ANNUAL WATER REPORT

2021

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INTRODUCTION

The District of Barriere is working to continually improve the water system and public awareness to meet the changing needs of our community.

Water safety is of the utmost importance to the District of Barriere. The supply of good, clean drinking water has been taken for granted by the general public in Canada until events such as the Walkerton E. Coli outbreak brought the safety of the water supply into the public eye.

This report has been submitted to Interior Health and is posted on the District of Barriere website: www.barriere.ca

We are dedicated to providing safe, clean water to the residents of Barriere as indicated in the following report.

WATER UTILITY OBJECTIVES

- To ensure adequate supply of high-quality water to the community.
- To effectively treat the raw water to provide potable water of integrity to the community.
- To ensure the adequate delivery of high-quality potable water to all points within the system for domestic and emergency purposes.
- To ensure effective management of all water system aspects and provide excellent customer service and information to the community.
- To manage water demand by effectively assessing and managing water losses from leakage in the system.
- To develop an effective water conservation program for operations and the wider community.
- To maintain water rates that encourage conservation and resource awareness while providing quality accessible water to consumers.

PROVINCIAL REQUIREMENTS

All drinking water in the water system must meet the Canadian Guidelines for Drinking Water Quality. In British Columbia, the Ministry of Health regulates water suppliers through the Drinking Water Protection Act. This legislation ensures safe drinking water in the Province. It requires that the water supplier monitor the drinking water source and distribution system to ensure compliance with the Drinking Water Protection regulations and report all results to the Health Authority. Water monitoring, inspection and testing, emergency response planning, cross connection control and security standards are all regulated for persons operating a water system.

Changes in water systems must be approved by the Interior Health Authority (IHA), and conform to the District's specifications.

Under the *BC Water Act*, the District must acquire licenses for withdrawal from water bodies.

Under the *Community Charter*, the District may, by bylaw, regulate, prohibit and impose requirements in relation to municipal service and public health. The District must make reports available to the public on request regarding fees imposed under this section.

SUPPLY SOURCES

Photo by Ellen Monteith

The District of Barriere's potable water system is supplied by a system of two wells, one being constructed during the 1990s, the second as recent as 2019. Both wells are located in the northeast quadrant of the community, adjacent to the Barriere River. Two deep wells are located at the north end of Spruce Crescent, and a third production well, is located on Bradford Road. The wells are summarized in Table 3.1 below. The location of these wells can be seen on the overall water system plan on the following page.

Table 3.1: Barriere's Supply Wells

Well	Year Built	Pumping Capacity (L/s)	Approximate Depth (m)	Known Issues Or Concerns
PW1 Bradford Park	2019	22	91.44	High Iron, Manganese
DW2 Spruce Crescent	1997	63	35	Increasing evidence of iron and manganese - limited lifespan

WATER TREATMENT

The well water is injected with a chlorine solution at the pump stations such that it contains an approximate free residual chlorine concentration of 0.5mg/L adjacent to the pump stations and has been measured to 0.3 mg/L at the more remote parts of the system.
In terms of the Interior Health Authority requirements, this treatment is satisfactory in a ground water source that is not under the influence of surface water, as these types of supply are given credit for filtration. Referencing the 4-3-2-1-0 requirements, the chlorine addresses the 4 and the 0, while the fact that the supply is a non-GWUDI well appears to be protected by a confining layer and addresses points 3, 2, and 1.

RESERVOIR STORAGE

The North reservoir is a rectangular concrete tank with sloping sides and a capacity of 1,540 m^3 (406,560 USG). It is located at the north end of the community adjacent to Barriere Lakes Road and has a free water level of 451 meters. A 350mm diameter supply main connects the reservoir with the rest of the system at the intersection of Lodgepole Road and Barriere Lakes Road.

The South reservoir is a rectangular concrete tank and has a capacity of 1,300m^3 (343,200 USG). It is located at the south end of the community near the top of Mountain Road and has a free water level of 451 meters. A 250mm diameter supply main connects the reservoir with the rest of the system at Mountain Road.

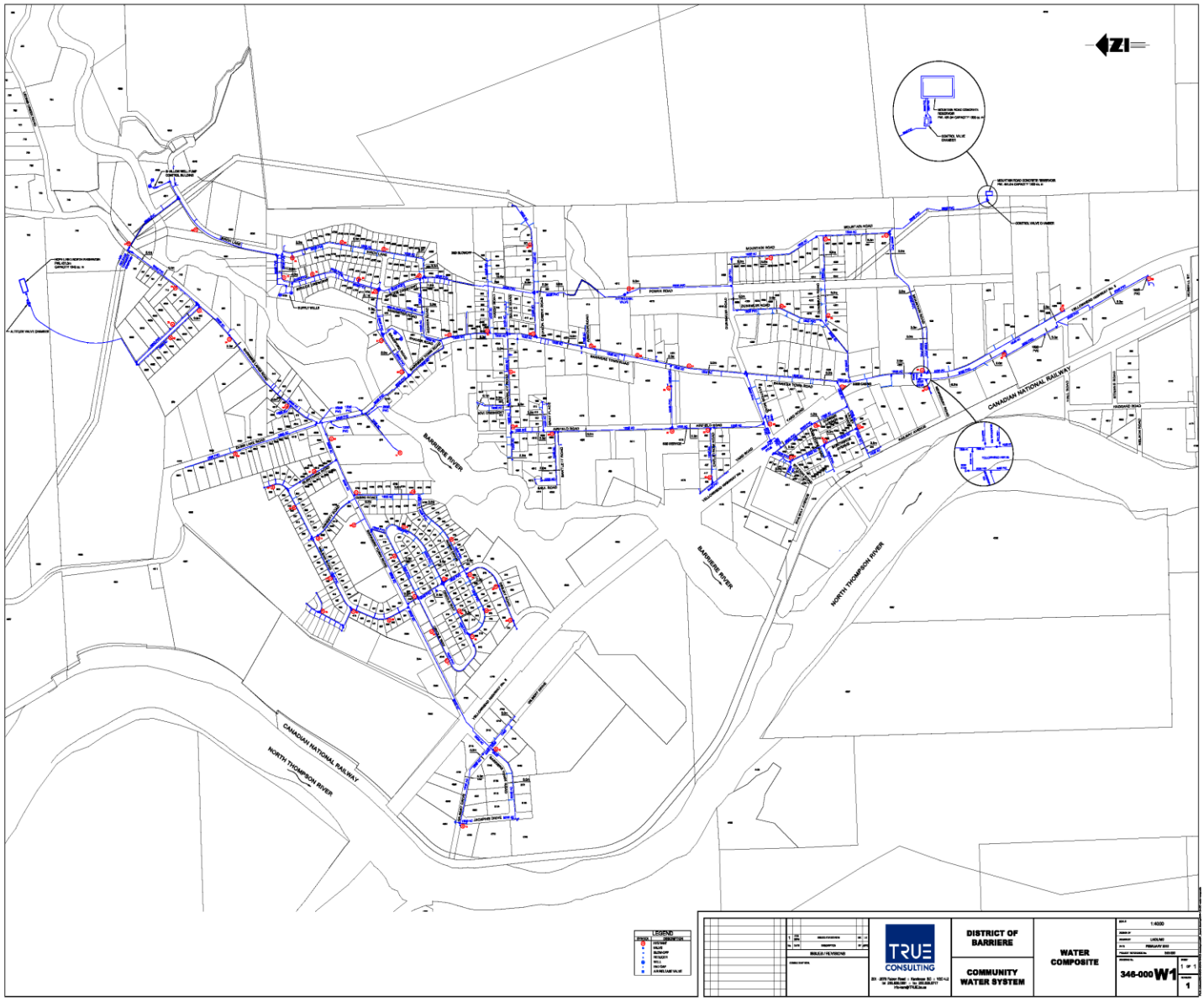
DISTRIBUTION SYSTEM

Approximately 24,750 meters of watermain are joined together to create the District of Barriere water system. The water system has been undergoing upgrades to ensure the water quality is safe for consumption. The first upgrades were from 1966 onwards when the pipes were asbestos cement. Beginning in the 1980's the pipes began to be upgraded to PVC pipes due to the potential health risks of leakage from decaying asbestos/cement pipe. The PVC pipes range in diameter from 100 mm to 350 mm and provide potable water to approximately 780 residential and 75 commercial service connections in Barriere.

Several sections of pipe within the District's water supply system are undersized, limiting flows and negatively impacting fire protection and pressures in certain parts of the network. Piping has been upgraded at the High School intersection along to Bradford Road, and from Barriere Town Road to Spruce Crescent.

In early 2021, the District began the process of drilling a new deep well alongside the current deep well (DW2) on Spruce Cres. This new well was given the moniker, "Deep Well 3 (DW3)" which is anticipated to be completed in the summer of 2022.

WATER SUPPLY SYSTEM



WATER SAMPLING AND TESTING

Bacteriological:
As required by the Interior Health Authority (IHA), staff takes weekly water samples for bacteriological testing for total coliforms and e-Coli bacteria. There are 3 different sampling sites used throughout Barriere.

Full Spectrum Analysis:
Water samples have been sent from the source water for a full spectrum analysis. Parameters such as alkalinity, metals, pH, turbidity, and hardness are tested. *SEE ATTACHMENT 4*

Summary:
In 2021 the District of Barriere had no positive bacteriological testing results pertaining to Total Coliforms or E.Coli and remained in compliance throughout the entire year of 2021.

EMERGENCY RESPONSE PLAN

The District of Barriere has an Emergency Response Plan for the water system. It identifies a number of potential emergencies that could occur and provides a systematic approach on how the District will deal with those emergencies. The plan is available for public viewing at the District Office, 4936 Barriere Town Road.

WATER QUALITY COMPLAINTS

The District of Barriere received a number of complaints in the spring of 2021 in respect to the quality of water being provided, which is a result of elevated minerals in the groundwater source. The wells have elevated iron and manganese levels, which once combined with chlorine create a brownish precipitate that showed up throughout the distribution system, therefore creating an aesthetically unpleasing water quality. Although the water was still safe for human consumption, the District of Barriere along with the Interior Health authority (IHA), continued maintaining the water quality advisory (WQA) that was implemented in 2019. The WQA is still in effect.

SYSTEM UPGRADES COMPLETED IN 2021

- Drilling of Replacement supply well (DW3). See Installation and Testing of Replacement Supply Well: WPID 40541. *SEE ATTACHMENT 3*
- G.A.R.P Assessment DW2 & Dw3, Spruce Crescent Well Field. *SEE ATTACHMENT 1*
- Expanded Cross Connection Control Program
- Two Water Main Extension's (Siska, Clary)
- Upgrade facility control and data acquisition systems from Radio communications to cellular
- Upgrade Water Meter Reader

- Identified a number of unmetered service connections and repaired multiple leaks (Water Loss/Conservation)
- Camera Inspected both North and South Reservoirs
- Located majority of the distribution system curb stops, and noted needs of repair
- New dedicated sample site at the southern most end of the water distribution system (near Esso) for reliable and representative daily water samples

POTENTIAL SYSTEM UPGRADES

- Biological manganese removal Water Treatment Plant
- New Proposed Production Well (DW4)
- Commission Replacement Well (DW3) and bring into service
- Upgrading water main on Barriere Town Road (Installed 1966, Asbestos cement) from Bradford Rd. to Mountain Rd. For removal of bottleneck and balance North and South reservoirs
- New Remote Chlorine Analyzer
- Install Dual Chlorine Pumps for redundancy at Spruce Cr. wellhouse
- Install new Deep Well Control Panel and Alarm Dialer

CROSS CONNECTION PROGRAM

The District of Barriere maintains a Cross Connection Control Program to prevent the potential backflow of non-potable water into the District's water distribution system. The Program is based on premises isolation to ensure there is a reliable barrier between private and public water systems. The program uses a priority approach with higher hazard ICI (Industrial, Commercial and Institutional) service connections being first in line for inspections and compliance mandates, as well as residential connections with auxiliary water. The District of Barriere Water System Bylaw # 189 gives the District authority to implement this program.

The District has a certified Cross Connection Control Inspector on staff who acts as the program administrator. He is also a certified Backflow Assembly Tester and is responsible for insuring all the Districts infrastructure is protected and in compliance with our program. The Inspector also performs inspections on new and existing facilities to determine whether there is a potential for contaminated water to flow back into the water distribution system.

All new ICI developments are required to be inspected for Cross Connections as a condition of the provision of water service.

In 2021, a total of 15 CCC inspections were conducted, including the reinspection of 6 District owned facilities to insure they continue to be properly isolated.

Backflow prevention devices are documented and tracked by the District to ensure they are tested annually and in good working order. This annual testing must be carried out by a certified

Backflow Assembly Tester. It is also worth noting that all residential outside hose bibs were confirmed have vacuum breakers installed (2012) and all new builds are required to have them.

The District also monitors for potential backflow situations through its water meter program. All service connections in the District must be metered and our water meters will detect and flag backflow occurrences and provide additional information on time of occurrence, duration and volume. If the situation were to occur, it would prompt immediate investigation and may trigger our Water System Emergency Response Plan.

2021 Summary Report

Total ICI Facilities/Premises (inc. District facilities and parks)	102
Total BFP's Tracked	47
Past Due Test Reports	11

Hazard (L/M/S)	Inspected Premises with CCs	Premises in Compliance
Sever	4	4
Moderate	15	13
Low	8	8
Total	27	25

The District will continue to improve and further implement its Cross Connection Control Program through inspections, tracking, program development and public education to eventually have all actual or potential cross connections identified and in compliance with our CCC Program.

OPERATOR CERTIFICATION

The District of Barriere currently employs 3 licensed operators, all in good standing with the EOCP. One Utilities Manager, who holds a Class 2 certification in Water Treatment and Water Distribution. One Water Technician 2, who holds a Class 2 certification in Water Treatment and a Class 1 certification in Water Distribution. One Water Technician 1, who holds a Class 1 certification in Water Distribution and will be obtaining his Class 1 certification in Water Treatment in 2021. The Water Technician 1 is also the District of Barriere's cross connection control inspector and certified backflow assembly tester.

SUMMARY OF SOURCE WATER PROTECTION EFFORTS

The District of Barriere currently has a wellhead protection plan in place to ensure a consistent effort is being made to protect our groundwater production wells. The wellhead protection plan assesses risks and makes recommendations with respect to source water protection. The plan notes that risks to production wells from activities within and outside the capture zone is low. Another measure the District of Barriere has implemented, is a property covenant on all surrounding resident homes which prohibits the use of fertilizers and pesticides. Further to this the District undertook a GWUDI/GARP study of its deep wells at the Spruce Crescent site to determine potential influences the nearby Barriere River may have. *SEE ATTACHMENT 1*

-APPENDIX I

WATER CONSUMPTION (US GALLONS)

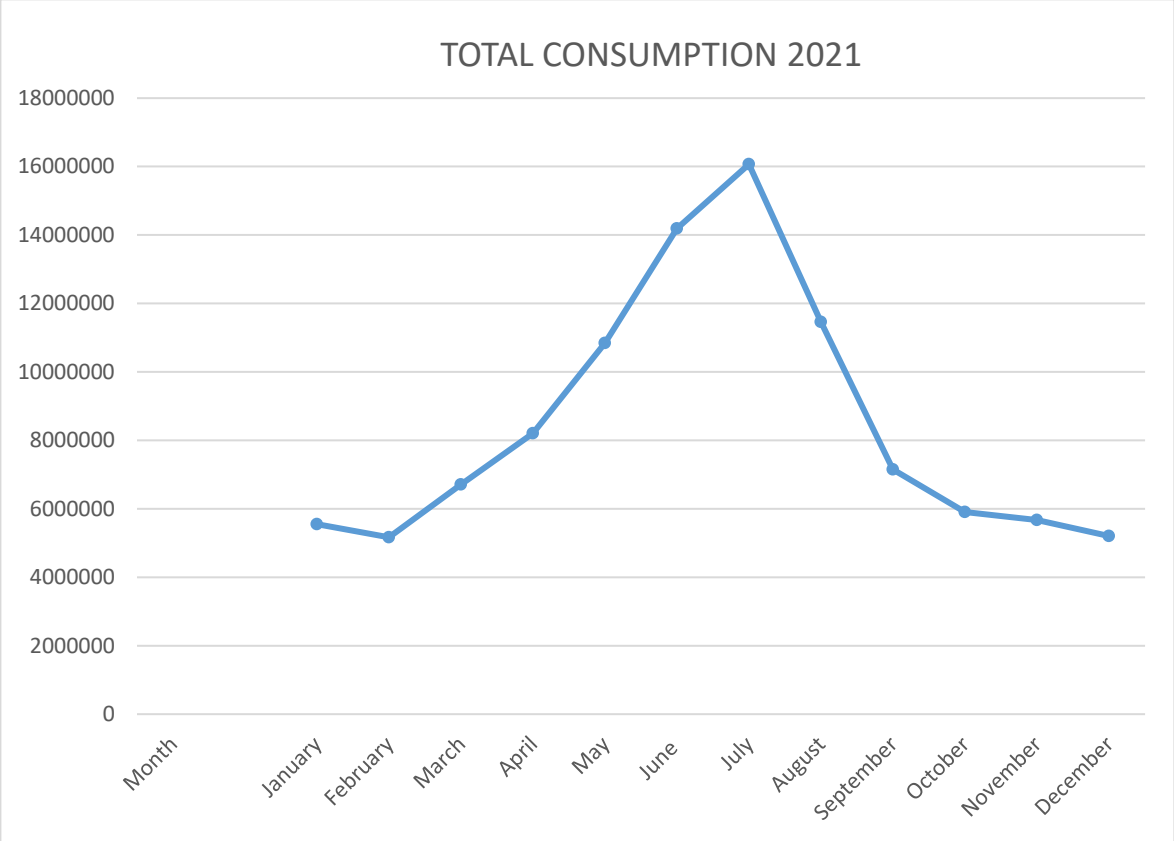
Month	2021 PW#1	2021 DW#2	2020 PW#1	2020 DW#2	2019 DW#2	2018 DW#2	2017 DW#2	2016 DW#2
January	0	5,554,308	0	7,434,506	7,358,400	6,412,300	7,629,400	4,931,000
February	1,996,269	3,171,904	0	7,210,840	6,008,155	5,847,300	6,897,000	6,322,000
March	6,709,999	0	0	5,874,752	7,132,632	5,912,900	6,292,600	4,934,600
April	2,972,517	5,229,866	0	6,451,104	9,876,852	6,691,300	6,600,696	7,709,200
May	190,547	10,650,658	0	9,001,828	9,152,742	17,302,700	13,297,400	17,569,100
June	90,902	14,100,544	0	6,221,416	18,399,654	19,729,400	22,456,500	17,845,000
July	615,574	15,452,256	736,639	6,657,220	18,752,814	23,890,600	35,345,355	17,679,600
August	167,274	11,291,344	0	9,915,824	11,149,300	22,315,700	22,934,300	21,965,999
September	264	7,145,984	0	7,292,080	9,736,024	10,752,300	15,454,700	8,767,500
October	0	5,908,984	0	5,500,160	7,593,404	7,878,900	7,513,400	5,742,000
November	0	5,671,928	0	4,974,608	6,130,388	7,597,200	6,111,800	4,161,900
December	0	5,207,212	0	5,207,212	8,256,120	8,322,100	8,127,500	4,578,300

Total Consumption for 2021: 102,128,334 US Gallons
Total Consumption for 2020: 82,478,189 US Gallons
Total Consumption for 2019: 119,537,215 US Gallons
Total Consumption for 2018: 145,826,200 US Gallons
Total Consumption for 2017: 158,865,845 US Gallons
Total Consumption for 2016: 122,206,199 US Gallons
Total Consumption for 2015: 142,223,460 US Gallons
Total Consumption for 2014: 141,532,585 US Gallons
Total Consumption for 2013: 172,664,965 US Gallons

APPENDIX II

WATER CONSUMPTION

2021 Total Water Consumption



APPENDIX III

LOUIS CREEK INDUSTRIAL PARK (LCIP)

The District of Barriere has a small water system in the Louis Creek Industrial Park (LCIP) which is located 4 kilometers south of the town of Barriere. This water system serves only the businesses which are located in the industrial park, along with 1 residential homeowner. The LCIP water system started production on June 1, 2020.

The water system consists of a 50-gpm production well, and a pump house where disinfection occurs. There is a non-potable storage reservoir which is located on the east side of the industrial park. Backup power is planned to be installed in 2022.

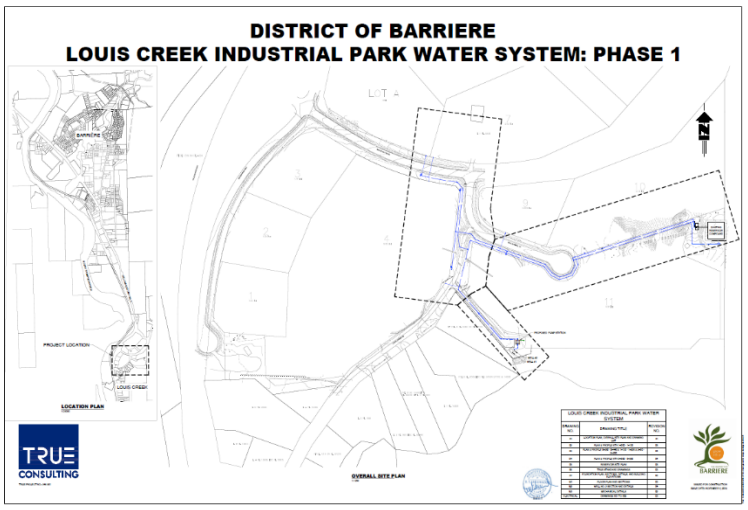
The district utility staff attends this site daily where chlorine levels and flows are monitored. Weekly bacteriological samples are collected for analysis from an outside independent laboratory. LCIP had no positive bacteriological testing results pertaining to Total Coliforms or E. Coli and remained in compliance throughout the entire year of 2021.

The District applied for a grant to fund a new reservoir and water system upgrades in the fall. The result of that grant application is expected in 2022.

A full spectrum analysis of the raw water source was conducted in 2021 and can be located in as an Addendum of this document.

LCIP WATER CONSUMPTION (CUBIC METERS)

Month	2021 LCIP	2020 LCIP
January	266.1	
February	219.6	
March	241.9	
April	148.6	
May	190.2	
June	170.7	551.2
July	651.9	428.5
August	262.7	388.0
September	140.7	327.7
October	141.9	320.0
November	135.9	359.4
December	253.5	337.9



Total Consumption for 2021: 2392.0 m3
Total Consumption for 2020: 2712.7 m3

western water ASSOCIATES
Consultants in Hydrogeology and Water Resources Management

DW2 & DW3, Spruce Crescent Water System, Barriere, BC
Stage 2 GARP Assessment

Prepared for:

District of Barriere
4936 Barriere Town Road
Barriere, B.C.

and

True Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

October 2021
Project: 20-105-03VR

western water
ASSOCIATES
Consultants in Hydrogeology and Water Resources Management

November 25, 2021

TRUE Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

Re: Stage 2 GARP Assessment: DW2 & DW3, Spruce Crescent Well Field, District of Barriere, B.C.

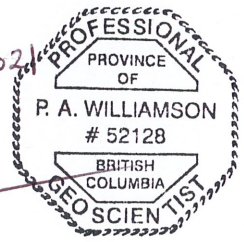
Western Water Associates Ltd. was retained to conduct a Stage 2 GARP assessment for DW2 & DW3 at the Spruce Crescent Well Field, located in the District of Barriere, B.C.

DW2 and DW3 are located in close proximity (~5 m apart) and extend to depths of 48.1 m (158 ft) and 45.1 m (148 ft) respectively. The wells are installed in what is interpreted to be a confined/semi-confined sand and gravel aquifer, with a confining unit composed of silt/clay that measures 23 m (75 ft) in thickness at a minimum. DW3 was installed in the spring of 2021 and has yet to be put into operation. As a result, sampling data was collected exclusively from DW2 throughout our assessment. Given the proximity and similar construction of the two wells, we infer that the findings of this GARP assessment are suitable to also encompass the future operation of DW3.

We trust that the professional opinions and advice presented in this document are sufficient for your current requirements. Should you have any questions, or if we can be of further assistance in this matter, please contact the undersigned.

WESTERN WATER ASSOCIATES LTD.

25-11-2021



Paul Williamson, M.Sc., P.Geo.
Hydrogeologist

Reviewed by:

Douglas Geller, M.Sc., P.Geo., FGC
Principal Hydrogeologist

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1. INTRODUCTION

This report presents the results of Western Water Associates Ltd.'s (WWAL) assessment of the District of Barriere (DoB) Spruce Crescent water system (DW2 and DW3) for the potential to be considered groundwater at risk of containing pathogens (GARP). The District and its engineering consultant TRUE Consulting (TRUE) requested that we undertake this work in order to fulfill a condition on the municipality's drinking water system operating permit with Interior Health (IH).

1.1 Assessment Framework: BC GUDI-GARP Guidelines

DW2 and DW3 were assessed using the criteria outlined in the *Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) (Ministry of Health, September 2017)*. This guidance document is the third version released by the Ministry of Health and has evolved through several draft versions, which have been reviewed and commented on by regulatory agencies and groundwater professionals in the province.

Our assessment also included elements of the Ontario GUDI Guidelines (2001), a widely used tool used for Groundwater under Direct Influence of Surface Water (GUDI) screening, as well as elements of U.S. Environmental Protection Agency (EPA) guidance documents, on which the B.C. Guidance is largely based. Professional practice guidelines outlined by Engineers and Geoscientists (EGBC) in the document entitled *Assessment of Groundwater at Risk of Containing Pathogens (GARP)* were also considered.

1.1.1 Definitions

The BC guidance document uses the U.S. EPA's (1999) definition for GUDI, which is "any water beneath the surface of the ground with:

a) significant occurrence of insects or other macro-organisms, algae, organic debris or large-diameter pathogens such as *Giardia lamblia, Cryptosporidium,* or

b) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH, which closely correlate to climatological or surface water conditions."

Although some groundwater supply sources may be hydraulically connected to surface water, the potential threat to human health only exists where conditions allow microbial pathogens to freely travel from surface water to the groundwater source (i.e., subsurface filtration of surface water is incomplete/inadequate). If a groundwater source is determined to be GUDI, the water must be treated to the same level as surface water with respect to pathogen removal and inactivation. The GUDI potential of a well source is determined by a professional hydrogeologist who applies professional judgment on a case-by-case basis.

The BC guidance document defines GARP as "any groundwater source that is likely to be contaminated from any sources of human disease-causing microorganisms (pathogens) including various types of bacteria, viruses and protozoa. Contamination may be continuous or intermittent". Potential sources of pathogens to groundwater may include sewage effluent discharge to land, agricultural waste stockpiles and surface water that is hydraulically connected to groundwater.

There is some overlap between the definitions of GARP and GUDI, which may lead to misinterpretation. GARP is a more encompassing definition that considers any possible source of microbiological contamination. GUDI should be considered a potential risk contributing to a well's GARP determination. It is possible for a well to not be considered GUDI, while being classified as GARP. For example, a well located a great distance from any surface water sources that is installed in an unconfined aquifer near a community wastewater dispersal field could be considered GARP but not GUDI.

1.2 Objectives

This project is intended to support the District of Barriere with long-term planning and decision making for the Spruce Crescent water system, as well as fulfilling its condition on permit. GARP assessments are key considerations in determining if treatment of groundwater supplies is required and, if so, to what degree. True groundwater sources found to be neither GUDI nor GARP may not require any water treatment, while sources with a higher risk of containing pathogens, surface water related or otherwise, typically require one or more forms of treatment to address the potential risk to human health.

The main objective of this study was to compile and collect the information necessary to assess the GARP status of wells DW2 and DW3 from the Spruce Crescent well field. Specifically, it was the intent of this study to classify the wells as either:

I. **GARP** – If one or more identified hazards pose an obvious risk of pathogenic contamination.
II. **GARP-viruses only** – If the source is only at risk of containing viruses but not at risk for large diameter pathogens associated with surface water (*Giardia* and *Cryptosporidium*).
III. **Low Risk** – The source has a low risk of containing pathogens ("secure groundwater").

2. WATER SYSTEM BACKGROUND AND OPERATION

The District of Barriere is located approximately 60 km north of Kamloops, at the confluence of the Barriere River and North Thompson River (Figure 1). The District provides water to approximately 780 residential and 75 commercial connections (DoB, 2020). At present, the District maintains two active well fields within the community: Spruce Crescent and Bradford Park. The District previously maintained a third well field containing two shallow wells that was taken offline in 2017 due to its GARP designation. The focus of this study is exclusively on DW2 and DW3 from the Spruce Crescent well field. DW1, the original well installed at Spruce Crescent, is currently offline and tentatively scheduled to be replaced. Select construction details of the three Spruce Crescent wells are provided in Table 2-1 below and well schematics are presented in Appendix A.

Table 2-1 Select Construction Details for the Spruce Crescent Supply Wells

Well Name	DW1	DW2	DW3
Well Plate Identification	12701	12702	40541
Well Tag Number	-	-	123551
Date Drilled	1994	1997	2021
Diameter	12-inch	8-inch	12-inch
Total Depth	230 ft	158 ft	148 ft
Screen Open Length	31.5 ft	20 ft	14 ft

Well Name	DW1	DW2	DW3
Screen Design	60 slot (196.5 to 228 ft)	100 slot (138 to 158 ft)	100 slot (133 to 147 ft)
Estimated Well Yield	45 L/s / 713 US gpm	63.1 L/s / 1000 US gpm	44.2 L/s / 700 US gpm

Notes: All depths given below ground; Well Plate Identification = the number on the metal identification plate attached to the well; Well Tag Number = the MFLNRORD unique database ID number for a given well

A fourth well, TW1, is also located on the Spruce Crescent site. Specific details surrounding this well's construction (e.g., well screen size and location) could not be located. However, the field measured depth of ~201 ft matches that of a written description of the well found in the DW1 completion report (SEACOR, 1994). Although the well is more than 40 ft deeper than DW2, our field observations indicate the wells have similar depths to water, and field testing demonstrated that pumping in DW2 and DW3 induced drawdown in TW1. Based on this, a transducer was installed in this well, as a means for measuring water levels in the aquifer over the duration of the GARP assessment.

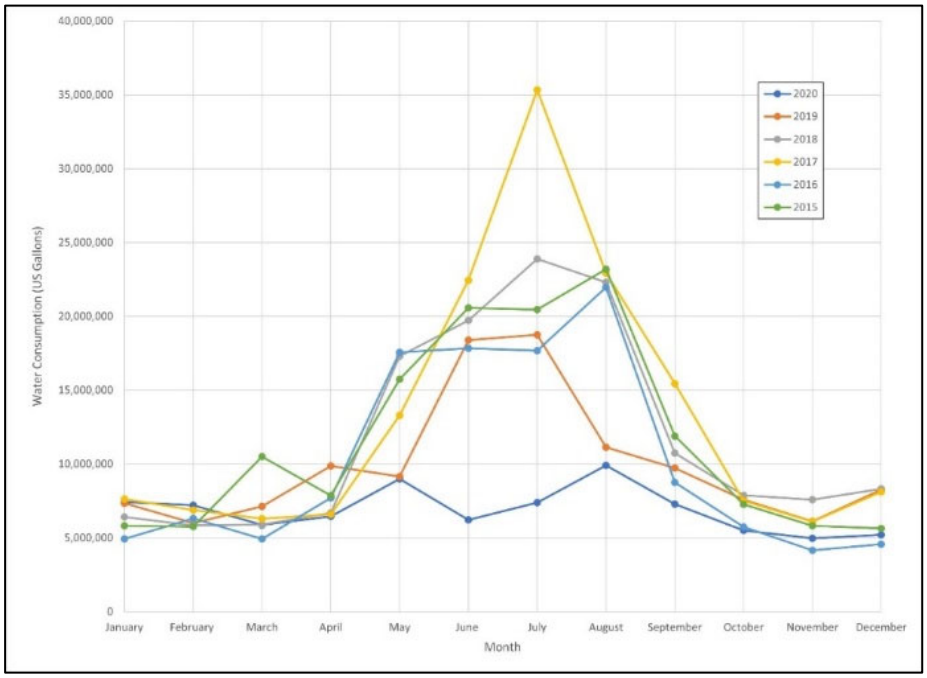
Over the last several years, the District has encountered elevated levels of iron and manganese in DW1, and a failure in the one of the well's filtration units limits production to a maximum flow rate of 28 L/s (400 US gpm) (DoB, 2020). Additionally, the Bradford Park well field is only used as an emergency backup due to consistent aesthetic water quality concerns and a limited maximum production rate (12 L/s /190 US gpm). As a result, the District has relied heavily on DW2 to meet the community's water demand in recent years. In the spring of 2021, DW3 was constructed at the site to address the lack of redundancy in the Spruce Crescent water system.

A large portion of the Stage 2 GARP assessment occurred at the same time as the construction of DW3, and the new well has yet to be incorporated into the water system. As a result, our assessment focused on DW2 (as its operation enabled us to conduct multiple rounds of sampling) and the Barriere River, which is located approximately 35 m from the well. Since DW3 is located in close proximity (5 m) and at a similar depth to DW2, we infer that the findings of this GARP assessment should be extended to encompass the future operation of DW3.

During testing of DW3, the well experienced persistent turbidity issues upon start up that eventually cleared after continued pumping. From a GARP perspective, turbidity in surface water can be the result of soil particles, organic matter, human waste discharge or potentially pathogens. If a connection to groundwater is established, infiltrating surface water can represent a risk to the water source containing pathogens. In the case of DW3 however, the source of turbidity is related exclusively to the aquifer formation, where a higher than typically silt content was discovered. We anticipate that once DW3 is placed into operation and continuously pumped, the turbidity issue will eventually be resolved.

As shown in Figure 2-1 below, the annual pattern in consumption for the DoB is typical of most domestic water systems in BC: low consumption during the late fall and winter, peak consumption in June, July and August. Total water demand for the Barriere community has steadily declined since 2017 (Table 2-2). This reduction is largely related to the District's implementation of water metering and billing throughout the community in 2019. Water restrictions related to lawn watering were implemented in 2020, which also lead to a further decrease.

Figure 2-1 District of Barriere Monthly Water Consumption (2015 – 2020)



Source: DoB, 2021

Table 2-2 District of Barriere Annual Water Consumption (2015-2020)

Year	Total Water Consumption (US Gallons)
2020	82,478,189
2019	119,537,215
2018	145,826,200
2017	158,865,845
2016	122,206,199
2015	142,223,460

3. SITE DESCRIPTION AND HYDROGEOLOGIC SETTING

3.1 Physiography and Climate

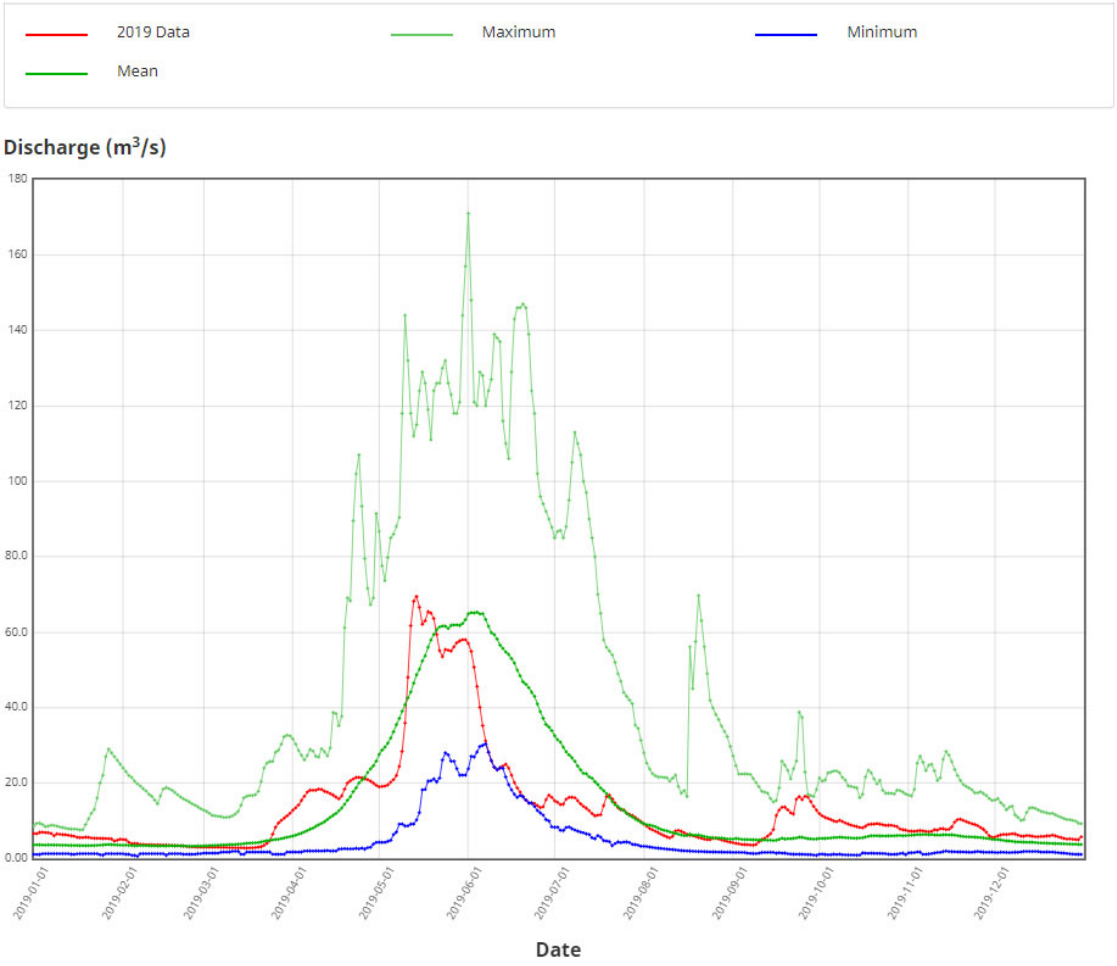
The community of Barriere is located in the Shuswap highlands, on the large alluvial fan/deltaic complex associated with the ingress of Barriere River into North Thompson River. Local relief ranges from the North Thompson River to the west at an elevation of 373 m above sea level (asl) up to Barriere mountain to the east at an elevation of 1283 m asl. The Spruce Crescent well field is located on the southern banks of Barriere River, near the eastern edge of the community (Figure 2). The property is on level ground in a predominately residential area at an elevation of 388 m asl.

The Barriere River flows to the southwest and passes the DW2 and DW3 at an approximate distance of 35 m before entering North Thompson River 2.3 km from the site. The North Thompson then flows

south before joining the Thompson River in the Kamloops area. Dixon Creek, which captures water from the highlands to the southeast, joins the Barriere River approximately 700 m to the northeast of the site. Several unnamed tributaries of Barriere River are also located upstream of the Spruce Crescent well field.

The Water Survey of Canada maintains a hydrometric station on Barriere River at the Barriere Town Road bridge, approximately 550 m downstream of the site. Figure 3-1 below presents a hydrograph of Barriere River that illustrates its freshet dominated discharge regime. Water levels typically begin to rise in early April in response to snowmelt, with peak levels occurring in late May or early June. Flows subsequently decline steadily towards baseflow levels in August or September.

Figure 3-1 Barriere River Discharge Hydrograph at Station 08LB020



Climate Normal data from the McLure climate station (ID 1165030) are summarized below. This station is approximately 15 km southwest of the project site at an elevation of 381 m asl, which is in the same range as the well site. The data indicate an average annual precipitation from a combination of rain and snowfall of 487 mm. Precipitation remains relatively consistent throughout the year, with peaks occurring in late spring/early summer and the late fall, and the driest period occurring in the late winter. The daily average air temperature is 7.7 degrees, with July and August typically the warmest months and December and January the coldest. Note that past climate data are not necessarily indicative of the future climate.

Table 3-1 Climate Normal Data 1981-2010 for McLure Station, ID 1165030

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	11.7	14.0	23.8	30.9	43.3	55.0	46.7	39.7	40.5	39.6	35.1	10.1	390.3
Snowfall (cm)	26.2	9.4	4.6	0.4	0.2	0.0	0.0	0.0	0.0	0.9	17.9	36.8	96.2
Precipitation (mm)	37.9	23.4	28.4	31.2	43.5	55.0	46.7	39.7	40.5	40.4	53.0	46.8	486.5
Daily Average (°C)	-4.5	-1.7	3.8	9.0	13.1	16.9	19.7	19.6	14.2	6.9	0.5	-4.5	7.7

3.2 Hydrogeologic Setting

Surficial geology mapping of the area (Paulen et al., 1998) indicates the surficial unit beneath the project site is characterized as fluvial plain deposits that include well sorted sand, gravel and over bank silt in post-Fraser glaciation floodplains, terraces and/or fans.

Bedrock mapping indicates the site overlies the boundary of two adjoining assemblages. The first is the metamorphic rocks of the Eagle Bay Assemblage that date back to 400 to 500 million years before present. The second is basaltic volcanic rocks of the Fennell Assemblage dated to 200 to 300 million years before present.

Provincial mapping identifies two aquifers that underlie the site: 1) Aquifer 293 III B, which extends north-south from the community of Little Fort to Barriere and remains in close proximity to the banks of the North Thompson River in the east-west direction, and 2) Aquifer 294 III B, which follows the banks of the Barriere River and extends from the community of Barriere to approximately 12 km upstream. Both aquifers are characterized as mostly unconfined sand and gravel units with low demand, moderate productivity and moderate vulnerability to contamination.

Attached Figure 2 displays transect A-A' and Figure 3 displays a cross section from this transect that we developed by interpreting available well logs from the area. The cross section indicates there are potentially multiple unmapped aquifers in the Barriere region, including a perched unit in upland areas northeast of the Spruce Crescent well field, a confined unit in which DW2 and DW3 are installed and a another deeper confined unit in which the DoB's Bradford water wells are installed. Based on the information provided on the well logs, the confined aquifer is moderately to highly productive, with a confining unit that ranges between 20-30 m in thickness near the drill site. We infer that recharge to the aquifer originates from multiple sources including leakage from Barriere River, infiltration of precipitation and snowmelt from upland areas and discharge from underlying bedrock.

Using data collected during the testing of DW3, WWAL estimated the transmissivity (T) and the storativity (S) of the confined aquifer beneath the Spruce Crescent well field. Our analysis indicated a T value of 2.5 X 10^3 m^2/day, which has an equivalent hydraulic conductivity (K) that is consistent with textbook values for sand & gravel aquifers (Freeze & Cherry, 1979). Additionally, we generated an S value of 6.7 X 10^{-4}, which is in line with typical values for confined aquifers (Freeze & Cherry, 1979).

The provincial GWELLS application indicates twenty-two wells (including those at the Spruce Crescent and Bradford Park well files) are registered within 1 km of the subject site wells. It should be noted that submission of well driller's logs to the Ministry was not mandatory until 2016; therefore, it is possible that

other unreported wells exist in the area. A summary of select well construction details is included in Table 3-2 below and the location of each well is displayed in Figure 2.

Table 3-2 Select Details for Wells within 1 km of the Spruce Crescent Well Field

WTN	Well Use	Finished Well Depth (ft)	Diameter (in)	Depth to Water (ft)	Reported Well Yield (US gpm)
DW1	Water Supply	230	12	-	713
DW2	Water Supply	158	8	-	1000
DW3	Water Supply	148	12	45	700
103072	Monitoring	336	6	-	100
112533	Monitoring	288	6	-	-
114383 (PW1)	Water Supply System	268	10	40	-
112850 (PW2?)	Water Supply System	258	10	40	-
114384 (PW3)	Water Supply System	313	10	-	-
40611	Unknown	250	6	175	10
116334	Private Domestic	159	6	82	10
27951	Unknown	138	6	64	10
105971	Irrigation	134	6	87	35
92069	Irrigation	118	6	85	40
59264	Irrigation	35	8	12	90
59348	Irrigation	39	8	6	-
76035	Water Supply System	158	10	45	-
103071	Monitoring	436	6	-	-
75937	Unknown	20	6	-	-
75939	Unknown	20	6	-	-
75940	Unknown	41	6	28	-
75938	Unknown	20	6	-	-
83966	Private Domestic	383	6	190	30
116544	Private Domestic	96	6	-	-

3.3 Land Use near the Spruce Crescent Well Field

Land use in the vicinity of the Spruce Crescent well field is predominately residential, with some agricultural activities in the area (Figure 4). Undeveloped forested areas and agricultural lands dominate the upland areas to the east and southeast. Barriere's commercial district is located south of the site.

Three potential sources of enteric viruses are located within 300 m of the Spruce Crescent wells, as shown in Figure 4: a cattle grazing area located immediately west of the well field, the Riverwalk wastewater treatment facility located ~170 m east of DW2 and DW3, and several residential septic fields located to the south-southwest of the well field. Field observations of the cattle grazing area did not identify any stockpiling of manure in the vicinity of the wells. The wastewater treatment facility is a relatively small operation that can services 27 residential properties in the area. Our understanding of the system is that effluent is treated to "Class A" standards (high quality municipal effluent receiving advanced treatment with the addition of UV disinfection and nitrogen reduction) and is discharged to two disposal fields located to the north and south of the building. At present, the treatment plant is operating

at ~15% of its maximum authorized daily discharge amount (True Consulting, 2021). Of the known residential septic fields in the area, the closest is located approximately 160 m from DW2/DW3. Discussion on the risk associated with these potential sources is provided in Section 5 below.

4. 2020-2021 FIELD PROGRAM – METHODS AND RESULTS

The following sections provide the methodology and results of the 2020-2021 field program. The program was designed to collect several types of data so that multiple lines of evidence could be used in the GARP determination. The works completed by WWAL constitute much of the scope for Level 1 and 2 hydrogeological investigations suggested by the BC guidance document. The field investigation program included:

1. Continuous water level monitoring of the aquifer and Barriere River throughout the assessment period.
2. Collection of multiple untreated groundwater samples from the DW2 wellhead and surface water from Barriere River for total coliform and *E. coli* analysis to better quantify the presence of bacteriological pathogens.
3. Collection of untreated groundwater samples from the supply wells and Barriere River for general potability to provide a means for geochemical comparison between sources.
4. Collection of biweekly field parameter data (pH, conductivity, temperature) from the supply well.
5. Collection of untreated samples from the supply well and Barriere River (when possible) for enumeration of aerobic spores. This is an experimental technique used by Hyperion Research intended to provide a qualitative measurement of the amount of groundwater filtration occurring in an aquifer. Aerobic spores are of similar size and shape to *Giardia* and *Cryptosporidium* and are common in surface water but absent in secure groundwater.
6. Collection of untreated groundwater samples from the supply wells for modified Method 1623 MPA analysis.

The field data collection program spanned from December 2020 to October 2021. The timing of the study included the period of peak surface water and groundwater levels (early spring). DoB Utilities Operator, Mr. Paul Amos, completed much of the field water quality measurements and WWAL hydrogeologist, Paul Williamson, P.Geo., visited the site on three occasions to collect MPA samples, water quality samples and field parameters.

4.1 Hydrometric Data (Monitoring Well and Barriere River)

The aquifer in which DW2 and DW3 are completed is interpreted to be under confined and/or semi-confined conditions. This means the aquifer is not in equilibrium with the earth's atmosphere, and water level changes occur in response to a change in pressure (or piezometric head) in the aquifer. Such changes are the result of a combination of stressors to the aquifer, including well pumping, natural groundwater recharge and discharge processes (i.e., the "hydrologic cycle"), barometric pressure, and induced groundwater recharge.

As mentioned above, a transducer was installed in an onsite monitoring well (TW1) to measure groundwater levels throughout the project. TW1 is located approximately 23 m from DW2. Water

levels for Barriere River were downloaded from the hydrometric station located ~550 m downstream of DW2. Both the monitoring well and the hydrometric station were benchmark surveyed to provide an elevation relative to sea level. Due to an internal error in the transducer, groundwater level data from December 2020 through March 2021could not be recovered. Groundwater and surface water elevation data are provided in Figure 4-1, while

Figure 4-2 provides groundwater elevation and total precipitation and mean temperature data from Vavenby Station, located 50 km northeast of the well site (the closest climate station with available data, in an area that is likely slightly wetter than Barriere on average). The following discussion summarizes findings based on review of the data and figures.

- The Barriere River hydrograph exhibits the characteristic pattern for streams in the interior regions of British Columbia: seasonal lows during the winter and early spring, an abrupt increase during spring freshet, with peak flow values in late spring/early summer; peak flow recession, as snowpacks became depleted by melt-off; followed by a steady and slow recession toward baseflow into the late summer and fall months.
- Groundwater responded in a somewhat similar fashion, as levels began to increase steadily around the time of freshet and began to decline approximately a week peak levels were reached in the river.
- Unexpectedly, groundwater levels began to recover at the beginning of July, when the river was continuing to approach seasonal low values. Typically, we would expect groundwater levels to continue declining at least into the early fall, if not straight through into the winter. DoB operational staff believed this may have coincided with the repair of two large water leaks in the distribution system. Additionally, several wildfires were present in the area around this time, and a call was made to the community to voluntarily reduce water consumption. Although unconfirmed, both events may have resulted in reduced pumping at DW2 and subsequent recovery in groundwater levels.
- Throughout the freshet period and subsequent decline, groundwater and river levels appear to rise and fall at similar times, with groundwater lagging a few days behind any changes that occurred in the river. This provides a good indicator that a hydraulic connection potentially exists between aquifer and the river. Since the aquifer is confined or semi-confined, this should be thought of as a pressure relationship, where the river exerts a hydraulic pressure across the confining layers, to which the aquifer responds with a corresponding change in aquifer pressure (piezometric head). The actual volume of water exchanged during this process is likely small compared to a) flow in the river and b) water held in storage in the aquifer. This is best seen in the way the water chemistries and microbiological content of surface water and groundwater remain distinct from each other over the long term (discussed in detail below).
-

- Figure 4-2 indicates that groundwater elevation tends to rise shortly after precipitation events. This suggests that precipitation may be a direct source of recharge to the aquifer. It is more likely, however, that this is a pressure response to the river (as described above), whereby precipitation results in a river level rise which is subsequently transferred to the aquifer.
- The river's elevation is consistently several metres higher than the elevation of groundwater. Under these conditions, if a connection between the aquifer and the river exists, the river will represent a source of recharge to the aquifer. This recharge, should it occur, would involve vertical flow (or more likely, pressure propagation) through fine-grained confining layers.

Figure 4-1 Groundwater (TW1) and Surface Water (Barriere River) Elevations

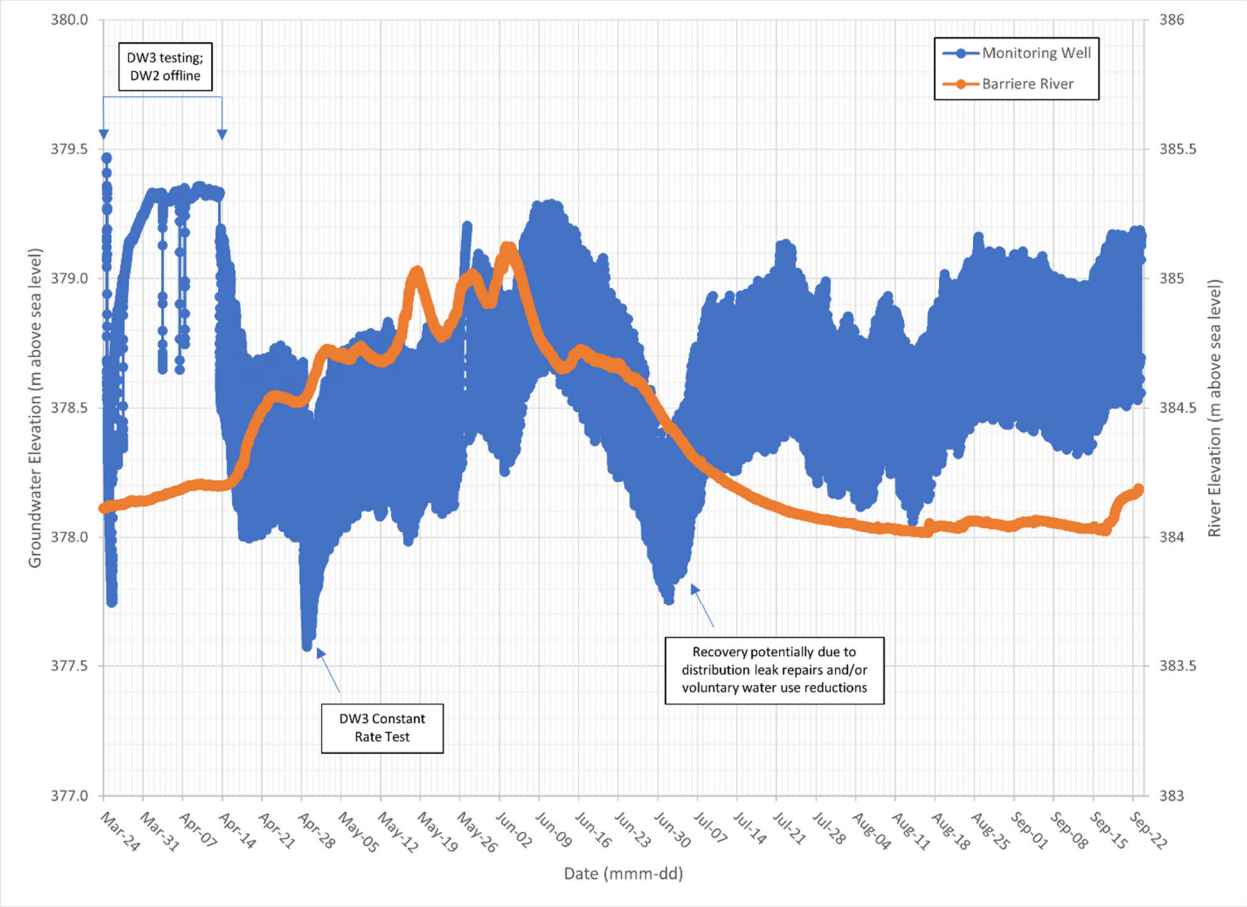
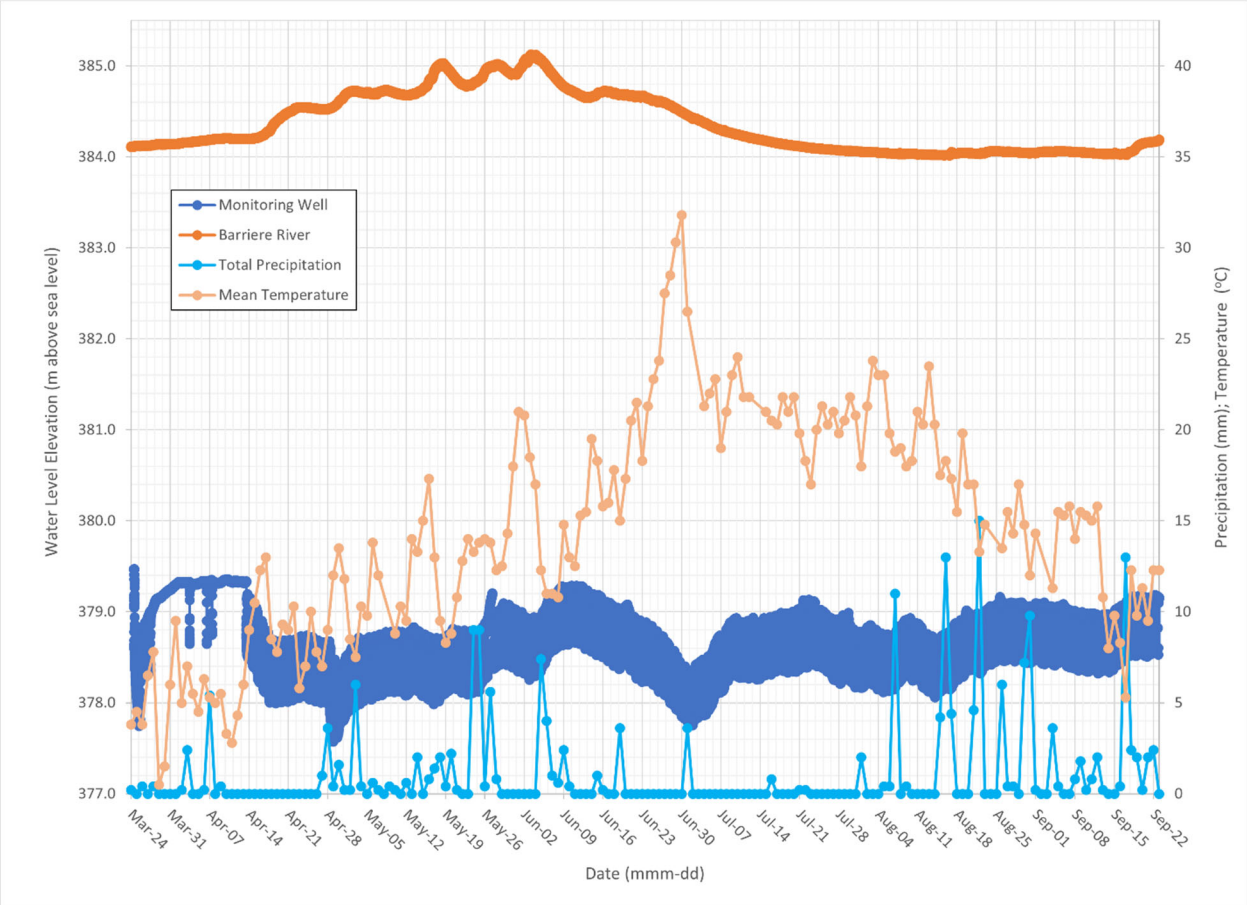


Figure 4-2 Groundwater & Surface Water Elevation, Precipitation and Temperature



4.2 Untreated Groundwater Microbiological Sampling

Throughout the assessment, a total of eight bacteriological samples (total coliforms and *E. coli*) were collected from DW2 (laboratory reports provided in Appendix B). During the construction of DW3, DW2 was temporarily not in use; therefore, samples were not collected between from early February until late April. A sampling tap in the pumphouse was used to collect the samples. The tap was wiped down with a chlorine solution and opened for 15 minutes to flush any stagnant, non-representative water from the system. To avoid cross contamination, a disposable pair of nitrile gloves was worn throughout sample collection and the sample was collected in clean, laboratory supplied bottles. Bacteriological samples were also collected from Barriere River, approximately 60 m to the north of the supply well.

All samples were transported to a laboratory in an ice-filled cooler within 24 hours. Water quality testing was completed by CARO Analytical, in Kelowna, BC, a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). Laboratory reports for the samples collected by WWAL are provided in Appendix B.

As shown in Table 4-1 below, the results of the microbiology testing indicated total coliforms and *E. coli* were not detected in groundwater from DW2. As expected, total coliforms were detected in Barriere

River during all sampling events and *E. coli* was detected during six of the eight events. The results are consistent with monitoring conducted by WWAL at other groundwater supply well locations across B.C.

Table 4-1 Microbiological Testing of Untreated Groundwater/Surface Water

Sample Date	DW2		Barriere River	
	Total Coliform	*E. coli*	Total Coliform	*E. coli*
01-Dec-2020	<1	<1	122	3
15-Dec-2020	<1	<1	>80	<1
26-Jan-2021	<1	<1	68	<1
27-Apr-2021	<1	<1	40	>10
17-May-2021	<1	<1	13	>1
15-Jun-2021	<1	<1	>80	7
29-Jun-2021	<1	<1	816	13
13-July-2021	<1	<1	1990	15
28-Sept-2021	<1	<1	>2420	5

4.2.1 Historical Microbiological Sampling

Comprehensive water quality samples, collected directly from the wellhead (i.e., prior to treatment), have been taken three times over the last six years by DoB operational staff. As shown in Table 4-2 below, total coliforms and *E. coli* were not detected in any of these samples. Laboratory results for these samples are provided in Appendix B.

Table 4-2 Summary of Historical DW2 Wellhead Bacteriological Testing Results

Sample Date	DW2	
	Total Coliform	*E. coli*
08-Oct-2013	<1	<1
13-Oct-2015	<1	<1
01-Nov-2020	<1	<1

4.3 Field Water Quality

During the assessment period, DoB water system operators completed field water quality measurements of groundwater and Barriere River on a biweekly basis. Dedicated field probes and calibration solutions were purchased for the project to measure temperature, pH, conductivity and Oxidation-Reduction Potential (ORP). The field instruments were calibrated prior to each sampling event. From the period of early February to late April 2020, DW2 was inactive due to the construction of DW3. A summary of all field measurements collected is presented in

Table 4-3. Time series plots for the four parameters are provided below.

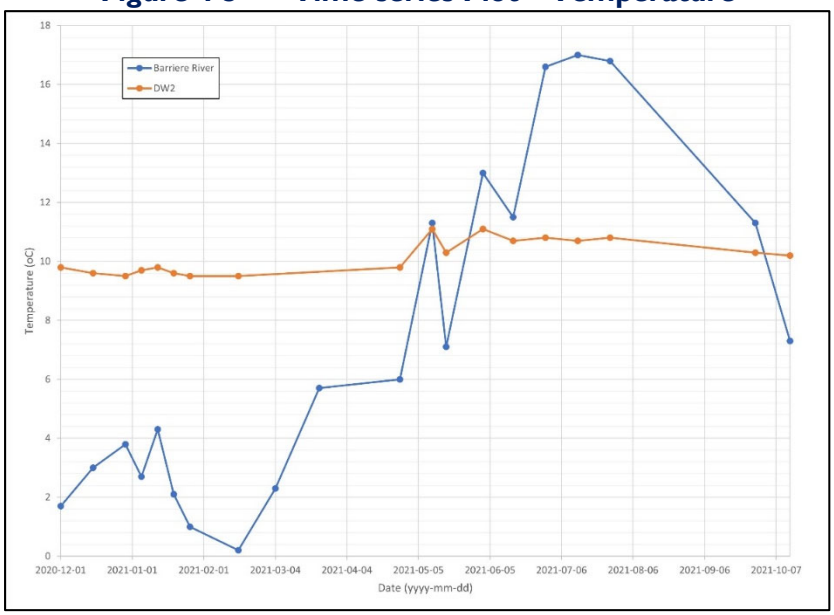
Table 4-3 Supply Well Field Measurement Summary

	Barriere River				DW2			
Date	Temp. (°C)	pH (unitless)	Cond. (µS/cm)	ORP (mV)	Temp, (°C)	pH (unitless)	Cond. (µS/cm)	ORP (mV)
2020-12-01	1.7	8.29	148.4	191	9.8	7.46	358	298
2020-12-15	3	8.69	152	279	9.6	7.64	346	259
2020-12-29	3.8	8.73	156.9	237	9.5	7.61	346	236
2021-01-05	2.7	8.77	187.5	212	9.7	7.54	355	241
2021-01-12	4.3	8.82	169.2	201	9.8	7.56	361	227
2021-01-19	2.1	8.71	169.6	202	9.6	7.62	345	209
2021-01-26	1	8.58	159.5	171	9.5	7.59	320	194
2021-02-16	0.2	8.72	146.5	184	9.5	7.5	331	197
2021-03-04	2.3	8.41	159.6	175	-	-	-	-
2021-03-23	5.7	8.64	174.5	175	-	-	-	-
2021-04-27	6	8.17	121.7	161	9.8	7.81	327	190
2021-05-11	11.3	8.58	111.5	127	11.1	7.46	343	207
2021-05-17	7.1	8.37	64.5	145	10.3	7.53	348	154
2021-06-02	13	8.5	59.2	146	11.1	7.52	363	198
2021-06-15	11.5	8.1	62	133	10.7	7.54	381	190
2021-06-29	16.6	7.93	62	153	10.8	7.48	405	189
2021-07-13	17	8.29	99.8	139	10.7	7.64	405	154
2021-07-27	16.8	8.35	112.9	142	10.8	7.61	414	154
2021-09-28	11.3	8.69	94.8	109	10.3	7.58	373	153
2021-10-13	7.3	9.06	91.6	112	10.2	7.60	374	176

4.3.1 Temperature

In most settings, ambient groundwater temperatures are found to be in the range of the mean annual air temperature for a given location. This proved to be true for DW2, where the mean annual value for the well (10.2 °C) was slightly warmer than the mean annual daily temperature from the closest climate station (7.7 °C; see Table 3-1 above). Also typical for groundwater, the measured temperatures for the well remained relatively consistent throughout the study with values that hovered around 10 to 11 °C. A slight uptick in temperature was noted after May of 2020. For Barriere River, temperatures varied considerably (typical of surface water) and followed seasonal trends, with the coldest measurements collected in the winter (minimum = 0.2°C in December) and the warmest in the late summer (maximum = 17°C in July).

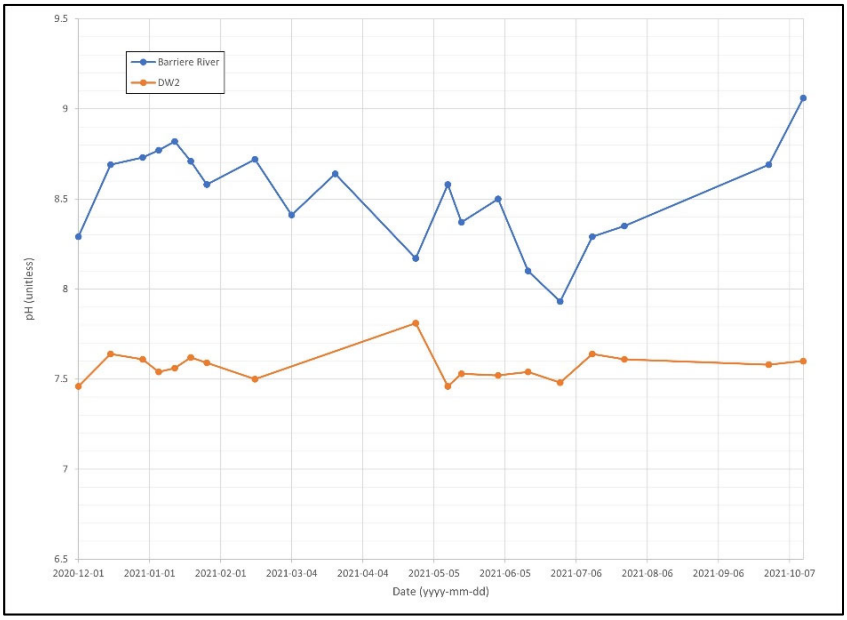
Figure 4-3 Time-series Plot – Temperature



4.3.2 pH

pH is the measure of the acidity/basicity of a given water source and is interrelated with other water characteristics such as temperature, dissolved organic carbon, hardness and buffering capacity (alkalinity). Over the assessment period, pH values from Barriere River ranged from 7.93 to 9.06, indicating a basic composition. The pH of the river remained consistently higher than groundwater throughout the study, and an overall downward trend in the pH of the river is observed from January to late June 2021. For groundwater, pH remained much more stable, with values that are slightly above neutral and range from 7.46 to 7.81. Fluctuations in the field pH data do not follow any apparent seasonal trend.

Figure 4-4 Time-series Plot – pH



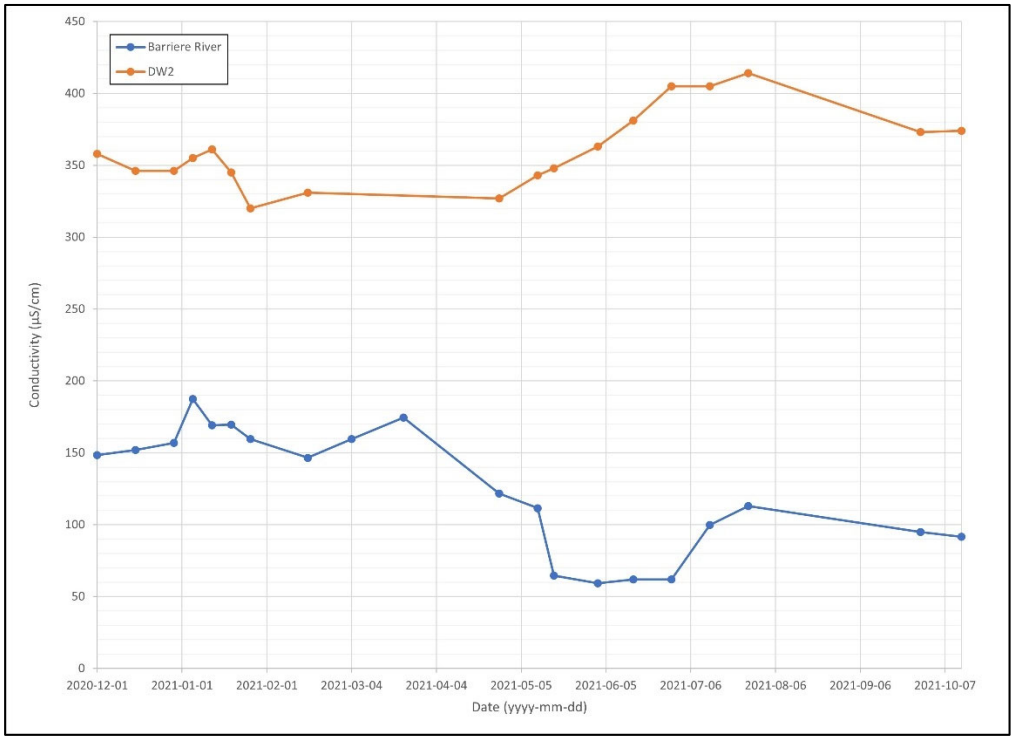
4.3.3 Conductivity

Conductivity is a measure of water's capability to transmit electrical flow and is directly related to the concentration of ions in solution, with higher ion concentrations producing higher conductivity readings. Ions in water can originate from natural sources such as carbonaceous minerals in the aquifer and/or from anthropogenic sources such as road salt or fertilizers. Groundwater generally has a higher conductivity than surface water, due to the extended duration the water spends in contact with the aquifer's matrix. Conductivity is perhaps the most useful field parameter for highlighting the differences between groundwater and surface water geochemistry.

From December 2020 to April 2021, the conductivity of the Barriere River was at its highest, with values that ranged from 147 to 188 µS/cm. This period is representative of baseflow conditions in the river when the proportion of discharged groundwater contributing to streamflow would typically be at its highest. From late April to October 2021, the values for conductivity decreased to a range of 59 to 121 µS/cm, during the period when snowmelt and/or precipitation represent a much more significant input of fresher (less mineralized) water into the river and the proportion of discharged groundwater in the river is reduced.

As expected, the conductivity of groundwater was consistently higher than the river measurements. Values throughout the assessment period remained relatively stable and ranged from 320 to 414 µS/cm. A slight increasing trend was noted to begin in late April and peak in July.

Figure 4-5 Time-series Plot – Conductivity

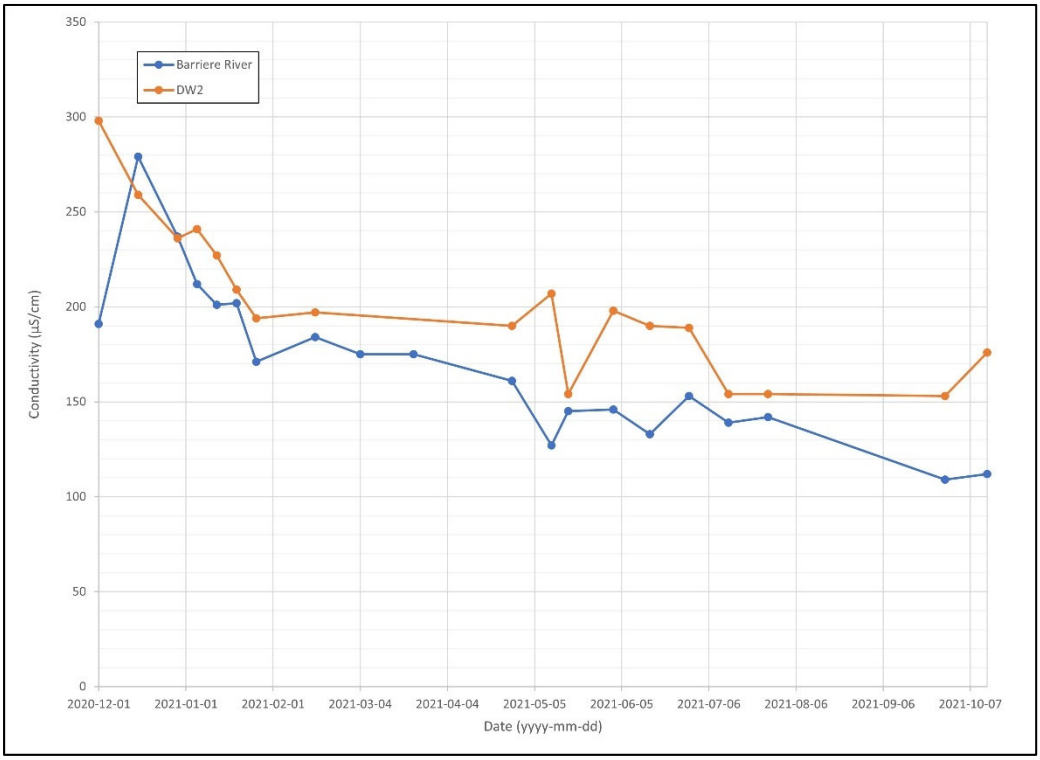


4.3.4 Oxidation-Reduction Potential (ORP)

ORP is a measurement of water's potential to gain or lose electrons. As it relates to groundwater flow systems, the theory is that in areas of groundwater recharge, infiltrating groundwater will have a higher concentration of dissolved oxygen and, therefore, a higher potential to be reduced and higher ORP values when measured. As groundwater moves through the aquifer's matrix, oxygen can be consumed by bacteriological and chemical reactions. In this case, groundwater is in a more reduced state, which results in lower and possibly negative ORP values when measured. Low and negative ORP values in groundwater can be associated with aquifers isolated from surface waters and nearby recharge sources.

ORP values for DW2 and Barriere River tracked closely together throughout the measurement period, with groundwater typically having slightly higher values than the river. A declining trend in ORP values was observed throughout the study, with the highest values occurring in December 2020 and the lowest in the late summer/fall of 2021. This is likely related to increasing ambient temperatures, as the solubility of dissolved oxygen in water decreases as temperatures increase.

Figure 4-6 Time-series Plot - ORP



4.4 Comparison of Groundwater-Surface Water Geochemistry

WWAL collected three sets of concurrent groundwater and surface water samples for potability testing. (laboratory reports provided in Appendix B). As expected, groundwater is more mineralized than the river and changes in chemistry from one sample to the next are typically less pronounced in the groundwater samples versus the surface water samples. For example, turbidity and iron values varied considerably in surface water over the three sampling events, whereas no variation was detected in groundwater. Parameters associated with anthropogenic impacts, such as nitrate and chloride, were slightly elevated in the groundwater samples compared to typical background conditions. However, these parameters were present at low concentrations, indicating limited impacts on the aquifer from local land use activities. The water samples were compared to the Guidelines for Canada Drinking Water Quality (GCDWQ) guidelines. These guidelines are only applicable to the groundwater samples and were therefore not applied to the surface water samples. As displayed in Table 4-4 below, all parameters in groundwater were found at concentrations less than the applicable standards.

Figure 4-7 presents a piper plot for the surface water and groundwater chemistry data collected for this project. The piper plot is a means for visualizing the relative proportion of common ions for a given sample and can highlight subtle differences between the samples. The piper plot indicates the chemical composition of the two water types is quite similar, with a slightly higher proportion of magnesium in groundwater samples. Overall, the two water types are classified as calcium-bicarbonate waters, as these two ions make up the bulk of the dissolved constituents in the samples. We typically expect to see water sampled from the same area, whether groundwater or surface water, to have a similar overall chemical composition.

Figure 4-7 Piper Plot of Groundwater and Surface Water

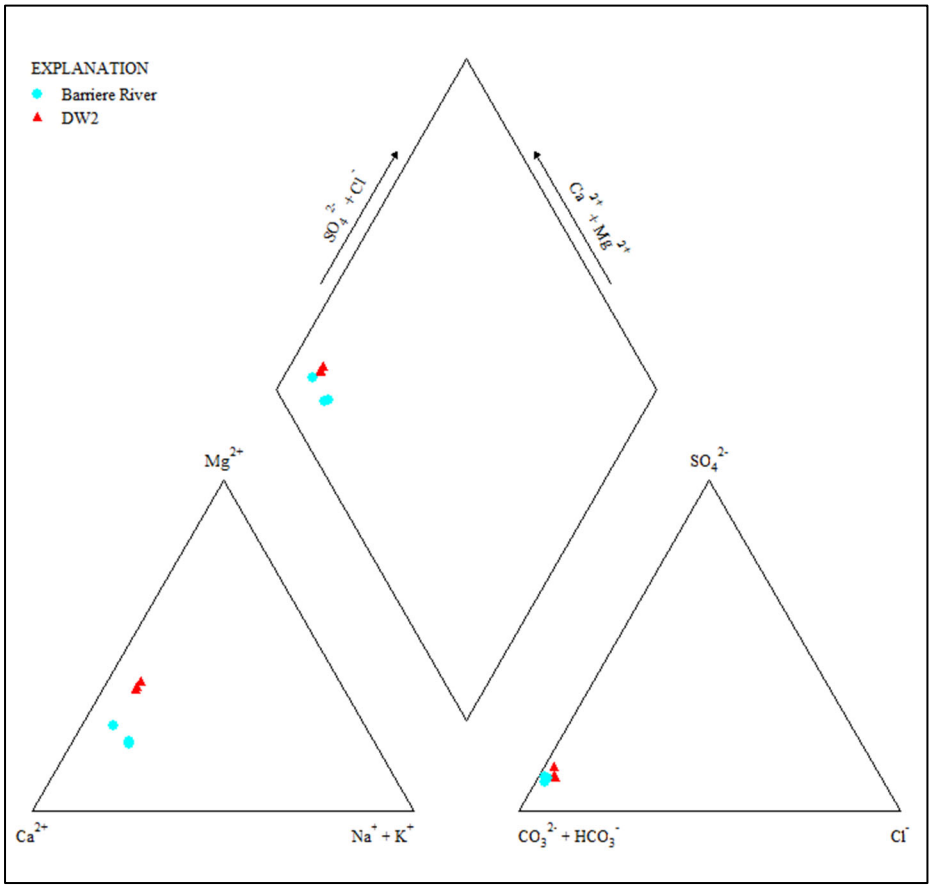


Table 4-4 Summary of Groundwater and Surface Water Geochemistry

Parameters	Units	DW2 2020-12-01	Barriere River* 2020-12-01	DW2 2021-05-17	Barriere River* 2021-05-17	DW2 2021-06-29	Barriere River* 2021-06-29	GCDWQ
General Parameters								
Conductivity	us/cm	314	132	348	60.4	381	58.5	n/a
Turbidity	NTU	<0.10	0.18	<0.10	8.65	<0.10	0.50	varies
Total Dissolved Solids	mg/L	180	87	194	53	238	43	AO ≤ 500
Hardness, Total (CaC03)	mg/L	152	62.7	162	30.2	190	27.8	n/a
Alkalinity, Total (CaCO3)	mg/L	150	59.5	156	27.6	188	30.3	n/a
Select Ions								
Fluoride	mg/L	0.069	0.044	0.088	0.037	0.089	0.033	MAC = 1.5
Nitrate, N	mg/L	0.503	0.0642	0.499	0.0854	0.379	0.0201	MAC =10
Nitrite, N	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	MAC = 1
Chloride	mg/L	4.65	0.72	4.84	<0.50	3.69	<0.50	AO ≤ 250
Sulfate	mg/L	13.7	5.76	15.5	2.35	23.4	2.44	AO ≤ 500
Total Metals								
Aluminum	mg/L	<0.0100	0.0242	<0.0100	0.554	<0.0100	0.0536	OG < 0.1
Arsenic	mg/L	0.00110	0.00016	0.00118	0.00048	0.00122	0.00122	MAC = 0.01
Barium	mg/L	<0.0200	<0.0200	<0.0200	<0.0200	<0.0200	<0.00200	MAC = 2
Boron	mg/L	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	MAC = 5
Cadmium	mg/L	<0.000200	<0.000200	<0.000200	<0.000200	<0.000200	<0.000200	MAC = 0.007
Calcium	mg/L	36.7	18.0	38.4	9.09	43.7	8.46	n/a
Chromium	mg/L	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	MAC = 0.05
Copper	mg/L	0.00333	<0.00100	0.00249	0.00231	0.00112	<0.00100	MAC = 2 AO = 1
Iron	mg/L	<0.030	0.032	<0.030	0.694	<0.030	0.060	AO ≤ 0.3
Lead	mg/L	0.00192	<0.000500	<0.000500	0.000891	<0.000500	<0.000500	MAC = 0.005
Manganese	mg/L	<0.00200	0.00501	0.00710	0.0343	0.00766	0.00310	MAC = 0.12 AO ≤ 0.02
Sodium	mg/L	6.12	2.09	6.50	<2.00	7.65	<2.00	AO ≤ 200
Uranium	mg/L	0.00194	0.00140	0.00214	0.00162	0.00211	0.000980	MAC = 0.02
Zinc	mg/L	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	AO ≤ 5

Notes: GCDWQ – Guidelines for Canadian Drinking Water Quality Guidelines, OG = Operational Guideline (designed for water treatment facilities); AO = Aesthetic Objective); MAC = Maximum Acceptable Concentration; *Surface water sample, not compared to GCDWQ

4.5 Microparticulate Analysis (MPA)

MPA sampling for this project was completed by a WWAL hydrogeologist following the methodology outlined by Hyperion Research, which is the only CALA Accredited laboratory in Western Canada for MPA testing. Microscopic analysis was completed by Peter Wallis, Ph.D. and his staff at Hyperion Research in Medicine Hat, AB.

The MPA sampling method conforms to U.S. EPA Method 1623 for identifying *giardia* and *Cyptosporidium* (US EPA, 2005) and the Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microparticulate Analysis (US EPA, 1992). The type of filter used (IDEXX Filta-Max) during sampling is named as an acceptable alternative filter in the Method 1623 guidance document and was recommended by Hyperion Research. According to Hyperion, the Filta-Max filter has superior organism recovery and requires smaller sampling volumes when compared to the standard filter. Particles trapped on the filter media are identified and enumerated in the

laboratory. Based on the number and proportion of primary and secondary particles, a matrix is used to assign a score that determines the risk of surface water contamination for a source, with 0-9 indicating a low risk, 10-19 a moderate risk and 20+ a high risk. Table 4-5 below summarizes the results of the modified MPA testing and the aerobic spore forming bacteria testing. Laboratory reports from Hyperion Research are provided in Appendix C.

The results of the MPA sampling from DW2 identified very few surface water indicator particles (laboratory reports provided in Appendix C). As a result, all three samples were assigned a low-risk rating for surface water contamination. Algae was detected during the May 2021 sample. Assuming the wellhead is secured from surface contamination, the presence of algae in the well sample would appear to be suspect. Moreover, the finding of algae occurred on only one occasion and only a single algae particle was noted by the analyst. Additionally, *Giardia* and *Cryptosporidium* were not detected in any of the three samples. Overall, the results indicate a consistent low risk of GUDI and that effective filtration is occurring in the subsurface, as would be expected given the geology and the confined aquifer setting.

Table 4-5 Summary of MPA Testing Results

Parameter	DW2	DW2	DW2
Sampling Date	01-Dec-2020	17-May-2021	29-June-2021
Water Filtered	250.8 L	250.8 L	250.8 L
Primary Particulates			
Diatoms	1	0	4
Other Algae	0	1	0
Insects/Larvae	0	0	0
Rotifers	0	0	0
Plant Debris	0	0	0
Giardia/Crypto	0	0	0
Secondary Particulates			
Nematodes	3	4	5
Pollen	1	6	5
Crustacea	0	0	0
Unknown	0	0	0
Additional Parameters			
Giardia cysts	0.0/100L	0.0/100L	0.0/100L
Cryptosporidium oocysts	0.0/100L	0.0/100L	0.0/100L
Overall Risk Factor	6 (low risk)	4 (low risk)	6 (low risk)

Note: Pollen is sometimes introduced during sample collection from suspended pollen in the air at the time of sampling.

4.6 Aerobic Spore Forming Bacteria Enumeration

The results of the aerobic spore forming bacteria (ASFB) in groundwater and surface water for the three sampling events are summarized in Table 4-6. As expected, ASFB were detected in all samples collected from Barriere River, with the highest concentrations occurring during the May sampling event. For the supply well, two of the three samples tested negative for ASFB, while the June sample contained 10 CFU/L. Qualitative interpretation of these results indicates that substantial filtration of groundwater is occurring in the aquifer prior the reaching DW2, and ASFB (and similarly sized *Giardia* and *Cryptosporidium*) are effectively being filtered.

Table 4-6 Results of Aerobic Spore Forming Bacteria Enumeration

Sample Location	01-Dec-2020	17-May-2021	29-Jun-2021
WPID 12702 (Supply Well)	0 CFU/L	0 CFU/L	10 CFU/L
Barriere River	110 CFU/L	9,516 CFU/L	770 CFU/L

5. DISCUSSION AND CONCLUSIONS

The Stage 2 GARP Assessment of DW2 (and by proxy, DW3) was commissioned based on the potential risk for pathogens to enter the supply well. The wells are positioned in relative close proximity to Barriere River and multiple potential pathogen sources have been identified within 300 m of the well.

Hydrometric data provides a good indication that a hydraulic connection potentially exists between the aquifer and Barriere River. This connection is related to pressure changes transmitted across the confining unit (aquitard) whereby the river exerts a hydraulic pressure across the fine-grained layers, to which the aquifer responds with a corresponding response expressed as a change in piezometric head (or water level in a well). The river's elevation was consistently found to be several metres higher than the elevation of groundwater. Under these conditions, the river represent a steady but slow source of recharge to the aquifer. This recharge, should it occur, would involve vertical flow through fine-grained confining layers, and water exchanged during this process is likely much less than flow in the river or water held in storage that flows naturally through the aquifer.

During testing of DW3, the well experienced persistent turbidity issues upon start up that eventually cleared after continued pumping. In this case, the source of turbidity is related exclusively to the aquifer formation, where a higher than typically silt content was discovered, and is not related to infiltrating surface water. As a result, the elevated turbidity does not represent a risk to the GARP status of the well and we anticipate that once DW3 is placed into operation and continuously pumped, the turbidity issue will eventually be resolved.

The measurement of field parameters throughout the assessment highlighted the difference between surface water and groundwater from the site. Temperature, pH and conductivity tended to be more stable (i.e., less fluctuations) in groundwater and were typically measured in distinctly different ranges for the two water sources. ORP, however, was found to be quite similar between groundwater and the river throughout the assessment, with groundwater tending to be slightly higher compared to the river.

Analytical testing indicates the supply well is chemically and bacteriologically of good quality and meets all Canadian drinking water aesthetic and health-based guidelines. DW2 is noted for being more mineralized than Barriere River, with the two sources, proportionally speaking, have a similar geochemical makeup.

Multiple lines of evidence suggest the aquifer is providing adequate filtration of any recharging water from Barriere River. Microbiological testing carried out during this study indicated total coliform and E. coli are present in Barriere River throughout the year, while testing of DW2 did not detect the presence of microbiological parameters in any of the samples analyzed. Additionally, historical sampling of untreated groundwater from DW2 did not detect total coliform or *E. coli.* in any of the samples.

ASFB testing also detected the ubiquitous presence of spores in Barriere River throughout the year, while ASFB was only found on one occasion in a DW2 sample at a value equal to the method detection limit. MPA sampling of DW2

identified a limited number of indicator particles, and *Giardia* or *Cryptosporidium* were not detected in any of the samples. Each of the three samples were assigned a low-risk rating for surface water contamination.

Potential pathogen sources within 300 m of the wells include a cow grazing area, infiltration fields from the Riverwalk wastewater treatment plant and multiple residential septic fields. The cattle grazing area is used on a seasonal basis and does not presently contain any observable stockpiles of manure. Additionally, the field is located in what is inferred to be a downgradient position relative to the supply wells; therefore, we consider the potential risk from this source to be low.

The infiltration beds from the Riverwalk treatment plant and multiple residential septic systems are located less than 200 m from the supply wells in potentially upgradient positions. A well head protection assessment of the wells (Kala, 1997) suggests the infiltration beds and septic fields fall within the 5-year capture zone of the wells. However, wastewater from these systems is disposed of in an upper, unconfined water bearing unit, and the Riverwalk plant is currently operating at around 15% of its intended capacity. Given the presence of a 23 m thick confining unit that separates the upper unconfined aquifer from the lower confined aquifer, it is likely that the DW2 and DW3 are sufficiently protected from wastewater disposal above, and that a pathway for virus or bacteria transport from surface to the confined aquifer likely does not exist.

We note that historical water quality data from DW2 appears to indicate that parameters associated with wastewater disposal (chloride and nitrate) have gradually increased over time (See Table 5-1 below). With that said, sampling for these parameters has been sporadic and it is challenging to draw any conclusions as to what trends may persist into the future with such a limited dataset. Additionally, the concentrations of these parameters remain low and far below Canadian Drinking Water Quality Guidelines (MAC = 10 mg/L for nitrate; AO = 200 mg/L for chloride) and, at the concentrations present, cannot necessarily be linked to wastewater disposal in the vicinity of the wells. Annual collection of untreated groundwater should be incorporated into the regular sampling program for the distribution system.

Table 5-1 Historical Chloride and Nitrate Concentrations from DW2

Date	Chloride (mg/L)	Nitrate (mg/L)
2013-10-08	2.1	0.178
2015-10-13	2.73	0.226
2020-11-04	4.98	0.511
2020-12-01	4.65	0.503
2021-05-17	4.84	0.499
2021-06-29	3.69	0.379

Note: CDWQG MAC = 10 mg/L for Nitrate; CDWQG AO = 200 mg/L for Chloride

Based on the evidence provided, it is our opinion that the aquifer for DW2 and DW3 supply wells receives sufficient filtration of recharging waters such that *Giardia* and *Cryptosporidium* are not likely to be present at any time of the year. As a result, the District of Barriere water system is unlikely to require additional filtration or UV inactivation for these pathogens. As viruses are typically one or two orders of magnitude smaller than bacteria, there is some risk that viruses, if present in Barriere River or in the upper, unconfined aquifer, may reach the wells. However, the river is relatively pristine and lacks significant upstream inputs of sewage and other wastes that would increase the

viral risk. Additionally, the presence of a 23 m thick confining layer above the source aquifer should provide sufficient protection from viruses present in the near subsurface.

In summary, we conclude that DW2 and DW3 are at **low risk of containing pathogens**. The existing practice of primary disinfection with contact time and maintaining a chlorine residual in the distribution system should remain in place to meet other Interior Health supported water system guidelines (e.g., Distribution System Guidelines, 2016).

6. RECOMMENDATIONS

Based on the above conclusions, we offer the following recommendations:

R1 The existing level of primary and residual disinfection should remain in place for the Barriere water distribution system. Ultimately, the level and type of water treatment required for a water source is at the discretion of the responsible Drinking Water Officer with the Interior Health Authority. This GARP report should be reviewed by Interior Health prior to a final determination on water treatment requirements.

R2 Efforts should be made to limit any potential sources of pathogens in proximity to the well (e.g., manure stockpiles, septic systems, compost heaps, animal grazing, etc.). We realize the well is located adjacent to private properties, and it will take a concerted effort to change any current land management practices. Education on the protection of the local water supply and potential sources of contamination should be provided to users of the community's water system.

R3 A comprehensive potability sample of untreated groundwater should be collected a minimum of every two years to monitor for any changes in the geochemistry of the water over time.

R4 We understand that future plans for the community's infrastructure potentially includes the decommissioning of the Riverwalk wastewater treatment plant. If feasible, we would support this action, as it would eliminate a potential source of risk to the community's water supply. Consideration should also be given to connecting all residential properties in the area to the municipal wastewater collection system.

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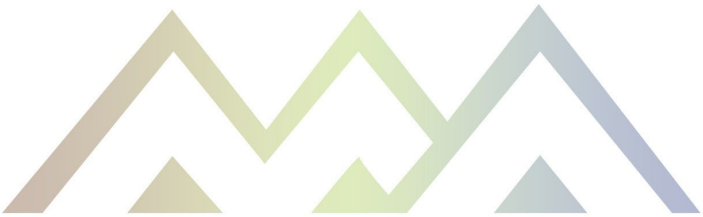

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Water Master Plan – Part I

District of Barriere

October 2020

Project No. 346-371

ENGINEERING ■ PLANNING ■ URBAN DESIGN ■ LAND SURVEYING

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List of Acronyms

ADD	Average Day Demand
BCGWCS	BC Groundwater Consulting Services
District	District of Barriere
GARP	Groundwater at Risk of Containing Pathogens
GCDWQ	Guidelines for Canadian Drinking Water Quality
GUDI	Groundwater Under Direct Influence
IHA	Interior Health Authority
MAC	Maximum Allowable Concentration
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MDD	Maximum Day Demand
MMCD	Master Municipal Construction Documents
MOE	Ministry of Environment
NTU	Nephlometric Turbidity Unit
TRUE	TRUE Consulting
UV	Ultra Violet

WTP	Water Treatment Plant

Units of Measure

ft	feet
Igpm	Imperial gallons per minute
km	kilometre
L/d	Litres per day
L/m	Litres per minute
L/s	Litres per second
lpcd	Litres per capita per day
m	metre
mg/L	milligrams per Litre
mm	millimetre
NTU	Nephelometric Turbidity Units
psi	pounds per square inch
USgpm	US gallons per minute

Referenced Reports

1	District of Barriere Official Community Plan, 2008
2	Golder, Well Head Protection Plan, January 24, 2008
3	District of Barriere Annual Report, 2019
4	District of Barriere Annual Water Report, 2018, 2016
5	Kala Geosciences, Wellhead Protection Assessment, September 8, 1997

Executive Summary

The purpose of Part I of the Water Master Plan is to identify water sources available to the District of Barriere (the District) and assess the associated water quality. The District has called for the preparation of this master plan to identify a sustainable, long term water source that will sufficiently provide the community with high quality water. The master plan is focused on development of the source and the associated treatment requirements.

Part II of the Water Master Plan will look at the water distribution system, fire-flow improvements, and looping opportunities to improve efficiency.

The District currently relies on Deep Well 2 (DW2) as its main source of drinking water and water quality to date has allowed for treatment using Chlorine only. The well was drilled in 1997 and is not capable of meeting maximum day demand (MDD) on its own. At times of high demand, the District must impose strict water restrictions. There is opportunity to supplement production with the Bradford Park Wells. The Bradford Park Wells cannot be operated at a high flow rate due to concerns regarding the stability of the sand filter pack, and though the water is safe to drink, it is aesthetically unpleasant. Deep Well 1 (DW1) could also be used to supplement supply, however DW1 does not meet the Guidelines for Canadian Drinking Water Quality (GCDWQ) criteria and a Boil Water Notice must be issued if the well is put into service. The DW1 source has been physically disconnected from the system.

The capacity and associated quality of the drinking water sources available to the District have been examined to identify a sustainable water supply for the District of Barriere. Treatment requirements for the water sources have been identified to determine order of magnitude costs associated with bringing those sources online for use by the District.

1.0 Background

1.1 Introduction

The District of Barriere has been successful in the ICIP infrastructure planning grant program and has called for the preparation of a Water Master Plan to assess available source and treatment options that will meet demand and water quality requirements. This document will also provide guidance regarding future capital expenditures.

The District of Barriere has had many challenges in acquiring a sustainable water source that will both meet Maximum Daily Demand (MDD) and satisfy the Guidelines for Canadian Drinking Water Quality (GCDWQ)

A Giardia outbreak in 1990 led the District to pursue a groundwater source. A brief overview of the District's existing groundwater infrastructure is as follows:

TABLE 1-1: DISTRICT OF BARRIERE WELL OVERVIEW

Shallow Wells (SW1, SW2)	▪ Incapable of meeting MDD ▪ High probability of being Groundwater at Risk of Containing Pathogens (GARP)
Deep Water Wells (DW1, DW2)	▪ DW2 is currently the main source ▪ DW1 contains manganese levels greater than the Maximum Allowable Concentration (MAC) ▪ May be GARP, assessment has not yet been completed
Bradford Park Production Wells (PW1, PW3)	▪ Incapable of meeting MDD ▪ Issues with the stability of the aquifer and quality of the water

A Groundwater Under the Direct Influence of Surface Water or Groundwater at Risk of Containing Pathogens Assessment (GUDI/GARP) has not been completed on any of the District's wells. The water quality of the sources has only been examined from previous testing.

An outline of the District's source water timeline is provided in Section 1.4.

1.2 Planning Documents

1.2.1 Official Community Plan

The District's planning in relation to water infrastructure is guided by the Official Community Plan.

Environment

3.2.1 To protect and enhance the quality of Barriere's rivers, streams and ground water sources in order to provide an integrity level that supports the ecological services of the North Thompson River and Barriere River and Watershed

a) Support and establish a Groundwater and Surface Water Protection Plan
b) Require the implementation of Barriere Riparian Area Regulations for all development occurring withing a Riparian Area
c) Require all new development to connect to the District Water system, except where physically or economically unfeasible, as determined by the District
d) Prohibit bulk water sales

3.2.2 To provide leadership to promote water conservation and further educational programs

a) Develop a Water Conservation Plan
b) Undertake a water metering program
g) Encourage requirements and incentives for low water use fixtures (e.g. low flow shower heads and toilets)
j) Promote water demand education, management and conservation as a component of a sustainable community

Infrastructure and Utility

3.5.6 To work towards connecting all of Barriere to the water and sewer systems

a) Promote responsible on-site water and septic system management for all existing systems
b) Review water use and encourage water metering for both residential and commercial sectors; and
c) Property owners and occupiers are encouraged to ensure that maintenance contracts for on-site septic systems are followed in accordance with the appropriate Provincial regulations.

1.2.2 2018 Annual Report

The District's Annual Report includes the objectives of the water utility.

Water Utility Objectives

- To ensure adequate supply of high-quality water to the community
- To effectively treat the raw water to provide potable water of integrity to the community
- To ensure the adequate delivery of high-quality potable water to all points within the system for domestic and emergency purposes
- To ensure effective management of all water system aspects and provide excellent customer service and information to the community
- To manage water demand by effectively assessing and managing water losses from leakage in the system.
- To develop an effective water conservation program for operations and the wider community
- To maintain water rates that encourage conservation and resource awareness while providing quality accessible water to consumers

1.3 Water Demand

The District of Barriere population was 1713 in 2016 (Census). The water supply has approximately 780 residential connections and 75 commercial connections (District of Barriere 2018 Annual Report).

Existing Flows

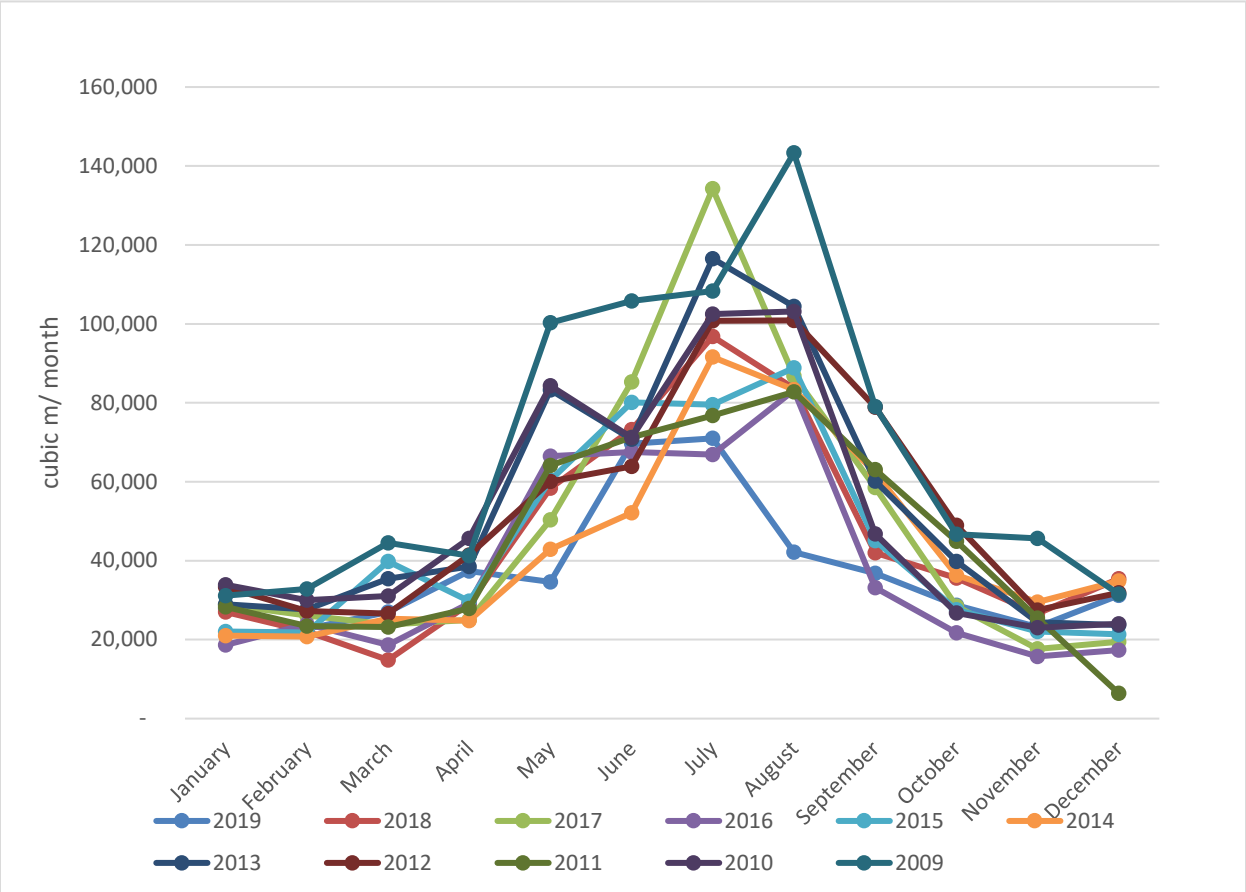


FIGURE 1-1: MONTHLY DEMAND

Future Growth Projection

Census population was 1773 in 2011 and 1713 in 2016. BC Stats have estimated significant growth in the years 2017, 2018 and 2019 as shown in Figure 1-2.

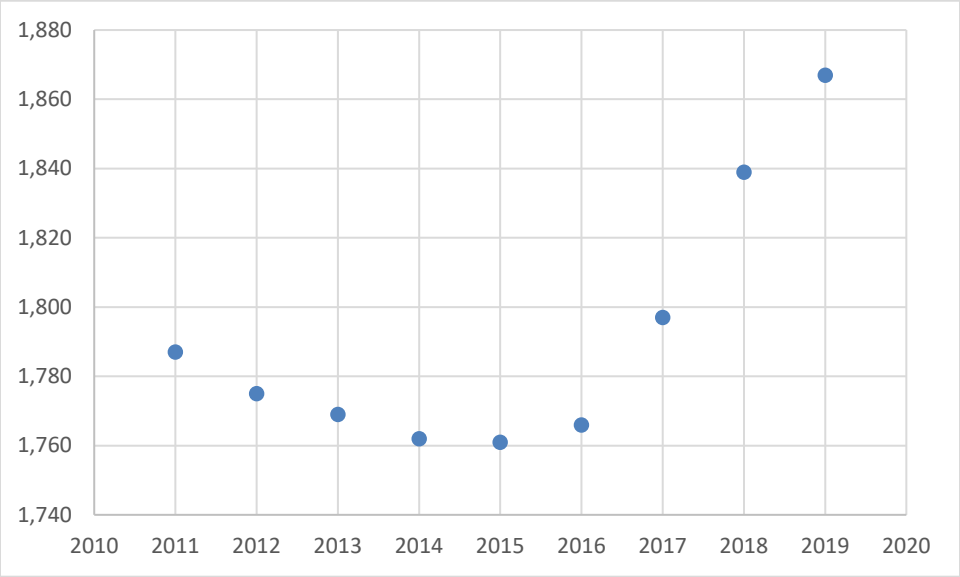


FIGURE 1-2: BARRIERE ESTIMATED POPULATION (BC STATS, 2020)

A range of growth scenarios have been calculated for use in estimating future water requirements (Table 1-3).

TABLE 1-2: FUTURE POPULATION GROWTH

	Growth Rate	2019	2025	2040	Difference (2019-2040)
Population	2%	1763	1985	2672	909
	0.5%	1763	1817	1958	195
	0.25%	1763	1790	1858	95

Design Demand

Based on past monthly flow data and population growth projections an MDD of 60L/s has been selected for water projects in Barriere.

1.4 District of Barriere Water Supply Timeline

Pre 1990 –	Barriere using surface water from Leonie Creek and Barriere River. The water is treated with chlorine in reservoir prior to distribution
1990 –	Up to 20 people in Barriere diagnosed with giardiasis
May – October 1990 –	MOE undertakes a sampling program, finding that Giardia is present in up to 90% of the surface water samples
February 1991 –	Pump testing of Shallow Water Wells. They were not capable of producing MDD.
April 1991 –	Slow sand filter pilot study (TRUE Consulting)
1991 –	TRUE memo recommends exploring treatment options for Leonie Creek, groundwater will not be sufficient for current or future demand
1994 –	DW1 Drilled
1997 –	DW2 Drilled
2009 –	Test wells drilled at Bradford Park under direction of BC Groundwater Consulting Services
2010 –	DW2 rehabilitated
April 2011-	Barriere applies for UBCM Gas Tax Grant for deep water well development
2012 –	Installation of universal water metering. Consumption reduced by 35 - 40%
2012 –	SCADA monitoring system installed
May 2012 –	District of Barriere using two deep water wells (DW1, DW2) as main water source, required to supplement in the summer with shallow water well under direct influence of surface water
May 2017 –	Drilling of PW2 fails due to heaving and sand lock of the drill string
July 2017 –	Breakthrough of fine sand into PW3 during pump testing
Fall 2017 –	Shallow water wells taken offline due to GUDI status
Winter 2018 –	Bradford Park Well development completed at lowest practical flow rate (12 L/s for each well)

February 2019 –	The flow meter at DW2 fails, requiring the District to take DW2 offline. The District puts Bradford Park PW1 online under close monitoring, various complaints regarding water colour are received.
April 15, 2019 –	District issues Water Quality Advisory
May 19, 2019 –	Bradford Park PW3 is re-developed
July 11, 2019 –	Bradford Park wells are put back on-line at a maximum of 50% of their individual maximum production rates (approx. 12 L/s per well).

2.0 Capacity and Condition of Current Water Supply

2.1 General

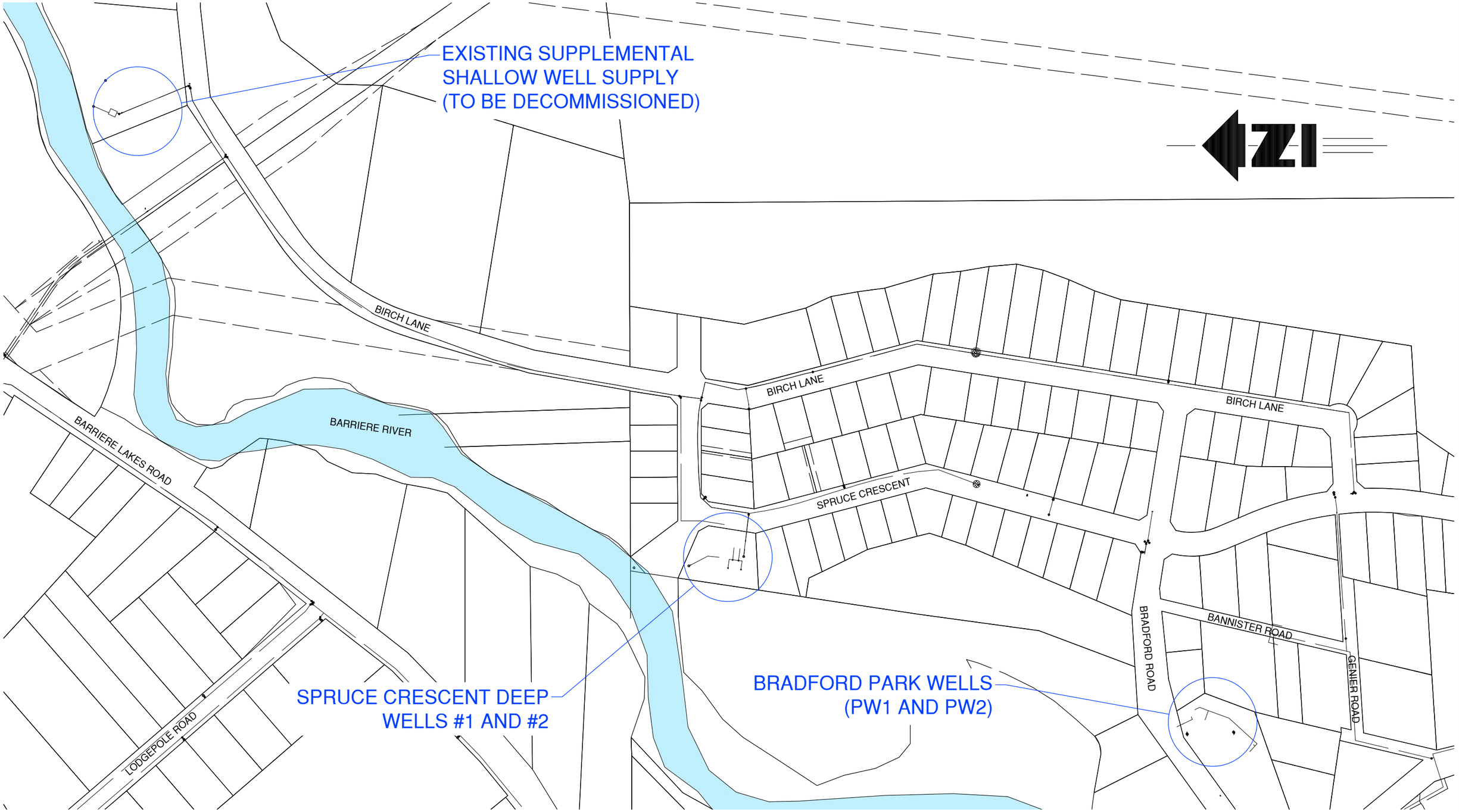
The District of Barriere's active water supply wells are on two sites, Spruce Crescent and Bradford Park. The Spruce Crescent wells were drilled in 1994 (DW1) and 1997 (DW2). DW2 is currently the District's main water source and is able to meet average day demand (ADD) of approximately 30 L/s. It is unable to meet maximum day demand (MDD). DW2 has reached the end of its useful life and as such, is not a sustainable source of water for the District. Each summer the District imposes severe seasonal watering restrictions to avoid bringing another well online. DW1 cannot supplement the system due to Manganese levels above the maximum allowable concentration (MAC), and the existing water treatment plant requires refurbishment to operate effectively. With refurbishment the existing filters would have a filtration capacity of approximately 38 L/s. DW1 has been disconnected from the system

The Bradford Park Wells (PW1 and PW3) were drilled in 2017. The District originally hoped to develop the twinned well system and remove the older Spruce Crescent wells from service. Unfortunately, the project has been unsuccessful. The Bradford Park wells have been difficult to develop. For example, the drilling of PW2 failed due to heaving conditions and sand-lock of the drill string and PW3 had sand breakthrough during pump testing that resulted in the well needing to be rescreened. Due to the challenging nature of the aquifer, it has been recommended that the wells are only operated at 50% of their capacity, meaning they are unable to meet demand requirements on their own.

In addition to difficult well development, the water supplied by the Bradford Park wells is aesthetically unpleasant. The District had to take DW2 offline for repairs in 2019 when a flow meter failed. Bradford Park PW1 was brought online with close monitoring and the District received numerous complaints about the aesthetic quality of the water. The Bradford Park well system has not proven to be a sustainable long-term drinking water source as planned.

Interior Health is currently completing their annual inspection of the drinking water system and has requested that GUDI/GARP assessments be completed for all the District's wells that are connected to the system. If it is determined that the wells are GUDI/GARP they will need to meet the Interior Health 4-3-2-1-0 treatment objective for surface water and groundwater at risk of containing pathogens as follows:

- 4 log (99.99%) removal or inactivation of viruses
- 3 log (99.9%) removal or inactivation of Giardia Lamblia and Cryptosporidium
- 2 treatment processes for all surface drinking water systems
- 1 NTU of turbidity with a target of 0.1 NTU
- 0 E. Coli



EXISTING WELL LOCATIONS

TRUE CONSULTING

DESIGN BY: SE	
SCALE: 1:5000	
DWG NO.: FIG: 2-1	REV: -
DRAWN BY: DJF	
DATE: OCT 2020	

FILE:r:\clients\300-399\346\346-371\03 drawings\cad\03 base drawings\346-371-base.dwg

The District's current source water supply is not capable of adequately supplying the needs of the community. DW2 can provide ADD, however the age and condition of DW2 is such that it is not a sustainable source for the District. Bradford Park wells PW1 and PW3 can supplement DW2, however these wells are sensitive to over-pumping, can only provide a fraction of the water requirements of the District, and the water is aesthetically displeasing. DW1 contains manganese that is elevated relative to the GCDWQ and this well has been disconnected from the system. The water source is the most critical component of the District's water system, and its current water source (DW2) is at high risk due to the age and condition of the well. The District does not have a redundant source of water in the event of mechanical failure at DW2.

2.2 Shallow Water Wells

The two shallow water wells were drilled in 1991 to a depth of approximately 12m. The shallow wells are categorized as being under the direct influence of surface water due to their proximity to the Barriere River and a history of measurable total coliform concentrations (Golder, 2008). Testing in February of 1991 showed that the wells were unable to support the demand of the community, Shallow Well 1 (SW1) is capable of producing 4 L/s and Shallow Well 2 (SW2) is capable of producing 10 L/s. The wells were disconnected from the water system in the Fall of 2017.

Due to the treatment required and the low production of the existing shallow wells, a shallow well water source is not recommended for long term servicing requirements.

FIGURE 2-2: SHALLOW WELL SITE

2.3 Spruce Crescent Wells – (DW1, DW2)

The Spruce Crescent site has two existing wells. As discussed in Section 2.1 DW2 is the District of Barriere's primary water source. This source can meet an average demand of approximately 30 L/s and has aesthetically acceptable water quality. DW1 remains disconnected from the system due to manganese levels above the MAC of 0.12 mg/L. Table 2-1 summarizes previously completed water quality testing.

Golder Associates compared the Barriere wells to the prevailing GUDI standard in the Well Head Protection Plan completed in 2008. Golder has assessed that DW1 and DW2 are likely not GUDI wells because they are located approximately 100m from the Barriere River in a confined aquifer. The wells have not been assessed against the current Ministry of Health GARP Standard (2015). It is expected that DW1 and DW2 would be classified as GARP or GARP-virus only.

The Spruce Crescent Wells have supplied consistent water quantity and quality for 25 years. However, the age of the wells and lack of redundancy puts the District in a vulnerable position. If DW2 fails, the District will be unable to meet demand. In particular, the District cannot put DW1 online without a boil water advisory.

If the Spruce Crescent wells were replaced, it could be reasonably expected that the new wells would have water quality and production rates similar to the existing wells. With refurbishment and expansion of the existing treatment plant, the wells would be able to sufficiently meet forecasted demand.

TABLE 2-1: DEEP WATER WELLS - MANGANESE AND TURBIDITY

	Date	Total Manganese* (mg/L)	Turbidity
Deep Well 1 DW1	October 8, 2013	0.12	5.22
	October 13, 2015	0.14	4.35
Deep Well 2 DW2	October 8, 2013	0.0058	0.23
	October 13, 2015	0.0052	0.18

* Manganese MAC =0.12 mg/L, AO = 0.02 mg/L

2.4 Bradford Park Production Wells (PW1, PW3)

The District has had a variety of issues associated with the development of the Bradford Park Wells. As discussed in Section 2.0 the wells are unable to meet demand requirements, they are vulnerable to sand breakthrough, and the water is aesthetically unpleasant. BCGWCS has recommended that the Bradford Park wells are operated at a maximum of 12 L/s each and monitored closely. Analytical testing results have been summarized in Table 2-2 below. All total Manganese results are above the aesthetic objective (AO) of 0.02 mg/L, and nearing the MAC of 0.12 mg/L.

The yield of the Bradford Park Wells is unable to meet demand requirements and they are not considered to be a sustainable long-term drinking water source. Nevertheless, it is recommended that they remain connected to the system for emergency back up purposes. The licensing application for the Bradford Park Wells is currently pending review.

TABLE 2-2: BRADFORD PARK WELLS – MANGANESE AND TURBIDITY

	Date	Total Manganese* (mg/L)	Turbidity
Bradford Park PW1	April 27, 2017	0.083	0.75
	May 30, 2019	0.0985	0.27
	April 22, 2020	0.104	-
Bradford Park PW3	August 17, 2017	0.106	2.61
	May 30, 2019	0.0713	0.48
	October 6, 2019	0.0615	0.46
	July 21, 2020	0.0755	-

* Manganese MAC = 0.12 mg/L, AO = 0.02 mg/L

2.5 Surface Water Sources

The District of Barriere utilized water licences on Barriere River and Leonie Creek as their primary water source prior to 1990. The District diverted water from Leonie Creek and chlorinated the water directly in the reservoir. Water from the Barriere river was pumped to a high lift pump station where it was chlorinated before entering the distribution system. In 1990 the community had several diagnosed cases of giardiasis. The Ministry of Environment undertook a 6-month sampling program and found that Giardia was present in approximately 90% of the surface water samples.

There are no readily available water quality results for these surface water sources. Drinking water treatment requirements for surface water must meet the Interior Health 4-3-2-1-0 treatment objectives.

The District continues to hold licenses over both sources. The existing surface water licenses would be sufficient to meet forecasted demands. Cost associated with the construction of a river intake and surface water treatment plant will be much greater than the development of a groundwater source. The development of a surface water treatment plant is seen as a potential future upgrade to the District's water system and would add additional redundancy and reliability to the water system.

TABLE 2-3: SUMMARY OF WATER SOURCES

Source Name	Description	Water License No.	Estimated Yield	Water Quality Concerns	Treatment Requirements	Comments
Leonie Creek	Surface Water	C050374 497796 m^3/year (15.8 L/s) average		Surface Water Source Limited Data	Subject to 4-3-2-1-0 treatment objectives	Recommend a sampling program to better understand water quality and come up with a treatment strategy Would require the construction of of new inlet structures, pipelines, and treatment
Barriere River	Surface Water	C032392 (1966) 248898 m^3/year (7.89 L/s) average C046787 (1974) 2488984 m^3/year (78 L/s) average		Surface Water Source Limited Data	Subject to 4-3-2-1-0 treatment objectives	
Shallow Well 1 (SW1) PW90-1	Drilled in 1991 Depth: 9.6 m		5.34 L/s (Hardy BBT. 1991)	Directly recharged by Barriere River Assumed to be GARP	Subject to 4-3-2-1-0 treatment objectives	Formal GARP assessment not completed, wells assumed to be under direct influence of surface water Yield not capable of meeting MDD
Shallow Well 2 (SW2) PW 91-1	Drilled in 1991 Depth: 11.6 m		15.26 L/s (Hardy BBT, 1991)	Directly recharged by Barriere River Assumed to be GARP	Subject to 4-3-2-1-0 treatment objectives	
Deep Well 1 (DW1) PW93-2	Drilled in 1994 Depth: 59.3 m Diameter: 300 mm		Approximately 44 L/s	May be GARP or GARP-virus only. Manganese levels above MAC. Deep Wells have elevated nitrate, close proximity to on-site sewage systems.	Requires Manganese removal filtration	GUDI/GARP assessment not completed Aged wells at risk of failure Capable of providing MDD if treatment system is updated
Deep Well 2 (DW2) PW97-1	Drilled in 1997 – currently districts main water source Depth:42.1m Diameter: 250mm		Approximately 50 L/s	May be GARP or GARP-virus only. Deep Wells have elevated nitrate, close proximity to on-site sewage systems.	No treatment required apart from disinfection	
Bradford Park Production Well 1 (PW1) PW17-1 Well ID: 48866	Well Tag #114383 Depth: 91.4 m Diameter: 250 mm	Temporary Licence for 25 L/s	A maximum of 12 L/s per well until recharge is determined	May be GARP or GARP-virus only. Manganese results above AO of 0.02 mg/L. Approaching MAC of 0.12 mg/L.	Manganese and Iron Removal may be required	GARP assessment not completed Will not meet ADD at current yield Aquifer vulnerable due to overpumping failure
Bradford Park Production Well 3 (PW3) PW17-3 Well ID: 48898	Well Tag #114384 Depth: 121.9 m Diameter: 250 mm	Temporary Licence for 25 L/s	A maximum of 12 L/s until recharge is determined			

3.0 Water Supply and Treatment Plant Upgrade Plan

The District of Barriere's highest priority for its water system is to establish a reliable high quality potable water supply for the community. It is important that the solution is cost effective, sustainable, and efficient. The District plans to apply for funding under the 3rd intake of the Investing in Canada Infrastructure - Rural and Northern Communities Grant Program for funding to increase the community's access to potable water and complete the first phase of water upgrades.

The proposed scope of work includes the following:

- Drill two additional wells at Spruce Crescent and decommission DW1 and retain DW2 as mechanical backup if possible
- Convert existing greensand filtration units to biological manganese removal filtration units for a total flow capacity of 38 L/s
- Expansion of the treatment plant including:
    - Additional biological manganese removal units for an additional flow capacity of 38 L/s
    - A chlorination room
    - A backup generator

The proposed upgrade plan is detailed in the attached cost estimate in Appendix A. Preliminary Design Drawings are located in Appendix C.

Phase 1 focuses on establishing a sustainable water source and sufficient water treatment for reliable service delivery. The first phase will ensure redundancy and provide sufficient potable water for demand requirements.

3.1 New Wells

The existing Deep wells have been found to require urgent replacement due to their age, condition and the extent to which Barriere relies on them as their main water source. The District recognized this urgency in 2009 when it initiated a groundwater assessment study. Unfortunately, the replacement wells drilled at Bradford Park did not meet the intended project objectives.

The new wells will be located close to the Barriere River. As such, the top of the well casings will be set at least 300mm above the local 200-year flood elevation.

The new wells at Spruce Crescent would be drilled and tested prior to finalizing the design of the water treatment systems. As such, this work would be scheduled for at least one year before the design and construction of the WTP improvements.

3.2 Treatment Plant

3.2.1 Design Parameters

Design Flow

The 20-year flow projection undertaken for this Master Plan report has an estimated Maximum Daily Demand of 5,200m^3/d (60 L/s).

The future MDD flow is expected to remain stable based on the following factors:

- The community has universal water metering.
- There is a history of relatively stable or declining population in the BC Interior.
- The District is not expecting to approve additional expansion of the system within the design period (to 2040).

Design Raw Water Quality

The treatment system will treat a blend of water from the existing wells, along with water from new wells on the Spruce Crescent site. The water quality from the new wells is expected to be similar to the existing deep wells. As such, the raw water quality is summarized as follows:

- Total manganese and iron at or exceeding aesthetic objective values
- Manganese exceeding maximum acceptable concentration
- Turbidity < 1.0 NTU
- Fecal coliforms and E coli < 1 CFU / 100ml

No concerns have been noted in relation to other parameters.

3.2.2 Manganese Removal

Manganese and iron removal is most commonly undertaken using greensand filters, such as the filters already installed at Spruce Crescent. These rely on the use of an oxidant to cause the manganese to be adsorbed onto the sand media.

The existing treatment system is no longer being used, but it could be refurbished for future use. The filters have been visually assessed and appear to be structurally sound. However, the mechanical and electrical systems are obsolete and need to be replaced. This is expected to include the replacement of pipework, media and the filter underdrains.

TABLE 3-1: EXISTING GREEN SAND FILTRATION UNITS

The refurbished filters can be used for manganese removal by processes other than greensand filtration. A range of treatment methods are available including sequestration, ion exchange, adsorption / filtration and biological filtration.

Sequestration: When manganese levels are less than the MAC, one potential method for addressing it is simply to mask its effects through sequestration. Sequestering manganese involves adding sodium phosphate to the water to effectively hide the presence of the dissolved metal for a short period of time. Sequestering is typically inexpensive but to be effective it is recommended that the water not have a maximum dissolved manganese concentration exceeding 0.1 mg/L.

Ion Exchange: In an ion exchange process, dissolved manganese ions are exchanged for sodium ions with an exchange resin. This is the very same process used for softening hard water. Therefore, an ion exchange process would be capable of softening the water in addition to removing the dissolved manganese. However, the sodium concentration of the treated water will increase substantially as the exchange resin indiscriminately replaces virtually all positively charged ions such as calcium, magnesium, iron and manganese with sodium ions. This increased sodium concentration could create health issues for those on the salt restricted diets.

Oxidation and Filtration: Manganese removal may also be achieved through the conventional chemical-physical process of oxidizing the dissolved manganese and removing the resulting insoluble manganic manganese with filtration. Oxidation can be performed through chlorination of the water, which has the added benefit of providing disinfection while removing the manganese.

Aeration with pure oxygen or potassium permanganate may be also used for oxidation in combination or potentially as an alternative to chlorination. Oxidation with potassium permanganate is particularly useful because it also regenerates the filter media but comes with complex handling requirements because of its hazardous nature. Sufficient contact time is required for the oxidation process to thoroughly precipitate the dissolved manganese. Filtration media can be greensand or proprietary media such as Filox. Filox can be used without an oxidant but the performance of the media is affected.

Biological Filtration: Another technology that is being used more in BC in recent times is biological filtration. Biological filtration makes use of innocuous bacteria already present in the groundwater that naturally feed on dissolved manganese. Within the filter vessel, the bacteria form a biofilm on the surface of the filter media that effectively consumes manganese. In addition to removing manganese, the removal of other dissolved metals such as iron and ammonia can be achieved.

Biological removal system has advantages that are relevant to the Barriere WTP, such as reduced waste volumes, reduced chemical requirements and a backwash waste that is free of oxidants and easier to dispose of.

The preferred treatment option for Barriere is biological manganese removal. Based on the dimensions of the existing filters, they will have a treatment capacity of 38 L/s. A further 38 L/s of treatment capacity is proposed in order to achieve the design MDD. This can be achieved by installing two additional filter units as shown on the drawings (Appendix C).

3.2.3 Disinfection

Chlorination will be required for primary disinfection, targeting bacteria, viruses. The chlorine will also provide a residual in the distribution system to preserve the quality of water and protect against contamination.

Space will be set aside for ultraviolet disinfection to ensure compliance with Interior Health Authority requirements in case the wells be classified as GARP in the future.

3.2.4 Backwash System

The proposed water treatment plant process will periodically backwash, producing biological suspended solids removed from the filters that must be disposed of. The backwash flow becomes a waste or process residual that has to be managed. The proposed site means that the waste can be allowed to settle, with the clear supernatant disposed of to the existing rock trap. The remaining concentrated solids will then flow to the Birch Lane WWTP for treatment.

It will be important to backwash the biological filters with unchlorinated water so a clean backwash water storage tank will be needed.

3.3 Building Design

3.3.1 Building Energy Efficiency

It has been confirmed by the Investing in Canada Infrastructure Program that in order to meeting the project funding criteria, the building design must target the BC Building Code values. Therefore the 2018 version of the BCBC applies to this funding application. There is no requirement to exceed these energy standards.

Barriere is assumed to be in the same climate zone as Kamloops. The BCBC (2018) assesses Kamloops as having 3,450 degree-days below 18˚C. The building will include other energy efficiency features such as;

- LED lighting
- High R rated overhead doors (e.g. Wayne Dalton Thermospan 150 Insulated Sectional Steel Door)
- High R value translucent wall panels in place of windows (e.g. Kalwall® window replacement panels)

3.3.2 Emerging Technologies, Environmental Considerations and Societal Impacts

Emerging Technologies: Given that this system provides drinking water to residents of the Barriere community and must be approved by Interior Health, the water treatment system will use proven technology. The proposed biological manganese removal process has been in use in Europe since the 1980s and is marketed by the Suez Corporation as the Mangazur process. Despite this, the process is relatively new to British Columbia. There are Mangazur plants working successfully at 100 Mile and 108 Mile. A biological manganese removal plant is also currently under construction in Burns Lake. This plant will be the first in BC to retrofit existing filters to the biological treatment method.

As far as possible, new building technologies aimed at energy efficiency will be implemented as part of the design.

Environmental Considerations: Apart from making use of energy efficient building features, the site selection makes use of existing disturbed land, minimizing impact on natural areas.

Societal Impacts: Access to clean drinking water will benefit members of the Barriere community. Residents will be affected by an increase in operating charges related to the new infrastructure.

4.0 Cost Summary

4.1 Capital Costs

The overall estimated capital cost of the new wells and treatment improvements is $3,870,360 with no opportunities for phasing. A preliminary capital cost estimate for the project is presented in Table 4-1 and more detailed cost estimates are included in Appendix A.

TABLE 4-1: WATER TREATMENT PLANT CAPITAL COST ESTIMATE

Item	Description	Estimate
General	Insurance, Bonding, Mobilization, Demobilization, Commissioning	$80, 000
Well Improvements	Wells, pumps, electrical	$795,000
Water Treatment Plant – Existing Manganese Removal System Modifications	Filtration Equipment and Services	$290,000
Manganese Removal System – Supply	Filtration Equipment	$500,000
Water Treatment Plant Foundation	Excavation, Backfill, Subbase, Foundation	$100,650
Water Treatment Plant Building	Pre-cast concrete structure, doors, windows, roof modifications	$306,750
Chlorination Room	Chemical Feed, Storage Tank	$83, 500
Emergency Diesel Generator	Generator, testing and commissioning	$150,000
Manganese Removal System - Installation	Installation	$85,000
Electrical, SCADA and Controls	Electrical, SCADA, Controls, Instrumentation	$318,000
Supply Piping	Site Piping	$62,500
Backwash Water Seepage Ponds – Supply Piping	Supply Piping, manholes	$55,8000
Chlorine Contact Piping	Piping, appurtenances	$150,000

Cost Estimate Summary

Subtotal	$2,977,200
Engineering – Allow (15%)	$446,580
Contingencies – Allow (15%)	$446,580
TOTAL PROJECT	**$3,870,360**

4.2 Annual Operating Costs

Annual operating costs for the new water treatment system have been calculated at approximately $77,450 per annum. The calculated annual operating costs relate primarily to the following items:

- Staff time
- Electricity
- Treatment chemicals

The detailed cost breakdown is as follows:

TABLE 4-2: POWER CONSUMPTION COSTS

Item	hp	kW	No. Connected	No. Duty 1	Runtime (hr/day)	kW-hr/d
Well Pump	150	111.9	2	1	8	895.2
Manganese Filtration System	10.0	7.5	2	1	20	149.2
Backwash Pump	30	22.4	2	1	0.67	14.99
General equipment		1			24	24.0
Lighting		0.06		10	1	0.6
Heating						25.2

Total Electricity	1109.2
Assumed Electrical Cost	$0.10
Total Daily Power Costs	$110.92
Total Annual Power Costs	**$40,484**

TABLE 4-3: OTHER CONSUMPTION COSTS

Type	Consumption (L/d)	Estimated Unit Cost ($/L)	Daily Cost
Sodium hypochlorite (disinfection)	28	$0.87	$24.36

Total Daily Consumption Costs	$24.36
Total Annual Consumption Costs	**$8,891**

TABLE 4-4: LABOUR COSTS

Type	Description	Hours/wk	Daily Cost
Weekly	Visual check of equipment, top up chemicals	8	$68.38
Annual	Recommended cleaning, oil changes, filter replacements	1	$8.55

Total Daily Labour Costs	$77
Total Annual Labour Costs	**$28,080**

Annual O&M Costs Summary

Total Annual Power Cost	$40,484
Total Annual Consumption Cost	$8,891
Total Annual Labour Costs	$28,080
Total Estimated Annual O&M Costs	**$77,455**

4.3 Lifecycle Costs

The annual cost of facility ownership for the upgrade has been calculated, taking into account the costs of constructing and operating the system. These costs are summarized in this section. The life cycle cost is broken down as follows:

Life cycle cost = Ownership Cost + Operating Cost

Ownership cost has been calculated based on the following formula:

Ownership Cost = Initial Cost / AP

Where,

AP = [(i(1+i)N)/((1+i)N -1]

i = 5% (inflation 2% and discount rate 3%)

N = The number of years of expected life

TABLE 4-5: EXPECTED OWNERSHIP COST FOR WATER TREATMENT PLANT

	Civil	Mechanical	Electrical
Facility Capital Cost	$702,367	$1,780,167	$494,667
Expected Life (years)	80	20	20
Factor	0.05	0.08	0.08
Annual Value of Replacement Cost	**$36,000**	**$143,000**	**$40,000**

The water treatment plant Life Cycle Cost is summarized as follows;

Ownership cost $219,000 per annum

Operating cost $77,000 per annum

Life cycle cost $296,000 per annum

It is proposed that a capital asset replacement fund would set aside funds to cover the ownership of the new assets.

4.4 Investing in Canada Infrastructure Program – Rural and Northern Communities

It is expected that a grant will be sought under the Investing in Canada Infrastructure Program – Rural and Northern Communities Fund. The grant funding includes the following design requirements:

- A construction completion date of no later than March 31, 2026.
- Drinking water quality must meet or exceed provincial standards.
- Building to meet or exceed any applicable energy efficiency standards for buildings outlined in the Pan-Canadian Framework on Clean Growth and Climate Change.

The following requirements listed in the grant criteria will not be allowed for in estimating costs, as they do not appear to be applicable to this project.

- Federal environmental assessment requirements applying to the project including a requirement to consult with Indigenous Groups (project not on Federal land and environmental effects not expected to trigger assessment)
- A climate lens - greenhouse gas emissions assessment that includes a cost-per-tonne calculation as required by Canada (Total estimated eligible expenditures < $10 million).
- A climate lens - climate change resilience assessment (Total estimated eligible expenditures < $10 million).
- A climate change resilience assessment (only required for projects that seek funding under the Adaptation, Resilience and Disaster Mitigation Outcome).
- A Value Engineering assessment (Total estimated eligible expenditures < $15 million).

5.0 Required Licenses, Permits and Approvals

5.1 Interior Health Authority

Interior Health supports the installation of a manganese filtration process for Barriere. On the basis of a GARP-virus only source, the unfulfilled requirements of the Interior Health treatment objectives would be:

- Reduce manganese levels to be consistently below the MAC of 0.12 mg/L, and
- Provide 4 log inactivation of viruses

Construction permits are required under the Drinking Water Protection Act and must be obtained before the construction, installation, alteration, or extension of a water supply system. The application for a Water Supply System Approval must be submitted along with sufficient design information to allow a health risk assessment of the proposed works. This includes how the design for the proposed water supply system or infrastructure upgrades complies with industry standards and water quality objectives.

For complex systems, or systems with advanced treatment processes, preliminary or pre-design discussions with the Public Health Engineer will assist in the application process.

Source water approval will also be needed for the proposed new wells. This should be received prior to commencing the design and construction of treatment systems.

5.2 Water Sustainability Act

Among other things, the *Water Sustainability Act (*2016) regulates the construction, maintenance, deactivation and decommissioning of wells. Generally, all wells apart from private single-home domestic wells are subject to the licensing provisions in the Act and enabling regulations (Water Sustainability Regulation, 2016). A licensed well is a well that is associated with a water licence to divert water for a specified purpose as per the terms of the water license.

The District of Barriere is considered to be an existing non-domestic groundwater user under the Act. Existing users are those who used groundwater for non-domestic purposes before February 29, 2016. The three-year transition period to licence non-domestic groundwater sources (including municipal wells) under the Water Sustainability Act and Regulation expired in 2019 but was then extended until March 2022. As of the date of this report, we understand applications have been submitted to FrontCounterBC for licensing of the Deep wells.

A separate application was submitted in 2017 for the licensing of the Bradford Park Wells. A temporary use license, valid for one year was granted on October 19, 2018 with the option to

extend the term an additional year to October 18, 2020. The full license is still pending and a temporary use license extension has been requested.

Separately to the licensing requirements, wells are required to be registered in the Ministry database. It appears that the Deep wells and Shallow wells are not currently in the government's GWELLS database of registered wells. Well log information for these wells will be submitted to the Ministry if such information was not already submitted with the existing use licence application.

The proposed Spruce Crescent replacement wells will require registration and either an amendment to the licence (if the existing use licence is issued in the next 1-2 years) or possibly, an amendment to the existing use licence application (in either case, the change would involve adding the new wells as "additional works" replacing the capacity of the old wells). If the plan is to decommission DW1 and DW2 once the new wells are commissioned, then the District need not apply for a new licence and as such there should be no delays associated with licensing.

5.3 Heritage Conservation Act

The Barriere area is within the traditional territory of the Simpcw First Nation and has been historically occupied by indigenous peoples.

The site of the Deep Wells has not been studied for its historical context. As such, an Archaeological Overview Assessment should be considered to be completed as part of this project phase. This assessment compiles existing knowledge about recorded archaeological site locations, historical First Nations' land use, and cultural and environmental context at the site location.

If it is found that there is a high potential for encountering protected archaeological sites and materials during construction then an Archaeological Impact Assessment (AIA) may be recommended prior to construction. The AIA would have the following objectives:

1. Identify (locate and map) general location and character of precontact cultural materials and deposits located in proposed development area
2. Assess existing disturbances to any identified archaeological sites
3. Determine the nature, extent, and intensity of proposed land-altering activities and evaluate their likelihood of adversely affecting any identified archaeological sites (or portions thereof); and
4. Provide recommendations for the further work required to effectively manage and protect any archaeological sites likely to be impacted by the project.

A Heritage Inspection Permit will be required for the AIA. A Heritage Investigation Permit may be required if significant intact archaeological deposits are identified during the AIA. Further work is then required to remove those deposits in a way that maximizes preservation of information (ie: detailed archaeological excavations). This permit and the work it authorizes may be required by

the MFLNRORD Archaeology Branch following the review of the AIA results and recommendations. A Site Alteration Permit is required if any archaeological sites or materials are identified during the AIA and the proponent wishes to proceed with construction that overlaps the site in whole or in part. All Heritage Conservation Act Permits (listed above) carry regulatory requirements for the consulting archaeologist and proponent. These include:

- an AIA report (including mapping),
- submission of Site Inventory Forms and site spatial data, analysis, cataloguing, and curation of artifacts, and
- distribution of study results to any interested First Nations.

Acquiring permits from the Archaeology Branch is known to be a time-consuming process and applicants should allow at least 5 months from the time of application to the permit issuance.

The next phase will consist of mitigative work required to manage identified archaeological deposits including acquiring a site alteration permit, conducting the work, and complete regulatory reporting and analysis. This is only required if an archaeological site or sites are encountered. This may require:

- archaeologist-directed monitoring of construction excavation:
- hand-excavation of any intact features or cultural horizons identified during the AIA:
- sampling (through screening and/or raking) of a sample of disturbed site sediments displaced by mechanical excavation:
- detailed mapping of project-related impacts and sampling:
- laboratory analysis, cataloguing, and curation of all artifacts and other cultural materials:
- Regulatory paperwork including a permit report and site information form updates to be submitted to Archaeology Branch.

5.4 Canadian Impact Assessment Act

The Canadian Impact Assessment Act 2019 outlines a process for assessing the impacts of major projects and projects carried out on federal lands or lands outside of Canada. An Impact Assessment is a planning and decision making tool used to assess positive and negative environmental, economic, health, and social effect of proposed projects and impacts to indigenous groups and the rights of indigenous peoples.

This project does not require a legislated Environmental Assessment because it does not result in physical activities associated with a designated project under the Act.

5.5 Riparian Areas Regulation

The BC Riparian Area Regulation applies to commercial, residential or industrial development (or their ancillary activities) within 30 m of the average annual high-water mark of a lake or stream. As the proposed work is an institutional development, the Regulation does not apply to this project.

5.6 Zoning Bylaw

The treatment building works will need to be in compliance with the District's Zoning Bylaw No. 111.

5.7 BC Building Code

The District will require this project to obtain a building permit under the BC Building Code. The BC Building Code sets minimum standards for health, safety, fire and structural protection, accessibility and energy and water efficiency. The Building Code requires Letters of Assurance in specific instances to document the parties responsible for design and field review of construction, and to obtain their professional assurances that the work substantially complies with the requirements of the Building Code, and that the requisite field reviews have been completed.

The following must be submitted to the authority having jurisdiction (District of Barriere) at the relevant stages of the project.

Schedule	**Registered Professionals of Record**
Schedule A – Confirmation of Commitment by Owner and Coordinating Registered Professional	Coordinating Registered Professional
Schedule B – Assurance of Professional Design and Commitment for Field Review & Summary of Design and Field Review Requirements	Geotechnical Engineer Structural Engineer Civil Engineer Electrical Engineer
Schedule C-A – Assurance of Coordination of Professional Field Review	Coordinating Registered Professional
Schedule C-B – Assurance of Professional Field Review and Compliance	Geotechnical Engineer Structural Engineer Civil Engineer Electrical Engineer

6.0 Long Term Water Supply and Treatment Upgrades

A membrane filtration system is proposed for the future surface water treatment system. A membrane system uses a synthetic membrane with pores designed to exclude particles down to a given size. The membranes are housed in modules or may be submerged in tanks. Membrane technology is recommended for the following reasons:

- Protozoa removal is not dependent on achieving optimal raw chemistry.
- Relatively compact size.
- Relative ease of operation (systems can be classified EOCP level 2)
- Often fully automated for unattended operation.
- Membrane integrity can be tested automatically.
- UV disinfection post treatment is not normally required by IHA with membrane systems

The treatment system would comprise parallel independent "trains". The precise capacity depends on the make and model of the individual system and the number of modules fitted.

Because this is a river source without a strong influence from upstream lakes, it may be necessary to pre-treat the water by clarification. Alternatively, a submerged membrane system may be appropriate for the water quality.

Coagulants would be used to allow the filter to remove dissolved materials such as organics. Other related systems inside the water treatment plant building include backwash chemical storage and feed systems, blowers for airwash during the backwash cycle, and backwash pumps.

There is sufficient space available at the shallow well site for the water treatment plant (see Figure 346-141-G1 in Appendix C). Figure 346-141-G1 (Appendix C) illustrates a membrane filtration system package system enclosed in a pre-engineered steel building. Pre-engineered steel buildings are relatively cost effective and functional and are best suited to locations where aesthetics is not a primary design requirement. The proposed site is not a location where a steel building would be out of place aesthetically.

If an additional water source is found to be needed in the future, the District should undertake regular river water sampling and testing in order to establish the specific characteristics of this water source. Pilot testing may also be required to determine the performance of the system.

APPENDIX A

Cost Estimates

BARRIERE WATER TREATMENT PLANT EXPANSION
AND GROUND WATER SUPPLY WELLS
COST ESTIMATE - CLASS "D"

	DESIGN CRITERIA					
	Design Flow:				L/s	USgpm
	Well#3 (Assumed)				60	951
	Well#4 (assumed)				60	951
ITEM		**UNIT**	**EST.**		**UNIT**	**ESTIMATE**
NO.	**DESCRIPTION**		**QUANT.**		**PRICE**	
1.0	**General**					
	Insurance and Bonding	allow				$35,000
	Mobilization	allow				$20,000
	Restoration and Demobilization	allow				$15,000
	Treatment Plant Commissioning	allow				$10,000
	Subtotal Part 1.0					**$80,000**
2.0	**Production Well#3 (Assumed 250mm Well x 50m)**					
	Well Drilling and Flow Test c/w Steel Casing and Well Screen	allow				$250,000
	Assumed 150HP Submersible Pump and Motor	allow				$45,000
	Stainless Steel SCH40, 304 L Riser Pipe & Check Valve	allow				$35,000
	Pitless Adapter Unit (NSF-61)	allow				$40,000
	Power Cable and Junction Box	allow				$10,000
	Level Sensor and Signal Cable	allow				$5,000
	Reinstall Surface Seal	allow				$5,000
	Subtotal Part 2.0					**$390,000**
3.0	**Production Well#4 (Assumed 250mm Well x 70m)**					
	Well Drilling and Flow Test c/w Steel Casing and Well Screen	allow				$265,000
	Assumed 150HP Submersible Pump	allow				$45,000
	Stainless Steel SCH40, 304 Riser Pipe & Check Valve	allow				$35,000
	Pitless Adapter Unit (NSF-61)	allow				$40,000
	Power Cables and Junction Box	allow				$10,000
	Level Sensor and Signal Cable	allow				$5,000
	Reinstall Surface Seal	allow				$5,000
	Subtotal Part 3.0					**$405,000**
4.0	**Existing Manganese Removal System Modifications**					
	Total Filtration Flow Capacity: 600 USgpm, 150 USgpm per Filter					
	Backwash Supply with Non-Chlorinated Well Water					
	Convert Four (4) Steel Pressure Filters to Biological Filtration,					
	Filter Media, Underdrains, Air Actuators For Existing Filter Valves,					
	Instrumentation, Dual Air Compressors, Receiving Tank, Refrigerant					
	Dryer, PLC Control Panel, Programming and Controls, Site Installation					
	Supervision, Start-up and Training, Process Guarantees and Support					
	Transportation of Equipment to Site (FOB)					**$250,000**
	Modify Existing WTP Inlet and Outlet Piping and Valves					**$40,000**
	Subtotal Part 4.0					**$290,000**

BARRIERE WATER TREATMENT PLANT EXPANSION
AND GROUND WATER SUPPLY WELLS
COST ESTIMATE - CLASS "D"

5.0	**Manganese Removal System**					
	Total Filtration Flow Capacity: 600 USgpm, 300 USgpm per Filter					
	Backwash Supply with Non-Chlorinated Well Water					
	Two Biological Manganese Steel Pressure Filters, Filter Media,					
	Underdrains, PLC, Controls, Valves, Instrumentation,					
	O&M Manuals, Air Scour Blower and (2) Air Compressor, Flowmeter,					
	Sample Sink, Stainless Steel Interconnect Piping, Static Mixers,					
	Site Installation Supervision, Start-up and Training, Process					
	Guarantees and Support, Transportation of Equipment to Site (FOB)					
	Subtotal Part 5.0					**$500,000**
6.0	**Water Treatment Plant Expansion Foundation (Post-Disaster Design)**					
	Foundation Excavation	m^3	325		$25	$8,125
	Foundation Backfill	m^3	245		$25	$6,125
	Foundation Subbase Crush	m^3	20		$100	$2,000
	Excavation Disposal	m^3	80		$30	$2,400
	Cast-in-Place Concrete Building Foundation and Door Pads	m^3	40		$2,000	$80,000
	Roll-up Door Bollards	ea	2		$1,000	$2,000
	Subtotal Part 6.0					**$100,650**
7.0	**Water Treatment Plant Expansion Building Structure (Post-Disaster Design)**					
	Precast Concrete Building Structure	allow				$150,000
	Wall and Ceiling Panels Painting	m^2	350		$25	$8,750
	Epoxy Paint on Floor slab	m^2	100		$100	$10,000
	Overhead Roll Up Door (10ft wide x 12ft high)	allow				$25,000
	Exterior Hollow Metal Insulated Door (3ft x 7ft)	ea	1		$3,500	$3,500
	Exterior Double Hollow Metal Insulated Door (6ft x 7ft)	ea	1		$5,000	$5,000
	Interior Metal Door /w window (3ft x 7ft)	ea	1		$3,000	$3,000
	Chemical Room Windows (8ft x 4ft)	ea	1		$1,500	$1,500
	Building Heating, Ventilation, Fans, Louvers and Dampers	allow				$50,000
	Building Plumbing c/w hot water tank, PRV, BFP, etc	allow				$30,000
	Chlorination Room Drainage Sump Grating	allow				$5,000
	Existing Building Roof Modifications	allow				$15,000
	Subtotal Part 7.0					**$306,750**
8.0	**Chlorination Room**					
	Chemical feed Pump Skid - 12.5% Sodium Hypochlorite c/w	LS	1		$50,000	$50,000
	Storage Tank, Level Transmitter, Float Switch					
	Chemical Transfer Pump	ea	1		$3,500	$3,500
	SCH80 PVC Process Piping, Valves, Fittings and Pipe Supports	allow				$6,000
	Safety Shower, Tempered Valve and Alarm with Flashing Light	allow				$15,000
	Dual Containment Piping w/ pipe supports	m				$5,000
	Static Mixer and Chemical Injection Quill	allow				$2,500
	Chemical Sump High Level Float Switch	ea	1		$1,500	$1,500
	Subtotal Part 8.0					**$83,500**

BARRIERE WATER TREATMENT PLANT EXPANSION
AND GROUND WATER SUPPLY WELLS
COST ESTIMATE - CLASS "D"

9.0	**Emergency Diesel Generator**					
	350kW Standby Power Rating at 1800 RPM, 600V, 3PH, 60HZ					
	Air Inlet System, Control System, Sound Enclosure, Cooling/Heating					
	System, Exhaust System, Fuel System (24 hours/900 Gallon fuel tank),					
	Generator, Circuit Breaker, Governing System, Lube System, Monitoring					
	System, Starting/Charging System, Testing and Commmissioing	allow				$150,000
	Subtotal Part 9.0					**$150,000**
10.0	**Manganese Removal System (Off-loading and Installation)**					
	TREATMENT PRESSURE FILTERS - INSTALL ONLY					
	Off-loading with Crane, Place 2 Filters, Anchor and Grout	allow				$10,000
	8 filter support pads					
	TREATMENT PROCESS PIPING & EQUIPMENT - INSTALL ONLY					$30,000
	Raw Water - Sch10 / 40, 304L SS, Filter Water - Sch10, 304LSS					
	BWS, BWW, FTW, DD, DR, V Piping - Sch10 / 40, 304L SS					
	Air Scour Piping - Sch10, 304L SS, Instrument & Process					
	Air SS Tubing, Pipe Couplings, Pipe Supports, etc…					
	TREATMENT PROCESS EQUIPMENT - INSTALLATION ONLY	allow				$30,000
	Butterfly Isolation Valves, Pneumatic Butterfly Valves					
	Flowmeter, Pressure Transmitters, Pressure Gauges, Static Mixer,					
	Sample Lines and Valves, Sample Sink, Air Valves, Pressure					
	Safety Valve, Check Valves, Ball Valves, Pipe Supports etc..					
	AIR SCOUR SYSTEM - INSTALLATION ONLY	allow				$5,000
	Install blower on concrete pad					
	Butterfly Valve, Flow Switch Low					
	AIR COMPRESSOR SYSTEM - INSTALLATION ONLY					
	Two vertical air compressors on concrete pad	allow				$10,000
	Refrigerant Dryer w/ isolation valves and wall supports, SS Isolation					
	Ball Valves, Flow Indicator, Solenoid Ball Valves, Check Valve					
	Subtotal Part 10.0					**$85,000**
11.0	**Electrical, SCADA and Controls**					
	BC Hydro Charges	allow				$50,000
	Electrical Service (600V, 3 ph, new secondary from existing pole)	allow				$15,000
	Remove and dispose existing electrical	allow				$20,000
	MCP c/w 150hp VFD drives, control panel, ltg panel, transformer	allow				$120,000
	Antenna Mast and Radio	allow				$5,000
	Treatment Plant / Building Electrical	allow				$35,000
	Building Electrical (Lights/Power)	allow				$15,000
	SCADA Hardware and Programming	allow				$25,000
	Supply Wells Electrical and Instrumentation	allow				$10,000
	Automatic Transfer Switch	allow				$20,000
	Water Treatment Plant Computer System	allow				$3,000
	Subtotal Part 11.0					**$318,000**

BARRIERE WATER TREATMENT PLANT EXPANSION
AND GROUND WATER SUPPLY WELLS
COST ESTIMATE - CLASS "D"

12.0	**Well#3 Supply Piping**					
	250mm (DR18) C900 PVC	l.m.	48		$500	$24,000
	250mm Gate Valves	ea.	1		$3,000	$3,000
	250mm Bends	ea.	2		$1,000	$2,000
	250mm Pipe Coupling and Uni-flange Restraint w/ Tie-rods	ea.	3		$500	$1,500
	Pressure Test	ea.	1		$1,000	$1,000
	Subtotal Part 12.0					**$31,500**
13.0	**Well#4 Supply Piping**					
	250mm (DR18) C900 PVC	l.m.	48		$500	$24,000
	250mm Gate Valves	ea.	1		$3,000	$3,000
	250mm Bends	ea.	2		$1,000	$2,000
	250mm Pipe Coupling and Uni-flange Restraint w/ Tie-rods	ea.	2		$500	$1,000
	Pressure Test	ea.	1		$1,000	$1,000
	Subtotal Part 13.0					**$31,000**
14.0	**Backwash Water Seepage Ponds - Supply Piping**					
	150mm (DR25) C900 PVC	l.m.	18		$350	$6,300
	1050mm Drainage Manhole	ea.	3		$7,500	$22,500
	150mm SCH40 Steel Pipe (underslab drain)	ea.	2		$5,000	$10,000
	Tie-in to existing Distribution Manholes	ea.	2		$3,500	$7,000
	150mm SCH40 Steel Pipe (distribution manhole connection)	ea.	2		$5,000	$10,000
	Subtotal Part 14.0					**$55,800**
15.0	**Chlorine Contact Piping**					
	600mm (DR18) C905 PVC					
	250mm Gate Valves					
	600mm Bends and Reducers					
	Pipe Coupling and Uni-flange Restraint w/ Tie-rods					
	Disinfect, Pressure Test, and Sample	allow				$150,000
	Subtotal Part 15.0					**$150,000**
	Cost Estimate Summary					
					Subtotal	**$2,977,200**
					Engineering - Allow (15%)	$446,580
					Contingencies - Allow (15%)	$446,580
					TOTAL PROJECT	**$3,870,360**

APPENDIX B

Western Water Technical Memo

western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

Technical Memorandum

Date: 19 October 2020 **File:** 20-105-01VR

To: Dave Underwood, P.Eng., TRUE

From: Doug Geller, M.Sc.,P.Geo., Western Water

Subject **DISTRICT OF BARRIERE GROUNDWATER SUPPLIES**

INTRODUCTION

We understand TRUE Consulting is assisting the District of Barriere (DoB) with a pending grant application to undertake water system improvements at the existing production well site located at Spruce Crescent in Barriere. This location currently contains a well pump house and two production wells, DW1 and DW2, which were built in the 1990s. TRUE has undertaken a preliminary assessment of infrastructure needs to upgrade this facility and the summary recommended program is as follows:

- Install two new supply wells at Spruce Crescent (DW1 replacement and DW2 replacement)
    - Target water supply of at least 500 USgpm per well
    - Target water quality: elevated iron (over AO), elevated manganese (over MAC), GARP classification (worst case scenario)
- Refurbish existing treatment plant to achieve 500 USgpm treatment capacity for iron and manganese
- Construct addition to existing treatment plant to achieve AN ADDITIONAL 500 USgpm treatment capacity for iron and manganese
- Construct a chlorination room in treatment plant addition
- Construct UV disinfection in the treatment plant addition (only needed if wells are classified as GARP)
- Construct a contact chamber and high lift pumping system

The remainder of this brief technical memo discusses the approach to the well installation program and related hydrogeological work programs including planning level cost estimates for installing the new wells, test pumped, and ready for completion of well site improvements (well pumps, power supply, and connection to existing and planned infrastructure).

WELLS AND LOCAL AQUIFER DESCRIPTION

The table below summarizes the main information about the wells as provided in a 1997 report by Kala and a 1994 report by Seacor for DW1.

Table 1: Summary information for DW1 and DW2

Well #	Ministry Plate #	Completed depth (ft / m)	Casing diameter	Screen interval (ft / m)	Yield (US gpm / L/s)	Year Drilled
DW1		232.4 / 70.9	12 inch	200.9 – 232.4 / 61.2-70.9	700 / 44	1993
DW2		158 / 48.2	10 inch	138-158 / 42.1 – 48.2	~800 / 50	1997?

Sources of information: Kala (1997), Seacor (1994) and TRUE drawings 346-042-21 and 346-091-01

Local aquifers mapped in the Barriere area include Aquifers 293 and 294. Both of these aquifers are classified by the Ministry as relatively shallow, mostly unconfined aquifers. Aquifer factsheets for 293 and 294 are attached to this memo. From a brief review of this Ministry information it is possible that DW1 and DW2 are completed in a deeper zone of Aquifer 294. This aquifer is classified as having moderate productivity, moderate vulnerability with relatively low demand (low aquifer stress index). The well log for DW1 (in Seacor 1994) shows a relatively thick layer of grey silty clay overlying the aquifer and a static water level of about 12 m below ground; this suggests the aquifer is confined at this location. Water bearing sand with sand and gravel is noted on the log between depths of about 48 and 62 m; with the lowermost 4 m screened by the well. The driller's log for DW2 has not been located yet but will be reviewed prior to drilling any replacement wells.

The formation in which the wells are screened is described (by Kala) as a "coarse textured gravely sand" with "high transmissivity." These characteristics make the aquifer a good target for developing groundwater. Replacement wells completed in this aquifer have high potential to produce at least 500 US gpm (31.5 L/s) and possibly more. 1990s testing of DW1 and DW2 showed wells capacities at that time were in the range of 600 to 800 US gpm.

WATER QUALITY OF DW1 AND DW2

Recent testing of samples collected from each well confirms that DW2 produces better-quality water than DW1. Although the existing information suggests the wells are completed in the same aquifer, the deep zone within which DW1 is screened appears to be geochemically different than the zone that DW2 produces from. Table 2 below summarizes the most recent data (from October 2015). It is worth noting that DW1 has not normally been operated whereas DW2 has seen nearly continuous operation in recent years. Data we reviewed suggest that the water quality of DW2 has remained stable over time, and that parameters such as manganese, iron and TDS (which are higher in the deeper well) do not seem to be escalating in DW2.

Table 2 Water Quality Summary

		DW1	DW2DW2	
Date		Oct 2015	Oct 2015	
Lab Work Order Number		L1687425	L1687424-1	
Parameter	**Units**			**GCDWQ**
pH (field / lab)	pH units	8.23	8.03	AO = 7 – 10.5
Conductivity lab)	ms/cm	573	372	
General Parameters and Nutrients				
Total Dissolved Solids	mg/L	331	221	AO ≤500
Hardness	mg/L	317	190	
Alkalinity (total)	mg/L`	283	180	
Nitrate, N	mg/L	<0.0050	0.226	MAC =10
Chloride	mg/L	0.63	2.73	AO ≤ 250
Sulfate	mg/L	48.5	20.2	AO ≤ 500
Selected Ions and Metals (total)				
Iron		0.682	<0.030	AO ≤ 0.30
Manganese		0.14	0.0052	AO ≤ 0.02; MAC = 0.12
Sodium		11.6	7.9	AO ≤ 200
Potassium		2.82	1.83	

Notes: GCDWQ = Guidelines for Canadian Drinking Water Quality;
MAC = Maximum Allowable Concentration Exceedances highlighted in orange;
AO = Aesthetic Objective Exceedances highlighted in green;

From the above summary, we see that water from DW1 is more mineralized with TDS, hardness and alkalinity higher than DW2 by a factor of approximately 1.5X. Iron and manganese in DW2 have been below the current AO and MAC (0.02 and 0.12 mg/L) since original testing of the well occurred in the 1990s. Nitrate and chloride are slightly elevated in DW2 compared to DW1 suggesting the shallower portion of the aquifer has received some anthropogenic water quality inputs, but only to a very minor degree as concentrations remain far below Guidelines.

From preliminary discussions with DoB and TRUE, it appears that there may be at least one additional test well located at the Spruce Crescent site. This test well may have been drilled around 2010 under the supervision of B.C. Groundwater Consulting (BCGW) but no further documentation is available.

From a water quality standpoint, it is our opinion that chances are good that a replacement well can be installed to a similar depth of DW2 that produces water of a similar quality and not requiring removal of iron and manganese. Further investigative work will be required in order to confirm this with a reasonable level of confidence; however, based on information available to us now, it seems feasible to develop the shallower aquifer zone that DW2 produces from with the long term prospect of water quality that remains lower in TDS, iron, and manganese than DW1. As noted above, choosing specific replacement well locations at the existing site will need to be done once we have had a chance to review the detailed lithology from all available well driller's reports.

A GARP study should also be done to help determine the level of treatment required. Based on the well depth (screens greater than 40 m deep in a sand formation), the wells would not likely be under direct influence of surface water and would likely be classified as either non-GARP or possibly GARP virus-only water sources. This will be resolved during Phase 1a of the work program as discussed below. The scope of the GARP study can be reviewed with Interior Health prior to implementation.

SUMMARY OF HYDROGEOLOGICAL PROGRAM Phase 1a and 1b

Following a detailed hydrogeological data review (including compilation of well driller's logs and well completion data for all wells at the Spruce Crescent location), and selection of a new well site at the Spruce Crescent property, **Phase 1a** would comprise the installation and testing of the first replacement well (DW3), targeting a similar depth zone for the well screen as in DW2 (approximately 45 to 50 m depth). The location of this well will be determined following additional detailed hydrogeological review and in consultation with the project team. TRUE's preliminary phasing plan (Drawing 346-161-G1) shows DW3 about 25 m north of DW2. Pending further review and a site visit, we would suggest moving the well closer to DW2 (about 6 to 10 m away). The replacement well would be nominal 12-inch (300 mm) diameter for the production casing with a target yield of at least 600 US gpm. Drilling would likely be undertaken with a dual-rotary rig for drilling and casing advancement followed by well development with a cable-tool rig to maximize well efficiency.

Concurrent with the well replacement program, a Level 2 GARP investigation would be undertaken to assess the GARP risk to DW2 and DW3. This would involve an approximate 9-month field sampling program including collecting concurrent surface water and groundwater samples and analyzing samples for conventional drinking water parameters, field parameters and microparticulate analysis (MPA) with supplemental aerobic spore enumeration. The 2017 Ministry of Health GARP Guidelines will be followed in completing this investigation at the end of which we will make a determination of the GARP risk of the wells and review the findings with Interior Health who would make the final decision about treatment / disinfection to be required in the long-term.

Phase 1b of the hydrogeological program would comprise installing the second replacement well (DW4), building on the success and learning from the DW3 program. This portion of the work is subject to pending grant application approval and would be undertaken in a separate effort from the DW3 program.

Once new wells are commissioned, any unused older wells will either be converted to observation wells or properly decommissioned in accordance with the Groundwater Protection Regulation.

COST ESTIMATE FOR NEW WELLS REPLACING DW1 AND DW2

The following table summarizes estimated budgets to complete two new test-production wells. The costs assume the work would be undertaken in different phases. The cost for the first replacement well, as noted, includes the budget for the recommended GARP study. The budgets provided include: well drilling, well development, well test pumping, hydrogeological oversight and reporting. Budgets do not include: site preparation, environmental permitting, archaeology services, installation of permanent pumps and

infrastructure to connect new wells to the water system (such costs are estimated separately by TRUE). A suggested budget allowance for future well decommissioning of unused wells is also provided.

Table 3 Well Program Summary Budget Estimates

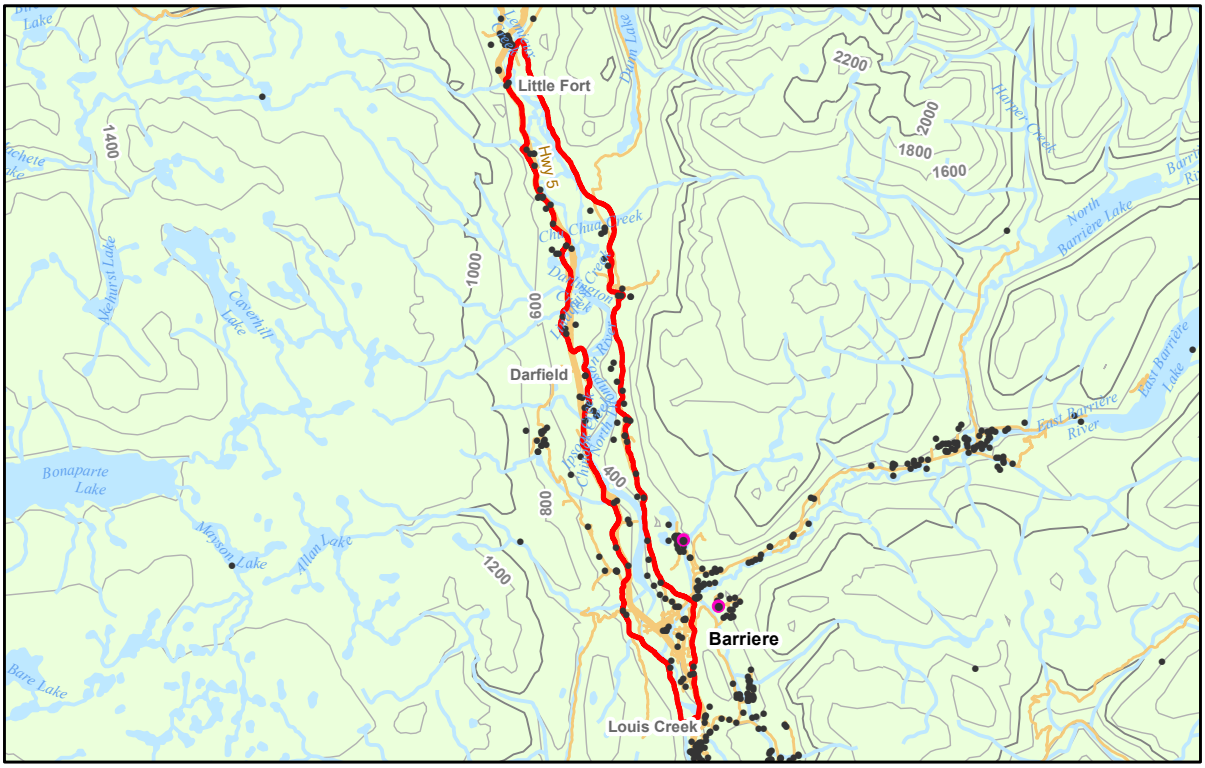
Component	Cost Estimate
Phase 1 a Replacement Well DW3	
Well Drilling, Installation and Development	$130,000
Pumping test (step test and 48 hr test with flows to 40 L/s)	$35,000
Hydrogeology - tendering, oversight, reporting, licensing (WWAL)	$38,000
Phase 1a GARP study (WWAL)	$23,000
Phase 1 a subtotal	$226,000
Phase 1a total with 15% contingency	**$259,900**
Phase 1 b Replacement Well DW4	
Well Drilling, Installation and Development	$130,000
Pumping test (step test and 48 hr test with flows to 40 L/s)	$35,000
Hydrogeology - tendering, oversight, reporting, licensing (WWAL)	$32,000
Phase 1 b subtotal	$197,000
Phase 1b total with 15% contingency	**$226,550**
TOTAL PROGRAM WELL DRILLING AND HYDROGEOLOGY	**$486,450**
Does not include: permanent well pumps, pitless units, power supply, connection to system, archaeology review, environmental permits or site preparation	
Allowance for decommissioning three wells (DW1, DW2 and one test well tbd)	$20,000

REFERENCES

Kala Groundwater Consulting 1997. Barriere Improvement District, Wellhead Protection Assessment, Barriere Deep Wells. Prepared for T.R. Underwood Engineering.

Seacor 1994. Groundwater Supply Development Program – 1994. Production Well PW94-01, Construction Supervision and Evaluation, Barriere Improvement District. Prepared for T.R. Underwood Engineering. (*DW1 completion report)*

Aquifer #293



Legend

- Registered Water Well - Artesian
- Registered Water Well
- Aquifer Boundary

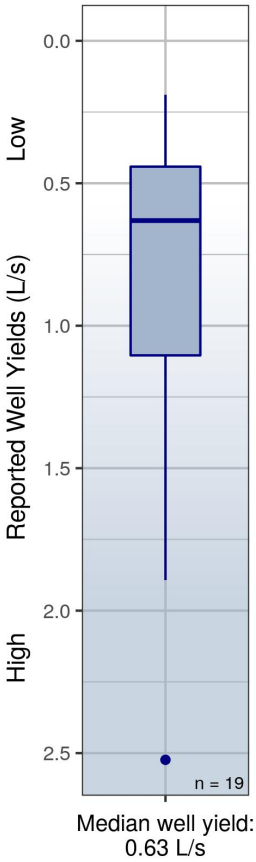
0 4 8 km

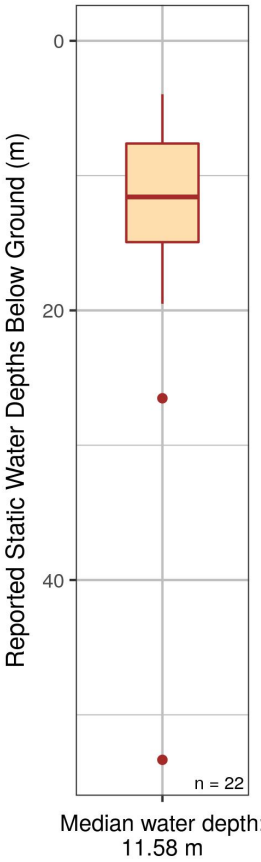
N

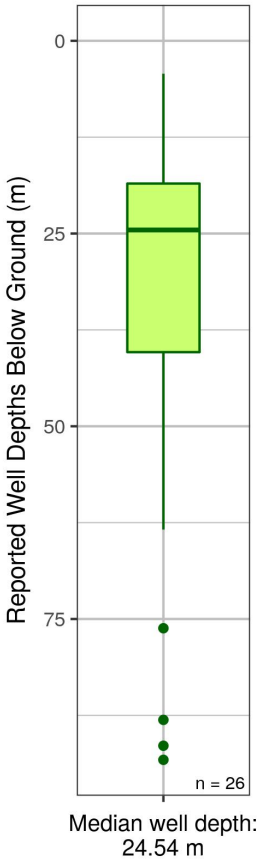
Aquifer Description (Mapping Report - 1996): Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along rivers of moderate stream order with the potential to be hydraulically influenced by the river (subtype = 1b).

Aquifer Details	
Region	Thompson-Okanagan
Water District	Kamloops
Aquifer Area	51.6 km^2
No. Wells Correlated to Aquifer	26
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IIIB
Hydraulic Connectivity[1]	Likely
Aquifer Stress Index	Less stressed
No. Water Licences Issued to Wells	1
Observation Wells (**Active**, Inactive)	None

[1] Based on broad regional assessment



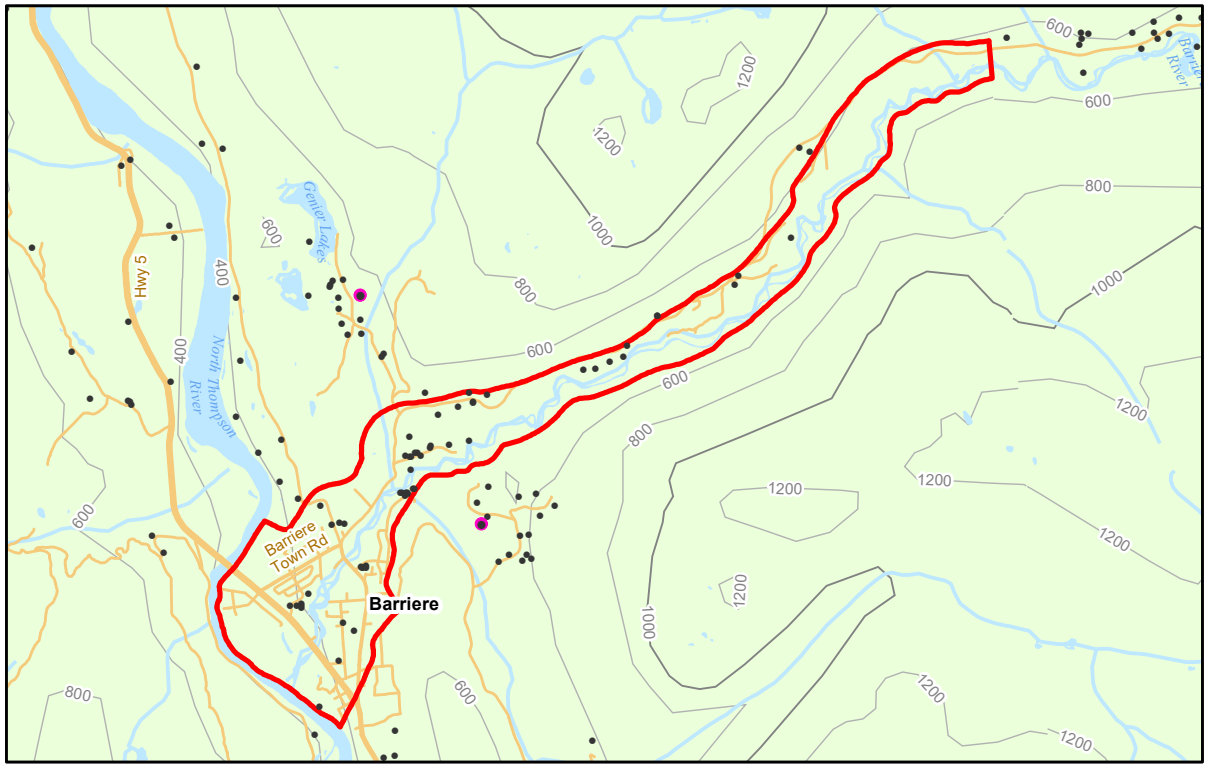




Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).

Factsheet generated: 2020-08-06. Aquifers online: https://apps.nrs.gov.bc.ca/gwells/aquifers.

Aquifer #294



Legend

- Registered Water Well - Artesian
- Registered Water Well
- Aquifer Boundary

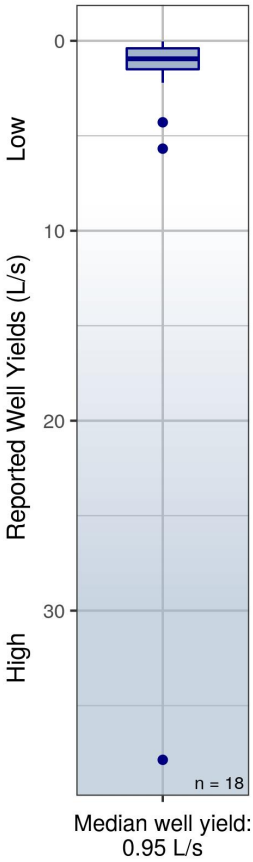
0 1 2 km

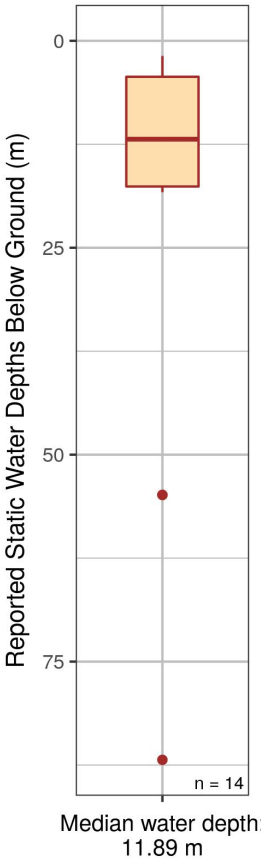
N

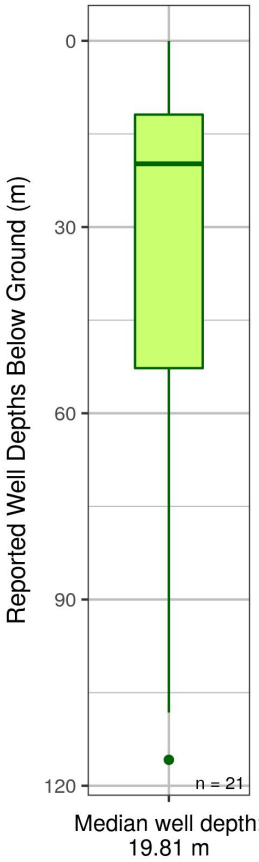
Aquifer Description (Mapping Report - 1996): Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along lower order (< 3-4) streams in confined valleys with relatively undeveloped floodplains, where aquifer thickness and lateral extent are more limited (subtype = 1c).

Aquifer Details	
Region	Thompson-Okanagan
Water District	Kamloops
Aquifer Area	11.7 km^2
No. Wells Correlated to Aquifer	21
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IIIB
Hydraulic Connectivity[1]	Likely
Aquifer Stress Index	Less stressed
No. Water Licences Issued to Wells	Unknown
Observation Wells (**Active**, Inactive)	None

[1] Based on broad regional assessment







Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).

Factsheet generated: 2020-08-06. Aquifers online: https://apps.nrs.gov.bc.ca/gwells/aquifers.

APPENDIX C

Preliminary Design Drawings

3
Plan 3295

PARK
KAP32420

ROAD
KAP89125

27
KAP89125

29
KAP89125

PHASE 1 OVERFLOW PIPING

EX WELL Nº 2

EXISTING SEEPAGE BEDS

PHASE 2 WELL SUPPLY PIPING

PHASE 1 PROPOSED WELL Nº 4

PHASE 1 WELL SUPPLY PIPING

PHASE 1 PROPOSED WELL Nº 3

EX WELL Nº 1

PHASE 1 BACKWASH WASTE PIPING

RAW WATER SUPPLY

PHASE 1 TREATED WATER PIPING

PHASE 2 PROPOSED SURFACE WATER TREATMENT PLANT

PHASE 1 EXISTING FILTRATION UPGRADE CEILING HEIGHT = 3.5m

PHASE 1 WTP EXPANSION FILTRATION AND UV STATION CEILING HEIGHT = 5.5m

PHASE 1 CHLORINE CONTACT CHAMBER AND PUMP STATION

PHASE 2 TREATED WATER PIPING

POTABLE WATER DISTRUBUTION

EXISTING WATERMAIN

SPRUCE CRESCENT

0 1:150 6

PHASING LEGEND

PHASE 1

PHASE 2

NOTE:
LOCATION OF PROPOSED BUILDINGS AND WELLS ARE FOR DEMONSTRATION ONLY

No.	DATE	DESCRIPTION	BY	APP'D
2	OCT 14/20	NOTED CEILING HEIGHT	DH	DU
1	OCT 14/20	ISSUED FOR CLIENT INFORMATION	DH	DU

ISSUES / REVISIONS

CONSULTANT SEAL

TRUE CONSULTING
201 - 2079 Falcon Road ■ Kamloops BC ■ V2C 4J2
tel 250.828.0881 ■ fax 250.828.0717
info@TRUE.bc.ca

DISTRICT OF BARRIERE

WATER TREATMENT AND SUPPLY WELLS

PROPOSED PHASING PLAN

SCALE	1:150 (24x36)
DESIGN BY	DH
DRAWN BY	DL
DATE	14 OCT 2020
PROJECT REFERENCE No.	346-141
DRAWING No.	346-141-G1
SHEET	1 OF 1
ISSUE/REV.	2

FILE: c:\clients\250\346-141\spruce crescent wtp expansion & wells\03 drawings\cad\dwg\phasing\346-141-g1

western water ASSOCIATES LTD
Consultants in Hydrogeology and Environmental Science

Installation and Testing of Replacement Supply Well: District of Barriere WPID 40541

Prepared for:

District of Barriere
4936 Barriere Town Road
Barriere, B.C.

and

True Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

June 2021
Project: 20-105-02VR

western water
ASSOCIATES LTD
Consultants in Hydrogeology and Environmental Science

June 22, 2021 WWAL Project: 20-105-02VR

TRUE Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

Re: Installation and Testing of Replacement Supply Well WPID 40541: Barriere, B.C.

Western Water Associates Ltd. (WWAL) is pleased to provide this completion report documenting the installation and testing of a new 300 mm (12-inch dimeter) production well for the District of Barriere.

The well is completed in a confined aquifer to a depth of 45.1 m (148 ft) and has a recommended yield of 44.2 L/s (700 US gpm).

Water quality testing indicates that groundwater is of good quality, and all parameters were found at concentrations less than health-based Guidelines for Canadian Drinking Water Quality (GCDWQ). Manganese was found at a concentration that exceeds the aesthetic objective.

We trust that the professional opinions and advice presented in this document are sufficient for your current requirements. Should you have any questions, or if we can be of further assistance in this matter, please contact the undersigned.

WESTERN WATER ASSOCIATES LTD.

22-06-2021
PROFESSIONAL PROVINCE OF P. A. WILLIAMSON # 52128 BRITISH COLUMBIA GEOSCIENTIST

Paul Williamson, M.Sc., P.Geo.
Hydrogeologist

Reviewed by:

Douglas Geller, M.Sc., P.Geo
Principal Hydrogeologist

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List of Abbreviations / Acronyms

asl	Above sea level
AO	Aesthetic Objectives
bgs	Below ground surface
btoc	Below top of casing
ENV	Ministry of Environment and Climate Change Strategy
GARP	Groundwater at Risk of Containing Pathogens
GCDWQ	Guidelines for Canadian Drinking Water Quality
MAC	Maximum Allowable Concentration
L/s	Litres per second
m asl	Metres above sea level
MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
mya	Million Years Ago
US gpm	US gallons per minute
WPID	Well Plate Identification
WTN	Well Tag Number
WWAL	Western Water Associates Ltd.

1. INTRODUCTION

At the request of True Consulting, Western Water Associates Ltd. (WWAL) oversaw the tendering, installation and testing of a replacement production well for the District of Barriere (The District), B.C. The 300 mm (12-inch) diameter well was installed to replace one of the existing production wells that provide water to the Barriere municipal system. This report documents the well construction and assessment program and presents the results of well yield and water quality testing.

1.1 Project Background

The District of Barriere is located approximately 60 km north of Kamloops, at the confluence of the Barriere River and the North Thompson River. The District provides water to approximately 780 residential and 75 commercial connections (DoB, 2018). As shown in Figure 1-1 below, water demand in the community has been slowly increasing over time and has a strong seasonal component related to increased domestic irrigation during warmer weather. Based on historical monthly flow data and population growth projections, a maximum daily demand of 60 L/s was estimated for future Barriere water infrastructure planning (True Consulting, 2020).

Figure 1-1 Monthly Water Demand for the District of Barriere (2009 to 2018)

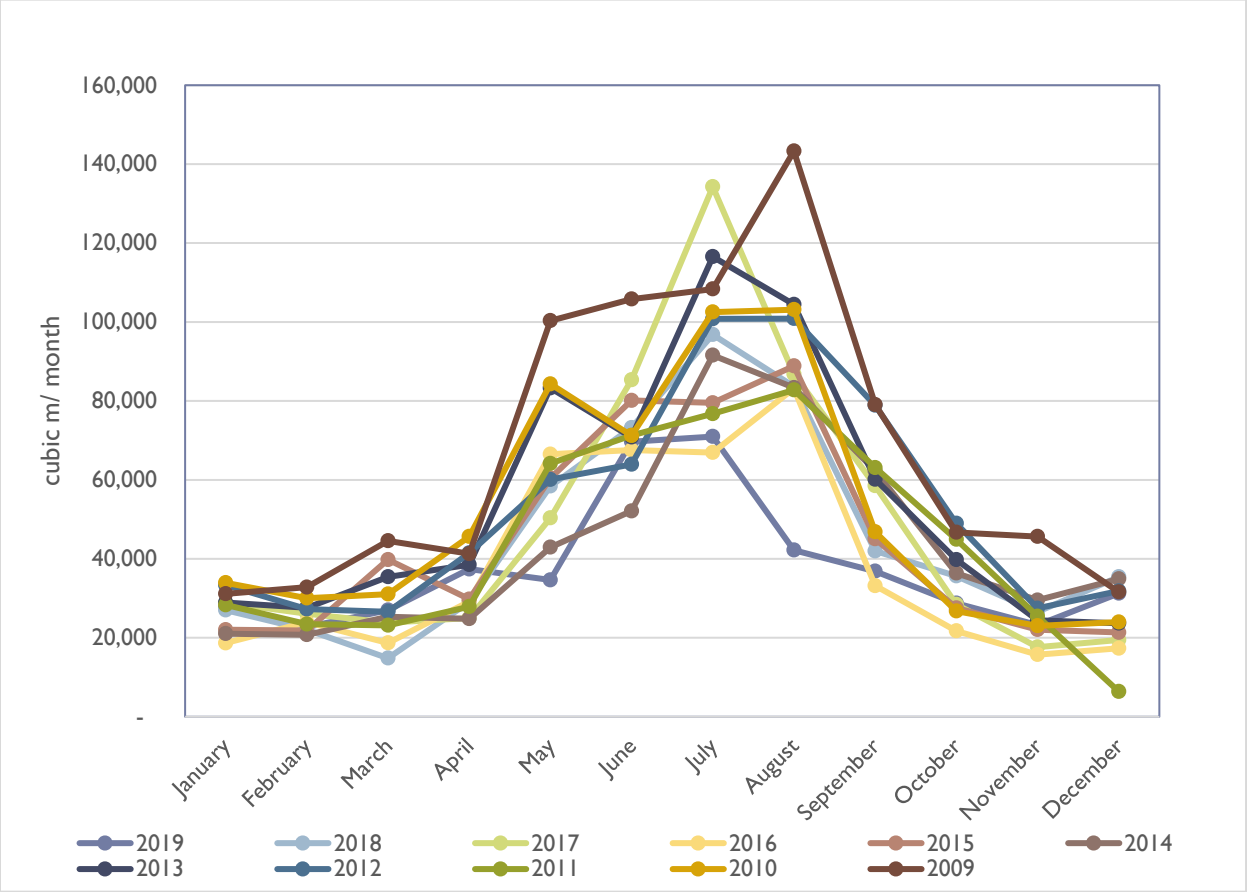


Image Source: True Consulting, 2020

At present, the District maintains two active well fields within the community: Spruce Crescent and Bradford Park (See attached Figure 2). The District previously maintained a third well field containing two shallow wells that was taken offline in 2017 due to its designation as groundwater at risk of containing pathogens (GARP). Select construction details on the District's active wells are provide in Table 1-1.

Table 1-1 Summary of Construction Details Active Barriere Supply Wells

Well Field	Spruce Crescent		Bradford Park	
Well Name	DW1	DW2	PW1	PW3
Well Plate Identification	12701	12702	48866	48898
Well Tag Number	-	-	114383	114384
Date Drilled	1994	1997	2016	2017
Diameter	12-inch	8-inch	10-inch	10-inch
Total Depth	230 ft	158 ft	268 ft	313 ft
Screen Open Length	31.5 ft	20 ft	33 ft	48 ft
Screen Design	60 slot (196.5-228 ft)	100 slot (138 to 158 ft)	20 to 100 slot (230 to 263 ft)	30 to 100 slot (270 to 308 ft)
Estimated Well Yield	45 L/s / 713 US gpm	63.1 L/s / 1000 US gpm	39 L/s / 600 US gpm	25 L/s / 400 US gpm

Sources: True Consulting, 2020; Kala Groundwater, 1997; BC Groundwater Services, 2018

Over several years, the District has encountered a number of issues related to the quality and quality of groundwater produced by the community's wells. Elevated levels of iron and manganese are present in DW1, and a failure in the one of the filtration units limits the well to a maximum flow rate of 28 L/s (400 US gpm) (DoB, 2018). The Bradford Park wells experience consistent aesthetic water quality concerns and, due to sand intrusion issues, have been limited to a maximum production rate of 12 L/s (190 US gpm) per well (True Consulting, 2020). As a result, the District relies almost exclusively on DW2 to meet the community's water demand. At present, DW2 is capable of meeting the average daily demand for the community but is unable to solely sustain the maximum daily demand during the summer period.

Based on the lack of redundancy in the Barriere water system, the District deemed it necessary to drill two additional wells at the Spruce Crescent site, with the goal of eventually replacing DW1 and DW2. Phase 1 of this project was the first replacement well (DW3), as described in the following report.

1.2 Scope of Services and Objectives

WWAL provided the following services for this project:

1) Reviewed available information on existing wells and existing water licences in the study area (both surface and groundwater).
2) Visited the Spruce Crescent site to identify potential well locations.
3) Obtained all necessary permits to complete the field program.
4) Prepared technical specifications for the drilling of the water supply wells and obtained competitive quotes to complete the drilling and pumping tests.

5) Oversaw well drilling, reviewed formation samples collected by the well driller, completed field grain size analysis and provided well screen design details to the well driller.
6) Designed and supervised pumping tests to determine the well yields, including step tests, constant rate tests and recovery monitoring. Installed a temporary water level transducer in a nearby monitoring well and collected manual water measurements from DW2 to assess for well interference.
7) Collected water samples to characterize the groundwater quality.
8) Analyzed and evaluated well testing data to determine a long-term well yield and provide recommendations for operating parameters.
9) Prepared this completion report for True Consulting and the District of Barriere.

The District meets the definition of an "Existing User" of non-domestic groundwater under the *Water Sustainability Act* and is in the process of licensing its prior uses of groundwater including DW1 and DW2. Although a new licence is not required for the replacement well, the above scope of work was undertaken in keeping with the Ministry's *Guidance for Technical Assessments in Support of an Application for Groundwater Use in B.C.* (Todd *et al.,* 2020; B.C. Water Science Series Report 2020-01).

2. SITE DESCRIPTION

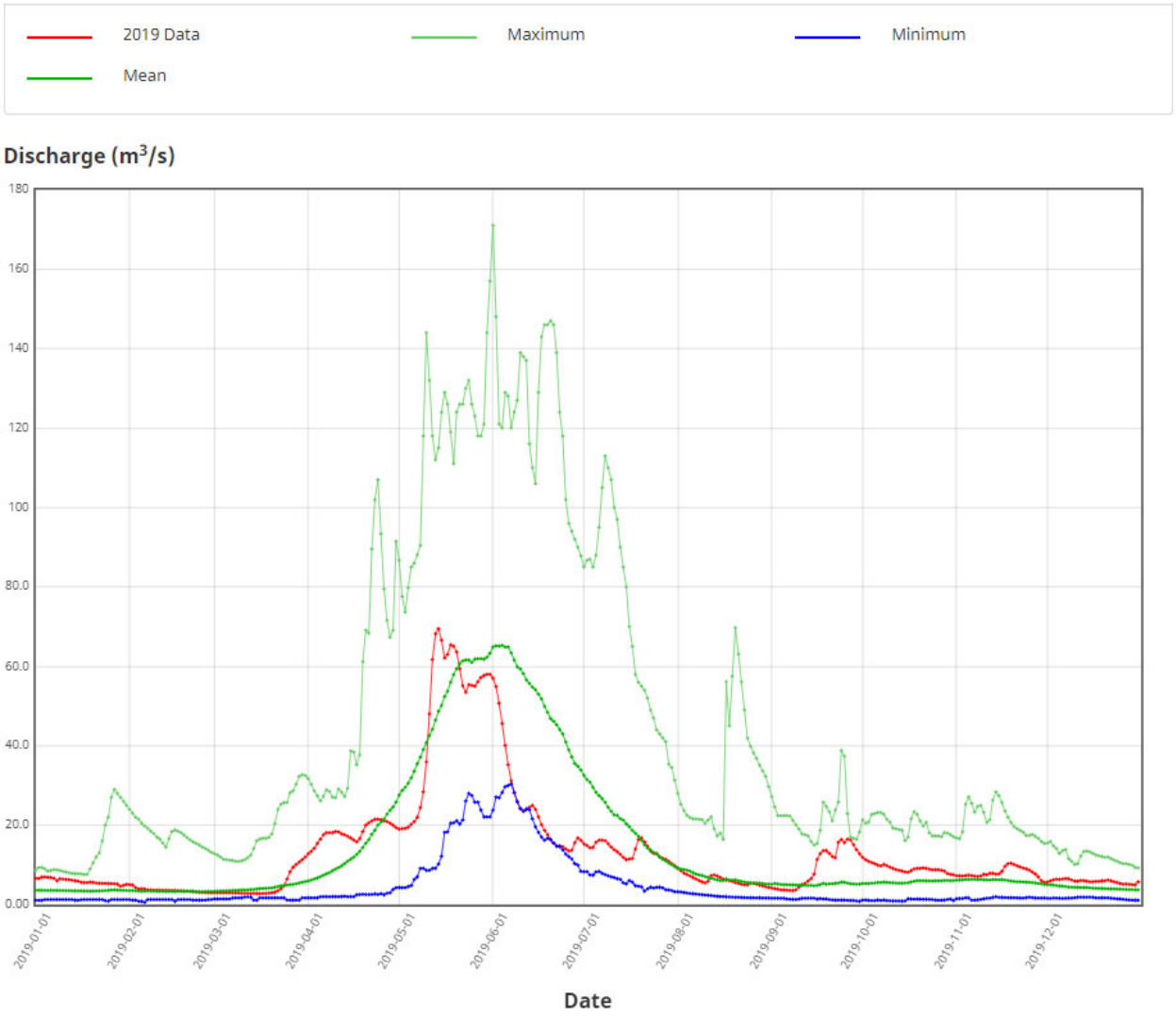
2.1 Physiography, Climate and Surrounding Land Use

The community of Barriere is located in the Shuswap highlands, on the large alluvial fan/deltaic complex associated with the ingress of the Barriere River into the North Thompson River. Local relief ranges from the North Thompson River to the west at an elevation of 373 m above sea level (asl) up to Barriere mountain to the east at an elevation of 1283 m asl. The Spruce Crescent well field is located on southern banks of Barriere River, near the eastern edge of the community (Figure 2). The property is on level ground in a residential area at an elevation of 388 m asl.

The Barriere River flows to the southwest and passes the replacement well at an approximate distance of 35 m before entering the North Thompson River 2.3 km from the site. The North Thompson then flows south before joining the Thompson River in the Kamloops area. Dixon Creek, which captures water from the highlands to the southeast, joins the Barriere River approximately 700 m to the northeast of the site. Several unnamed tributaries of the Barriere River are also located upstream of the Spruce Crescent well field.

The Water Survey of Canada maintains a hydrometric station on the Barriere River at the Barriere Town Road bridge, approximately 550 m downstream of the site. Figure 2-1 below presents a hydrograph of the Barriere River that illustrates its freshet dominated discharge regime. Water levels typically begin to rise in early April in response to snowmelt, with peak levels occurring in late May or early June. Flows subsequently decline steadily towards baseflow levels in August or September.

Figure 2-1 Barriere River Discharge Hydrograph at Station 08LB020



Climate Normal data from the McLure climate station (ID 1165030) are summarized in Table 2-1 below. This station is approximately 15 km west of the project site at an elevation of 381 m asl, which is in the same range as the well site. The data indicate an average annual precipitation from a combination of rain and snowfall of 487 mm. Precipitation remains relatively consistent throughout the year, with peaks occurring in late spring/early summer and the late fall, and the driest period occurring in the late winter. The daily average air temperature is 7.7 degrees, with July and August typically the warmest months and December and January the coldest. Note that past climate data are not necessarily indicative of the future climate. Please refer to Section 4.5 for a further discussion on climate change.

Table 2-1 Climate Normal Data 1981-2010 for McLure Station, ID 1165030

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	11.7	14.0	23.8	30.9	43.3	55.0	46.7	39.7	40.5	39.6	35.1	10.1	390.3
Snowfall (cm)	26.2	9.4	4.6	0.4	0.2	0.0	0.0	0.0	0.0	0.9	17.9	36.8	96.2
Precipitation (mm)	37.9	23.4	28.4	31.2	43.5	55.0	46.7	39.7	40.5	40.4	53.0	46.8	486.5
Daily Average (°C)	-4.5	-1.7	3.8	9.0	13.1	16.9	19.7	19.6	14.2	6.9	0.5	-4.5	7.7

Land use in the immediate area of the Spruce Crescent well field is predominately residential. An agricultural field is located immediately west of the site. Undeveloped forested areas and agricultural lands dominate the upland areas to the east and southeast. Barriere's commercial district is located south of the site.

2.2 Hydrogeologic Setting

Surficial geology mapping of the area (Paulen et al., 1998) indicates the surficial unit beneath the project site is characterized as fluvial plain deposits that include well sorted sand, gravel and over bank silt in post-Fraser glaciation floodplains, terraces and/or fans.

Bedrock mapping indicates the site overlies the boundary of two adjoining assemblages. The first is the metamorphic rocks of the Eagle Bay Assemblage that date back to 400 to 500 million years before present. The second is basaltic volcanic rocks of the Fennell Assemblage dated to 200 to 300 million years before present.

Provincial mapping indicates there are two aquifers that underlie the site: 1) Aquifer 293 III B, which extends north-south from the community of Little Fort to Barriere and remains in close proximity to the banks of the North Thompson River in the east-west direction, and 2) Aquifer 294 III B, which follows the banks of the Barriere River and extends from the community of Barriere to approximately12 km upstream. Both aquifers are characterized as mostly unconfined sand and gravel units with low demand, moderate productivity and moderate vulnerability to contamination.

Attached Figure 2 displays transect A-A' and Figure 3 displays a cross section from this transect that we developed by interpreting available well logs from the area. The cross section indicates there are potentially multiple unmapped aquifers in the Barriere region, including a perched unit in upland areas northeast of the drill site, a confined unit in which DW2 is installed and a second, deeper confined unit in which the DoB's Bradford water wells are installed. For this project, the first confined unit was the target for the replacement well. Based on the information provided on the well logs, the confined aquifer is moderately to highly productive, with a confining unit that ranges between 20-30 m in thickness near the drill site. We infer that recharge to the aquifer originates from multiple sources including leakage from the Barriere River, infiltration of precipitation and snowmelt from upland areas and discharge from underlying bedrock.

2.3 Reported Groundwater Wells in the Area

The provincial GWELLS database indicates twenty-two wells (including the Spruce Crescent and Bradford Park wells) are registered within 1 km of the subject site wells. It should be noted that submission of well driller's logs to the Ministry was not mandatory until 2016; therefore, it is possible that other unreported wells exist in the area. A summary of select well construction details is included in Table 2-2 below and the location of each well is displayed in Figure 2.

Table 2-2 Select Well Details for wells with 1 km of the Project Site

WTN	Well Use	Finished Well Depth (ft)	Diameter (in)	Depth to Water (ft)	Reported Well Yield (US gpm)
DW1	Water Supply	230	12	-	713
DW2	Water Supply	158	8	-	1000
103072	Monitoring	336	6	-	100
112533	Monitoring	288	6	-	-
114383 (PW1)	Water Supply System	268	10	40	-
112850 (PW2?)	Water Supply System	258	10	40	-
114384 (PW3)	Water Supply System	313	10	-	-
40611	Unknown	250	6	175	10
116334	Private Domestic	159	6	82	10
27951	Unknown	138	6	64	10
105971	Irrigation	134	6	87	35
92069	Irrigation	118	6	85	40
59264	Irrigation	35	8	12	90
59348	Irrigation	39	8	6	-
76035	Water Supply System	158	10	45	-
103071	Monitoring	436	6	-	-
75937	Unknown	20	6	-	-
75939	Unknown	20	6	-	-
75940	Unknown	41	6	28	-
75938	Unknown	20	6	-	-
83966	Private Domestic	383	6	190	30
116544	Private Domestic	96	6	-	-

3. WELL CONSTRUCTION AND DEVELOPMENT

The replacement well was drilled and developed by Scott Burrows (Qualified Well Driller #04121407) of Drillwell Enterprises Ltd with a dual rotary drill rig (Foremost DR24). The following sections describe the construction and completion of the well.

3.1 Lithology and Construction Details

The lithology observed during drilling consisted of three informally defined units, as outlined in Table 3-1. The borehole was advanced to a final depth of 53.3 m (175 ft), with water-bearing material first noted at an approximate depth of 4.0 (13 ft) in the surficial unit and 39.6 m (130 ft) in the confined unit. For further lithological information, refer to the completed well driller's log provided in Appendix A and the well schematic diagram in Figure 3-3.

Table 3-1 Lithology Log for WPID 54938

Depth (m)	Depth (ft)	Lithology
0 – 5.2	0 – 17	Gravel & Cobbles
5.2 – 39.6	17 – 130	Silt, some sand
39.6 – 45.7	130 – 150	Coarse Gravel, increased silt with depth (wet, high production)
45.7 – 46.6	150 – 153	Till and Clay
46.6 – 49.7	153 – 163	Sand and Gravel
49.7 – 53.3	163 – 175	Sand

Throughout drilling, formation samples were collected at 0.6 (2 ft) intervals in sampling bags. Nine samples from a depth range of 40.2 to 53.0 m (132 to 174 ft) within the saturated material were selected for field grain size analysis (Appendix B). Several factors were weighed for the well screen design including the grain size analysis, input from the well driller, and the District's desire to maximize the amount of water the well could produce. The thin layer of till and clay observed from 45.7 to 46.6 m (150-153 ft) during drilling was not described in the lithologies for DW1 or DW2, which lead to the conclusion that this material was likely a non-continuous lens in the stratigraphy and not a confining unit. As a result, a 11.6 m (38 ft) long telescoping stainless steel well screen well design was selected that included a 4.3 m (14 ft) upper screen with 100 slot openings (2.5 mm/0.100 inch) and a 2.7 m (9 ft) lower screen with 50 slot openings, separated by a blank section across the till and clay unit.

After installation, the screen was exposed to the formation by pulling back the production casing. The well was then developed using the surge and bail method with a cable-tool rig. During surging, the operators encountered an atypical amount of fine material and required approximately 70 hours to develop the well prior to test pumping.

3.2 Well Testing Methodology and Completion Details

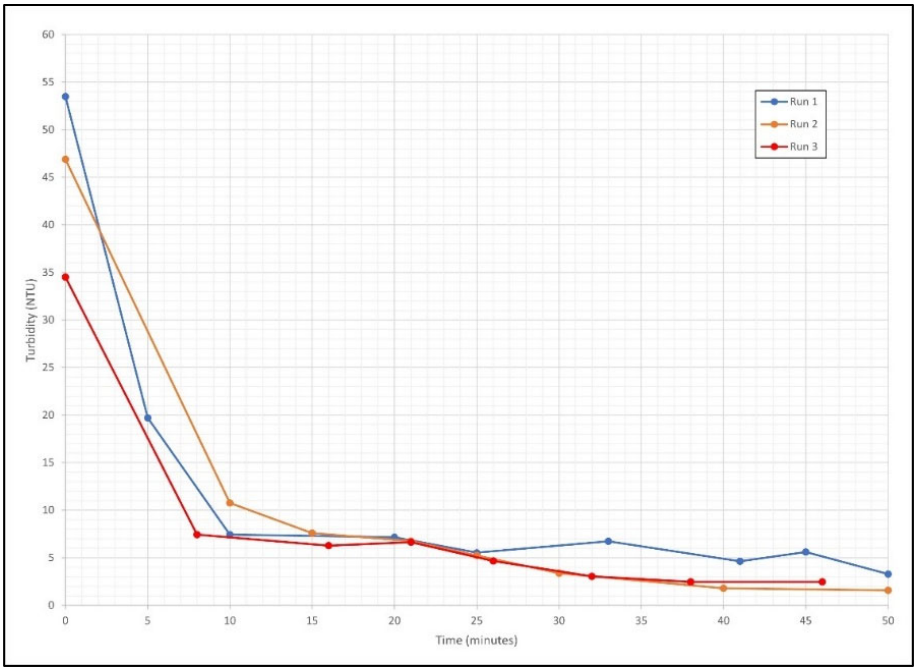
Under the oversight of WWAL hydrogeologists Douglas Geller, P.Geo. and Paul Williamson, P.Geo., the testing program on the supply well began on March 2, 2021. Monashee Aquifer Testing supplied, installed, and operated a submersible pump for the testing program. Water level measurements were collected with an electric well sounder to the nearest 100th of a foot, referenced to the top of the production casing. Flows were controlled with a gate valve on the discharge head and measured with an inline digital flow meter. A Rossum sand tester was used throughout testing to detect the presence of sand and, if present, quantify how much sand was produced.

The initial plan for testing was to discharge water through lay-flat hose to the Barriere River, a short distance from the well. To dissipate the energy from the discharging water and prevent erosion, the creek bank was covered with plastic tarps and plywood in the vicinity of the discharge hose. Prior to the

testing program, we installed a water level transducer in the onsite monitoring well located approximately 20 m to the southeast of the production well. A driller's log for this well could not be located but the DW1 construction report (Seacor Environmental Engineering, 1994) indicates the well reaches a depth of 61.6 m (202 ft).

The assessment was scheduled to begin with a variable-rate step test, followed by a 48-hour constant rate test. Upon pump fire up, discharge water was observed to be dark grey in colour and heavily laden with silt, with turbidity readings above the measurable range of the meter. With continued pumping, the discharge water cleared significantly; however, turbidity would again surge whenever the pump was stopped and restarted and when the flow rate increased. A series of 50-60 min tests were then run at 600 US gpm, with turbidity measurements collected throughout. As shown in Figure 3-1, turbidity would spike upon start up of the pump but would quickly subside as pumping continued.

Figure 3-1 Turbidity Readings, March 3rd, 2021 at 600 US gpm



To better assess for the source of turbidity, a downhole well camera was installed in the well on March 4, 2021, beneath a submersible pump with a discharge rate capability of up to 450 US gpm. An initial pass through the well indicated several areas of the lower screen that were encrusted with what appeared to be silt (Photo 1). Several cycle tests of the well indicated that the ingress of turbidity was predominately entering from multiple areas in the lower screen (Photo 2). Little to no suspended material was observed to be passing through the upper screen section during this phase of testing.

Photos 1 & 2 – Well Camera Survey (March 4, 2021)

Photo 1: Silt encrusted in Lower Screen

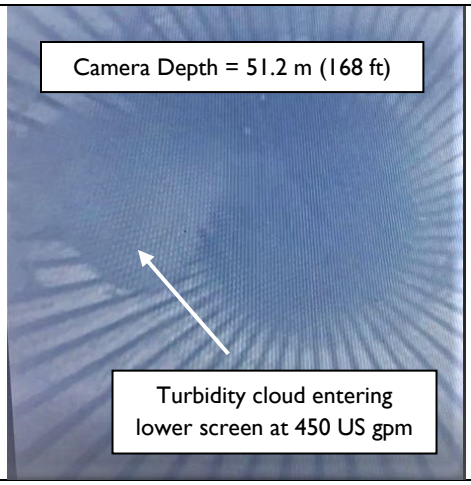
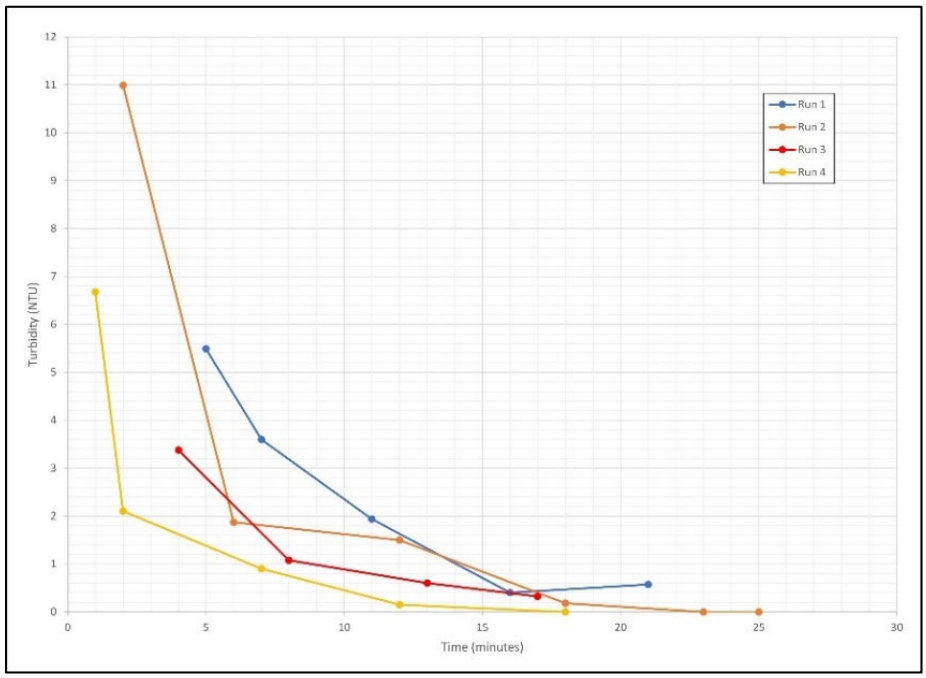


Photo 2: Turbidity entering well during pumping

Based on the results of the camera survey, the decision was made to further develop the lower screen. Using an air-jetting tool that forces highly focused air into the well screen, Drillwell completed approximately 25 hours of additional development on the lower screen. Testing commenced shortly after with a series of cycle tests at 600 US gpm. The results indicated a significant improvement from the previous test; however, turbidity continued to be elevated upon pump start-up before quickly dissipating. We then proceed with a constant rate test over a 16-hour period at 600 US gpm followed by an hour of recovery. Testing was then concluded with series of brief cycle tests at 600 US gpm. As shown in Figure 3-2 turbidity again spiked upon sstart-up before subsiding to below 1 NTU within 15 minutes.

Figure 3-2 Turbidity Readings, March 24th, 2021 at 600 US gpm



Water quality results collected at the end of the two pumping tests indicated that the concentrations of iron and manganese were elevated in comparison to a recent sample collected from DW2 (See Table 3-2 below). Based on the positioning of the screens in the two wells, we inferred that the iron and manganese likely originated from the lower well screen. Given the District's desire to maintain their existing water quality without the need for additional treatment, a third round of testing was authorized that would focus on assessing both the production and quality of only the upper screen. This was accomplished by inserting a packer unit, fabricated by Drillwell, into the blank section of the screen that largely blocked off the lower portion of the well. Although the packer functioned as intended, the vertical support rods inside the screen prevented the packer from forming a complete seal and some minor leakage from the lower screen was possible.

The third round of assessment proceeded with a step test (200, 400, 600 US gpm) followed by a 12-hour constant rate test at 600 US gpm. Water level measurements were collected from nearby DW2 throughout testing to quantify the degree of interference between the two wells. Similar to previous results, a surge of turbid water was observed during the initial stages of each step that quickly tapered off with continued pumping. An increase in sand production was also noted in the Rossum sand tester during this phase of testing. The driller noted that this increase was likely a side effect of the packer directly transmitting vibration from the pump down into the well screen. A similar effect is not expected once a permanent pump is installed in the completed well. Water quality testing indicted that the concentrations of iron and manganese were approximately half the values measured in the initial test (Table 3-2).

Table 3-2 Iron and Manganese Concentrations for WPID 40541

Parameter	December 1 (DW2)	March 4 (DW3 - Both Screens)	March 26 (DW3 - Both Screens)	April 28 (DW3 - Upper Screen)
Iron	<0.030	0.092	0.228	0.044
Manganese	<0.00200	0.0582	0.0615	0.0318

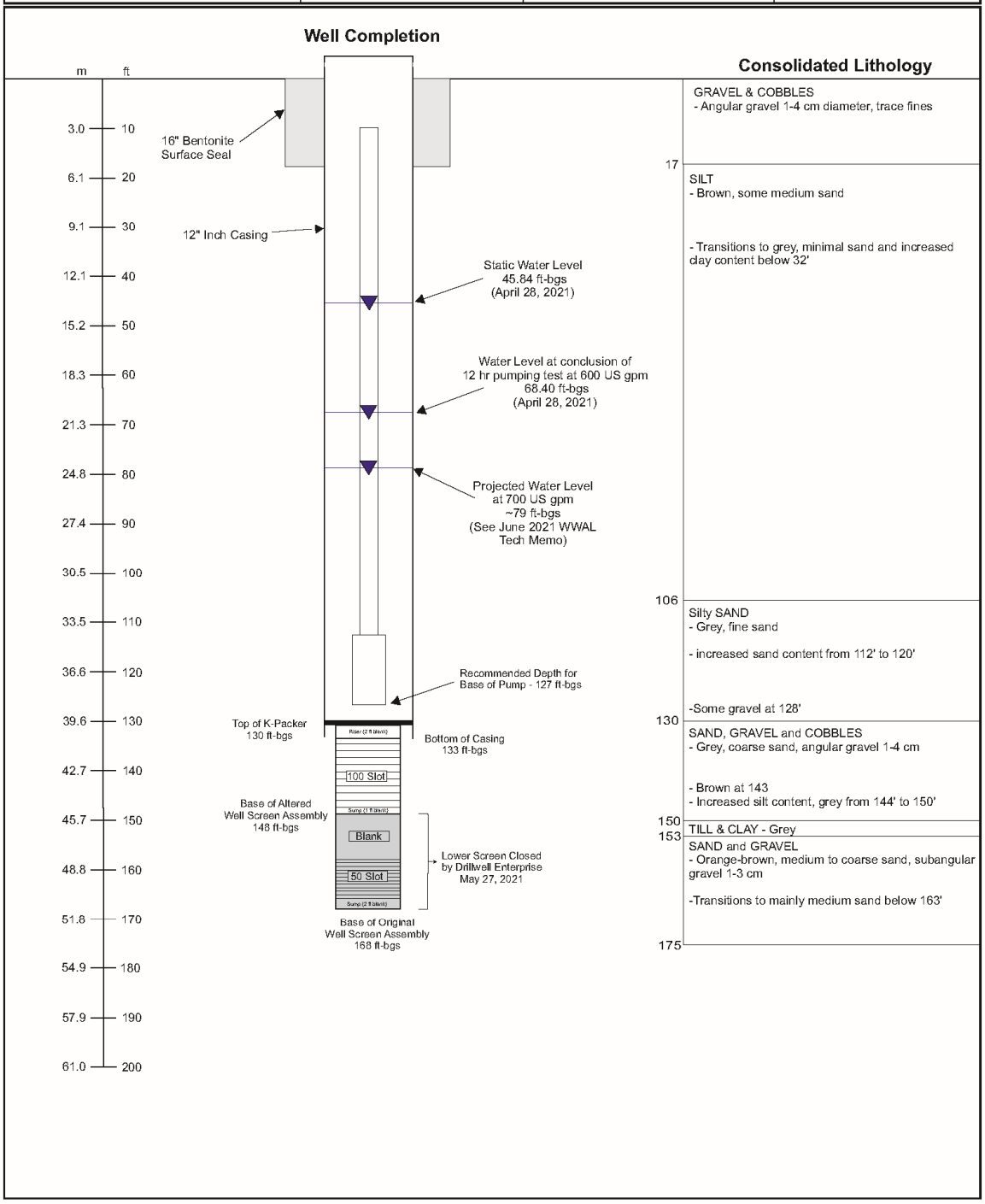
With the improved water quality and minimal decline in the production of the well (discussed further below), the decision was made to permanently seal off the lower well screen. On May 25, 2021, Drillwell backfilled the well with clean gravel, followed by bentonite and a cement cap. Select details for the final construction of the replacement well are provided in Table 3-3 below and on the well schematic provided in Figure 3-3.

Table 3-3 Final Construction Details for WPID 40541

Well Information	WPID 40541
Date Drilled	January-May 2021
Drilling Company	Drillwell Enterprises Ltd.
Production Casing Diameter	300 m (12 in)
Casing Height Above Ground	0.74 m (2.4 ft)
Completed Depth (bgs)	45.1 m (148 ft)
Top of Screen Assembly (K-packer)	39.6 m (130 ft)
Screen Length	4.3 m (14 ft)
Screen Slot Size and Depth (bgs)	100 slot: 40.5 to 44.7 m (132.8 to 146.8 ft)
Static Water Level (bgs): April 28, 2021	13.97 m (45.84 ft)

Figure 3-3 Well Schematic

western water ASSOCIATES LTD Consultants in Hydrogeology and Water Resources Management	**Well Plate Number: 40541**	Driller: Drillwell Enterprises	Drawn By: Paul W.
	Well Yield: ~700 US gpm	Drilling Method: Dual Rotary	Static Water Level: ~46 ft
WWAL Proj: 20-105-02VR Date: June 2021	Casing Diameter: 12 inch	Development Method: Cable Tool	Screen Diameter: 12" TS



4. WELL TESTING RESULTS

As mentioned above, one step test (upper screen only) and two constant rate tests (both screens, upper screen only) were conducted on the replacement well. We processed and plotted pumping test data into a series of graphs (Appendix C), the results of which we analyzed to estimate well performance and aquifer properties. The following sections summarize the results of the analysis and provide recommendations for operation and yield of the well.

During each step of the test, water levels declined rapidly in the first minute in response to an increase in the pumping rate. Within the first few minutes, the rate of decline slowed significantly and approached stabilization for the remainder of the step. Similar results were observed during the constant rate tests, where water levels initially declined rapidly followed by a slow progressive drawdown for the remainder of the test. Following pump shutoff, water levels recovered at or above 95% within 30 minutes. Summary pumping test data are provided in Table 4-1 below, with the full dataset are provided in Appendix C.

Table 4-1 Well Testing Summary

Flow Rate		Step/Test Duration	Drawdown		Specific Capacity		Available Drawdown Remaining	Available Drawdown Used	Table & Figures
L/sec	US gpm	minutes	metres	feet	L/s/m	US gpm/ft	metres	%	-
Constant Rate Test –Upper and Lower Screens (March 24-25, 2021)									
37.9	600	960	5.53	18.85	6.8	33.0	17.1	24.36	Table A2 Figures A2, A3
Step Test – Upper Screen Only (April 28, 2021)									
12.6	200	60	0.66	2.15	19.3	93.0	22.0	2.9	Table A1 Figure A1
25.2	400	60	2.42	7.95	10.4	50.3	20.3	10.7	
37.9	600	60	6.36	20.88	6.0	28.7	16.3	28.0	
Constant Rate Test – Upper Screen Only (April 28-29, 2021)									
37.9	600	720	6.87	22.55	5.5	26.6	15.8	30.3	Table A3 Figures A2, A3

Available Drawdown = Difference between static water level (13.97 m/45.84 ft) and the top of the well screen assembly (39.62 m /130 ft) minus a pump intake submergence allowance of 3.0 m (9.84 ft) = 22.7 m/74.3 ft.

4.1 Well Yield

The industry-accepted methodology for assessing long-term well yield is to apply a 30% safety factor to the available drawdown in the well and to multiply this by the specific capacity projected forward for 100 days of continuous pumping. This method is outlined in the guidelines for obtaining a Certificate of Public Convenience and Necessity (CPCN Guidelines, Allen *et al.*, 1999). Available drawdown is defined as the length of the water column between the static water level and the base of the well, with a pump submergence allowance.

The safety factor is applied to account for variability in water levels and available drawdown in the well. Water level variability can potentially be influenced by several factors including seasonal recharge to the aquifer, interference resulting from pumping in nearby wells and, in the long term, climate change.

Using the CPCN approach, the guidelines state well capacity can be estimated with the following empirical relationship:

$$Q\ (flow)\ =\ 0.7\ *\ X\ *\ \frac{Q}{s}$$ [Equation 1]

Where: X = estimated available drawdown
Q = pumping rate
s = projected drawdown at 100 days

As shown in Figure A3 (Appendix C), we estimated a theoretical sustainable yield of 78.4 L/s (1240 US gpm) for both screens and 67.6 L/s (1070 US gpm) for the upper screen only. These values exceeded the testing flow rate of 37.9 L/s (600 US gpm) and the theoretical transmitting capacity of the screen (~47 L/s; ~750 US gpm) therefore, we conservatively rate the yield of the well at 44.2 L/s (700 US gpm)

4.2 Well Interference

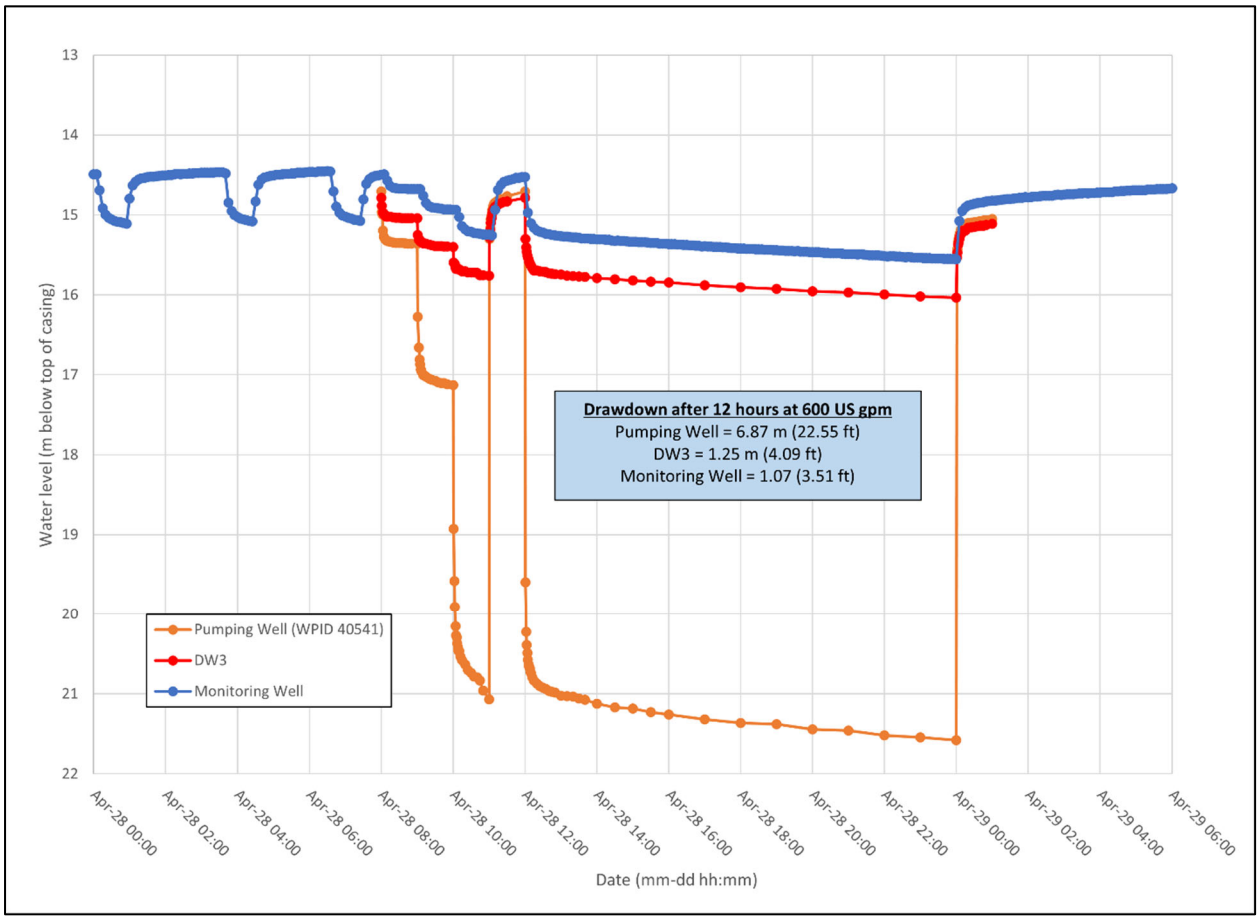
As a means of investigating potential interference effects, manual water measurements were collected from DW2 and a pressure transducer was also installed in a nearby onsite monitoring well (TW1) during the testing of the upper screen. Approximately 30 minutes prior to testing, pumping at DW2 was switched off and remained inoperative until six hours after the constant rate test had concluded. Table 4-2 presents the total drawdown observed in the two monitored wells at the completion of the constant rate test, and Figure 4-1 displays the hydrograph of all observed wells.

Table 4-2 Measured Drawdown in Observation Wells

Well ID	Depth	Approx. Distance from WPID 54938	Maximum Drawdown During Pumping*
DW2 (WPID 12702)	48.2 m (158 ft)	5.2 m	1.25 m (4.09 ft)
Onsite MW (TW1)	61.6 (202 ft)	19.4 m	1.07 m (3.51 ft)

* Drawdown from beginning of step test to conclusion of constant rate test.

Figure 4-1 Observed Drawdown during DW3 Pumping Test – Upper Screen Only



In the short term, it is our understanding that the District may periodically run DW2 and DW3 to meet peak summertime water demands. The results of the pumping test confirm that the DW2 and DW3 will interfere with each other if both wells are running simultaneously. However, a relatively small amount of available drawdown was used by the pumping well during testing and the extent of interference between the two wells was limited. Based on this, we infer that the degree of interference will not be a significant limitation to operating both wells simultaneously during peak periods.

4.3 Seasonal Groundwater Level Variation

At present, the Province does not have an observation well installed in either Aquifer 293 or Aquifer 294, and the District does not collect and maintain long term water level data from DW2. As a result, the magnitude of seasonal fluctuation the well will typically experience cannot be determined. However, our experience with wells installed in similar formations (i.e., confined, unconsolidated) indicates water levels will typically fluctuate approximately 1 to 3 m over a given year, with the potential for higher values during wetter than normal periods or over times of prolonged drought. We expect that seasonal fluctuations in groundwater are influenced by water levels in the Barriere River, variations in precipitation and the normal operation of the Spruce Crescent wells, and we infer that groundwater levels are typically highest in the late spring and lowest towards the end of the summer.

After 12 hours of pumping, approximately 16 m of available drawdown (which accounts for a pump intake submergence allowance) remained in the well. Based on this and the anticipated use of the well, it is reasonable to conclude that natural seasonal fluctuations will not be significant enough to limit the ability of the well to supply the community with water.

4.4 Aquifer Properties

WWAL assessed the properties of the aquifer using AQTESOLV™, a commercially available hydrogeological analysis software package, and drawdown data from DW2. Although drawdown data was also collected from the onsite monitoring well, this data could not be included in our analysis due to a lack of construction details for the well. AQTESOLV reports for each analysis are included in Appendix D and summarized in Table 4-3.

As discussed previously, the replacement well is installed in a confined sand and gravel unit. In the DW2 completion report, Kala Groundwater Consulting (1997) used pumping test data from DW1, DW2 and TW1 to estimate the aquifer's characteristics. The results of their analysis estimated transmissivity (T) values that ranged 5.2×10^2 to 2.8×10^3 m^2/day, with storativity (S) values in the vicinity of 2×10^{-3}. Their analysis included models that accounted for unconfined, confined and leaky confined conditions.

For our analysis, we applied the traditional Theis (1935) and Doughty-Babu (1984) methods for confined aquifers. The values for T were nearly identical for the confined aquifer analyses and have equivalent hydraulic conductivity values (K) that are consistent with textbook values for sand & gravel aquifers (Freeze & Cherry, 1979). For storativity, the confined models were again nearly identical and are in line with typical values for confined aquifers (Freeze & Cherry, 1979).

Several factors at the site introduced some uncertainty into our estimates of T and S: 1) DW2 was operating until approximately 30 minutes prior to the test, and it is unlikely that the aquifer was full recovered before the start of testing, 2) leakage from the lower screen potentially occurred during testing, and 3) the duration of the test was limited to 12 hours so longer term effects in the aquifer (e.g., leakage, boundary conditions) were unlikely to be detected. As a result, deviations from the idealized models are present in the data. Since the values for T and S were in the range of those previously calculated, we believe our analysis provides a reasonable estimate of the aquifer's hydraulic characteristics.

Table 4-3 Summary of Estimated Aquifer Transmissivity

Analysis – Aquifer Type	Transmissivity (m^2/day)	Storativity (dimensionless)
Theis (1935) – Confined	2.5×10^3	6.7×10^{-4}
Dougherty-Babu (1984) - Confined	2.5×10^3	6.3×10^{-4}

4.5 Climate Change

Climate change is an ongoing process that can alter groundwater flow regimes and impact the sustainability of groundwater supplies. The Pacific Climate Impacts Consortium has analyzed past climate data trends to assist in projecting future changes. The project site falls within the Thompson Okanagan Region, where climate models project warming will continue throughout the 21st century, with the summer period predicted to warm at a slightly higher rate. Seasonal precipitation is expected to rise approximately 10% above current values, except for the summer period, when a 10% decrease is predicted.

Warming of the climate is expected to decrease the size and duration of the snowpack across the region, creating a shift towards rainfall-dominant watersheds. This could lead to increased runoff events and mid-winter thaws, which may alter the period when seasonal aquifer recharge occurs. With increased temperatures and decreased precipitation in the summer, groundwater levels may decline to depths below typical seasonal low values. This would result in less available drawdown during periods when groundwater is typically relied upon more heavily for irrigation or water supply.

4.6 Recommended Completions and Operating Parameters

Based on the well testing program, we recommend a maximum operating rate of 44.2 L/s (700 US gpm). Please refer to our technical memorandum issued on June 4, 2021 for discussion on the projected drawdown at this flow rate. We recommend that the bottom of the submersible pump assembly be located approximately 0.9 m (3 ft) above the K-packer of the well screen assembly, at a depth of 38.7 m (127 ft). Careful measurements should be made by the pump installation contractor to ensure this recommendation is followed. We recommend installing two 1-inch PVC tubes with the permanent pump extending to the top of the pump. The first would house a pressure transducer, while the second would allow for manual water level measurements.

As with all production wells, operational performance (pumping rate and drawdown) should be monitored on a continuous basis and assessed regularly against the baseline well performance indicated in this report. This can be assessed by completing a one-hour drawdown test on the well once per year. During the test, the flow rate and water level should be recorded at 5-minute intervals. At the end of the test, a specific capacity can be calculated by dividing the pumping rate by the end of test drawdown. When specific capacity is found to decline by 15% from baseline values presented in this report, plans for well re-development should be made.

5. WATER QUALITY

WWAL collected a water sample towards the conclusion of the constant rate test of the upper screen. Prior to collection, the sampling tap was wiped down with a chlorine solution and opened for 15 minutes to flush any stagnant, non-representative water from the discharge assembly. To avoid cross contamination, a disposable pair of nitrile gloves was worn throughout sample collection. The sample was collected in clean, laboratory supplied bottles and transported to the laboratory in an ice-filled cooler within 24 hours. Water quality testing was completed by ALS Environmental in Kamloops, BC, a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA).

WWAL defines the term potable as water which is pure enough and of sufficient quality to be consumed or used by humans with low risk of immediate or long-term harm. Under this definition, select biological, chemical and physical parameters must be at values below health-based Maximum Acceptable Concentrations (MAC), as outlined in the Guidelines for Canadian Drinking Water Quality (GCDWQ). The GCDWQ also outlines Aesthetic Objectives (AO), which address select parameters that may affect the taste, odour and/or colour of water. Exceedances of these aesthetic parameters do not signify that a water source is not potable but can indicate that treatment may be necessary to address consumer concerns. Table 5-1 below provides the water quality testing results. For comparison purposes, a recent samples from DW2 has also been included. Complete laboratory reports are provided in Appendix E.

Table 5-1 Water Quality Summary

Parameter	Units	WPID 40541 (April 28, 2021)	DW2 (May 17, 2021)	GCDWQ
pH (field)	pH units	8.26	7.82	AO = 7-10.5
Conductivity (field)	µs/cm	368	348	--
Turbidity (lab)	NTU	0.26	<0.1	varies
General Parameters and Nutrients				
Total Dissolved Solids	mg/L	218	194	AO < 500
Total Hardness (as $CaCO_3$)	mg/L	200	162	--
Alkalinity (total)	mg/L	183	156	--
Fluoride	mg/L	0.092	0.088	MAC = 1.5
Nitrate, N	mg/L	0.400	0.499	MAC =10
Nitrite, N	mg/L	<0.0010	<0.0010	MAC = 1
Chloride	mg/L	4.06	4.84	AO < 250
Sulfate	mg/L	20.5	15.5	AO < 500
Selected Ions and Metals (Total)				
Aluminum	mg/L	0.0262	<0.0100	OG < 0.1
Arsenic	mg/L	0.00149	0.00118	MAC = 0.01
Barium	mg/L	0.0203	<0.0200	MAC = 2
Boron	mg/L	<0.100	<0.100	MAC = 5
Cadmium	mg/L	<0.000200	<0.000200	MAC = 0.007
Copper	mg/L	0.00331	0.00249	MAC = 2 AO ≤ 1
Iron	mg/L	0.044	<0.030	AO ≤ 0.3
Lead	mg/L	<0.000500	<0.000500	MAC = 0.005
Manganese	mg/L	**0.0318**	0.00710	MAC = 0.12 AO ≤ 0.02
Sodium	mg/L	6.83	6.50	AO < 200
Uranium	mg/L	0.00238	0.00214	MAC = 0.02
Zinc	mg/L	<0.0500	<0.0500	AO ≤ 5
Microbiological Parameters				
Total Coliforms	CFU/100mL	<1	<1	MAC < 1
E. Coli	CFU/100mL	<1	<1	MAC < 1

Notes: GCDWQ = Guidelines for Canadian Drinking Water Quality; MAC = Maximum Acceptable Concentration (flagged as orange); AO = Aesthetic Objective (flagged as green); OG = Operational Guideline, for water treatment plants

Overall, the analytical results indicate the water from the production well is of good quality, with moderate levels of mineralization. A comparison to the GCDWQ indicates that all parameters analyzed were below health-based MAC guidelines; therefore, the water is considered potable. Manganese was detected at a concentration that exceeds the aesthetic objective, a common finding in the interior of British Columbia.

A comparison of water qualities indicates that DW2 is slightly less mineralized than the replacement well, a finding that supports leakage from the lower screen was occurring during testing. In particular, manganese is noted for being lower in DW2, below the aesthetic objective. With the lower screen now permanently sealed off, additional sampling from the well can confirm typical manganese levels for the new well.

6. GROUNDWATER AT RISK OF CONTAINING PATHOGENS (GARP)

At the request of the Interior Health Authority, a Stage 2 GARP determination is currently in progress for DW2. Given its proximity and similar construction, the results of the GARP determination will extend to include DW3. The outcome of the GARP assessment is anticipated in the spring of 2022.

7. SOURCE PROTECTION CONSIDERATIONS

The Groundwater Protection Regulation specifies that proposed water supply wells must be sited at a distance of at least 15 m from an existing water supply well on a different property. The Health Hazard Regulation indicates a proposed well must be located at least 6 m from any private dwelling and 30 m from any probable source of contamination (e.g., a septic field); except 120 m from cemeteries and dumping grounds (landfills). In addition, the Municipal Wastewater Regulation requires regulated effluent disposal fields to be at least 90 m from water supply wells.

In the near term, Dw2 and DW3 wells may be used simultaneously during times of peak water demands. Existing land use within 500 m of the new well includes agricultural lands, residential properties, the community fair grounds, undeveloped forested areas. We recommend that any fuels or chemicals be stored more than 30 m from the well and any activities involving heavy equipment maintenance should be moved outside of this radius. Septic systems of any design are not permitted within 30 m of a well.

If not already in place, consideration should be given to developing a Source Water Protection Plan and an Emergency Response Plan to deal with the low likelihood but high consequence scenario of an accidental release of contaminants in close proximity to the well. Such plans are typically a condition for some regulated drinking water systems.

8. CONCLUSIONS

C1 A new 300 mm diameter production well was constructed for the District of Barriere in Barriere, B.C. The well was completed in what we infer to be an unmapped confined aquifer. The well was drilled and developed by Drillwell Enterprises, and the well completion is compliant with B.C. *Groundwater Protection Regulation* requirements.

C2 Based on the results of the testing program, the new well has a recommended yield of 44.2 L/s (700 US gpm).

C3 Groundwater levels in existing well DW2 and a nearby onsite monitoring well were measured for potential interference effects during the assessment of the production well. Our assessment indicated that DW2 and DW3 will interfere with each other to some degree during normal operations. However, we infer that the degree of interference will not be a significant limitation to operating both wells simultaneously during peak periods.

C4 The magnitude of seasonal fluctuations in groundwater was estimated based on similar confined aquifer systems. Our assessment found that annual fluctuations in water levels are not expected to limit the ability of the well to meet project water demands.

C5 Water quality testing indicates water from the new production well is of good quality, with relatively moderate levels of mineralization. A comparison to the GCDWQ indicates that all parameters are below health-based guidelines, and therefore the water is considered potable. Manganese was found at a concentration that exceeds the aesthetic objective, which is a common finding in B.C.

C6 A Stage 2 GARP assessment is currently underway for the DW2 and DW3, with the outcome anticipated in the spring of 2022.

9. RECOMMENDATIONS

R1 We recommend a maximum operating rate of 44.2 L/s (700 US gpm) for the new production well.

R2 Submersible Pump Installation:

- The specifications for pump depth and sounding tubes outlined in Section 4.6 should be followed.
- Well performance recommendations provided in Section 4.6 should also be followed.
- We recommend that a means for measuring flow (preferably a flow meter with totalizer) be installed to quantify the total volume pumped from the well.

R3 Once the submersible pump has been installed, a series of start-stop tests should be run to determine the average duration of elevated turbidity in the well upon fire up. A solution for the elevated turbidity will need to be incorporated into the final engineered design of the system (e.g., pump to waste, blending with DW2).

R4 A complete IHA water quality sample should be collected once the well is up and running. Additionally, we recommend sampling for total manganese on at least a quarterly basis for the first year of operation. This will allow for manganese concentrations to be tracked over time.

R5 Installation of a buried pitless adapter unit will damage the surface seal around the production casing. If this occurs, it must be repaired by the Qualified Well Pump Installer retained to install the permanent pump in accordance with the *Groundwater Protection Regulation*.

R6 Final grading of the well sites should be such that a slight mound is constructed around the production well casings to prevent ponding of water near the well head.

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2. The scope and the period of service provided by Western Water Associates Ltd are subject to restrictions and limitations outlined in subsequent numbered limitations.
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FIGURES

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water ASSOCIATES LTD

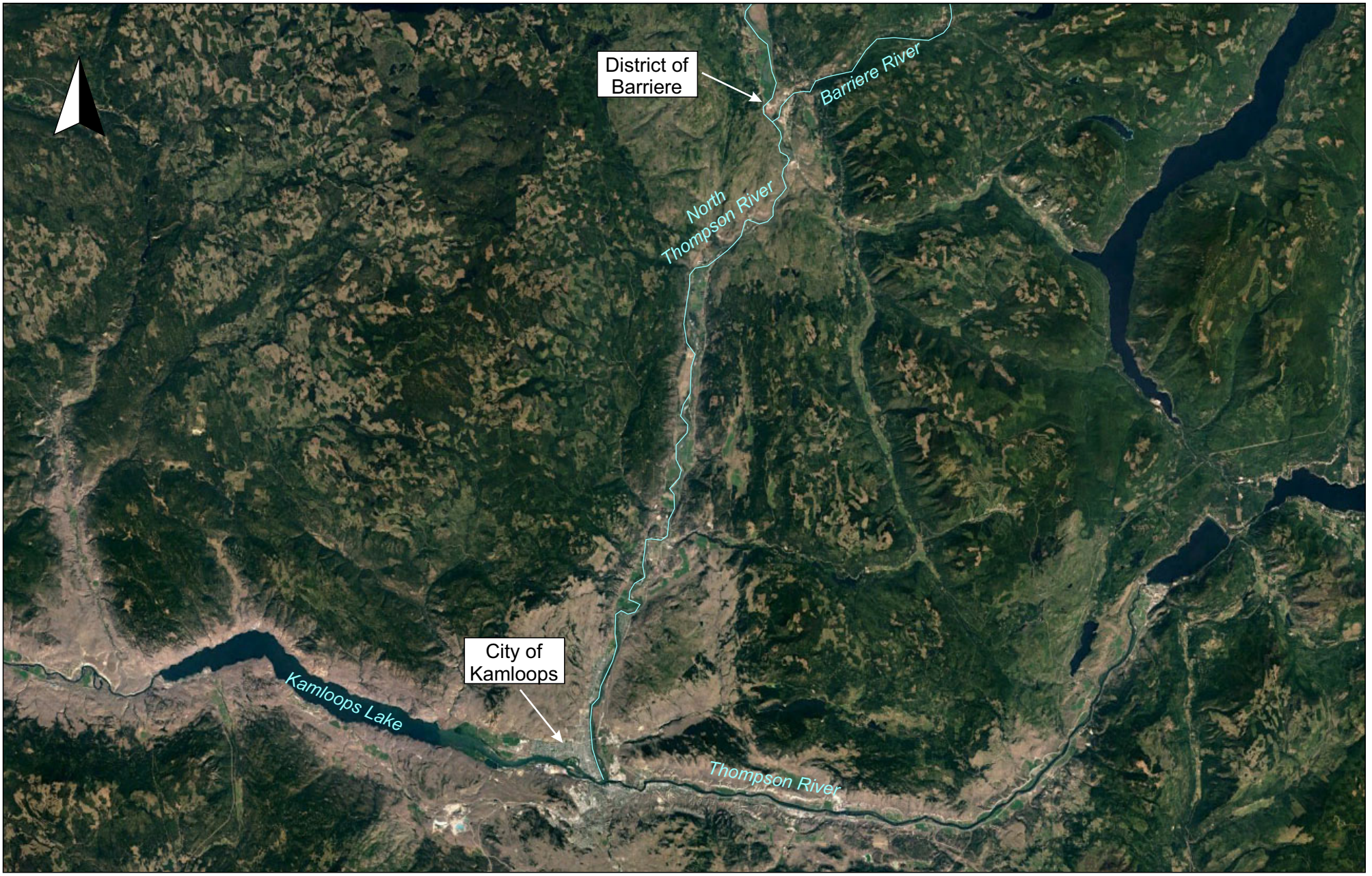

Figure 1 - General Site Location

Date: May 2021	WWAL Project: 20-105-02VR	Client: District of Barriere
Drawn by: PW	District of Barriere DW2 Well Replacement	Image Source: Google Earth Pro (2021)

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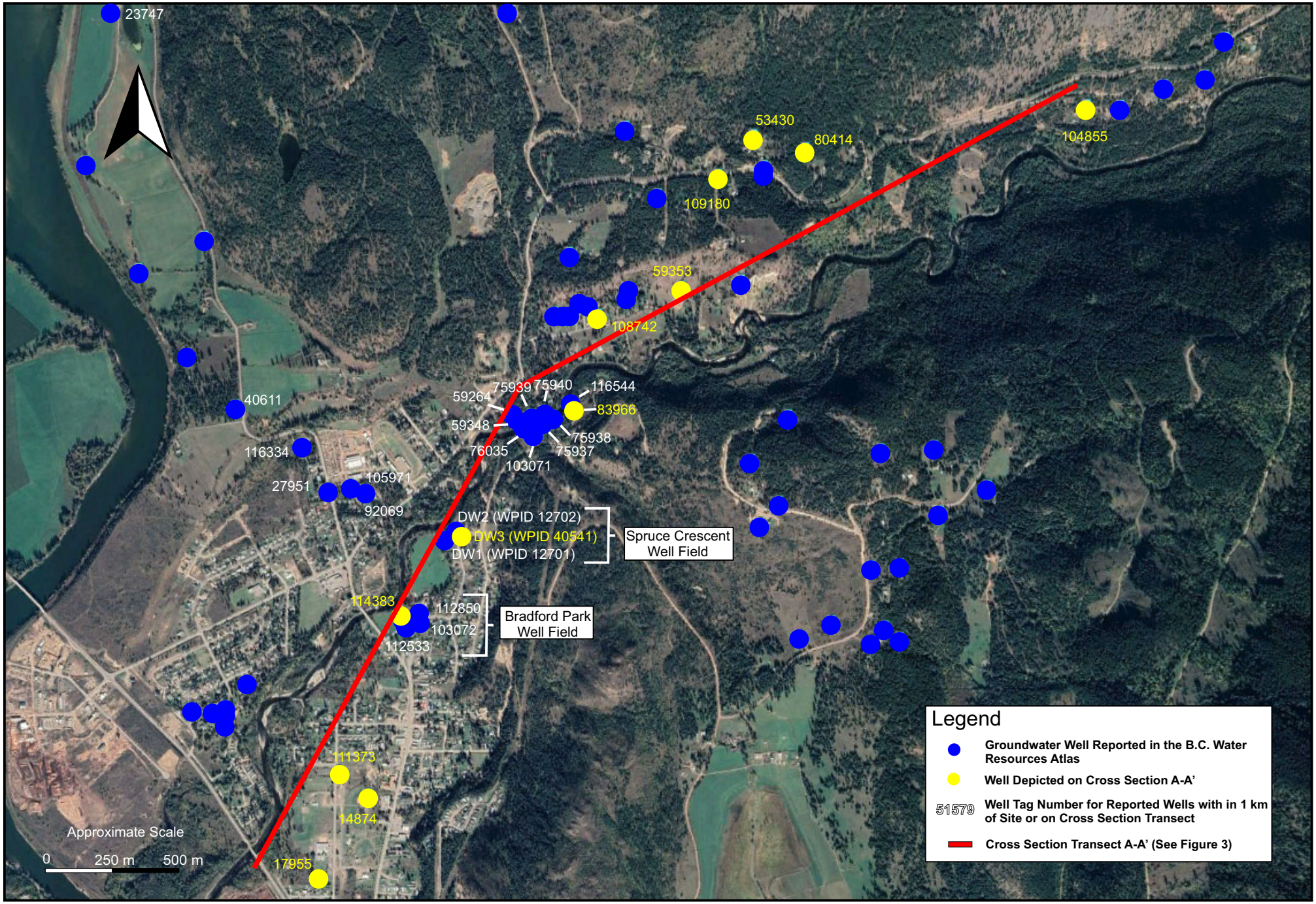

Figure 2 - Project Site, Reported Well in the Area and Transect A-A'

Date: May 2021	Image Source: Google Earth Pro (2021)		WWAL Project #: 20-105-02VR
Drawn by: PW	Checked by: DG	Client: District of Barriere	Project: District of Barriere DW2 Replacement Well

western water ASSOCIATES LTD
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Northwest
A

Southeast
A'

Approximate Elevation (m asl)

525
500
475
450
425
400
375
350
325
300
275
250

Perched Aquifer?

Aquifer 293/294

Aquifer 294

Confining Unit

Deep Confined Aquifer

2nd Deep Confined Aquifer?

17955
Gravel
Clay
Clay with Sandy Silt Layers

14874
Sand & Gravel
Clay

111373
Gravel
Clay

PW3 (114384)
Sand, Gravel & Boulders
Grey Silt & Clay
Grey Sand & Clay
Grey Clay & Rock
Sand & Gravel
Grey Fine Sand, Silt & Clay

DW3 (WPID 40541)
Sand, Gravel & Cobbles
Grey Silt
Grey Silty Sand
Sand & Gravel
Grey Clay Till
Red/Brown Sand, some Gravel

59348
Sand, Gravel & Boulders
Clay

83966
Sand, Gravel & Cobbles
Silty Clay
Silty Clay
Brown Sand & Gravel
Grey Silty Clay
Sand & Gravel
Grey Clay Till & Boulders
Sand & Gravel
Clay Till

108742
Silty Sand & Gravel
Sand & Gravel
Grey Silty Fine Sand
Sand & Gravel
Grey Silty Sand

59353
Silty Clay
Sand, Gravel & Boulders
Brown Silty Clay
Grey Silty Clay
Grey Silty Sand

109180
Sand, Gravel & Boulders
Sand
Grey Silt
Unknown ?
Sand
Sand & Gravel
Silt & Clay
Sand & Gravel

53430
Till & Boulders
Gravel
Sand
Clay

80414
Sand, Gravel & Cobbles
Grey Sand, Silt & Clay
Brown Sand, Gravel and Cobbles
Brown Sand (Fine to Medium)

104855
Sand & Gravel
Sand, Silt & Clay
Clay/Silt
Silty Sand
Clay
Sand
Sand & Gravel

Horizontal Scale 0 m 250 m 500 m

Note: All wells projected on to transect line; Cross Section Elevations obtained from Google Earth Pro

Figure 3 - Cross-section A - A' (See Figure 2)

Date: June 2021	Cross Section Transect A-A' from Figure 2	Project: District of Barriere Replacement Well	
Drawn by: PW	Checked by: DG	Client: District of Barriere	WWAL Project: 20-105-02VR

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Appendix A
Well Driller's Log

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water ASSOCIATES LTD

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The Best Place on Earth

Ministry of Environment

☒ **Well Construction Report**
☐ **Well Closure Report**
☐ **Well Alteration Report**

DRILLWELL ENTERPRISES LTD.
4994 Polkey Road
Duncan, B.C. V9L 6W3
Phone: 250-746-5268
Stamp company address/ phone/fax/e-mail here, if desired.

Ministry Well ID Plate Number: 40541
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: DISTRICT OF BARRIÈRE
Mailing address: 4936 BARRIERE TOWN RD Town BARRIÈRE Prov. BC Postal Code V0E 1E0
Well Location: Address: Street no. 4795 Street name SPRUCE CRES. Town BARRIÈRE
(or) **Legal description:** Lot Plan KAP 32420 D.L. 1354 Block Sec. Twp. Rg. Land District
(or) **PID:** (and) **Description of well location (attach sketch, if nec.):**

NAD 83: Zone: 10U (see note 2) (and) **UTM Easting:** 0701185 m **UTM Northing:** 5675062 m (or) **Latitude (see note 3):** **Longitude:**

Method of drilling: ☐ air rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ excavating ☒ other (specify): DUAL ROTARY
Orientation of well: ☒ vertical ☐ horizontal Ground elevation: 1312 ft (asl) Method (see note 4): GPS
Class of well (see note 5): 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 7-14) or closure description (see notes 15 and 16)

From ft (bgl)	To ft (bgl)	Relative Hardness	Colour	Material Description (Use recommended terms on reverse. List in order of decreasing amount, if applicable)	Water-bearing Estimated Flow (USgpm)	Observations (e.g., fractured, weathered, well sorted, silty wash), closure details
0	10			COBBLES		
10	17			GRAVEL W COBBLES		
17	94		BROWN	SILT, MED. SAND		
94	113		GREY	SILT, FEW STONES		
113	130		GREEN	SILTY GREY SAND & SILT		
130	143		GREY	COARSE GRAVEL, COBBLES, SANDY		
143	144		BROWN	COARSE GRAVEL & SAND		
144	150		GREY	COARSE GRAVEL, SILTY		
150	153		GREY	TILL & CLAY		
153	163		BROWN	CLEANER GRAVEL		
163	175		ORANGE	COARSE SAND		

Casing details

From ft (bgl)	To ft (bgl)	Dia in	Casing Material / Open Hole	Wall Thickness in	Drive Shoe
0	17.5	16"	STEEL - REMOVED	—	—
0	133	12"	STEEL	0.375	P.R.

Surface seal: Type: BENTONITE CHIP Depth: 17.5 ft
Method of installation: ☒ Poured ☐ Pumped Thickness: 2 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
130	132.8	12" tel	kpack & O WIND	—
132.8	146.8	12" tel	SS SCREEN	0.100"
146.8	157.1	12" tel	zero wind SS SCREEN	—
157.1	166.1	12" tel	SS SCREEN	0.050"
166.1	168.2	12" tel	SUMP	—

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: ~70 hrs
Notes:

Well yield estimated by:

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

Obvious water quality characteristics:

☐ Fresh ☐ Salty ☐ Clear ☐ Cloudy ☐ Sediment ☐ Gas
Colour/odour: Water sample collected: ☐

Well driller (print clearly):

Name (first, last) (see note 19): SCOTT BURROWS
Registration no. (see note 20): WD 04121407
Consultant (if applicable; name and company): PAUL @ WESTERN WATER

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

Final well completion data:

Total depth drilled: 175 ft Finished well depth: 168 ft (bgl)
Final stick up: 29 in Depth to bedrock: — ft (bgl)
SWL: 45.5' ft (btoc) Estimated well yield: 500+ USgpm
Artesian flow: — USgpm, or Artesian pressure: — ft
Type of well cap: WELDED Well disinfected: ☒ Yes ☐ No
Where well ID plate is attached: well CASING

Well closure information:

Reason for closure:
Method of closure: ☐ Poured ☐ Pumped
Sealant material: Backfill material:
Details of closure (see note 17):

Date of work (YYYY/MM/DD):
Started: 2021/01/26 **Completed:** 2021/03/19
Comments:

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.

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

BRITISH COLUMBIA
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Ministry of Environment

☐ Well Construction Report
☐ Well Closure Report
☑ Well Alteration Report

DRILLWELL ENTERPRISES LTD
4994 Polkey Road
Duncan, B.C. V9L 6W3
Phone: 250-746-5268

Stamp company name/address, phone/fax/e-mail here, if desired.

Ministry Well ID Plate Number: 40541
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: District of Barrière

Mailing address: 4936 Barriere Town Road Town Barrière Prov. BC Postal Code V0E1E0

Well Location: Address: Street no. 4795 Street name Spruce Crescent Town Barriere

(or) **Legal description:** Lot Plan KAP32420 D.L. 1354 Block Sec. Twp. Rg. Land District

(or) **PID:** (and) **Description of well location (attach sketch, if nec.):**

NAD 83: Zone: 10 (see note 2) (and) **UTM Easting:** 0701185 m **UTM Northing:** 5675062 m (or) **Latitude (see note 3):** **Longitude:**

Method of drilling: ☐ air rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ excavating ☐ other (specify):

Orientation of well: ☐ vertical ☐ horizontal Ground elevation: 1312 ft (asl) Method (see note 4): GPS

Class of well (see note 5): 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 7-14) or closure description (see notes 15 and 16)

From ft (bgl)	To ft (bgl)	Relative Hardness	Colour	Material Description (Use recommended terms on reverse. List in order of decreasing amount, if applicable)	Water-bearing Estimated Flow (USgpm)	Observations (e.g., fractured, weathered, well sorted, silty wash), closure details

Casing details

From ft (bgl)	To ft (bgl)	Dia in	Casing Material / Open Hole	Wall Thickness in	Drive Shoe

Surface seal: Type: Depth: 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

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: hrs
Notes:

Well yield estimated by:

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

Obvious water quality characteristics:

☐ Fresh ☐ Salty ☐ Clear ☐ Cloudy ☐ Sediment ☐ Gas
Colour/odour: Water sample collected: ☐

Final well completion data:

Total depth drilled: ft Finished well depth: 148 ft (bgl)
Final stick up: in Depth to bedrock: ft (bgl)
SWL: ft (btoc) Estimated well yield: 500 + USgpm
Artesian flow: USgpm, or Artesian pressure: ft
Type of well cap: WELDED Well disinfected: ☒ Yes ☐ No
Where well ID plate is attached: WELL CASING

Well closure information:

Reason for closure:
Method of closure: ☐ Poured ☐ Pumped
Sealant material: Backfill material:
Details of closure (see note 17):

Well driller (print clearly):

Name (first, last) (see note 19): Nick Sampson
Registration no. (see note 20): WD 15052001
Consultant (if applicable; name and company): PAUL @ WESTERN WATER

Date of work (YYYY/MM/DD):
Started: 2021/05/25 **Completed:** 2021/05/27
Comments: CLOSED LOWER HOLE WITH CEMENT PLUG @ 148'

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.

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

Appendix B
Field Grain Size Analysis

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water ASSOCIATES LTD

Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 132 ft

Date/ Time: Jan 28 2020

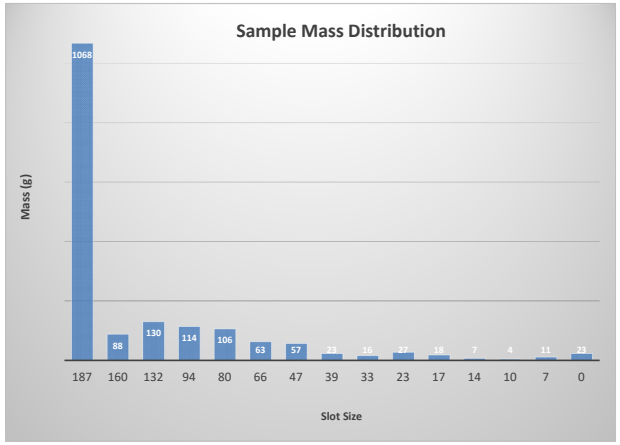
Field soil description/notes:

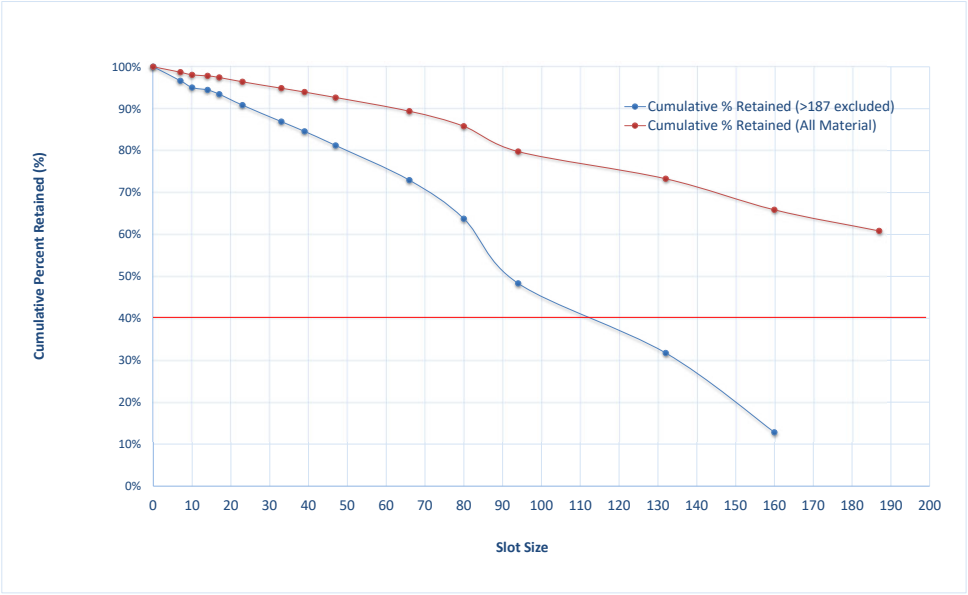
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	1068		61%		61%
Gravel	3.35	5	160	88	13%	5%	13%	66%
Fine Gravel		6	132	130	19%	7%	32%	73%
Coarse Sand	2	8	94	114	17%	6%	48%	80%
Medium Sand	1.7	10	80	106	15%	6%	64%	86%
Medium Sand	1.4	12	66	63	9%	4%	73%	89%
Medium Sand	1	16	47	57	8%	3%	81%	93%
Medium Sand		18	39	23	3%	1%	85%	94%
Medium Sand	0.841	20	33	16	2%	1%	87%	95%
Fine Sand	0.595	30	23	27	4%	2%	91%	96%
Fine Sand	0.42	40	17	18	3%	1%	93%	97%
Fine Sand		45	14	7	1%	0%	94%	98%
Fine Sand	0.25	60	10	4	1%	0%	95%	98%
Fine Sand		80	7	11	2%	1%	97%	99%
			0	23	3%	1%	100%	100%
Total (All)				1755	100%	100%		
Total (exclude >187)				687				





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Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 138

Date/ Time: Jan 28 2020

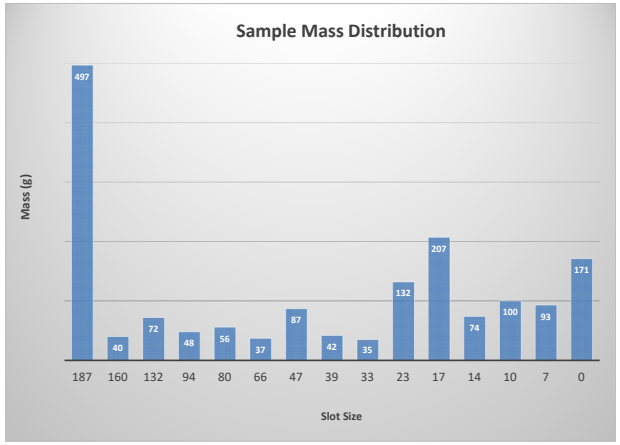
Field soil description/notes:

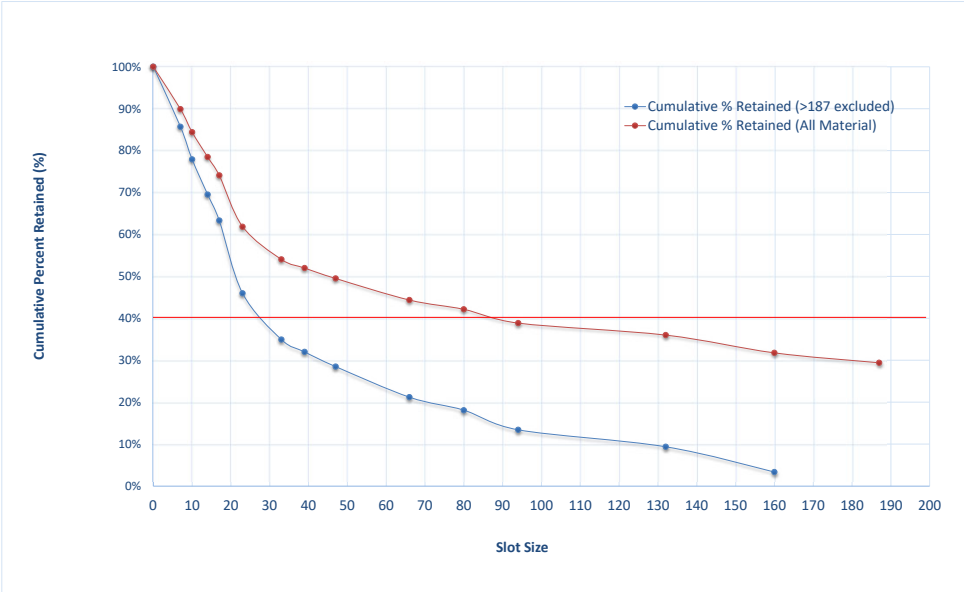
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	497		29%		29%
Gravel	3.35	5	160	40	3%	2%	3%	32%
Fine Gravel		6	132	72	6%	4%	9%	36%
Coarse Sand	2	8	94	48	4%	3%	13%	39%
Medium Sand	1.7	10	80	56	5%	3%	18%	42%
Medium Sand	1.4	12	66	37	3%	2%	21%	44%
Medium Sand	1	16	47	87	7%	5%	28%	49%
Medium Sand		18	39	42	4%	2%	32%	52%
Medium Sand	0.841	20	33	35	3%	2%	35%	54%
Fine Sand	0.595	30	23	132	11%	8%	46%	62%
Fine Sand	0.42	40	17	207	17%	12%	63%	74%
Fine Sand		45	14	74	6%	4%	70%	78%
Fine Sand	0.25	60	10	100	8%	6%	78%	84%
Fine Sand		80	7	93	8%	5%	86%	90%
			0	171	14%	10%	100%	100%
Total (All)				1691	100%	100%		
Total (exclude >187)				1194				





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Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 142

Date/ Time: Jan 28 2020

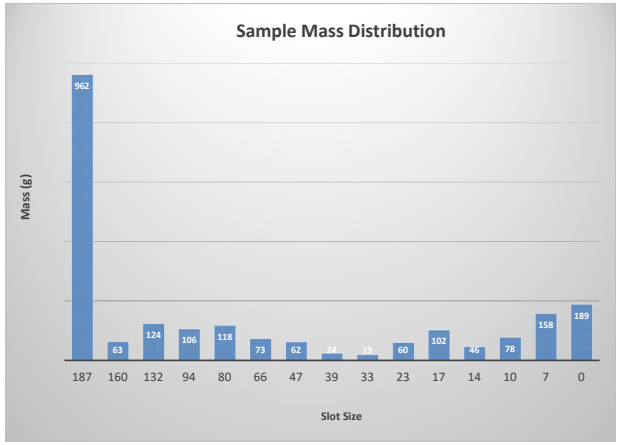
Field soil description/notes:

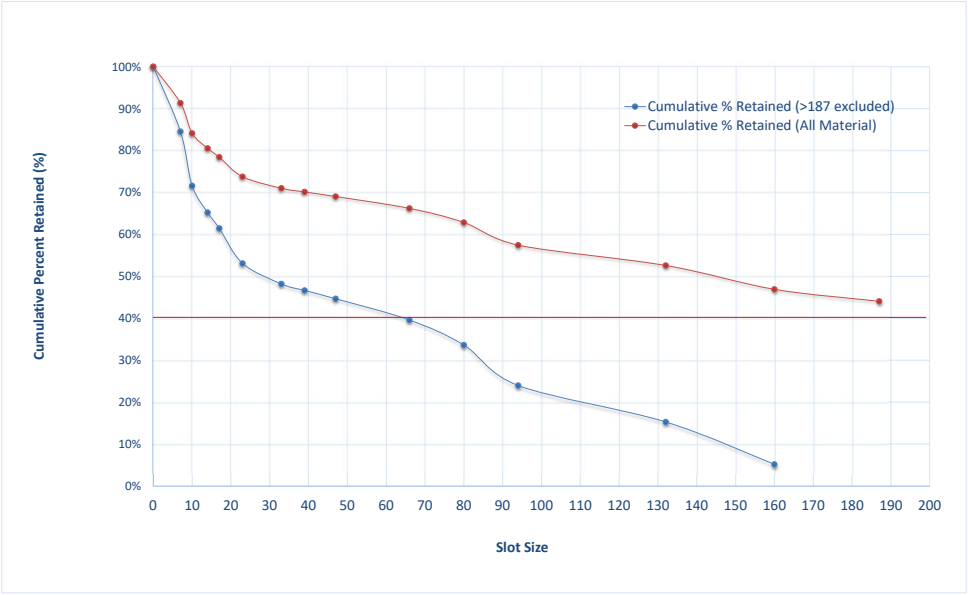
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	962		44%		44%
Gravel	3.35	5	160	63	5%	3%	5%	47%
Fine Gravel		6	132	124	10%	6%	15%	53%
Coarse Sand	2	8	94	106	9%	5%	24%	57%
Medium Sand	1.7	10	80	118	10%	5%	34%	63%
Medium Sand	1.4	12	66	73	6%	3%	40%	66%
Medium Sand	1	16	47	62	5%	3%	45%	69%
Medium Sand		18	39	24	2%	1%	47%	70%
Medium Sand	0.841	20	33	19	2%	1%	48%	71%
Fine Sand	0.595	30	23	60	5%	3%	53%	74%
Fine Sand	0.42	40	17	102	8%	5%	61%	78%
Fine Sand		45	14	46	4%	2%	65%	81%
Fine Sand	0.25	60	10	78	6%	4%	72%	84%
Fine Sand		80	7	158	13%	7%	85%	91%
			0	189	15%	9%	100%	100%
Total (All)				2184	100%	100%		
Total (exclude >187)				1222				





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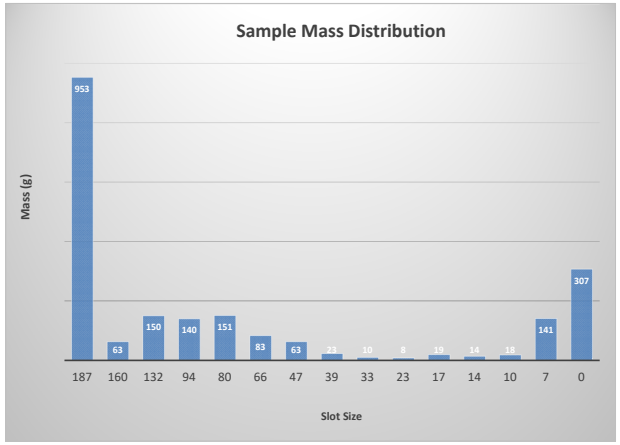
Consultants in Hydrogeology and Water Resources Management

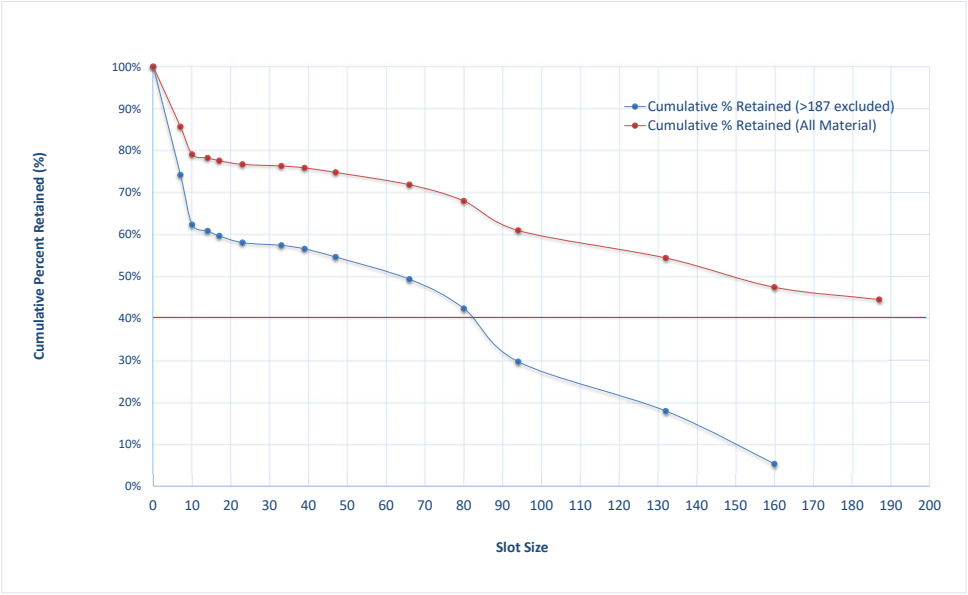
Field Particle Size Analysis

Project No.	**20-105-02VR**
Client:	**District of Barriere/ True Consulting**
Location:	**Barriere**
Location On Site:	
Borehole / Well Name	**DW3**
Sample depth (bgs) ft	**146**
Date/ Time:	**Jan 28 2020**
Field soil description/notes:	
Data Entry By:	**PW**
Checked By:	**RR**

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	953		44%		44%
Gravel	3.35	5	160	63	5%	3%	5%	47%
Fine Gravel		6	132	150	13%	7%	18%	54%
Coarse Sand	2	8	94	140	12%	7%	30%	61%
Medium Sand	1.7	10	80	151	13%	7%	42%	68%
Medium Sand	1.4	12	66	83	7%	4%	49%	72%
Medium Sand	1	16	47	63	5%	3%	55%	75%
Medium Sand		18	39	23	2%	1%	57%	76%
Medium Sand	0.841	20	33	10	1%	0%	57%	76%
Fine Sand	0.595	30	23	8	1%	0%	58%	77%
Fine Sand	0.42	40	17	19	2%	1%	60%	78%
Fine Sand		45	14	14	1%	1%	61%	78%
Fine Sand	0.25	60	10	18	2%	1%	62%	79%
Fine Sand		80	7	141	12%	7%	74%	86%
			0	307	26%	14%	100%	100%
Total (All)				2143	100%	100%		
Total (exclude >187)				1190				





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Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 156

Date/ Time: Jan 28 2020

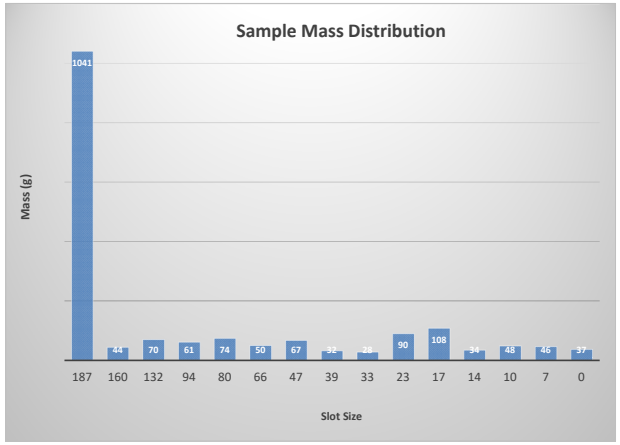
Field soil description/notes:

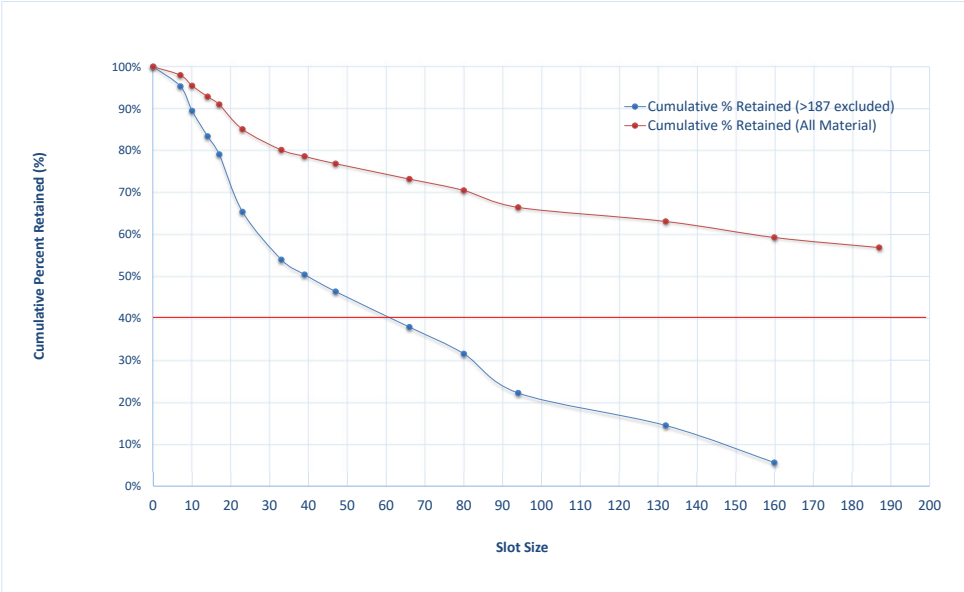
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	1041		57%		57%
Gravel	3.35	5	160	44	6%	2%	6%	59%
Fine Gravel		6	132	70	9%	4%	14%	63%
Coarse Sand	2	8	94	61	8%	3%	22%	66%
Medium Sand	1.7	10	80	74	9%	4%	32%	70%
Medium Sand	1.4	12	66	50	6%	3%	38%	73%
Medium Sand	1	16	47	67	8%	4%	46%	77%
Medium Sand		18	39	32	4%	2%	50%	79%
Medium Sand	0.841	20	33	28	4%	2%	54%	80%
Fine Sand	0.595	30	23	90	11%	5%	65%	85%
Fine Sand	0.42	40	17	108	14%	6%	79%	91%
Fine Sand		45	14	34	4%	2%	83%	93%
Fine Sand	0.25	60	10	48	6%	3%	89%	95%
Fine Sand		80	7	46	6%	3%	95%	98%
			0	37	5%	2%	100%	100%
Total (All)				1830	100%	100%		
Total (exclude >187)				789				





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Consultants in Hydrogeology and Water Resources Management

Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 160

Date/ Time: Jan 28 2020

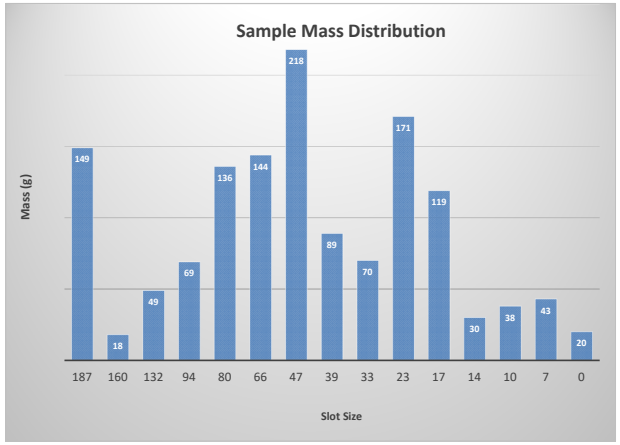
Field soil description/notes:

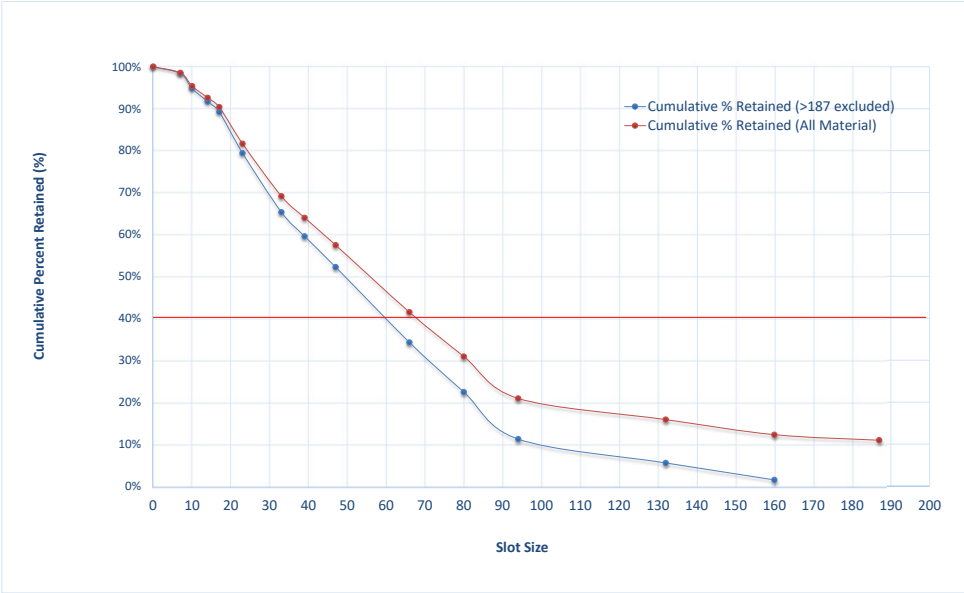
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	149		11%		11%
Gravel	3.35	5	160	18	1%	1%	1%	12%
Fine Gravel		6	132	49	4%	4%	6%	16%
Coarse Sand	2	8	94	69	6%	5%	11%	21%
Medium Sand	1.7	10	80	136	11%	10%	22%	31%
Medium Sand	1.4	12	66	144	12%	11%	34%	41%
Medium Sand	1	16	47	218	18%	16%	52%	57%
Medium Sand		18	39	89	7%	7%	60%	64%
Medium Sand	0.841	20	33	70	6%	5%	65%	69%
Fine Sand	0.595	30	23	171	14%	13%	79%	82%
Fine Sand	0.42	40	17	119	10%	9%	89%	90%
Fine Sand		45	14	30	2%	2%	92%	93%
Fine Sand	0.25	60	10	38	3%	3%	95%	95%
Fine Sand		80	7	43	4%	3%	98%	99%
			0	20	2%	1%	100%	100%
Total (All)				1363	100%	100%		
Total (exclude >187)				1214				





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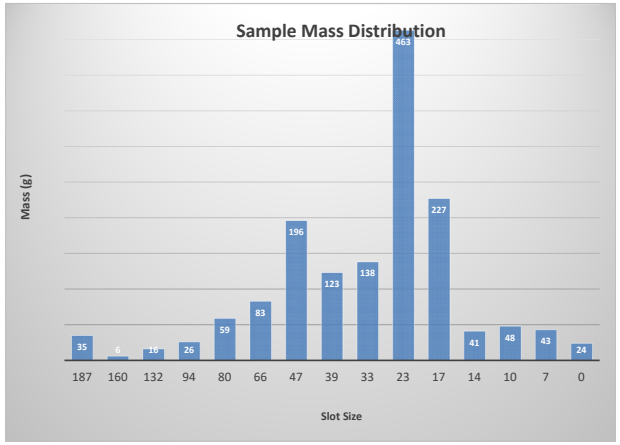
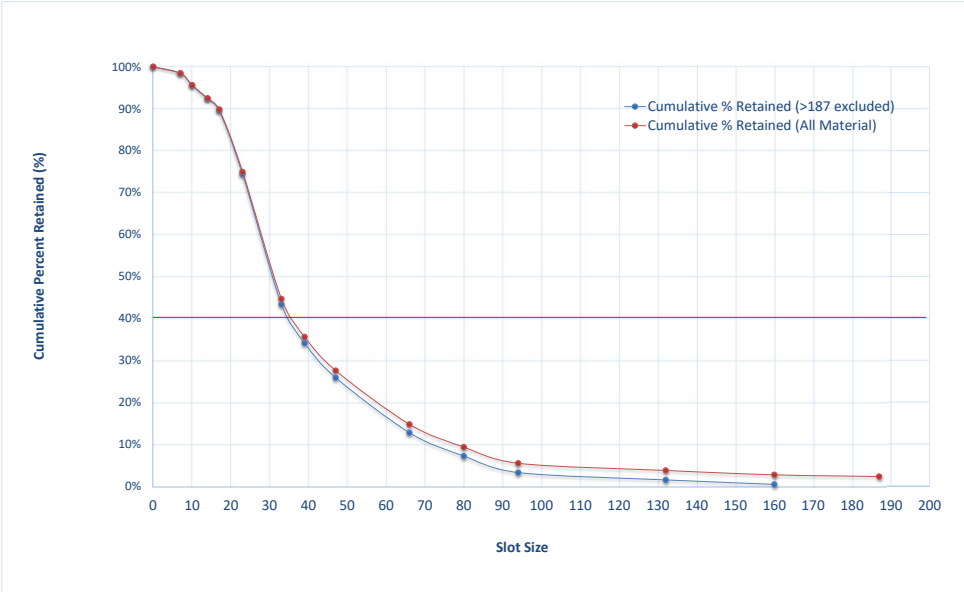
Field Particle Size Analysis

Project No.	**20-105-02VR**
Client:	**District of Barriere/ True Consulting**
Location:	**Barriere**
Location On Site:	
Borehole / Well Name	**DW3**
Sample depth (bgs) ft	**166**
Date/ Time:	**Jan 28 2020**
Field soil description/notes:	
Data Entry By:	**PW**
Checked By:	**RR**

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	35		2%		2%
Gravel	3.35	5	160	6	0%	0%	0%	3%
Fine Gravel		6	132	16	1%	1%	1%	4%
Coarse Sand	2	8	94	26	2%	2%	3%	5%
Medium Sand	1.7	10	80	59	4%	4%	7%	9%
Medium Sand	1.4	12	66	83	6%	5%	13%	15%
Medium Sand	1	16	47	196	13%	13%	26%	28%
Medium Sand		18	39	123	8%	8%	34%	36%
Medium Sand	0.841	20	33	138	9%	9%	43%	45%
Fine Sand	0.595	30	23	463	31%	30%	74%	75%
Fine Sand	0.42	40	17	227	15%	15%	90%	90%
Fine Sand		45	14	41	3%	3%	92%	92%
Fine Sand	0.25	60	10	48	3%	3%	96%	96%
Fine Sand		80	7	43	3%	3%	98%	98%
			0	24	2%	2%	100%	100%
Total (All)				1528	100%	100%		
Total (exclude >187)				1493				





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Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 170

Date/ Time: Jan 28 2020

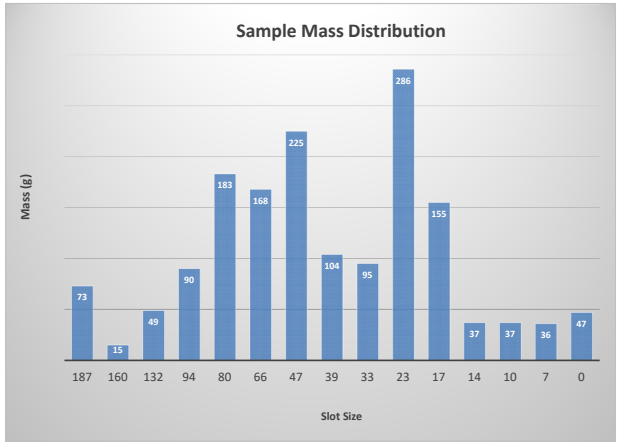
Field soil description/notes:

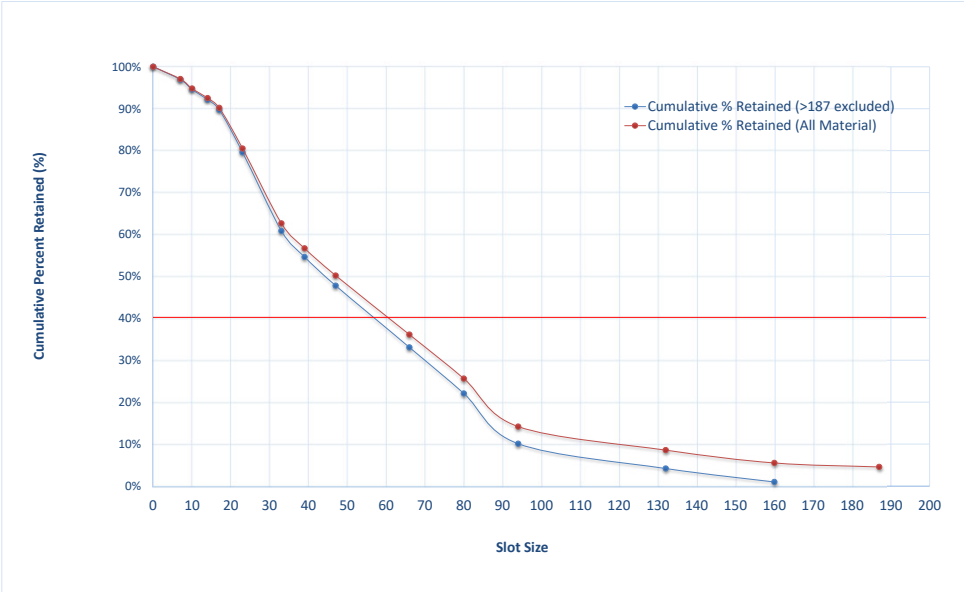
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	73		5%		5%
Gravel	3.35	5	160	15	1%	1%	1%	6%
Fine Gravel		6	132	49	3%	3%	4%	9%
Coarse Sand	2	8	94	90	6%	6%	10%	14%
Medium Sand	1.7	10	80	183	12%	11%	22%	26%
Medium Sand	1.4	12	66	168	11%	11%	33%	36%
Medium Sand	1	16	47	225	15%	14%	48%	50%
Medium Sand		18	39	104	7%	7%	55%	57%
Medium Sand	0.841	20	33	95	6%	6%	61%	63%
Fine Sand	0.595	30	23	286	19%	18%	80%	81%
Fine Sand	0.42	40	17	155	10%	10%	90%	90%
Fine Sand		45	14	37	2%	2%	92%	93%
Fine Sand	0.25	60	10	37	2%	2%	95%	95%
Fine Sand		80	7	36	2%	2%	97%	97%
			0	47	3%	3%	100%	100%
Total (All)				1600	100%	100%		
Total (exclude >187)				1527				





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Field Particle Size Analysis

Project No. 20-105-02VR

Client: District of Barriere/ True Consulting

Location: Barriere

Location On Site:

Borehole / Well Name DW3

Sample depth (bgs) ft 174

Date/ Time: Jan 28 2020

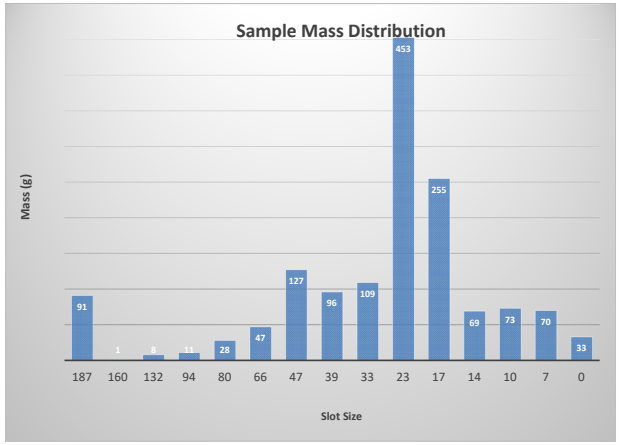
Field soil description/notes:

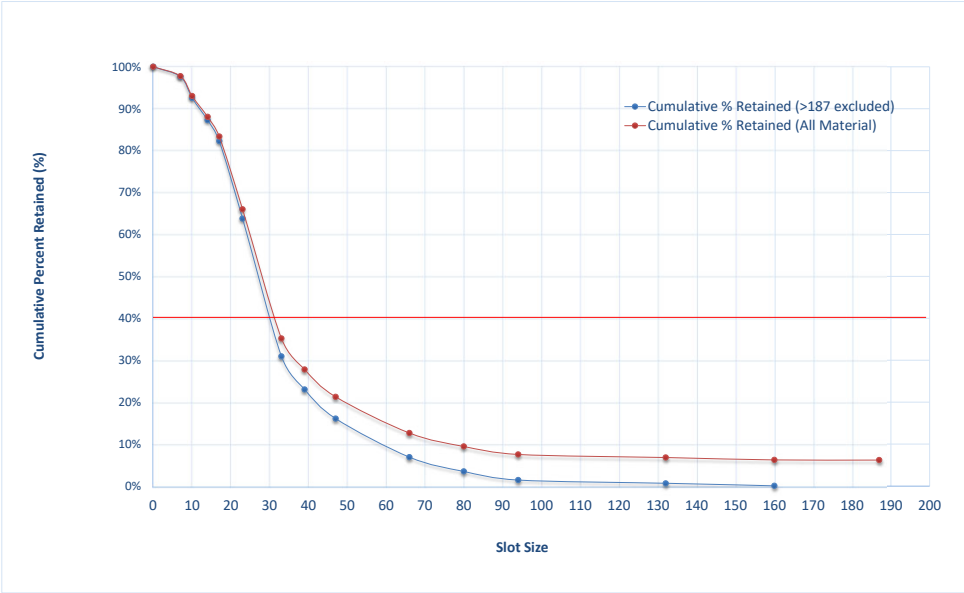
Data Entry By: PW

Checked By: RR

Fill in yellow cells with weight of eac htray

Sediment Type	Nominal aperture size (mm)	Mesh Size	Slot Size Range	Sieve Fraction Retained	> 187 excluded	All Material	Cumulative % Retained (>187 Excluded)	Cumulative % Retained (All Material)
				Weight (g)		% Wt.		%
Coarse Gravel		4	187	91		6%		6%
Gravel	3.35	5	160	1	0%	0%	0%	6%
Fine Gravel		6	132	8	1%	1%	1%	7%
Coarse Sand	2	8	94	11	1%	1%	1%	8%
Medium Sand	1.7	10	80	28	2%	2%	3%	9%
Medium Sand	1.4	12	66	47	3%	3%	7%	13%
Medium Sand	1	16	47	127	9%	9%	16%	21%
Medium Sand		18	39	96	7%	7%	23%	28%
Medium Sand	0.841	20	33	109	8%	7%	31%	35%
Fine Sand	0.595	30	23	453	33%	31%	64%	66%
Fine Sand	0.42	40	17	255	18%	17%	82%	83%
Fine Sand		45	14	69	5%	5%	87%	88%
Fine Sand	0.25	60	10	73	5%	5%	93%	93%
Fine Sand		80	7	70	5%	5%	98%	98%
			0	33	2%	2%	100%	100%
Total (All)				1471	100%	100%		
Total (exclude >187)				1380				





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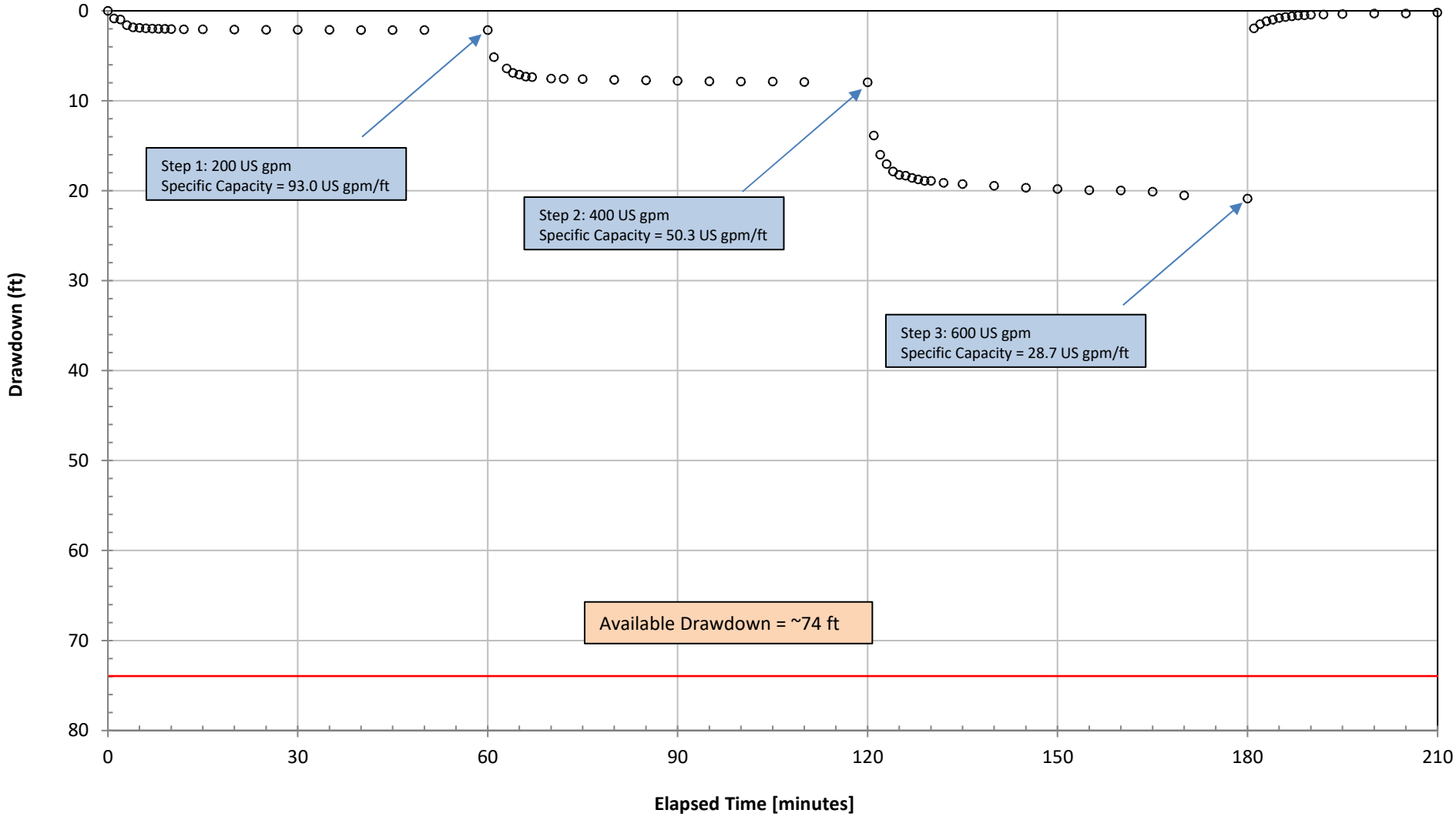
Appendix C
Pumping Test Data and Graphs

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water ASSOCIATES LTD

Project No: 20-105-02VR, Table A1: Step Test (Upper Screen Only) - Barriere Replacement Well WPID 40541											
Well depth = 148 ft	Well diameter = 12 in		Measurement method =		Flowmeter		Pump Depth = 120 ft				
Comments	Real Time	Time since pump started, t (minutes)	Water level measurement (btoc) (m)	Water level measurement (btoc) (ft)	Water level changes (m)	Drawdown (ft)	Drawdown (m)	Pumping Rate (l/s)	Pumping Rate (USgpm)	Specific Capacity	
										L/s/m	Usgpm/ft
STATIC	2021-04-28 8:00	0	14.71	48.25	--	0.00	0.00	0.0	0	--	--
		1	14.96	49.10	0.26	0.85	0.26	12.6	200	48.71	235.29
		2	15.00	49.20	0.03	0.95	0.29	12.6	200	43.58	210.53
		3	15.19	49.85	0.20	1.60	0.49	12.6	200	25.88	125.00
		4	15.27	50.10	0.08	1.85	0.56	12.6	200	22.38	108.11
		5	15.28	50.13	0.01	1.88	0.57	12.6	200	22.02	106.38
		6	15.30	50.20	0.02	1.95	0.59	12.6	200	21.23	102.56
		7	15.31	50.22	0.01	1.97	0.60	12.6	200	21.02	101.52
		8	15.32	50.25	0.01	2.00	0.61	12.6	200	20.70	100.00
		9	15.32	50.26	0.00	2.01	0.61	12.6	200	20.60	99.50
		10	15.32	50.28	0.01	2.03	0.62	12.6	200	20.39	98.52
		12	15.33	50.30	0.01	2.05	0.62	12.6	200	20.20	97.56
		15	15.34	50.32	0.01	2.07	0.63	12.6	200	20.00	96.62
		20	15.34	50.34	0.01	2.09	0.64	12.6	200	19.81	95.69
		25	15.35	50.36	0.01	2.11	0.64	12.6	200	19.62	94.79
		30	15.35	50.36	0.00	2.11	0.64	12.6	200	19.62	94.79
		35	15.35	50.36	0.00	2.11	0.64	12.6	200	19.62	94.79
		40	15.36	50.38	0.01	2.13	0.65	12.6	200	19.44	93.90
		45	15.36	50.39	0.00	2.14	0.65	12.6	200	19.35	93.46
		50	15.36	50.39	0.00	2.14	0.65	12.6	200	19.35	93.46
		60	15.36	50.40	0.00	2.15	0.66	12.6	200	19.26	93.02
		61	16.28	53.40	0.91	5.15	1.57	25.2	400	16.08	77.67
		63	16.66	54.65	0.38	6.40	1.95	25.2	400	12.94	62.50
		64	16.81	55.15	0.15	6.90	2.10	25.2	400	12.00	57.97
		65	16.87	55.35	0.06	7.10	2.16	25.2	400	11.66	56.34
		66	16.93	55.56	0.06	7.31	2.23	25.2	400	11.33	54.72
		67	16.95	55.62	0.02	7.37	2.25	25.2	400	11.23	54.27
		70	17.00	55.78	0.05	7.53	2.30	25.2	400	11.00	53.12
		72	17.01	55.80	0.01	7.55	2.30	25.2	400	10.97	52.98
		75	17.02	55.85	0.02	7.60	2.32	25.2	400	10.89	52.63
		80	17.05	55.93	0.02	7.68	2.34	25.2	400	10.78	52.08
		85	17.06	55.98	0.02	7.73	2.36	25.2	400	10.71	51.75
		90	17.07	56.02	0.01	7.77	2.37	25.2	400	10.66	51.48
		95	17.09	56.08	0.02	7.83	2.39	25.2	400	10.57	51.09
		100	17.10	56.11	0.01	7.86	2.40	25.2	400	10.53	50.89
		105	17.10	56.12	0.00	7.87	2.40	25.2	400	10.52	50.83
		110	17.12	56.16	0.01	7.91	2.41	25.2	400	10.47	50.57
		120	17.13	56.20	0.01	7.95	2.42	25.2	400	10.42	50.31
		121	18.93	62.10	1.80	13.85	4.22	37.9	600	8.97	43.32
		122	19.58	64.25	0.66	16.00	4.88	37.9	600	7.76	37.50
		123	19.90	65.30	0.32	17.05	5.20	37.9	600	7.28	35.19
		124	20.15	66.12	0.25	17.87	5.45	37.9	600	6.95	33.58
		125	20.27	66.50	0.12	18.25	5.56	37.9	600	6.81	32.88
		126	20.30	66.59	0.03	18.34	5.59	37.9	600	6.77	32.72
		127	20.37	66.83	0.07	18.58	5.66	37.9	600	6.68	32.29
		128	20.42	67.00	0.05	18.75	5.71	37.9	600	6.62	32.00
		129	20.47	67.15	0.05	18.90	5.76	37.9	600	6.57	31.75
		130	20.47	67.15	0.00	18.90	5.76	37.9	600	6.57	31.75
		132	20.53	67.37	0.07	19.12	5.83	37.9	600	6.50	31.38
		135	20.58	67.52	0.05	19.27	5.87	37.9	600	6.45	31.14
		140	20.63	67.70	0.05	19.45	5.93	37.9	600	6.39	30.85
		145	20.70	67.93	0.07	19.68	6.00	37.9	600	6.31	30.49
		150	20.74	68.05	0.04	19.80	6.03	37.9	600	6.27	30.30
		155	20.79	68.20	0.05	19.95	6.08	37.9	600	6.23	30.08
		160	20.79	68.22	0.01	19.97	6.09	37.9	600	6.22	30.05
		165	20.83	68.35	0.04	20.10	6.13	37.9	600	6.18	29.85
		170	20.96	68.77	0.13	20.52	6.25	37.9	600	6.05	29.24
		180	21.07	69.13	0.11	20.88	6.36	37.9	600	5.95	28.74
		181	15.30	50.19	-5.77	1.94	0.59	-	-	-	-
		182	15.16	49.74	-0.14	1.49	0.45	-	-	-	-
		183	15.06	49.40	-0.10	1.15	0.35	-	-	-	-
		184	15.01	49.25	-0.05	1.00	0.30	-	-	-	-
		185	14.95	49.04	-0.06	0.79	0.24	-	-	-	-
		186	14.92	48.95	-0.03	0.70	0.21	-	-	-	-
		187	14.89	48.85	-0.03	0.60	0.18	-	-	-	-
		188	14.87	48.78	-0.02	0.53	0.16	-	-	-	-
		189	14.86	48.74	-0.01	0.49	0.15	-	-	-	-
		190	14.84	48.70	-0.01	0.45	0.14	-	-	-	-
		192	14.83	48.67	-0.01	0.42	0.13	-	-	-	-
		195	14.82	48.62	-0.02	0.37	0.11	-	-	-	-
		200	14.80	48.56	-0.02	0.31	0.09	-	-	-	-
		205	14.80	48.55	0.00	0.30	0.09	-	-	-	-
		210	14.77	48.45	-0.03	0.20	0.06	-	-	-	-

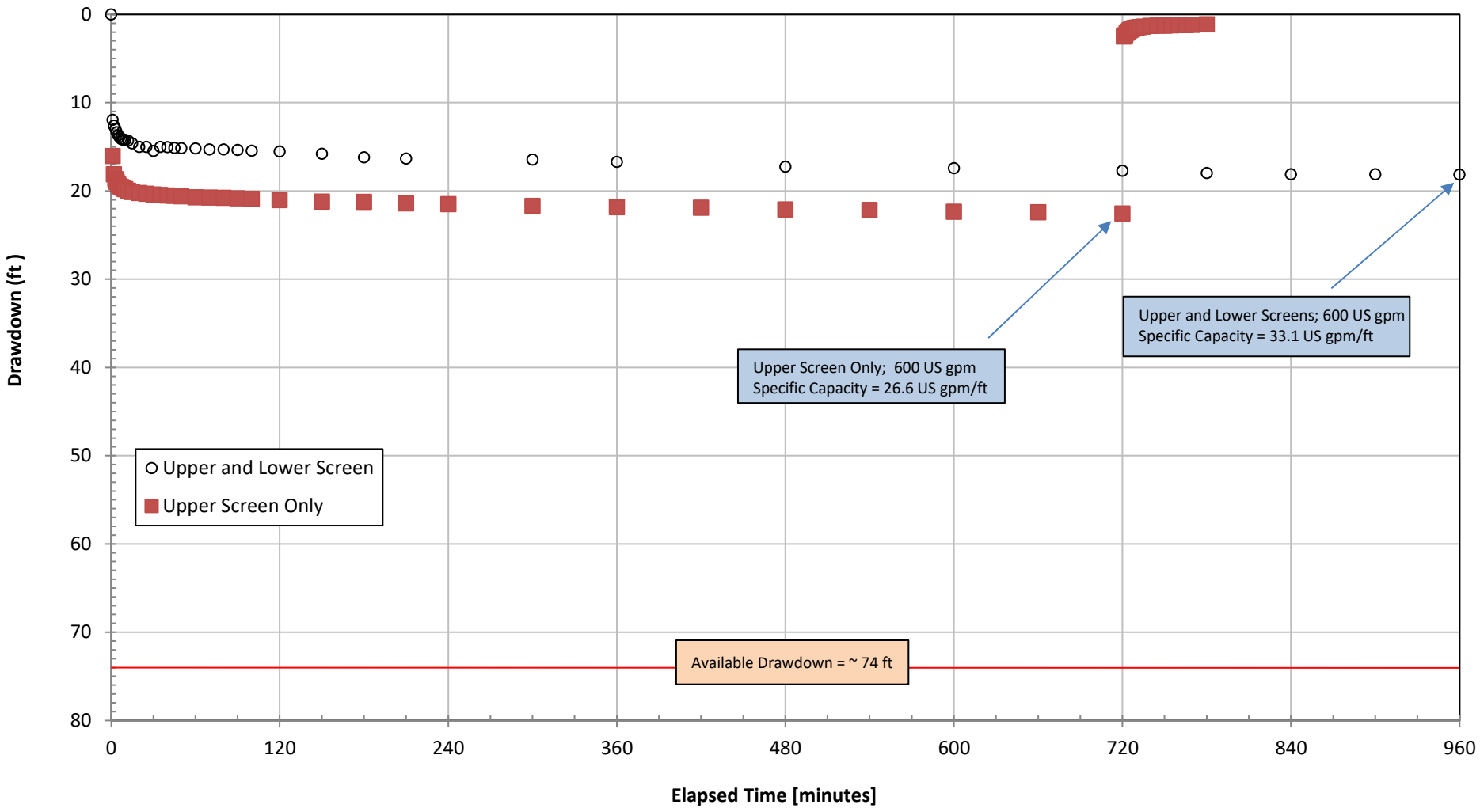


Barriere Replacement Well (WPID 40541)	TITLE **Figure A1 - Step Test Hydrograph: 200, 400 & 600 US gpm**			
western water ASSOCIATES LTD Consultants in Hydrogeology and Water Resources Management	DRAWN PW	DATE April 28, 2021	JOB NO. 20-105-02VR	
	CHECKED DG	SCALE n/a	DWG. NO. n/a	
	REVIEWED	FILE NO.	**FIGURE NO.**	

Project No: 20-105-02VR, Table A2: Constant Rate Test #1 (Two Screens) - Barriere Replacement Well WPID 40541											
Well depth = 168 ft	Well diameter = 12 in		Measurement method =		Flowmeter	Pump Depth = 120 ft					
Comments	Real Time	Time since pump started, t (minutes)	Water level measurement (btoc) (m)	Water level measurement (btoc) (ft)	Water level changes (m)	Drawdown (ft)	Drawdown (m)	Pumping Rate (l/s)	Pumping Rate (USgpm)	Specific Capacity	
										L/s/m	Usgpm/ft
STATIC		0	13.81	45.30	--	0.00	0.00	0.00	0	--	--
		1	17.45	57.25	3.64	11.95	3.64	37.85	600	10.39	50.21
		2	17.65	57.90	0.20	12.60	3.84	37.85	600	9.86	47.62
		3	17.75	58.25	0.11	12.95	3.95	37.85	600	9.59	46.33
		4	17.88	58.65	0.12	13.35	4.07	37.85	600	9.30	44.94
		5	17.98	59.00	0.11	13.70	4.18	37.85	600	9.07	43.80
		6	18.04	59.20	0.06	13.90	4.24	37.85	600	8.94	43.17
		7	18.10	59.40	0.06	14.10	4.30	37.85	600	8.81	42.55
		8	18.13	59.49	0.03	14.19	4.32	37.85	600	8.75	42.28
		9	18.13	59.48	0.00	14.18	4.32	37.85	600	8.76	42.31
		10	18.15	59.54	0.02	14.24	4.34	37.85	600	8.72	42.13
		12	18.16	59.59	0.02	14.29	4.36	37.85	600	8.69	41.99
		15	18.26	59.90	0.09	14.60	4.45	37.85	600	8.51	41.10
		20	18.38	60.30	0.12	15.00	4.57	37.85	600	8.28	40.00
		25	18.38	60.30	0.00	15.00	4.57	37.85	600	8.28	40.00
		30	18.52	60.78	0.15	15.48	4.72	37.85	600	8.02	38.76
		35	18.38	60.30	-0.15	15.00	4.57	37.85	600	8.28	40.00
		40	18.39	60.35	0.02	15.05	4.59	37.85	600	8.25	39.87
		45	18.42	60.44	0.03	15.14	4.61	37.85	600	8.20	39.63
		50	18.42	60.45	0.00	15.15	4.62	37.85	600	8.20	39.60
		60	18.44	60.49	0.01	15.19	4.63	37.85	600	8.18	39.50
		70	18.47	60.60	0.03	15.30	4.66	37.85	600	8.12	39.22
		80	18.47	60.61	0.00	15.31	4.67	37.85	600	8.11	39.19
		90	18.49	60.65	0.01	15.35	4.68	37.85	600	8.09	39.09
		100	18.52	60.75	0.03	15.45	4.71	37.85	600	8.04	38.83
		120	18.54	60.84	0.03	15.54	4.74	37.85	600	7.99	38.61
		150	18.62	61.10	0.08	15.80	4.82	37.85	600	7.86	37.97
		180	18.74	61.50	0.12	16.20	4.94	37.85	600	7.67	37.04
		210	18.79	61.64	0.04	16.34	4.98	37.85	600	7.60	36.72
		300	18.82	61.75	0.03	16.45	5.01	37.85	600	7.55	36.47
		360	18.90	62.01	0.08	16.71	5.09	37.85	600	7.43	35.91
		480	19.06	62.55	0.16	17.25	5.26	37.85	600	7.20	34.78
		600	19.12	62.73	0.05	17.43	5.31	37.85	600	7.13	34.42
		720	19.20	63.00	0.08	17.70	5.39	37.85	600	7.02	33.90
		780	19.29	63.28	0.09	17.98	5.48	37.85	600	6.91	33.37
		840	19.33	63.41	0.04	18.11	5.52	37.85	600	6.86	33.13
		900	19.33	63.42	0.00	18.12	5.52	37.85	600	6.85	33.11
		960	19.34	63.45	0.01	18.15	5.53	37.85	600	6.84	33.06

Project No: 20-105-02VR, Table A3: Constant Rate Test #2 (Upper Screen Only) - Barriere Replacement Well WPID 40541

Well depth = 148 ft	Well diameter = 12 in		Measurement method =		Flowmeter	Pump Depth = 120 ft					
Comments	Real Time	Time since pump started, t (minutes)	Water level measurement (btoc) (m)	Water level measurement (btoc) (ft)	Water level changes (m)	Drawdown (ft)	Drawdown (m)	Pumping Rate (l/s)	Pumping Rate (USgpm)	Specific Capacity	
										L/s/m	Usgpm/ft
STATIC		0	14.71	48.25	--	0.00	0.00	0.00	0	--	--
		1	19.60	64.30	4.89	16.05	4.89	37.85	600	7.74	37.38
		2	20.22	66.35	0.62	18.10	5.52	37.85	600	6.86	33.15
		3	20.39	66.90	0.17	18.65	5.68	37.85	600	6.66	32.17
		4	20.49	67.23	0.10	18.98	5.78	37.85	600	6.54	31.61
		5	20.57	67.50	0.08	19.25	5.87	37.85	600	6.45	31.17
		6	20.63	67.70	0.06	19.45	5.93	37.85	600	6.39	30.85
		7	20.66	67.79	0.03	19.54	5.96	37.85	600	6.36	30.71
		8	20.69	67.87	0.02	19.62	5.98	37.85	600	6.33	30.58
		9	20.73	68.00	0.04	19.75	6.02	37.85	600	6.29	30.38
		10	20.74	68.06	0.02	19.81	6.04	37.85	600	6.27	30.29
		12	20.80	68.23	0.05	19.98	6.09	37.85	600	6.22	30.03
		15	20.84	68.36	0.04	20.11	6.13	37.85	600	6.18	29.84
		20	20.87	68.49	0.04	20.24	6.17	37.85	600	6.14	29.64
		25	20.90	68.58	0.03	20.33	6.20	37.85	600	6.11	29.51
		30	20.92	68.65	0.02	20.40	6.22	37.85	600	6.09	29.41
		35	20.94	68.70	0.02	20.45	6.23	37.85	600	6.07	29.34
		40	20.96	68.78	0.02	20.53	6.26	37.85	600	6.05	29.23
		45	20.97	68.81	0.01	20.56	6.27	37.85	600	6.04	29.18
		50	20.98	68.85	0.01	20.60	6.28	37.85	600	6.03	29.13
		60	21.02	68.98	0.04	20.73	6.32	37.85	600	5.99	28.94
		70	21.03	69.00	0.01	20.75	6.32	37.85	600	5.99	28.92
		80	21.04	69.02	0.01	20.77	6.33	37.85	600	5.98	28.89
		90	21.06	69.10	0.02	20.85	6.35	37.85	600	5.96	28.78
		100	21.08	69.15	0.02	20.90	6.37	37.85	600	5.94	28.71
		120	21.12	69.30	0.05	21.05	6.42	37.85	600	5.90	28.50
		150	21.17	69.45	0.05	21.20	6.46	37.85	600	5.86	28.30
		180	21.18	69.50	0.02	21.25	6.48	37.85	600	5.84	28.24
		210	21.23	69.65	0.05	21.40	6.52	37.85	600	5.80	28.04
		240	21.26	69.75	0.03	21.50	6.55	37.85	600	5.78	27.91
		300	21.32	69.95	0.06	21.70	6.61	37.85	600	5.72	27.65
		360	21.37	70.10	0.05	21.85	6.66	37.85	600	5.68	27.46
		420	21.38	70.15	0.02	21.90	6.67	37.85	600	5.67	27.40
		480	21.44	70.35	0.06	22.10	6.74	37.85	600	5.62	27.15
		540	21.46	70.40	0.02	22.15	6.75	37.85	600	5.61	27.09
		600	21.52	70.60	0.06	22.35	6.81	37.85	600	5.56	26.85
		660	21.54	70.68	0.02	22.43	6.84	37.85	600	5.54	26.75
		720	21.58	70.80	0.04	22.55	6.87	37.85	600	5.51	26.61
		721	15.47	50.75	-6.11	2.50	0.76	-	-	-	-
		722	15.42	50.60	-0.05	2.35	0.72	-	-	-	-
		723	15.34	50.32	-0.09	2.07	0.63	-	-	-	-
		724	15.30	50.20	-0.04	1.95	0.59	-	-	-	-
		725	15.25	50.05	-0.05	1.80	0.55	-	-	-	-
		726	15.23	49.97	-0.02	1.72	0.52	-	-	-	-
		727	15.21	49.89	-0.02	1.64	0.50	-	-	-	-
		728	15.18	49.82	-0.02	1.57	0.48	-	-	-	-
		729	15.17	49.78	-0.01	1.53	0.47	-	-	-	-
		730	15.16	49.75	-0.01	1.50	0.46	-	-	-	-
		732	15.15	49.70	-0.02	1.45	0.44	-	-	-	-
		735	15.13	49.64	-0.02	1.39	0.42	-	-	-	-
		740	15.10	49.54	-0.03	1.29	0.39	-	-	-	-
		745	15.10	49.53	0.00	1.28	0.39	-	-	-	-
		750	15.09	49.51	-0.01	1.26	0.38	-	-	-	-
		755	15.08	49.49	-0.01	1.24	0.38	-	-	-	-
		760	15.07	49.46	-0.01	1.21	0.37	-	-	-	-
		765	15.07	49.45	0.00	1.20	0.37	-	-	-	-
		770	15.07	49.43	-0.01	1.18	0.36	-	-	-	-
		780	15.05	49.38	-0.02	1.13	0.34	-	-	-	-
		1140	15.08	49.48	0.03	1.23	0.37	-	-	-	-



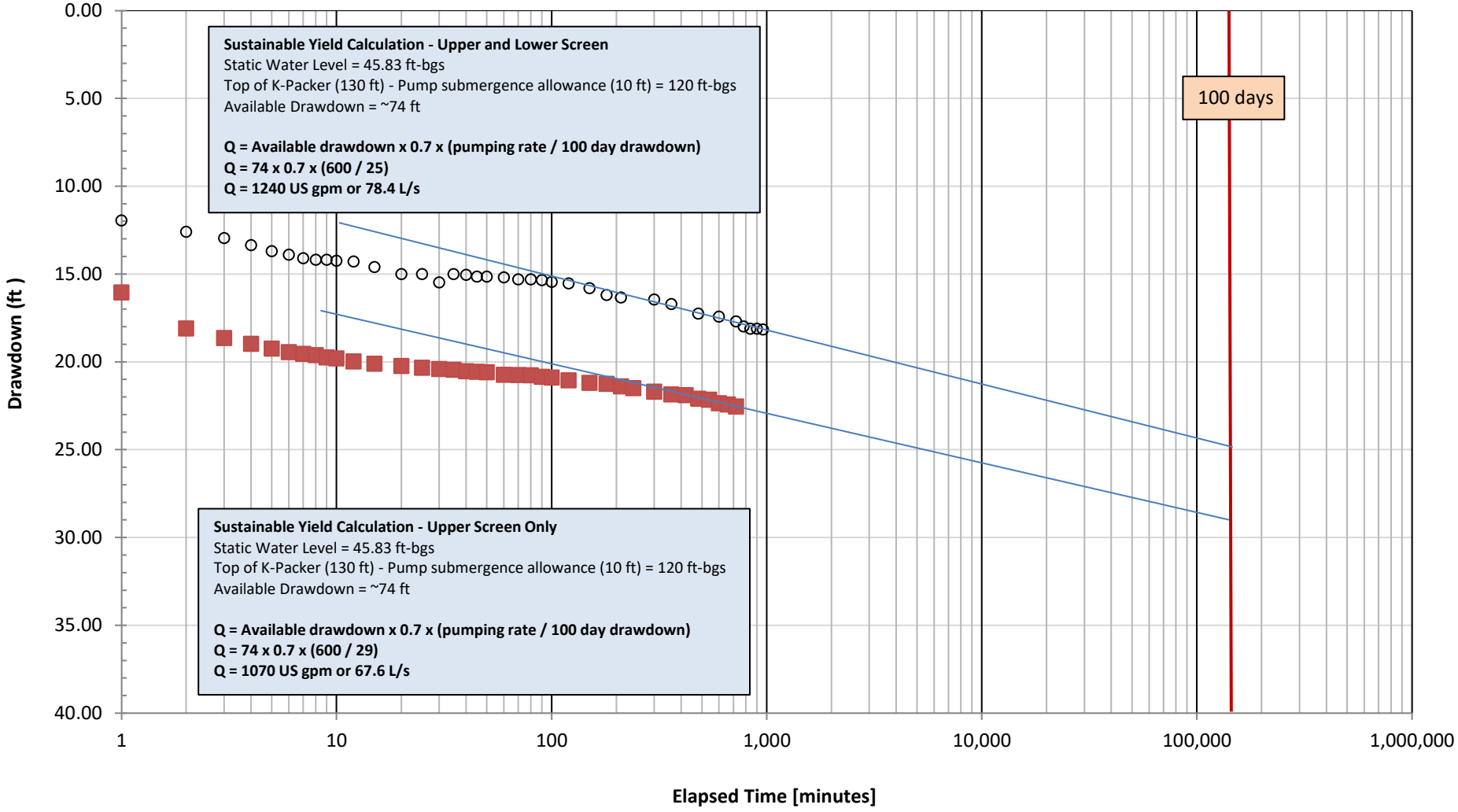
Barriere Replacement Well
(WPID 40541)

TITLE

Figure A2 - Constant Rate Hydrograph: 600 US gpm

western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

DRAWN	PW	DATE	April 28, 2021	JOB NO.	20-105-02VR
CHECKED	DG	SCALE	n/a	DWG. NO.	n/a
REVIEWED		FILE NO.		FIGURE NO.	



Barriere Replacement Well
(WPID 40541)

TITLE **Figure A3 - Semi Log Plot - Constant Rate Pumping Test, 600 US gpm**

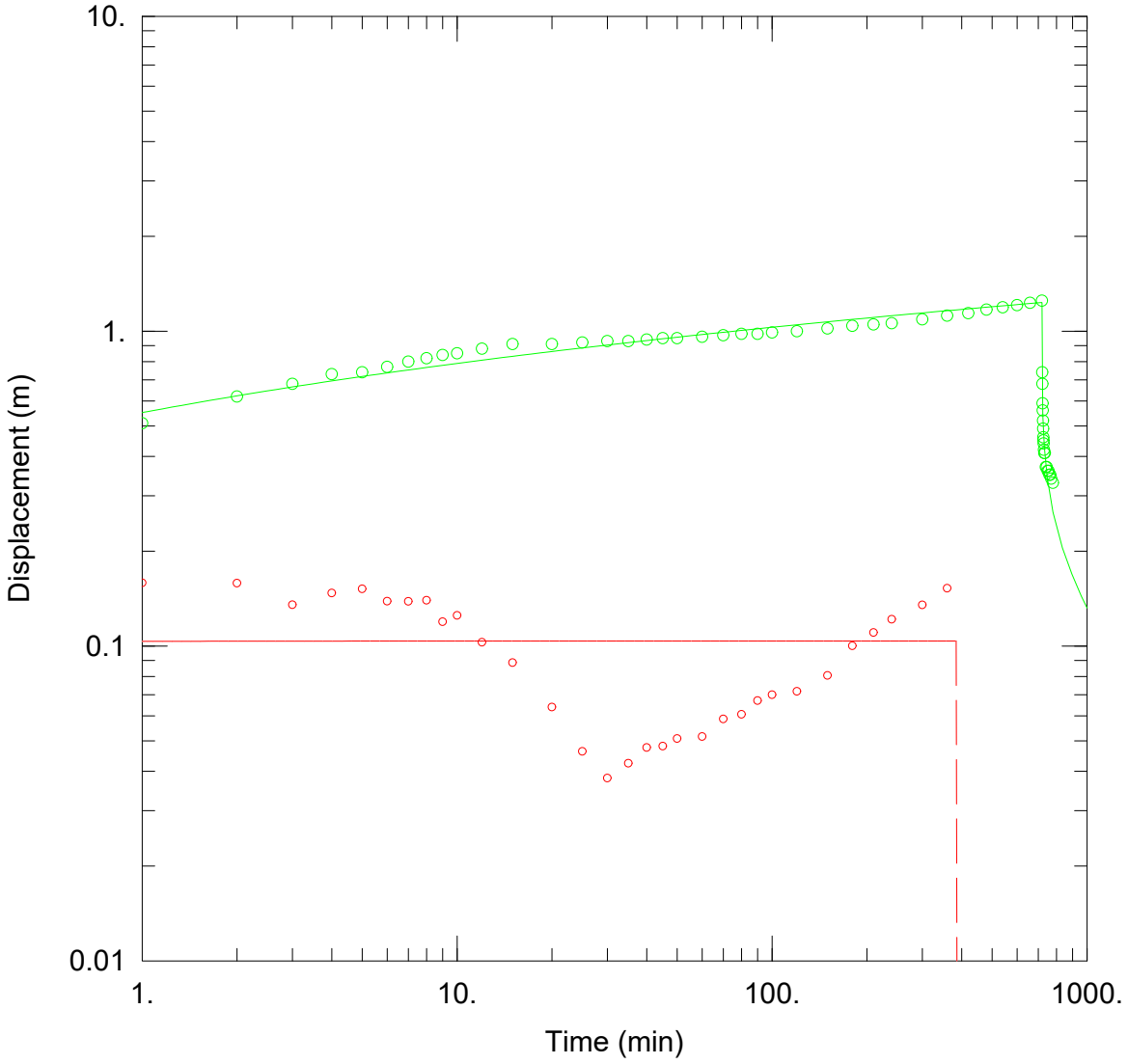
western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

DRAWN	PW	DATE	April 28, 2021	JOB NO.	20-105-02VR
CHECKED	DG	SCALE	n/a	DWG. NO.	n/a
REVIEWED		FILE NO.		FIGURE NO.	

Appendix D
AQTESOLV Transmissivity Analysis

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water ASSOCIATES LTD



WELL TEST ANALYSIS

Data Set: D:\Dropbox (WWA)\WWAL\Projects\2020\20-105-02VR Barriere Well DW3\Data Analysis\Aqtesolv\Barriere 12 hr test.aqt
Date: 06/09/21 Time: 11:48:14

PROJECT INFORMATION

Company: Western Water Associates Ltd.
Client: District of Barriere
Project: 20-105-02VR
Location: Barriere, BC
Test Well: WPID 40541
Test Date: April 28-29, 2021

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
WPID 40541	0	0

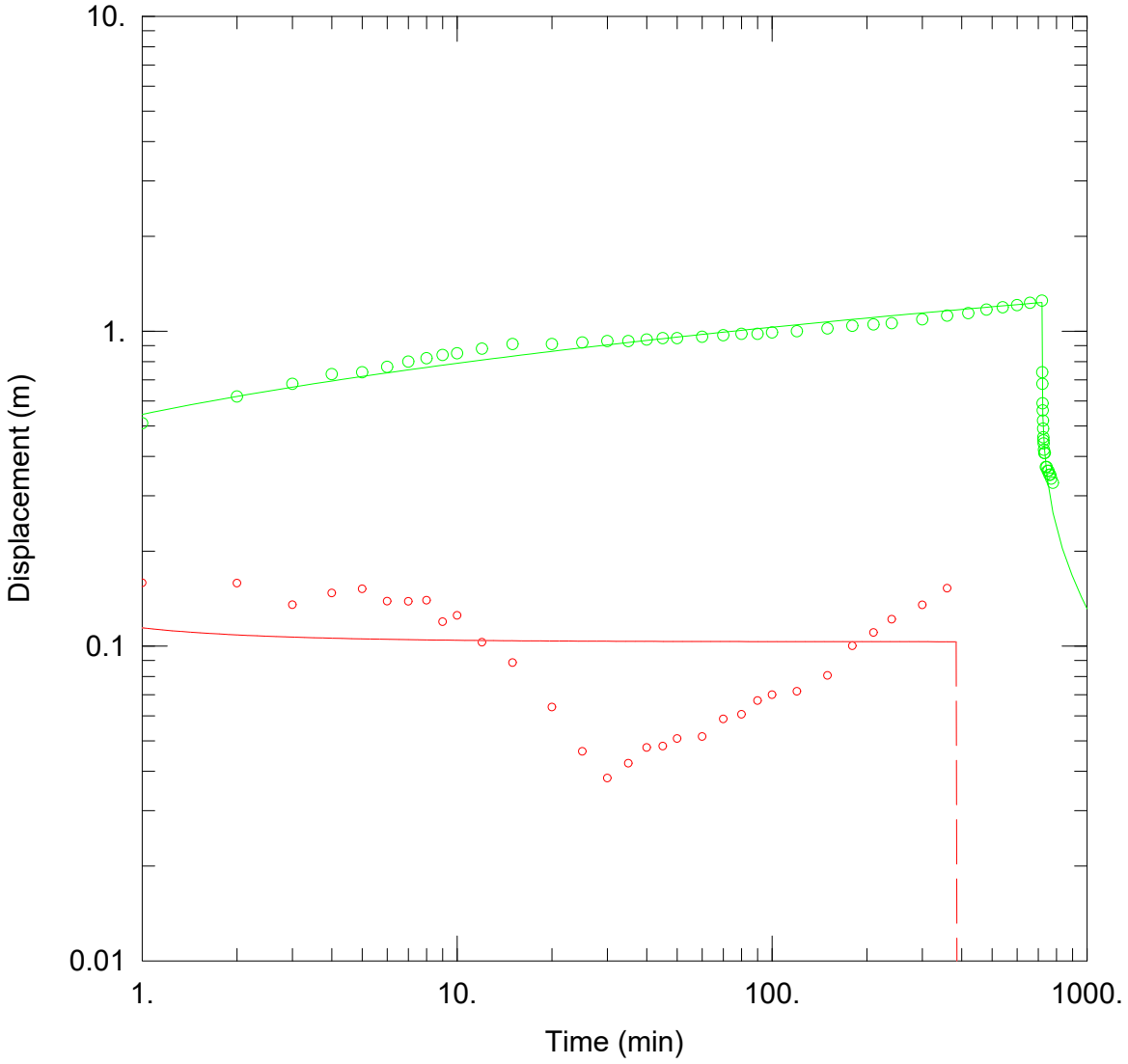
Observation Wells

Well Name	X (m)	Y (m)
○ DW2	5.2	0

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 2508.8 m^2/day
S = 0.0006687
Kz/Kr = 1.
b = 8.5 m



WELL TEST ANALYSIS

Data Set: D:\Dropbox (WWA)\WWAL\Projects\2020\20-105-02VR Barriere Well DW3\Data Analysis\Aqtesolv\Barriere 12 hr test.aqt
Date: 06/09/21 Time: 11:59:11

PROJECT INFORMATION

Company: Western Water Associates Ltd.
Client: District of Barriere
Project: 20-105-02VR
Location: Barriere, BC
Test Well: WPID 40541
Test Date: April 28-29, 2021

AQUIFER DATA

Saturated Thickness: 8.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
WPID 40541	0	0

Observation Wells

Well Name	X (m)	Y (m)
○ DW2	5.2	0

SOLUTION

Aquifer Model: Confined Solution Method: Dougherty-Babu

T = 2522.7 m^2/day S = 0.0006325
Kz/Kr = 1. Sw = 0.
r(w) = 0.13 m r(c) = 0.152 m

Appendix E
Water Quality Report

District of Barriere Replacement Well
Groundwater Development and Evaluation
WWAL Ref: 20-105-02VR

western water
ASSOCIATES LTD

CERTIFICATE OF ANALYSIS

REPORTED TO	Western Water Associates Ltd 106 - 5145 26th Street Vernon, BC V1T 8G4		
ATTENTION	Paul Williamson	**WORK ORDER**	21C0927
PO NUMBER		**RECEIVED / TEMP**	2021-03-05 14:00 / 6°C
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13
PROJECT INFO		**COC NUMBER**	B096892

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.

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

Authorized By:

DRAFT REPORT
DATA SUBJECT TO CHANGE

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
40541 (21C0927-01) | Matrix: Water | Sampled: 2021-03-04 16:30						
Anions						
Chloride	**3.98**	AO ≤ 250	0.10	mg/L	2021-03-06	
Fluoride	< 0.10	MAC = 1.5	0.10	mg/L	2021-03-06	
Nitrate (as N)	**0.362**	MAC = 10	0.010	mg/L	2021-03-06	
Nitrite (as N)	< 0.010	MAC = 1	0.010	mg/L	2021-03-06	
Sulfate	**15.6**	AO ≤ 500	1.0	mg/L	2021-03-06	
Calculated Parameters						
Hardness, Total (as CaCO3)	**154**	N/A	0.500	mg/L	N/A	
Langelier Index	< -5.0	N/A	-5.0		2021-03-12	
Nitrogen, Organic	**0.0780**	N/A	0.0500	mg/L	N/A	
Dissolved Metals						
Lithium, dissolved	**0.00178**	N/A	0.00010	mg/L	2021-03-10	
Aluminum, dissolved	< 0.0050	N/A	0.0050	mg/L	2021-03-10	
Antimony, dissolved	< 0.00020	N/A	0.00020	mg/L	2021-03-10	
Arsenic, dissolved	**0.00154**	N/A	0.00050	mg/L	2021-03-10	
Barium, dissolved	**0.0175**	N/A	0.0050	mg/L	2021-03-10	
Beryllium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Bismuth, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Boron, dissolved	< 0.0500	N/A	0.0500	mg/L	2021-03-10	
Cadmium, dissolved	< 0.000010	N/A	0.000010	mg/L	2021-03-10	
Calcium, dissolved	**34.3**	N/A	0.20	mg/L	2021-03-10	
Chromium, dissolved	**0.00099**	N/A	0.00050	mg/L	2021-03-10	
Cobalt, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Copper, dissolved	**0.00319**	N/A	0.00040	mg/L	2021-03-10	
Iron, dissolved	< 0.010	N/A	0.010	mg/L	2021-03-10	
Lead, dissolved	< 0.00020	N/A	0.00020	mg/L	2021-03-10	
Magnesium, dissolved	**16.6**	N/A	0.010	mg/L	2021-03-10	
Manganese, dissolved	**0.0560**	N/A	0.00020	mg/L	2021-03-10	
Mercury, dissolved	< 0.000010	N/A	0.000010	mg/L	2021-03-10	
Molybdenum, dissolved	**0.00147**	N/A	0.00010	mg/L	2021-03-10	
Nickel, dissolved	< 0.00040	N/A	0.00040	mg/L	2021-03-10	
Phosphorus, dissolved	< 0.050	N/A	0.050	mg/L	2021-03-10	
Potassium, dissolved	**1.68**	N/A	0.10	mg/L	2021-03-10	
Selenium, dissolved	< 0.00050	N/A	0.00050	mg/L	2021-03-10	
Silicon, dissolved	**8.7**	N/A	1.0	mg/L	2021-03-10	
Silver, dissolved	< 0.000050	N/A	0.000050	mg/L	2021-03-10	
Sodium, dissolved	**6.20**	N/A	0.10	mg/L	2021-03-10	
Strontium, dissolved	**0.229**	N/A	0.0010	mg/L	2021-03-10	
Sulfur, dissolved	**4.7**	N/A	3.0	mg/L	2021-03-10	
Tellurium, dissolved	< 0.00050	N/A	0.00050	mg/L	2021-03-10	
Thallium, dissolved	< 0.000020	N/A	0.000020	mg/L	2021-03-10	
Thorium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Tin, dissolved	< 0.00020	N/A	0.00020	mg/L	2021-03-10	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
40541 (21C0927-01) | Matrix: Water | Sampled: 2021-03-04 16:30, Continued						
Dissolved Metals, Continued						
Titanium, dissolved	< 0.0050	N/A	0.0050	mg/L	2021-03-10	
Tungsten, dissolved	< 0.0010	N/A	0.0010	mg/L	2021-03-10	
Uranium, dissolved	**0.00201**	N/A	0.000020	mg/L	2021-03-10	
Vanadium, dissolved	< 0.0010	N/A	0.0010	mg/L	2021-03-10	
Zinc, dissolved	**0.0123**	N/A	0.0040	mg/L	2021-03-10	
Zirconium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
General Parameters						
Alkalinity, Total (as CaCO3)	**162**	N/A	1.0	mg/L	2021-03-10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-03-10	
Alkalinity, Bicarbonate (as CaCO3)	**162**	N/A	1.0	mg/L	2021-03-10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-03-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	N/A	1.0	mg/L	2021-03-10	
Ammonia, Total (as N)	< 0.050	None Required	0.050	mg/L	2021-03-06	
Carbon, Total Organic	**0.83**	N/A	0.50	mg/L	2021-03-10	
Colour, True	< 5.0	AO ≤ 15	5.0	CU	2021-03-06	
Conductivity (EC)	**298**	N/A	2.0	µS/cm	2021-03-10	
Cyanide, Total	< 0.0020	MAC = 0.2	0.0020	mg/L	2021-03-09	
Nitrogen, Total Kjeldahl	**0.078**	N/A	0.050	mg/L	2021-03-10	
Solids, Total Dissolved	**179**	AO ≤ 500	15	mg/L	2021-03-11	
Sulfide, Total	< 0.020	AO ≤ 0.05	0.020	mg/L	2021-03-10	
Turbidity	**1.13**	OG < 1	0.10	NTU	2021-03-06	
UV Transmittance @ 254 nm - Unfiltered	**97.1**	N/A	0.10	% T	2021-03-06	
Microbiological Parameters						
Coliforms, Total	< 1	MAC = 0	1	CFU/100 mL	2021-03-05	
Background Colonies	< 1	N/A	1	CFU/100 mL	2021-03-05	
Coliforms, Fecal	< 1	N/A	1	CFU/100 mL	2021-03-05	
Heterotrophic Plate Count	< 5	N/A	5	CFU/mL	2021-03-05	
E. coli	< 1	MAC = 0	1	CFU/100 mL	2021-03-05	
Total Metals						
Aluminum, total	**0.0546**	OG < 0.1	0.0050	mg/L	2021-03-10	
Antimony, total	**0.00039**	MAC = 0.006	0.00020	mg/L	2021-03-10	
Arsenic, total	**0.00177**	MAC = 0.01	0.00050	mg/L	2021-03-10	
Barium, total	**0.0181**	MAC = 2	0.0050	mg/L	2021-03-10	
Beryllium, total	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Bismuth, total	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Boron, total	< 0.0500	MAC = 5	0.0500	mg/L	2021-03-10	
Cadmium, total	< 0.000010	MAC = 0.005	0.000010	mg/L	2021-03-10	
Calcium, total	**36.2**	None Required	0.20	mg/L	2021-03-10	
Chromium, total	**0.00102**	MAC = 0.05	0.00050	mg/L	2021-03-10	
Cobalt, total	**0.00011**	N/A	0.00010	mg/L	2021-03-10	
Copper, total	**0.00376**	MAC = 2	0.00040	mg/L	2021-03-10	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
40541 (21C0927-01) | Matrix: Water | Sampled: 2021-03-04 16:30, Continued						
Total Metals, Continued						
Iron, total	**0.092**	AO ≤ 0.3	0.010	mg/L	2021-03-10	
Lead, total	< 0.00020	MAC = 0.005	0.00020	mg/L	2021-03-10	
Lithium, total	**0.00187**	N/A	0.00010	mg/L	2021-03-10	
Magnesium, total	**16.9**	None Required	0.010	mg/L	2021-03-10	
Manganese, total	**0.0582**	MAC = 0.12	0.00020	mg/L	2021-03-10	
Mercury, total	< 0.000010	MAC = 0.001	0.000010	mg/L	2021-03-10	
Molybdenum, total	**0.00139**	N/A	0.00010	mg/L	2021-03-10	
Nickel, total	< 0.00040	N/A	0.00040	mg/L	2021-03-10	
Phosphorus, total	**0.062**	N/A	0.050	mg/L	2021-03-10	
Potassium, total	**1.80**	N/A	0.10	mg/L	2021-03-10	
Selenium, total	< 0.00050	MAC = 0.05	0.00050	mg/L	2021-03-10	
Silicon, total	**8.0**	N/A	1.0	mg/L	2021-03-10	
Silver, total	< 0.000050	None Required	0.000050	mg/L	2021-03-10	
Sodium, total	**6.18**	AO ≤ 200	0.10	mg/L	2021-03-10	
Strontium, total	**0.210**	7	0.0010	mg/L	2021-03-10	
Sulfur, total	**5.9**	N/A	3.0	mg/L	2021-03-10	
Tellurium, total	< 0.00050	N/A	0.00050	mg/L	2021-03-10	
Thallium, total	< 0.000020	N/A	0.000020	mg/L	2021-03-10	
Thorium, total	< 0.00010	N/A	0.00010	mg/L	2021-03-10	
Tin, total	< 0.00020	N/A	0.00020	mg/L	2021-03-10	
Titanium, total	**0.0057**	N/A	0.0050	mg/L	2021-03-10	
Tungsten, total	< 0.0010	N/A	0.0010	mg/L	2021-03-10	
Uranium, total	**0.00198**	MAC = 0.02	0.000020	mg/L	2021-03-10	
Vanadium, total	< 0.0010	N/A	0.0010	mg/L	2021-03-10	
Zinc, total	**0.0131**	AO ≤ 5	0.0040	mg/L	2021-03-10	
Zirconium, total	< 0.00010	N/A	0.00010	mg/L	2021-03-10	

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analysis Description	Method Ref.	Technique	Accredited	Location
Alkalinity in Water	SM 2320 B* (2017)	Titration with H2SO4	✓	Kelowna
Ammonia, Total in Water	SM 4500-NH3 G* (2017)	Automated Colorimetry (Phenate)	✓	Kelowna
Anions in Water	SM 4110 B (2017)	Ion Chromatography	✓	Kelowna
Carbon, Total Organic in Water	SM 5310 B (2017)	Combustion, Infrared CO2 Detection	✓	Kelowna
Coliforms, Fecal in Water	SM 9222 D (2017)	Membrane Filtration / m-FC Agar	✓	Kelowna
Coliforms, Total in Water	SM 9222* (2017)	Membrane Filtration / Chromocult Agar	✓	Kelowna
Colour, True in Water	SM 2120 C (2017)	Spectrophotometry (456 nm)	✓	Kelowna
Conductivity in Water	SM 2510 B (2017)	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* (2017)	Membrane Filtration / Chromocult Agar	✓	Kelowna
Hardness in Water	SM 2340 B (2017)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	✓	N/A
Heterotrophic Plate Count in Water	SM 9215 D (2017)	Membrane Filtration / Membrane Filtration	✓	Kelowna
Langelier Index in Water	SM 2330 B (2017)	Calculation		N/A
Mercury, dissolved in Water	EPA 245.7*	BrCl2 Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Mercury, total in Water	EPA 245.7*	BrCl2 Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Nitrogen, Total Kjeldahl in Water	SM 4500-Norg D* (2017)	Block Digestion and Flow Injection Analysis	✓	Kelowna
Solids, Total Dissolved in Water	SM 2540 C* (2017)	Gravimetry (Dried at 103-105C)	✓	Kelowna
Sulfide, Total in Water	SM 4500-S2 D* (2017)	Colorimetry (Methylene Blue)	✓	Edmonton
Total Metals in Water	EPA 200.2 / EPA 6020B	HNO3+HCl Hot Block Digestion / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	✓	Richmond
Transmittance at 254 nm - Unfiltered in Water	SM 5910 B* (2017)	Ultraviolet Absorption	✓	Kelowna
Turbidity in Water	SM 2130 B (2017)	Nephelometry	✓	Kelowna

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)
% T	Percent Transmittance
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
AO	Aesthetic Objective
CFU/100 mL	Colony Forming Units per 100 millilitres
CFU/mL	Colony Forming Units per millilitre
CU	Colour Units (referenced against a platinum cobalt standard)
MAC	Maximum Acceptable Concentration (health based)
mg/L	Milligrams per litre
NTU	Nephelometric Turbidity Units
OG	Operational Guideline (treated water)
µS/cm	Microsiemens per centimetre

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ASTM	ASTM International Test Methods
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 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. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:acrump@caro.ca

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

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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 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
Anions, Batch B1C0463										
Blank (B1C0463-BLK1)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Chloride	< 0.10	0.10	mg/L							
Fluoride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
Blank (B1C0463-BLK2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Chloride	< 0.10	0.10	mg/L							
Fluoride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
LCS (B1C0463-BS1)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Chloride	16.0	0.10	mg/L	16.0		100	90-110			
Fluoride	4.10	0.10	mg/L	4.00		102	88-108			
Nitrate (as N)	4.04	0.010	mg/L	4.00		101	90-110			
Nitrite (as N)	1.99	0.010	mg/L	2.00		100	85-115			
Sulfate	16.1	1.0	mg/L	16.0		101	90-110			
LCS (B1C0463-BS2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Chloride	15.9	0.10	mg/L	16.0		99	90-110			
Fluoride	4.13	0.10	mg/L	4.00		103	88-108			
Nitrate (as N)	4.03	0.010	mg/L	4.00		101	90-110			
Nitrite (as N)	1.95	0.010	mg/L	2.00		97	85-115			
Sulfate	16.1	1.0	mg/L	16.0		101	90-110			
Dissolved Metals, Batch B1C0870										
Blank (B1C0870-BLK1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Lithium, dissolved	< 0.00010	0.00010	mg/L							
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							

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1C0870, Continued										
Blank (B1C0870-BLK1), Continued				Prepared: 2021-03-09, Analyzed: 2021-03-09						
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							
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	< 0.0010	0.0010	mg/L							
Zinc, dissolved	< 0.0040	0.0040	mg/L							
Zirconium, dissolved	< 0.00010	0.00010	mg/L							
LCS (B1C0870-BS1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Lithium, dissolved	0.0180	0.00010	mg/L	0.0200		90	80-120			
Aluminum, dissolved	0.0175	0.0050	mg/L	0.0199		88	80-120			
Antimony, dissolved	0.0166	0.00020	mg/L	0.0200		83	80-120			
Arsenic, dissolved	0.0180	0.00050	mg/L	0.0200		90	80-120			
Barium, dissolved	0.0183	0.0050	mg/L	0.0198		93	80-120			
Beryllium, dissolved	0.0184	0.00010	mg/L	0.0198		93	80-120			
Bismuth, dissolved	0.0180	0.00010	mg/L	0.0200		90	80-120			
Boron, dissolved	< 0.0500	0.0500	mg/L	0.0200		110	80-120			
Cadmium, dissolved	0.0186	0.000010	mg/L	0.0199		93	80-120			
Calcium, dissolved	1.80	0.20	mg/L	2.02		89	80-120			
Chromium, dissolved	0.0191	0.00050	mg/L	0.0198		97	80-120			
Cobalt, dissolved	0.0186	0.00010	mg/L	0.0199		93	80-120			
Copper, dissolved	0.0188	0.00040	mg/L	0.0200		94	80-120			
Lead, dissolved	0.0192	0.00020	mg/L	0.0199		96	80-120			
Magnesium, dissolved	1.94	0.010	mg/L	2.02		96	80-120			
Manganese, dissolved	0.0171	0.00020	mg/L	0.0199		86	80-120			
Molybdenum, dissolved	0.0166	0.00010	mg/L	0.0200		83	80-120			
Nickel, dissolved	0.0190	0.00040	mg/L	0.0200		95	80-120			
Phosphorus, dissolved	2.09	0.050	mg/L	2.00		104	80-120			
Potassium, dissolved	1.84	0.10	mg/L	2.02		91	80-120			
Selenium, dissolved	0.0181	0.00050	mg/L	0.0200		91	80-120			
Silicon, dissolved	2.0	1.0	mg/L	2.00		101	80-120			
Silver, dissolved	0.0180	0.000050	mg/L	0.0200		90	80-120			

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1C0870, Continued										
LCS (B1C0870-BS1), Continued				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Sodium, dissolved	1.90	0.10	mg/L	2.02		94	80-120			
Strontium, dissolved	0.0182	0.0010	mg/L	0.0200		91	80-120			
Sulfur, dissolved	7.3	3.0	mg/L	5.00		146	80-120			
Tellurium, dissolved	0.0174	0.00050	mg/L	0.0200		87	80-120			
Thallium, dissolved	0.0171	0.000020	mg/L	0.0199		86	80-120			
Thorium, dissolved	0.0163	0.00010	mg/L	0.0200		82	80-120			
Tin, dissolved	0.0169	0.00020	mg/L	0.0200		84	80-120			
Titanium, dissolved	0.0214	0.0050	mg/L	0.0200		107	80-120			
Tungsten, dissolved	0.0174	0.0010	mg/L	0.0200		87	80-120			
Uranium, dissolved	0.0165	0.000020	mg/L	0.0200		83	80-120			
Vanadium, dissolved	0.0186	0.0010	mg/L	0.0200		93	80-120			
Zinc, dissolved	0.0190	0.0040	mg/L	0.0200		95	80-120			
Zirconium, dissolved	0.0171	0.00010	mg/L	0.0200		86	80-120			
Duplicate (B1C0870-DUP1)			**Source: 21C0927-01**	Prepared: 2021-03-10, Analyzed: 2021-03-10						
Lithium, dissolved	0.00177	0.00010	mg/L		0.00178			< 1	20	
Aluminum, dissolved	< 0.0050	0.0050	mg/L		< 0.0050				20	
Antimony, dissolved	< 0.00020	0.00020	mg/L		< 0.00020				20	
Arsenic, dissolved	0.00160	0.00050	mg/L		0.00154				20	
Barium, dissolved	0.0184	0.0050	mg/L		0.0175				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	< 0.0500	0.0500	mg/L		< 0.0500				20	
Cadmium, dissolved	0.000026	0.000010	mg/L		< 0.000010				20	
Calcium, dissolved	34.1	0.20	mg/L		34.3			< 1	20	
Chromium, dissolved	0.00091	0.00050	mg/L		0.00099				20	
Cobalt, dissolved	< 0.00010	0.00010	mg/L		< 0.00010				20	
Copper, dissolved	0.00341	0.00040	mg/L		0.00319			7	20	
Iron, dissolved	< 0.010	0.010	mg/L		< 0.010				20	
Lead, dissolved	< 0.00020	0.00020	mg/L		< 0.00020				20	
Magnesium, dissolved	16.2	0.010	mg/L		16.6			3	20	
Manganese, dissolved	0.0556	0.00020	mg/L		0.0560			< 1	20	
Molybdenum, dissolved	0.00157	0.00010	mg/L		0.00147			6	20	
Nickel, dissolved	< 0.00040	0.00040	mg/L		< 0.00040				20	
Phosphorus, dissolved	< 0.050	0.050	mg/L		< 0.050				20	
Potassium, dissolved	1.61	0.10	mg/L		1.68			5	20	
Selenium, dissolved	< 0.00050	0.00050	mg/L		< 0.00050				20	
Silicon, dissolved	8.1	1.0	mg/L		8.7			7	20	
Silver, dissolved	< 0.000050	0.000050	mg/L		< 0.000050				20	
Sodium, dissolved	6.04	0.10	mg/L		6.20			3	20	
Strontium, dissolved	0.225	0.0010	mg/L		0.229			2	20	
Sulfur, dissolved	< 3.0	3.0	mg/L		4.7				20	
Tellurium, dissolved	< 0.00050	0.00050	mg/L		< 0.00050				20	
Thallium, dissolved	< 0.000020	0.000020	mg/L		< 0.000020				20	
Thorium, dissolved	< 0.00010	0.00010	mg/L		< 0.00010				20	
Tin, dissolved	0.00038	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	0.00199	0.000020	mg/L		0.00201			< 1	20	
Vanadium, dissolved	< 0.0010	0.0010	mg/L		< 0.0010				20	
Zinc, dissolved	0.0122	0.0040	mg/L		0.0123				20	
Zirconium, dissolved	< 0.00010	0.00010	mg/L		< 0.00010				20	
Reference (B1C0870-SRM1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Lithium, dissolved	0.100	0.00010	mg/L	0.100		100	70-130			
Aluminum, dissolved	0.223	0.0050	mg/L	0.235		95	70-130			
Antimony, dissolved	0.0458	0.00020	mg/L	0.0431		106	70-130			

APPENDIX 2: QUALITY CONTROL RESULTS

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1C0870, Continued										
Reference (B1C0870-SRM1), Continued				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Arsenic, dissolved	0.450	0.00050	mg/L	0.423		106	70-130			
Barium, dissolved	3.15	0.0050	mg/L	3.30		96	70-130			
Beryllium, dissolved	0.211	0.00010	mg/L	0.209		101	70-130			
Boron, dissolved	1.53	0.0500	mg/L	1.65		93	70-130			
Cadmium, dissolved	0.220	0.000010	mg/L	0.221		100	70-130			
Calcium, dissolved	7.33	0.20	mg/L	7.72		95	70-130			
Chromium, dissolved	0.430	0.00050	mg/L	0.434		99	70-130			
Cobalt, dissolved	0.126	0.00010	mg/L	0.124		102	70-130			
Copper, dissolved	0.817	0.00040	mg/L	0.815		100	70-130			
Iron, dissolved	1.23	0.010	mg/L	1.27		97	70-130			
Lead, dissolved	0.112	0.00020	mg/L	0.110		102	70-130			
Magnesium, dissolved	6.95	0.010	mg/L	6.59		106	70-130			
Manganese, dissolved	0.314	0.00020	mg/L	0.342		92	70-130			
Molybdenum, dissolved	0.415	0.00010	mg/L	0.404		103	70-130			
Nickel, dissolved	0.847	0.00040	mg/L	0.835		101	70-130			
Phosphorus, dissolved	0.438	0.050	mg/L	0.499		88	70-130			
Potassium, dissolved	3.03	0.10	mg/L	2.88		105	70-130			
Selenium, dissolved	0.0343	0.00050	mg/L	0.0324		106	70-130			
Sodium, dissolved	19.0	0.10	mg/L	18.0		105	70-130			
Strontium, dissolved	0.906	0.0010	mg/L	0.935		97	70-130			
Thallium, dissolved	0.0359	0.000020	mg/L	0.0385		93	70-130			
Uranium, dissolved	0.230	0.000020	mg/L	0.258		89	70-130			
Vanadium, dissolved	0.849	0.0010	mg/L	0.873		97	70-130			
Zinc, dissolved	0.883	0.0040	mg/L	0.848		104	70-130			
Dissolved Metals, Batch B1C0951										
Blank (B1C0951-BLK1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, dissolved	< 0.000010	0.000010	mg/L							
Matrix Spike (B1C0951-MS1)		**Source: 21C0927-01**		Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, dissolved	0.000255	0.000010	mg/L	0.000250	< 0.000010	102	70-130			
Reference (B1C0951-SRM1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, dissolved	0.00597	0.000010	mg/L	0.00581		103	70-130			
General Parameters, Batch B1C0590										
Blank (B1C0590-BLK1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
UV Transmittance @ 254 nm - Unfiltered	< 0.10	0.10	% T							
LCS (B1C0590-BS1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
UV Transmittance @ 254 nm - Unfiltered	37.3	0.10	% T	36.2		103	95-105			
General Parameters, Batch B1C0594										
Blank (B1C0594-BLK1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	< 0.050	0.050	mg/L							
Blank (B1C0594-BLK2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	< 0.050	0.050	mg/L							
Blank (B1C0594-BLK3)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	< 0.050	0.050	mg/L							

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B1C0594, Continued										
LCS (B1C0594-BS1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	0.950	0.050	mg/L	1.00		95	90-115			
LCS (B1C0594-BS2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	0.960	0.050	mg/L	1.00		96	90-115			
LCS (B1C0594-BS3)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Ammonia, Total (as N)	0.972	0.050	mg/L	1.00		97	90-115			
General Parameters, Batch B1C0598										
Blank (B1C0598-BLK1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Colour, True	< 5.0	5.0	CU							
Blank (B1C0598-BLK2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Colour, True	< 5.0	5.0	CU							
LCS (B1C0598-BS1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Colour, True	20	5.0	CU	20.0		101	85-115			
LCS (B1C0598-BS2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Colour, True	20	5.0	CU	20.0		100	85-115			
General Parameters, Batch B1C0615										
Blank (B1C0615-BLK1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Turbidity	< 0.10	0.10	NTU							
Blank (B1C0615-BLK2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Turbidity	< 0.10	0.10	NTU							
LCS (B1C0615-BS1)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Turbidity	38.2	0.10	NTU	40.0		96	90-110			
LCS (B1C0615-BS2)				Prepared: 2021-03-06, Analyzed: 2021-03-06						
Turbidity	38.6	0.10	NTU	40.0		96	90-110			
General Parameters, Batch B1C0682										
Blank (B1C0682-BLK1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Carbon, Total Organic	< 0.50	0.50	mg/L							
Blank (B1C0682-BLK2)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Carbon, Total Organic	< 0.50	0.50	mg/L							
LCS (B1C0682-BS1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Carbon, Total Organic	10.1	0.50	mg/L	10.0		101	78-116			
LCS (B1C0682-BS2)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Carbon, Total Organic	9.83	0.50	mg/L	10.0		98	78-116			
General Parameters, Batch B1C0744										
Blank (B1C0744-BLK1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Cyanide, Total	< 0.0020	0.0020	mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B1C0744, Continued										
LCS (B1C0744-BS1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Cyanide, Total	0.0180	0.0020	mg/L	0.0200		90	82-120			
LCS Dup (B1C0744-BSD1)				Prepared: 2021-03-09, Analyzed: 2021-03-09						
Cyanide, Total	0.0184	0.0020	mg/L	0.0200		92	82-120	3	10	
General Parameters, Batch B1C0848										
Blank (B1C0848-BLK1)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Nitrogen, Total Kjeldahl	< 0.050	0.050	mg/L							
Blank (B1C0848-BLK2)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Nitrogen, Total Kjeldahl	< 0.050	0.050	mg/L							
LCS (B1C0848-BS1)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Nitrogen, Total Kjeldahl	1.09	0.050	mg/L	1.00		109	85-115			
LCS (B1C0848-BS2)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Nitrogen, Total Kjeldahl	1.09	0.050	mg/L	1.00		109	85-115			
General Parameters, Batch B1C0857										
Blank (B1C0857-BLK1)				Prepared: 2021-03-11, Analyzed: 2021-03-11						
Solids, Total Dissolved	< 15	15	mg/L							
Blank (B1C0857-BLK2)				Prepared: 2021-03-11, Analyzed: 2021-03-11						
Solids, Total Dissolved	< 15	15	mg/L							
LCS (B1C0857-BS1)				Prepared: 2021-03-11, Analyzed: 2021-03-11						
Solids, Total Dissolved	237	15	mg/L	240		99	85-115			
LCS (B1C0857-BS2)				Prepared: 2021-03-11, Analyzed: 2021-03-11						
Solids, Total Dissolved	225	15	mg/L	240		94	85-115			
General Parameters, Batch B1C0937										
Blank (B1C0937-BLK1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Sulfide, Total	< 0.020	0.020	mg/L							
LCS (B1C0937-BS1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Sulfide, Total	0.412	0.020	mg/L	0.400		103	80-120			
Matrix Spike (B1C0937-MS1)		**Source: 21C0927-01**		Prepared: 2021-03-10, Analyzed: 2021-03-10						
Sulfide, Total	0.474	0.020	mg/L	0.470	< 0.020	101	70-130			
General Parameters, Batch B1C0963										
Blank (B1C0963-BLK1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
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							
LCS (B1C0963-BS1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Alkalinity, Total (as CaCO3)	104	1.0	mg/L	100		104	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B1C0963, Continued										
LCS (B1C0963-BS2)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Conductivity (EC)	1410	2.0	µS/cm	1410		100	95-104			
Microbiological Parameters, Batch B1C0518										
Blank (B1C0518-BLK1)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Coliforms, Total	< 1	1	CFU/100 mL							
E. coli	< 1	1	CFU/100 mL							
Blank (B1C0518-BLK2)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Coliforms, Total	< 1	1	CFU/100 mL							
E. coli	< 1	1	CFU/100 mL							
Blank (B1C0518-BLK3)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Coliforms, Total	< 1	1	CFU/100 mL							
E. coli	< 1	1	CFU/100 mL							
Blank (B1C0518-BLK4)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Coliforms, Total	< 1	1	CFU/100 mL							
E. coli	< 1	1	CFU/100 mL							
Microbiological Parameters, Batch B1C0545										
Blank (B1C0545-BLK1)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Coliforms, Fecal	< 1	1	CFU/100 mL							
Microbiological Parameters, Batch B1C0583										
Blank (B1C0583-BLK1)				Prepared: 2021-03-05, Analyzed: 2021-03-05						
Heterotrophic Plate Count	< 5	5	CFU/mL							
Duplicate (B1C0583-DUP1)			**Source: 21C0927-01**	Prepared: 2021-03-05, Analyzed: 2021-03-05						
Heterotrophic Plate Count	< 5	5	CFU/mL		< 5				67	
Total Metals, Batch B1C0873										
Blank (B1C0873-BLK1)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
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							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C0873, Continued										
Blank (B1C0873-BLK1), Continued				Prepared: 2021-03-09, Analyzed: 2021-03-10						
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	< 0.0010	0.0010	mg/L							
Zinc, total	< 0.0040	0.0040	mg/L							
Zirconium, total	< 0.00010	0.00010	mg/L							
LCS (B1C0873-BS1)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Aluminum, total	0.0239	0.0050	mg/L	0.0199		120	80-120			
Antimony, total	0.0195	0.00020	mg/L	0.0200		98	80-120			
Arsenic, total	0.0212	0.00050	mg/L	0.0200		106	80-120			
Barium, total	0.0200	0.0050	mg/L	0.0198		101	80-120			
Beryllium, total	0.0218	0.00010	mg/L	0.0198		110	80-120			
Bismuth, total	0.0210	0.00010	mg/L	0.0200		105	80-120			
Boron, total	< 0.0500	0.0500	mg/L	0.0200		110	80-120			
Cadmium, total	0.0202	0.000010	mg/L	0.0199		101	80-120			
Calcium, total	2.16	0.20	mg/L	2.02		107	80-120			
Chromium, total	0.0215	0.00050	mg/L	0.0198		109	80-120			
Cobalt, total	0.0216	0.00010	mg/L	0.0199		109	80-120			
Copper, total	0.0215	0.00040	mg/L	0.0200		107	80-120			
Lead, total	0.0225	0.00020	mg/L	0.0199		113	80-120			
Lithium, total	0.0216	0.00010	mg/L	0.0200		108	80-120			
Magnesium, total	2.29	0.010	mg/L	2.02		113	80-120			
Manganese, total	0.0197	0.00020	mg/L	0.0199		99	80-120			
Molybdenum, total	0.0200	0.00010	mg/L	0.0200		100	80-120			
Nickel, total	0.0219	0.00040	mg/L	0.0200		110	80-120			
Phosphorus, total	2.18	0.050	mg/L	2.00		109	80-120			
Potassium, total	2.26	0.10	mg/L	2.02		112	80-120			
Selenium, total	0.0202	0.00050	mg/L	0.0200		101	80-120			
Silicon, total	2.3	1.0	mg/L	2.00		113	80-120			
Silver, total	0.0205	0.000050	mg/L	0.0200		102	80-120			
Sodium, total	2.22	0.10	mg/L	2.02		110	80-120			
Strontium, total	0.0189	0.0010	mg/L	0.0200		95	80-120			
Sulfur, total	5.2	3.0	mg/L	5.00		105	80-120			
Tellurium, total	0.0166	0.00050	mg/L	0.0200		83	80-120			
Thallium, total	0.0201	0.000020	mg/L	0.0199		101	80-120			
Thorium, total	0.0192	0.00010	mg/L	0.0200		96	80-120			
Tin, total	0.0201	0.00020	mg/L	0.0200		100	80-120			
Titanium, total	0.0259	0.0050	mg/L	0.0200		130	80-120			SPK1
Tungsten, total	0.0194	0.0010	mg/L	0.0200		97	80-120			
Uranium, total	0.0198	0.000020	mg/L	0.0200		99	80-120			
Vanadium, total	0.0220	0.0010	mg/L	0.0200		110	80-120			
Zinc, total	0.0224	0.0040	mg/L	0.0200		112	80-120			
Zirconium, total	0.0200	0.00010	mg/L	0.0200		100	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C0927
PROJECT	20-105-02VR	**REPORTED**	2021-03-12 16:13

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C0873, Continued										
Reference (B1C0873-SRM1)				Prepared: 2021-03-09, Analyzed: 2021-03-10						
Aluminum, total	0.298	0.0050	mg/L	0.299		100	70-130			
Antimony, total	0.0513	0.00020	mg/L	0.0517		99	70-130			
Arsenic, total	0.134	0.00050	mg/L	0.119		113	70-130			
Barium, total	0.791	0.0050	mg/L	0.801		99	70-130			
Beryllium, total	0.0537	0.00010	mg/L	0.0501		107	70-130			
Boron, total	3.73	0.0500	mg/L	4.11		91	70-130			
Cadmium, total	0.0510	0.000010	mg/L	0.0503		101	70-130			
Calcium, total	10.0	0.20	mg/L	10.7		94	70-130			
Chromium, total	0.268	0.00050	mg/L	0.250		107	70-130			
Cobalt, total	0.0417	0.00010	mg/L	0.0384		109	70-130			
Copper, total	0.520	0.00040	mg/L	0.487		107	70-130			
Iron, total	0.521	0.010	mg/L	0.504		103	70-130			
Lead, total	0.308	0.00020	mg/L	0.278		111	70-130			
Lithium, total	0.433	0.00010	mg/L	0.398		109	70-130			
Magnesium, total	4.23	0.010	mg/L	3.59		118	70-130			
Manganese, total	0.107	0.00020	mg/L	0.111		97	70-130			
Molybdenum, total	0.202	0.00010	mg/L	0.196		103	70-130			
Nickel, total	0.267	0.00040	mg/L	0.248		107	70-130			
Phosphorus, total	0.309	0.050	mg/L	0.213		145	70-130			SRM
Potassium, total	6.82	0.10	mg/L	5.89		116	70-130			
Selenium, total	0.131	0.00050	mg/L	0.120		109	70-130			
Sodium, total	9.76	0.10	mg/L	8.71		112	70-130			
Strontium, total	0.376	0.0010	mg/L	0.393		96	70-130			
Thallium, total	0.0800	0.000020	mg/L	0.0787		102	70-130			
Uranium, total	0.0341	0.000020	mg/L	0.0344		99	70-130			
Vanadium, total	0.417	0.0010	mg/L	0.391		107	70-130			
Zinc, total	2.81	0.0040	mg/L	2.50		113	70-130			
Total Metals, Batch B1C0952										
Blank (B1C0952-BLK1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, total	< 0.000010	0.000010	mg/L							
Matrix Spike (B1C0952-MS1)			**Source: 21C0927-01**	Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, total	0.000245	0.000010	mg/L	0.000250	< 0.000010	98	70-130			
Reference (B1C0952-SRM1)				Prepared: 2021-03-10, Analyzed: 2021-03-10						
Mercury, total	0.00585	0.000010	mg/L	0.00581		101	70-130			

QC Qualifiers:

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

SRM Recovery of one or more analytes on Standard Reference Material (SRM) analysis are outside of control limits.

CERTIFICATE OF ANALYSIS

REPORTED TO	Western Water Associates Ltd 106 - 5145 26th Street Vernon, BC V1T 8G4		
ATTENTION	Paul Williamson	**WORK ORDER**	21C3584
PO NUMBER		**RECEIVED / TEMP**	2021-03-26 14:00 / 16°C
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59
PROJECT INFO		**COC NUMBER**	B11619

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.

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

Authorized By:

Alana Crump
Team Lead, Client Service

TEST RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
40541 (21C3584-01) | Matrix: Water | Sampled: 2021-03-25 12:00						
Calculated Parameters						
Hardness, Total (as CaCO3)	**181**	N/A	0.500	mg/L	N/A	
Dissolved Metals						
Lithium, dissolved	**0.00209**	N/A	0.00010	mg/L	2021-04-04	
Aluminum, dissolved	**0.0050**	N/A	0.0050	mg/L	2021-04-04	
Antimony, dissolved	< 0.00020	N/A	0.00020	mg/L	2021-04-04	
Arsenic, dissolved	**0.00154**	N/A	0.00050	mg/L	2021-04-04	
Barium, dissolved	**0.0211**	N/A	0.0050	mg/L	2021-04-04	
Beryllium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-04-04	
Bismuth, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-04-04	
Boron, dissolved	< 0.0500	N/A	0.0500	mg/L	2021-04-04	
Cadmium, dissolved	**0.000015**	N/A	0.000010	mg/L	2021-04-04	
Calcium, dissolved	**41.3**	N/A	0.20	mg/L	2021-04-04	
Chromium, dissolved	**0.00076**	N/A	0.00050	mg/L	2021-04-04	
Cobalt, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-04-04	
Copper, dissolved	**0.00317**	N/A	0.00040	mg/L	2021-04-06	
Iron, dissolved	**0.014**	N/A	0.010	mg/L	2021-04-04	
Lead, dissolved	**0.00031**	N/A	0.00020	mg/L	2021-04-04	
Magnesium, dissolved	**18.9**	N/A	0.010	mg/L	2021-04-04	
Manganese, dissolved	**0.0519**	N/A	0.00020	mg/L	2021-04-06	
Mercury, dissolved	< 0.000010	N/A	0.000010	mg/L	2021-03-31	
Molybdenum, dissolved	**0.00167**	N/A	0.00010	mg/L	2021-04-04	
Nickel, dissolved	< 0.00040	N/A	0.00040	mg/L	2021-04-06	
Phosphorus, dissolved	**0.051**	N/A	0.050	mg/L	2021-04-04	
Potassium, dissolved	**1.99**	N/A	0.10	mg/L	2021-04-04	
Selenium, dissolved	< 0.00050	N/A	0.00050	mg/L	2021-04-04	
Silicon, dissolved	**8.1**	N/A	1.0	mg/L	2021-04-04	
Silver, dissolved	< 0.000050	N/A	0.000050	mg/L	2021-04-04	
Sodium, dissolved	**6.73**	N/A	0.10	mg/L	2021-04-04	
Strontium, dissolved	**0.276**	N/A	0.0010	mg/L	2021-04-04	
Sulfur, dissolved	**6.5**	N/A	3.0	mg/L	2021-04-04	
Tellurium, dissolved	< 0.00050	N/A	0.00050	mg/L	2021-04-04	
Thallium, dissolved	< 0.000020	N/A	0.000020	mg/L	2021-04-04	
Thorium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-04-04	
Tin, dissolved	< 0.00020	N/A	0.00020	mg/L	2021-04-06	
Titanium, dissolved	< 0.0050	N/A	0.0050	mg/L	2021-04-04	
Tungsten, dissolved	< 0.0010	N/A	0.0010	mg/L	2021-04-04	
Uranium, dissolved	**0.00230**	N/A	0.000020	mg/L	2021-04-04	
Vanadium, dissolved	< 0.0010	N/A	0.0010	mg/L	2021-04-04	
Zinc, dissolved	**0.0158**	N/A	0.0040	mg/L	2021-04-06	
Zirconium, dissolved	< 0.00010	N/A	0.00010	mg/L	2021-04-04	
Total Metals						
Aluminum, total	**0.126**	OG < 0.1	0.0050	mg/L	2021-04-01	

TEST RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	Guideline	RL	Units	Analyzed	Qualifier
40541 (21C3584-01) | Matrix: Water | Sampled: 2021-03-25 12:00, Continued						
Total Metals, Continued						
Antimony, total	< 0.00020	MAC = 0.006	0.00020	mg/L	2021-04-01	
Arsenic, total	**0.00219**	MAC = 0.01	0.00050	mg/L	2021-04-01	
Barium, total	**0.0210**	MAC = 2	0.0050	mg/L	2021-04-01	
Beryllium, total	< 0.00010	N/A	0.00010	mg/L	2021-04-01	
Bismuth, total	< 0.00010	N/A	0.00010	mg/L	2021-04-01	
Boron, total	< 0.0500	MAC = 5	0.0500	mg/L	2021-04-01	
Cadmium, total	**0.000014**	MAC = 0.005	0.000010	mg/L	2021-04-01	
Calcium, total	**41.8**	None Required	0.20	mg/L	2021-04-01	
Chromium, total	**0.00102**	MAC = 0.05	0.00050	mg/L	2021-04-01	
Cobalt, total	**0.00018**	N/A	0.00010	mg/L	2021-04-01	
Copper, total	**0.00340**	MAC = 2	0.00040	mg/L	2021-04-01	
Iron, total	**0.228**	AO ≤ 0.3	0.010	mg/L	2021-04-01	
Lead, total	**0.00029**	MAC = 0.005	0.00020	mg/L	2021-04-01	
Lithium, total	**0.00262**	N/A	0.00010	mg/L	2021-04-01	
Magnesium, total	**19.3**	None Required	0.010	mg/L	2021-04-01	
Manganese, total	**0.0615**	MAC = 0.12	0.00020	mg/L	2021-04-01	
Mercury, total	< 0.000010	MAC = 0.001	0.000010	mg/L	2021-03-31	
Molybdenum, total	**0.00162**	N/A	0.00010	mg/L	2021-04-01	
Nickel, total	**0.00063**	N/A	0.00040	mg/L	2021-04-01	
Phosphorus, total	**0.053**	N/A	0.050	mg/L	2021-04-01	
Potassium, total	**1.79**	N/A	0.10	mg/L	2021-04-01	
Selenium, total	< 0.00050	MAC = 0.05	0.00050	mg/L	2021-04-01	
Silicon, total	**8.2**	N/A	1.0	mg/L	2021-04-01	
Silver, total	< 0.000050	None Required	0.000050	mg/L	2021-04-01	
Sodium, total	**6.87**	AO ≤ 200	0.10	mg/L	2021-04-01	
Strontium, total	**0.277**	7	0.0010	mg/L	2021-04-01	
Sulfur, total	**7.4**	N/A	3.0	mg/L	2021-04-01	
Tellurium, total	< 0.00050	N/A	0.00050	mg/L	2021-04-01	
Thallium, total	< 0.000020	N/A	0.000020	mg/L	2021-04-01	
Thorium, total	< 0.00010	N/A	0.00010	mg/L	2021-04-01	
Tin, total	< 0.00020	N/A	0.00020	mg/L	2021-04-01	
Titanium, total	**0.0125**	N/A	0.0050	mg/L	2021-04-01	
Tungsten, total	< 0.0010	N/A	0.0010	mg/L	2021-04-01	
Uranium, total	**0.00229**	MAC = 0.02	0.000020	mg/L	2021-04-01	
Vanadium, total	**0.0035**	N/A	0.0010	mg/L	2021-04-01	CST2
Zinc, total	**0.0127**	AO ≤ 5	0.0040	mg/L	2021-04-01	
Zirconium, total	< 0.00010	N/A	0.00010	mg/L	2021-04-01	

Sample Qualifiers:

CST2 The reporting limit has been raised.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analysis Description	Method Ref.	Technique	Accredited	Location
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 (2017)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	✓	N/A
Mercury, dissolved in Water	EPA 245.7*	BrCl2 Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Mercury, total in Water	EPA 245.7*	BrCl2 Oxidation / Cold Vapor Atomic Fluorescence Spectrometry (CVAFS)	✓	Richmond
Total Metals in Water	EPA 200.2 / EPA 6020B	HNO3+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
AO	Aesthetic Objective
MAC	Maximum Acceptable Concentration (health based)
mg/L	Milligrams per litre
OG	Operational Guideline (treated water)
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

Guidelines Referenced in this Report:

Guidelines for Canadian Drinking Water Quality (Health Canada, June 2019)

Note: In some cases, the values displayed on the report represent the lowest guideline and are to be verified by the end user

General Comments:

The results in this report apply to the 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. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:acrump@caro.ca

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	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

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 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
Dissolved Metals, Batch B1C3107										
Blank (B1C3107-BLK1)				Prepared: 2021-03-31, Analyzed: 2021-03-31						
Mercury, dissolved	< 0.000010	0.000010	mg/L							
Reference (B1C3107-SRM1)				Prepared: 2021-03-31, Analyzed: 2021-03-31						
Mercury, dissolved	0.00567	0.000010	mg/L	0.00581		98	70-130			
Dissolved Metals, Batch B1D0237										
Blank (B1D0237-BLK1)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Lithium, dissolved	< 0.00010	0.00010	mg/L							
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							
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							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1D0237, Continued										
Blank (B1D0237-BLK1), Continued				Prepared: 2021-04-04, Analyzed: 2021-04-04						
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	< 0.0010	0.0010	mg/L							
Zinc, dissolved	< 0.0040	0.0040	mg/L							
Zirconium, dissolved	< 0.00010	0.00010	mg/L							
Blank (B1D0237-BLK2)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Nickel, dissolved	< 0.00040	0.00040	mg/L							
Blank (B1D0237-BLK3)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Nickel, dissolved	< 0.00040	0.00040	mg/L							
LCS (B1D0237-BS1)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Lithium, dissolved	0.0203	0.00010	mg/L	0.0200		101	80-120			
Aluminum, dissolved	0.0239	0.0050	mg/L	0.0199		120	80-120			
Antimony, dissolved	0.0220	0.00020	mg/L	0.0200		110	80-120			
Arsenic, dissolved	0.0192	0.00050	mg/L	0.0200		96	80-120			
Barium, dissolved	0.0204	0.0050	mg/L	0.0198		103	80-120			
Beryllium, dissolved	0.0202	0.00010	mg/L	0.0198		102	80-120			
Bismuth, dissolved	0.0216	0.00010	mg/L	0.0200		108	80-120			
Boron, dissolved	< 0.0500	0.0500	mg/L	0.0200		118	80-120			
Cadmium, dissolved	0.0207	0.000010	mg/L	0.0199		104	80-120			
Calcium, dissolved	2.04	0.20	mg/L	2.02		101	80-120			
Chromium, dissolved	0.0199	0.00050	mg/L	0.0198		100	80-120			
Cobalt, dissolved	0.0201	0.00010	mg/L	0.0199		101	80-120			
Copper, dissolved	0.0209	0.00040	mg/L	0.0200		105	80-120			
Iron, dissolved	1.96	0.010	mg/L	2.02		97	80-120			
Lead, dissolved	0.0211	0.00020	mg/L	0.0199		106	80-120			
Magnesium, dissolved	2.05	0.010	mg/L	2.02		101	80-120			
Manganese, dissolved	0.0207	0.00020	mg/L	0.0199		104	80-120			
Molybdenum, dissolved	0.0198	0.00010	mg/L	0.0200		99	80-120			
Nickel, dissolved	0.0199	0.00040	mg/L	0.0200		99	80-120			
Phosphorus, dissolved	1.98	0.050	mg/L	2.00		99	80-120			
Potassium, dissolved	1.95	0.10	mg/L	2.02		96	80-120			
Selenium, dissolved	0.0210	0.00050	mg/L	0.0200		105	80-120			
Silicon, dissolved	1.7	1.0	mg/L	2.00		87	80-120			
Silver, dissolved	0.0208	0.000050	mg/L	0.0200		104	80-120			
Sodium, dissolved	2.04	0.10	mg/L	2.02		101	80-120			
Strontium, dissolved	0.0199	0.0010	mg/L	0.0200		100	80-120			
Sulfur, dissolved	3.9	3.0	mg/L	5.00		78	80-120			SPK1
Tellurium, dissolved	0.0215	0.00050	mg/L	0.0200		108	80-120			
Thallium, dissolved	0.0217	0.000020	mg/L	0.0199		109	80-120			
Thorium, dissolved	0.0205	0.00010	mg/L	0.0200		102	80-120			
Tin, dissolved	0.0231	0.00020	mg/L	0.0200		116	80-120			
Titanium, dissolved	0.0204	0.0050	mg/L	0.0200		102	80-120			
Tungsten, dissolved	0.0203	0.0010	mg/L	0.0200		101	80-120			
Uranium, dissolved	0.0206	0.000020	mg/L	0.0200		103	80-120			
Vanadium, dissolved	0.0192	0.0010	mg/L	0.0200		96	80-120			
Zinc, dissolved	0.0240	0.0040	mg/L	0.0200		120	80-120			
Zirconium, dissolved	0.0206	0.00010	mg/L	0.0200		103	80-120			
LCS (B1D0237-BS2)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Lithium, dissolved	0.0213	0.00010	mg/L	0.0200		106	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1D0237, Continued										
LCS (B1D0237-BS2), Continued				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Aluminum, dissolved	0.0214	0.0050	mg/L	0.0199		108	80-120			
Antimony, dissolved	0.0204	0.00020	mg/L	0.0200		102	80-120			
Arsenic, dissolved	0.0188	0.00050	mg/L	0.0200		94	80-120			
Barium, dissolved	0.0192	0.0050	mg/L	0.0198		97	80-120			
Beryllium, dissolved	0.0205	0.00010	mg/L	0.0198		104	80-120			
Bismuth, dissolved	0.0214	0.00010	mg/L	0.0200		107	80-120			
Boron, dissolved	< 0.0500	0.0500	mg/L	0.0200		104	80-120			
Cadmium, dissolved	0.0195	0.000010	mg/L	0.0199		98	80-120			
Calcium, dissolved	1.99	0.20	mg/L	2.02		99	80-120			
Chromium, dissolved	0.0200	0.00050	mg/L	0.0198		101	80-120			
Cobalt, dissolved	0.0198	0.00010	mg/L	0.0199		100	80-120			
Copper, dissolved	0.0208	0.00040	mg/L	0.0200		104	80-120			
Iron, dissolved	1.94	0.010	mg/L	2.02		96	80-120			
Lead, dissolved	0.0206	0.00020	mg/L	0.0199		103	80-120			
Magnesium, dissolved	2.15	0.010	mg/L	2.02		107	80-120			
Manganese, dissolved	0.0201	0.00020	mg/L	0.0199		101	80-120			
Molybdenum, dissolved	0.0191	0.00010	mg/L	0.0200		95	80-120			
Nickel, dissolved	0.0197	0.00040	mg/L	0.0200		99	80-120			
Phosphorus, dissolved	2.01	0.050	mg/L	2.00		100	80-120			
Potassium, dissolved	2.01	0.10	mg/L	2.02		100	80-120			
Selenium, dissolved	0.0200	0.00050	mg/L	0.0200		100	80-120			
Silicon, dissolved	2.2	1.0	mg/L	2.00		112	80-120			
Silver, dissolved	0.0203	0.000050	mg/L	0.0200		101	80-120			
Sodium, dissolved	2.18	0.10	mg/L	2.02		108	80-120			
Strontium, dissolved	0.0188	0.0010	mg/L	0.0200		94	80-120			
Sulfur, dissolved	4.4	3.0	mg/L	5.00		88	80-120			
Tellurium, dissolved	0.0196	0.00050	mg/L	0.0200		98	80-120			
Thallium, dissolved	0.0210	0.000020	mg/L	0.0199		105	80-120			
Thorium, dissolved	0.0196	0.00010	mg/L	0.0200		98	80-120			
Tin, dissolved	0.0213	0.00020	mg/L	0.0200		107	80-120			
Titanium, dissolved	0.0202	0.0050	mg/L	0.0200		101	80-120			
Tungsten, dissolved	0.0202	0.0010	mg/L	0.0200		101	80-120			
Uranium, dissolved	0.0198	0.000020	mg/L	0.0200		99	80-120			
Vanadium, dissolved	0.0193	0.0010	mg/L	0.0200		96	80-120			
Zinc, dissolved	0.0224	0.0040	mg/L	0.0200		112	80-120			
Zirconium, dissolved	0.0194	0.00010	mg/L	0.0200		97	80-120			
Reference (B1D0237-SRM1)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Lithium, dissolved	0.106	0.00010	mg/L	0.100		106	70-130			
Aluminum, dissolved	0.231	0.0050	mg/L	0.235		98	70-130			
Antimony, dissolved	0.0480	0.00020	mg/L	0.0431		111	70-130			
Arsenic, dissolved	0.444	0.00050	mg/L	0.423		105	70-130			
Barium, dissolved	3.42	0.0050	mg/L	3.30		104	70-130			
Beryllium, dissolved	0.218	0.00010	mg/L	0.209		104	70-130			
Boron, dissolved	1.75	0.0500	mg/L	1.65		106	70-130			
Cadmium, dissolved	0.233	0.000010	mg/L	0.221		105	70-130			
Calcium, dissolved	7.53	0.20	mg/L	7.72		98	70-130			
Chromium, dissolved	0.447	0.00050	mg/L	0.434		103	70-130			
Cobalt, dissolved	0.128	0.00010	mg/L	0.124		104	70-130			
Copper, dissolved	0.860	0.00040	mg/L	0.815		105	70-130			
Iron, dissolved	1.28	0.010	mg/L	1.27		101	70-130			
Lead, dissolved	0.118	0.00020	mg/L	0.110		107	70-130			
Magnesium, dissolved	6.91	0.010	mg/L	6.59		105	70-130			
Manganese, dissolved	0.343	0.00020	mg/L	0.342		100	70-130			
Molybdenum, dissolved	0.419	0.00010	mg/L	0.404		104	70-130			
Nickel, dissolved	0.864	0.00040	mg/L	0.835		103	70-130			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B1D0237, Continued										
Reference (B1D0237-SRM1), Continued				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Phosphorus, dissolved	0.517	0.050	mg/L	0.499		104	70-130			
Potassium, dissolved	2.96	0.10	mg/L	2.88		103	70-130			
Selenium, dissolved	0.0334	0.00050	mg/L	0.0324		103	70-130			
Sodium, dissolved	18.5	0.10	mg/L	18.0		103	70-130			
Strontium, dissolved	0.948	0.0010	mg/L	0.935		101	70-130			
Thallium, dissolved	0.0419	0.000020	mg/L	0.0385		109	70-130			
Uranium, dissolved	0.265	0.000020	mg/L	0.258		103	70-130			
Vanadium, dissolved	0.858	0.0010	mg/L	0.873		98	70-130			
Zinc, dissolved	0.884	0.0040	mg/L	0.848		104	70-130			
Reference (B1D0237-SRM2)				Prepared: 2021-04-04, Analyzed: 2021-04-04						
Lithium, dissolved	0.105	0.00010	mg/L	0.100		105	70-130			
Aluminum, dissolved	0.229	0.0050	mg/L	0.235		97	70-130			
Antimony, dissolved	0.0447	0.00020	mg/L	0.0431		104	70-130			
Arsenic, dissolved	0.438	0.00050	mg/L	0.423		104	70-130			
Barium, dissolved	3.19	0.0050	mg/L	3.30		97	70-130			
Beryllium, dissolved	0.214	0.00010	mg/L	0.209		102	70-130			
Boron, dissolved	1.69	0.0500	mg/L	1.65		103	70-130			
Cadmium, dissolved	0.218	0.000010	mg/L	0.221		99	70-130			
Calcium, dissolved	7.54	0.20	mg/L	7.72		98	70-130			
Chromium, dissolved	0.441	0.00050	mg/L	0.434		102	70-130			
Cobalt, dissolved	0.126	0.00010	mg/L	0.124		102	70-130			
Copper, dissolved	0.821	0.00040	mg/L	0.815		101	70-130			
Iron, dissolved	1.27	0.010	mg/L	1.27		100	70-130			
Lead, dissolved	0.114	0.00020	mg/L	0.110		103	70-130			
Magnesium, dissolved	7.00	0.010	mg/L	6.59		106	70-130			
Manganese, dissolved	0.333	0.00020	mg/L	0.342		97	70-130			
Molybdenum, dissolved	0.409	0.00010	mg/L	0.404		101	70-130			
Nickel, dissolved	0.832	0.00040	mg/L	0.835		100	70-130			
Phosphorus, dissolved	0.589	0.050	mg/L	0.499		118	70-130			
Potassium, dissolved	2.97	0.10	mg/L	2.88		103	70-130			
Selenium, dissolved	0.0338	0.00050	mg/L	0.0324		104	70-130			
Sodium, dissolved	18.5	0.10	mg/L	18.0		103	70-130			
Strontium, dissolved	0.888	0.0010	mg/L	0.935		95	70-130			
Thallium, dissolved	0.0404	0.000020	mg/L	0.0385		105	70-130			
Uranium, dissolved	0.243	0.000020	mg/L	0.258		94	70-130			
Vanadium, dissolved	0.855	0.0010	mg/L	0.873		98	70-130			
Zinc, dissolved	0.886	0.0040	mg/L	0.848		104	70-130			
Total Metals, Batch B1C3081										
Blank (B1C3081-BLK1)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
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							
Lead, total	< 0.00020	0.00020	mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C3081, Continued										
Blank (B1C3081-BLK1), Continued				Prepared: 2021-03-31, Analyzed: 2021-04-01						
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	< 0.0010	0.0010	mg/L							
Zinc, total	< 0.0040	0.0040	mg/L							
Zirconium, total	< 0.00010	0.00010	mg/L							
Blank (B1C3081-BLK2)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
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							
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							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C3081, Continued										
Blank (B1C3081-BLK2), Continued				Prepared: 2021-03-31, Analyzed: 2021-04-01						
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	0.0013	0.0010	mg/L							BLK
Zinc, total	< 0.0040	0.0040	mg/L							
Zirconium, total	< 0.00010	0.00010	mg/L							
Blank (B1C3081-BLK3)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	< 0.0050	0.0050	mg/L							
LCS (B1C3081-BS1)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	0.0252	0.0050	mg/L	0.0199		127	80-120			SPK1
Antimony, total	0.0210	0.00020	mg/L	0.0200		105	80-120			
Arsenic, total	0.0195	0.00050	mg/L	0.0200		97	80-120			
Barium, total	0.0199	0.0050	mg/L	0.0198		100	80-120			
Beryllium, total	0.0210	0.00010	mg/L	0.0198		106	80-120			
Bismuth, total	0.0210	0.00010	mg/L	0.0200		105	80-120			
Boron, total	< 0.0500	0.0500	mg/L	0.0200		122	80-120			SPK1
Cadmium, total	0.0201	0.000010	mg/L	0.0199		101	80-120			
Calcium, total	1.92	0.20	mg/L	2.02		95	80-120			
Chromium, total	0.0203	0.00050	mg/L	0.0198		102	80-120			
Cobalt, total	0.0206	0.00010	mg/L	0.0199		103	80-120			
Copper, total	0.0213	0.00040	mg/L	0.0200		106	80-120			
Iron, total	1.96	0.010	mg/L	2.02		97	80-120			
Lead, total	0.0201	0.00020	mg/L	0.0199		101	80-120			
Lithium, total	0.0220	0.00010	mg/L	0.0200		110	80-120			
Magnesium, total	2.11	0.010	mg/L	2.02		105	80-120			
Manganese, total	0.0206	0.00020	mg/L	0.0199		104	80-120			
Molybdenum, total	0.0192	0.00010	mg/L	0.0200		96	80-120			
Nickel, total	0.0204	0.00040	mg/L	0.0200		102	80-120			
Phosphorus, total	2.15	0.050	mg/L	2.00		108	80-120			
Potassium, total	2.04	0.10	mg/L	2.02		101	80-120			
Selenium, total	0.0200	0.00050	mg/L	0.0200		100	80-120			
Silicon, total	2.1	1.0	mg/L	2.00		107	80-120			
Silver, total	0.0203	0.000050	mg/L	0.0200		101	80-120			
Sodium, total	2.15	0.10	mg/L	2.02		106	80-120			
Strontium, total	0.0198	0.0010	mg/L	0.0200		99	80-120			
Sulfur, total	4.9	3.0	mg/L	5.00		98	80-120			
Tellurium, total	0.0201	0.00050	mg/L	0.0200		101	80-120			
Thallium, total	0.0206	0.000020	mg/L	0.0199		104	80-120			
Thorium, total	0.0196	0.00010	mg/L	0.0200		98	80-120			
Tin, total	0.0214	0.00020	mg/L	0.0200		107	80-120			
Titanium, total	0.0210	0.0050	mg/L	0.0200		105	80-120			
Tungsten, total	0.0204	0.0010	mg/L	0.0200		102	80-120			
Uranium, total	0.0197	0.000020	mg/L	0.0200		99	80-120			
Vanadium, total	0.0210	0.0010	mg/L	0.0200		105	80-120			
Zinc, total	0.0202	0.0040	mg/L	0.0200		101	80-120			
Zirconium, total	0.0200	0.00010	mg/L	0.0200		100	80-120			
LCS (B1C3081-BS2)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	0.0206	0.0050	mg/L	0.0199		103	80-120			
Antimony, total	0.0208	0.00020	mg/L	0.0200		104	80-120			
Arsenic, total	0.0192	0.00050	mg/L	0.0200		96	80-120			
Barium, total	0.0197	0.0050	mg/L	0.0198		100	80-120			
Beryllium, total	0.0204	0.00010	mg/L	0.0198		103	80-120			
Bismuth, total	0.0208	0.00010	mg/L	0.0200		104	80-120			
Boron, total	< 0.0500	0.0500	mg/L	0.0200		117	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C3081, Continued										
LCS (B1C3081-BS2), Continued				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Cadmium, total	0.0196	0.000010	mg/L	0.0199		98	80-120			
Calcium, total	1.93	0.20	mg/L	2.02		95	80-120			
Chromium, total	0.0203	0.00050	mg/L	0.0198		103	80-120			
Cobalt, total	0.0201	0.00010	mg/L	0.0199		101	80-120			
Copper, total	0.0206	0.00040	mg/L	0.0200		103	80-120			
Iron, total	1.91	0.010	mg/L	2.02		95	80-120			
Lead, total	0.0200	0.00020	mg/L	0.0199		101	80-120			
Lithium, total	0.0218	0.00010	mg/L	0.0200		109	80-120			
Magnesium, total	2.08	0.010	mg/L	2.02		103	80-120			
Manganese, total	0.0203	0.00020	mg/L	0.0199		102	80-120			
Molybdenum, total	0.0192	0.00010	mg/L	0.0200		96	80-120			
Nickel, total	0.0198	0.00040	mg/L	0.0200		99	80-120			
Phosphorus, total	2.01	0.050	mg/L	2.00		100	80-120			
Potassium, total	2.01	0.10	mg/L	2.02		100	80-120			
Selenium, total	0.0191	0.00050	mg/L	0.0200		96	80-120			
Silicon, total	2.1	1.0	mg/L	2.00		105	80-120			
Silver, total	0.0201	0.000050	mg/L	0.0200		101	80-120			
Sodium, total	2.10	0.10	mg/L	2.02		104	80-120			
Strontium, total	0.0196	0.0010	mg/L	0.0200		98	80-120			
Sulfur, total	4.9	3.0	mg/L	5.00		97	80-120			
Tellurium, total	0.0194	0.00050	mg/L	0.0200		97	80-120			
Thallium, total	0.0205	0.000020	mg/L	0.0199		103	80-120			
Thorium, total	0.0199	0.00010	mg/L	0.0200		99	80-120			
Tin, total	0.0212	0.00020	mg/L	0.0200		106	80-120			
Titanium, total	0.0200	0.0050	mg/L	0.0200		100	80-120			
Tungsten, total	0.0200	0.0010	mg/L	0.0200		100	80-120			
Uranium, total	0.0199	0.000020	mg/L	0.0200		99	80-120			
Vanadium, total	0.0218	0.0010	mg/L	0.0200		109	80-120			
Zinc, total	0.0206	0.0040	mg/L	0.0200		103	80-120			
Zirconium, total	0.0196	0.00010	mg/L	0.0200		98	80-120			
Duplicate (B1C3081-DUP2)		**Source: 21C3584-01**		Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	0.147	0.0050	mg/L		0.126			16	20	
Antimony, total	< 0.00020	0.00020	mg/L		< 0.00020				20	
Arsenic, total	0.00221	0.00050	mg/L		0.00219				20	
Barium, total	0.0203	0.0050	mg/L		0.0210				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	< 0.0500	0.0500	mg/L		< 0.0500				20	
Cadmium, total	< 0.000010	0.000010	mg/L		0.000014				20	
Calcium, total	41.3	0.20	mg/L		41.8			1	20	
Chromium, total	0.00103	0.00050	mg/L		0.00102				20	
Cobalt, total	0.00018	0.00010	mg/L		0.00018				20	
Copper, total	0.00332	0.00040	mg/L		0.00340			2	20	
Iron, total	0.242	0.010	mg/L		0.228			6	20	
Lead, total	0.00030	0.00020	mg/L		0.00029				20	
Lithium, total	0.00257	0.00010	mg/L		0.00262			2	20	
Magnesium, total	19.1	0.010	mg/L		19.3			< 1	20	
Manganese, total	0.0613	0.00020	mg/L		0.0615			< 1	20	
Molybdenum, total	0.00150	0.00010	mg/L		0.00162			8	20	
Nickel, total	0.00067	0.00040	mg/L		0.00063				20	
Phosphorus, total	0.050	0.050	mg/L		0.053				20	
Potassium, total	1.78	0.10	mg/L		1.79			< 1	20	
Selenium, total	< 0.00050	0.00050	mg/L		< 0.00050				20	
Silicon, total	8.1	1.0	mg/L		8.2			< 1	20	
Silver, total	< 0.000050	0.000050	mg/L		< 0.000050				20	

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C3081, Continued										
Duplicate (B1C3081-DUP2), Continued		**Source: 21C3584-01**		Prepared: 2021-03-31, Analyzed: 2021-04-01						
Sodium, total	6.77	0.10	mg/L		6.87			2	20	
Strontium, total	0.273	0.0010	mg/L		0.277			2	20	
Sulfur, total	8.0	3.0	mg/L		7.4				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	0.0144	0.0050	mg/L		0.0125				20	
Tungsten, total	< 0.0010	0.0010	mg/L		< 0.0010				20	
Uranium, total	0.00225	0.000020	mg/L		0.00229			2	20	
Vanadium, total	0.0035	0.0010	mg/L		0.0035				20	
Zinc, total	0.0121	0.0040	mg/L		0.0127				20	
Zirconium, total	< 0.00010	0.00010	mg/L		< 0.00010				20	
Reference (B1C3081-SRM1)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	0.288	0.0050	mg/L	0.299		96	70-130			
Antimony, total	0.0500	0.00020	mg/L	0.0517		97	70-130			
Arsenic, total	0.122	0.00050	mg/L	0.119		102	70-130			
Barium, total	0.764	0.0050	mg/L	0.801		95	70-130			
Beryllium, total	0.0517	0.00010	mg/L	0.0501		103	70-130			
Boron, total	3.94	0.0500	mg/L	4.11		96	70-130			
Cadmium, total	0.0493	0.000010	mg/L	0.0503		98	70-130			
Calcium, total	10.2	0.20	mg/L	10.7		95	70-130			
Chromium, total	0.255	0.00050	mg/L	0.250		102	70-130			
Cobalt, total	0.0400	0.00010	mg/L	0.0384		104	70-130			
Copper, total	0.507	0.00040	mg/L	0.487		104	70-130			
Iron, total	0.499	0.010	mg/L	0.504		99	70-130			
Lead, total	0.284	0.00020	mg/L	0.278		102	70-130			
Lithium, total	0.425	0.00010	mg/L	0.398		107	70-130			
Magnesium, total	3.69	0.010	mg/L	3.59		103	70-130			
Manganese, total	0.107	0.00020	mg/L	0.111		96	70-130			
Molybdenum, total	0.191	0.00010	mg/L	0.196		98	70-130			
Nickel, total	0.251	0.00040	mg/L	0.248		101	70-130			
Phosphorus, total	0.221	0.050	mg/L	0.213		104	70-130			
Potassium, total	6.08	0.10	mg/L	5.89		103	70-130			
Selenium, total	0.118	0.00050	mg/L	0.120		99	70-130			
Sodium, total	8.85	0.10	mg/L	8.71		102	70-130			
Strontium, total	0.389	0.0010	mg/L	0.393		99	70-130			
Thallium, total	0.0812	0.000020	mg/L	0.0787		103	70-130			
Uranium, total	0.0344	0.000020	mg/L	0.0344		100	70-130			
Vanadium, total	0.396	0.0010	mg/L	0.391		101	70-130			
Zinc, total	2.37	0.0040	mg/L	2.50		95	70-130			
Reference (B1C3081-SRM2)				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Aluminum, total	0.289	0.0050	mg/L	0.299		97	70-130			
Antimony, total	0.0507	0.00020	mg/L	0.0517		98	70-130			
Arsenic, total	0.123	0.00050	mg/L	0.119		104	70-130			
Barium, total	0.784	0.0050	mg/L	0.801		98	70-130			
Beryllium, total	0.0519	0.00010	mg/L	0.0501		104	70-130			
Boron, total	3.95	0.0500	mg/L	4.11		96	70-130			
Cadmium, total	0.0501	0.000010	mg/L	0.0503		100	70-130			
Calcium, total	10.2	0.20	mg/L	10.7		95	70-130			
Chromium, total	0.259	0.00050	mg/L	0.250		104	70-130			
Cobalt, total	0.0403	0.00010	mg/L	0.0384		105	70-130			
Copper, total	0.513	0.00040	mg/L	0.487		105	70-130			
Iron, total	0.507	0.010	mg/L	0.504		101	70-130			
Lead, total	0.285	0.00020	mg/L	0.278		102	70-130			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Western Water Associates Ltd	**WORK ORDER**	21C3584
PROJECT	20-105-02VR	**REPORTED**	2021-04-06 16:59

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B1C3081, Continued										
Reference (B1C3081-SRM2), Continued				Prepared: 2021-03-31, Analyzed: 2021-04-01						
Lithium, total	0.438	0.00010	mg/L	0.398		110	70-130			
Magnesium, total	3.75	0.010	mg/L	3.59		105	70-130			
Manganese, total	0.110	0.00020	mg/L	0.111		99	70-130			
Molybdenum, total	0.196	0.00010	mg/L	0.196		100	70-130			
Nickel, total	0.254	0.00040	mg/L	0.248		102	70-130			
Phosphorus, total	0.264	0.050	mg/L	0.213		124	70-130			
Potassium, total	6.11	0.10	mg/L	5.89		104	70-130			
Selenium, total	0.119	0.00050	mg/L	0.120		99	70-130			
Sodium, total	8.95	0.10	mg/L	8.71		103	70-130			
Strontium, total	0.399	0.0010	mg/L	0.393		101	70-130			
Thallium, total	0.0821	0.000020	mg/L	0.0787		104	70-130			
Uranium, total	0.0349	0.000020	mg/L	0.0344		101	70-130			
Vanadium, total	0.396	0.0010	mg/L	0.391		101	70-130			
Zinc, total	2.42	0.0040	mg/L	2.50		97	70-130			
Total Metals, Batch B1C3108										
Blank (B1C3108-BLK1)				Prepared: 2021-03-31, Analyzed: 2021-03-31						
Mercury, total	< 0.000010	0.000010	mg/L							
Reference (B1C3108-SRM1)				Prepared: 2021-03-31, Analyzed: 2021-03-31						
Mercury, total	0.00573	0.000010	mg/L	0.00581		99	70-130			

QC Qualifiers:

BLK	Analyte concentration in the Method Blank is above the Reporting Limit (RL).
SPK1	The recovery of this analyte was outside of established control limits. The data was accepted based on performance of other batch QC.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **KS2101257**	Page	: 1 of 5
Client	: **Western Water Associates Ltd**	Laboratory	: Kamloops - Environmental
Contact	: Paul Williamson	Account Manager	: Amanda Lampreau
Address	: #106-5145 26th Street Vernon BC Canada V1T 8G4	Address	: 1445 McGill Road, Unit 2B Kamloops BC Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: 20-105-03VR	Date Samples Received	: 29-Apr-2021 10:25
PO	: ----	Date Analysis Commenced	: 29-Apr-2021
C-O-C number	: ----	Issue Date	: 07-May-2021 16:38
Sampler	: ----		
Site	: Barriere		
Quote number	: KS20-WESW100-007		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Erick Magalhaes	Analyst	Inorganics, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
CU	colour units (1 CU = 1 mg/L Pt)
mg/L	milligrams per litre
MPN/100mL	most probable number per 100 mL
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: 40541	----	----	----	----
					Client sampling date / time: 28-Apr-2021 23:30	----	----	----	----
					KS2101257-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	183	----	----	----	----
colour, true	----	E329	5.0	CU	<5.0	----	----	----	----
conductivity	----	E100	2.0	µS/cm	368	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L	200	----	----	----	----
pH	----	E108	0.10	pH units	8.26	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	218	----	----	----	----
turbidity	----	E121	0.10	NTU	0.26	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.60	mg/L	200	----	----	----	----
Anions and Nutrients									
chloride	16887-00-6	E235.Cl	0.50	mg/L	4.06	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.092	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.400	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	20.5	----	----	----	----
Bacteriological Tests									
coliforms, total	----	E010	1	MPN/100mL	<1	----	----	----	----
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0100	mg/L	0.0262	----	----	----	----
antimony, total	7440-36-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00149	----	----	----	----
barium, total	7440-39-3	E420	0.0200	mg/L	0.0203	----	----	----	----
boron, total	7440-42-8	E420	0.100	mg/L	<0.100	----	----	----	----
cadmium, total	7440-43-9	E420	0.000200	mg/L	<0.000200	----	----	----	----
calcium, total	7440-70-2	E420	0.100	mg/L	48.0	----	----	----	----
chromium, total	7440-47-3	E420	0.00200	mg/L	<0.00200	----	----	----	----
copper, total	7440-50-8	E420	0.00100	mg/L	0.00331	----	----	----	----
iron, total	7439-89-6	E420	0.030	mg/L	0.044	----	----	----	----
lead, total	7439-92-1	E420	0.000500	mg/L	<0.000500	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	19.6	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: 40541	----	----	----	----
					Client sampling date / time: 28-Apr-2021 23:30	----	----	----	----
					KS2101257-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
manganese, total	7439-96-5	E420	0.00200	mg/L	0.0318	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	----	----	----	----
potassium, total	7440-09-7	E420	0.100	mg/L	1.70	----	----	----	----
selenium, total	7782-49-2	E420	0.00100	mg/L	<0.00100	----	----	----	----
sodium, total	17341-25-2	E420	2.00	mg/L	6.83	----	----	----	----
uranium, total	7440-61-1	E420	0.000100	mg/L	0.00238	----	----	----	----
zinc, total	7440-66-6	E420	0.0500	mg/L	<0.0500	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0011	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00162	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0210	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000078	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	47.5	----	----	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	<0.000010	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	0.00068	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00303	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000173	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0021	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	19.9	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0322	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00157	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.92	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: **40541**	----	----	----	----
					Client sampling date / time: 28-Apr-2021 23:30	----	----	----	----
					KS2101257-001	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	0.00086	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000268	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	8.35	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	7.34	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.292	----	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	7.38	----	----	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	<0.00020	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	<0.00010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	<0.00010	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00218	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00099	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0103	----	----	----	----
zirconium, dissolved	7440-67-7	E421	0.00020	mg/L	<0.00020	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **KS2101257**	Page	: 1 of 9
Client	: **Western Water Associates Ltd**	Laboratory	: Kamloops - Environmental
Contact	: Paul Williamson	Account Manager	: Amanda Lampreau
Address	: #106-5145 26th Street Vernon BC Canada V1T 8G4	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: 20-105-03VR	Date Samples Received	: 29-Apr-2021 10:25
PO	: ----	Issue Date	: 07-May-2021 16:38
C-O-C number	: ----		
Sampler	: ----		
Site	: Barriere		
Quote number	: KS20-WESW100-007		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
40541	E235.Cl	28-Apr-2021	----	----	----		01-May-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
40541	E235.F	28-Apr-2021	----	----	----		01-May-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
40541	E235.NO3-L	28-Apr-2021	----	----	----		01-May-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
40541	E235.NO2-L	28-Apr-2021	----	----	----		01-May-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
40541	E235.SO4	28-Apr-2021	----	----	----		01-May-2021	28 days	3 days	✓
Bacteriological Tests : Total Coliforms and E. coli (Enzyme Substrate)										
Sterile HDPE (Sodium thiosulphate)										
40541	E010	28-Apr-2021	----	----	----		29-Apr-2021	1 days	15 hrs	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
40541	E509	28-Apr-2021	04-May-2021	----	6 days	✓	04-May-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE - dissolved (lab preserved) 40541	E421	28-Apr-2021	03-May-2021	----	5 days	✓	03-May-2021	180 days	1 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE 40541	E290	28-Apr-2021	----	----	----		01-May-2021	14 days	3 days	✓
Physical Tests : Colour (True) by Spectrometer										
HDPE 40541	E329	28-Apr-2021	----	----	----		01-May-2021	3 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE 40541	E100	28-Apr-2021	----	----	----		01-May-2021	28 days	3 days	✓
Physical Tests : pH by Meter										
HDPE 40541	E108	28-Apr-2021	----	----	----		01-May-2021	0.25 hrs	63 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE 40541	E162	28-Apr-2021	----	----	----		04-May-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE 40541	E121	28-Apr-2021	----	----	----		01-May-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) 40541	E508	28-Apr-2021	----	----	----		04-May-2021	28 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE - total (lab preserved) 40541	E420	28-Apr-2021	----	----	----		05-May-2021	180 days	7 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	189043	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	189036	1	14	7.1	5.0	✓
Colour (True) by Spectrometer	E329	189044	1	2	50.0	5.0	✓
Conductivity in Water	E100	189042	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	190752	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190159	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	189038	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	189034	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	189037	1	14	7.1	5.0	✓
pH by Meter	E108	189041	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	189035	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	191085	1	20	5.0	5.0	✓
Total Coliforms and E. coli (Enzyme Substrate)	E010	188388	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	190643	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190353	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189090	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	189043	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	189036	1	14	7.1	5.0	✓
Colour (True) by Spectrometer	E329	189044	1	2	50.0	5.0	✓
Conductivity in Water	E100	189042	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	190752	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190159	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	189038	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	189034	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	189037	1	14	7.1	5.0	✓
pH by Meter	E108	189041	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	189035	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	191085	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	190643	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190353	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189090	1	20	5.0	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	189043	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	189036	1	14	7.1	5.0	✓
Colour (True) by Spectrometer	E329	189044	1	2	50.0	5.0	✓
Conductivity in Water	E100	189042	1	11	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Method Blanks (MB) - Continued							
Dissolved Mercury in Water by CVAAS	E509	190752	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190159	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	189038	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	189034	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	189037	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	189035	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	191085	1	20	5.0	5.0	✓
Total Coliforms and E. coli (Enzyme Substrate)	E010	188388	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	190643	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190353	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189090	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Chloride in Water by IC	E235.Cl	189036	1	14	7.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	190752	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190159	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	189038	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	189034	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	189037	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	189035	1	14	7.1	5.0	✓
Total Mercury in Water by CVAAS	E508	190643	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190353	1	17	5.8	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Coliforms and E. coli (Enzyme Substrate)	E010 Kamloops - Environmental	Water	APHA 9223 (mod)	The enzyme substrate test simultaneously detects Total Coliforms and E. coli in a 100 mL sample after incubation at 35.0 ±0.5°C for either 18 or 24 hours (dependent on reagent used).
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Colour (True) by Spectrometer	E329 Vancouver - Environmental	Water	APHA 2120 C (mod)	Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment.
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO_3.
Dissolved Mercury Water Filtration	EP509	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
	Vancouver - Environmental			

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **KS2101257**	Page	: 1 of 14
Client	: Western Water Associates Ltd	Laboratory	: Kamloops - Environmental
Contact	: Paul Williamson	Account Manager	: Amanda Lampreau
Address	: #106-5145 26th Street Vernon BC Canada V1T 8G4	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: 20-105-03VR	Date Samples Received	: 29-Apr-2021 10:25
PO	: ----	Date Analysis Commenced	: 29-Apr-2021
C-O-C number	: ----	Issue Date	: 07-May-2021 16:38
Sampler	: ----		
Site	: Barriere		
Quote number	: KS20-WESW100-007		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Erick Magalhaes	Analyst	Inorganics, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 189041)											
KS2101248-001	Anonymous	pH	----	E108	0.10	pH units	8.25	8.26	0.121%	4%	----
Physical Tests (QC Lot: 189042)											
KS2101248-001	Anonymous	conductivity	----	E100	2.0	µS/cm	383	386	0.780%	10%	----
Physical Tests (QC Lot: 189043)											
KS2101248-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	184	184	0.272%	20%	----
Physical Tests (QC Lot: 189044)											
KS2101248-001	Anonymous	colour, true	----	E329	5.0	CU	<5.0	<5.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 189090)											
KS2101248-001	Anonymous	turbidity	----	E121	0.10	NTU	55.8	57.3	2.65%	15%	----
Physical Tests (QC Lot: 191085)											
KS2101248-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	244	245	0.409%	20%	----
Anions and Nutrients (QC Lot: 189034)											
VA21A8088-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0758	0.0767	1.22%	20%	----
Anions and Nutrients (QC Lot: 189035)											
VA21A8088-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	4.10	4.09	0.278%	20%	----
Anions and Nutrients (QC Lot: 189036)											
VA21A8088-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 189037)											
VA21A8088-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 189038)											
VA21A8088-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.048	0.050	0.002	Diff <2x LOR	----
Bacteriological Tests (QC Lot: 188388)											
KS2101254-001	Anonymous	coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	<1	0	Diff <2x LOR	----
		coliforms, total	----	E010	1	MPN/100mL	<1	<1	0	Diff <2x LOR	----
Total Metals (QC Lot: 190353)											
KS2101257-001	40541	aluminum, total	7429-90-5	E420	0.0100	mg/L	0.0262	0.0249	0.0013	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00149	0.00157	5.47%	20%	----
		barium, total	7440-39-3	E420	0.0200	mg/L	0.0203	0.0204	0.00014	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Total Metals (QC Lot: 190353) - continued											
KS2101257-001	40541	calcium, total	7440-70-2	E420	0.100	mg/L	48.0	43.3	10.4%	20%	----
		chromium, total	7440-47-3	E420	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00100	mg/L	0.00331	0.00324	0.00006	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.030	mg/L	0.044	0.046	0.001	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	19.6	19.6	0.0413%	20%	----
		manganese, total	7439-96-5	E420	0.00200	mg/L	0.0318	0.0311	2.27%	20%	----
		potassium, total	7440-09-7	E420	0.100	mg/L	1.70	1.70	0.174%	20%	----
		selenium, total	7782-49-2	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	2.00	mg/L	6.83	6.80	0.028	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000100	mg/L	0.00238	0.00222	7.03%	20%	----
		zinc, total	7440-66-6	E420	0.0500	mg/L	<0.0500	<0.0500	0	Diff <2x LOR	----
Total Metals (QC Lot: 190643)											
KS2101237-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 190159)											
FJ2100209-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0074	0.0078	0.0005	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00046	0.00047	0.00001	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0288	0.0282	2.37%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.015	0.016	0.0004	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000538	0.0000522	3.06%	20%	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	12.3	12.2	1.16%	20%	----
		cesium, dissolved	7440-46-2	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00035	0.00034	0.00001	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0182	0.0182	0.438%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	3.76	3.61	4.25%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00013	0.00013	0.000002	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00148	0.00148	0.344%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00833	0.00803	3.69%	20%	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 190159) - continued											
FJ2100209-001	Anonymous	phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.332	0.315	0.017	Diff <2x LOR	----
		rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	0.00049	0.00054	0.00005	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00415	0.00449	7.82%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	0.172	0.180	0.008	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	14.6	13.9	5.12%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.0220	0.0214	2.56%	20%	----
		sulfur, dissolved	7704-34-9	E421	0.50	mg/L	9.51	9.36	1.64%	20%	----
		tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		thorium, dissolved	7440-29-1	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00160	0.00162	0.854%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0022	0.0023	0.0001	Diff <2x LOR	----
		zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 190752)											
KS2101257-001	40541	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 189042)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 189043)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 189044)						
colour, true	----	E329	5	CU	<5.0	----
Physical Tests (QCLot: 189090)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 191085)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 189034)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 189035)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 189036)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 189037)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 189038)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Bacteriological Tests (QCLot: 188388)						
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	----
coliforms, total	----	E010	1	MPN/100mL	<1	----
Total Metals (QCLot: 190353)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 190353) - continued						
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 190643)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 190159)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cesium, dissolved	7440-46-2	E421	0.00001	mg/L	<0.000010	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
rubidium, dissolved	7440-17-7	E421	0.0002	mg/L	<0.00020	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 190159) - continued						
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
tellurium, dissolved	13494-80-9	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
thorium, dissolved	7440-29-1	E421	0.0001	mg/L	<0.00010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
tungsten, dissolved	7440-33-7	E421	0.0001	mg/L	<0.00010	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	<0.00020	----
Dissolved Metals (QCLot: 190752)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 189041)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 189042)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	98.8	90.0	110	----
Physical Tests (QCLot: 189043)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100.0	85.0	115	----
Physical Tests (QCLot: 189044)									
colour, true	----	E329	5	CU	100 CU	103	85.0	115	----
Physical Tests (QCLot: 189090)									
turbidity	----	E121	0.1	NTU	200 NTU	102	85.0	115	----
Physical Tests (QCLot: 191085)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	107	85.0	115	----
Anions and Nutrients (QCLot: 189034)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 189035)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 189036)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 189037)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 189038)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	99.8	90.0	110	----
Total Metals (QCLot: 190353)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	96.8	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	99.2	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	93.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	98.0	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	97.5	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	97.3	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	98.3	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	95.1	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 190353) - continued									
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	97.8	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	103	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	97.9	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	95.4	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	98.2	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	97.0	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	100	80.0	120	----
Total Metals (QCLot: 190643)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	99.1	80.0	120	----
Dissolved Metals (QCLot: 190159)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	99.3	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.0	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
cesium, dissolved	7440-46-2	E421	0.00001	mg/L	0.05 mg/L	98.1	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	99.3	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	99.7	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	99.0	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	98.8	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.6	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	104	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
rubidium, dissolved	7440-17-7	E421	0.0002	mg/L	0.1 mg/L	104	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 190159) - continued									
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	100	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	108	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.5	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	99.6	80.0	120	----
tellurium, dissolved	13494-80-9	E421	0.0002	mg/L	0.1 mg/L	112	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	102	80.0	120	----
thorium, dissolved	7440-29-1	E421	0.0001	mg/L	0.1 mg/L	93.8	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	101	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.9	80.0	120	----
tungsten, dissolved	7440-33-7	E421	0.0001	mg/L	0.1 mg/L	97.0	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	96.5	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	105	80.0	120	----
zirconium, dissolved	7440-67-7	E421	0.0002	mg/L	0.1 mg/L	96.6	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	99.0	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 189034)										
VA21A8088-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.63 mg/L	2.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 189035)										
VA21A8088-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 189036)										
VA21A8088-002	Anonymous	chloride	16887-00-6	E235.Cl	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 189037)										
VA21A8088-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.505 mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 189038)										
VA21A8088-002	Anonymous	fluoride	16984-48-8	E235.F	1.02 mg/L	1 mg/L	102	75.0	125	----
Total Metals (QCLot: 190353)										
KS2101257-001	40541	aluminum, total	7429-90-5	E420	0.190 mg/L	0.2 mg/L	94.9	70.0	130	----
		antimony, total	7440-36-0	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0198 mg/L	0.02 mg/L	98.8	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		boron, total	7440-42-8	E420	0.092 mg/L	0.1 mg/L	92.4	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00390 mg/L	0.004 mg/L	97.6	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0385 mg/L	0.04 mg/L	96.2	70.0	130	----
		copper, total	7440-50-8	E420	0.0185 mg/L	0.02 mg/L	92.4	70.0	130	----
		iron, total	7439-89-6	E420	1.89 mg/L	2 mg/L	94.5	70.0	130	----
		lead, total	7439-92-1	E420	0.0188 mg/L	0.02 mg/L	94.0	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		potassium, total	7440-09-7	E420	3.95 mg/L	4 mg/L	98.7	70.0	130	----
		selenium, total	7782-49-2	E420	0.0396 mg/L	0.04 mg/L	98.9	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		uranium, total	7440-61-1	E420	0.00365 mg/L	0.004 mg/L	91.2	70.0	130	----
		zinc, total	7440-66-6	E420	0.390 mg/L	0.4 mg/L	97.6	70.0	130	----
Total Metals (QCLot: 190643)										
KS2101248-001	Anonymous	mercury, total	7439-97-6	E508	0.0000991 mg/L	0.0001 mg/L	99.1	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 190159)										
FJ2100209-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.197 mg/L	0.2 mg/L	98.4	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0216 mg/L	0.02 mg/L	108	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0203 mg/L	0.02 mg/L	101	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0432 mg/L	0.04 mg/L	108	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00781 mg/L	0.01 mg/L	78.1	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.108 mg/L	0.1 mg/L	108	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00416 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cesium, dissolved	7440-46-2	E421	0.00984 mg/L	0.01 mg/L	98.4	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0197 mg/L	0.02 mg/L	98.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.97 mg/L	2 mg/L	98.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0197 mg/L	0.02 mg/L	98.3	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.108 mg/L	0.1 mg/L	108	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.6 mg/L	10 mg/L	106	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.10 mg/L	4 mg/L	102	70.0	130	----
		rubidium, dissolved	7440-17-7	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0452 mg/L	0.04 mg/L	113	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.55 mg/L	10 mg/L	95.5	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00386 mg/L	0.004 mg/L	96.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	21.6 mg/L	20 mg/L	108	70.0	130	----
		tellurium, dissolved	13494-80-9	E421	0.0460 mg/L	0.04 mg/L	115	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00374 mg/L	0.004 mg/L	93.6	70.0	130	----
		thorium, dissolved	7440-29-1	E421	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0198 mg/L	0.02 mg/L	99.0	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0400 mg/L	0.04 mg/L	100	70.0	130	----
		tungsten, dissolved	7440-33-7	E421	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00380 mg/L	0.004 mg/L	95.0	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 190159) - continued										
FJ2100209-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.445 mg/L	0.4 mg/L	111	70.0	130	----
		zirconium, dissolved	7440-67-7	E421	0.0420 mg/L	0.04 mg/L	105	70.0	130	----
Dissolved Metals (QCLot: 190752)										
VA21A8088-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000980 mg/L	0.0001 mg/L	98.0	70.0	130	----

Chain of Custody (COC) / Analytical Request Form

COC Number: 20 - 886055

Page 1 of 1

Canada Toll Free: 1 800 668 9878

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Report To	Contact and company name below will appear on the final report
Company:	WESTERN WATER
Contact:	PAUL W
Phone:	250-540 6999
	Company address below will appear on the final report
Street:	106-5145 26TH ST
City/Province:	VERNON
Postal Code:	
Invoice To	Same as Report To ☒ YES ☐ NO
	Copy of Invoice with Report ☒ YES ☐ NO
Company:	
Contact:	

Reports / Recipients

Select Report Format: ☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☐ YES ☐ NO ☐ N/A

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☒ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: paul@westernwater.ca

Email 2:

Email 3:

Invoice Recipients

Select Invoice Distribution: ☒ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: paul@westernwater.ca

Email 2: amanda@westernwater.ca

Turnaround Time (TAT) Requested

☒ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-routine tests

AFFIX ALS BARCODE LABEL HERE (ALS use only)

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm am/pm

For all tests with rush TATs requested, please contact your AM to confirm availability.

Project Information

ALS Account # / Quote #:

Job #: 20-105-02V1 BANNIERE

PO / AFE:

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#:

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (ALS use only): KS2101257

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Drinking Water Prep	Dissolved Metals	SAMPLES ON HOLD	EXTENDED STORAGE REQUIRED	SUSPECTED HAZARD (see notes)
	40541	28-Apr-21	23:30	DW		X	X			

Environmental Division
Kamloops
Work Order Reference
KS2101257

Telephone : +1 250 372 3588

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☒ NO

Are samples for human consumption/ use? ☐ YES ☒ NO

Notes / Specify Limits for result evaluation by selecting from drop-down below (Excel COC only)

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☐ ICE ☐ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Intact: ☐ YES ☐ N/A Sample Custody Seals Intact: ☐ YES ☐ N/A

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
6							

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (ALS use only)

Received by:	Date:	Time:
CH	Apr 29/21	1025

FINAL SHIPMENT RECEPTION (ALS use only)

Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

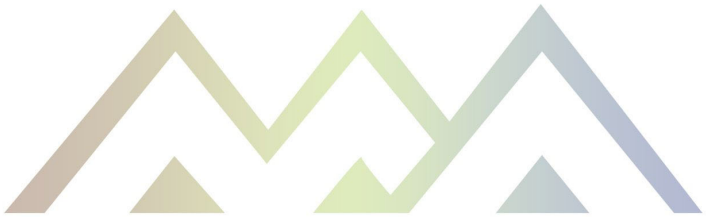
WHITE - LABORATORY COPY YELLOW - CLIENT COPY

AUG 2020 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

White Paper Co. 604 951-3900



Groundwater Supply Development and Management

Source Water Assessment and Protection

Well Monitoring & Maintenance

Environmental & Water Quality Monitoring

Storm & Wastewater Disposal to Ground

Groundwater Modeling

Aquifer Test Design and Analysis

Geothermal / Geoexchange Systems

Policy and Guideline Development

Applied Research

Rural Subdivision Services

Environmental Assessment & Permitting

| #106 – 5145 26th Street, Vernon, BC, Canada, V1T 8G4 | Prince George | Victoria | P:1.250.541.1030 | www.westernwater.ca |

ALS Environmental

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **KS2103634**	Page	: 1 of 6
Amendment	: **1**		
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Ian Crosson	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere Water	Date Samples Received	: 03-Nov-2021 12:40
PO	: ----	Date Analysis Commenced	: 03-Nov-2021
C-O-C number	: ----	Issue Date	: 18-Nov-2021 14:51
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS02		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Aaron Yu	Laboratory Analyst	Inorganics, Burnaby, British Columbia
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non -infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	*Description*
µS/cm	Microsiemens per centimetre
CU	colour units (1 CU = 1 mg/L Pt)
mg/L	milligrams per litre
MPN/100mL	most probable number per 100 mL
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result is greater than the Guideline Upper Limit or the result is lower than the Guideline Lower Limit.
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit.

Workorder Comments

Amendment (18/11/2021): This report has been amended and re-released to allow the reporting of guidelines

Analytical Results Evaluation

Matrix: **Water**

Analyte	CAS Number	Unit	Client sample ID: Bradford Park PW1 - Raw Analysis	----	----	----	----	----	----
			Sampling date/time: 03-Nov-2021 09:05	----	----	----	----	----	----
			Sub-Matrix: Water	----	----	----	----	----	----
			KS2103634-001	--------	--------	--------	--------	--------	--------
Physical Tests									
alkalinity, total (as CaCO3)	----	mg/L	228	----	----	----	----	----	----
colour, true	----	CU	<5.0	----	----	----	----	----	----
conductivity	----	µS/cm	459	----	----	----	----	----	----
pH	----	pH units	8.24	----	----	----	----	----	----
solids, total dissolved [TDS]	----	mg/L	254	----	----	----	----	----	----
turbidity	----	NTU	0.22	----	----	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	mg/L	205	----	----	----	----	----	----
Anions and Nutrients									
chloride	16887-00-6	mg/L	0.70	----	----	----	----	----	----
fluoride	16984-48-8	mg/L	0.192	----	----	----	----	----	----
nitrate (as N)	14797-55-8	mg/L	<0.0050	----	----	----	----	----	----
nitrite (as N)	14797-65-0	mg/L	<0.0010	----	----	----	----	----	----
sulfate (as SO4)	14808-79-8	mg/L	28.9	----	----	----	----	----	----
Bacteriological Tests									
coliforms, total	----	MPN/100mL	<1	----	----	----	----	----	----
coliforms, Escherichia coli [E. coli]	----	MPN/100mL	<1	----	----	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	mg/L	<0.0100	----	----	----	----	----	----
antimony, total	7440-36-0	mg/L	<0.00050	----	----	----	----	----	----
arsenic, total	7440-38-2	mg/L	0.00628	----	----	----	----	----	----
barium, total	7440-39-3	mg/L	0.0363	----	----	----	----	----	----
boron, total	7440-42-8	mg/L	<0.100	----	----	----	----	----	----
cadmium, total	7440-43-9	mg/L	<0.000200	----	----	----	----	----	----
calcium, total	7440-70-2	mg/L	44.1	----	----	----	----	----	----
chromium, total	7440-47-3	mg/L	<0.00200	----	----	----	----	----	----
copper, total	7440-50-8	mg/L	<0.00100	----	----	----	----	----	----

Analytical Results Evaluation

Matrix: **Water**

Analyte	CAS Number	Unit	Client sample ID	Bradford Park PW1 - Raw Analysis	----	----	----	----	----	----
			Sampling date/time	03-Nov-2021 09:05	----	----	----	----	----	----
			Sub-Matrix	Water	----	----	----	----	----	----
			KS2103634-001		--------	--------	--------	--------	--------	--------
Total Metals										
iron, total	7439-89-6	mg/L		0.072	----	----	----	----	----	----
lead, total	7439-92-1	mg/L		<0.000500	----	----	----	----	----	----
magnesium, total	7439-95-4	mg/L		23.0	----	----	----	----	----	----
manganese, total	7439-96-5	mg/L		0.0958	----	----	----	----	----	----
mercury, total	7439-97-6	mg/L		<0.0000050	----	----	----	----	----	----
potassium, total	7440-09-7	mg/L		3.21	----	----	----	----	----	----
selenium, total	7782-49-2	mg/L		<0.00100	----	----	----	----	----	----
sodium, total	17341-25-2	mg/L		12.6	----	----	----	----	----	----
uranium, total	7440-61-1	mg/L		0.000187	----	----	----	----	----	----
zinc, total	7440-66-6	mg/L		<0.0500	----	----	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Summary of Guideline Breaches by Sample

SampleID/Client ID	Matrix	Analyte	Analyte Summary	Guideline	Category	Result	Limit
Bradford Park PW1 - Raw Analysis	Water	manganese, total	No summary description available for this compound in this guideline.	BCDWQG	AO	0.0958 mg/L	0.02 mg/L

Summary of Guideline Limits

Analyte	CAS Number	Unit	BCDWQG AO	BCDWQG MAC	BCDWQG OG
Physical Tests					
alkalinity, total (as CaCO3)	----	mg/L			
colour, true	----	CU	15 CU		
conductivity	----	µS/cm			
hardness (as CaCO3), from total Ca/Mg	----	mg/L			
pH	----	pH units	7-10.5 pH units		
solids, total dissolved [TDS]	----	mg/L	500 mg/L		
turbidity	----	NTU			1 NTU
Anions and Nutrients					
chloride	16887-00-6	mg/L	250 mg/L		
fluoride	16984-48-8	mg/L		1.5 mg/L	
nitrate (as N)	14797-55-8	mg/L		10 mg/L	
nitrite (as N)	14797-65-0	mg/L		1 mg/L	
sulfate (as SO4)	14808-79-8	mg/L			
Bacteriological Tests					
coliforms, Escherichia coli [E. coli]	----	MPN/100mL		1 MPN/100mL	
coliforms, total	----	MPN/100mL		1 MPN/100mL	
Total Metals					
aluminum, total	7429-90-5	mg/L	0.1 mg/L	2.9 mg/L	
antimony, total	7440-36-0	mg/L		0.006 mg/L	
arsenic, total	7440-38-2	mg/L		0.01 mg/L	
barium, total	7440-39-3	mg/L		2 mg/L	
boron, total	7440-42-8	mg/L		5 mg/L	
cadmium, total	7440-43-9	mg/L		0.007 mg/L	
calcium, total	7440-70-2	mg/L			
chromium, total	7440-47-3	mg/L		0.05 mg/L	
copper, total	7440-50-8	mg/L	1 mg/L	2 mg/L	
iron, total	7439-89-6	mg/L	0.3 mg/L		
lead, total	7439-92-1	mg/L		0.005 mg/L	
magnesium, total	7439-95-4	mg/L			
manganese, total	7439-96-5	mg/L	0.02 mg/L		
mercury, total	7439-97-6	mg/L		0.001 mg/L	
potassium, total	7440-09-7	mg/L			
selenium, total	7782-49-2	mg/L		0.01 mg/L	
sodium, total	17341-25-2	mg/L	200 mg/L		
uranium, total	7440-61-1	mg/L		0.02 mg/L	
zinc, total	7440-66-6	mg/L	5 mg/L	3 mg/L	

Please refer to the General Comments section for an explanation of any qualifiers detected.

Key:

BCDWQG	British Columbia Drinking Water Quality Guidelines (JAN, 2020
AO	Aesthetic Objective/Other Value
MAC	Maximium Acceptable Concentrations
OG	Operational Guidance

ALS Environmental

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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number 15 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	DISTRICT OF BARRIERE
Contact:	IAN CROSSON
Phone:	705-205-7765 250-672-9751 Fax 250-672-9708
	Company address below will appear on the final report
Street:	P.O. Box 219
City/Province:	BARRIERE
Postal Code:	BC
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☑ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution	
Select Report Format:	☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report	☐ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	inquiry@barriere.ca
Email 2	icrosson@barriere.ca
Email 3	pamos@barriere.ca

Invoice Distribution	
Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	inquiry@barriere.ca
Email 2	

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
4 day [P4]	☐	1 Business day [E1]	☐
3 day [P3]	☐	Same Day, Weekend or Statutory holiday [E0]	☐
2 day [P2]	☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information	
ALS Account # / Quote #:	
Job #:	
PO / AFE:	
LSD:	

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#:
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only)

ALS Contact: **Sampler:**

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	Bradford Park PW1 - Raw Water Analysis	03/11/21	9:05 am	Grab	6
	CL2 Free: C				
	CL2 Total: C				
*	***Please reference WO# ~~L1887242~~ for required analysis*** KS2002453				

Environmental Division Kamloops

Work Order Reference KS2103634

Telephone : +1 250 372 3588

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? ☐ YES ☐ NO	
Are samples for human drinking water use? ☐ YES ☐ NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☒ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
11					

SHIPMENT RELEASE (client use)		
Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (lab use only)		
Received by: WH	Date: NOV 0 3 2021	Time: 12:40

FINAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white report copy.

1 If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **KS2103547**	Page	: 1 of 4
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Ian Crosson	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops BC Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere	Date Samples Received	: 27-Oct-2021 11:30
PO	: ----	Date Analysis Commenced	: 28-Oct-2021
C-O-C number	: ----	Issue Date	: 15-Nov-2021 11:24
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS02		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
µS/cm	Microsiemens per centimetre
CU	colour units (1 CU = 1 mg/L Pt)
mg/L	milligrams per litre
MPN/100mL	most probable number per 100 mL
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	Spruce Crescent DW2 - Raw Water Analysis	----	----	----	----
					Client sampling date / time	27-Oct-2021 09:25	----	----	----	----
						KS2103547-001	--------	--------	--------	--------
						Result	----	----	----	----
Physical Tests										
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L		178	----	----	----	----
colour, true	----	E329	5.0	CU		<5.0	----	----	----	----
conductivity	----	E100	2.0	µS/cm		356	----	----	----	----
pH	----	E108	0.10	pH units		8.03	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L		226	----	----	----	----
turbidity	----	E121	0.10	NTU		<0.10	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.60	mg/L		182	----	----	----	----
Anions and Nutrients										
chloride	16887-00-6	E235.Cl	0.50	mg/L		3.34	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L		0.085	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L		0.361	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L		<0.0010	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L		19.8	----	----	----	----
Bacteriological Tests										
coliforms, total	----	E010	1	MPN/100mL		<1	----	----	----	----
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL		<1	----	----	----	----
Total Metals										
aluminum, total	7429-90-5	E420	0.0100	mg/L		<0.0100	----	----	----	----
antimony, total	7440-36-0	E420	0.00050	mg/L		<0.00050	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.00125	----	----	----	----
barium, total	7440-39-3	E420	0.0200	mg/L		<0.0200	----	----	----	----
boron, total	7440-42-8	E420	0.100	mg/L		<0.100	----	----	----	----
cadmium, total	7440-43-9	E420	0.000200	mg/L		<0.000200	----	----	----	----
calcium, total	7440-70-2	E420	0.100	mg/L		42.0	----	----	----	----
chromium, total	7440-47-3	E420	0.00200	mg/L		<0.00200	----	----	----	----
copper, total	7440-50-8	E420	0.00100	mg/L		0.00507	----	----	----	----
iron, total	7439-89-6	E420	0.030	mg/L		<0.030	----	----	----	----
lead, total	7439-92-1	E420	0.000500	mg/L		0.000858	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		18.8	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: Spruce Crescent DW2 - Raw Water Analysis	----	----	----	----
					Client sampling date / time: 27-Oct-2021 09:25	----	----	----	----
					KS2103547-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
manganese, total	7439-96-5	E420	0.00200	mg/L	0.00995	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	----	----	----	----
potassium, total	7440-09-7	E420	0.100	mg/L	1.75	----	----	----	----
selenium, total	7782-49-2	E420	0.00100	mg/L	<0.00100	----	----	----	----
sodium, total	17341-25-2	E420	2.00	mg/L	7.47	----	----	----	----
uranium, total	7440-61-1	E420	0.000100	mg/L	0.00218	----	----	----	----
zinc, total	7440-66-6	E420	0.0500	mg/L	<0.0500	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 15 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	DISTRICT OF BARRIERE
Contact:	IAN CROSSON
Phone:	705-205-7765 250-672-9751 Fax 250-672-9708
	Company address below will appear on the final report
Street:	P.O. Box 219
City/Province:	BARRIERE
Postal Code:	BC
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☑ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution	
Select Report Format:	☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report	☐ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	inquiry@barriere.ca
Email 2	icrosson@barriere.ca
Email 3	pamos@barriere.ca

Invoice Distribution	
Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	inquiry@barriere.ca
Email 2	

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
	4 day [P4] ☐		1 Business day [E1] ☐
	3 day [P3] ☐		Same Day, Weekend or Statutory holiday [E0] ☐
	2 day [P2] ☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information	
ALS Account # / Quote #:	
Job #:	
PO / AFE:	
LSD:	

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only) KS2103547

ALS Contact: **Sampler:**

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	Spruce Crescent DW2 - Raw Water Analysis	27/10/21	9:25am	Grab	6
	CL2 Free: 0				
	CL2 Total: 0				
	Ntu - .26				
	Please reference WO# L1687242 for required analysis				

Environmental Division
Kamloops
Work Order Reference
KS2103547

Telephone : +1 250 372 3588

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? ☐ YES ☐ NO	
Are samples for human drinking water use? ☐ YES ☐ NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	
9			

SHIPMENT RELEASE (client use)		
Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date: OCT 27 2021	Time: 1130

FINAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **KS2103545**	Page	: 1 of 4
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Ian Crosson	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops BC Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere	Date Samples Received	: 27-Oct-2021 11:30
PO	: ----	Date Analysis Commenced	: 28-Oct-2021
C-O-C number	: ----	Issue Date	: 15-Nov-2021 11:19
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS01		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
µS/cm	Microsiemens per centimetre
CU	colour units (1 CU = 1 mg/L Pt)
mg/L	milligrams per litre
MPN/100mL	most probable number per 100 mL
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: Louis Creek - Raw Water Analysis	----	----	----	----
					Client sampling date / time: 27-Oct-2021 10:00	----	----	----	----
					KS2103545-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	199	----	----	----	----
colour, true	----	E329	5.0	CU	<5.0	----	----	----	----
conductivity	----	E100	2.0	µS/cm	412	----	----	----	----
pH	----	E108	0.10	pH units	8.24	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	263	----	----	----	----
turbidity	----	E121	0.10	NTU	<0.10	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.60	mg/L	216	----	----	----	----
Anions and Nutrients									
chloride	16887-00-6	E235.Cl	0.50	mg/L	1.98	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.104	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	38.8	----	----	----	----
Bacteriological Tests									
coliforms, total	----	E010	1	MPN/100mL	<1	----	----	----	----
coliforms, Escherichia coli [E. coli]	----	E010	1	MPN/100mL	<1	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0100	mg/L	<0.0100	----	----	----	----
antimony, total	7440-36-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00147	----	----	----	----
barium, total	7440-39-3	E420	0.0200	mg/L	<0.0200	----	----	----	----
boron, total	7440-42-8	E420	0.100	mg/L	<0.100	----	----	----	----
cadmium, total	7440-43-9	E420	0.000200	mg/L	<0.000200	----	----	----	----
calcium, total	7440-70-2	E420	0.100	mg/L	62.3	----	----	----	----
chromium, total	7440-47-3	E420	0.00200	mg/L	<0.00200	----	----	----	----
copper, total	7440-50-8	E420	0.00100	mg/L	0.00160	----	----	----	----
iron, total	7439-89-6	E420	0.030	mg/L	0.039	----	----	----	----
lead, total	7439-92-1	E420	0.000500	mg/L	<0.000500	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	14.8	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	**Louis Creek - Raw Water Analysis**	**----**	**----**	**----**	**----**
				Client sampling date / time	27-Oct-2021 10:00	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**KS2103545-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Total Metals									
manganese, total	7439-96-5	E420	0.00200	mg/L	0.0605	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	----	----	----	----
potassium, total	7440-09-7	E420	0.100	mg/L	3.43	----	----	----	----
selenium, total	7782-49-2	E420	0.00100	mg/L	<0.00100	----	----	----	----
sodium, total	17341-25-2	E420	2.00	mg/L	4.55	----	----	----	----
uranium, total	7440-61-1	E420	0.000100	mg/L	<0.000100	----	----	----	----
zinc, total	7440-66-6	E420	0.0500	mg/L	<0.0500	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 15 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	DISTRICT OF BARRIERE
Contact:	IAN CROSSON
Phone:	705-205-7765 250-672-9751 Fax 250-672-9708
	Company address below will appear on the final report
Street:	P.O. Box 219
City/Province:	BARRIERE
Postal Code:	BC
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☑ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☐ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: inquiry@barriere.ca

Email 2: icrosson@barriere.ca

Email 3: pamos@barriere.ca

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: inquiry@barriere.ca

Email 2:

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ | 3 day [P3] ☐ | 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ | Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information	
ALS Account # / Quote #:	
Job #:	
PO / AFE:	
LSD:	

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only)	ALS Contact:	Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	Louis Creek - Raw Water Analysis	27/10/21	10:00	Grab	6
	CL2 Free: 0				
	CL2 Total: 0				
	Ntu - 024				
	Please reference WO# L1687242 for required analysis				

Environmental Division Kamloops
Work Order Reference
KS2103545

Telephone : +1 250 372 3588

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human drinking water use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
9					

SHIPMENT RELEASE (client use)		
Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date: OCT 27 2021	Time: 1130

FINAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.