	Irrigation: Private	30,220 (m ³ /year) ¹	Private individual
F006469	Irrigation: Private	30,220 (m ³ /year) ¹	Private individual
F006469	Irrigation: Private	30,220 (m ³ /year) ¹	Private individual
F006472	Stream storage: Non-power	30,220 (m ³ /year) ²	Private individual
F006472	Stream storage: Non-power	30,220 (m ³ /year) ²	Private individual
F059328	Stream storage: Non-power	39,471 (m ³ /year) ²	Private individual

¹ This is the maximum licensed demand for this purpose; there are multiple points of diversion, and the quantity at each point of diversion is unknown. ² This is the total demand for one purpose; there is one point of diversion.

Associated completed two water quality sampling events in 2023, collecting one sample from Summers Creek in April and one sample from Missezula Lake in September. These samples were analyzed for alkalinity, dissolved and total organic carbon, chloride, conductivity, hardness, pH, TDS, total suspended solids, ammonia-N, nitrate-N, nitrite-N, total nitrogen, total Kjeldahl nitrogen, orthophosphate, total phosphorus, dissolved phosphorus, and total and dissolved metals. Field parameters were measured at the time of sampling for conductivity, oxygen-reduction potential, dissolved oxygen, pH, temperature, and turbidity. The results were compared to the BC aquatic life and wildlife guidelines. All results met the applicable guidelines, except dissolved oxygen, which was below the BC chronic aquatic life minimum guideline (8 mg/L) in the creek sample (7.3 mg/L) and lake sample (7.6 mg/L).

7.3.3 Potential Impacts of Residuals Discharge on Receiving Waters

As a preliminary screening, the impact of discharging residuals to Summers Creek was assessed using a bulk dilution assessment. Bulk dilution is a concept under the *Municipal Wastewater Regulation* (BC Reg. 87/2012) that generally indicates the capacity of a stream or river to accept discharge. The MWR guidance was used in the absence of specific guidance for discharging WTP residuals.

Section 2 of the Regulation defines the dilution ratio as the 2-year return period, 7-day low flow in the receiving stream divided by the maximum weekly (7-day) effluent flow. If the dilution ratio is less than 40:1, additional restrictions and investigations are necessary,³ and discharge is prohibited if dilution is less than 10:1.

Following this methodology, the estimated bulk dilution for the three scenarios of residual waste streams are presented in Table 7-6. The predicted downstream concentrations for select parameters of concern are presented in Table 7-7, along with the BC Approved and Working Water Quality Guidelines for freshwater aquatic life (ENV 2023a) and federal environmental quality guidelines for aluminum (ECCC 2022).

The estimated bulk dilution of Summers Creek is highest for the groundwater scenario without RO, at 620:1, as this is the scenario with the lowest effluent flow (0.1 L/s). The lowest bulk dilution is estimated for the groundwater scenario

³ Specifically for discharging municipal wastewater, if the dilution ratio is <40:1, the wastewater may be discharged only if advanced treatment requirements are met, if no other discharge options are available, and is the discharge is authorized by a director.

with RO, at 27:1, which has the highest effluent flow (2.3 L/s). The bulk dilution for the lake source scenario is 155:1, with an effluent flow of 0.4 L/s. However, discharge is more likely to be approved for the lake scenario and the groundwater scenario without RO because the dilution ratio for each is greater than 40:1.

A general principle in assessing municipal discharge is that water quality in a receiving stream should meet water quality guidelines after it mixes with the discharge.⁴ Associated therefore compared the predicted downstream concentration of select parameters for the three residual discharge scenarios with the BC AL guidelines. The lake scenario downstream concentration was also compared with the federal water quality guideline for aluminum.

Associated calculated the concentrations of select parameters in the creek after the discharged residuals mix with creek water (C_F) for the three treatment options. The input parameters are presented in Table 7-6, and downstream concentrations were calculated using the following equation:

$$C_F = [(Q_R \times C_R) + (Q_E \times C_E)] \div (Q_R + Q_E)$$

Table 7-7 Dilution Calculation Flow Inputs

Symbol	Flow	Waste Streamflow (L/s)	Source	Bulk Dilution
Q_R	River flow	62	Environmental flow needs	–
Q_E	Effluent flow (lake scenario)	0.4	Dissolved air flotation sludge and filter backwash	155
Q_E	Effluent flow (groundwater scenario with reverse osmosis)	2.3	Manganese filter backwash and reverse osmosis cleaning waste	27
Q_E	Effluent flow (groundwater scenario without reverse osmosis)	0.1	Manganese filter backwash	620

⁴ Further requirements when considering the use of initial dilution zones (IDZ) are outlined in the Ministry of Environment and Climate Change Strategy's Technical Guidance 11. Such requirements are that water quality must not be acutely toxic within the IDZ, the IDZ should not adversely affect sensitive aquatic habitat and should maintain adequate passage for fish, the plume within the IDZ should not contact the shoreline in a way that inhibits mixing or allows potential contaminants to accumulate, and the IDZ should not overlap with the IDZs of any other authorized discharges (ENV 2019).

Table 7-8 Dilution Calculation Parameter Concentrations

Parameter	River Background Concentration (C_R)	Effluent Concentration (Lake Scenario) (C_E)	Effluent Concentration (Groundwater Scenario With Reverse Osmosis) (C_E)	Effluent Concentration (Groundwater Scenario With Reverse Osmosis) (C_E)
Total aluminum (mg/L)	0.0058	119	–	–
Total iron (mg/L)	0.01	–	0.87	16.30
Total manganese (mg/L)	0.002	–	0.480	29.70
Total ammonia-N (mg/L)	0.055	–	0.890	–
Sulphate (mg/L)	10.6	–	1,245.0	–
Total arsenic (mg/L)	0.0005	–	0.0060	–
Total selenium (mg/L)	0.0005	–	0.01	–

The only parameter of concern for the lake scenario is total aluminum, which results from the use of alum in the treatment process. Total aluminum in the discharge for this scenario is estimated to be 119 mg/L. After dilution, the final concentration in Summers Creek is 0.77 mg/L, which is about three times the BC AL chronic guideline (0.289 mg/L). The BC AL chronic guideline for aluminum is calculated based on several parameters. In this case, it was calculated using hardness of 147 mg/L, pH 7.63, and dissolved organic carbon of 4.72 mg/L, based on the results of the water quality sampling that Associated completed at Summers Creek in April 2023. Aluminum is known to be toxic to fish and has also been shown to adversely affect the growth and reproductivity of terrestrial plants and animals (WLRS 2023). Brook trout (*Salvelinus fontinalis*) has been identified in Summers Creek and has an effect concentration for total aluminum of 0.103 mg/L and a normalized effect concentration of 0.171 mg/L (WLRS 2023). The predicted downstream concentration under the lake scenario exceeds these guidelines and effect concentrations, indicating that discharging residuals under this scenario has the potential to impact aquatic life in Summers Creek. If the lake is chosen as the raw water source, Associated recommends either treating the residual waste stream to remove aluminum or dispose of it in location other than Summers Creek.

All parameters of concern for the two groundwater scenarios (with and without RO) meet the most stringent applicable water quality guideline in the creek after the water mixes with the discharge. This suggests that the discharging residuals from these two scenarios would not impact aquatic life in Summers Creek, given that environmental flow is maintained in the creek. The groundwater option without RO is the preferred option from the receiving water standpoint, as it produces the lowest volume of residuals and does not cause guideline exceedances in Summers Creek.

Table 7-9 Predicted Downstream Concentrations for Select Parameters

Parameter	Predicted Downstream Concentration	BC Aquatic Life Acute Guideline ¹	BC Aquatic Life Chronic Guideline ²	Federal Water Quality Guideline	Downstream Concentration Relative to the Most Stringent Guideline
Scenario: Lake					
Total aluminum (mg/L)	0.77	–	0.289	1.2	266%
Scenario: Groundwater with reverse osmosis					
Total iron (mg/L)	0.04	1	–	–	4%
Total manganese (mg/L)	0.02	2.15	1.25	–	2%
Total ammonia-N (mg/L)	0.08	2.22	0.428	–	4%
Sulphate (mg/L)	54.75	–	209	–	26%
Total arsenic (mg/L)	0.0007	–	0.005	–	15%
Total selenium (mg/L)	0.0008	–	0.002	–	42%
Scenario: Groundwater without reverse osmosis					
Total iron (mg/L)	0.04	1	–	–	4%
Total manganese (mg/L)	0.05	2.15	1.25	–	4%

Values in bold indicate that estimated downstream concentrations exceed a water quality guideline. ¹ Acute guidelines are a short-term maximum concentration. ² Chronic guidelines are long-term, typically assessed by calculating the average concentration over a specified period (i.e., five samples in 30 days). The chronic guidelines are more stringent than the acute guidelines because they are designed to protect from repeated or ongoing exposure.

7.4 Opinion of Probable Cost

Associated developed opinion of probable costs for the treatment infrastructure recommended for the groundwater and surface water options, as follows:

- Option 1 – surface water: \$2,990,000
- Option 2 – groundwater: \$4,647,500
- Option 3 – groundwater (simplified): \$2,470,000

The assumptions used to estimate these costs are listed in Appendix F, Table F-1, and the breakdown details for the capital opinion of probable costs are provided in Appendix F, Table F-2.

The opinion of probable costs for annual operation and maintenance are \$53,500, \$83,400, and \$53,500 for Options 1, 2, and 3, respectively. The breakdown details for the opinion of probable costs for annual operation and maintenance, and a 20-year life cycle cost estimate, are provided in Appendix F, Table F-3.

8 EVALUATION OF THREE OPTIONS

As part of evaluating the three options, Associated:

- Prepared an advantages and disadvantages table, with input from a hydrogeologist, an engineer, and a limnologist;
- Met with Interior Health and the community; and
- Completed a multi-criteria evaluation with an importance weighting.

8.1 Pros and Cons

Table 8-1 presents the pros and cons.

Table 8-1 Advantages and Disadvantages of the Three Treatment Options

	Option 1 – Surface Water	Option 2 – Groundwater	Option 3 – Groundwater (Simplified Treatment)
Pros	• Already have licences for surface water use	• Treatment also removes hardness from water	• Includes redundant treatment equipment • Lowest operational complexity
Cons	• Budget does not allow for redundancy in treatment equipment • Additional treatment needed for waste management; sludge will need to be disposed of off site • Waste discharge permit will be required • Lake pumping upgrades will be required	• Budget does not allow for redundancy in treatment equipment • High volume of waste; difficult to dispose of • Waste discharge permit will be required • Potentially frequent replacement of spent cartridge filters will be needed • Will require the community to reduce consumption by half	• Water hardness is not treated • Water softeners are hard on septic fields • Waste discharge permit will be required • Will require the community to reduce consumption by half

8.2 Feedback from Interior Health and the Community

Associated summarized the results from the engineering and environmental tasks into a PowerPoint presentation and presented it to Interior Health in person at the RDOS office in Penticton on August 7, 2024, and to the community through a virtual information session on August 8, 2024. A copy of the presentation was also made available on RDOS's communication website, and was up for at least 1 month at time of this writing. (Appendix G provides a copy

of the home page, downloaded on September 20, 2024, and a PDF copy of the slides.) Below are some highlights from these meetings.

Interior Health made the following comments:

- Regarding low water levels in the lake during drought years, and that the current pump cannot pump into the WTP at low water levels: Interior Health commented that RDOS need to plan for the future and under the future climate scenarios, it is possible that drought years will be more frequent. RDOS explained that detailed design (the next phase of the project) will include review of backup mechanisms to pump at low water levels. The intake itself is in a suitable location.
- Regarding population growth and people who retire staying longer in the community: If water conservation is in place, they can adapt to that as long as it is clearly communicated and planned for.
- Regarding manganese: Interior Health is familiar with other communities that are next to a lake and switching from wells to surface water because of the manganese and biofouling in the lines. This is not aesthetically pleasing even if levels are below the health-based guideline.
- Regarding equipment redundancy: Interior Health commented that it is not necessary to have 100% redundancy, but maybe if there is a train of, for example, four smaller units (vs. two larger units), then one extra smaller unit can be added to the design. Associated agreed that this could be looked at during detailed design.

Members of the community made the following comments:

- The community thanked the project team for all the detailed work and the clear communication of a complex problem.
- The flow rates in Options 2 and 3 do not sound appealing as it would be hard to reduce water conservation that much (by 40%).
- Option 1 appears to have the fewest hurdles compared to the other options.
- Alternative options: If there was a Level 2 operator in the community, is it viable to look at the cost of the filter replacements only (meaning, returning to True's 2018 design, with no pre-filtration treatment for algae)? Interior Health stated that algae can clog filters every 2–3 days. RDOS's concern with this idea is what happens if that operator moves from the community?

8.3 Multi-criterion Decision-Making Tool

Associated and RDOS met on May 1, 2024, to evaluate the three options and rank them on a five-point scale (1 = poor and 5 = excellent) based on multiple criteria from four general categories: engineering, land access, community acceptance, and environmental. A matrix was developed and scores were agreed on for each option using the evaluation criteria in each category. An importance weighting was built into the matrix as some criteria are considered more important than others; RDOS evaluated the importance weightings with the operator team. The results were further refined by Associated in September 2024, incorporating feedback from the meeting with Interior Health, which occurred on August 7, 2024, and with the community on August 8, 2024.

The results of the multi-criterion evaluation are as follows (Table 8-2):

1. Highest score: Option 1 – Lake source with residuals management (design to be completed in a future phase): 3 out of 5.
2. Lowest score: Option 2 – Groundwater well with RO: 1.6 out of 5.
3. Middle score: Option 3 – Groundwater well with simplified treatment (TDS and hardness not addressed): 2.5 out of 5.

Table 8-2 Multi-criterion Evaluation of Three Water Source and Treatment Options

General Category	Grading Criterion	Option 1 – Lake (With Residuals Handling)	Option 2 – Well With RO	Option 3 – Well, Simplified Treatment	Importance Weighting	Poor Score (1) Definition	Excellent Score (5) Definition
Engineering	Opinion of probable costs: Capital costs (for source improvements, treatment, storage, tie-in)	3	4	5	10%	High-cost capital investment (e.g., advanced treatment needed for the lake option).	Low-cost capital investment (e.g., greensand and chlorine only for Option 3).
	Opinion of probable costs: Operations and maintenance costs, and equipment redundancy	3	1	4	30%	High-cost operations and maintenance. Difficult to operate; may require a Level III or IV operator. Continuous operation needed. No redundancy.	Low-cost operations and maintenance. Easy to operate (Level II operator if just chlorination). Batch operation. Lots of redundancy.
Land Access and Community Acceptance	Room for production well, treatment plant, and storage	1	1	1	5%	No room for production wells, treatment plant, and storage. Would need to negotiate lease with the Province.	Lots of room for production wells, treatment plant, and storage. Land owned by RDOS.
	Capacity of packaged plant or well to meet current water demand	2.5	1.0	1.0	15%	Capacity of packaged plant or well is 60% or less of the current water demand. Water conservation efforts of 40% will be needed.	Capacity of packaged plant meets the current water demand. No water conservation efforts needed.
	Community acceptance of water quality (taste and odour)	5	4	1	5%	Not acceptable. Different from what the community members have now.	Similar to what the community members have now.
Environmental	Source protection	4	2	2	5%	Wells are near drinking water hazards and in an unconfined aquifer. Lake is open to boat access, with year-round boat storage nearby.	Wells are in a confined aquifer, with few drinking water hazards nearby. The lake is protected or is part of a moratorium on boats.
	Confidence in water supply	5	1	1	15%	Project will need a water licence amendment. Major issues in water supply quantity.	No licensing changes needed. No major issues in water supply quantity.
	Confidence in water quality dataset (historical)	3	1	1	2%	Few samples.	Lots of historical data.
	Uncertainty in timeline or approval from other environmental regulations	1	2	2.5	13%	Waste discharge stream would require a waste discharge permit under the <i>Environmental Management Act</i> ; the application process would be complex and could take 1–3 years.	No waste discharge permit required.
	Score	3.0	1.6	2.5	100%		

9 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

9.1 Summary and Conclusions

Associated completed a groundwater investigation and conceptual design water supply upgrade study for the MLWS, owned and operated by RDOS. Associated oversaw drilling of a new 6-inch water supply well (WIPN 52992). Associated then designed and performed a 48-hour pumping test, conducted water quality sampling, and assessed the new well to determine its viability as a potential water source for the community.

Regarding using groundwater as a source, Associated makes the following conclusions:

- WIPN 52992 is completed in a sand and gravel, provincially unmapped aquifer and has a long-term sustainable yield of 5.14 L/s (81.4 USgpm) (including a 30% factor of safety). This sustainable yield would supply approximately 57% of True's calculated MDD of 9.02 L/s (143 USgpm).
- WIPN 52992 is completed in an aquifer with a leaky aquitard, allowing recharge from an overlying aquifer. This overlying aquifer is hydraulically connected to Missezula Lake, thus the well is also hydraulically connected to Missezula Lake.
- The static water level in WIPN 52992 is 20.63 m bgs (992 m asl), the lake elevation is 1,012 m asl, and the lake's bottom within 150 m of the well is 23 m deep (989 m asl).
- Associated calculated a radius of influence of 150 m from WIPN 52992, at which the well may cause 2.5 m of drawdown in another well. There is no room for a second well due to the small size of the valley-bottom sand and gravel aquifer.
- The water chemistry in WIPN 52992 is distinct from that in old well WIPN 43254 and Missezula Lake. WIPN 52992 has the following water quality exceedances of the GCDWQ and BC SDWQG: total organic carbon, TDS, aluminum (total), and manganese (total). Note however, the Health Canada technical support document for hardness states that hardness in excess of 500 mg/L is considered unacceptable for most domestic purposes, thus the well's hardness concentration of 564 mg/L, should be considered an exceedance.

Since the groundwater source was determined to be not viable unless the community implemented significant water conservation, Associated completed further investigations into the existing lake source, including conceptual-level engineering treatability studies to manage for algae and dilution modelling in Summers Creek to investigate ways to manage the treatment plant residuals and waste stream.

Associated presents the three treatment options below. All three options require some water conservation measures because none of the options will meet the 2018 MDD of 9.02 L/s or the July 2021 MDD of 11 L/s.

- **Option 1: Lake source**
 - Design flow rate: 7.6 L/s (reduced design flow rate selected to provide a treatment option within RDOS's proposed budget for the treatment system)
 - Treatment processes: Coagulant/pH adjustment, DAF, filtration, and chlorination
 - Residuals management: Dilution modelling indicates that concentrations of aluminum will not meet the aquatic life guideline in Summers Creek; therefore, further investigation is needed to select the most appropriate treatment for the MLWS that would remove aluminum before the residuals are discharged to the creek.
- **Option 2: Groundwater**
 - Design flow rate: 5.14 L/s (limitation is well capacity)

- Treatment processes: Oxidant, greensand media filter, pre-RO filtration, RO and RO bypass line, and chlorination/pH stabilization
- Residuals management: Approval to discharge to Summers Creek would only be possible if no other options are available due to the large volume of waste that would need to be discharged from this treatment facility.
- **Option 3: Groundwater, simplified treatment**
 - Design flow rate: 5.14 L/s (limitation is well capacity)
 - Treatment processes: Oxidant, greensand media filter, and chlorination
 - Residuals management: Approval is likely; dilution ratios are acceptable, and dilution modelling indicates aquatic life guidelines will be met in Summers Creek.

The advantages and disadvantages for each option are presented in Section 8.1. A community meeting was held, and using a multi-criterion decision-making procedure (Table 8-2), Option 1 ranked the highest.

9.2 Recommendations

Associated provides the following recommendations with respect to this groundwater investigation and conceptual design water supply upgrade study:

- Do not continue to explore groundwater as an option. The new well, WIPN 52922, does not provide sufficient yield to meet the 2018 MDD because there is not enough room in the valley-bottom sand and gravel aquifer for a second well due to small size and narrow shape of the aquifer. The decision-making criteria placed the well source with two treatment options as second and third out of the three options considered.
- Complete preliminary design for Option 1. The design scope should include:
 - Inspection of the existing intake infrastructure.
 - Survey, geotechnical, and environmental inspection of the proposed WTP site.
 - Confirmation of the existing electrical and water services to the proposed WTP site.
 - Additional investigation into residuals management options to allow for removal of aluminum and some storage. The latter may be required for periods when residuals cannot be discharged to Summers Creek because the required dilution ratio cannot be met (for example, if the weir at the outlet of Missezula Lake gets jammed and no flow is released to Summers Creek). Once this is completed, apply to the Ministry of Environment and Climate Change Strategy for an effluent discharge permit for the wastewater treatment plant residuals.
- Review the MLWS current and projected water demand, and assess the extent of water loss in the water system.
- Review the proposed approach to treatment for the MLWS with Interior Health, particularly with respect to redundancy in the proposed treatment infrastructure.
- Conduct bench-scale and/or pilot-scale testing of the proposed treatment to optimize treatment parameters ahead of building treatment at fullscale.
- Continue to explore land ownership options with Ministry of Transportation and Infrastructure, and the ministry responsible for crown land.

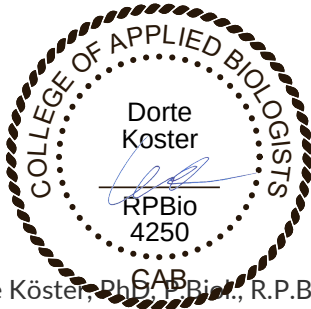
CLOSURE

This report was prepared for the Regional District Okanagan-Similkameen to help select a water source and treatment scenario for the Misesezula Lake water system upgrades project.

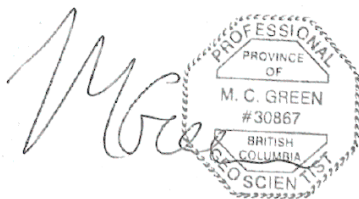
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Respectfully submitted,

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APPENDIX A – SUMMARY TABLE

Appendix A - Water Quality Summary Table

Sampling Location						Creek 1	Lake 1	Lake 1		WIPN43254	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992
Date Sampled						18-Apr-23	18-Apr-23	26-Sep-23		18-Apr-23	17-Oct-23	17-Oct-23	18-Oct-23	19-Oct-23	26-Sep-23
Lab Sample ID						23D2099-01	23D2099-02	23I3411-01		23D2099-03	23J2279-01	23J2279-02	23J2279-03	23J2669-01	23I3411-02
Sample Type								Normal							Normal
Analyte	Unit	Guideline													
		GCDWQ MAC	GCDWQ AO	<u>BC SDWOG MAC</u>	<u>BC SDWOG AO</u>										
Field Results															
Conductivity	µS/cm	NG	NG	NG	NG	165.7	171.6	224.8		281.1	593	-	693	-	676
Oxidation reduction potential	mV	NG	NG	NG	NG	31.6	54.2	53.2		-267	-35.2	-	-12.1	-	53.4
Dissolved oxygen	mg/L	NG	NG	NG	NG	7.3	5.9	7.63		0.06	5.1	-	5.28	-	6.53
pH		NG	7.0 - 10.5 ^{2.1}	NG	NG	7.63	7.63	8.47		7.88	7.85	-	7.85	-	8.13
Temperature	°C	NG	15	NG	15	3.1	3.7	13.3		7.6	8.6	-	8.7	-	-
Turbidity	NTU	N ^{1.1}	NG	N ^{3.1}	NG	0.61	0.69	1.07		218	1.21	-	0.88	-	6.86
Lab Results															
General															
Alkalinity (bicarbonate, as CaCO3)	mg/L	NG	NG	NG	NG	125	41.9	164		221	-	-	206	-	225
Alkalinity (carbonate, as CaCO3)	mg/L	NG	NG	NG	NG	<1.0	<1.0	<1.0		<1.0	-	-	<1.0	-	<1.0
Alkalinity (hydroxide, as CaCO3)	mg/L	NG	NG	NG	NG	<1.0	<1.0	<1.0		<1.0	-	-	<1.0	-	<1.0
Alkalinity (phenolphthalein, as CaCO3)	mg/L	NG	NG	NG	NG	<1.0	<1.0	<1.0		<1.0	-	-	<1.0	-	<1.0
Alkalinity (total, as CaCO3)	mg/L	NG	NG	NG	NG	125	41.9	164		221	-	-	206	-	225
Dissolved organic carbon	mg/L	NG	NG	NG	NG	4.72	1.83	5.18		5.03	-	-	-	-	3.71
Total organic carbon	mg/L	NG	NG	4.0	NG	<u>4.98</u>	2.14	<u>6.54</u>		<u>4.55</u>	-	-	<u>4.8</u>	-	<u>4.13</u>
Chloride	mg/L	NG	250	NG	250	7.98	2.41	10.1		9.81	-	-	9.04	-	10.3
Colour	CU	NG	15	NG	15	-	-	-		-	-	-	<5.0	-	-
Conductivity	µS/cm	NG	NG	NG	NG	287	85.8	289		454	-	-	966	-	971
Total cyanide	mg/L	0.2 ^{1.2}	NG	0.2 ^{3.2}	NG	-	-	-		-	-	-	0.0024	-	-
Fluoride	mg/L	1.5	NG	1.5	NG	-	-	-		-	-	-	0.13	-	-
Hardness (as CaCO3), dissolved	mg/L	NG	NG	NG	NG	147	26.9	152		240	-	-	564	-	574
Hardness (as CaCO3), from total Ca/Mg	mg/L	NG	NG	NG	NG	133	30.6	146		259	464	507	555	583	536
Langelier Index		NG	NG	NG	NG	-	-	-		-	-	-	0.9	-	-
pH		NG	7.0 - 10.5 ^{2.2}	NG	NG	7.64	6.74	8.26		8	-	-	7.96	-	8.15
Total dissolved solids	mg/L	NG	500	NG	NG	165	45	187		267	-	-		-	756
Total dissolved solids (computed)	mg/L	NG	500	NG	NG	-	-	-		-	-	-	708	-	-
Total suspended solids	mg/L	NG	NG	NG	NG	<2.0	4.6	<2.0		224	-	-		-	16.2
Sulphate	mg/L	NG	500 ^{2.3}	NG	500	9.8	2.1	10.6		<1.0	-	-	349	-	390
Temperature of observed pH	°C	NG	NG	NG	NG	-	-	-		-	-	-	21.9	-	-
Turbidity	NTU	N ^{1.3}	NG	N ^{3.3}	NG	-	-	-		-	-	-	2.76	-	-
UV transmittance at 254 nm - unfiltered	%	NG	NG	NG	NG	-	-	-		-	-	-	85	-	-
Nutrients															
Ammonia (total, as N)	mg/L	NG	NG	NG	NG	<0.050	<0.050	0.055		0.542	-	-	0.282	-	0.247
Nitrate (as N)	mg/L	10	NG	10	NG	0.022	<0.010	<0.010		<0.010	-	-	0.015	-	<0.010
Nitrate + Nitrite (as N)	mg/L	10 ^{1.4}	NG	NG	NG	0.0218	<0.0100	<0.0100		<0.0100	-	-	-	-	<0.0100
Nitrate + Nitrite (as N) (calculated)	mg/L	10 ^{1.5}	NG	NG	NG	0.022	<0.014	<0.014		<0.014	-	-	0.015	-	<0.014
Nitrite (as N)	mg/L	1	NG	1.0	NG	<0.010	<0.010	<0.010		<0.010	-	-	<0.010	-	<0.010
Total nitrogen	mg/L	NG	NG	NG	NG	0.173	0.122	0.283		0.781	-	-	-	-	0.529

Appendix A - Water Quality Summary Table

Sampling Location						Creek 1	Lake 1	Lake 1		WIPN43254	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992
Date Sampled						18-Apr-23	18-Apr-23	26-Sep-23		18-Apr-23	17-Oct-23	17-Oct-23	18-Oct-23	19-Oct-23	26-Sep-23
Lab Sample ID						23D2099-01	23D2099-02	23I3411-01		23D2099-03	23J2279-01	23J2279-02	23J2279-03	23J2669-01	23I3411-02
Sample Type								Normal							Normal
Analyte	Unit	Guideline													
		GCDWQ MAC	GCDWQ AO	BC SDWOG MAC	BC SDWOG AO										
Total kjeldahl nitrogen	mg/L	NG	NG	NG	NG	0.151	0.122	0.283		0.781	-	-	0.419	-	0.529
Total organic nitrogen	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	0.137	-	-
Orthophosphate (dissolved, as P)	mg/L	NG	NG	NG	NG	<0.0050	<0.0050	<0.0050		0.005	-	-	-	-	<0.0050
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	NG	NG	NG	N ^{4.1}	<0.050	<0.050	<0.050		0.118	-	-	0.06	-	0.065
Phosphorus (total, by ICPMS/ICPOES)	mg/L	NG	NG	NG	N ^{4.2}	<0.050	<0.050	<0.050		0.473	0.071	0.078	0.072	0.072	0.091
Phosphorus (total, APHA 4500-P)	mg/L	NG	NG	NG	N ^{4.3}	0.0192	0.0219	<0.0050		0.462	-	-	0.0646	-	0.0564
Phosphorus (dissolved, APHA 4500-P)	mg/L	NG	NG	NG	N ^{4.4}	0.0119	0.0068	<0.0050		0.0114	-	-	-	-	0.0193
Potassium (dissolved)	mg/L	NG	NG	NG	NG	1.42	0.41	1.55		2.3	-	-	1.73	-	1.6
Potassium (total)	mg/L	NG	NG	NG	NG	1.3	0.45	1.43		2.77	1.62	1.65	1.66	1.66	1.49
Microbiological															
Total coliforms (counts)	CFU/100 mL	0 ^{1.6}	NG	NG	NG	-	-	-		-	-	-	<1	-	-
E. coli (counts)	CFU/100 mL	0 ^{1.7}	NG	10 ^{3.4}	NG	-	-	-		-	-	-	<1	-	-
Total Metals															
Aluminum (total)	mg/L	2.9 ^{1.8}	0.100 ^{2.4}	9.5	NG	<0.0050	0.0094	0.0058		6.34	0.0393	0.0254	0.0073	<0.0050	0.115
Antimony (total)	mg/L	0.006	NG	0.006	NG	<0.00020	<0.00020	<0.00020		<0.00020	0.00059	0.00052	0.0004	0.0003	0.00331
Arsenic (total)	mg/L	0.010 ^{1.9}	NG	0.01	NG	0.00053	<0.00050	0.00058		0.00227	0.00208	0.00169	0.00133	0.00113	0.0021
Barium (total)	mg/L	2.0 ^{1.10}	NG	NG	NG	0.0328	0.0097	0.0363		0.32	0.181	0.192	0.195	0.203	0.116
Beryllium (total)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		0.00014	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (total)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Boron (total)	mg/L	5	NG	5.0	NG	<0.0500	<0.0500	<0.0500		<0.0500	0.0724	0.0701	0.071	0.0756	0.0639
Cadmium (total)	mg/L	0.007 ^{1.11}	NG	0.005	NG	<0.000010	<0.000010	<0.000010		0.00017	<0.000020	<0.000010	<0.000010	<0.000010	0.000048
Calcium (total)	mg/L	NG	NG	NG	NG	37.4	9.17	40.9		74.3	163	179	196	206	189
Chromium (total)	mg/L	0.05	NG	0.05	NG	<0.00050	<0.00050	<0.00050		0.011	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (total)	mg/L	NG	NG	0.001	NG	<0.00010	<0.00010	<0.00010		<u>0.00472</u>	0.00015	0.00012	<0.00010	<0.00010	0.00039
Copper (total)	mg/L	2 ^{1.12}	1 ^{2.5}	2.0 ^{3.5}	1.0	0.00073	0.0006	0.00088		0.0499	0.00256	0.00458	0.00157	0.00267	0.0016
Iron (total)	mg/L	NG	0.3	NG	0.3	<0.010	0.011	<0.010		<u>11.2</u>	0.193	0.19	0.187	0.203	<u>0.589</u>
Lead (total)	mg/L	0.005 ^{1.13}	NG	0.005	NG	<0.00020	<0.00020	<0.00020		0.00317	0.00024	<0.00020	<0.00020	<0.00020	0.00086
Lithium (total)	mg/L	NG	NG	NG	NG	0.00102	0.00026	0.00112		0.00518	0.00352	0.00366	0.00374	0.0039	0.00392
Magnesium (total)	mg/L	NG	NG	NG	NG	9.54	1.86	10.7		17.7	13.7	14.6	16	16.8	15.5
Manganese (total)	mg/L	0.12 ^{1.14}	0.02 ^{2.6}	0.12	0.02	0.00236	0.00218	0.0009		<u>0.527</u>	<u>0.129</u>	<u>0.141</u>	<u>0.155</u>	<u>0.163</u>	<u>0.153</u>
Mercury (total)	mg/L	0.001	NG	0.001	NG	<0.000010	<0.000010	<0.000010		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (total)	mg/L	NG	NG	0.088	NG	0.00069	0.00014	0.00078		0.0018	0.00457	0.00413	0.00286	0.00196	0.00611
Nickel (total)	mg/L	NG	NG	0.08	NG	<0.00040	<0.00040	<0.00040		0.0105	<0.00040	<0.00040	<0.00040	<0.00040	0.00085
Selenium (total)	mg/L	0.05	NG	0.01	NG	<0.00050	<0.00050	<0.00050		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00296
Silicon (total, as Si)	mg/L	NG	NG	NG	NG	6.5	2.1	6.5		23.2	9.3	9.7	9.9	9.8	10.1
Silver (total)	mg/L	NG	NG	NG	NG	<0.000050	<0.000050	<0.000050		0.000106	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (total)	mg/L	NG	200	NG	NG	8.01	2.08	8.97		7.78	10	10.2	10.8	10.8	10.9
Strontium (total)	mg/L	7.0 ^{1.15}	NG	7.0	NG	0.18	0.043	0.191		0.568	1.92	2.04	2.22	2.29	2.34
Sulphur (total)	mg/L	NG	NG	NG	NG	3.2	<3.0	3.4		<3.0	88.4	104	121	132	122

Appendix A - Water Quality Summary Table

Sampling Location						Creek 1	Lake 1	Lake 1		WIPN43254	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992
Date Sampled						18-Apr-23	18-Apr-23	26-Sep-23		18-Apr-23	17-Oct-23	17-Oct-23	18-Oct-23	19-Oct-23	26-Sep-23
Lab Sample ID						23D2099-01	23D2099-02	23I3411-01		23D2099-03	23J2279-01	23J2279-02	23J2279-03	23J2669-01	23I3411-02
Sample Type								Normal							Normal
Analyte	Unit	Guideline													
		GCDWQ MAC	GCDWQ AO	BC SDWOG MAC	BC SDWOG AO										
Tellurium (total)	mg/L	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (total)	mg/L	NG	NG	NG	NG	<0.000020	<0.000020	<0.000020		0.000039	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Thorium (total)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		0.0004	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (total)	mg/L	NG	NG	NG	NG	<0.00020	<0.00020	<0.00020		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (total)	mg/L	NG	NG	NG	NG	<0.0050	<0.0050	<0.0050		0.293	<0.0050	<0.0050	<0.0050	<0.0050	0.0059
Tungsten (total)	mg/L	NG	NG	NG	NG	<0.0010	<0.0010	<0.0010		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (total)	mg/L	0.02	NG	0.02	NG	0.000187	0.000042	0.000234		0.000278	0.000594	0.00049	0.000335	0.000251	0.00101
Vanadium (total)	mg/L	NG	NG	NG	NG	<0.0050	<0.0050	<0.0050		0.0271	<0.0050	<0.0050	<0.0050	<0.0050	0.0079
Zinc (total)	mg/L	NG	5.0	3.0	5.0	<0.0040	0.013	<0.0040		0.022	0.0071	0.0101	0.0048	0.0104	<0.0040
Zirconium (total)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		0.00154	0.00016	<0.00010	<0.00010	<0.00010	0.00016
Dissolved Metals															
Aluminum (dissolved)	mg/L	2.9 ^{1.16}	0.100 ^{2.7}	9.5	NG	<0.0050	<0.0050	<0.0050		0.0234	-	-	<0.0050	-	<0.0050
Antimony (dissolved)	mg/L	0.006	NG	0.006	NG	<0.00020	<0.00020	<0.00020		<0.00020	-	-	0.00034	-	0.00355
Arsenic (dissolved)	mg/L	0.010 ^{1.17}	NG	0.01	NG	0.00058	<0.00050	0.00068		<0.00050	-	-	0.00132	-	0.00196
Barium (dissolved)	mg/L	2.0 ^{1.18}	NG	NG	NG	0.0377	0.0089	0.0371		0.269	-	-	0.197	-	0.116
Beryllium (dissolved)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		<0.00010	-	-	<0.00010	-	<0.00010
Bismuth (dissolved)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		<0.00010	-	-	<0.00010	-	<0.00010
Boron (dissolved)	mg/L	5	NG	5.0	NG	<0.0500	<0.0500	<0.0500		<0.0500	-	-	0.0619	-	0.0693
Cadmium (dissolved)	mg/L	0.007 ^{1.19}	NG	0.005	NG	<0.000010	<0.000010	<0.000010		<0.000010	-	-	<0.000010	-	<0.000010
Calcium (dissolved)	mg/L	NG	NG	NG	NG	41.6	8.14	41.7		71.1	-	-	199	-	201
Chromium (dissolved)	mg/L	0.05	NG	0.05	NG	<0.00050	<0.00050	<0.00050		<0.00050	-	-	<0.00050	-	<0.00050
Cobalt (dissolved)	mg/L	NG	NG	0.001	NG	<0.00010	<0.00010	<0.00010		0.00012	-	-	<0.00010	-	0.0003
Copper (dissolved)	mg/L	2 ^{1.20}	1 ^{2.8}	2.0 ^{3.6}	1.0	0.00055	<0.00040	0.00088		<0.00040	-	-	<0.00040	-	<0.00040
Iron (dissolved)	mg/L	NG	0.3	NG	0.3	<0.010	<0.010	<0.010		<u>3.04</u>	-	-	0.158	-	0.271
Lead (dissolved)	mg/L	0.005 ^{1.21}	NG	0.005	NG	<0.00020	<0.00020	<0.00020		<0.00020	-	-	<0.00020	-	<0.00020
Lithium (dissolved)	mg/L	NG	NG	NG	NG	0.00114	0.00022	0.00114		0.00203	-	-	0.00386	-	0.0042
Magnesium (dissolved)	mg/L	NG	NG	NG	NG	10.3	1.59	11.5		15	-	-	16.1	-	17.1
Manganese (dissolved)	mg/L	0.12 ^{1.22}	0.02 ^{2.9}	0.12	0.02	0.00107	0.0018	0.00034		<u>0.347</u>	-	-	<u>0.156</u>	-	<u>0.152</u>
Mercury (dissolved)	mg/L	0.001	NG	0.001	NG	<0.000010	<0.000010	<0.000010		<0.000010	-	-	<0.000010	-	<0.000010
Molybdenum (dissolved)	mg/L	NG	NG	0.088	NG	0.00068	0.00011	0.00064		0.00245	-	-	0.00238	-	0.00525
Nickel (dissolved)	mg/L	NG	NG	0.08	NG	<0.00040	<0.00040	<0.00040		0.00097	-	-	<0.00040	-	0.00076
Selenium (dissolved)	mg/L	0.05	NG	0.01	NG	<0.00050	<0.00050	<0.00050		<0.00050	-	-	<0.00050	-	0.00305
Silicon (dissolved, as Si)	mg/L	NG	NG	NG	NG	7.2	1.9	6.2		12.2	-	-	10	-	9.7
Silver (dissolved)	mg/L	NG	NG	NG	NG	<0.000050	<0.000050	<0.000050		<0.000050	-	-	<0.000050	-	<0.000050
Sodium (dissolved)	mg/L	NG	200	NG	NG	8.62	1.89	9.75		7.73	-	-	10.9	-	11.5
Strontium (dissolved)	mg/L	7.0 ^{1.23}	NG	7.0	NG	0.202	0.0399	0.201		0.59	-	-	2.29	-	2.43
Sulphur (dissolved)	mg/L	NG	NG	NG	NG	3.4	<3.0	3.1		<3.0	-	-	123	-	117
Tellurium (dissolved)	mg/L	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050		<0.00050	-	-	<0.00050	-	<0.00050
Thallium (dissolved)	mg/L	NG	NG	NG	NG	<0.000020	<0.000020	<0.000020		<0.000020	-	-	<0.000020	-	<0.000020
Thorium (dissolved)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		<0.00010	-	-	<0.00010	-	<0.00010

Appendix A - Water Quality Summary Table

Sampling Location						Creek 1	Lake 1	Lake 1		WIPN43254	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992
Date Sampled						18-Apr-23	18-Apr-23	26-Sep-23		18-Apr-23	17-Oct-23	17-Oct-23	18-Oct-23	19-Oct-23	26-Sep-23
Lab Sample ID						23D2099-01	23D2099-02	23I3411-01		23D2099-03	23J2279-01	23J2279-02	23J2279-03	23J2669-01	23I3411-02
Sample Type								Normal							Normal
Analyte	Unit	Guideline													
		GCDWQ MAC	GCDWQ AO	BC SDWOG MAC	BC SDWOG AO										
Tin (dissolved)	mg/L	NG	NG	NG	NG	<0.00020	<0.00020	<0.00020		<0.00020	-	-	<0.00020	-	<0.00020
Titanium (dissolved)	mg/L	NG	NG	NG	NG	<0.0050	<0.0050	<0.0050		<0.0050	-	-	<0.0050	-	<0.0050
Tungsten (dissolved)	mg/L	NG	NG	NG	NG	<0.0010	<0.0010	<0.0010		<0.0010	-	-	<0.0010	-	<0.0010
Uranium (dissolved)	mg/L	0.02	NG	0.02	NG	0.000162	0.000026	0.000187		<0.000020	-	-	0.000259	-	0.000867
Vanadium (dissolved)	mg/L	NG	NG	NG	NG	<0.0050	<0.0050	<0.0050		<0.0050	-	-	<0.0050	-	0.007
Zinc (dissolved)	mg/L	NG	5.0	3.0	5.0	<0.0040	0.0109	<0.0040		<0.0040	-	-	0.0046	-	<0.0040
Zirconium (dissolved)	mg/L	NG	NG	NG	NG	<0.00010	<0.00010	<0.00010		<0.00010	-	-	<0.00010	-	<0.00010
Miscellaneous Organic Substances															
Chloroethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0020	-	-
1,2-Dibromoethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0003	-	-
1,2-Dichloropropane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
1,3-Dichloropropylene (cis + trans)	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Extractable Petroleum Hydrocarbons C10-C19	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.250	-	-
Extractable Petroleum Hydrocarbons C19-C32	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.250	-	-
HEPHw	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.250	-	-
LEPHw	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.250	-	-
Methyl tert-butyl ether (MTBE)	mg/L	NG	0.015	NG	0.015	-	-	-		-	-	-	<0.0010	-	-
VHw6-10	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.100	-	-
Vinyl chloride	mg/L	0.002 ^{1.24}	NG	0.002	NG	-	-	-		-	-	-	<0.0010	-	-
VPHw	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.100	-	-
Monocyclic Aromatic Hydrocarbons (MAHs)															
Benzene	mg/L	0.005	NG	0.005	NG	-	-	-		-	-	-	<0.0005	-	-
Ethylbenzene	mg/L	0.14	0.0016	0.14	0.0016	-	-	-		-	-	-	<0.0010	-	-
Styrene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Toluene	mg/L	0.06	0.024	0.06	0.024	-	-	-		-	-	-	<0.0010	-	-
Xylenes	mg/L	0.09	0.02	0.09	0.02	-	-	-		-	-	-	<0.0020	-	-
Polycyclic Aromatic Hydrocarbons (PAHs)															
Acenaphthene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Acenaphthylene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000200	-	-
Acridine	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Anthracene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000010	-	-
Benz[a]anthracene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000010	-	-
Benzo[a]pyrene	mg/L	0.00004	NG	NG	NG	-	-	-		-	-	-	<0.000010	-	-
Benzo[b+j]fluoranthene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Benzo[g,h,i]perylene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Benzo[k]fluoranthene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
2-Chloronaphthalene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000100	-	-
Chrysene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-

Appendix A - Water Quality Summary Table

Sampling Location						Creek 1	Lake 1	Lake 1		WIPN43254	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992	WIPN 52992
Date Sampled						18-Apr-23	18-Apr-23	26-Sep-23		18-Apr-23	17-Oct-23	17-Oct-23	18-Oct-23	19-Oct-23	26-Sep-23
Lab Sample ID						23D2099-01	23D2099-02	23I3411-01		23D2099-03	23J2279-01	23J2279-02	23J2279-03	23J2669-01	23I3411-02
Sample Type								Normal							Normal
Analyte	Unit	Guideline													
		GCDWQ MAC	GCDWQ AO	BC SDWOG MAC	BC SDWOG AO										
Dibenz[a,h]anthracene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000010	-	-
Fluoranthene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000030	-	-
Fluorene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Indeno[1,2,3-cd]pyrene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
1-Methylnaphthalene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000100	-	-
2-Methylnaphthalene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000100	-	-
Naphthalene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000200	-	-
Phenanthrene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000100	-	-
Pyrene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000020	-	-
Quinoline	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.000050	-	-
Chlorinated Hydrocarbons															
1,2-Dichlorobenzene	mg/L	NG	NG	0.2	0.003	-	-	-		-	-	-	<0.0005	-	-
1,3-Dichlorobenzene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
1,4-Dichlorobenzene	mg/L	0.005	0.001	0.005	0.001	-	-	-		-	-	-	<0.0010	-	-
1,1-Dichloroethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
1,2-Dichloroethane	mg/L	0.005	NG	0.005	NG	-	-	-		-	-	-	<0.0010	-	-
1,1-Dichloroethylene	mg/L	0.014	NG	0.014	NG	-	-	-		-	-	-	<0.0010	-	-
cis-1,2-Dichloroethylene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
trans-1,2-Dichloroethylene	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Monochlorobenzene	mg/L	NG	NG	0.08	0.03	-	-	-		-	-	-	<0.0010	-	-
1,1,2,2-Tetrachloroethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0005	-	-
Tetrachloroethylene	mg/L	0.01	NG	0.01	NG	-	-	-		-	-	-	<0.0010	-	-
1,1,1-Trichloroethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
1,1,2-Trichloroethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Trichloroethylene	mg/L	0.005	NG	0.005	NG	-	-	-		-	-	-	<0.0010	-	-
Halogenated Methanes															
Bromodichloromethane	mg/L	0.100 ^{1.25}	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Bromoform	mg/L	0.100 ^{1.26}	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Carbon tetrachloride	mg/L	0.002	NG	0.002	NG	-	-	-		-	-	-	<0.0005	-	-
Chloroform	mg/L	0.100 ^{1.27}	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Dibromochloromethane	mg/L	0.100 ^{1.28}	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Dibromomethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-
Dichloromethane	mg/L	0.05	NG	0.05	NG	-	-	-		-	-	-	<0.0030	-	-
Total Trihalomethanes (calculated)	mg/L	0.100 ^{1.29}	NG	NG	NG	-	-	-		-	-	-	<0.0020	-	-
Trichlorofluoromethane	mg/L	NG	NG	NG	NG	-	-	-		-	-	-	<0.0010	-	-



Legend for Reports for 2023-8374 Missezula Lake Water System Upgrade Water Quality Results

<	Less than reported detection limit
>	Greater than reported upper detection limit
>=	Greater than or equal to
A	Absent

BC SDWQG AO BC Source Drinking Water Quality Guidelines - Aesthetic Objectives (2020 and updates)

BC SDWQG MAC BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (2020 and updates)

Calc Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.

GCDWQ AO Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives

GCDWQ MAC Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations

L Laboratory reading type (Lab result)

m asl metres above sea level

N Narrative type of guideline or standard, or Result Note.

ND Non-detect. Result is less than lower detection limit.

NG No Guideline

NR No Result

NS No Standard

NT Not Tested

OG Overgrown

P Present

PR Presumptive

TK Test kit reading type (Field result)

TNTC Too numerous to count

Highlighted value has a lower detection limit that is greater than the guideline/standard maximum and/or the guideline/standard minimum, or has an upper detection limit that is less than the guideline/standard maximum and/or the guideline/standard minimum.

100 The maximum guideline/standard value cannot be determined because either a result for a dependent analyte is not available for the sample, or the guideline/standard is based on a formula or lookup table that has more than 2 dependent analytes and is not currently calculated in this software application.

<u>BC SDWQG AO</u>	Highlighted value exceeds BC SDWQG AO
<u>BC SDWQG MAC</u>	Highlighted value exceeds BC SDWQG MAC
GCDWQ AO	Highlighted value exceeds GCDWQ AO
GCDWQ MAC	Highlighted value exceeds GCDWQ MAC
<u>SL Criteria Override</u>	Highlighted value exceeds sampling location criteria override

Guideline Notes for Reports for 2023-8374 Missezula Lake Water System Upgrade Water Quality Results

1. Notes for Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC)

Note 1.1 for Turbidity:

Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated water turbidity levels from individual filters should meet the requirements described in GCDWQ.

For systems that use groundwater that is not under the direct influence of surface water, which are considered less vulnerable to faecal contamination, turbidity should generally be below 1.0 NTU.

For effective operation of the distribution system, it is good practice to ensure that water entering the distribution system has turbidity levels below 1.0 NTU.

Note 1.2 for Total cyanide:

The MAC for free cyanide is 0.2 mg/L. A maximum of 0.2 mg/L was used, in this report, to identify exceedances for total cyanide as a means for determining the potential for exceeding the free cyanide guideline.

Note 1.3 for Turbidity:

Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated water turbidity levels from individual filters should meet the requirements described in GCDWQ.

For systems that use groundwater that is not under the direct influence of surface water, which are considered less vulnerable to faecal contamination, turbidity should generally be below 1.0 NTU.

For effective operation of the distribution system, it is good practice to ensure that water entering the distribution system has turbidity levels below 1.0 NTU.

Note 1.4 for Nitrate + Nitrite (as N):

The MAC for Nitrate (as N) is 10 mg/L

Note 1.5 for Nitrate + Nitrite (as N) (calculated):

The MAC for Nitrate (as N) is 10 mg/L

Note 1.6 for Total coliforms (counts):

The maximum acceptable concentration (MAC) of total coliforms in water leaving a treatment plant and in non-disinfected groundwater leaving the well is none detectable per 100 mL.

Total coliforms should be monitored in the distribution system because they are used to indicate changes in water quality. Detection of total coliforms from consecutive samples from the same site or from more than 10% of the samples collected in a given sampling period should be investigated.

Note 1.7 for E. coli (counts):

MAC is none detectable per 100 mL

Note 1.8 for Aluminum (total):

The maximum acceptable concentration (MAC) for total aluminum in drinking water is 2.9 mg/L (2 900 µg/L) based on a locational running annual average of a minimum of quarterly samples taken in the distribution system. (Update March 5, 2021)

Note 1.9 for Arsenic (total):

Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable.

Note 1.10 for Barium (total):

Update January 24, 2020. The MAC was revised from 1.0 mg/L to 2.0 mg/L.

Note 1.11 for Cadmium (total):

A maximum acceptable concentration (MAC) of 0.007 mg/L (7 µg/L) is established for total cadmium in drinking water, based on a sample of water taken at the tap. (Update July 14, 2020)

Note 1.12 for Copper (total):

A maximum acceptable concentration (MAC) of 2 mg/L is established for total copper in drinking water, based on a sample of water taken at the tap. Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on Copper, June 2019.

Note 1.13 for Lead (total):

The maximum acceptable concentration (MAC) for total lead in drinking water is 0.005 mg/L (5 µg/L), based on a sample of water taken at the tap and using the appropriate protocol for the type of building being sampled. Every effort should be made to maintain lead levels in drinking water as low as reasonably achievable (or ALARA). (GCDWQ: Guideline Technical Document; March, 2019)

Note 1.14 for Manganese (total):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on manganese, May 2019.

Note 1.15 for Strontium (total):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on strontium, May 2019.

Note 1.16 for Aluminum (dissolved):

The maximum acceptable concentration (MAC) for total aluminum in drinking water is 2.9 mg/L (2 900 µg/L) based on a locational running annual average of a minimum of quarterly samples taken in the distribution system. (Update March 5, 2021)

Note 1.17 for Arsenic (dissolved):

Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable.

Note 1.18 for Barium (dissolved):

Update January 24, 2020. The MAC was revised from 1.0 mg/L to 2.0 mg/L.

Note 1.19 for Cadmium (dissolved):

A maximum acceptable concentration (MAC) of 0.007 mg/L (7 µg/L) is established for total cadmium in drinking water, based on a sample of water taken at the tap. (Update July 14, 2020)

Note 1.20 for Copper (dissolved):

A maximum acceptable concentration (MAC) of 2 mg/L is established for total copper in drinking water, based on a sample of water taken at the tap. Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on Copper, June 2019.

Note 1.21 for Lead (dissolved):

The maximum acceptable concentration (MAC) for total lead in drinking water is 0.005 mg/L (5 µg/L), based on a sample of water taken at the tap and using the appropriate protocol for the type of building being sampled. Every effort should be made to maintain lead levels in drinking water as low as reasonably achievable (or ALARA). (GCDWQ: Guideline Technical Document; March, 2019)

Note 1.22 for Manganese (dissolved):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on manganese, May 2019.

Note 1.23 for Strontium (dissolved):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on strontium, May 2019.

Note 1.24 for Vinyl chloride:

Every effort should be made to maintain vinyl chloride levels in drinking water as low as reasonably achievable.

Note 1.25 for Bromodichloromethane:

The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds.

Note 1.26 for Bromoform:

The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds.

Note 1.27 for Chloroform:

The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds.

Note 1.28 for Dibromochloromethane:

The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds.

Note 1.29 for Total Trihalomethanes (calculated):

Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform compounds. The maximum acceptable concentration (MAC) for trihalomethanes (THMs) in drinking water is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels. Utilities should make every effort to maintain concentrations as low as reasonably achievable without compromising the effectiveness of disinfection.

2. Notes for Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives (GCDWQ AO)

Note 2.1 for pH:

The operational guideline for pH is a range of 7.0 to 10.5 in finished drinking water.

Note 2.2 for pH:

The operational guideline for pH is a range of 7.0 to 10.5 in finished drinking water.

Note 2.3 for Sulphate:

There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L. Health authorities should be notified of drinking water sources containing above 500 mg/L.

Note 2.4 for Aluminum (total):

The operational guidance (OG) value for total aluminum in drinking water is 0.100 mg/L (100 µg/L) to optimize water treatment and distribution system operations. This value is based on a locational running annual average. The sampling frequency required to calculate the locational running annual average will vary based on the type of treatment facility and the sampling location. (Update March 5, 2021)

Note 2.5 for Copper (total):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on Copper, June 2019.

Note 2.6 for Manganese (total):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on manganese, May 2019.

Note 2.7 for Aluminum (dissolved):

The operational guidance (OG) value for total aluminum in drinking water is 0.100 mg/L (100 µg/L) to optimize water treatment and distribution system operations. This value is based on a locational running annual average. The sampling frequency required to calculate the locational running annual average will vary based on the type of treatment facility and the sampling location. (Update March 5, 2021)

Note 2.8 for Copper (dissolved):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on Copper, June 2019.

Note 2.9 for Manganese (dissolved):

Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on manganese, May 2019.

3. Notes for BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (2020 and updates) (BC SDWQG MAC)

General Notes:

Reference: British Columbia Ministry of Environment and Climate Change Strategy. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary.

The source drinking water quality guidelines apply to the ambient water before it is treated and distributed for domestic use. The guidelines apply to drinking water sources from surface water and groundwater.

Note 3.1 for Turbidity:

For raw drinking water without treatment for particulates the guideline is: ≤ 1 NTU of turbidity.

For raw drinking water with treatment for particulates the guideline is:

Natural background turbidity is ≤ 50 NTU: Change from background should not exceed 5 NTU.

Natural background turbidity is > 50 NTU: Change from background should not exceed 10% of the background turbidity.

Note 3.2 for Total cyanide:

The MAC for free cyanide is 0.2 mg/L. A maximum of 0.2 mg/L was used to identify exceedances for total cyanide as a means for determining the potential for exceeding the free cyanide guideline. (Reference: Guidelines for Canadian Drinking Water Quality)

Note 3.3 for Turbidity:

For raw drinking water without treatment for particulates the guideline is: ≤ 1 NTU of turbidity.

For raw drinking water with treatment for particulates the guideline is:

Natural background turbidity is ≤ 50 NTU: Change from background should not exceed 5 NTU.

Natural background turbidity is > 50 NTU: Change from background should not exceed 10% of the background turbidity.

Note 3.4 for E. coli (counts):

The MAC is ≤ 10 E. coli /100 mL; 90th percentile (minimum of 5 samples).

Note 3.5 for Copper (total):

Includes short-term and long-term exposure.

Note 3.6 for Copper (dissolved):

Includes short-term and long-term exposure.

4. Notes for BC Source Drinking Water Quality Guidelines - Aesthetic Objectives (2020 and updates) (BC SDWQG AO)

General Notes:

Reference: British Columbia Ministry of Environment and Climate Change Strategy. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary.

The source drinking water quality guidelines apply to the ambient water before it is treated and distributed for domestic use. The guidelines apply to drinking water sources from surface water and groundwater.

Note 4.1 for Phosphorus (dissolved, by ICPMS/ICPOES):

The AO for lakes is 0.01 mg/L. For lakes with residence time > 6 months, measure total P during spring overturn. For lakes with residence time < 6 months, measure mean epilimnetic total P during the growing season (ENV 1985).

Note 4.2 for Phosphorus (total, by ICPMS/ICPOES):

The AO for lakes is 0.01 mg/L. For lakes with residence time > 6 months, measure total P during spring overturn. For lakes with residence time < 6 months, measure mean epilimnetic total P during the growing season (ENV 1985).

Note 4.3 for Phosphorus (total, APHA 4500-P):

The AO for lakes is 0.01 mg/L. For lakes with residence time > 6 months, measure total P during spring overturn. For lakes with residence time < 6 months, measure mean epilimnetic total P during the growing season (ENV 1985).

Note 4.4 for Phosphorus (dissolved, APHA 4500-P):

The AO for lakes is 0.01 mg/L. For lakes with residence time > 6 months, measure total P during spring overturn. For lakes with residence time < 6 months, measure mean epilimnetic total P during the growing season (ENV 1985).

APPENDIX B – LABORATORY REPORTS

CERTIFICATE OF ANALYSIS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon) #200 - 2800 29th Street Vernon, BC V1T 9P9	WORK ORDER	2313411
ATTENTION	Marta Green	RECEIVED / TEMP REPORTED	2023-09-27 14:51 / 6.3°C 2023-10-03 13:28
PO NUMBER		COC NUMBER	No Number
PROJECT	2023-8374		
PROJECT INFO	Misessula Lake Water System Upgrade		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks



You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry



It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve



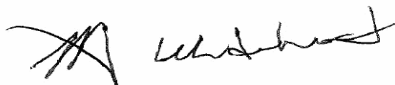
Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
<https://www.caro.ca/terms-conditions>

If you have any questions or concerns, please contact me at bwhitehead@caro.ca

Authorized By:

Brent Whitehead
Account Manager



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#108 4475 Wayburne Drive Burnaby, BC V5G 4X4

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 23I3411
2023-10-03 13:28

Analyte	Result	RL	Units	Analyzed	Qualifier
Lake 1 (23I3411-01) Matrix: Water Sampled: 2023-09-26 17:00					PRES
Anions					
Chloride	10.1	0.10	mg/L	2023-09-28	
Nitrate (as N)	< 0.010	0.010	mg/L	2023-09-28	
Nitrite (as N)	< 0.010	0.010	mg/L	2023-09-28	
Phosphate (as P)	< 0.0050	0.0050	mg/L	2023-09-28	
Sulfate	10.6	1.0	mg/L	2023-09-28	
Calculated Parameters					
Hardness, Dissolved (as CaCO ₃)	152	0.500	mg/L	N/A	
Nitrate+Nitrite (as N)	< 0.0100	0.0100	mg/L	N/A	
Nitrogen, Total	0.283	0.0500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2023-09-29	
Arsenic, dissolved	0.00068	0.00050	mg/L	2023-09-29	
Barium, dissolved	0.0371	0.0050	mg/L	2023-09-29	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Boron, dissolved	< 0.0500	0.0500	mg/L	2023-09-29	
Cadmium, dissolved	< 0.000010	0.000010	mg/L	2023-09-29	
Calcium, dissolved	41.7	0.20	mg/L	2023-09-29	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2023-09-29	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Copper, dissolved	0.00088	0.00040	mg/L	2023-09-29	
Iron, dissolved	< 0.010	0.010	mg/L	2023-09-29	
Lead, dissolved	< 0.00020	0.00020	mg/L	2023-09-29	
Lithium, dissolved	0.00114	0.00010	mg/L	2023-09-29	
Magnesium, dissolved	11.5	0.010	mg/L	2023-09-29	
Manganese, dissolved	0.00034	0.00020	mg/L	2023-09-29	
Mercury, dissolved	< 0.000010	0.000010	mg/L	2023-10-01	
Molybdenum, dissolved	0.00064	0.00010	mg/L	2023-09-29	
Nickel, dissolved	< 0.00040	0.00040	mg/L	2023-09-29	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2023-09-29	
Potassium, dissolved	1.55	0.10	mg/L	2023-09-29	
Selenium, dissolved	< 0.00050	0.00050	mg/L	2023-09-29	
Silicon, dissolved	6.2	1.0	mg/L	2023-09-29	
Silver, dissolved	< 0.000050	0.000050	mg/L	2023-09-29	
Sodium, dissolved	9.75	0.10	mg/L	2023-09-29	
Strontium, dissolved	0.201	0.0010	mg/L	2023-09-29	
Sulfur, dissolved	3.1	3.0	mg/L	2023-09-29	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2023-09-29	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2023-09-29	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Tin, dissolved	< 0.00020	0.00020	mg/L	2023-09-29	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 23I3411
2023-10-03 13:28

Analyte	Result	RL	Units	Analyzed	Qualifier
Lake 1 (23I3411-01) Matrix: Water Sampled: 2023-09-26 17:00, Continued					PRES
<i>Dissolved Metals, Continued</i>					
Titanium, dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2023-09-29	
Uranium, dissolved	0.000187	0.000020	mg/L	2023-09-29	
Vanadium, dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2023-09-29	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
<i>General Parameters</i>					
Alkalinity, Total (as CaCO ₃)	164	1.0	mg/L	2023-09-28	
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Alkalinity, Bicarbonate (as CaCO ₃)	164	1.0	mg/L	2023-09-28	
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Ammonia, Total (as N)	0.055	0.050	mg/L	2023-09-28	
Carbon, Total Organic	6.54	0.50	mg/L	2023-09-28	
Carbon, Dissolved Organic	5.18	0.50	mg/L	2023-09-28	
Conductivity (EC)	289	2.0	µS/cm	2023-09-28	
Nitrogen, Total Kjeldahl	0.283	0.050	mg/L	2023-09-29	
pH	8.26	0.10	pH units	2023-09-28	HT2
Phosphorus, Total (as P)	< 0.0050	0.0050	mg/L	2023-09-29	
Phosphorus, Total Dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Solids, Total Dissolved	187	15	mg/L	2023-09-28	
Solids, Total Suspended	< 2.0	2.0	mg/L	2023-09-28	
<i>Total Metals</i>					
Aluminum, total	0.0058	0.0050	mg/L	2023-10-01	
Antimony, total	< 0.00020	0.00020	mg/L	2023-10-01	
Arsenic, total	0.00058	0.00050	mg/L	2023-10-01	
Barium, total	0.0363	0.0050	mg/L	2023-10-01	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-01	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-01	
Boron, total	< 0.0500	0.0500	mg/L	2023-10-01	
Cadmium, total	< 0.000010	0.000010	mg/L	2023-10-01	
Calcium, total	40.9	0.20	mg/L	2023-10-01	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-01	
Cobalt, total	< 0.00010	0.00010	mg/L	2023-10-01	
Copper, total	0.00088	0.00040	mg/L	2023-10-01	
Iron, total	< 0.010	0.010	mg/L	2023-10-01	
Lead, total	< 0.00020	0.00020	mg/L	2023-10-01	
Lithium, total	0.00112	0.00010	mg/L	2023-10-01	
Magnesium, total	10.7	0.010	mg/L	2023-10-01	
Manganese, total	0.00090	0.00020	mg/L	2023-10-01	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-01	
Molybdenum, total	0.00078	0.00010	mg/L	2023-10-01	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL	Units	Analyzed	Qualifier
Lake 1 (2313411-01) Matrix: Water Sampled: 2023-09-26 17:00, Continued					PRES
<i>Total Metals, Continued</i>					
Nickel, total	< 0.00040	0.00040	mg/L	2023-10-01	
Phosphorus, total	< 0.050	0.050	mg/L	2023-10-01	
Potassium, total	1.43	0.10	mg/L	2023-10-01	
Selenium, total	< 0.00050	0.00050	mg/L	2023-10-01	
Silicon, total	6.5	1.0	mg/L	2023-10-01	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-01	
Sodium, total	8.97	0.10	mg/L	2023-10-01	
Strontium, total	0.191	0.0010	mg/L	2023-10-01	
Sulfur, total	3.4	3.0	mg/L	2023-10-01	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-01	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-01	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-01	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-01	
Titanium, total	< 0.0050	0.0050	mg/L	2023-10-01	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-01	
Uranium, total	0.000234	0.000020	mg/L	2023-10-01	
Vanadium, total	< 0.0050	0.0050	mg/L	2023-10-01	
Zinc, total	< 0.0040	0.0040	mg/L	2023-10-01	
Zirconium, total	< 0.00010	0.00010	mg/L	2023-10-01	

WIPN 52992 (2313411-02) | Matrix: Water | Sampled: 2023-09-26 17:00

PRES

Anions

Chloride	10.3	0.10	mg/L	2023-09-28	
Nitrate (as N)	< 0.010	0.010	mg/L	2023-09-28	
Nitrite (as N)	< 0.010	0.010	mg/L	2023-09-28	
Phosphate (as P)	< 0.0050	0.0050	mg/L	2023-09-28	
Sulfate	390	1.0	mg/L	2023-09-28	

Calculated Parameters

Hardness, Dissolved (as CaCO3)	574	0.500	mg/L	N/A	
Nitrate+Nitrite (as N)	< 0.0100	0.0100	mg/L	N/A	
Nitrogen, Total	0.529	0.0500	mg/L	N/A	

Dissolved Metals

Aluminum, dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Antimony, dissolved	0.00355	0.00020	mg/L	2023-09-29	
Arsenic, dissolved	0.00196	0.00050	mg/L	2023-09-29	
Barium, dissolved	0.116	0.0050	mg/L	2023-09-29	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Boron, dissolved	0.0693	0.0500	mg/L	2023-09-29	
Cadmium, dissolved	< 0.000010	0.000010	mg/L	2023-09-29	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

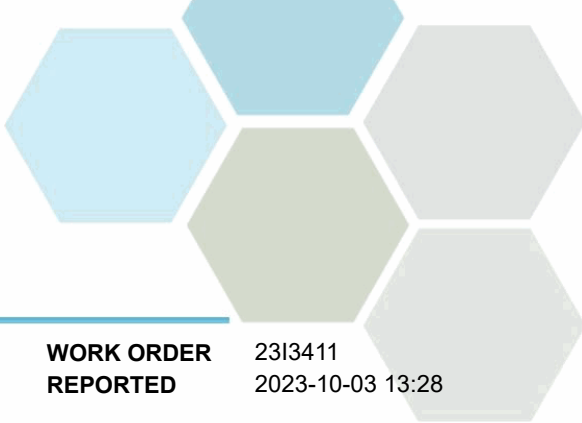
Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (2313411-02) Matrix: Water Sampled: 2023-09-26 17:00, Continued					PRES
Dissolved Metals, Continued					
Calcium, dissolved	201	0.20	mg/L	2023-09-29	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2023-09-29	
Cobalt, dissolved	0.00030	0.00010	mg/L	2023-09-29	
Copper, dissolved	< 0.00040	0.00040	mg/L	2023-09-29	
Iron, dissolved	0.271	0.010	mg/L	2023-09-29	
Lead, dissolved	< 0.00020	0.00020	mg/L	2023-09-29	
Lithium, dissolved	0.00420	0.00010	mg/L	2023-09-29	
Magnesium, dissolved	17.1	0.010	mg/L	2023-09-29	
Manganese, dissolved	0.152	0.00020	mg/L	2023-09-29	
Mercury, dissolved	< 0.000010	0.000010	mg/L	2023-10-01	
Molybdenum, dissolved	0.00525	0.00010	mg/L	2023-09-29	
Nickel, dissolved	0.00076	0.00040	mg/L	2023-09-29	
Phosphorus, dissolved	0.065	0.050	mg/L	2023-09-29	
Potassium, dissolved	1.60	0.10	mg/L	2023-09-29	
Selenium, dissolved	0.00305	0.00050	mg/L	2023-09-29	
Silicon, dissolved	9.7	1.0	mg/L	2023-09-29	
Silver, dissolved	< 0.000050	0.000050	mg/L	2023-09-29	
Sodium, dissolved	11.5	0.10	mg/L	2023-09-29	
Strontium, dissolved	2.43	0.0010	mg/L	2023-09-29	
Sulfur, dissolved	117	3.0	mg/L	2023-09-29	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2023-09-29	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2023-09-29	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
Tin, dissolved	< 0.00020	0.00020	mg/L	2023-09-29	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2023-09-29	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2023-09-29	
Uranium, dissolved	0.000867	0.000020	mg/L	2023-09-29	
Vanadium, dissolved	0.0070	0.0050	mg/L	2023-09-29	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2023-09-29	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2023-09-29	
General Parameters					
Alkalinity, Total (as CaCO ₃)	225	1.0	mg/L	2023-09-28	
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Alkalinity, Bicarbonate (as CaCO ₃)	225	1.0	mg/L	2023-09-28	
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0	mg/L	2023-09-28	
Ammonia, Total (as N)	0.247	0.050	mg/L	2023-09-28	
Carbon, Total Organic	4.13	0.50	mg/L	2023-09-28	
Carbon, Dissolved Organic	3.71	0.50	mg/L	2023-09-28	
Conductivity (EC)	971	2.0	µS/cm	2023-09-28	
Nitrogen, Total Kjeldahl	0.529	0.050	mg/L	2023-09-29	
pH	8.15	0.10	pH units	2023-09-28	HT2

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (2313411-02) Matrix: Water Sampled: 2023-09-26 17:00, Continued					PRES
General Parameters, Continued					
Phosphorus, Total (as P)	0.0564	0.0050	mg/L	2023-09-29	
Phosphorus, Total Dissolved	0.0193	0.0050	mg/L	2023-09-29	
Solids, Total Dissolved	756	15	mg/L	2023-09-28	
Solids, Total Suspended	16.2	2.0	mg/L	2023-09-28	
Total Metals					
Aluminum, total	0.115	0.0050	mg/L	2023-10-01	
Antimony, total	0.00331	0.00020	mg/L	2023-10-01	
Arsenic, total	0.00210	0.00050	mg/L	2023-10-01	
Barium, total	0.116	0.0050	mg/L	2023-10-01	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-01	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-01	
Boron, total	0.0639	0.0500	mg/L	2023-10-01	
Cadmium, total	0.000048	0.000010	mg/L	2023-10-01	
Calcium, total	189	0.20	mg/L	2023-10-01	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-01	
Cobalt, total	0.00039	0.00010	mg/L	2023-10-01	
Copper, total	0.00160	0.00040	mg/L	2023-10-01	
Iron, total	0.589	0.010	mg/L	2023-10-01	
Lead, total	0.00086	0.00020	mg/L	2023-10-01	
Lithium, total	0.00392	0.00010	mg/L	2023-10-01	
Magnesium, total	15.5	0.010	mg/L	2023-10-01	
Manganese, total	0.153	0.00020	mg/L	2023-10-01	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-01	
Molybdenum, total	0.00611	0.00010	mg/L	2023-10-01	
Nickel, total	0.00085	0.00040	mg/L	2023-10-01	
Phosphorus, total	0.091	0.050	mg/L	2023-10-01	
Potassium, total	1.49	0.10	mg/L	2023-10-01	
Selenium, total	0.00296	0.00050	mg/L	2023-10-01	
Silicon, total	10.1	1.0	mg/L	2023-10-01	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-01	
Sodium, total	10.9	0.10	mg/L	2023-10-01	
Strontium, total	2.34	0.0010	mg/L	2023-10-01	
Sulfur, total	122	3.0	mg/L	2023-10-01	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-01	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-01	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-01	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-01	
Titanium, total	0.0059	0.0050	mg/L	2023-10-01	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-01	
Uranium, total	0.00101	0.000020	mg/L	2023-10-01	
Vanadium, total	0.0079	0.0050	mg/L	2023-10-01	
Zinc, total	< 0.0040	0.0040	mg/L	2023-10-01	



TEST RESULTS

REPORTED TO PROJECT	Associated Environmental Consultants Inc. (Vernon) 2023-8374	WORK ORDER REPORTED	2313411 2023-10-03 13:28
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Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (2313411-02) Matrix: Water Sampled: 2023-09-26 17:00, Continued					PRES
Total Metals, Continued					
Zirconium, total	0.00016		0.00010 mg/L	2023-10-01	

Sample Qualifiers:					
HT2	The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.				
PRES	Sample has been preserved for TOC in the laboratory and the holding time has been extended.				

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

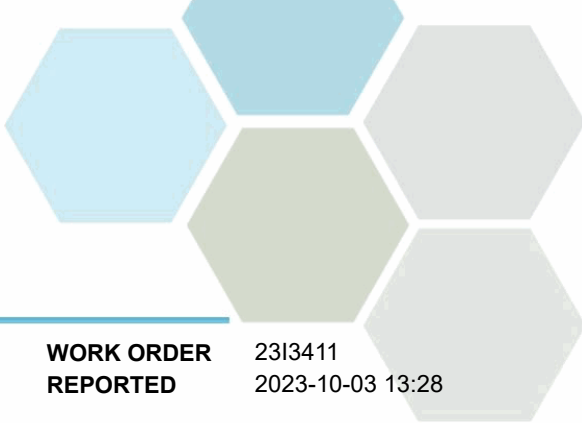
WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analysis Description	Method Ref.	Technique	Accredited	Location
Alkalinity in Water	SM 2320 B* (2021)	Titration with H ₂ SO ₄	✓	Kelowna
Ammonia, Total in Water	SM 4500-NH ₃ G* (2021)	Automated Colorimetry (Phenate)	✓	Kelowna
Anions in Water	SM 4110 B (2020)	Ion Chromatography	✓	Kelowna
Carbon, Dissolved Organic in Water	SM 5310 B (2022)	Combustion, Infrared CO ₂ Detection	✓	Kelowna
Carbon, Total Organic in Water	SM 5310 B (2022)	Combustion, Infrared CO ₂ Detection	✓	Kelowna
Conductivity in Water	SM 2510 B (2021)	Conductivity Meter	✓	Kelowna
Dissolved Metals in Water	EPA 200.8 / EPA 6020B	0.45 µm Filtration / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond
Hardness in Water	SM 2340 B (2021)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	✓	N/A
Mercury, dissolved in Water	EPA 245.7*	BrCl ₂ Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Mercury, total in Water	EPA 245.7*	BrCl ₂ Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Nitrogen, Total Kjeldahl in Water	SM 4500-Norg D* (2021)	Block Digestion and Flow Injection Analysis	✓	Kelowna
pH in Water	SM 4500-H+ B (2021)	Electrometry	✓	Kelowna
Phosphorus, Total Dissolved in Water	SM 4500-P B.5* (2011) / SM 4500-P F (2021)	Persulfate Digestion / Automated Colorimetry (Ascorbic Acid)	✓	Kelowna
Phosphorus, Total in Water	SM 4500-P B.5* (2011) / SM 4500-P F (2021)	Persulfate Digestion / Automated Colorimetry (Ascorbic Acid)	✓	Kelowna
Solids, Total Dissolved in Water	Solids in Water, Filtered / SM 2540 C* (2020)	Solids in Water, Filtered / Gravimetry (Dried at 103-105C)	✓	Kelowna
Solids, Total Suspended in Water	Solids in Water, Filtered / SM 2540 D* (2020)	Solids in Water, Filtered / Gravimetry (Dried at 103-105C)	✓	Kelowna
Total Metals in Water	EPA 200.2 / EPA 6020B	HNO ₃ +HCl Hot Block Digestion / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, pH > 7 = basic
µS/cm	Microsiemens per centimetre
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association



APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT	Associated Environmental Consultants Inc. (Vernon) 2023-8374	WORK ORDER REPORTED	2313411 2023-10-03 13:28
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General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Caro will dispose of all samples within 30 days of sample receipt, unless otherwise agreed.

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APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk):** A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup):** An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS):** A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS):** A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM):** A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Anions, Batch B312833

Blank (B312833-BLK2)			Prepared: 2023-09-29, Analyzed: 2023-09-29						
Chloride	< 0.10	0.10 mg/L							
Nitrate (as N)	< 0.010	0.010 mg/L							
Nitrite (as N)	< 0.010	0.010 mg/L							
Phosphate (as P)	< 0.0050	0.0050 mg/L							
Sulfate	< 1.0	1.0 mg/L							

LCS (B312833-BS2)			Prepared: 2023-09-29, Analyzed: 2023-09-29						
Chloride	15.7	0.10 mg/L	16.0		98	90-110			
Nitrate (as N)	3.97	0.010 mg/L	4.00		99	90-110			
Nitrite (as N)	2.00	0.010 mg/L	2.00		100	85-115			
Phosphate (as P)	0.978	0.0050 mg/L	1.00		98	80-120			
Sulfate	15.4	1.0 mg/L	16.0		96	90-110			

Dissolved Metals, Batch B312997

Blank (B312997-BLK1)			Prepared: 2023-09-29, Analyzed: 2023-09-29						
Aluminum, dissolved	< 0.0050	0.0050 mg/L							
Antimony, dissolved	< 0.00020	0.00020 mg/L							
Arsenic, dissolved	< 0.00050	0.00050 mg/L							
Barium, dissolved	< 0.0050	0.0050 mg/L							
Beryllium, dissolved	< 0.00010	0.00010 mg/L							
Bismuth, dissolved	< 0.00010	0.00010 mg/L							
Boron, dissolved	< 0.0500	0.0500 mg/L							
Cadmium, dissolved	< 0.000010	0.000010 mg/L							
Calcium, dissolved	< 0.20	0.20 mg/L							
Chromium, dissolved	< 0.00050	0.00050 mg/L							
Cobalt, dissolved	< 0.00010	0.00010 mg/L							
Copper, dissolved	< 0.00040	0.00040 mg/L							
Iron, dissolved	< 0.010	0.010 mg/L							
Lead, dissolved	< 0.00020	0.00020 mg/L							
Lithium, dissolved	< 0.00010	0.00010 mg/L							
Magnesium, dissolved	< 0.010	0.010 mg/L							
Manganese, dissolved	< 0.00020	0.00020 mg/L							
Molybdenum, dissolved	< 0.00010	0.00010 mg/L							
Nickel, dissolved	< 0.00040	0.00040 mg/L							
Phosphorus, dissolved	< 0.050	0.050 mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Dissolved Metals, Batch B3I2997, Continued

Blank (B3I2997-BLK1), Continued

Prepared: 2023-09-29, Analyzed: 2023-09-29

Potassium, dissolved	< 0.10	0.10 mg/L							
Selenium, dissolved	< 0.00050	0.00050 mg/L							
Silicon, dissolved	< 1.0	1.0 mg/L							
Silver, dissolved	< 0.000050	0.000050 mg/L							
Sodium, dissolved	< 0.10	0.10 mg/L							
Strontium, dissolved	< 0.0010	0.0010 mg/L							
Sulfur, dissolved	< 3.0	3.0 mg/L							
Tellurium, dissolved	< 0.00050	0.00050 mg/L							
Thallium, dissolved	< 0.000020	0.000020 mg/L							
Thorium, dissolved	< 0.00010	0.00010 mg/L							
Tin, dissolved	< 0.00020	0.00020 mg/L							
Titanium, dissolved	< 0.0050	0.0050 mg/L							
Tungsten, dissolved	< 0.0010	0.0010 mg/L							
Uranium, dissolved	< 0.000020	0.000020 mg/L							
Vanadium, dissolved	< 0.0050	0.0050 mg/L							
Zinc, dissolved	< 0.0040	0.0040 mg/L							
Zirconium, dissolved	< 0.00010	0.00010 mg/L							

LCS (B3I2997-BS1)

Prepared: 2023-09-29, Analyzed: 2023-09-29

Aluminum, dissolved	4.13	0.0050 mg/L	4.00		103	80-120			
Antimony, dissolved	0.0421	0.00020 mg/L	0.0400		105	80-120			
Arsenic, dissolved	0.426	0.00050 mg/L	0.400		107	80-120			
Barium, dissolved	0.0424	0.0050 mg/L	0.0400		106	80-120			
Beryllium, dissolved	0.0414	0.00010 mg/L	0.0400		103	80-120			
Bismuth, dissolved	0.0406	0.00010 mg/L	0.0400		101	80-120			
Boron, dissolved	0.425	0.0500 mg/L	0.400		106	80-120			
Cadmium, dissolved	0.0413	0.000010 mg/L	0.0400		103	80-120			
Calcium, dissolved	4.06	0.20 mg/L	4.00		102	80-120			
Chromium, dissolved	0.0412	0.00050 mg/L	0.0400		103	80-120			
Cobalt, dissolved	0.0420	0.00010 mg/L	0.0400		105	80-120			
Copper, dissolved	0.0426	0.00040 mg/L	0.0400		107	80-120			
Iron, dissolved	4.22	0.010 mg/L	4.00		106	80-120			
Lead, dissolved	0.0409	0.00020 mg/L	0.0400		102	80-120			
Lithium, dissolved	0.0410	0.00010 mg/L	0.0400		103	80-120			
Magnesium, dissolved	4.22	0.010 mg/L	4.00		105	80-120			
Manganese, dissolved	0.0425	0.00020 mg/L	0.0400		106	80-120			
Molybdenum, dissolved	0.0410	0.00010 mg/L	0.0400		102	80-120			
Nickel, dissolved	0.0424	0.00040 mg/L	0.0400		106	80-120			
Phosphorus, dissolved	4.18	0.050 mg/L	4.00		105	80-120			
Potassium, dissolved	4.21	0.10 mg/L	4.00		105	80-120			
Selenium, dissolved	0.400	0.00050 mg/L	0.400		100	80-120			
Silicon, dissolved	4.1	1.0 mg/L	4.00		103	80-120			
Silver, dissolved	0.0424	0.000050 mg/L	0.0400		106	80-120			
Sodium, dissolved	4.23	0.10 mg/L	4.00		106	80-120			
Strontium, dissolved	0.0398	0.0010 mg/L	0.0400		100	80-120			
Sulfur, dissolved	40.1	3.0 mg/L	40.0		100	80-120			
Tellurium, dissolved	0.0403	0.00050 mg/L	0.0400		101	80-120			
Thallium, dissolved	0.0408	0.000020 mg/L	0.0400		102	80-120			
Thorium, dissolved	0.0422	0.00010 mg/L	0.0400		106	80-120			
Tin, dissolved	0.0411	0.00020 mg/L	0.0400		103	80-120			
Titanium, dissolved	0.0436	0.0050 mg/L	0.0400		109	80-120			
Tungsten, dissolved	0.0418	0.0010 mg/L	0.0400		105	80-120			
Uranium, dissolved	0.0414	0.000020 mg/L	0.0400		104	80-120			
Vanadium, dissolved	0.0424	0.0050 mg/L	0.0400		106	80-120			
Zinc, dissolved	0.419	0.0040 mg/L	0.400		105	80-120			
Zirconium, dissolved	0.0425	0.00010 mg/L	0.0400		106	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Dissolved Metals, Batch B3J0009

Blank (B3J0009-BLK1)			Prepared: 2023-10-01, Analyzed: 2023-10-01						
Mercury, dissolved	< 0.000010	0.000010 mg/L							
LCS (B3J0009-BS1)			Prepared: 2023-10-01, Analyzed: 2023-10-01						
Mercury, dissolved	0.000270	0.000010 mg/L	0.000250		108	80-120			

General Parameters, Batch B3I2815

Blank (B3I2815-BLK1)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3I2815-BLK2)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3I2815-BLK3)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3I2815-BLK4)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3I2815-BLK5)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3I2815-BLK6)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
LCS (B3I2815-BS1)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	1.00	0.050 mg/L	1.00		100	85-115			
LCS (B3I2815-BS2)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	1.01	0.050 mg/L	1.00		101	85-115			
LCS (B3I2815-BS3)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	1.00	0.050 mg/L	1.00		100	85-115			
LCS (B3I2815-BS4)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	1.03	0.050 mg/L	1.00		103	85-115			
LCS (B3I2815-BS5)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	0.976	0.050 mg/L	1.00		98	85-115			
LCS (B3I2815-BS6)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Ammonia, Total (as N)	0.959	0.050 mg/L	1.00		96	85-115			

General Parameters, Batch B3I2823

Blank (B3I2823-BLK1)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Alkalinity, Total (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0 mg/L							
Conductivity (EC)	< 2.0	2.0 µS/cm							
Blank (B3I2823-BLK2)			Prepared: 2023-09-28, Analyzed: 2023-09-28						
Alkalinity, Total (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0 mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0 mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3I2823, Continued									
Blank (B3I2823-BLK2), Continued				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0 mg/L							
Conductivity (EC)	< 2.0	2.0 µS/cm							
LCS (B3I2823-BS1)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Alkalinity, Total (as CaCO ₃)	108	1.0 mg/L	100		108	80-120			
Alkalinity, Phenolphthalein (as CaCO ₃)	52.6	1.0 mg/L	50.0		105	0-200			
LCS (B3I2823-BS2)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Alkalinity, Total (as CaCO ₃)	107	1.0 mg/L	100		107	80-120			
Alkalinity, Phenolphthalein (as CaCO ₃)	47.2	1.0 mg/L	50.0		94	0-200			
LCS (B3I2823-BS3)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Conductivity (EC)	1400	2.0 µS/cm	1410		100	95-105			
LCS (B3I2823-BS4)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Conductivity (EC)	1410	2.0 µS/cm	1410		100	95-105			
Reference (B3I2823-SRM1)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
pH	7.03	0.10 pH units	7.01		100	98-102			
Reference (B3I2823-SRM2)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
pH	7.04	0.10 pH units	7.01		100	98-102			
General Parameters, Batch B3I2845									
Blank (B3I2845-BLK1)				Prepared: 2023-09-25, Analyzed: 2023-09-28					
Carbon, Total Organic	< 0.50	0.50 mg/L							
Carbon, Dissolved Organic	< 0.50	0.50 mg/L							
LCS (B3I2845-BS1)				Prepared: 2023-09-25, Analyzed: 2023-09-28					
Carbon, Total Organic	9.41	0.50 mg/L	10.0		94	78-116			
Carbon, Dissolved Organic	9.48	0.50 mg/L	10.0		95	78-116			
General Parameters, Batch B3I2859									
Blank (B3I2859-BLK1)				Prepared: 2023-09-28, Analyzed: 2023-09-29					
Nitrogen, Total Kjeldahl	< 0.050	0.050 mg/L							
Blank (B3I2859-BLK2)				Prepared: 2023-09-28, Analyzed: 2023-09-29					
Nitrogen, Total Kjeldahl	< 0.050	0.050 mg/L							
LCS (B3I2859-BS1)				Prepared: 2023-09-28, Analyzed: 2023-09-29					
Nitrogen, Total Kjeldahl	1.01	0.050 mg/L	1.00		101	85-115			
LCS (B3I2859-BS2)				Prepared: 2023-09-28, Analyzed: 2023-09-29					
Nitrogen, Total Kjeldahl	1.02	0.050 mg/L	1.00		102	85-115			
General Parameters, Batch B3I2892									
Blank (B3I2892-BLK1)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Solids, Total Dissolved	< 15	15 mg/L							
LCS (B3I2892-BS1)				Prepared: 2023-09-28, Analyzed: 2023-09-28					
Solids, Total Dissolved	240	15 mg/L	240		100	85-115			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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WORK ORDER REPORTED 2313411
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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3I2892, Continued									
Duplicate (B3I2892-DUP1)		Source: 2313411-02		Prepared: 2023-09-28, Analyzed: 2023-09-28					
Solids, Total Dissolved	762	15 mg/L		756			< 1	15	
General Parameters, Batch B3I2905									
Blank (B3I2905-BLK1)		Prepared: 2023-09-28, Analyzed: 2023-09-28							
Solids, Total Suspended	< 2.0	2.0 mg/L							
LCS (B3I2905-BS1)		Prepared: 2023-09-28, Analyzed: 2023-09-28							
Solids, Total Suspended	96.0	10.0 mg/L	100		96	85-115			
General Parameters, Batch B3I2913									
Blank (B3I2913-BLK1)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
Phosphorus, Total Dissolved	< 0.0050	0.0050 mg/L							
Blank (B3I2913-BLK2)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
Phosphorus, Total Dissolved	< 0.0050	0.0050 mg/L							
Blank (B3I2913-BLK3)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
Blank (B3I2913-BLK4)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
LCS (B3I2913-BS1)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	0.100	0.0050 mg/L	0.100		100	85-115			
Phosphorus, Total Dissolved	0.101	0.0050 mg/L	0.100		101	85-115			
LCS (B3I2913-BS2)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	0.100	0.0050 mg/L	0.100		100	85-115			
Phosphorus, Total Dissolved	0.0998	0.0050 mg/L	0.100		100	85-115			
LCS (B3I2913-BS3)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	0.100	0.0050 mg/L	0.100		100	85-115			
LCS (B3I2913-BS4)		Prepared: 2023-09-28, Analyzed: 2023-09-29							
Phosphorus, Total (as P)	0.102	0.0050 mg/L	0.100		102	85-115			
Total Metals, Batch B3I3057									
Blank (B3I3057-BLK1)		Prepared: 2023-09-30, Analyzed: 2023-10-01							
Aluminum, total	< 0.0050	0.0050 mg/L							
Antimony, total	< 0.00020	0.00020 mg/L							
Arsenic, total	< 0.00050	0.00050 mg/L							
Barium, total	< 0.0050	0.0050 mg/L							
Beryllium, total	< 0.00010	0.00010 mg/L							
Bismuth, total	< 0.00010	0.00010 mg/L							
Boron, total	< 0.0500	0.0500 mg/L							
Cadmium, total	< 0.000010	0.000010 mg/L							
Calcium, total	< 0.20	0.20 mg/L							
Chromium, total	< 0.00050	0.00050 mg/L							
Cobalt, total	< 0.00010	0.00010 mg/L							
Copper, total	< 0.00040	0.00040 mg/L							
Iron, total	< 0.010	0.010 mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Total Metals, Batch B313057, Continued

Blank (B313057-BLK1), Continued

Prepared: 2023-09-30, Analyzed: 2023-10-01

Lead, total	< 0.00020	0.00020 mg/L							
Lithium, total	< 0.00010	0.00010 mg/L							
Magnesium, total	< 0.010	0.010 mg/L							
Manganese, total	< 0.00020	0.00020 mg/L							
Molybdenum, total	< 0.00010	0.00010 mg/L							
Nickel, total	< 0.00040	0.00040 mg/L							
Phosphorus, total	< 0.050	0.050 mg/L							
Potassium, total	< 0.10	0.10 mg/L							
Selenium, total	< 0.00050	0.00050 mg/L							
Silicon, total	< 1.0	1.0 mg/L							
Silver, total	< 0.000050	0.000050 mg/L							
Sodium, total	< 0.10	0.10 mg/L							
Strontium, total	< 0.0010	0.0010 mg/L							
Sulfur, total	< 3.0	3.0 mg/L							
Tellurium, total	< 0.00050	0.00050 mg/L							
Thallium, total	< 0.000020	0.000020 mg/L							
Thorium, total	< 0.00010	0.00010 mg/L							
Tin, total	< 0.00020	0.00020 mg/L							
Titanium, total	< 0.0050	0.0050 mg/L							
Tungsten, total	< 0.0010	0.0010 mg/L							
Uranium, total	< 0.000020	0.000020 mg/L							
Vanadium, total	< 0.0050	0.0050 mg/L							
Zinc, total	< 0.0040	0.0040 mg/L							
Zirconium, total	< 0.00010	0.00010 mg/L							

LCS (B313057-BS1)

Prepared: 2023-09-30, Analyzed: 2023-10-01

Aluminum, total	4.02	0.0050 mg/L	4.00		100	80-120			
Antimony, total	0.0403	0.00020 mg/L	0.0400		101	80-120			
Arsenic, total	0.399	0.00050 mg/L	0.400		100	80-120			
Barium, total	0.0393	0.0050 mg/L	0.0400		98	80-120			
Beryllium, total	0.0391	0.00010 mg/L	0.0400		98	80-120			
Bismuth, total	0.0399	0.00010 mg/L	0.0400		100	80-120			
Boron, total	0.404	0.0500 mg/L	0.400		101	80-120			
Cadmium, total	0.0398	0.000010 mg/L	0.0400		100	80-120			
Calcium, total	3.86	0.20 mg/L	4.00		96	80-120			
Chromium, total	0.0402	0.00050 mg/L	0.0400		100	80-120			
Cobalt, total	0.0407	0.00010 mg/L	0.0400		102	80-120			
Copper, total	0.0403	0.00040 mg/L	0.0400		101	80-120			
Iron, total	4.09	0.010 mg/L	4.00		102	80-120			
Lead, total	0.0395	0.00020 mg/L	0.0400		99	80-120			
Lithium, total	0.0381	0.00010 mg/L	0.0400		95	80-120			
Magnesium, total	4.07	0.010 mg/L	4.00		102	80-120			
Manganese, total	0.0409	0.00020 mg/L	0.0400		102	80-120			
Molybdenum, total	0.0409	0.00010 mg/L	0.0400		102	80-120			
Nickel, total	0.0402	0.00040 mg/L	0.0400		101	80-120			
Phosphorus, total	3.99	0.050 mg/L	4.00		100	80-120			
Potassium, total	4.01	0.10 mg/L	4.00		100	80-120			
Selenium, total	0.405	0.00050 mg/L	0.400		101	80-120			
Silicon, total	4.4	1.0 mg/L	4.00		109	80-120			
Silver, total	0.0401	0.000050 mg/L	0.0400		100	80-120			
Sodium, total	4.25	0.10 mg/L	4.00		106	80-120			
Strontium, total	0.0402	0.0010 mg/L	0.0400		100	80-120			
Sulfur, total	40.5	3.0 mg/L	40.0		101	80-120			
Tellurium, total	0.0390	0.00050 mg/L	0.0400		97	80-120			
Thallium, total	0.0387	0.000020 mg/L	0.0400		97	80-120			
Thorium, total	0.0413	0.00010 mg/L	0.0400		103	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374

WORK ORDER REPORTED 2313411
2023-10-03 13:28

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3I3057, Continued									
LCS (B3I3057-BS1), Continued					Prepared: 2023-09-30, Analyzed: 2023-10-01				
Tin, total	0.0416	0.00020 mg/L	0.0400		104	80-120			
Titanium, total	0.0401	0.0050 mg/L	0.0400		100	80-120			
Tungsten, total	0.0415	0.0010 mg/L	0.0400		104	80-120			
Uranium, total	0.0419	0.000020 mg/L	0.0400		105	80-120			
Vanadium, total	0.0402	0.0050 mg/L	0.0400		100	80-120			
Zinc, total	0.406	0.0040 mg/L	0.400		101	80-120			
Zirconium, total	0.0407	0.00010 mg/L	0.0400		102	80-120			

Total Metals, Batch B3J0008

Blank (B3J0008-BLK1)					Prepared: 2023-10-01, Analyzed: 2023-10-01				
Mercury, total	< 0.000010	0.000010 mg/L							
LCS (B3J0008-BS1)					Prepared: 2023-10-01, Analyzed: 2023-10-01				
Mercury, total	0.000258	0.000010 mg/L	0.000250		103	80-120			

CERTIFICATE OF ANALYSIS

REPORTED TO Associated Environmental Consultants Inc. (Vernon)
#200 - 2800 29th Street
Vernon, BC V1T 9P9

ATTENTION Marta Green

PO NUMBER 223-8374.000.002

PROJECT 2023-8374.000.002

PROJECT INFO [info]

WORK ORDER 23J2279

RECEIVED / TEMP 2023-10-18 16:57 / 8.0°C

REPORTED 2023-10-30 14:23

COC NUMBER B131668

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

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You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

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Authorized By:

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Account Manager

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TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (23J2279-01) Matrix: Water Sampled: 2023-10-17 14:30					
Calculated Parameters					
Hardness, Total (as CaCO3)	464	0.500	mg/L	N/A	
Total Metals					
Aluminum, total	0.0393	0.0050	mg/L	2023-10-24	
Antimony, total	0.00059	0.00020	mg/L	2023-10-24	
Arsenic, total	0.00208	0.00050	mg/L	2023-10-24	
Barium, total	0.181	0.0050	mg/L	2023-10-24	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-24	
Boron, total	0.0724	0.0500	mg/L	2023-10-24	
Cadmium, total	< 0.000020	0.000010	mg/L	2023-10-24	RA1
Calcium, total	163	0.20	mg/L	2023-10-24	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Cobalt, total	0.00015	0.00010	mg/L	2023-10-24	
Copper, total	0.00256	0.00040	mg/L	2023-10-24	
Iron, total	0.193	0.010	mg/L	2023-10-24	
Lead, total	0.00024	0.00020	mg/L	2023-10-24	
Lithium, total	0.00352	0.00010	mg/L	2023-10-24	
Magnesium, total	13.7	0.010	mg/L	2023-10-24	
Manganese, total	0.129	0.00020	mg/L	2023-10-24	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-26	
Molybdenum, total	0.00457	0.00010	mg/L	2023-10-24	
Nickel, total	< 0.00040	0.00040	mg/L	2023-10-24	
Phosphorus, total	0.071	0.050	mg/L	2023-10-24	
Potassium, total	1.62	0.10	mg/L	2023-10-24	
Selenium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Silicon, total	9.3	1.0	mg/L	2023-10-24	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-24	
Sodium, total	10.0	0.10	mg/L	2023-10-24	
Strontium, total	1.92	0.0010	mg/L	2023-10-24	
Sulfur, total	88.4	3.0	mg/L	2023-10-24	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-24	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-24	
Titanium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-24	
Uranium, total	0.000594	0.000020	mg/L	2023-10-24	
Vanadium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Zinc, total	0.0071	0.0040	mg/L	2023-10-24	
Zirconium, total	0.00016	0.00010	mg/L	2023-10-24	

WIPN 52992 (23J2279-02) | Matrix: Water | Sampled: 2023-10-17 20:40

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (23J2279-02) Matrix: Water Sampled: 2023-10-17 20:40, Continued					
Calculated Parameters					
Hardness, Total (as CaCO3)	507	0.500	mg/L	N/A	
Total Metals					
Aluminum, total	0.0254	0.0050	mg/L	2023-10-24	
Antimony, total	0.00052	0.00020	mg/L	2023-10-24	
Arsenic, total	0.00169	0.00050	mg/L	2023-10-24	
Barium, total	0.192	0.0050	mg/L	2023-10-24	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-24	
Boron, total	0.0701	0.0500	mg/L	2023-10-24	
Cadmium, total	< 0.000010	0.000010	mg/L	2023-10-24	
Calcium, total	179	0.20	mg/L	2023-10-24	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Cobalt, total	0.00012	0.00010	mg/L	2023-10-24	
Copper, total	0.00458	0.00040	mg/L	2023-10-24	
Iron, total	0.190	0.010	mg/L	2023-10-24	
Lead, total	< 0.00020	0.00020	mg/L	2023-10-24	
Lithium, total	0.00366	0.00010	mg/L	2023-10-24	
Magnesium, total	14.6	0.010	mg/L	2023-10-24	
Manganese, total	0.141	0.00020	mg/L	2023-10-24	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-26	
Molybdenum, total	0.00413	0.00010	mg/L	2023-10-24	
Nickel, total	< 0.00040	0.00040	mg/L	2023-10-24	
Phosphorus, total	0.078	0.050	mg/L	2023-10-24	
Potassium, total	1.65	0.10	mg/L	2023-10-24	
Selenium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Silicon, total	9.7	1.0	mg/L	2023-10-24	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-24	
Sodium, total	10.2	0.10	mg/L	2023-10-24	
Strontium, total	2.04	0.0010	mg/L	2023-10-24	
Sulfur, total	104	3.0	mg/L	2023-10-24	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-24	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-24	
Titanium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-24	
Uranium, total	0.000490	0.000020	mg/L	2023-10-24	
Vanadium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Zinc, total	0.0101	0.0040	mg/L	2023-10-24	
Zirconium, total	< 0.00010	0.00010	mg/L	2023-10-24	

WIPN 52992 (23J2279-03) | Matrix: Water | Sampled: 2023-10-18 10:00

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (23J2279-03) Matrix: Water Sampled: 2023-10-18 10:00, Continued					
Anions					
Chloride	9.04	0.10	mg/L	2023-10-21	
Fluoride	0.13	0.10	mg/L	2023-10-21	
Nitrate (as N)	0.015	0.010	mg/L	2023-10-21	
Nitrite (as N)	< 0.010	0.010	mg/L	2023-10-21	
Sulfate	349	1.0	mg/L	2023-10-21	
BCMOE Aggregate Hydrocarbons					
VHw (6-10)	< 100	100	µg/L	2023-10-24	
VPHw	< 100	100	µg/L	N/A	
EPHw10-19	< 250	250	µg/L	2023-10-24	
EPHw19-32	< 250	250	µg/L	2023-10-24	
LEPHw	< 250	250	µg/L	N/A	
HEPHw	< 250	250	µg/L	N/A	
Surrogate: 2-Methylnonane (EPH/F2-4)	65	60-140	%	2023-10-24	
Calculated Parameters					
Hardness, Dissolved (as CaCO3)	564	0.500	mg/L	N/A	
Langelier Index	0.9	-5.0		2023-10-25	CT6
Nitrogen, Organic	0.137	0.0500	mg/L	N/A	
Solids, Total Dissolved	708	10.0	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2023-10-24	
Antimony, dissolved	0.00034	0.00020	mg/L	2023-10-24	
Arsenic, dissolved	0.00132	0.00050	mg/L	2023-10-24	
Barium, dissolved	0.197	0.0050	mg/L	2023-10-24	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2023-10-24	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2023-10-24	
Boron, dissolved	0.0619	0.0500	mg/L	2023-10-24	
Cadmium, dissolved	< 0.000010	0.000010	mg/L	2023-10-24	
Calcium, dissolved	199	0.20	mg/L	2023-10-24	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2023-10-24	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2023-10-24	
Copper, dissolved	< 0.00040	0.00040	mg/L	2023-10-24	
Iron, dissolved	0.158	0.010	mg/L	2023-10-24	
Lead, dissolved	< 0.00020	0.00020	mg/L	2023-10-24	
Lithium, dissolved	0.00386	0.00010	mg/L	2023-10-24	
Magnesium, dissolved	16.1	0.010	mg/L	2023-10-24	
Manganese, dissolved	0.156	0.00020	mg/L	2023-10-24	
Mercury, dissolved	< 0.000010	0.000010	mg/L	2023-10-26	
Molybdenum, dissolved	0.00238	0.00010	mg/L	2023-10-24	
Nickel, dissolved	< 0.00040	0.00040	mg/L	2023-10-24	
Phosphorus, dissolved	0.060	0.050	mg/L	2023-10-24	
Potassium, dissolved	1.73	0.10	mg/L	2023-10-24	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
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WIPN 52992 (23J2279-03) | Matrix: Water | Sampled: 2023-10-18 10:00, Continued

Dissolved Metals, Continued

Selenium, dissolved	< 0.00050	0.00050	mg/L	2023-10-24	
Silicon, dissolved	10.0	1.0	mg/L	2023-10-24	
Silver, dissolved	< 0.000050	0.000050	mg/L	2023-10-24	
Sodium, dissolved	10.9	0.10	mg/L	2023-10-24	
Strontium, dissolved	2.29	0.0010	mg/L	2023-10-24	
Sulfur, dissolved	123	3.0	mg/L	2023-10-24	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2023-10-24	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2023-10-24	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2023-10-24	
Tin, dissolved	< 0.00020	0.00020	mg/L	2023-10-24	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2023-10-24	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2023-10-24	
Uranium, dissolved	0.000259	0.000020	mg/L	2023-10-24	
Vanadium, dissolved	< 0.0050	0.0050	mg/L	2023-10-24	
Zinc, dissolved	0.0046	0.0040	mg/L	2023-10-24	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2023-10-24	

General Parameters

Alkalinity, Total (as CaCO ₃)	206	1.0	mg/L	2023-10-23	
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0	mg/L	2023-10-23	
Alkalinity, Bicarbonate (as CaCO ₃)	206	1.0	mg/L	2023-10-23	
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0	mg/L	2023-10-23	
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0	mg/L	2023-10-23	
Ammonia, Total (as N)	0.282	0.050	mg/L	2023-10-22	
Carbon, Total Organic	4.80	0.50	mg/L	2023-10-29	
Colour, True	< 5.0	5.0	CU	2023-10-20	
Conductivity (EC)	966	2.0	µS/cm	2023-10-23	
Cyanide, Total	0.0024	0.0020	mg/L	2023-10-23	
Nitrogen, Total Kjeldahl	0.419	0.050	mg/L	2023-10-25	
pH	7.96	0.10	pH units	2023-10-23	HT2
Phosphorus, Total (as P)	0.0646	0.0050	mg/L	2023-10-20	
Temperature, at pH	21.9		°C	2023-10-23	HT2
Turbidity	2.76	0.10	NTU	2023-10-21	
UV Transmittance @ 254 nm - Unfiltered	85.0	0.10	% T	2023-10-20	

Microbiological Parameters

Coliforms, Total	< 1	1	CFU/100 mL	2023-10-19	
E. coli	< 1	1	CFU/100 mL	2023-10-19	

Polycyclic Aromatic Hydrocarbons (PAH)

Acenaphthene	< 0.050	0.050	µg/L	2023-10-25	
Acenaphthylene	< 0.200	0.200	µg/L	2023-10-25	
Acridine	< 0.050	0.050	µg/L	2023-10-25	
Anthracene	< 0.010	0.010	µg/L	2023-10-25	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
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WIPN 52992 (23J2279-03) | Matrix: Water | Sampled: 2023-10-18 10:00, Continued

Polycyclic Aromatic Hydrocarbons (PAH), Continued

Benz(a)anthracene	< 0.010	0.010	µg/L	2023-10-25	
Benzo(a)pyrene	< 0.010	0.010	µg/L	2023-10-25	
Benzo(b+j)fluoranthene	< 0.050	0.050	µg/L	2023-10-25	
Benzo(g,h,i)perylene	< 0.050	0.050	µg/L	2023-10-25	
Benzo(k)fluoranthene	< 0.050	0.050	µg/L	2023-10-25	
2-Chloronaphthalene	< 0.100	0.100	µg/L	2023-10-25	
Chrysene	< 0.050	0.050	µg/L	2023-10-25	
Dibenz(a,h)anthracene	< 0.010	0.010	µg/L	2023-10-25	
Fluoranthene	< 0.030	0.030	µg/L	2023-10-25	
Fluorene	< 0.050	0.050	µg/L	2023-10-25	
Indeno(1,2,3-cd)pyrene	< 0.050	0.050	µg/L	2023-10-25	
1-Methylnaphthalene	< 0.100	0.100	µg/L	2023-10-25	
2-Methylnaphthalene	< 0.100	0.100	µg/L	2023-10-25	
Naphthalene	< 0.200	0.200	µg/L	2023-10-25	
Phenanthrene	< 0.100	0.100	µg/L	2023-10-25	
Pyrene	< 0.020	0.020	µg/L	2023-10-25	
Quinoline	< 0.050	0.050	µg/L	2023-10-25	
Surrogate: Acridine-d9	102	50-140	%	2023-10-25	
Surrogate: Naphthalene-d8	85	50-140	%	2023-10-25	
Surrogate: Perylene-d12	80	50-140	%	2023-10-25	

Total Metals

Aluminum, total	0.0073	0.0050	mg/L	2023-10-24	
Antimony, total	0.00040	0.00020	mg/L	2023-10-24	
Arsenic, total	0.00133	0.00050	mg/L	2023-10-24	
Barium, total	0.195	0.0050	mg/L	2023-10-24	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-24	
Boron, total	0.0710	0.0500	mg/L	2023-10-24	
Cadmium, total	< 0.000010	0.000010	mg/L	2023-10-24	
Calcium, total	196	0.20	mg/L	2023-10-24	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Cobalt, total	< 0.00010	0.00010	mg/L	2023-10-24	
Copper, total	0.00157	0.00040	mg/L	2023-10-24	
Iron, total	0.187	0.010	mg/L	2023-10-24	
Lead, total	< 0.00020	0.00020	mg/L	2023-10-24	
Lithium, total	0.00374	0.00010	mg/L	2023-10-24	
Magnesium, total	16.0	0.010	mg/L	2023-10-24	
Manganese, total	0.155	0.00020	mg/L	2023-10-24	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-26	
Molybdenum, total	0.00286	0.00010	mg/L	2023-10-24	
Nickel, total	< 0.00040	0.00040	mg/L	2023-10-24	
Phosphorus, total	0.072	0.050	mg/L	2023-10-24	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL	Units	Analyzed	Qualifier
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WIPN 52992 (23J2279-03) | Matrix: Water | Sampled: 2023-10-18 10:00, Continued

Total Metals, Continued

Potassium, total	1.66	0.10	mg/L	2023-10-24	
Selenium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Silicon, total	9.9	1.0	mg/L	2023-10-24	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-24	
Sodium, total	10.8	0.10	mg/L	2023-10-24	
Strontium, total	2.22	0.0010	mg/L	2023-10-24	
Sulfur, total	121	3.0	mg/L	2023-10-24	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-24	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-24	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-24	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-24	
Titanium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-24	
Uranium, total	0.000335	0.000020	mg/L	2023-10-24	
Vanadium, total	< 0.0050	0.0050	mg/L	2023-10-24	
Zinc, total	0.0048	0.0040	mg/L	2023-10-24	
Zirconium, total	< 0.00010	0.00010	mg/L	2023-10-24	

Volatile Organic Compounds (VOC)

Benzene	< 0.5	0.5	µg/L	2023-10-24	
Bromodichloromethane	< 1.0	1.0	µg/L	2023-10-24	
Bromoform	< 1.0	1.0	µg/L	2023-10-24	
Carbon tetrachloride	< 0.5	0.5	µg/L	2023-10-24	
Chlorobenzene	< 1.0	1.0	µg/L	2023-10-24	
Chloroethane	< 2.0	2.0	µg/L	2023-10-24	
Chloroform	< 1.0	1.0	µg/L	2023-10-24	
Dibromochloromethane	< 1.0	1.0	µg/L	2023-10-24	
1,2-Dibromoethane	< 0.3	0.3	µg/L	2023-10-24	
Dibromomethane	< 1.0	1.0	µg/L	2023-10-24	
1,2-Dichlorobenzene	< 0.5	0.5	µg/L	2023-10-24	
1,3-Dichlorobenzene	< 1.0	1.0	µg/L	2023-10-24	
1,4-Dichlorobenzene	< 1.0	1.0	µg/L	2023-10-24	
1,1-Dichloroethane	< 1.0	1.0	µg/L	2023-10-24	
1,2-Dichloroethane	< 1.0	1.0	µg/L	2023-10-24	
1,1-Dichloroethylene	< 1.0	1.0	µg/L	2023-10-24	
cis-1,2-Dichloroethylene	< 1.0	1.0	µg/L	2023-10-24	
trans-1,2-Dichloroethylene	< 1.0	1.0	µg/L	2023-10-24	
Dichloromethane	< 3.0	3.0	µg/L	2023-10-24	
1,2-Dichloropropane	< 1.0	1.0	µg/L	2023-10-24	
1,3-Dichloropropene (cis + trans)	< 1.0	1.0	µg/L	2023-10-24	
Ethylbenzene	< 1.0	1.0	µg/L	2023-10-24	
Methyl tert-butyl ether	< 1.0	1.0	µg/L	2023-10-24	
Styrene	< 1.0	1.0	µg/L	2023-10-24	

TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (23J2279-03) Matrix: Water Sampled: 2023-10-18 10:00, Continued					
<i>Volatile Organic Compounds (VOC), Continued</i>					
1,1,2,2-Tetrachloroethane	< 0.5	0.5	µg/L	2023-10-24	
Tetrachloroethylene	< 1.0	1.0	µg/L	2023-10-24	
Toluene	< 1.0	1.0	µg/L	2023-10-24	
1,1,1-Trichloroethane	< 1.0	1.0	µg/L	2023-10-24	
1,1,2-Trichloroethane	< 1.0	1.0	µg/L	2023-10-24	
Trichloroethylene	< 1.0	1.0	µg/L	2023-10-24	
Trichlorofluoromethane	< 1.0	1.0	µg/L	2023-10-24	
Vinyl chloride	< 1.0	1.0	µg/L	2023-10-24	
Xylenes (total)	< 2.0	2.0	µg/L	2023-10-24	
Surrogate: Toluene-d8	113	70-130	%	2023-10-24	
Surrogate: 4-Bromofluorobenzene	112	70-130	%	2023-10-24	
Surrogate: 1,4-Dichlorobenzene-d4	114	70-130	%	2023-10-24	

Sample Qualifiers:

CT6 Results were based on lab temperature & lab pH.
 HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.
 RA1 The Reporting Limit for this sample has been raised due to matrix interference.

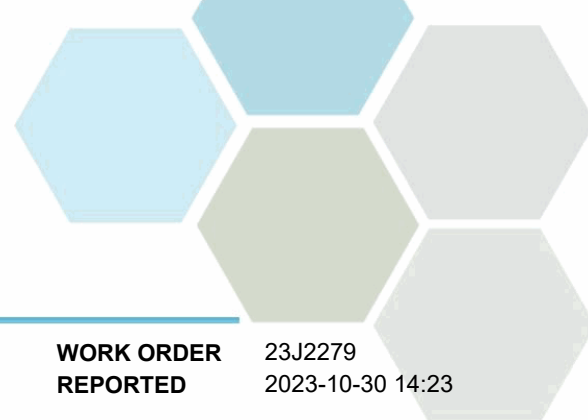
APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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Analysis Description	Method Ref.	Technique	Accredited	Location
Alkalinity in Water	SM 2320 B* (2021)	Titration with H ₂ SO ₄	✓	Kelowna
Ammonia, Total in Water	SM 4500-NH ₃ G* (2021)	Automated Colorimetry (Phenate)	✓	Kelowna
Anions in Water	SM 4110 B (2020)	Ion Chromatography	✓	Kelowna
Carbon, Total Organic in Water	SM 5310 B (2022)	Combustion, Infrared CO ₂ Detection	✓	Kelowna
Coliforms, Total in Water	SM 9222* (2015)	Membrane Filtration / Chromocult Agar	✓	Kelowna
Colour, True in Water	SM 2120 C (2021)	Spectrophotometry (456 nm)	✓	Kelowna
Conductivity in Water	SM 2510 B (2021)	Conductivity Meter	✓	Kelowna
Cyanide, SAD in Water	ASTM D7511-12	Flow Injection with In-Line UV Digestion and Amperometry	✓	Kelowna
Dissolved Metals in Water	EPA 200.8 / EPA 6020B	0.45 µm Filtration / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond
E. coli in Water	SM 9222* (2015)	Membrane Filtration / Chromocult Agar	✓	Kelowna
EPH in Water	EPA 3511* / BCMOE EPHw	Hexane MicroExtraction (Base/Neutral) / Gas Chromatography (GC-FID)	✓	Richmond
Hardness in Water	SM 2340 B (2021)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	✓	N/A
HEPHw in Water	BCMOE LEPH/HEPH	Calculation		N/A
Langelier Index in Water	SM 2330 B (2021)	Calculation		N/A
LEPHw in Water	BCMOE LEPH/HEPH	Calculation		N/A
Mercury, dissolved in Water	EPA 245.7*	BrCl ₂ Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Mercury, total in Water	EPA 245.7*	BrCl ₂ Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Nitrogen, Total Kjeldahl in Water	SM 4500-Norg D* (2021)	Block Digestion and Flow Injection Analysis	✓	Kelowna
pH in Water	SM 4500-H+ B (2021)	Electrometry	✓	Kelowna
Phosphorus, Total in Water	SM 4500-P B.5* (2011) / SM 4500-P F (2021)	Persulfate Digestion / Automated Colorimetry (Ascorbic Acid)	✓	Kelowna
Polycyclic Aromatic Hydrocarbons in Water	EPA 3511* / EPA 8270D	Hexane MicroExtraction (Base/Neutral) / GC-MSD (SIM)	✓	Richmond
Solids, Total Dissolved in Water	SM 1030 E (2021)	SM 1030 E		N/A
Total Metals in Water	EPA 200.2 / EPA 6020B	HNO ₃ +HCl Hot Block Digestion / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond
Transmittance at 254 nm - Unfiltered in Water	SM 5910 B* (2021)	Ultraviolet Absorption	✓	Kelowna
Turbidity in Water	SM 2130 B (2020)	Nephelometry	✓	Kelowna
VH in Water	EPA 5030B / BCMOE VHw	Purge&Trap / Gas Chromatography (GC-FID)	✓	Richmond
Volatile Organic Compounds in Water	EPA 5030B / EPA 8260D	Purge&Trap / GC-MSD (SIM)	✓	Richmond
VPHw in Water	BCMOE VPH	Calculation: VH - (Benzene + Toluene + Ethylbenzene + Xylenes + Styrene)		N/A

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method



APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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Glossary of Terms:

RL	Reporting Limit (default)
% T	Percent Transmittance
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
°C	Degrees Celcius
CFU/100 mL	Colony Forming Units per 100 millilitres
CU	Colour Units (referenced against a platinum cobalt standard)
mg/L	Milligrams per litre
NTU	Nephelometric Turbidity Units
pH units	pH < 7 = acidic, pH > 7 = basic
µg/L	Micrograms per litre
µS/cm	Microsiemens per centimetre
ASTM	ASTM International Test Methods
BCMOE	British Columbia Environmental Laboratory Manual, British Columbia Ministry of Environment
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Caro will dispose of all samples within 30 days of sample receipt, unless otherwise agreed.

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APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk):** A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup):** An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS):** A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS):** A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM):** A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Anions, Batch B3J1927

Blank (B3J1927-BLK1)			Prepared: 2023-10-21, Analyzed: 2023-10-21						
Chloride	< 0.10	0.10 mg/L							
Fluoride	< 0.05	0.05 mg/L							
Nitrate (as N)	< 0.010	0.010 mg/L							
Nitrite (as N)	< 0.010	0.010 mg/L							
Sulfate	< 0.5	0.5 mg/L							

LCS (B3J1927-BS1)			Prepared: 2023-10-21, Analyzed: 2023-10-21						
Chloride	16.2	0.10 mg/L	16.0		101	90-110			
Fluoride	4.10	0.05 mg/L	4.00		102	88-108			
Nitrate (as N)	3.93	0.010 mg/L	4.00		98	90-110			
Nitrite (as N)	2.08	0.010 mg/L	2.00		104	85-115			
Sulfate	16.2	0.5 mg/L	16.0		101	90-110			

BCMOE Aggregate Hydrocarbons, Batch B3J2324

Blank (B3J2324-BLK1)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
EPHw10-19	< 250	250 µg/L							
EPHw19-32	< 250	250 µg/L							
Surrogate: 2-Methylnonane (EPH/F2-4)	1420	µg/L	2200		65	60-140			

LCS (B3J2324-BS2)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
EPHw10-19	16400	250 µg/L	15400		107	70-130			
EPHw19-32	21000	250 µg/L	22200		95	70-130			
Surrogate: 2-Methylnonane (EPH/F2-4)	1410	µg/L	2200		64	60-140			

LCS Dup (B3J2324-BSD2)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
EPHw10-19	16900	250 µg/L	15400		110	70-130	3	20	
EPHw19-32	21800	250 µg/L	22200		98	70-130	4	20	
Surrogate: 2-Methylnonane (EPH/F2-4)	1370	µg/L	2200		62	60-140			

BCMOE Aggregate Hydrocarbons, Batch B3J2379

Blank (B3J2379-BLK1)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
VHw (6-10)	< 100	100 µg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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BCMOE Aggregate Hydrocarbons, Batch B3J2379, Continued

LCS (B3J2379-BS2)

Prepared: 2023-10-24, Analyzed: 2023-10-24

VHw (6-10)	1910	100 µg/L	2190	87	70-130				
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Dissolved Metals, Batch B3J2295

Blank (B3J2295-BLK1)

Prepared: 2023-10-24, Analyzed: 2023-10-24

Aluminum, dissolved	< 0.0050	0.0050 mg/L							
Antimony, dissolved	< 0.00020	0.00020 mg/L							
Arsenic, dissolved	< 0.00050	0.00050 mg/L							
Barium, dissolved	< 0.0050	0.0050 mg/L							
Beryllium, dissolved	< 0.00010	0.00010 mg/L							
Bismuth, dissolved	< 0.00010	0.00010 mg/L							
Boron, dissolved	< 0.0500	0.0500 mg/L							
Cadmium, dissolved	< 0.000010	0.000010 mg/L							
Calcium, dissolved	< 0.20	0.20 mg/L							
Chromium, dissolved	< 0.00050	0.00050 mg/L							
Cobalt, dissolved	< 0.00010	0.00010 mg/L							
Copper, dissolved	< 0.00040	0.00040 mg/L							
Iron, dissolved	< 0.010	0.010 mg/L							
Lead, dissolved	< 0.00020	0.00020 mg/L							
Lithium, dissolved	< 0.00010	0.00010 mg/L							
Magnesium, dissolved	< 0.010	0.010 mg/L							
Manganese, dissolved	< 0.00020	0.00020 mg/L							
Molybdenum, dissolved	< 0.00010	0.00010 mg/L							
Nickel, dissolved	< 0.00040	0.00040 mg/L							
Phosphorus, dissolved	< 0.050	0.050 mg/L							
Potassium, dissolved	< 0.10	0.10 mg/L							
Selenium, dissolved	< 0.00050	0.00050 mg/L							
Silicon, dissolved	< 1.0	1.0 mg/L							
Silver, dissolved	< 0.000050	0.000050 mg/L							
Sodium, dissolved	< 0.10	0.10 mg/L							
Strontium, dissolved	< 0.0010	0.0010 mg/L							
Sulfur, dissolved	< 3.0	3.0 mg/L							
Tellurium, dissolved	< 0.00050	0.00050 mg/L							
Thallium, dissolved	< 0.000020	0.000020 mg/L							
Thorium, dissolved	< 0.00010	0.00010 mg/L							
Tin, dissolved	< 0.00020	0.00020 mg/L							
Titanium, dissolved	< 0.0050	0.0050 mg/L							
Tungsten, dissolved	< 0.0010	0.0010 mg/L							
Uranium, dissolved	< 0.000020	0.000020 mg/L							
Vanadium, dissolved	< 0.0050	0.0050 mg/L							
Zinc, dissolved	< 0.0040	0.0040 mg/L							
Zirconium, dissolved	< 0.00010	0.00010 mg/L							

LCS (B3J2295-BS1)

Prepared: 2023-10-24, Analyzed: 2023-10-24

Aluminum, dissolved	3.97	0.0050 mg/L	4.00	99	80-120				
Antimony, dissolved	0.0404	0.00020 mg/L	0.0400	101	80-120				
Arsenic, dissolved	0.402	0.00050 mg/L	0.400	100	80-120				
Barium, dissolved	0.0397	0.0050 mg/L	0.0400	99	80-120				
Beryllium, dissolved	0.0401	0.00010 mg/L	0.0400	100	80-120				
Bismuth, dissolved	0.0411	0.00010 mg/L	0.0400	103	80-120				
Boron, dissolved	0.397	0.0500 mg/L	0.400	99	80-120				
Cadmium, dissolved	0.0396	0.000010 mg/L	0.0400	99	80-120				
Calcium, dissolved	3.97	0.20 mg/L	4.00	99	80-120				
Chromium, dissolved	0.0401	0.00050 mg/L	0.0400	100	80-120				
Cobalt, dissolved	0.0400	0.00010 mg/L	0.0400	100	80-120				
Copper, dissolved	0.0407	0.00040 mg/L	0.0400	102	80-120				

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B3J2295, Continued									
LCS (B3J2295-BS1), Continued				Prepared: 2023-10-24, Analyzed: 2023-10-24					
Iron, dissolved	4.09	0.010 mg/L	4.00		102	80-120			
Lead, dissolved	0.0409	0.00020 mg/L	0.0400		102	80-120			
Lithium, dissolved	0.0403	0.00010 mg/L	0.0400		101	80-120			
Magnesium, dissolved	4.09	0.010 mg/L	4.00		102	80-120			
Manganese, dissolved	0.0400	0.00020 mg/L	0.0400		100	80-120			
Molybdenum, dissolved	0.0387	0.00010 mg/L	0.0400		97	80-120			
Nickel, dissolved	0.0399	0.00040 mg/L	0.0400		100	80-120			
Phosphorus, dissolved	3.93	0.050 mg/L	4.00		98	80-120			
Potassium, dissolved	4.01	0.10 mg/L	4.00		100	80-120			
Selenium, dissolved	0.405	0.00050 mg/L	0.400		101	80-120			
Silicon, dissolved	4.2	1.0 mg/L	4.00		105	80-120			
Silver, dissolved	0.0398	0.000050 mg/L	0.0400		99	80-120			
Sodium, dissolved	4.06	0.10 mg/L	4.00		101	80-120			
Strontium, dissolved	0.0404	0.0010 mg/L	0.0400		101	80-120			
Sulfur, dissolved	39.3	3.0 mg/L	40.0		98	80-120			
Tellurium, dissolved	0.0399	0.00050 mg/L	0.0400		100	80-120			
Thallium, dissolved	0.0404	0.000020 mg/L	0.0400		101	80-120			
Thorium, dissolved	0.0396	0.00010 mg/L	0.0400		99	80-120			
Tin, dissolved	0.0402	0.00020 mg/L	0.0400		101	80-120			
Titanium, dissolved	0.0432	0.0050 mg/L	0.0400		108	80-120			
Tungsten, dissolved	0.0417	0.0010 mg/L	0.0400		104	80-120			
Uranium, dissolved	0.0417	0.000020 mg/L	0.0400		104	80-120			
Vanadium, dissolved	0.0399	0.0050 mg/L	0.0400		100	80-120			
Zinc, dissolved	0.401	0.0040 mg/L	0.400		100	80-120			
Zirconium, dissolved	0.0403	0.00010 mg/L	0.0400		101	80-120			
Duplicate (B3J2295-DUP1)				Source: 23J2279-03 Prepared: 2023-10-24, Analyzed: 2023-10-24					
Aluminum, dissolved	< 0.0050	0.0050 mg/L	< 0.0050					20	
Antimony, dissolved	0.00034	0.00020 mg/L	0.00034					20	
Arsenic, dissolved	0.00138	0.00050 mg/L	0.00132					20	
Barium, dissolved	0.199	0.0050 mg/L	0.197				< 1	20	
Beryllium, dissolved	< 0.00010	0.00010 mg/L	< 0.00010					20	
Bismuth, dissolved	< 0.00010	0.00010 mg/L	< 0.00010					20	
Boron, dissolved	0.0619	0.0500 mg/L	0.0619					20	
Cadmium, dissolved	< 0.000010	0.000010 mg/L	< 0.000010					20	
Calcium, dissolved	199	0.20 mg/L	199				< 1	20	
Chromium, dissolved	< 0.00050	0.00050 mg/L	< 0.00050					20	
Cobalt, dissolved	< 0.00010	0.00010 mg/L	< 0.00010					20	
Copper, dissolved	< 0.00040	0.00040 mg/L	< 0.00040					20	
Iron, dissolved	0.158	0.010 mg/L	0.158				< 1	20	
Lead, dissolved	< 0.00020	0.00020 mg/L	< 0.00020					20	
Lithium, dissolved	0.00382	0.00010 mg/L	0.00386				1	20	
Magnesium, dissolved	16.2	0.010 mg/L	16.1				< 1	20	
Manganese, dissolved	0.157	0.00020 mg/L	0.156				< 1	20	
Molybdenum, dissolved	0.00233	0.00010 mg/L	0.00238				2	20	
Nickel, dissolved	< 0.00040	0.00040 mg/L	< 0.00040					20	
Phosphorus, dissolved	0.068	0.050 mg/L	0.060					20	
Potassium, dissolved	1.75	0.10 mg/L	1.73				< 1	20	
Selenium, dissolved	< 0.00050	0.00050 mg/L	< 0.00050					20	
Silicon, dissolved	9.8	1.0 mg/L	10.0				3	20	
Silver, dissolved	< 0.000050	0.000050 mg/L	< 0.000050					20	
Sodium, dissolved	10.9	0.10 mg/L	10.9				< 1	20	
Strontium, dissolved	2.29	0.0010 mg/L	2.29				< 1	20	
Sulfur, dissolved	120	3.0 mg/L	123				3	20	
Tellurium, dissolved	< 0.00050	0.00050 mg/L	< 0.00050					20	
Thallium, dissolved	< 0.000020	0.000020 mg/L	< 0.000020					20	

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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WORK ORDER REPORTED 23J2279
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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B3J2295, Continued									
Duplicate (B3J2295-DUP1), Continued		Source: 23J2279-03		Prepared: 2023-10-24, Analyzed: 2023-10-24					
Thorium, dissolved	< 0.00010	0.00010 mg/L		< 0.00010				20	
Tin, dissolved	< 0.00020	0.00020 mg/L		< 0.00020				20	
Titanium, dissolved	< 0.0050	0.0050 mg/L		< 0.0050				20	
Tungsten, dissolved	< 0.0010	0.0010 mg/L		< 0.0010				20	
Uranium, dissolved	0.000265	0.000020 mg/L		0.000259			2	20	
Vanadium, dissolved	< 0.0050	0.0050 mg/L		< 0.0050				20	
Zinc, dissolved	0.0045	0.0040 mg/L		0.0046				20	
Zirconium, dissolved	< 0.00010	0.00010 mg/L		< 0.00010				20	

Dissolved Metals, Batch B3J2574

Blank (B3J2574-BLK1)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	< 0.000010	0.000010 mg/L							
Blank (B3J2574-BLK2)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	< 0.000010	0.000010 mg/L							
Blank (B3J2574-BLK3)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	< 0.000010	0.000010 mg/L							
Blank (B3J2574-BLK4)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	< 0.000010	0.000010 mg/L							
LCS (B3J2574-BS1)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	0.000237	0.000010 mg/L		0.000250	95	80-120			
LCS (B3J2574-BS2)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	0.000232	0.000010 mg/L		0.000250	93	80-120			
LCS (B3J2574-BS3)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	0.000223	0.000010 mg/L		0.000250	89	80-120			
LCS (B3J2574-BS4)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, dissolved	0.000229	0.000010 mg/L		0.000250	92	80-120			
Duplicate (B3J2574-DUP2)		Source: 23J2279-03		Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, dissolved	< 0.000010	0.000010 mg/L		< 0.000010				20	

General Parameters, Batch B3J1782

Blank (B3J1782-BLK1)		Prepared: 2023-10-29, Analyzed: 2023-10-30							
Carbon, Total Organic	< 0.50	0.50 mg/L							
Blank (B3J1782-BLK2)		Prepared: 2023-10-29, Analyzed: 2023-10-30							
Carbon, Total Organic	< 0.50	0.50 mg/L							
LCS (B3J1782-BS1)		Prepared: 2023-10-29, Analyzed: 2023-10-30							
Carbon, Total Organic	8.82	0.50 mg/L		10.0	88	78-116			
LCS (B3J1782-BS2)		Prepared: 2023-10-29, Analyzed: 2023-10-29							
Carbon, Total Organic	9.56	0.50 mg/L		10.0	96	78-116			

General Parameters, Batch B3J1933

Blank (B3J1933-BLK1)		Prepared: 2023-10-19, Analyzed: 2023-10-20							
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3J1933, Continued									
Blank (B3J1933-BLK2)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
Blank (B3J1933-BLK3)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
Blank (B3J1933-BLK4)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	< 0.0050	0.0050 mg/L							
LCS (B3J1933-BS1)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	0.103	0.0050 mg/L	0.100		103	85-115			
LCS (B3J1933-BS2)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	0.104	0.0050 mg/L	0.100		104	85-115			
LCS (B3J1933-BS3)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	0.105	0.0050 mg/L	0.100		105	85-115			
LCS (B3J1933-BS4)				Prepared: 2023-10-19, Analyzed: 2023-10-20					
Phosphorus, Total (as P)	0.104	0.0050 mg/L	0.100		104	85-115			
General Parameters, Batch B3J1941									
Blank (B3J1941-BLK1)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
Colour, True	< 5.0	5.0 CU							
Blank (B3J1941-BLK2)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
Colour, True	< 5.0	5.0 CU							
LCS (B3J1941-BS1)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
Colour, True	21	5.0 CU	20.0		107	85-115			
LCS (B3J1941-BS2)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
Colour, True	20	5.0 CU	20.0		101	85-115			
General Parameters, Batch B3J2077									
Blank (B3J2077-BLK1)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	< 0.10	0.10 NTU							
Blank (B3J2077-BLK2)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	< 0.10	0.10 NTU							
Blank (B3J2077-BLK3)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	< 0.10	0.10 NTU							
LCS (B3J2077-BS1)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	1.75	0.10 NTU	1.69		104	90-110			
LCS (B3J2077-BS2)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	15.3	0.10 NTU	14.6		105	90-110			
LCS (B3J2077-BS3)				Prepared: 2023-10-21, Analyzed: 2023-10-21					
Turbidity	146	0.10 NTU	140		104	90-110			

General Parameters, Batch B3J2119

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3J2119, Continued									
Blank (B3J2119-BLK1)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3J2119-BLK2)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3J2119-BLK3)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3J2119-BLK4)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3J2119-BLK5)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
Blank (B3J2119-BLK6)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	< 0.050	0.050 mg/L							
LCS (B3J2119-BS1)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.959	0.050 mg/L	1.00		96	85-115			
LCS (B3J2119-BS2)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.932	0.050 mg/L	1.00		93	85-115			
LCS (B3J2119-BS3)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.944	0.050 mg/L	1.00		94	85-115			
LCS (B3J2119-BS4)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.957	0.050 mg/L	1.00		96	85-115			
LCS (B3J2119-BS5)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.921	0.050 mg/L	1.00		92	85-115			
LCS (B3J2119-BS6)				Prepared: 2023-10-22, Analyzed: 2023-10-22					
Ammonia, Total (as N)	0.924	0.050 mg/L	1.00		92	85-115			

General Parameters, Batch B3J2159

Blank (B3J2159-BLK1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	< 0.0020	0.0020 mg/L							
Blank (B3J2159-BLK2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	< 0.0020	0.0020 mg/L							
LCS (B3J2159-BS1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	0.0194	0.0020 mg/L	0.0200		97	82-120			
LCS (B3J2159-BS2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	0.0195	0.0020 mg/L	0.0200		98	82-120			
LCS Dup (B3J2159-BSD1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	0.0178	0.0020 mg/L	0.0200		89	82-120	9	10	
LCS Dup (B3J2159-BSD2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Cyanide, Total	0.0180	0.0020 mg/L	0.0200		90	82-120	8	10	

General Parameters, Batch B3J2186

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3J2186, Continued									
Blank (B3J2186-BLK1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Bicarbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0 mg/L							
Conductivity (EC)	< 2.0	2.0 µS/cm							
Temperature, at pH	21.7	°C							
Blank (B3J2186-BLK2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Bicarbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0 mg/L							
Conductivity (EC)	< 2.0	2.0 µS/cm							
Temperature, at pH	22.4	°C							
Blank (B3J2186-BLK3)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Phenolphthalein (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Bicarbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Carbonate (as CaCO ₃)	< 1.0	1.0 mg/L							
Alkalinity, Hydroxide (as CaCO ₃)	< 1.0	1.0 mg/L							
Conductivity (EC)	< 2.0	2.0 µS/cm							
Temperature, at pH	22.7	°C							
LCS (B3J2186-BS1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	97.3	1.0 mg/L	100		97	80-120			
Alkalinity, Phenolphthalein (as CaCO ₃)	15.6	1.0 mg/L	50.0		31	0-200			
LCS (B3J2186-BS2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	103	1.0 mg/L	100		103	80-120			
Alkalinity, Phenolphthalein (as CaCO ₃)	12.4	1.0 mg/L	50.0		25	0-200			
LCS (B3J2186-BS3)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Alkalinity, Total (as CaCO ₃)	98.3	1.0 mg/L	100		98	80-120			
Alkalinity, Phenolphthalein (as CaCO ₃)	50.5	1.0 mg/L	50.0		101	0-200			
LCS (B3J2186-BS4)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Conductivity (EC)	1400	2.0 µS/cm	1410		100	95-105			
LCS (B3J2186-BS5)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Conductivity (EC)	1410	2.0 µS/cm	1410		100	95-105			
LCS (B3J2186-BS6)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
Conductivity (EC)	1410	2.0 µS/cm	1410		100	95-105			
Reference (B3J2186-SRM1)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
pH	7.01	0.10 pH units	7.01		100	98-102			
Reference (B3J2186-SRM2)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
pH	7.01	0.10 pH units	7.01		100	98-102			
Reference (B3J2186-SRM3)				Prepared: 2023-10-23, Analyzed: 2023-10-23					
pH	7.01	0.10 pH units	7.01		100	98-102			

General Parameters, Batch B3J2314

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B3J2314, Continued									
Blank (B3J2314-BLK1)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
UV Transmittance @ 254 nm - Unfiltered	< 0.10	0.10 % T							
LCS (B3J2314-BS1)				Prepared: 2023-10-20, Analyzed: 2023-10-20					
UV Transmittance @ 254 nm - Unfiltered	34.9	0.10 % T	36.1		97	95-105			
General Parameters, Batch B3J2358									
Blank (B3J2358-BLK1)				Prepared: 2023-10-24, Analyzed: 2023-10-25					
Nitrogen, Total Kjeldahl	< 0.050	0.050 mg/L							
Blank (B3J2358-BLK2)				Prepared: 2023-10-24, Analyzed: 2023-10-25					
Nitrogen, Total Kjeldahl	< 0.050	0.050 mg/L							
LCS (B3J2358-BS1)				Prepared: 2023-10-24, Analyzed: 2023-10-25					
Nitrogen, Total Kjeldahl	0.981	0.050 mg/L	1.00		98	85-115			
LCS (B3J2358-BS2)				Prepared: 2023-10-24, Analyzed: 2023-10-25					
Nitrogen, Total Kjeldahl	0.991	0.050 mg/L	1.00		99	85-115			
Microbiological Parameters, Batch B3J1859									
Blank (B3J1859-BLK1)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK2)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK3)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK4)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK5)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK6)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK7)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK8)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							
Blank (B3J1859-BLK9)				Prepared: 2023-10-19, Analyzed: 2023-10-19					
Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Microbiological Parameters, Batch B3J1859, Continued

Blank (B3J1859-BLKA)

Prepared: 2023-10-19, Analyzed: 2023-10-19

Coliforms, Total	< 1	1 CFU/100 mL							
E. coli	< 1	1 CFU/100 mL							

Polycyclic Aromatic Hydrocarbons (PAH), Batch B3J2324

Blank (B3J2324-BLK1)

Prepared: 2023-10-24, Analyzed: 2023-10-24

Acenaphthene	< 0.050	0.050 µg/L							
Acenaphthylene	< 0.200	0.200 µg/L							
Acridine	< 0.050	0.050 µg/L							
Anthracene	< 0.010	0.010 µg/L							
Benz(a)anthracene	< 0.010	0.010 µg/L							
Benzo(a)pyrene	< 0.010	0.010 µg/L							
Benzo(b+j)fluoranthene	< 0.050	0.050 µg/L							
Benzo(g,h,i)perylene	< 0.050	0.050 µg/L							
Benzo(k)fluoranthene	< 0.050	0.050 µg/L							
2-Chloronaphthalene	< 0.100	0.100 µg/L							
Chrysene	< 0.050	0.050 µg/L							
Dibenz(a,h)anthracene	< 0.010	0.010 µg/L							
Fluoranthene	< 0.030	0.030 µg/L							
Fluorene	< 0.050	0.050 µg/L							
Indeno(1,2,3-cd)pyrene	< 0.050	0.050 µg/L							
1-Methylnaphthalene	< 0.100	0.100 µg/L							
2-Methylnaphthalene	< 0.100	0.100 µg/L							
Naphthalene	< 0.200	0.200 µg/L							
Phenanthrene	< 0.100	0.100 µg/L							
Pyrene	< 0.020	0.020 µg/L							
Quinoline	< 0.050	0.050 µg/L							
Surrogate: Acridine-d9	0.987	µg/L	0.898		110	50-140			
Surrogate: Naphthalene-d8	19.0	µg/L	22.2		85	50-140			
Surrogate: Perylene-d12	17.5	µg/L	22.2		79	50-140			

LCS (B3J2324-BS1)

Prepared: 2023-10-24, Analyzed: 2023-10-25

Acenaphthene	15.3	0.050 µg/L	22.1		69	50-140			
Acenaphthylene	16.2	0.200 µg/L	21.9		74	50-140			
Acridine	16.4	0.050 µg/L	22.0		74	50-140			
Anthracene	19.2	0.010 µg/L	22.1		87	50-140			
Benz(a)anthracene	16.0	0.010 µg/L	22.1		73	50-140			
Benzo(a)pyrene	16.4	0.010 µg/L	21.9		75	50-140			
Benzo(b+j)fluoranthene	37.5	0.050 µg/L	43.8		86	50-140			
Benzo(g,h,i)perylene	18.8	0.050 µg/L	21.9		86	50-140			
Benzo(k)fluoranthene	13.0	0.050 µg/L	22.0		59	50-140			
2-Chloronaphthalene	16.1	0.100 µg/L	21.9		74	50-140			
Chrysene	17.5	0.050 µg/L	21.8		80	50-140			
Dibenz(a,h)anthracene	18.8	0.010 µg/L	22.2		84	50-140			
Fluoranthene	20.8	0.030 µg/L	22.2		94	50-140			
Fluorene	17.2	0.050 µg/L	22.7		76	50-140			
Indeno(1,2,3-cd)pyrene	16.1	0.050 µg/L	21.9		73	50-140			
1-Methylnaphthalene	19.3	0.100 µg/L	22.0		88	50-140			
2-Methylnaphthalene	18.0	0.100 µg/L	22.0		82	50-140			
Naphthalene	19.2	0.200 µg/L	22.0		87	50-140			
Phenanthrene	17.7	0.100 µg/L	21.9		81	50-140			
Pyrene	20.7	0.020 µg/L	22.2		93	50-140			
Quinoline	298	0.050 µg/L	22.2		NR	50-140			SPK1
Surrogate: Acridine-d9	0.743	µg/L	0.898		83	50-140			
Surrogate: Naphthalene-d8	20.4	µg/L	22.2		92	50-140			
Surrogate: Perylene-d12	18.5	µg/L	22.2		83	50-140			

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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Polycyclic Aromatic Hydrocarbons (PAH), Batch B3J2324, Continued

Total Metals, Batch B3J2351

Blank (B3J2351-BLK1)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
Aluminum, total	< 0.0050	0.0050 mg/L							
Antimony, total	< 0.00020	0.00020 mg/L							
Arsenic, total	< 0.00050	0.00050 mg/L							
Barium, total	< 0.0050	0.0050 mg/L							
Beryllium, total	< 0.00010	0.00010 mg/L							
Bismuth, total	< 0.00010	0.00010 mg/L							
Boron, total	< 0.0500	0.0500 mg/L							
Cadmium, total	< 0.000010	0.000010 mg/L							
Calcium, total	< 0.20	0.20 mg/L							
Chromium, total	< 0.00050	0.00050 mg/L							
Cobalt, total	< 0.00010	0.00010 mg/L							
Copper, total	< 0.00040	0.00040 mg/L							
Iron, total	< 0.010	0.010 mg/L							
Lead, total	< 0.00020	0.00020 mg/L							
Lithium, total	< 0.00010	0.00010 mg/L							
Magnesium, total	< 0.010	0.010 mg/L							
Manganese, total	< 0.00020	0.00020 mg/L							
Molybdenum, total	< 0.00010	0.00010 mg/L							
Nickel, total	< 0.00040	0.00040 mg/L							
Phosphorus, total	< 0.050	0.050 mg/L							
Potassium, total	< 0.10	0.10 mg/L							
Selenium, total	< 0.00050	0.00050 mg/L							
Silicon, total	< 1.0	1.0 mg/L							
Silver, total	< 0.000050	0.000050 mg/L							
Sodium, total	< 0.10	0.10 mg/L							
Strontium, total	< 0.0010	0.0010 mg/L							
Sulfur, total	< 3.0	3.0 mg/L							
Tellurium, total	< 0.00050	0.00050 mg/L							
Thallium, total	< 0.000020	0.000020 mg/L							
Thorium, total	< 0.00010	0.00010 mg/L							
Tin, total	< 0.00020	0.00020 mg/L							
Titanium, total	< 0.0050	0.0050 mg/L							
Tungsten, total	< 0.0010	0.0010 mg/L							
Uranium, total	< 0.000020	0.000020 mg/L							
Vanadium, total	< 0.0050	0.0050 mg/L							
Zinc, total	< 0.0040	0.0040 mg/L							
Zirconium, total	< 0.00010	0.00010 mg/L							

LCS (B3J2351-BS1)			Prepared: 2023-10-24, Analyzed: 2023-10-24						
Aluminum, total	4.04	0.0050 mg/L	4.00	101	80-120				
Antimony, total	0.0410	0.00020 mg/L	0.0400	103	80-120				
Arsenic, total	0.401	0.00050 mg/L	0.400	100	80-120				
Barium, total	0.0413	0.0050 mg/L	0.0400	103	80-120				
Beryllium, total	0.0395	0.00010 mg/L	0.0400	99	80-120				
Bismuth, total	0.0401	0.00010 mg/L	0.0400	100	80-120				
Boron, total	0.397	0.0500 mg/L	0.400	99	80-120				
Cadmium, total	0.0404	0.000010 mg/L	0.0400	101	80-120				
Calcium, total	4.06	0.20 mg/L	4.00	102	80-120				
Chromium, total	0.0402	0.00050 mg/L	0.0400	101	80-120				
Cobalt, total	0.0408	0.00010 mg/L	0.0400	102	80-120				
Copper, total	0.0408	0.00040 mg/L	0.0400	102	80-120				
Iron, total	3.99	0.010 mg/L	4.00	100	80-120				
Lead, total	0.0405	0.00020 mg/L	0.0400	101	80-120				
Lithium, total	0.0392	0.00010 mg/L	0.0400	98	80-120				

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3J2351, Continued									
LCS (B3J2351-BS1), Continued				Prepared: 2023-10-24, Analyzed: 2023-10-24					
Magnesium, total	4.12	0.010 mg/L	4.00		103	80-120			
Manganese, total	0.0411	0.00020 mg/L	0.0400		103	80-120			
Molybdenum, total	0.0395	0.00010 mg/L	0.0400		99	80-120			
Nickel, total	0.0394	0.00040 mg/L	0.0400		98	80-120			
Phosphorus, total	4.04	0.050 mg/L	4.00		101	80-120			
Potassium, total	4.05	0.10 mg/L	4.00		101	80-120			
Selenium, total	0.409	0.00050 mg/L	0.400		102	80-120			
Silicon, total	4.4	1.0 mg/L	4.00		109	80-120			
Silver, total	0.0404	0.000050 mg/L	0.0400		101	80-120			
Sodium, total	3.93	0.10 mg/L	4.00		98	80-120			
Strontium, total	0.0405	0.0010 mg/L	0.0400		101	80-120			
Sulfur, total	40.5	3.0 mg/L	40.0		101	80-120			
Tellurium, total	0.0392	0.00050 mg/L	0.0400		98	80-120			
Thallium, total	0.0404	0.000020 mg/L	0.0400		101	80-120			
Thorium, total	0.0411	0.00010 mg/L	0.0400		103	80-120			
Tin, total	0.0404	0.00020 mg/L	0.0400		101	80-120			
Titanium, total	0.0396	0.0050 mg/L	0.0400		99	80-120			
Tungsten, total	0.0418	0.0010 mg/L	0.0400		105	80-120			
Uranium, total	0.0409	0.000020 mg/L	0.0400		102	80-120			
Vanadium, total	0.0405	0.0050 mg/L	0.0400		101	80-120			
Zinc, total	0.397	0.0040 mg/L	0.400		99	80-120			
Zirconium, total	0.0410	0.00010 mg/L	0.0400		103	80-120			
Duplicate (B3J2351-DUP1)				Source: 23J2279-01 Prepared: 2023-10-24, Analyzed: 2023-10-24					
Aluminum, total	0.0379	0.0050 mg/L	0.0393				4	20	
Antimony, total	0.00062	0.00020 mg/L	0.00059					20	
Arsenic, total	0.00194	0.00050 mg/L	0.00208					20	
Barium, total	0.182	0.0050 mg/L	0.181				< 1	20	
Beryllium, total	< 0.00010	0.00010 mg/L	< 0.00010					20	
Bismuth, total	< 0.00010	0.00010 mg/L	< 0.00010					20	
Boron, total	0.0593	0.0500 mg/L	0.0724					20	
Cadmium, total	< 0.000010	0.000010 mg/L	< 0.000020					20	
Calcium, total	160	0.20 mg/L	163				2	20	
Chromium, total	< 0.00050	0.00050 mg/L	< 0.00050					20	
Cobalt, total	0.00014	0.00010 mg/L	0.00015					20	
Copper, total	0.00245	0.00040 mg/L	0.00256				4	20	
Iron, total	0.189	0.010 mg/L	0.193				2	20	
Lead, total	0.00020	0.00020 mg/L	0.00024					20	
Lithium, total	0.00349	0.00010 mg/L	0.00352				< 1	20	
Magnesium, total	13.7	0.010 mg/L	13.7				< 1	20	
Manganese, total	0.128	0.00020 mg/L	0.129				< 1	20	
Molybdenum, total	0.00453	0.00010 mg/L	0.00457				1	20	
Nickel, total	0.00073	0.00040 mg/L	< 0.00040					20	
Phosphorus, total	0.062	0.050 mg/L	0.071					20	
Potassium, total	1.60	0.10 mg/L	1.62				1	20	
Selenium, total	< 0.00050	0.00050 mg/L	< 0.00050					20	
Silicon, total	9.3	1.0 mg/L	9.3				< 1	20	
Silver, total	< 0.000050	0.000050 mg/L	< 0.000050					20	
Sodium, total	9.71	0.10 mg/L	10.0				3	20	
Strontium, total	1.89	0.0010 mg/L	1.92				2	20	
Sulfur, total	87.1	3.0 mg/L	88.4				1	20	
Tellurium, total	< 0.00050	0.00050 mg/L	< 0.00050					20	
Thallium, total	< 0.000020	0.000020 mg/L	< 0.000020					20	
Thorium, total	< 0.00010	0.00010 mg/L	< 0.00010					20	
Tin, total	< 0.00020	0.00020 mg/L	< 0.00020					20	
Titanium, total	< 0.0050	0.0050 mg/L	< 0.0050					20	

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3J2351, Continued									
Duplicate (B3J2351-DUP1), Continued		Source: 23J2279-01		Prepared: 2023-10-24, Analyzed: 2023-10-24					
Tungsten, total	< 0.0010	0.0010 mg/L		< 0.0010				20	
Uranium, total	0.000596	0.000020 mg/L		0.000594			< 1	20	
Vanadium, total	< 0.0050	0.0050 mg/L		< 0.0050				20	
Zinc, total	0.0066	0.0040 mg/L		0.0071				20	
Zirconium, total	< 0.00010	0.00010 mg/L		0.00016				20	
Matrix Spike (B3J2351-MS1)		Source: 23J2279-02		Prepared: 2023-10-24, Analyzed: 2023-10-24					
Aluminum, total	4.31	0.0050 mg/L	4.00	0.0254	107	70-130			
Antimony, total	0.0456	0.00020 mg/L	0.0400	0.00052	113	70-130			
Arsenic, total	0.439	0.00050 mg/L	0.400	0.00169	109	70-130			
Barium, total	0.225	0.0050 mg/L	0.0400	0.192	82	70-130			
Beryllium, total	0.0424	0.00010 mg/L	0.0400	< 0.00010	106	70-130			
Bismuth, total	0.0421	0.00010 mg/L	0.0400	< 0.00010	105	70-130			
Boron, total	0.487	0.0500 mg/L	0.400	0.0701	104	70-130			
Cadmium, total	0.0434	0.000010 mg/L	0.0400	< 0.000010	108	70-130			
Calcium, total	174	0.20 mg/L	4.00	179	NR	70-130			MS2
Chromium, total	0.0432	0.00050 mg/L	0.0400	< 0.00050	107	70-130			
Cobalt, total	0.0420	0.00010 mg/L	0.0400	0.00012	105	70-130			
Copper, total	0.0450	0.00040 mg/L	0.0400	0.00458	101	70-130			
Iron, total	4.39	0.010 mg/L	4.00	0.190	105	70-130			
Lead, total	0.0426	0.00020 mg/L	0.0400	0.00020	106	70-130			
Lithium, total	0.0457	0.00010 mg/L	0.0400	0.00366	105	70-130			
Magnesium, total	18.1	0.010 mg/L	4.00	14.6	88	70-130			
Manganese, total	0.176	0.00020 mg/L	0.0400	0.141	87	70-130			
Molybdenum, total	0.0482	0.00010 mg/L	0.0400	0.00413	110	70-130			
Nickel, total	0.0403	0.00040 mg/L	0.0400	< 0.00040	100	70-130			
Phosphorus, total	4.48	0.050 mg/L	4.00	0.078	110	70-130			
Potassium, total	6.03	0.10 mg/L	4.00	1.65	110	70-130			
Selenium, total	0.433	0.00050 mg/L	0.400	< 0.00050	108	70-130			
Silicon, total	13.4	1.0 mg/L	4.00	9.7	94	70-130			
Silver, total	0.0435	0.000050 mg/L	0.0400	< 0.000050	109	70-130			
Sodium, total	13.9	0.10 mg/L	4.00	10.2	93	70-130			
Strontium, total	1.98	0.0010 mg/L	0.0400	2.04	NR	70-130			MS2
Sulfur, total	139	3.0 mg/L	40.0	104	87	70-130			
Tellurium, total	0.0425	0.00050 mg/L	0.0400	< 0.00050	106	70-130			
Thallium, total	0.0429	0.000020 mg/L	0.0400	< 0.000020	107	70-130			
Thorium, total	0.0442	0.00010 mg/L	0.0400	< 0.00010	110	70-130			
Tin, total	0.0448	0.00020 mg/L	0.0400	< 0.00020	112	70-130			
Titanium, total	0.0442	0.0050 mg/L	0.0400	< 0.0050	108	70-130			
Tungsten, total	0.0455	0.0010 mg/L	0.0400	< 0.0010	114	70-130			
Uranium, total	0.0445	0.000020 mg/L	0.0400	0.000490	110	70-130			
Vanadium, total	0.0483	0.0050 mg/L	0.0400	< 0.0050	110	70-130			
Zinc, total	0.442	0.0040 mg/L	0.400	0.0101	108	70-130			
Zirconium, total	0.0461	0.00010 mg/L	0.0400	< 0.00010	115	70-130			

Total Metals, Batch B3J2581

Blank (B3J2581-BLK1)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, total	< 0.000010	0.000010 mg/L							
Blank (B3J2581-BLK2)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, total	< 0.000010	0.000010 mg/L							
Blank (B3J2581-BLK3)		Prepared: 2023-10-25, Analyzed: 2023-10-26							
Mercury, total	< 0.000010	0.000010 mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3J2581, Continued									
Blank (B3J2581-BLK4)				Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, total	< 0.000010	0.000010 mg/L							
LCS (B3J2581-BS1)				Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, total	0.000245	0.000010 mg/L	0.000250		98	80-120			
LCS (B3J2581-BS2)				Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, total	0.000240	0.000010 mg/L	0.000250		96	80-120			
LCS (B3J2581-BS3)				Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, total	0.000233	0.000010 mg/L	0.000250		93	80-120			
LCS (B3J2581-BS4)				Prepared: 2023-10-25, Analyzed: 2023-10-26					
Mercury, total	0.000233	0.000010 mg/L	0.000250		93	80-120			
Duplicate (B3J2581-DUP1)				Source: 23J2279-01		Prepared: 2023-10-25, Analyzed: 2023-10-26			
Mercury, total	< 0.000010	0.000010 mg/L		< 0.000010				20	

Volatile Organic Compounds (VOC), Batch B3J2379

Blank (B3J2379-BLK1)				Prepared: 2023-10-24, Analyzed: 2023-10-24					
Benzene	< 0.5	0.5 µg/L							
Bromodichloromethane	< 1.0	1.0 µg/L							
Bromoform	< 1.0	1.0 µg/L							
Carbon tetrachloride	< 0.5	0.5 µg/L							
Chlorobenzene	< 1.0	1.0 µg/L							
Chloroethane	< 2.0	2.0 µg/L							
Chloroform	< 1.0	1.0 µg/L							
Dibromochloromethane	< 1.0	1.0 µg/L							
1,2-Dibromoethane	< 0.3	0.3 µg/L							
Dibromomethane	< 1.0	1.0 µg/L							
1,2-Dichlorobenzene	< 0.5	0.5 µg/L							
1,3-Dichlorobenzene	< 1.0	1.0 µg/L							
1,4-Dichlorobenzene	< 1.0	1.0 µg/L							
1,1-Dichloroethane	< 1.0	1.0 µg/L							
1,2-Dichloroethane	< 1.0	1.0 µg/L							
1,1-Dichloroethylene	< 1.0	1.0 µg/L							
cis-1,2-Dichloroethylene	< 1.0	1.0 µg/L							
trans-1,2-Dichloroethylene	< 1.0	1.0 µg/L							
Dichloromethane	< 3.0	3.0 µg/L							
1,2-Dichloropropane	< 1.0	1.0 µg/L							
1,3-Dichloropropene (cis + trans)	< 1.0	1.0 µg/L							
Ethylbenzene	< 1.0	1.0 µg/L							
Methyl tert-butyl ether	< 1.0	1.0 µg/L							
Styrene	< 1.0	1.0 µg/L							
1,1,2,2-Tetrachloroethane	< 0.5	0.5 µg/L							
Tetrachloroethylene	< 1.0	1.0 µg/L							
Toluene	< 1.0	1.0 µg/L							
1,1,1-Trichloroethane	< 1.0	1.0 µg/L							
1,1,2-Trichloroethane	< 1.0	1.0 µg/L							
Trichloroethylene	< 1.0	1.0 µg/L							
Trichlorofluoromethane	< 1.0	1.0 µg/L							
Vinyl chloride	< 1.0	1.0 µg/L							
Xylenes (total)	< 2.0	2.0 µg/L							
Surrogate: Toluene-d8	26.8	µg/L	25.0		107	70-130			
Surrogate: 4-Bromofluorobenzene	26.4	µg/L	24.9		106	70-130			
Surrogate: 1,4-Dichlorobenzene-d4	29.1	µg/L	25.0		116	70-130			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2279
2023-10-30 14:23

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Volatile Organic Compounds (VOC), Batch B3J2379, Continued									
LCS (B3J2379-BS1)					Prepared: 2023-10-24, Analyzed: 2023-10-24				
Benzene	22.4	0.5 µg/L	20.1		112	70-130			
Bromodichloromethane	22.2	1.0 µg/L	20.0		111	70-130			
Bromoform	23.7	1.0 µg/L	20.1		118	70-130			
Carbon tetrachloride	21.1	0.5 µg/L	20.0		106	70-130			
Chlorobenzene	18.3	1.0 µg/L	20.1		91	70-130			
Chloroethane	23.6	2.0 µg/L	20.1		118	60-140			
Chloroform	22.6	1.0 µg/L	20.1		112	70-130			
Dibromochloromethane	21.0	1.0 µg/L	20.1		104	70-130			
1,2-Dibromoethane	22.2	0.3 µg/L	20.1		110	70-130			
Dibromomethane	23.1	1.0 µg/L	20.0		116	70-130			
1,2-Dichlorobenzene	17.8	0.5 µg/L	20.1		88	70-130			
1,3-Dichlorobenzene	17.1	1.0 µg/L	20.1		85	70-130			
1,4-Dichlorobenzene	17.1	1.0 µg/L	20.1		85	70-130			
1,1-Dichloroethane	23.2	1.0 µg/L	20.1		115	70-130			
1,2-Dichloroethane	23.7	1.0 µg/L	20.1		118	70-130			
1,1-Dichloroethylene	21.7	1.0 µg/L	20.1		108	70-130			
cis-1,2-Dichloroethylene	24.0	1.0 µg/L	20.1		119	70-130			
trans-1,2-Dichloroethylene	23.9	1.0 µg/L	20.1		119	70-130			
Dichloromethane	23.5	3.0 µg/L	20.1		117	70-130			
1,2-Dichloropropane	23.2	1.0 µg/L	20.1		116	70-130			
1,3-Dichloropropene (cis + trans)	41.1	1.0 µg/L	40.2		102	70-130			
Ethylbenzene	17.7	1.0 µg/L	20.1		88	70-130			
Methyl tert-butyl ether	23.0	1.0 µg/L	20.0		115	70-130			
Styrene	18.3	1.0 µg/L	20.1		91	70-130			
1,1,2,2-Tetrachloroethane	23.7	0.5 µg/L	20.1		118	70-130			
Tetrachloroethylene	19.7	1.0 µg/L	20.1		98	70-130			
Toluene	23.0	1.0 µg/L	20.1		115	70-130			
1,1,1-Trichloroethane	32.3	1.0 µg/L	20.1		161	70-130			SPK1
1,1,2-Trichloroethane	23.8	1.0 µg/L	20.1		118	70-130			
Trichloroethylene	19.7	1.0 µg/L	20.1		98	70-130			
Trichlorofluoromethane	58.1	1.0 µg/L	20.1		289	60-140			SPK1
Vinyl chloride	23.7	1.0 µg/L	20.1		118	60-140			
Xylenes (total)	63.9	2.0 µg/L	60.2		106	70-130			
Surrogate: Toluene-d8	23.1	µg/L	25.0		92	70-130			
Surrogate: 4-Bromofluorobenzene	22.0	µg/L	24.9		88	70-130			
Surrogate: 1,4-Dichlorobenzene-d4	25.8	µg/L	25.0		103	70-130			

QC Qualifiers:

MS2 The native sample concentration is greater than the spike concentration hence the matrix spike limits do not apply.

SPK1 The recovery of this analyte was outside of established control limits. The data was accepted based on performance of other batch QC.

CERTIFICATE OF ANALYSIS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon) #200 - 2800 29th Street Vernon, BC V1T 9P9	WORK ORDER	23J2669
ATTENTION	Marta Green	RECEIVED / TEMP	2023-10-20 09:45 / 20.0°C
PO NUMBER	223-8374.000.002	REPORTED	2023-10-27 13:37
PROJECT	2023-8374.000.002	COC NUMBER	B133383
PROJECT INFO	[info]		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks



You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry



It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve



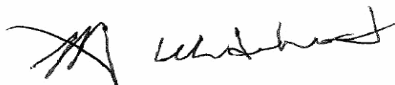
Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

By engaging our services, you are agreeing to CARO Analytical Service's Standard Terms and Conditions outlined here:
<https://www.caro.ca/terms-conditions>

If you have any questions or concerns, please contact me at bwhitehead@caro.ca

Authorized By:

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TEST RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2669
2023-10-27 13:37

Analyte	Result	RL	Units	Analyzed	Qualifier
WIPN 52992 (23J2669-01) Matrix: Water Sampled: 2023-10-19 08:30					
Calculated Parameters					
Hardness, Total (as CaCO3)	583	0.500	mg/L	N/A	
Total Metals					
Aluminum, total	< 0.0050	0.0050	mg/L	2023-10-27	
Antimony, total	0.00030	0.00020	mg/L	2023-10-27	
Arsenic, total	0.00113	0.00050	mg/L	2023-10-27	
Barium, total	0.203	0.0050	mg/L	2023-10-27	
Beryllium, total	< 0.00010	0.00010	mg/L	2023-10-27	
Bismuth, total	< 0.00010	0.00010	mg/L	2023-10-27	
Boron, total	0.0756	0.0500	mg/L	2023-10-27	
Cadmium, total	< 0.000010	0.000010	mg/L	2023-10-27	
Calcium, total	206	0.20	mg/L	2023-10-27	
Chromium, total	< 0.00050	0.00050	mg/L	2023-10-27	
Cobalt, total	< 0.00010	0.00010	mg/L	2023-10-27	
Copper, total	0.00267	0.00040	mg/L	2023-10-27	
Iron, total	0.203	0.010	mg/L	2023-10-27	
Lead, total	< 0.00020	0.00020	mg/L	2023-10-27	
Lithium, total	0.00390	0.00010	mg/L	2023-10-27	
Magnesium, total	16.8	0.010	mg/L	2023-10-27	
Manganese, total	0.163	0.00020	mg/L	2023-10-27	
Mercury, total	< 0.000010	0.000010	mg/L	2023-10-27	
Molybdenum, total	0.00196	0.00010	mg/L	2023-10-27	
Nickel, total	< 0.00040	0.00040	mg/L	2023-10-27	
Phosphorus, total	0.072	0.050	mg/L	2023-10-27	
Potassium, total	1.66	0.10	mg/L	2023-10-27	
Selenium, total	< 0.00050	0.00050	mg/L	2023-10-27	
Silicon, total	9.8	1.0	mg/L	2023-10-27	
Silver, total	< 0.000050	0.000050	mg/L	2023-10-27	
Sodium, total	10.8	0.10	mg/L	2023-10-27	
Strontium, total	2.29	0.0010	mg/L	2023-10-27	
Sulfur, total	132	3.0	mg/L	2023-10-27	
Tellurium, total	< 0.00050	0.00050	mg/L	2023-10-27	
Thallium, total	< 0.000020	0.000020	mg/L	2023-10-27	
Thorium, total	< 0.00010	0.00010	mg/L	2023-10-27	
Tin, total	< 0.00020	0.00020	mg/L	2023-10-27	
Titanium, total	< 0.0050	0.0050	mg/L	2023-10-27	
Tungsten, total	< 0.0010	0.0010	mg/L	2023-10-27	
Uranium, total	0.000251	0.000020	mg/L	2023-10-27	
Vanadium, total	< 0.0050	0.0050	mg/L	2023-10-27	
Zinc, total	0.0104	0.0040	mg/L	2023-10-27	
Zirconium, total	< 0.00010	0.00010	mg/L	2023-10-27	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2669
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Analysis Description	Method Ref.	Technique	Accredited	Location
Hardness in Water	SM 2340 B* (2021)	Calculation: 2.497 [total Ca] + 4.118 [total Mg] (Est)	✓	N/A
Mercury, total in Water	EPA 245.7*	BrCl ₂ Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Total Metals in Water	EPA 200.2 / EPA 6020B	HNO ₃ +HCl Hot Block Digestion / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the received samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Caro will dispose of all samples within 30 days of sample receipt, unless otherwise agreed.

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
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WORK ORDER REPORTED 23J2669
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The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk):** A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup):** An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS):** A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS):** A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM):** A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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Total Metals, Batch B3J2601

Blank (B3J2601-BLK1)			Prepared: 2023-10-25, Analyzed: 2023-10-27						
Aluminum, total	< 0.0050	0.0050 mg/L							
Antimony, total	< 0.00020	0.00020 mg/L							
Arsenic, total	< 0.00050	0.00050 mg/L							
Barium, total	< 0.0050	0.0050 mg/L							
Beryllium, total	< 0.00010	0.00010 mg/L							
Bismuth, total	< 0.00010	0.00010 mg/L							
Boron, total	< 0.0500	0.0500 mg/L							
Cadmium, total	< 0.000010	0.000010 mg/L							
Calcium, total	< 0.20	0.20 mg/L							
Chromium, total	< 0.00050	0.00050 mg/L							
Cobalt, total	< 0.00010	0.00010 mg/L							
Copper, total	< 0.00040	0.00040 mg/L							
Iron, total	< 0.010	0.010 mg/L							
Lead, total	< 0.00020	0.00020 mg/L							
Lithium, total	< 0.00010	0.00010 mg/L							
Magnesium, total	< 0.010	0.010 mg/L							
Manganese, total	< 0.00020	0.00020 mg/L							
Molybdenum, total	< 0.00010	0.00010 mg/L							
Nickel, total	< 0.00040	0.00040 mg/L							
Phosphorus, total	< 0.050	0.050 mg/L							
Potassium, total	< 0.10	0.10 mg/L							
Selenium, total	< 0.00050	0.00050 mg/L							
Silicon, total	< 1.0	1.0 mg/L							
Silver, total	< 0.000050	0.000050 mg/L							
Sodium, total	< 0.10	0.10 mg/L							
Strontium, total	< 0.0010	0.0010 mg/L							
Sulfur, total	< 3.0	3.0 mg/L							
Tellurium, total	< 0.00050	0.00050 mg/L							
Thallium, total	< 0.000020	0.000020 mg/L							
Thorium, total	< 0.00010	0.00010 mg/L							
Tin, total	< 0.00020	0.00020 mg/L							
Titanium, total	< 0.0050	0.0050 mg/L							
Tungsten, total	< 0.0010	0.0010 mg/L							
Uranium, total	< 0.000020	0.000020 mg/L							
Vanadium, total	< 0.0050	0.0050 mg/L							
Zinc, total	< 0.0040	0.0040 mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

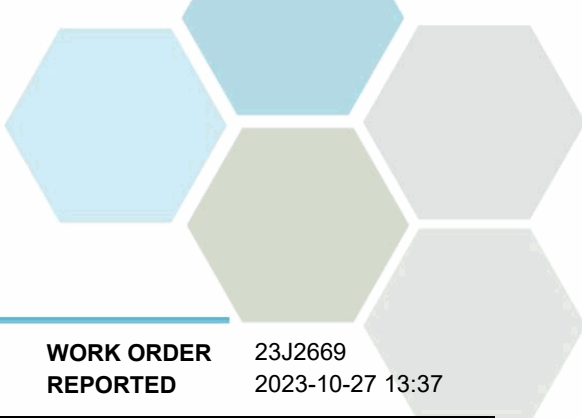
REPORTED TO PROJECT Associated Environmental Consultants Inc. (Vernon)
2023-8374.000.002

WORK ORDER REPORTED 23J2669
2023-10-27 13:37

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3J2601, Continued									
Blank (B3J2601-BLK1), Continued					Prepared: 2023-10-25, Analyzed: 2023-10-27				
Zirconium, total	< 0.00010	0.00010 mg/L							
LCS (B3J2601-BS1)					Prepared: 2023-10-25, Analyzed: 2023-10-27				
Aluminum, total	4.04	0.0050 mg/L	4.00		101	80-120			
Antimony, total	0.0397	0.00020 mg/L	0.0400		99	80-120			
Arsenic, total	0.404	0.00050 mg/L	0.400		101	80-120			
Barium, total	0.0402	0.0050 mg/L	0.0400		100	80-120			
Beryllium, total	0.0424	0.00010 mg/L	0.0400		106	80-120			
Bismuth, total	0.0407	0.00010 mg/L	0.0400		102	80-120			
Boron, total	0.440	0.0500 mg/L	0.400		110	80-120			
Cadmium, total	0.0402	0.000010 mg/L	0.0400		100	80-120			
Calcium, total	4.21	0.20 mg/L	4.00		105	80-120			
Chromium, total	0.0413	0.00050 mg/L	0.0400		103	80-120			
Cobalt, total	0.0405	0.00010 mg/L	0.0400		101	80-120			
Copper, total	0.0404	0.00040 mg/L	0.0400		101	80-120			
Iron, total	4.06	0.010 mg/L	4.00		102	80-120			
Lead, total	0.0406	0.00020 mg/L	0.0400		102	80-120			
Lithium, total	0.0425	0.00010 mg/L	0.0400		106	80-120			
Magnesium, total	4.12	0.010 mg/L	4.00		103	80-120			
Manganese, total	0.0407	0.00020 mg/L	0.0400		102	80-120			
Molybdenum, total	0.0407	0.00010 mg/L	0.0400		102	80-120			
Nickel, total	0.0402	0.00040 mg/L	0.0400		100	80-120			
Phosphorus, total	4.12	0.050 mg/L	4.00		103	80-120			
Potassium, total	4.06	0.10 mg/L	4.00		102	80-120			
Selenium, total	0.405	0.00050 mg/L	0.400		101	80-120			
Silicon, total	4.0	1.0 mg/L	4.00		100	80-120			
Silver, total	0.0410	0.000050 mg/L	0.0400		102	80-120			
Sodium, total	3.99	0.10 mg/L	4.00		100	80-120			
Strontium, total	0.0405	0.0010 mg/L	0.0400		101	80-120			
Sulfur, total	40.1	3.0 mg/L	40.0		100	80-120			
Tellurium, total	0.0376	0.00050 mg/L	0.0400		94	80-120			
Thallium, total	0.0407	0.000020 mg/L	0.0400		102	80-120			
Thorium, total	0.0415	0.00010 mg/L	0.0400		104	80-120			
Tin, total	0.0403	0.00020 mg/L	0.0400		101	80-120			
Titanium, total	0.0403	0.0050 mg/L	0.0400		101	80-120			
Tungsten, total	0.0402	0.0010 mg/L	0.0400		101	80-120			
Uranium, total	0.0405	0.000020 mg/L	0.0400		101	80-120			
Vanadium, total	0.0409	0.0050 mg/L	0.0400		102	80-120			
Zinc, total	0.403	0.0040 mg/L	0.400		101	80-120			
Zirconium, total	0.0400	0.00010 mg/L	0.0400		100	80-120			

Total Metals, Batch B3J2699

Blank (B3J2699-BLK1)					Prepared: 2023-10-26, Analyzed: 2023-10-26				
Mercury, total	< 0.000010	0.000010 mg/L							
Blank (B3J2699-BLK2)					Prepared: 2023-10-26, Analyzed: 2023-10-26				
Mercury, total	< 0.000010	0.000010 mg/L							
Blank (B3J2699-BLK3)					Prepared: 2023-10-26, Analyzed: 2023-10-27				
Mercury, total	< 0.000010	0.000010 mg/L							
Blank (B3J2699-BLK4)					Prepared: 2023-10-26, Analyzed: 2023-10-27				
Mercury, total	< 0.000010	0.000010 mg/L							



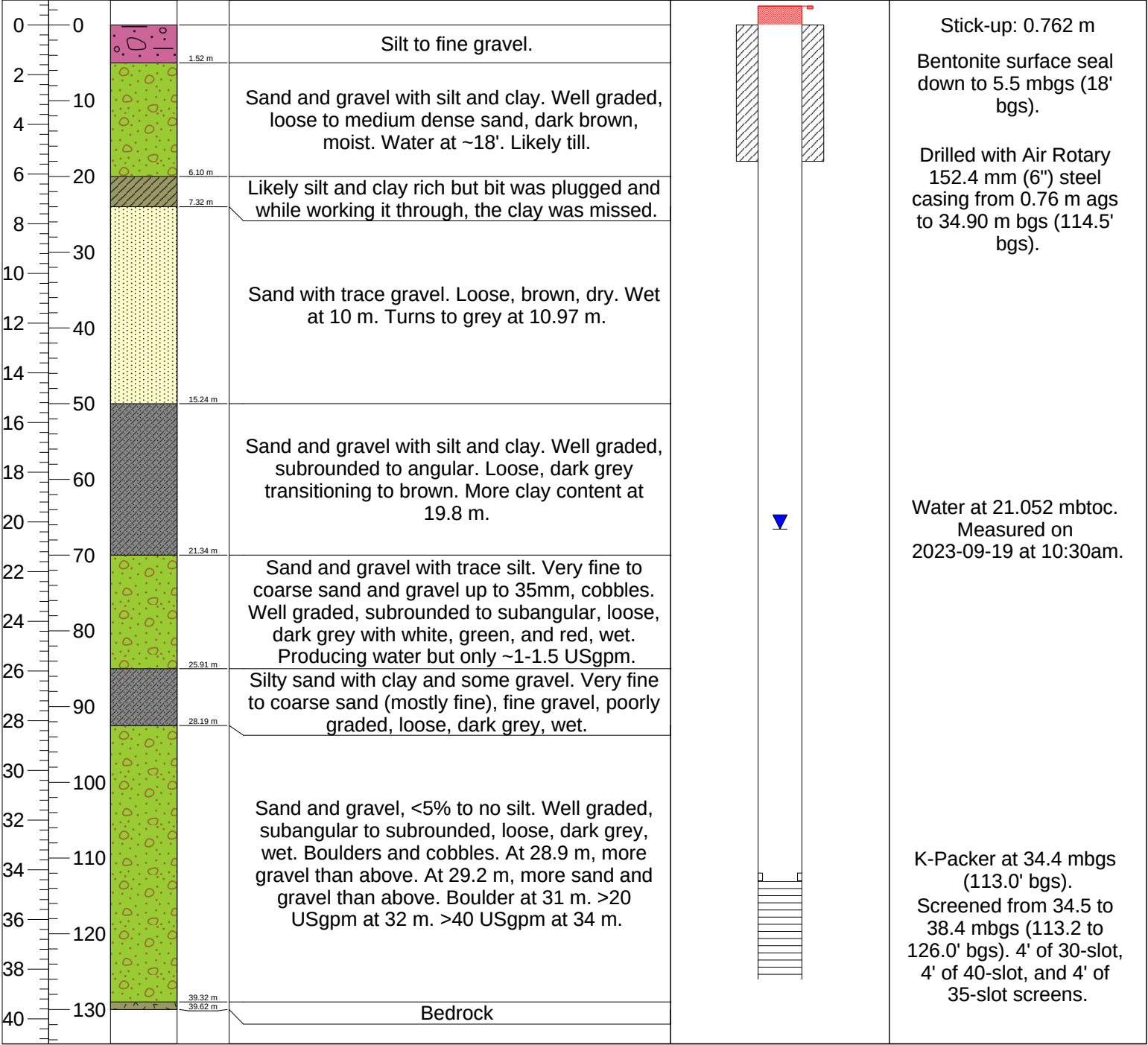
APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT	Associated Environmental Consultants Inc. (Vernon) 2023-8374.000.002	WORK ORDER REPORTED	23J2669 2023-10-27 13:37
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Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B3J2699, Continued									
LCS (B3J2699-BS1)				Prepared: 2023-10-26, Analyzed: 2023-10-26					
Mercury, total	0.000240	0.000010 mg/L	0.000250		96	80-120			
LCS (B3J2699-BS2)				Prepared: 2023-10-26, Analyzed: 2023-10-27					
Mercury, total	0.000241	0.000010 mg/L	0.000250		96	80-120			
LCS (B3J2699-BS3)				Prepared: 2023-10-26, Analyzed: 2023-10-27					
Mercury, total	0.000229	0.000010 mg/L	0.000250		92	80-120			
LCS (B3J2699-BS4)				Prepared: 2023-10-26, Analyzed: 2023-10-27					
Mercury, total	0.000241	0.000010 mg/L	0.000250		96	80-120			

APPENDIX C – WELL LOG

Project Details			Well / Borehole ID		Location	
Project Number: 2023-8374-00 Client: Regional District of Okanagan-Similkameen Location: Missezula Lake, BC			WIPN 52992		Northing (m): 5515766	Survey Method:
					Easting (m): 680192	GPS (+/- 3m)
					Elevation (m):	Zone:
						10U
Subsurface Profile				Well Completion		
Depth (m) (ft)	Graphic Log	Description		Well Construction		Details





Ministry of
Environment

- ☒ Well Construction Report
☐ Well Closure Report
☐ Well Alteration Report

Stamp company name/address,
phone/fax/email here, if desired.
250-497-8284

Ministry Well ID Plate Number: 43254
Ministry Well Tag Number:
☐ Confirmation/alternative specs. attached
☐ Original well construction report attached

Red lettering indicates minimum mandatory information. See reverse for notes & definitions of abbreviations.

Owner name: R.D.O.S
Mailing address: 101 MARTIN ST Town PENTICTON Prov. B.C. Postal Code
Well Location (see note 2): Address: Street no. Street name MISSEZOLA RD Town PRINCETON
or Legal description: Lot Plan D.L. Block Sec. Twp. Rg. Land District
or PID: (and) Description of well location (attach sketch, if nec.): HOUSE BY THE LAKE BESIDE THE PUMP
NAD 83: Zone: UTM Easting: UTM Northing: Latitude (see note 4): 49°46'02.2"N Longitude: 120°29'50.9"W
Method of drilling: ☐ air rotary ☐ dual rotary ☒ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ other (specify):
Orientation of well: ☒ vertical ☐ horizontal Ground elevation: ft (asl) Method (see note 5):
Class of well (see note 6): WATER SUPPLY Sub-class of well: DOMESTIC
Water supply wells: indicate intended water use: ☐ private domestic ☒ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify):

Lithologic description (see notes 8-13) or closure description (see notes 14 and 15)

From ft (bgl)	To ft (bgl)	Surficial Material						Bedrock Material						Colour						Hardness				Water Content					Observations (e.g. other geological materials (e.g. boulders), est. water bearing flow (USgpm), or closure details)							
		Clay	Silt	Till	Sand with clay/silt	Sand, fine-med	Sand, med-coarse	Sand with gravel	Siltstone/shale	Sandstone	Conglomerate	Limestone	Basalt	Volcanic	Crystalline	Other Surficial/ Bedrock	Red	Orange	Brown	Tan	Light Grey	Blue	Green	Dark Grey	Very Hard	Hard	Dense/Stiff	Loose		Dry	Moist	Wet	High Production	Lost circulation	Not Available	
0	22																																			TOPSOIL MIX
22	24																																			
24	28																																			
28	36																																			
36	54																																			
54	62																																			
62	72																																			
72	88																																			
88	100																																			

Casing details

From ft (bgl)	To ft (bgl)	Dia in	Casing Material/Open Hole (see note 17)	Wall Thickness in	Drive Shoe
0	15	8	STEEL	.250	N
			REMOVED		
0	100	6"	STEEL	.250	Y

Surface seal: Type: BENTONITE Depth: 15 ft
Method of installation: ☒ Poured ☐ Pumped Thickness: in
Backfill: Type: Depth: ft
Liner: ☐ PVC ☐ Other (specify):
Diameter: in Thickness: in
From: ft (bgl) To: ft (bgl) Perforated: From: ft (bgl) To: ft (bgl)

Screen details

From ft (bgl)	To ft (bgl)	Dia in	Type (see note 18)	Slot Size
91	100	6	TELESCOPIC	25/30

Intake: ☒ Screen ☐ Open bottom ☐ Uncased hole
Screen type: ☒ Telescope ☐ Pipe size
Screen material: ☒ Stainless steel ☐ Plastic ☐ Other (specify):
Screen opening: ☒ Continuous slot ☐ Slotted ☐ Perforated pipe
Screen bottom: ☒ Bail ☐ Plug ☐ Plate ☐ Other (specify):
Filter pack: From: ft To: ft Thickness: in
Type and size of material:

Developed by:

☐ Air lifting ☒ Surging ☐ Jetting ☒ Pumping ☒ Bailing
Other (specify): Total duration: 8 hrs
Notes:

Well yield estimated by:

☒ Pumping ☐ Air lifting ☐ Bailing ☐ Other (specify):
Rate: 10+ USgpm Duration: 2 hrs
SWL before test: 66 ft (btoc) Pumping water level: ft (btoc)

Obvious water quality characteristics:

☒ Fresh ☐ Salty ☒ Clear ☐ Cloudy ☐ Sediment ☐ Gas
Colour/odour: NONE Water sample collected: ☐

Well driller (print clearly):

Name (first, last) (see note 19): RYAN GARDINER
Registration no. (see note 20): 10102601
Consultant (if applicable; name and company): RDOS
SHANE FENSKE

DECLARATION: Well construction, well alteration or well closure, as the case may be, has been done in accordance with the requirements in the Water Act and the Ground Water Protection Regulation.

Signature of
Driller Responsible

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction, alteration or closure, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

Final well completion data:

Total depth drilled: ft Finished well depth: 100 ft (bgl)
Final stick up: 30 in Depth to bedrock: ft (bgl)
SWL: 66 ft (btoc) Estimated well yield: 10+ USgpm
Artesian flow: USgpm, or Artesian pressure: ft
Type of well cap: VERMIN Well disinfected: ☒ Yes ☐ No
Where well ID plate is attached: CASING

Well closure information:

Reason for closure:
Method of closure: ☐ Poured ☐ Pumped
Sealant material: Backfill material:
Details of closure (see note 16):

Date of work (YYYY/MM/DD):

Started: 2022/06/28 Completed: 2022/07/04

Comments: WELL WAS PUMPED TO CLEAR
NOT FOR FLOW RATE AS PER SHANE

white: Customer copy
canary: Driller copy
pink: Ministry copy

Sheet of

General

1. Requirements for well construction and well closure reports are found in Part 5 of the *Water Act* and the Ground Water Protection Regulation. Part 5 of the act and regulation are available at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/index.html#leg.
2. A minimum of one of the well location descriptors must be completed (e.g. Address OR Legal OR PID) plus the description of the well location.
3. The current Ministry standard datum for mapping and geodetic use is the North American Datum of 1983 (NAD 83). To determine GPS coordinates using a Global Positioning System (GPS), set the datum to NAD 83.
4. For latitude and longitude coordinates, provide coordinates either in degree, minutes and seconds (e.g., 50° 2' 21.037") or decimal degrees (e.g., 50.039175°).
5. For the method of determining ground elevation, enter: GPS, differential GPS, level, altimeter, 1:50,000 map, 1:20,000 map, 1:10,000 map or 1:5,000 map.
6. The classes and sub-classes of wells are shown below:

Class	Sub-class (if applicable)
Water supply	Domestic; Non-domestic
Monitoring	Temporary; Permanent
Recharge or injection	
Dewatering or drainage	Temporary; Permanent
Remediation	Temporary; Permanent
Geotechnical	Borehole; Test pit; Special type of hole; Closed loop geothermal
7. Well reports submitted to the Deputy Comptroller, or retained by the person responsible, as required under the *Water Act* and the Ground Water Protection Regulation, shall be considered part of the Provincial Government records and is subject to the *Freedom of Information and Protection of Privacy Act*.

How to Fill Out the Lithologic Description Table

8. Each row in the lithologic description table represents either a depth interval or depth in the well.
9. A row could represent a depth interval (e.g., from 0 feet to 12 feet), such as for a geologic stratum or a specific depth (e.g., 120 feet), such as for a depth location of a water-bearing fracture.
10. For each depth interval, indicate with a check mark (✓) or X the hardness, colour, and type of surficial material or bedrock material. Only make one selection for each class.

The classification system for surficial material, bedrock material, colour and hardness has been adopted with permission from *The Guide for Using the Hydrogeologic Classification System for Logging Water Well Boreholes* (Thomas M. Hanna, RPG, 2006).
11. "Crystalline" bedrock material includes granitic rocks, such as granodiorite, or metamorphic rocks, such as gneiss or schist.
12. For a depth interval, if the type of surficial material or bedrock material is not listed in the table indicate with a check mark (✓) or X and specify the geologic material encountered in the Observation field.
13. If a water-bearing fracture is encountered, the depth of the fracture the estimated flow of water in the fracture should be recorded in the Observations column.

How to Fill Out the Closure Description Table and the Well Closure Information Section

14. Each row in the closure description table represents either a depth interval (e.g., from 0 feet to 12 feet) or depth (e.g., 120 feet) in the well.
15. For a depth interval, enter the type of backfill or sealant material(s) in the Observations column.
16. Indicate in "Details of closure" whether casing(s) or screen(s) were pulled or left in place. If casing(s) were left in place, indicate whether it was perforated or ripped.

Casing Details

17. "Casing Material / Open hole" includes cement, plastic, steel, other, open hole, or casing pulled.

If a surface seal is required, details of the casing used to create the annular space for the surface seal can be entered in the first row of the table. Enter the depth interval, casing diameter, and record "casing pulled" under "Casing Material / Open hole".

Screen Details

18. "Type" includes riser pipe, K-packer, screen, screen blank, or tail pipe.

Well Driller

19. Fill in the name of the driller who constructed the well.

Registration Number of Driller Responsible

20. Fill in the registration number on the Qualified Well Driller identification card. If the work was completed by a driller who is not registered as a Qualified Well Driller, the Qualified Well Driller who is directly supervising the work should fill in their registration number on their Qualified Well Driller identification card. The Qualified Well Driller signs the form.

Definitions of Abbreviations

- asl.....above sea level
bgl.....below ground level
btoc.....below top of casing
Dia Diameter
D.L.....District Lot
ft.....feet
hrs.....hours
in.....inches
NAD 83.....North American Datum (1983)
PID.....Parcel Identifier
Rg.....Range
Sec Section
SWL.....static water level
Twp.....Township
USgpm.....US gallons per minute
UTM.....Universal Transverse Mercator Grid

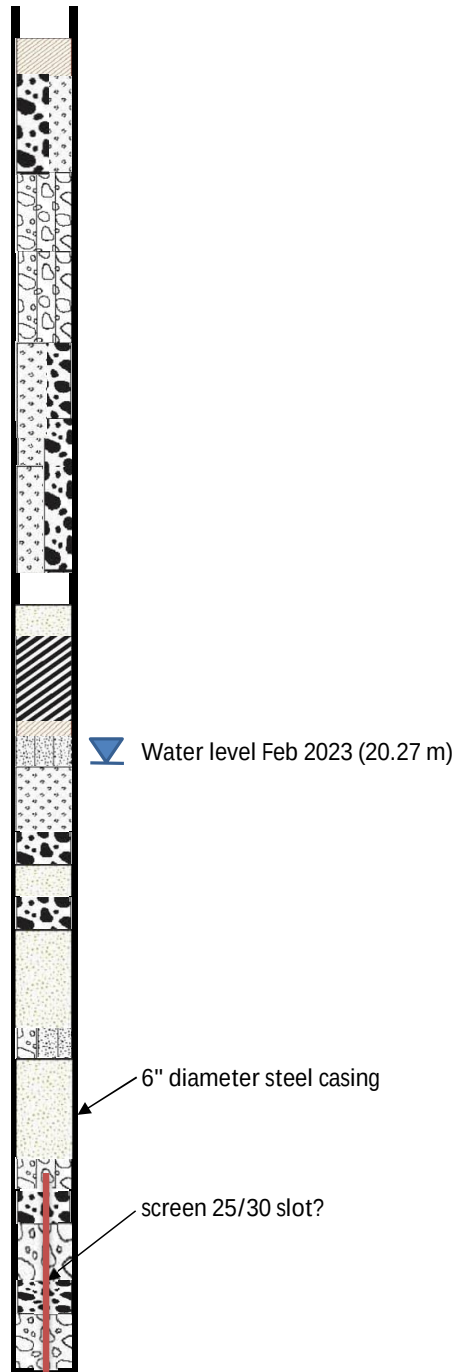
Return Completed Forms to:

Ground Water Data Technician
Water Stewardship Division, Ministry of Environment
PO Box 9362 Stn Prov Govt
Victoria BC V8W 9M2



Well Name:	Well Plate # 43254
Field hydrogeologist:	None
Drilling Contractor:	Value Contracting Okanagan
Construction start :	28-Jun-22
Construction end:	04-Jul-22

Sample Depth (ft)	Sample Depth (m)	Soil Description
22	6.7	Unknown
24	7.3	CL - clay, low to medium plasticity
26	7.9	SW/GW - well graded sand and gravel
28	8.5	
30	9.1	
32	9.8	GM - silty gravel
24	7.3	
26	7.9	
28	8.5	
40	12.2	
42	12.8	SW/GW - well graded sand and gravel
44	13.4	
46	14.0	
48	14.6	
50	15.2	
52	15.8	
54	16.5	Unknown
56	17.1	
58	17.7	SP - poorly graded sand
60	18.3	CH - clay, high plasticity
62	18.9	
64	19.5	
66	20.1	SM - silty sand
68	20.7	SW- well graded sand
70	21.3	
72	21.9	GW - well graded gravel
74	22.6	SP - poorly graded sand
76	23.2	GW - well graded gravel
78	23.8	SP - poorly graded, gravelly sand
80	24.4	
82	25.0	
84	25.6	GM/SM - silty sand and gravel
86	26.2	SP - poorly graded sand, trace gravel
88	26.8	
90	27.4	
92	28.0	GM - silty gravel
94	28.7	GW - well graded sandy gravel
96	29.3	GP - poorly graded sandy gravel, fine grain sand
98	29.9	GW - well graded sandy gravel
100	30.5	GP - poorly graded sandy gravel, coarse grain sand



Sieved

APPENDIX D – ENVIRONMENTAL MANAGEMENT PLAN



Associated
Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

REPORT

Regional District of Okanagan-Similkameen

Missezula Lake Water System Upgrade: Environmental Management Plan for Pumping Test



OCTOBER 2023



Platinum
member

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1 INTRODUCTION

1.1 Background

The Missezula Lake water system (MLWS) provides water to 190 residential and seasonal recreational lots in the Missezula Lake community, located 45 km north of Princeton. The 2018 maximum daily demand (MDD) of this community is estimated at 9 L/s (143 U.S. gallons per minute), and the highest daily water use on July 31, 2021 was 11 L/s (174 U.S. gallons per minute). The MLWS currently sources its water from a lake intake built in 2002 that has a single barrier of treatment provided via a chlorination building and chlorine contact chamber. During July and August 2021, the water levels in Missezula Lake were below average, and the Ministry of Forests (MOF) identified a need to release more water from the lake which would further lower its levels. The Missezula Lake community expressed concern over MOF's plan, as the additional releases could result in the water system infrastructure becoming non-functional, triggering a state of emergency for the community. Regional District of Okanagan Similkameen (RDOS), who owns and operates the MLWS, imposed water conservation measures, but understood that this was only a temporary solution. The possibility of future drought conditions and releases from Missezula Lake by MOF prompted RDOS to start looking at alternative water sources. In July 2022, RDOS completed an exploratory drill program to gain an understanding of the water table and general geology in the area. The investigation revealed an aquifer that has the potential to provide the water system with a more reliable and treatable water source. Associated Environmental Consultants Inc (Associated) was contracted to complete water quality sampling, aquifer testing and engineering conceptual design to assess the feasibility of a groundwater-sourced water system.

In April 2023, Marta Green, P.Geo., of Associated, travelled to Missezula Lake to collect water samples from well identification plate number (WIPN) 43254, Missezula Lake, and Summers Creek in anticipation of a future pumping test. During the purging of WIPN 43254 the maximum pumping rate was less than 0.2 L/s (3 USgpm), which raised concerns about its viability as a water source. Analysis of the water sample revealed total organic carbon (TOC), cobalt (total), and manganese (total and dissolved) that exceeded BC Source Drinking Water Quality Guidelines (BC SDW) for maximum acceptable concentration (MAC). Additionally, Guidelines for Canadian Drinking Water (GC DW) were exceeded for aluminum (total). RDOS and Associated determined that WIPN 43254 would not be a suitable drinking water sources due to the low pumping rate and drinking water quality exceedances. As a result, a new well, WIPN 52992, was drilled in September 2023 adjacent to WIPN 43254, and aquifer testing using this well is being planned.

1.2 Objectives

This environmental management plan (EMP) describes the site-specific environmental management strategies that will minimize the potential negative effects on the environment during WIPN 52992 aquifer testing. This EMP is to be reviewed and implemented by all on-site personnel before drilling.

2 SITE DESCRIPTION

WIPN 52992 is located on crown land west of Missezula Lake Road and east of Missezula Lake (Figure 1 in Appendix A). The area surrounding the well is comprised of roadways and residential lots. The headwaters of Summers Creek flows out of Missezula Lake, via a RDOS-owned and manually controlled dam. This outlet is located approximately 75 m south of the WIPN 52992. Seasonal streamflow records for the Missezula Lake outlet are available from 1970 to

1980, the mean streamflow's for the month of September were recorded as 32 L/s (0.032 m³/s).^{1,2} There are eight irrigation licenses on Summers Creek and eight domestic licenses that total 13.0 L/s (409 ML/year) and 0.35 L/s (11 ML/year), respectively. The eight irrigation licenses are only permitted to withdraw water from April 1 to September 31.

A site investigation completed by Associated's Marta Green, P.Geo, on April 18, 2023, assessed site well locations and discharge locations for the pumping test. On September 19, 2023, Dylan Riley of Associated field- supervised the drilling of WIPN 52992. The well diameter is 150 mm (6-inches), and the depth is 37.79 (124 ft) below ground level, with bedrock found a depth of 39.62 (130 ft). The aquifer is from 21.3 m to 39.6 m (70 ft to 130 ft), with a water table at about 18.3 m (60 ft), making the aquifer confined. The 3.6 m long screen (35, 40, and 30 slots) was installed from 34.1 to 37.8 m (112 to 124 ft). The Project footprint is limited to the areas that will be directly affected by the pump test. It includes the well heads at the drilling site, a 10 by 10 m area surrounding each well head, and the 75 m water discharge path and discharge receptor.

3 SCOPE OF AQUIFER TESTING

Aquatech will install and operate the pump during the aquifer testing. Cassie Ragan, G.I.T, will be the Field Hydrogeologist, overseen by Marta Green, P.Geo., who will act as the Qualified Professional. The duration of the pumping test is anticipated to be 24 or 48 hours. The duration will depend on whether the water levels stay above the top of the aquifer, in which case 24 hours of testing is sufficient. If the water levels drop down below the top of the aquifer, a 48-hour test is required to meet Provincial Guidelines.

The tasks that will be completed to assess and evaluate groundwater resources are listed below, a more detailed schedule of works can be found in Appendix B.

- A four hour step test with four one hour step tests at 2.5 L/s (40 usgpm) steps at approximately 5.7L/s, 8.2 L/s, 10.7 L/s, and 13.2 L/s (90, 130, 170, and 210 USgpm).
- A 24 or 48 hour constant rate pumping, followed by water quality sampling with a pumping rate up to 13.2 L/s (210 USgpm).³

The water from the aquifer testing will be discharged into a rip rap lined area Summers Creek, immediately downstream of the dam (75 m to south of WIPN 52992).

4 ENVIRONMENTAL CONDITIONS

4.1 Vegetation

The Project Area is located Cascade Dry Cool Interior Douglas Fir (IDFdk2) biogeoclimatic variant.⁴ Background searches revealed 10 listed plant species that have the occur within the Project footprint (Table C-1, Appendix C).⁵

¹ Historical streamflow records for October are not available. Station records paste 1980 were not available for this hydrometric station.

² True Consulting. 2018. Missezula Lake Waterworks District Water System Assessment. Available at:

<https://www.rdos.bc.ca/assets/PUBLICWORKS/Utilities/Water/Missezula-Lake/20180428RptTrueConsultingMissezula.pdf>

³ Constant rate pumping test rate will depend on the results of the step test

⁴ iMap BC. 2023. iMapBC 2.0 (Public). Available at: <http://maps.gov.bc.ca/ess/sv/imapbc/>

⁵ BC Conservation Data Centre. Species and Ecosystem Explorer, B.C. (2023). Conservation Data Centre, Ministry of Environment, Victoria, British Columbia, Canada. Available at: <http://www.env.gov.bc.ca/atrisk/toolintro.html>

Many of the listed species frequently occur in grasslands or forested areas, and therefore are not expected to occur within the project footprint which is located on a sandy beach. No listed plant communities were listed as likely to occur within 10 km of the Project footprint.

4.2 Wildlife

There are two documented wildfire species at risk within 10 km of the Project footprint: Williamson's sapsucker (*Sphyrapicus thyroideus*) and mountain beaver (*Aplodontia rufa*). The species occurred approximately 8 km (mountain beaver) and 9 km (Williamson's sapsucker) from the project footprint. Mountain Beaver habitat, which includes forested areas, is not found within the project footprint and therefore the probability of occurrence within the project footprint is low. A complete list of species at risk with the potential to occur on site can be found in Table C-2, Appendix C. Environmental impacts on wildlife are expected to be minimal during testing of the groundwater wells and are limited to temporary noise disturbances.

4.3 Aquatic Habitat

The WIPN 52992 is adjacent to Missezula lake and approximately 120 m from Summers Creek. The discharge site for the well is on Summers Creek, approximately 30 m downstream of Missezula Lake outlet. Summers Creek and Missezula Lake are both fish bearing. A search of BC Fish Inventories Data Queries indicates numerous species in Summers Creek and Missezula Lake, including rainbow trout (*Ornorchymus mykiss*), brook trout (*Salvelinus fontinalis*), mountain whitefish (*Prosopium williamsoni*), and kokanee salmon (*Oncorhynchus nerka*). There is potential for brook trout and rainbow trout spawning to occur near the outlet of Missezula Lake (headwaters of Summers Creek), these species spawn from September to November and May to June respectively.⁶ Kokanee salmon are restricted to stream inlets and Missezula Lake in this watershed⁷ and the Missezula dam is considered a fish barrier between Summers Creek and Missezula Lake for much of the year. Mountain whitefish also have the potential to spawn in Summers Creek, with their spawning period typically occurring from October to November. A complete list of species known to occur in Summers Creek and Missezula Lake can be found in Table B-3, Appendix B.

4.4 Water Quality

Surface water samples from Summers Creek were collected by Associated on April 18, 2023, and ground and surface water were sampled from Missezula Lake and WIPN 52992 by Associated on September 19, 2023. The water samples were analyzed by CARO Analytical, and the results were compared to the BC Approved and Working Water Quality Guidelines for aquatic life, wildlife, and irrigation^{8,9}, where those criteria existed. In WIPN 52922 the analyzed parameters met all acute BC Water Quality Guidelines for Aquatic Life (BC AL), and all chronic BC AL guides except for dissolved oxygen (DO), and selenium (total and dissolved) (Table 4-1). Additionally, and met all BC Water Quality

⁶ Government of British Columbia. 2017. Information For: Missezula Lake Water License Holders and Local Residents. Available at: <https://www.rdos.bc.ca/assets/PUBLICWORKS/Utilities/Water/Missezula-Lake/2017Fisheries-ManagementSectionMissezulaInformationBulletin.pdf>

⁷ Government of BC: Fisheries Management Section. 2017. Information For: Missezula Lake Water Licence Holders and Local Residents. Available at: <https://www.rdos.bc.ca/assets/PUBLICWORKS/Utilities/Water/Missezula-Lake/2017Fisheries-ManagementSectionMissezulaInformationBulletin.pdf>

⁸ British Columbia Ministry of Environment and Climate Change Strategy (ENV). 2021a. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture - Guideline Summary. Water Quality Guideline Series, WQG-20. Prov. B.C., Victoria B.C. Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

⁹ B.C. Ministry of Environment and Climate Change Strategy (ENV). 2021b. Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. Water Quality Guideline Series, WQG-08. Prov. B.C., Victoria B.C. Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

Guidelines for Wildlife (BC WL), except for selenium (total and dissolved). Temperature was not measured in the field, but is assumed to be approximately 8°C.

Selenium concentrations in Summers Creek were below the detection limit (0.00050) for both total and dissolved fractions (Table 4-1). DO was measured in the field as 7.3 mg/L.

Table 3-1
Summary of Selenium and Dissolved Oxygen in WIPN 52992 and Summers Creek

Parameter	Applicable Guideline ¹	Guideline Limit ¹	WIPN 52992	Summers Creek
Dissolved Oxygen	BC AL	5.0 mg/L ²	6.53 mg/L	<0.0050 ³
Total Selenium	BC AL	0.002 mg/L	0.0296 mg/L	<0.0050 ³
Dissolved Selenium	BC AL	0.002 mg/L	0.0305 mg/L	<0.0050 ³

1. Guidelines include BC Water Quality Guidelines for aquatic life (chronic and acute), wildlife, livestock irrigation. Only the most stringent guideline value is included.
2. Minimum concentration for acute guideline. Chronic guideline is minimum of 8 mg/L.
3. Value below detection limit.

5 KEY PROJECT PERSONNEL

Contact information for the key project personnel is provided in Table 4-1.

Table 4-1
Key Personnel

Personnel	Role	Telephone Number	Email Address
Marta Green, P.Geo., Associated Environmental Consultants Inc.	Qualified Professional (Hydrogeology)	250-545-3672 250-503-7330	greenm@ae.ca
Cassie Ragan, G.I.T, Associated Environmental Consultants Inc.	Field Hydrogeologist Environmental Monitor	778-506-2162 604-600-3256	raganc@ae.ca
Renee Larsen, A.Ag, Associated Environmental Consultants Inc.	Environmental Scientist, providing EMP and lab support	250-545-3672 250-540-3059	larsenr@ae.ca
Myron Semegen, RDOS	Client contact	250-490-4117	msemegen@rdos.bc.ca
Adam Cunningham, RDOS	Operator	250-488-0788	acunningham@rdos.bc.ca
Randy Woods AquaTech	Pumping test contractor	250-765-4730 250-470-8869	ats2006inc@gmail.com

6 POTENTIAL ENVIRONMENTAL IMPACTS

The Project work will require accessing WIPN 52992 and conducting a up to a 4-hour step test and up to a 48-hour pumping test to monitor the aquifer characteristics to determine the viability of the well as a water source. The water pumped from WIPN 52992 during the aquifer testing will be directed, by hose, into Summers Creek approximately 30 m from the Missezula Lake outlet. The discharge site on Summers Creek is lined with riprap, reducing the risk of scouring and increased turbidity in the creek.

As the Project is located in a residential area the impact to large ranging mammals is expected to be minimal. Small-ranging animals, such as mice, voles, amphibians, and reptiles, may be affected by the Project through disturbance resulting in habitat avoidance or abandonment. The location of the drill site on a sandy beach reduces the risk of disturbance to den sites for the at-risk species of small range mammals (e.g. mountain beaver), as the at-risk species in the area generally den in forested areas and grasslands.

Works will take place within the vicinity of Missezula Lake. The distance between the well and lake is 10 m, and the equipment used during the aquifer testing poses minimal risk for erosion. The well will be chlorinated to disinfect the water before collecting a drinking water sample. This is done to prevent any potential microbial contamination from equipment used during works, which could otherwise affect the accuracy of the test results. After chlorination, the water will be de-chlorinated in a 5000 L pool to remove any remaining chlorine. This ensures that the sample is suitable for testing and safe for discharge into Summers Creek. Summers Creek flows out of Missezula Lake and both waterbodies are fish bearing. Fish present in Summers Creek, and to a lesser extent Missezula Lake, may be impacted by the temperature and chemical differences (i.e. DO and selenium) of the discharge water.

The groundwater sampled from WIPN 52992 exceeded chronic guidelines aquatic life and wildlife for total and dissolved selenium and for dissolved oxygen. These exceedances are expected to have minimal impact on aquatic species and wildlife for the following reasons:

- Chronic guidelines apply to five or more samples collected over a 30-day period and the water from WIPN 52992 will discharge into Summers Creek for 48 hours or less; therefore, any alterations to water quality are not anticipated to persist for 30 days or more.
- DO in the groundwater is expected to increase as it discharges into Summers Creek due to aeration of water as it flows onto the dry rip rap channel.
- Sodium ascorbate will be used to de-chlorinate the water prior to discharge which has less impacts to DO than other de-chlorination products (e.g. sodium ascorbate).
- Water from Missezula dam (water license 111484) can be discharged into Summers Creek if flows are low to increase dilution.

By following the mitigation measures described in this EMP, impacts will be minimized. No environmental permits or provincial approvals are anticipated for the Project.

The aquifer testing activities may result in the following potential environmental effects:

- *Introduction of deleterious substances to nearby waterbodies and residences.* The discharge from the pump test will enter Summers Creek. The discharged water exceeds aquatic life guidelines for total selenium and DO but is not expected to have deleterious effects on aquatic life due to short interval pumping, aeration of the discharge waters and dilution of discharge water (see detailed explanation above).

- *Increased turbidity.* If the discharge from the pump test enters Summers Creek where the channel is not lined with riprap, sedimentation may occur, which may result in temporary degradation of water quality in Summers Creek and Missezula Lake.
- *Increased water temperature.* The water discharged from the pump test will be approximately 8°C, while water in Summers Creek is anticipated to be between 5°C and 10°C. The temperature difference can pose a threat to fish and hibernating reptiles and amphibians.
- *Encroachment of Invasive Species.* The Project footprint is a sandy beach with minimal vegetation; therefore, there is a low risk of invasive species encroachment.
- *Disturbance to wildlife habitat.* Works may temporarily disturb wildlife habitat within or adjacent to the Project.
- *Disturbance to wildlife due to noise.* Continuous pumping during the pump test will be noisy and could disturb diurnal (e.g., birds calling) and nocturnal (e.g., hunting by birds of prey) activities of wildlife in the area.
- *Loss of vegetation.* The Project footprint is a sandy beach with minimal vegetation; therefore, no removal of vegetation is expected to occur.
- *Disturbance of fish in nearby waterbodies.* Increased flow in Summers Creek may disturb spawning fish species (i.e., mountain whitefish) instream.

7 ENVIRONMENTAL MANAGEMENT PRACTICES AND MITIGATION MEASURES

The following practices and mitigation strategies must be followed during the construction outlined above. These practices and procedures are intended to avoid or minimize environmental effects on water quality, soils, vegetation, wildlife, and wildlife habitat.

- Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia;¹⁰
- Erosion and Sediment Control Best Management Practices;¹¹ and
- A Field Guide to Fuel Handling, Transportation & Storage.¹²

The site-specific mitigation strategies in the following sections are intended to minimize potential negative effects of the Project on the environmental components in the Project.

7.1 Environmental Work Windows

The Project is expected to be completed on October 20, 2023, which is outside the breeding bird season and the migratory breeding window (April 1 to August 15). No tree removal is anticipated for the pump tests.

The instream work windows for species found in Summers Creek and Missezula Lake are detailed below. Works will not take place instream, but the discharge from WIPN 52992 has the potential to impact these species. Work will be conducted within the work window of rainbow trout. Work will occur outside the work window for kokanee salmon

¹⁰ British Columbia Ministry of Environment (MOE). 2014. Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia West Coast Region. Available at: <http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare/DWC-Section%205-8-WC-Region.pdf>

¹¹ Erosion and Sediment Control Association of BC. 2017. ESC Best Management Practices. Available at: <http://escabc.com/?page=BMPS>

¹² British Columbia Ministry of Water, Land and Air Protection (MWLAP). 2002. A Field Guide to Fuel Handling, Transportation & Storage. 3rd Edition. B.C. Ministry of Water. Land and Air Protection.

and mountain whitefish, but it should be noted that kokanee salmon in the watershed are restricted to stream inlets and Missezula Lake.

Species	Work Window
Kokanee (KO; stream spawning)	Jun 1 - Aug 31
Mountain Whitefish (WM)	May 1 - Sep 30
Rainbow Trout (RB)	Jul 22 - Oct 31

7.2 Environmental Monitoring

The Field Hydrogeologist from Associated will be on site during step test and constant rate pumping test. The Field Hydrogeologist will measure dissolved oxygen, temperature, turbidity, pH, and conductivity at a minimum of 1-hour intervals while onsite (~8 hours per day) during the step test and the first 8 hours of the constant rate pumping test.

7.3 Water Quality

Maintenance of water quality is an important objective of the Project. The EM will conduct water quality monitoring at a minimum rate of once per hour while onsite (~8 hours per day) to confirm that mitigation measures are effective and that turbidity in Summers Creek and Missezula Lake does not exceed the BC Approved Water Quality Guidelines, as follows:

- Change from background of 8 nephelometric turbidity units (NTU) at any one time for a duration of 24 hours in all waters during clear flows or in clear waters;
- Change from background of 2 NTU at any one time for a duration of 30 days in all waters during clear flows of in clear waters;
- Change from background of 5 NTU at any time when background is 8 to 50 NTU during high flows or in turbid waters; and
- Change from background of 10% when background is >50 NTU at any time during high flows or in turbid waters.

On Project completion, the site will be restored to its original condition to prevent any impacts to water quality. Any vegetated areas disturbed during drilling will be cleared of drilling waste, re-contoured to match the pre-disturbance topography, revegetated, and/or seeded with weed-free seed mix (Section 6.6).

7.4 Disturbance of Fish Species in Nearby Waterbodies

As the works are scheduled to take place during the mountain whitefish spawning period, the Environmental Monitor (EM) will conduct an initial assessment of Summers Creek before work commences to identify and document spawning fish locations. If spawning activities are identified, the EM will revisit these identified locations during the pumping test to ensure that the discharge from the test, which is anticipated to be 10% of the total flow, does not disrupt any ongoing spawning activities.

BC Approved Water Quality Guidelines has guidelines around acceptable rates of temperature change in fish bearing bodies of water. For aquatic life in freshwater streams, hourly rate of change cannot exceed $\pm 1^{\circ}\text{C}$, and in lakes temperatures cannot exceed an hourly rate of change of $\pm 0.5^{\circ}\text{C}$. There is potential for a moderate temperature difference to exist between the discharge water ($\sim 8^{\circ}\text{C}$) and the water in Summers Creek. An EM will be onsite to

monitor water temperature changes during the pump test. The EM will test water temperature hourly at three locations: the outlet of Missezula Lake, Summers Creek at the discharge and 100 m downstream of the discharge. If rate of change approaches the exceedance of $\pm 1^{\circ}\text{C}$ per hour in Summers Creek at the downstream monitoring location, then the valve from Missezula dam will be opened to increase flow into Summers Creek. If the rate of change continues to increase or exceeds $\pm 1^{\circ}\text{C}$ per hour in Summers Creek, the pumping test will be halted.

During this time DO will also be monitored to ensure it does not decline below the acute BC AL guideline of 5 mg/L.

7.5 Direct Loss of Vegetation Through Physical Disturbance

The contractor will implement the following measures to minimize loss of vegetation through physical disturbance:

- Do not remove mature trees unless their presence constitutes a threat to human safety. Obtain permission from the EM before removing any mature vegetation.
- Limit the removal of established grasses and forbs.
- Do not deposit material on native vegetation.
- Minimize damage to shrubs and ground cover, including the root zones. Contain all works within the footprint of the well (10 m x 10 m).

7.6 Encroachment of Invasive Species

The contractor will implement the following measures to prevent establishment and spread of invasive plant species and promote revegetation with desired species:

- Check all vehicles that enter the Project Area, and those that move between disturbed and undisturbed areas, for plant material to minimize the risk of encroachment of invasive species.
- Restore any exposed soil with certified weed-free grass and forb seed mix that is appropriate for the local area with a combination of quick germinating pioneer species and slow to establish but desired native species. Seed immediately on completion of drilling to prevent invasive plants from establishing.
- Clean all machinery and equipment to remove all plant material before entering or leaving the Project Area.

7.7 Erosion and Sediment Control

The contractor will implement following measures for erosion and sediment control (ESC) measures to mitigated impacts during the well pumping test:

- Discharge into Summers Creek where the channel has been lined with riprap.
- Monitor turbidity levels in Summers Creek and Missezula Lake.
- Ensure that the turbidity levels are within BC Approved Water Quality Guidelines for protection aquatic life (Section 7.4).
- Ensure no sediment is entering the summers creek from areas adjacent or upslope of the discharge.
- If sediment is entering the Summers Creek place silt fence properly keyed into the soil (6-10 cm deep) to mitigate the source.

7.8 Safe Material Storage and Waste Management

The contractor will implement the following measures for safe material storage and waste management:

- Store all materials on previously disturbed ground and separately from wastes.

- Cover any materials that are vulnerable to rain damage.
- Keep the Project Area tidy and clean at all times. Dispose of all routine waste materials (e.g., packaging, food waste, flagging, etc.) responsibly, in appropriate waste containers (e.g., bear-proof containers) and remove them from the site daily.
- Store hazardous materials (e.g., gasoline, lubricating oils) in secondary containment. Handle wastes generated during construction in a manner that prevents or minimizes loss, and that allows containment, including secondary containment, and recovery in the event of a spill.
- Keep an updated list of hazardous materials used in construction. Ensure that the on-site safety coordinator maintains material safety data sheets for any dangerous goods and controlled products proposed for use and make the sheets available to on-site personnel. Train all on-site personnel in the safe handling of hazardous materials.
- Clearly label hazardous materials and store them appropriately.
- Clearly mark hazardous waste disposal containers and keep them contained in a manner compliant with applicable legislation.
- Locate areas for fuel storage, handling, fuelling, and equipment repair/maintenance on flat, stable ground, away from sensitive ecosystems and at least 30 m from waterbodies.
- Ensure that fuel storage containers are no more than 5 years old and that they are sealed and labelled. Check them regularly for leaks, store them in secondary containment when on site.

7.9 Spill Prevention and Emergency Response

The contractor will implement the following measures for spill prevention and emergency response to spills:

- Ensure that all equipment and machines on site carries suitable spill kits that are appropriate for containing the greatest volume of spill possible given the type of machinery or equipment.
- Ensure that all equipment operators are familiar with the available spill kits and that they are trained on spill prevention measures.
- Ensure that all equipment, machinery, and tools are in good working order and clean of oil, grease, or other contaminants; biodegradable oils are not required for operating machinery.
- Locate areas for fuel storage, handling, fuelling, and equipment repair/maintenance on flat, stable ground, away from sensitive ecosystems and at least 30 m from waterbodies.
- Inspect equipment daily, or before use, for any leaks or excess oil or grease.

Any person who discovers a spill incident will immediately conduct an initial assessment of the magnitude of the problem and determine whether they can remedy the situation or if they require additional help. The drilling supervisor and EM should be notified of the spill. The BC Spill Response personnel will be contacted at their 24-hour emergency contact number (**1-800-663-3456**) for spills greater than 1 L. The following emergency response procedures will be implemented:

- Cease operations near the emergency.
- Assess the hazard to persons in the vicinity and ensure personal safety and the safety of others.
- Identify the product and the source of the spill.
- Assess whether the spill can be readily stopped, contained, or brought under control, and as safety permits, stop or control the spill.
- If a volatile, flammable material is spilled, immediately warn everyone in the vicinity, control the sources of ignition, and ventilate the area.

- Report the spill to the site supervisor and the EM without delay and obtain assistance as necessary.
- Perform or resume safe, effective action to contain and clean up spilled materials.
- Ensure that any spill kit waste materials are disposed of by a specialized hydrocarbon and hazardous waste service provider with a valid waste collection permit.

8 SITE CLOSURE AND REHABILITATION

The Project is expected to have minimal impact on vegetation and wildlife. If any vegetated areas are disturbed, reseedling of disturbed areas with an appropriate seed mix will be required (Section 7.6).

Questions regarding the contents of this environmental management plan or reports of wildlife encounters during drilling should be directed to the undersigned (250-241-7001) immediately.

Prepared by:



Renée Larsen, A.Ag.
Environmental Scientist

Reviewed by:



Heather Taylor, R.P.Bio.
Specialist, Regulatory Advisor



C:\USERS\ARSEN\DOCUMENTS\PROJECTS\MISSEZULA_LAKE\MISSEZULA_LAKE.APRX



- WIPN 43254
- WIPN 52992
- ★ Discharge Location
- Streams

AE PROJECT NO. 2023-8374
 SCALE 1:3,251
 COORD. SYSTEM NAD 1983 UTM ZONE 11N
 DATE 2023-10-16
 REV 00
 DRAWN BY RL
 CHECKED BY MG

FIGURE 1 - SITE OVERVIEW

REGIONAL DISTRICT OF
 OKANAGAN-SIMILKAMEEN

MISSEZULA LAKE WATER
 SYSTEM UPGRADE

Appendix B – Pumping Test Schedule

Table B-1
Pumping Test Schedule

Mon, Oct 16	Associated and Aqua Tech mobilize to site, measure static water level, install pump, install Associated's datalogger, chlorinate well to 100 ppm and recirculate overnight. Setup de-chlorination pool and discharge hoses.
Tues, Oct 17	Four one hour step tests, stepping up no more than 40 USgpm (2.5 L/s) each step, starting at 90 USgpm (5.7 L/s) and finishing at 210 USgpm (13.2 L/s; anticipated steps 90, 130, 170, 210 USgpm). Recovery readings for four hours. Discharge water conveyed to de-chlorination pool, complete de-chlorination and only discharge water into Summers Creek that has a chloring concentration of 0 ppm. The pool is 1500 gallon (5,678 L), and one well volume is 310 L, allowing for 18 well volumes to be de-chlorinated at one time. Typically, chlorine is removed within the first three to five well volumes. The de-chlorination product is sodium ascorbate and the amount of produce used will be calculated for the removal of 100 ppm chlorine. Since DO in the ground water was slightly below BC AL and BC WL guidelines, we will implement a monitoring plan for DO with mitigation actions if DO is at risk of declining below 5 mg/L in Summers Creek (Section 7.4).
Wed, Oct 18	24 or 48 hour constant rate test (CRT) at rate that will be determined based on results of step test (ideally 13.2 L/s, 210 USgpm). Discharge water discharged directly to Summers Creek. AE to collect water samples from sampling port at approximately two and six hrs into CRT.
Thur, Oct 19	CRT will extend to 48 hour interval if deemed necessary. Associated will advise based on the following: If water level has drawn down into confined aquifer, continue CRT to 48 hours (likely). If water level remains above confined aquifer, cease CRT at 24 hours (unlikely). Associated will collect water sample from sampling port 24 hrs into CRT.
Friday, Oct 20	Terminate CRT when instructed by Associated. Leave pump installed and record recovery for four hours. Remove pump and re-install Associated's datalogger downhole, chlorinate well, and demobilize.

Appendix C – Listed Plant and Wildlife Species

Table C-1
Listed Plants and Communities with Typical Habitat

Species	BC Status	Typical Habitat
Cascade Rockcress (<i>Boechera cascadiensis</i>)	Blue	Conifer forest and sparsely vegetated rock
Columbian Carpet Moss (<i>Bryoerythrophyllum columbianum</i>)	Blue	Moderate elevation grassland steppe and ledges and bluffs near rivers
Cusick's Paintbrush (<i>Castilleja cusickii</i>)	Blue	Moist valleys and mountain foothills and meadows
Heart-Leaved Springbeauty (<i>Claytonia cordifolia</i>)	Blue	Conifer forest and sparsely vegetated rock
Slender Collomia (<i>Collomia tenella</i>)	Red	Conifer forests, grasslands, sagebrush steppe, and sparsely vegetated rock.
Suksdorf's Monkey-Flower (<i>Erythranthe suksdorfii</i>)	Blue	Rock and sparsely vegetated rock
Sulphur Lupine (<i>Lupinus sulphureus</i>)	Blue	Grassland shrub
Whitebark Pine (<i>Pinus albicaulis</i>)	Blue	Conifer forest and sparsely vegetated rock
Alkaline Wing-Nerved Moss (<i>Pterygoneurum kozlovii</i>)	Blue	Grassy edges of alkaline depressions
Short-Flowered Evening-Primrose (<i>Taraxia breviflora</i>)	Red	Grasslands and sagebrush steppe

Source: BC Conservation Data Centre. 2022. Red-listed species or subspecies (taxa) are those at risk of being lost (extirpated, endangered, or threatened); Blue-listed species are those of special concern. Status under *Species at Risk Act* (SARA): federally designated species listed as Extirpated, Endangered, Threatened, or of Special Concern are listed in SARA Schedule 1. Note: ¹ Based on habitat suitability.

Table C-3: Fish Species Documented in Missezula Lake and Summers Creek

Species	BC Status	Waterbody
Rainbow Trout (<i>Oncorhynchus mykiss</i>)	Yellow	Summers Creek Missezula Lake
Brook Trout (<i>Salvelinus fontinalis</i>)	Exotic	Summers Creek Missezula Lake
Peamouth Chub (<i>Mylocheilus caurinus</i>)	Yellow	Missezula Lake
Pygmy Whitefish (<i>Prosopium coulterii</i>)	Yellow	Missezula Lake

Species	BC Status	Waterbody
Kokanee Salmon (<i>Oncorhynchus nerka</i>)	N/A	Mishezula Lake
Bering Cisco (<i>Coregonus laurettae</i>)	N/A	Mishezula Lake
Northern Pikeminnow (<i>Ptychocheilus oregonensis</i>)	Yellow	Mishezula Lake
Longnose Sucker (<i>Catostomus Catostomus</i>)	Yellow	Mishezula Lake
Mountain Whitefish (<i>Prosopium williamsoni</i>)	Yellow	Mishezula Lake
Largescale Sucker (<i>Catostomus macrocheilus</i>)	Yellow	Mishezula Lake
Chiselmouth (<i>Acrocheilus alutaceus</i>)	Yellow	Mishezula Lake
Slimy Sculpin (<i>Cottus cognatus</i>)	Yellow	Summers Creek
Mottled Sculpin (<i>Cottus bairdii</i>)	N/A	Summers Creek
Sucker (General)	N/A	Mishezula Lake
Chub (General)	N/A	Mishezula Lake

APPENDIX E – PUMPING TEST DATA

Appendix E - Table E-1
Pumping Test Water Level Data
Pumping Well (WIPN 52992)



Well ID:	WIPN 52992	Static Water Level (m bd)	21.25	(69.73 ft) measured Oct 16 PM prior to pump install	Datum (m atoc)	0.05 (0.177 ft/2.125 inches)
Start Date/Time	Oct 17, 2023 @ 9:00 (CRT) Oct 19, 2023 @ 9:00 (recovery)	Pre-Test Water Level (m bd)	21.44	(70.33 ft) measured 12+ hrs after pump install	Stick-up (m)	0.762 (2.50 ft)
Client	RDOS	Total Well Depth (m btoc)	39.23	(128.7 ft btoc)	Available drawdown (m)	10.72
Project	2023-8374.000.002	Pump Intake Depth (m bd)	34.14	(112 ft)	Top of pump assembly (m bd)	32.16 (105.5 ft btoc)
Test	Step Tests	Pump Used	Goulds 225H20 turbine		Datalogger (m bd)	32.16 (105.5 ft btoc)
Contractor	Aqua Tech	Pumping Rate (L/s)	5.68	90 (USgpm)	Barologger	hanging on fence during tes
Date	Clock Time	Time Elapsed (min)	Depth to Water (m bd)	Depth to Water (ft 1/10 bd)	Drawdown (m)	Flow Rate (Usgpms) + Comments
October 17, 2023	09:00:00	0	21.44	70.33	0.00	90 US gpm
	09:01:00	1	22.48	73.74	1.04	
	09:02:00	2	23.62	77.48	2.18	
	09:03:00	3	23.93	78.50	2.49	
	09:04:00	4	24.18	79.32	2.74	
	09:05:00	5	24.41	80.09	2.97	
	09:06:00	6	24.61	80.73	3.17	
	09:07:00	7	24.79	81.32	3.35	
	09:08:00	8	24.95	81.85	3.51	
	09:09:00	9	25.10	82.35	3.66	
	09:10:00	10	25.23	82.79	3.79	
	09:12:00	12	25.49	83.63	4.05	
	09:14:00	14	25.72	84.38	4.28	
	09:16:00	16	25.91	85.00	4.47	
	09:18:00	18	26.09	85.61	4.65	
	09:20:00	20	26.25	86.11	4.81	
	09:25:00	25	26.59	87.25	5.15	
		30	26.87	88.17	5.43	
		35	27.12	88.99	5.68	
		40	27.35	89.72	5.91	
		50	27.69	90.86	6.25	
		60	27.97	91.75	6.53	
		70	28.19	92.48	6.75	
		80	28.38	93.11	6.94	
		90	28.54	93.65	7.10	
	10:40:00	100	28.67	94.05	7.23	
		120	28.88	94.74	7.44	
	11:20:00	140	29.03	95.24	7.59	
	11:40:00	160	29.14	95.61	7.70	
	12:00:00	180	29.22	95.86	7.78	
	12:20:00	200	29.29	96.10	7.85	

Appendix E - Table E-1
Pumping Test Water Level Data



Date	Clock Time	Time Elapsed (min)	Depth to Water (m bd)	Depth to Water (ft 1/10 bd)	Drawdown (m)	Flow Rate (Usgpms) + Comments
	13:10:00	250	29.39	96.44	7.95	
	14:00:00	300	29.46	96.65	8.02	
	14:50:00	350	29.52	96.86	8.08	
	15:40:00	400	29.55	96.96	8.11	
	16:30:00	450	29.57	97.00	8.13	
	17:20:00	500	29.58	97.04	8.14	
	19:00:00	600	29.61	97.13	8.17	
	20:40:00	700	29.63	97.21	8.19	
	22:20:00	800	29.64	97.24	8.20	
October 18, 2023	00:00:00	900	29.66	97.30	8.22	
	01:40:00	1000	29.67	97.35	8.23	
	03:20:00	1200	29.72	97.51	8.28	
	05:00:00	1400	29.73	97.55	8.29	
	06:40:00	1600	29.74	97.58	8.30	
	08:20:00	1800	29.73	97.54	8.29	
	10:00:00	2000	29.73	97.53	8.29	
		2200	29.71	97.49	8.27	
		2400	29.70	97.44	8.26	
		2600	29.68	97.37	8.24	
		2800	29.66	97.30	8.22	
October 19, 2023	09:00:00	2880	29.64	97.25	8.20	
	09:00:00	0	29.64	97.25	8.20	% RECOVERY
		1	28.12	92.26	6.68	19%
		2	27.75	91.04	6.31	23%
		3	27.49	90.18	6.05	26%
		4	27.27	89.48	5.83	29%
		5	27.04	88.73	5.60	32%
		6	26.85	88.10	5.41	34%
		7	26.66	87.47	5.22	36%
		8	26.47	86.86	5.03	39%
		9	26.31	86.31	4.87	41%
	09:10:00	10	26.14	85.76	4.70	43%
		12	25.84	84.79	4.40	46%
		14	25.60	83.98	4.16	49%
		16	25.38	83.26	3.94	52%
		18	25.18	82.60	3.74	54%
	09:20:00	20	24.99	82.00	3.55	57%
		25	24.59	80.68	3.15	62%
		30	24.25	79.56	2.81	66%
		35	23.96	78.61	2.52	69%
	09:40:00	40	23.72	77.81	2.28	72%
		45	23.52	77.16	2.08	75%
		50	23.35	76.61	1.91	77%
	10:00:00	60	23.09	75.75	1.65	80%
		70	22.88	75.08	1.44	82%

Appendix E - Table E-1
Pumping Test Water Level Data



Date	Clock Time	Time Elapsed (min)	Depth to Water (m bd)	Depth to Water (ft 1/10 bd)	Drawdown (m)	Flow Rate (Usgpms) + Comments
		80	22.71	74.51	1.27	85%
		90	22.56	74.01	1.12	86%
		100	22.42	73.55	0.98	88%
	11:00:00	120	22.19	72.80	0.75	91%
		140	21.91	71.89	0.47	94%
		160	21.84	71.65	0.40	95%
	12:00:00	180	21.78	71.46	0.34	96%
		200	21.74	71.33	0.30	96%
	13:00:00	240	21.71	71.22	0.27	Pump and datalogger pulled. Datalogger reinstalled shortly after.
	14:00:00	300	21.65	71.03	0.21	97%
	18:27:00	567	21.49	70.50	0.05	99%
October 20, 2023	07:08:00	1328	21.66	71.07	0.22	97%
	12:16:00	1636	21.36	70.09	-0.08	101%
	18:28:00	2008	21.34	70.02	-0.10	101%
October 21, 2023	07:43:00	2803	21.32	69.94	-0.12	Final measurement. Dataloggers pulled by Randy Woods midday.

Appendix E - Table E-2
Pumping Test Water Level Data
Observation Well (WIPN 43254)



Well ID:	WIPN 43254 (observation well)	Static Water Level (m btoc)	21.34	(70.02 ft)	Datum	top of casing
Start Date/Time	Oct 17, 2023 @ 9:00 (CRT on WIPN 52992) Oct 19, 2023 @9:00	Pre-Test Water Level (m btoc)	21.37	(70.10 ft)	Stick-up (m)	0.67 (2.2 ft)
Client	RDOS	Total Well Depth (m)	30.48 (100 ft) based on well log - not measured		Available drawdown (m)	NA
Project	2023-8374.000.002	Pump Intake Depth (m bd)	NA		Top of pump assembly (m bd)	NA
Test	CRT on WIPM 52992 (5 m away)	Pump Used	NA		Datalogger	NA - manual measurements
Contractor	Aqua Tech	Pumping Rate (L/s)	NA - observation well		Barologger	NA

Clock Time	Clock Time	Time Elapsed (min)	Depth to Water (m)	Depth to Water (ft 1/10)	Drawdown (m)	Flow Rate (Usgpsms) + Comments
October 17, 2023	09:00:00	0	21.37	70.10	0.00	
	09:01:00	1	21.37	70.10	0.00	
	09:02:00	2	21.37	70.10	0.00	
	09:03:00	3	21.37	70.10	0.00	
	09:04:00	4	21.37	70.10	0.00	
	09:05:00	5	21.37	70.10	0.00	
	09:06:00	6	21.37	70.10	0.00	
	09:07:00	7	21.37	70.10	0.00	
	09:08:00	8	21.37	70.10	0.00	
	09:09:00	9	21.37	70.11	0.00	
	09:10:00	10	21.37	70.12	0.00	
	09:12:00	12	21.37	70.12	0.00	
	09:14:00	14	21.38	70.13	0.01	
	09:16:00	16	21.38	70.13	0.01	
	09:18:00	18				missed reading
	09:20:00	20	21.38	70.15	0.01	
	09:25:00	25	21.39	70.17	0.02	
		30	21.40	70.20	0.03	
		35	21.40	70.22	0.03	
		40	21.41	70.25	0.04	
		50	21.42	70.28	0.05	
		60	21.43	70.30	0.06	
		70	21.46	70.40	0.09	
		80	21.48	70.47	0.11	
		90	21.50	70.53	0.13	
	10:40:00	100	21.52	70.60	0.15	
		120	21.56	70.73	0.19	
	11:20:00	140	21.60	70.86	0.23	
	11:40:00	160	21.64	71.00	0.27	
	12:00:00	180	21.68	71.14	0.31	
	12:20:00	200	21.73	71.29	0.36	

Appendix E - Table E-2
Pumping Test Water Level Data



Clock Time	Clock Time	Time Elapsed (min)	Depth to Water (m)	Depth to Water (ft 1/10)	Drawdown (m)	Flow Rate (Usgpsms) + Comments
	13:10:00	250	21.85	71.67	0.48	
	14:00:00	300	21.97	72.09	0.60	missed reading
	14:50:00	350	22.10	72.51	0.73	
	15:40:00	400	22.24	72.95	0.87	
	16:30:00	450	22.36	73.37	0.99	
	17:20:00	500	22.50	73.82	1.13	
	19:00:00	600	22.77	74.70	1.40	
	20:40:00	700	23.02	75.54	1.65	
	22:20:00	800	23.27	76.35	1.90	
October 18, 2023	00:00:00	900	23.51	77.12	2.14	
	01:40:00	1000	23.72	77.81	2.35	
	03:20:00	1200	24.09	79.02	2.72	
	05:00:00	1400	24.42	80.11	3.05	
	06:40:00	1600	24.70	81.05	3.33	
	08:20:00	1800	24.94	81.84	3.57	
	10:00:00	2000	25.15	82.52	3.78	
		2200	25.33	83.11	3.962	
		2400	25.49	83.62	4.117	
		2600	25.62	84.04	4.245	
		2800	25.73	84.41	4.358	
		2880	25.76	84.52	4.392	
October 19, 2023	09:00:00	0	25.76	84.52	4.392	% RECOVERY
		10	25.76	84.52	4.392	0%
		20	25.76	84.52	4.392	0%
		30	25.76	84.51	4.389	0%
		40	24.84	81.51	3.474	21%
		45	24.59	80.67	3.218	27%
		50	24.42	80.12	3.05	31%
		60	24.14	79.21	2.77	37%
		72	23.88	78.36	2.51	43%
		80	23.71	77.80	2.34	47%
		90	23.55	77.25	2.18	50%
		100	23.39	76.75	2.02	54%
	11:00:00	120	23.15	75.94	1.78	60%
		140	22.92	75.21	1.55	65%
		160	22.77	74.71	1.40	68%
	12:00:00	180	22.68	74.41	1.31	70%
		200	22.60	74.16	1.23	72%
	13:00:00	240	22.49	73.78	1.12	logger re-installed shortly after.
October 19, 2023	14:00:00	300	22.38	73.44	1.01	77%
	18:20:00	560	21.98	72.10	0.61	86%
October 20, 2023	07:04:00	1324	21.39	70.17	0.02	100%
	12:12:00	1632	21.62	70.92	0.25	94%
	18:32:00	2012	21.57	70.78	0.20	95%
October 21, 2023	07:40:00	2080	21.52	70.60	0.15	97%

Data Set: C:\Users\rileyd\Desktop\WCS Projects\RDOS - Missezula Lake - 2023-8374\PumpTestAnalysis_PW_Only

Date: 07/11/24

Time: 12:11:51

PROJECT INFORMATION

Company: Associated Environmental

Client: RDOS

Project: 2023-8374

Location: Missezula Lake

Test Date: 2023-10-17

Test Well: WIPN 52992

AQUIFER DATA

Saturated Thickness: 11.92 m

Anisotropy Ratio (K_z/K_r): 1.PUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: WIPN 52992

X Location: 0. m

Y Location: 0. m

Casing Radius: 0.0762 m

Well Radius: 0.0762 m

Partially Penetrating Well

Depth to Top of Screen: 6.8 m

Depth to Bottom of Screen: 10.7 m

No. of pumping periods: 2

<u>Pumping Period Data</u>			
<u>Time (min)</u>	<u>Rate (L/sec)</u>	<u>Time (min)</u>	<u>Rate (L/sec)</u>
0.	5.678	2880.	0.

OBSERVATION WELL DATA

No. of observation wells: 1

Observation Well No. 1: WIPN 52992

X Location: 0. m

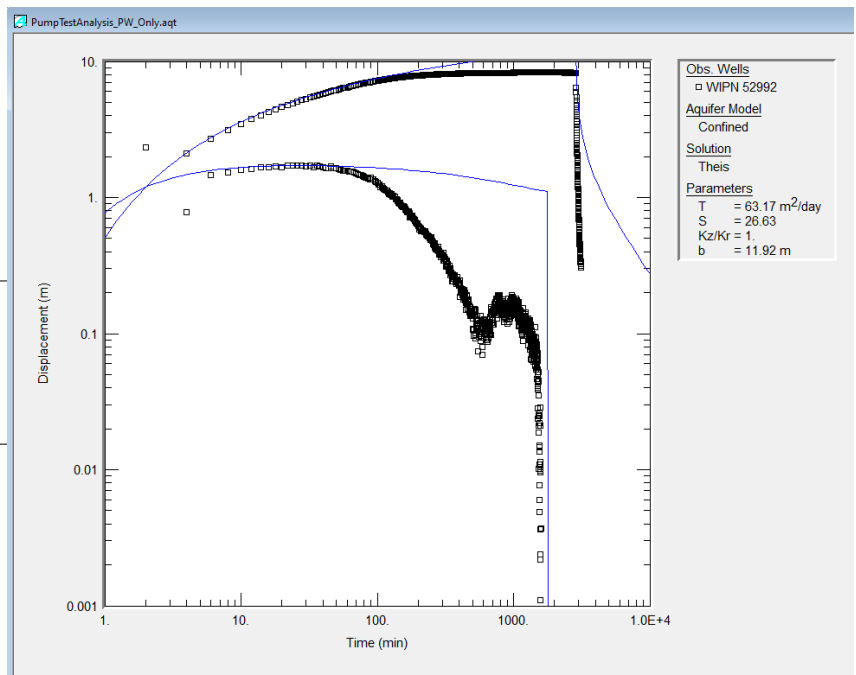
Y Location: 0. m

Radial distance from WIPN 52992: 0. m

Partially Penetrating Well

Depth to Top of Screen: 6.8 m

Depth to Bottom of Screen: 10.7 m



Data Set: C:\Users\rileyd\Desktop\WCS Projects\RDOS - Missezula Lake - 2023-8374\PumpTestAnalysis_PW_Onl

Date: 07/11/24

Time: 12:51:26

PROJECT INFORMATION

Company: Associated Environmental

Client: RDOS

Project: 2023-8374

Location: Missezula Lake

Test Date: 2023-10-17

Test Well: WIPN 52992

AQUIFER DATA

Saturated Thickness: 11.92 m

Anisotropy Ratio (K_z/K_r): 1.Aquitard Thickness (b'): 1. mAquitard Thickness (b''): 1. mPUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: WIPN 52992

X Location: 0. m

Y Location: 0. m

Casing Radius: 0.0762 m

Well Radius: 0.0762 m

Partially Penetrating Well

Depth to Top of Screen: 6.8 m

Depth to Bottom of Screen: 10.7 m

No. of pumping periods: 2

Pumping Period Data			
Time (min)	Rate (L/sec)	Time (min)	Rate (L/sec)
0.	5.678	2880.	0.

OBSERVATION WELL DATA

No. of observation wells: 1

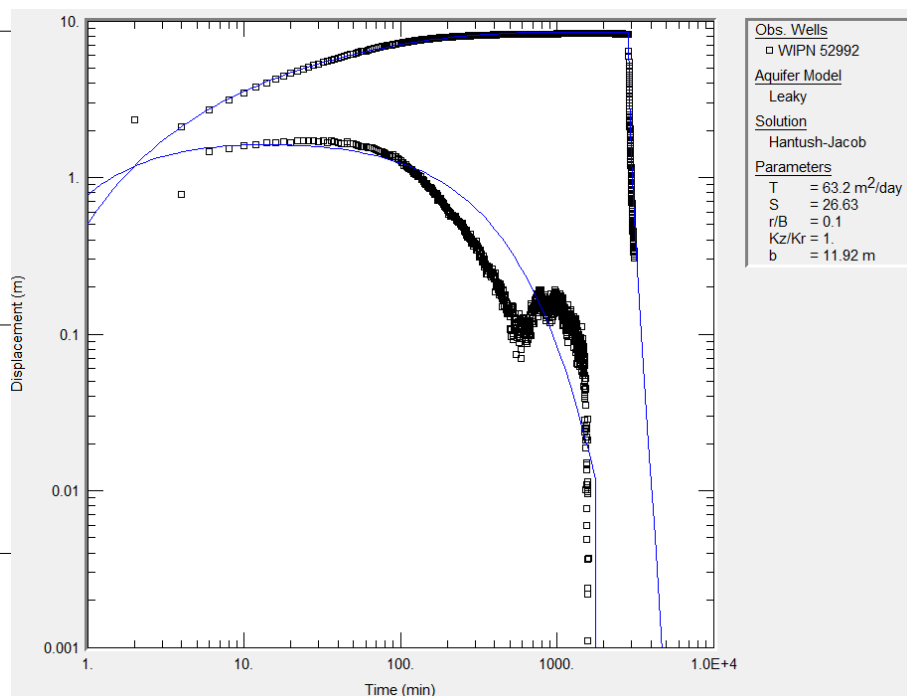
Observation Well No. 1: WIPN 52992

X Location: 0. m

Y Location: 0. m

Radial distance from WIPN 52992: 0. m

Partially Penetrating Well



APPENDIX F – OPINION OF PROBABLE COSTS

Appendix F-1: Treatment Assumptions of Opinion of Probable Cost Estimates

Option 1 - Surface Water	Option 2 - Groundwater	Option 3 - Groundwater (Simplified)
Capital Costs		
Treatment facility sized for 7.6 L/s maximum capacity	Treatment facility sized for 8.6 L/s maximum capacity Requires a network of wells capable of providing 8.6 L/s of groundwater supply.	Treatment facility sized for 11 L/s maximum capacity Requires a network of wells capable of providing 11 L/s of groundwater supply.
Treatment equipment enclosed in pre-fabricated structure	Treatment equipment enclosed in pre-fabricated structure	Treatment equipment enclosed in pre-fabricated structure
No redundant DAF unit (i.e. no standby unit) No redundant media filter (i.e. no standby unit) N+1 redundancy for chemical pumps.	No redundant media filter (i.e. no standby unit) N+1 redundancy for chemical pumps.	Includes one additional manganese filtration unit as contingency (N+1 redundancy). N+1 redundancy for chemical pumps.
System uses treated water from the distribution system to backwash filters.	System uses treated water from the distribution system to backwash filters and hydraulic clean membranes.	System uses treated water from the distribution system to backwash filters.
Costs based on scenario that all WTP, storage, and residual management infrastructure can all fit at one site.	Costs based on scenario that all WTP, storage, and residual management infrastructure can all fit at one site.	Costs based on scenario that all WTP, storage, and residual management infrastructure can all fit at one site.
Costs based on construction site in an already environmentally disturbed site with no tree clearing, blasting, and minimal excavation or fill required.	Costs based on construction site in an already environmentally disturbed site with no tree clearing, blasting, and minimal excavation or fill required.	Costs based on construction site in an already environmentally disturbed site with no tree clearing, blasting, and minimal excavation or fill required.
Includes allowance for civil site work, electrical upgrades and electrical service fees.	Includes allowance for civil site work, electrical upgrades and electrical service fees.	Includes allowance for civil site work, electrical upgrades and electrical service fees.
Waste discharged to a lagoon or drying bed for discharging the supernatant to environment.	Includes waste holding tank, sized for residuals generated when running WTP at maximum capacity for four days (800 m3)	Includes residuals equalization tank to allow constant discharge flow of residuals to the environment.
Plan for treatment equipment to be offline for 1 hr/day for filter backwashes Includes on-site storage tank sized for 1 hour treated water (for 7.6 L/s, storage volume 28 m3)	Plan for treatment equipment to be offline 1 hr/day for routine cleanings of manganese removal filter and RO membranes. Includes on-site storage tank sized for 1 hour treated water (for 8.6 L/s, storage volume 31 m3)	
Cost of upgrading existing intake not included.	Cost to install groundwater supply well network not included.	Cost to install groundwater supply well network not included.
Annual and Lifecycle Costs		
Chemical and power consumption based on annual average flow from WTP equal to 40% of the WTP's maximum design capacity.	Chemical and power consumption based on annual average flow from WTP equal to 40% of the WTP's maximum design capacity.	Chemical and power consumption based on annual average flow from WTP equal to 40% of the WTP's maximum design capacity.
Average 5 hours of operator support/week at \$65/hr	Average 5 hours of operator support/week at \$65/hr	Average 5 hours of operator support/week at \$65/hr
Average power rate of \$0.15 /kWh	Average power rate of \$0.15 /kWh	Average power rate of \$0.15 /kWh
Average chlorination dose of 1.0 mg/L	Average chlorination dose of 1.0 mg/L	Average chlorination dose of 1.0 mg/L
Cost of periodic sludge removal from residuals lagoon or drying bed not included in estimates.	Collection of accumulated residuals and offsite disposal not included in estimate.	Collection of accumulated residuals and offsite disposal not included in estimate.
4% Annual Discount Rate used to calculate present value of lifecycle costs.	4% Annual Discount Rate used to calculate present value of lifecycle costs.	4% Annual Discount Rate used to calculate present value of lifecycle costs.
Annual miscellaneous costs for maintenance and parts replacement calculated as 1% of mechanical capital costs, plus 1% of electrical costs, and 0.2% of structural costs.	Annual miscellaneous costs for maintenance and parts replacement calculated as 1% of mechanical capital costs, plus 1% of electrical costs, and 0.2% of structural costs.	Annual miscellaneous costs for maintenance and parts replacement calculated as 1% of mechanical capital costs, plus 1% of electrical costs, and 0.2% of structural costs.
Cost of replacing chemical pumps included every 10 years.	Cost of replacing chemical pumps included every 10 years.	Cost of replacing chemical pumps included every 10 years.
Cost of replacing filter backwash pumps included every 15 years.	Cost of replacing membrane permeate and backpulse pumps, and media filter backwash pumps included every 15 years.	Cost of replacing media filter backwash pumps included every 15 years.
Cost of media replacement included every 10 years.	Cost of replacing filter backwash pumps included every 15 years. Cost of replacing membrane cartridges every 6 years.	Cost of media replacement included every 10 years.

Appendix F-2: Capital Opinion of Probable Costs

Description	Option 1 - Surface Water	Option 2 - Groundwater	Option 3 - Groundwater (Simplified)
Pre-fabricated water treatment plant	\$ 1,600,000	\$ 1,600,000	\$ 1,400,000
Treated water storage	\$ 50,000	\$ 60,000	\$ -
Residuals management infrastructure	\$ 50,000	\$ 1,145,000	\$ -
Civil site work	\$ 200,000	\$ 200,000	\$ 150,000
Electrical connections and service upgrades allowance	\$ 100,000	\$ 100,000	\$ 100,000
Contractor indirect costs (15%)	\$ 300,000	\$ 470,000	\$ 250,000
Subtotal	\$ 2,300,000	\$ 3,575,000	\$ 1,900,000
Engineering & Contingency (30%)	\$ 690,000	\$ 1,072,500	\$ 570,000
Total	\$ 2,990,000	\$ 4,647,500	\$ 2,470,000

Appendix F-3: Operations and Maintenance Opinion of Probable Costs

Description	Option 1 - Surface Water	Option 2 - Groundwater	Option 3 - Groundwater (Simplified)
Annual Labour Costs	\$ 20,000	\$ 20,000	\$ 20,000
Annual Chemical Costs	\$ 400	\$ 23,400	\$ 500
Annual Power Costs	\$ 19,000	\$ 23,700	\$ 20,700
Annual Replacement Costs	\$ 14,100	\$ 16,300	\$ 12,300
Annual Costs Total	\$ 53,500	\$ 83,400	\$ 53,500
20-Year Lifecycle Cost - Present Value	\$ 3,770,000	\$ 5,970,000	\$ 3,260,000

APPENDIX G – RDOS REGIONAL CONNECTIONS PROJECT WEBSITE



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Missezula Lake Water System Upgrade Investigation

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The Missezula Lake Water System (MLWS) is a small water system located 45 kilometres north of Princeton, BC. The system provides drinking water to approximately 190 residential/seasonal lots.

The MLWS was built in 1972 by Arvec Construction, which originally drew source water from Dillard Creek. A chlorination building and a chlorine contact main were also present in the Dillard Creek area to provide a single barrier of treatment and a chlorine residual throughout the distribution system.

In 2002 an upgrade project was carried out, which replaced the creek intake with a raw water intake in Missezula Lake. This upgrade project also included the construction of the chlorination building, chlorine contact chamber, high lift pump station, and emergency power supply generator building.

May 17, 2024

Work continues on the Missezula Lake Water System Upgrade project. Find out more by clicking on the link below.

<https://rdosregionalconnections.ca/38738/widgets/181826/documents/130265>
(<https://rdosregionalconnections.ca/38738/widgets/181826/documents/130265>)

Information Session Bulletin - August 8, 2024



**Missezula Lake
Water System
Information Session**
Thursday, August 8, 2024
9:00 to 10:30 am

Join the electronic meeting to ask questions

<https://rdos.webex.com>
Meeting #: 2773 653 3108 Password: RD@S
or via phone: 1-833-311-4101

Presentation by: RDOS Utilities Department and
Associated Environmental Consultants (AE)

Topics: Information session on the current
status of the Missezula Lake Water System.
Question and answer session to follow.



More information:
<https://rdosregionalconnections.ca>
or contact Myron Semegen, RDOS Project Manager at 250-490-4117

Missezula Lake Water System Information Session Presentation File - August 8, 2024

Presentation File

Missezula Lake Water System Upgrade Information Presentation

(https://rdosregionalconnections.ca/download_file/655/609)

PDF (2.78 MB)



A presentation of the work that has been
done to identify and review the various
water sources and treatment options
available to the Missezula Lake property
owners.

Missezula Lake Water System Information Session, Webex Meeting Recording - August 8, 2024

Recording of the information presentation session held on August 8, 2024.

Missezula Lake Water System Information Session Recording - August 8, 2024
(<https://rdos.webex.com/rdos/ldr.php?RCID=d46b6f36ca027210fffab9557101c180>)



**Missezula Lake Newsletter Spring
2024.pdf**
PDF (7.56 MB)

(https://rdosregionalconnections.ca/download_file/607/609)

Key Dates



Thursday, August 08, 2024 9:00 am to 10:30 am

Missezula Lake Water System upgrade information session

Online information session on the current status of the Missezula Lake Water System. Presentations by the RDOS Utilities department and Associated Environmental Consultants (AE). Question and answer session to follow.

Join the electronic meeting:

<https://rdos.webex.com> (<https://rdos.webex.com>)

Meeting #: 2773 653 3108

Password: RD@S

or via phone: 1-833-311-4101



1 March 2023

Contract Consultant to perform Engineering Analysis of Ground Water Supply



13 March 2023 to 13 April 2023

Project Initiation, project Management and Background Review



3 April 2023 to 30 May 2023

Water Sampling and Aquifer Testing

See more

Who's Listening



Liisa Bloomfield

Senior Manager of Utilities, RDOS

Phone: 250-490-4229



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Project Manager - Engineering Technologist, RDOS

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Darcy Kirkpatrick

Administrative Assistant, RDOS

Phone: 250-490-4112

Email: dkirkpatrick@rdos.bc.ca (mailto:dkirkpatrick@rdos.bc.ca)

Lifecycle



Project Initiation and Background Review

Gather and review all available information from past reports and other available sources, including information on hydrology, climate, soils, aquifers, and wells in the area. We will review and assess the test hole drilling report.



Water Sampling and Aquifer Testing

Water sample collection, pumping test contractor, site mobilization, constant rate pumping test, water sample collection and analysis.



Liaison with Regulatory Agencies and Utilities

Liaise with BC Ministry of Forest, Interior Health and BC Utilities in support conceptual design of production well.



Conceptual Design

Prepare the design of the production well, including location, material, diameter, depth and screen length, and specifications.

Outline the treatment and storage requirements to tie into existing MLWS infrastructure.



Conceptual Design Report

Complete evaluation of the groundwater compared to existing Missezula Lake source. Prepare Class D cost estimate for capital, operational and maintenance expenses.

[See less](#)

Contact Us

Have questions or want to learn more about a project, contact us below:



250-492-0237



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Mishezula Lake Water System Improvement Project

Conceptual Design Phase: Update to the Community before selecting an option and moving to detailed design

Marta Green, P.Geo., Keith Kohut, P.Eng.,
Dörte Köster, R.P.Bio.

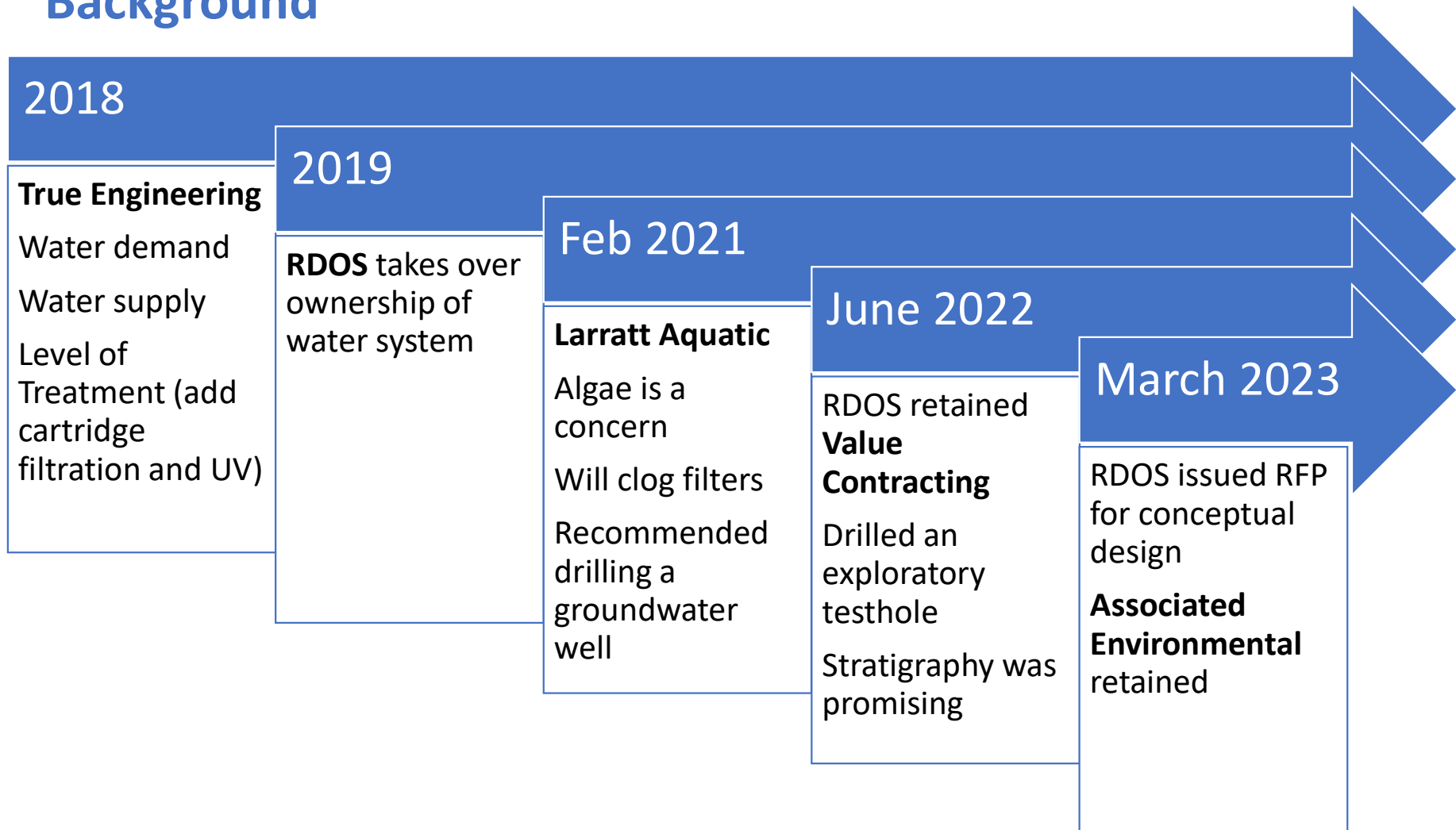


Presentation Outline

- Why the project (objective)
- What has been done to date
- Well drilling and pumping test results
- Treatment Options
- Recommendations
- Next steps



Background



Project Objectives: Water Source and Treatment

“What is the **best water source and treatment option** to meet Interior Health drinking water treatment objectives, knowing that we need to **address algae?**”

“How do we **incorporate treatment for algae into the successful funding grant and borrowing limits** as a constraint?”

Algae

- Larrat Aquatic (2021) described the lake ecosystem
- "High algae densities during the late summer and early fall ... increased raw water turbidity above 1 NTU"
- Blue-green algae (potential toxin-producers) are present, but not in concerning numbers
- Diatom algae can significantly reduce filtration efficiency, particularly during the spring bloom (June-July)



Figure 17: Diatom algae removed from clogged drinking water filter

Associated's Work to Date

Sept 19 2023

Attempted to sample from existing well – **pumped sand.**

Drilled a second well.

October 17 2023

Pumping test

Well yield **did not meet maximum day demand**

Groundwater quality **exceeded guidelines** for manganese and high TDS

Required a pivot to re-evaluate lake

November 2023

Brought in **engineering**

Contacted suppliers to **add DAF and switch from cartridge filters to a vessel filter**

April 2024

Budgets came in **really high \$5-6M!**

Went back to suppliers with a new adjusted “ask”:

“What volume can you flow through a package plant within budget constraint?”

July 2024

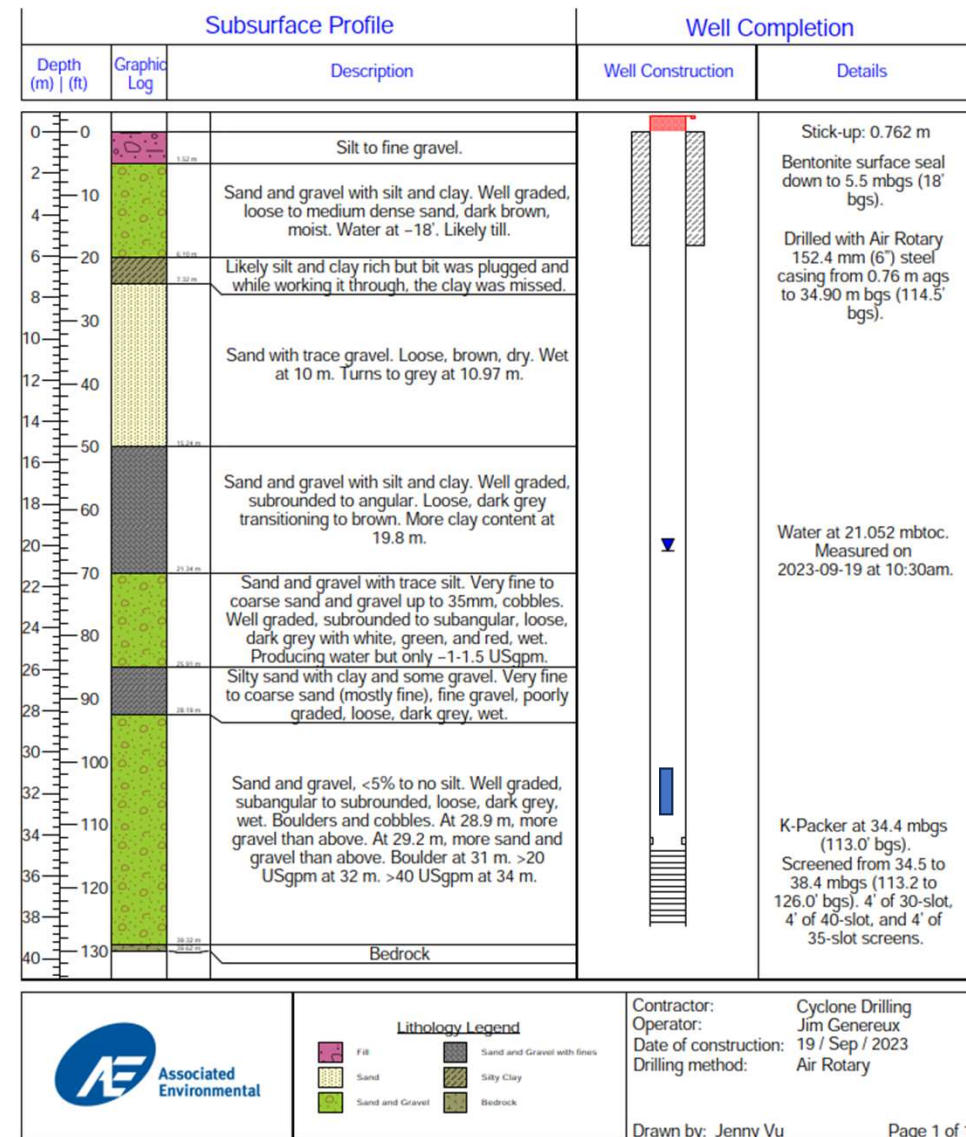
Residual management and dilution modeling

Reviewed other risks/project constraints

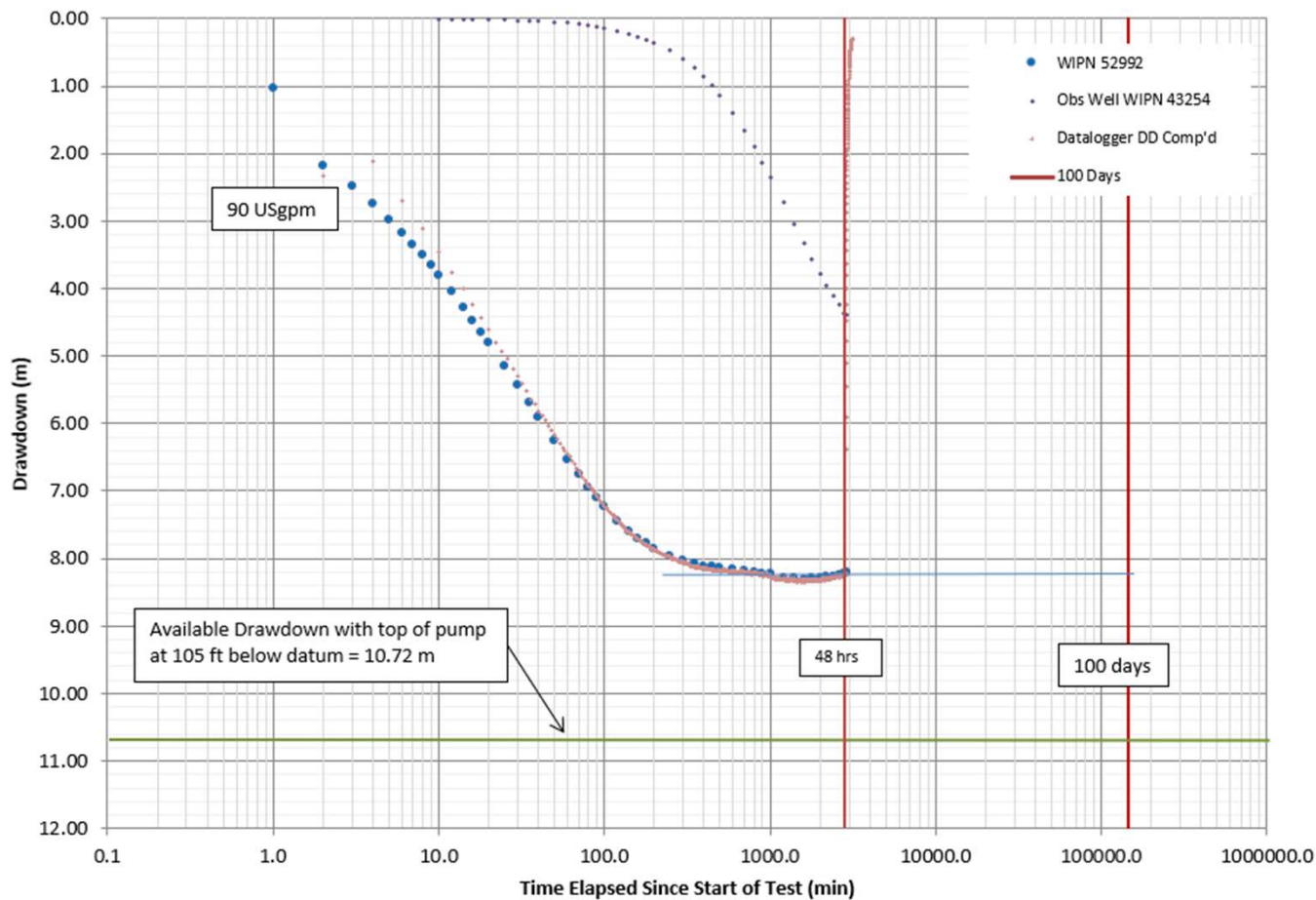
Summary of options

Groundwater Well Drilling and Testing Results

- Stratigraphy:
 - 0-26 m: SAND
 - 26.19-28.19m: Sand with silt and clay (aquitard)
 - 28.19-39.62m: SAND and GRAVEL AQUIFER (11.43 m thick)
 - 39m: Bedrock
- Screened from 113-126 ft (34.5-38.4 m) deep. Static water level: 20.63 mbgs. Available drawdown: 10.7m (with top of pump set at 31.3 m bgs)
- 4 m of screen: 30 and 40 slot, gives a theoretical screen transmitting capacity: 220-230 USgpm (13.9-14.5 L/s) but the driller's air lift test was at 90 USgpm (5.7 L/s)



Groundwater Quantity – Pumping Test

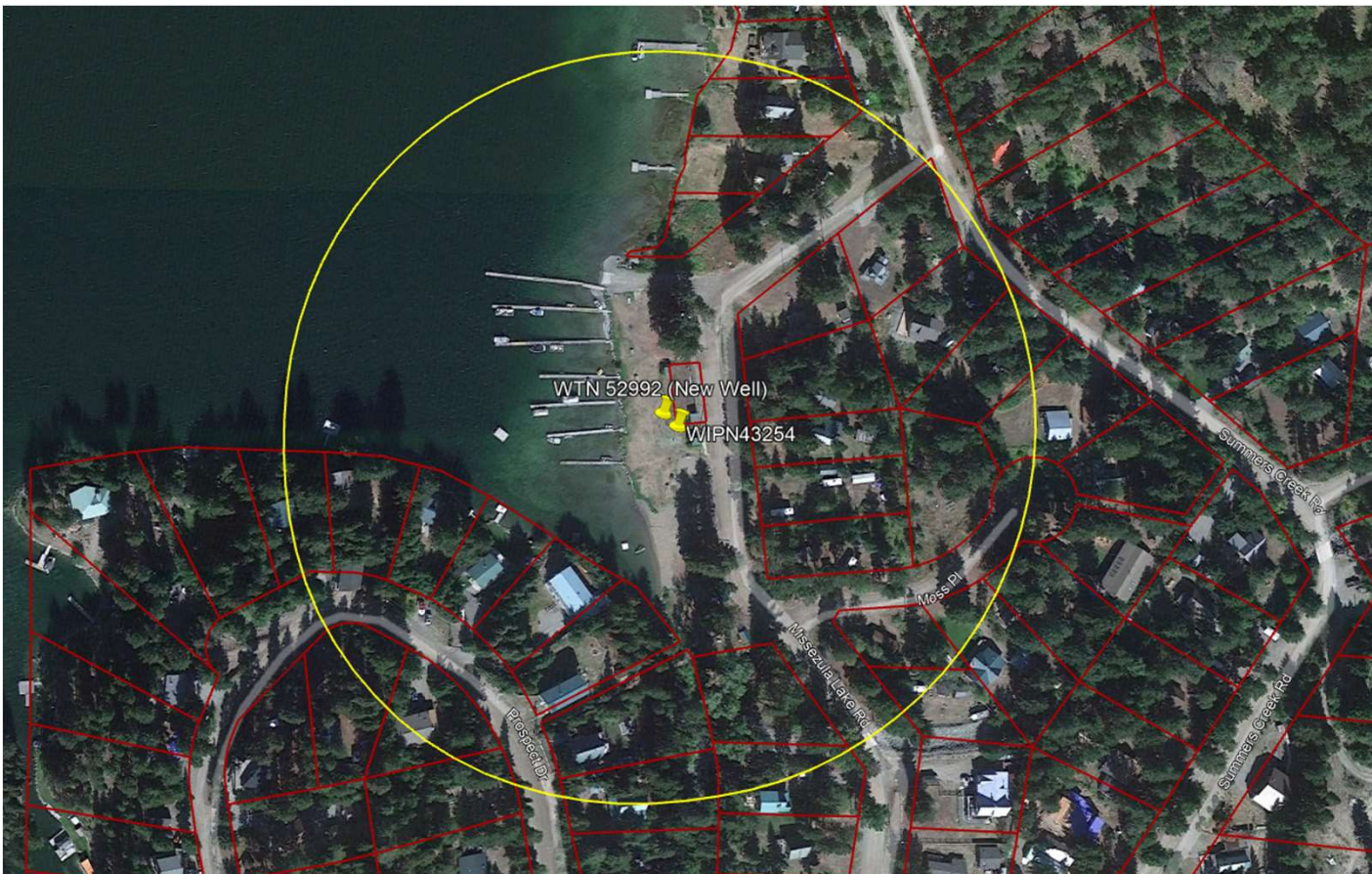


- Test pumping rate: 90 USgpm (5.7 L/s)
- Water level stabilizes (flat lines) indicating recharge to the aquifer
- Response indicates a leaky aquifer, i.e., recharge is from an upper aquifer
- Limited available drawdown (10.7m) due to low static water level and thin aquifer
- Sustainable well yield calculated to be 81.5 USgpm (5.1 L/s) with 30% safety factor

Well yield (groundwater availability) compared to Demand

Unit	m³/d	USgpd	USgpm	L/s	Notes
Water Demand					
ADD	284	75,000	52.1	3.29	From True 2018 report page 11.
MDD	776	205,000	142.4	8.98	From True 2018 report page 11. This is what you aim for wells to achieve. Based on 190 lots x 4 persons/lot x 350 lpcd, plus some allowance for water loss and outdoor watering.
PHD	1080	285,300	198.1	12.50	From True 2018 report page 11.
2023-07-31 Actual flow	950	250,964	174.3	11.00	From RDOS records. RDOS looking into the reason for high flow the summer of 2023.
1.5 times MDD	1164	307,500	213.5	13.5	Industry standard for pumping tests (from ISC guideline - probably best guideline on this topic in BC)
Water Supply/Groundwater Availability					
Water licence	444.379	117,393	81.5	5.14	This is averaged over the whole year, so reasonable to assume the community will stay under this volume since only a dozen homes or so in winter.
New well yield	441.482	116,640	81.0	5.10	The newly drilled well sustainable well yield with 30% safety factor. A second well with similar yield, would be needed to meet MDD (combined would be 162 USgpm, or 10.20 L/s), but no room for a second well.

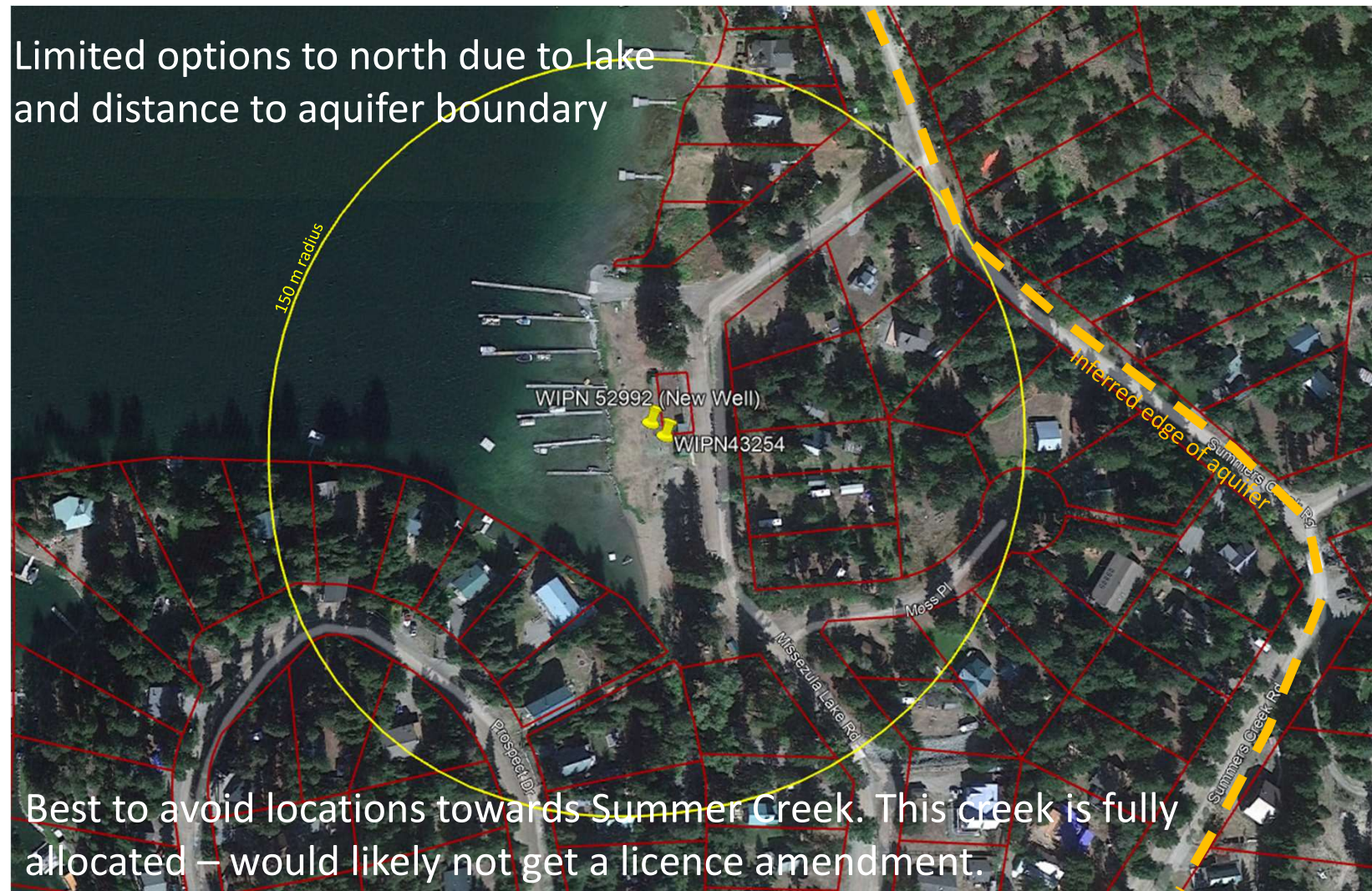
Groundwater Quantity – Well Interference and Second Well Location



- Estimated well interference from pumping test to determine where a second well could be placed
- Location about 150 m away estimated to have 2.5 m drawdown
- If second well constructed here (assuming identical aquifer) nearly all available drawdown used if both wells pumping

Groundwater Quantity – Second Well Location

Limited options to north due to lake and distance to aquifer boundary



Raw Water Quality

Parameter	Surface Water Samples	Groundwater Samples	GCDWQ Objective
Turbidity	0.61 – 1.07 (Ave 0.84)	0.88 – 1.21 (Ave 1.045)	< 1.0
Hardness (mg/L as CaCO ₃)	133 – 146 (Ave 140)	464 – 583 (Ave 527)	See note
Algae	Present in summer	-	-
Total Iron (mg/L)	< 0.01	0.19 – 0.20 (Ave 0.19)	≤0.3
Total Manganese (mg/L)	0.001 – 0.002 (Ave 0.002)	0.13 – 0.16 (Ave 0.15)	≤ 0.02 (AO) ≤ 0.12 (MAC)
Total Dissolved Solids (TDS; mg/L)	165 – 187 (Ave 176)	708	≤500

AO = aesthetic based standard, not health-based

MAC = health-based standard

Note: Not official limit for hardness, though hardness > 500 is considered very hard

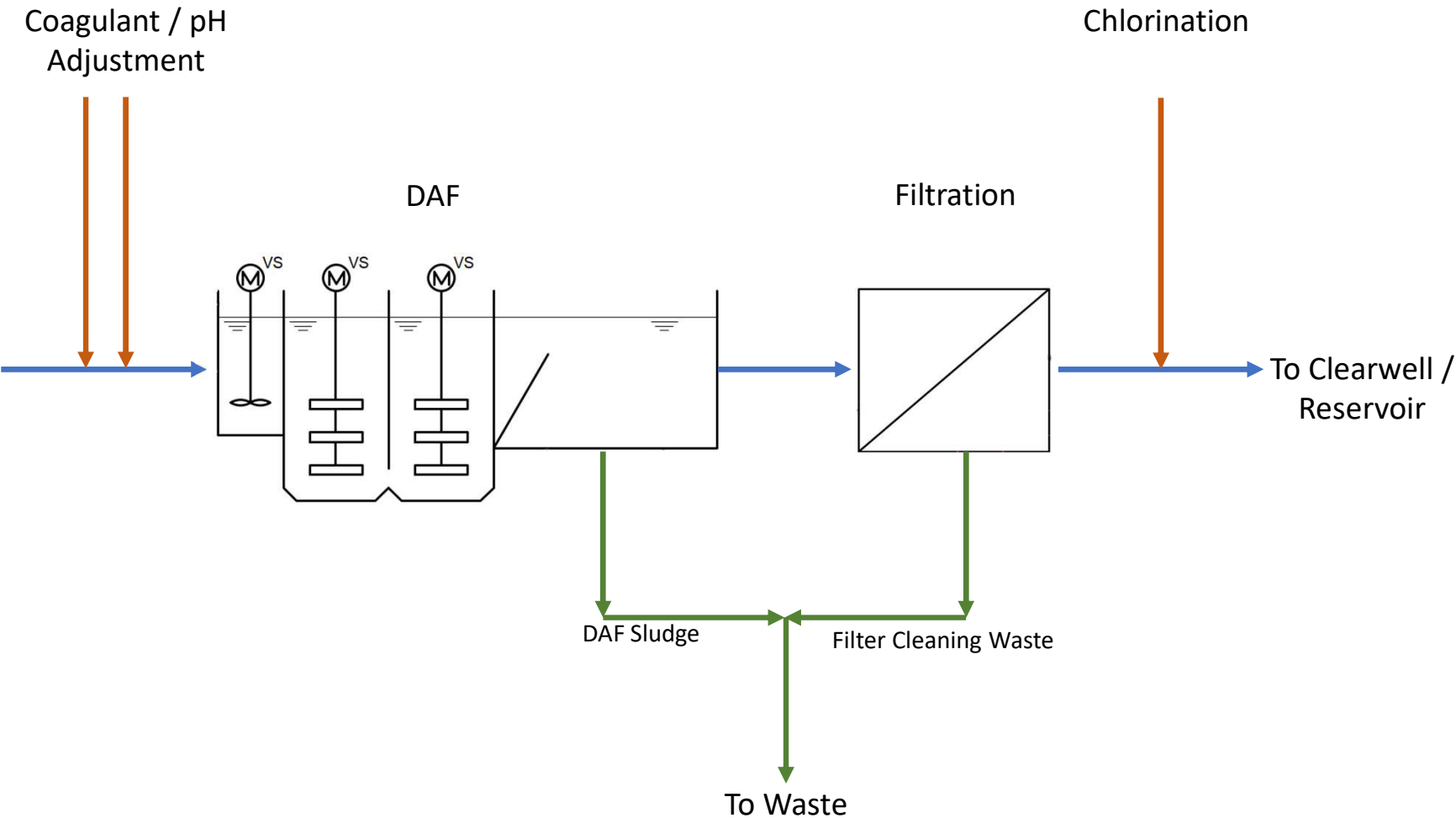
Treatment Objectives

Option	Surface Water	Groundwater
Treatment for Microorganisms	<i>Cryptosporidium</i> <i>Giardia</i> Viruses	Viruses
Treatment for Physical / Chemical Parameters	Turbidity Algae	Manganese
Other Physical / Chemical Parameters	-	Hardness TDS

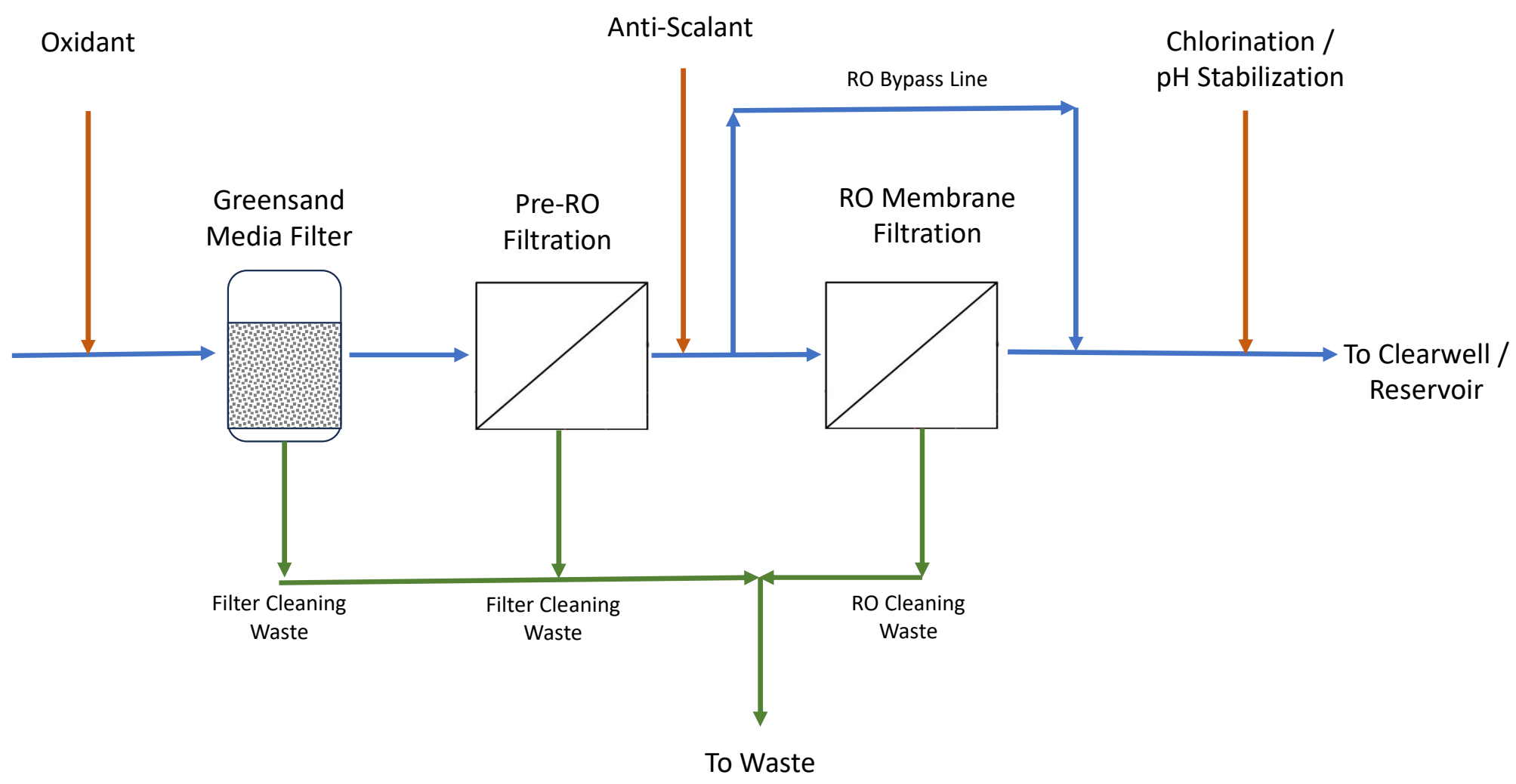
Hardness and TDS

- Hardness: 527 mg/L as CaCO_3 (Health Canada 1979)
 - Over 500 mg/L is considered very hard. 17 out of 525 cities in Canada had hardness above 500 mg/L (Ont and Sask)
 - No aesthetic or health-based guideline but guidelines states “Those in excess of 500 mg/L are unacceptable for most domestic purposes”
 - Leads to scaling of hot water pipes, boilers and other household appliances
 - Increases soap consumption
 - Water softener can be used to reduce hardness but due to sodium a separate unsoftened supply is recommended for drinking and cooking purposes
- TDS: 708 mg/L (Health Canada 1991)
 - Aesthetic objective is 500 mg/L.
 - Above that can cause scaling and can change taste and odour
 - <600 mg/L considered to be “good” palatability, >1200 mg/L “unpalatable” to most

Option 1 – Surface Water: Typical Treatment



Option 2 – Groundwater: Typical Treatment

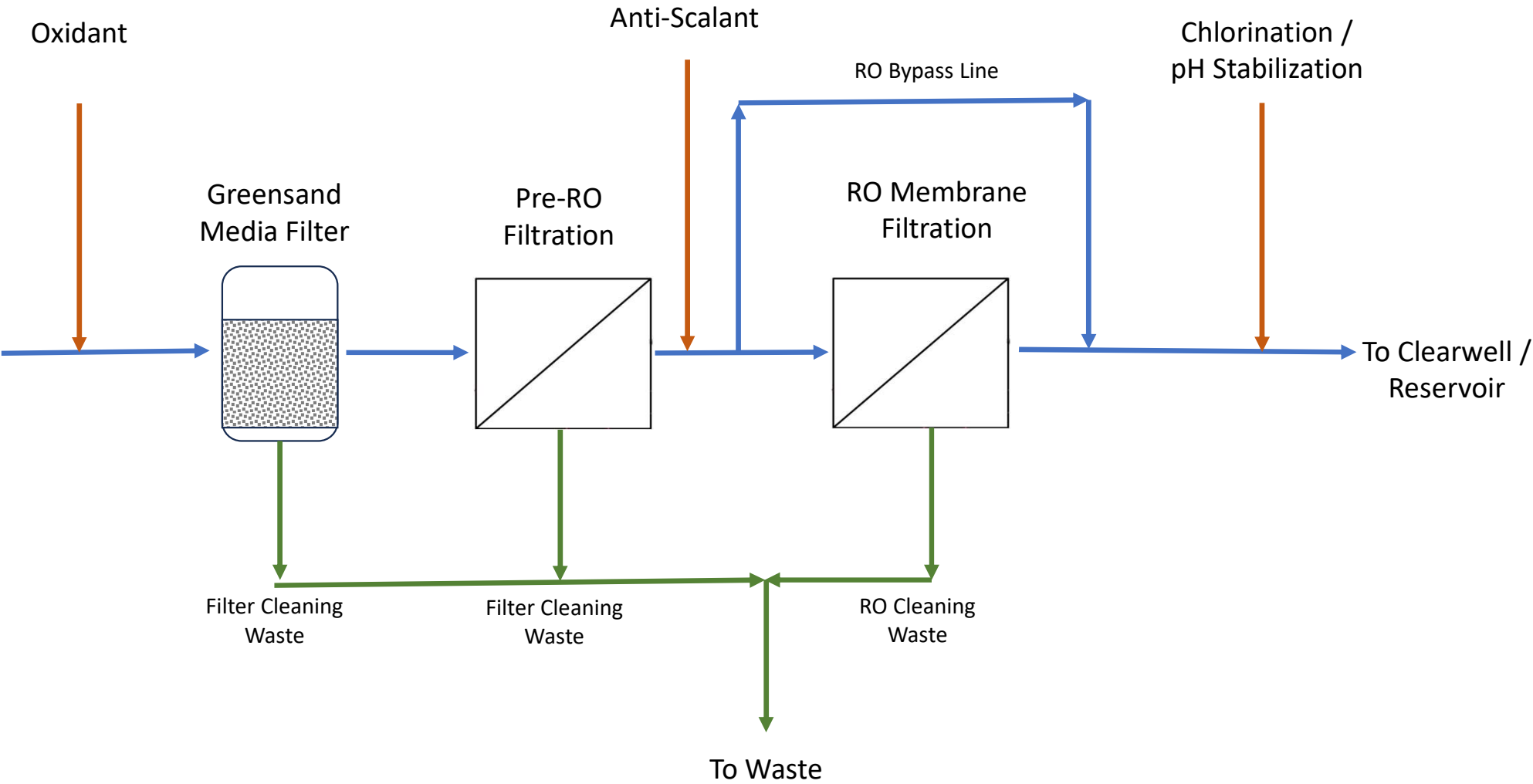


Capital Cost Constraints (WTP only)

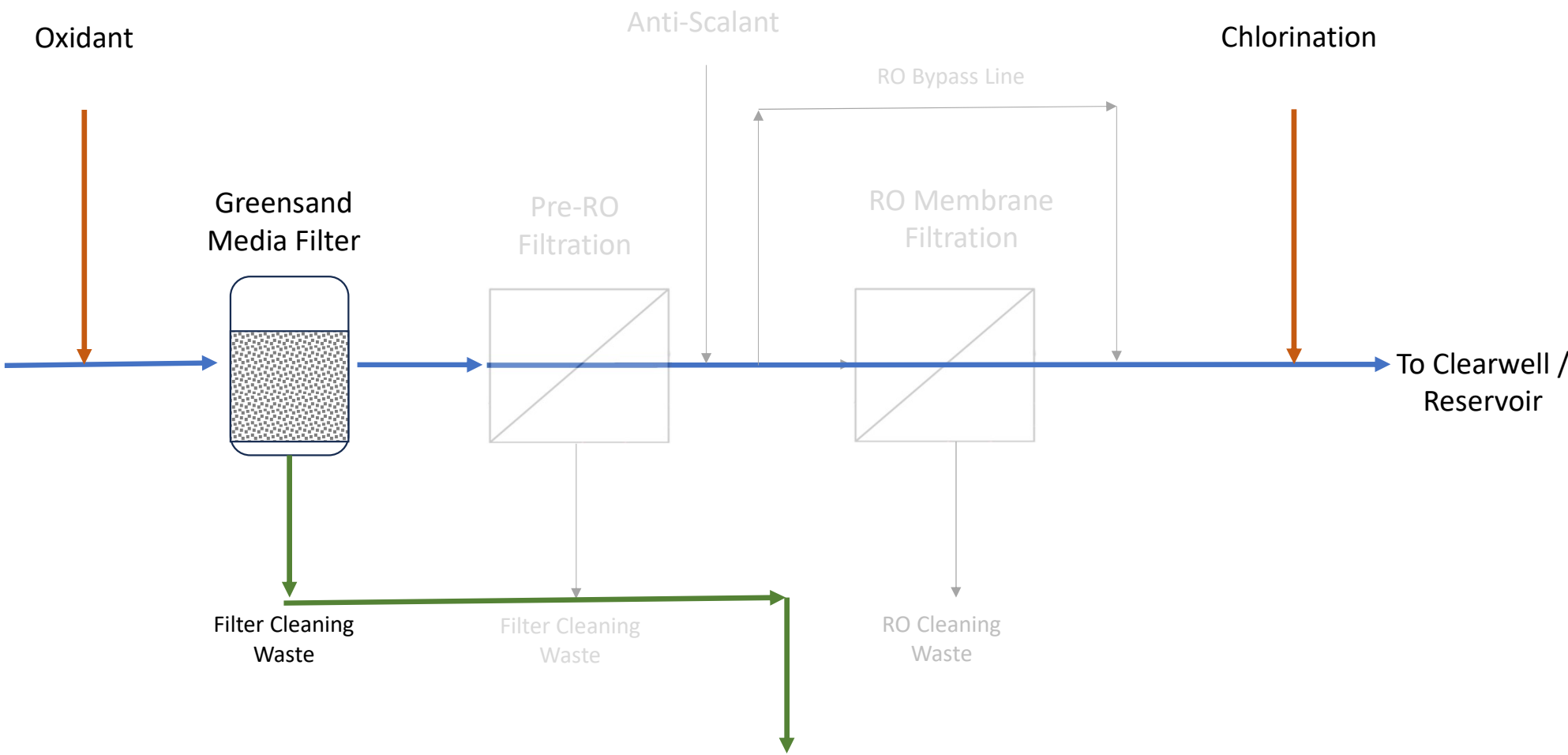
Water Source	Option 1 – Surface Water	Option 2 - Groundwater
Design Flowrate	11 L/s	11 L/s
Housing	New building, built on site	New building, built on site
Redundancy	N+1 for all equipment	N+1 for all equipment
Capital Cost (OPC – Class “D”)	\$4.8 m	\$5.0 m
30% Engineering & Contingency	\$ 1.4 m	\$1.5 m
Total Estimate	\$6.2 m	\$6.5 m
Cost per Flow (\$ per L/s)	\$564,000 / L/s	\$591,000 / L/s

Note: Class “D” Opinion of Probable Cost accurate to +/- 50%

Option 2 – Groundwater: Typical Treatment



Option 3 – Groundwater (Simplified)
(TDS and hardness not addressed)



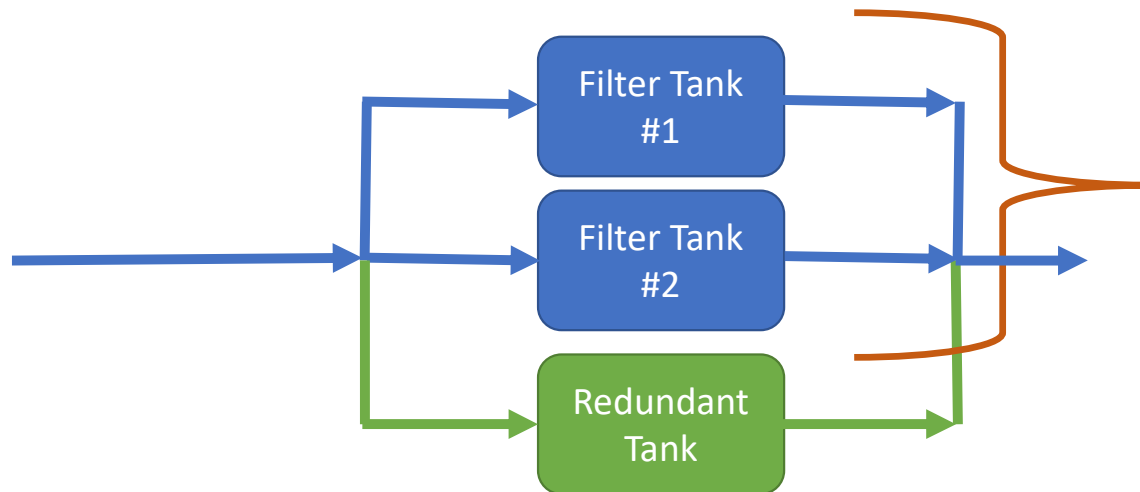
What can we do?

Water Source	Revised Option 1 – Surface Water	Revised Option 2 – Groundwater	Revised Option 3 – Groundwater (Simplified)
Design Flowrate	~~11 L/s~~ 7.6	~~11 L/s~~ 8.6 (Well restricted to 5.1 L/s)	11 L/s (Well restricted to 5.1 L/s)
Housing	~~New building, built on site~~ Prefab structure	~~New building, built on site~~ Prefab structure	Prefab structure
Redundancy	~~N+1 for all equipment~~ No redundant DAF / filters	~~N+1 for all equipment~~ No redundant filters / RO units	N+1 for all equipment
WTP Capital Cost (OPC – Class “D”)	\$1.6 m	\$1.6 m	\$1.4 m
30% Engineering & Contingency	\$0.5 m	\$0.5 m	\$0.4
Total Estimate	\$2.1m	\$2.1 m	\$1.8

Note: Class “D” OPC accurate to +/- 50%

What “no redundancy” means

- Redundant (i.e. backup) treatment equipment is industry best practice and recommended in the “Design Guidelines for Drinking Water Systems in BC”
- Options 1 & 2 have no redundant treatment processes (for budgetary reasons)
- Option 3 we can fit “n+1” redundancy within the target budget
 - i.e. we are including one additional filter vessel and chemical pump more than what is needed



- In this example, two tanks are needed to treat flow
- A third tank is installed as redundancy / back-up

Redundancy for Missezula treatment options

- The filter systems will need downtime for cleaning, around 1 hr/day
 - For Option 3, the redundant/extra filter vessel will come online while one vessel is being cleaned.
 - Max flow through the WTP can be maintained at all times.
 - Options 1 and 2 will have reduced flow or have to pause operation when filters are being cleaned
- Need storage to supply treated water during that downtime
 - Option 1 = 36 m³ of storage for 1 hr of max WTP flow
 - Option 2 = 31 m³ of storage for 1 hr of max WTP flow
 - Option 3 – no storage needed because redundant processes turn on when the main equipment is offline for cleaning. Max flow through WTP can be maintained at all times.

Redundancy and “the unexpected”

- Redundant units also give you backup equipment in case the unexpected shuts down the primary equipment
- For Option 3, if something goes offline, the redundant equipment comes on line.
 - This buys the operator time to respond and resolve the issue
- For Options 1 & 2, if something goes offline, no redundant equipment is available to pick up the slack.
 - An immediate response by the operator is required to restore full flow through the WTP

Residual Waste Considerations

Description	Option 1 – Surface Water	Option 2 – Groundwater	Option 3- Groundwater (Simplified)
Waste Generated	• DAF sludge • Filter backwash waste	• Greensand media backwash waste • RO hydraulic cleaning waste • RO chemical cleaning waste (neutralized) • Spent cartridge filters	• Greensand media backwash waste
Waste Flows	• 0.4 L/s	• 2.3 L/s	• 0.1 L/s

Residuals Discharge to Receiving Environment (Summer Creek)

	Option 1 – Surface Water	Option 2 – Groundwater	Option 3 – Groundwater (Simplified)
Main limitation	Aluminum exceedance	Insufficient dilution	None
Dilution (rule: >40 min)	155 x	27 x	620 x
Residuals Flow	0.4 L/s	2.3 L/s	0.1 L/s
Creek Flow	EFN* (62 L/s)	EFN* (62 L/s)	EFN* (62 L/s)
Downstream water quality assessment	Aluminum guideline exceeded	Guidelines met	Guidelines met
Regulatory Implications (Effluent Discharge Application to Ministry of Environment)	Approval unlikely without adding residuals management (settling lagoon/box) – not modeled yet	Approval only possible if no other options are available (dilution low)	Approval likely

*EFN = Environmental Flow Needs. Actual creek flows may be lower in drought years or for several day if debris accumulates and stops flow before weir gate is fixed/maintained and debris removed. Recommend during detailed design to further assess alternative disposal options whenever flow is less than the EFN.

Surface Water – How do we get the alum out of the waste?



- Separate into sludge and water
- Aluminum trapped in sludge
- Examples:
 - Lagoons
 - Drying beds
 - Geotubes
 - Gravity thickeners



Revised Capital Costs (WTP only)

Water Source	Option 1 – Surface Water	Option 2 - Groundwater	Option 3 – Groundwater (simplified treatment)
Design Flowrate	7.6 L/s	8.6 L/s (5 L/s ¹)	11 L/s (5 L/s ¹)
WTP Capital Cost (OPC – Class “D”)	\$1.6 m	\$1.6 m	\$1.4 m
Extra Storage for Redundancy	\$85,000	\$65,000	-
Residuals Management	\$200,000	??	-
Subtotal	\$1.9 m	> \$1.6 m	\$1.4 m
30% Engineering & Contingency	\$0.6 m	> \$0.5 m	\$0.4 m
Total Estimate²	\$2.5 m	> \$2.1 m	\$1.8 m
Cost per Flow (\$ per L/s)	\$329,000 / L/s	> \$244,000 / L/s	\$164,000 / L/s

Note 1: Pricing is based on 11 L/s, but the well yield is 5 L/s and a second well at a similar well yield is not likely to be successful. As a result, costs will be lower than these estimates.

Note 2: Class “D” OPC accurate to +/- 50%

O&M Considerations

Water Source	Option 1 – Surface Water	Option 2 – Groundwater	Option 3 – Groundwater (Simplified)
O&M Considerations			
Labour	Visit 1-2 times/week	- Visit 1-2 times/week - Prefiltration maintenance	Visit 1-2 times/week
Power Consumption	- Lights and heating - Process chemical pumps - DAF mixers - DAF sludge skimmer - DAF compressor - DAF recycle pump - DAF sludge pump - Filter backwash pumps	- Lights and heating - Process chemical pumps - Filter backwash pumps - Membrane permeate pumps - Membrane hydraulic cleaning pumps - Membrane chemical circulation pumps - Membrane chemical cleaning dosing pumps	- Lights and heating - Process chemical pumps - Filter backwash pumps - Waste recycle pumps
Chemicals	- Sodium hypochlorite - Soda ash - Polymer - Chlorine waste neutralizer	- Sodium hypochlorite - Anti-scalant - Membrane cleans (chlorine) - Membrane cleans (acid) - Chlorine waste neutralizer - Acid waste neutralizer	Sodium hypochlorite

* QUANTIFYING CHEMICAL AND ENERGY COSTS WILL DEPEND ON WHAT WE SET AS THE “AVERAGE” FLOW

Pros & Cons

Description	Option 1 – Surface Water	Option 2 – Groundwater	Option 3 – Groundwater (Simplified Treatment)
Pros	• Already have licenses for surface water use.	• Treatment also removes hardness from water.	• Includes redundant treatment equipment. • Lowest operational complexity.
Cons	• Budget does not allow any redundancy in treatment equipment. • Additional treatment needed for waste management – sludge disposal offsite will be needed. • Waste discharge permit required. • Lake pumping upgrades will be required.	• Budget does not allow any redundancy in treatment equipment. • High volume of waste – difficult to dispose of. • Waste discharge permit required. • Potentially frequent replacement of spent cartridge filters needed. • Will require the community to reduce consumption by half	• Water hardness not treated. Water softeners hard on septic fields • Waste discharge permit required. • Will require the community to reduce consumption by half

Recommendations (depends on priorities)

1. Abundant, softer water, higher cost

= Option 1: Lake source, with DAF, media filtration, chlorination

- Investigate redundancy (storage of treated water) for “the unexpected”
- Investigate waste stream for aluminum (add lagoon/drying beds and recalculate dilution in Summer Creek)

2. Limited quantity (half current use), hard water, and lower cost

= Option 3: Groundwater Source with filtration to remove manganese and chlorination to remove viruses (but no hardness or TDS removal)

- Water auditing and water conservation planning
- Water Licence Amendment application to switch from surface water to groundwater

Next Steps

1. Present results to date to community (this presentation)
2. Complete Draft Report
3. RDOS to finalize option selection
4. Complete Final Conceptual Design Report
5. Complete detailed design, tendering and construction



Questions/Comments?



Contact: Myron
Semegen, Project
Manager, RDOS

