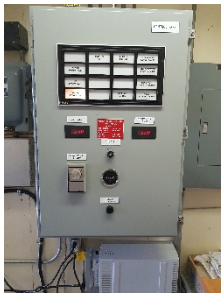
Lac La Hache Groundwater Supply and Treatment Feasibility Study

Cariboo Regional District



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Project No. 397-441

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1.0 Introduction

1.1 Background

The Cariboo Regional District (CRD) owns and operates the Lac La Hache Community Water System (LWS). The community of Lac La Hache is located along highway 97 approximately 25km North of 100 Mile House. There are approximately 258 permanent residents residing in 148 private dwellings, according to the 2016 census.

The community is serviced by a community water system originally constructed in 1982 with the latest upgrades happening in 2002. The water system services residential, business, community services and recreation.

At present the LWS is comprised of the following components:

- Two groundwater wells (The Community Hall Well and the Lake Well)
- Wood framed pumphouse
- 533,000 litre cast-in-place concrete water reservoir
- 10.5 kilometres of distribution watermain pipe
- 216 service connections (193 residential and 23 commercial)
- 44 gate valves, 16 fire hydrants, 9 blow offs and various other water system appurtenances.

Water demand fluctuates from year to year, and throughout the year as well. Yearly water uses varies between 42,000 cubic metres and 80,000 cubic meters annually. The existing wells for the LWS provide enough water to meet community demand. However; due to consistent poor water quality from the Lake Well, the CRD no longer draws from the Lake Well leaving the system with one reliable water source. The Community Hall Well, the primary source for the LWS, meets all maximum allowable concentration and aesthetic objectives set out in the Guidelines for Canadian Drinking Water Quality (GCDWQ). The Lake Well has not been used since 2016 and is only kept in operation as an emergency back up water supply. The water quality of the Lake Well is not aesthetically pleasing to water system users, and the Operators avoid using the Lake Well as much as possible. Refer to the Appendices of this report for a overview of the existing and proposed infrastructure.

The CRD is looking to obtain a second reliable, high quality water source. The CRD is also proposing to increase the safety of the water system by providing a free chlorine residual in the system which is currently not present.

1.2 Project Scope

In the fall of 2019 the CRD retained the services of TRUE Consulting (TRUE) to complete a feasibility level study to present options for improvements to the LWS. TRUE subsequently retained the services of Western Water Associates Ltd. (WWAL) to assist with the hydrogeological aspect of the project.

The purpose of this feasibility study is to identify potential new and existing community well sites and determine the associated water treatment options relevant to each site. Each option will be discussed in regard to their pros and cons and a level D construction cost estimate prepared in regard to groundwater well construction and water treatment processes.

1.3 References

This report draws information from:

- Health Canada Guidelines for Canadian Drinking Water Quality
- British Columbia 2012 Design Guidelines for Rural Residential Community Water Systems
- British Columbia 2013 Drinking Water Protection Act
- British Columbia Water Allocation Restrictions 2011
- Statistics Canada 2016 Census
- Lac La Hache Water Conservation Plan 2020
- Wester Water Associates Ltd. Groundwater Feasibility Assessment 2020

2.0 Design Considerations

2.1 Water Demands

According to census Canada, the population of Lac La Hache has gone from 245 in 2006 to 258 in 2016. This population growth represents only a 0.5% annual growth over the last 10 years. It is not known how many of the 258 people recorded in the Censes Canada statistics are connected to the LWS; however, it is known that 193 residential, and 23 commercial water services existing on the system. For the purposes of this feasibility study, we will assume 2.5 people per home for each residential service connection. This assumption represents a 483 person residential user base.

Annual average water consumption rates between 1996 and 2019 were used in determining the water system demand. Pumphouse records collected by the CRD over the past 23 years were provided to Western Water Associates and their findings are summarized in the Groundwater Feasibility Assessment appended to this study.

The pumphouse water use records showed that the average day demand (ADD) of the LWS is 166,000L/day or 344L/day per person. This per person rate is based on the above assumed 483 person user base and does not account for non-permanent users or commercial and public sector consumption. Water supply and treatment infrastructure is typically designed for an estimated 20 year future demand. Therefore, assuming a 1.5% annual increase in water use, the 2040 ADD of the LWS would be approximately 225,000 L/day.

The existing and future water demands on the LWS are identified in Table 2-1 below. The maximum day demand (MDD) and peak hour demand (PHD) for water usage is based recommended rural community water system design factors of MDD = 2.5 X ADD and PHD = 4.0 X ADD.

Table 2-1: Existing and Future Water Demand

Demand	Cu.m. / Day		L / sec		US GPM	
Year	**2020**	**2040**	**2020**	**2040**	**2020**	**2040**
ADD	166	225	1.92	2.49	30.4	39.5
MDD	415	565	4.80	6.54	76.1	103.7
PHD	N/A	N/A	7.68	9.96	121.7	157.9

The calculated 20 year future maximum day demand of the LWS is 6.54 L/sec (104 US GPM). This represents a 37% (28 US GPM) increase in water demand over the next 20 years. As per the Ministry of Environments Living Water Smart: British Columbia's Water Plan, the LWS will strive to achieve 50% of this increased demand through water conservation measures. The other 50% would increase total water demand from 76.1 US GPM to 90.1 US GPM. This maximum design flow is well below the estimated 200 US GPM yield of the existing groundwater wells.

2.2 Water Quality

Water samples taken by the CRD over the past 23 years were analyzed for comparison with the GCDWQ. Table 2-2 below summarizes the results of the water quality analysis. Please refer to WWAL's report for a complete table of results.

Table 2-2: Groundwater Quality Summary – Lac La Hache Community Well and Lake Well

Parameter	Units	Average Results 1996 - 2018	Average Results 2010 - 2017	Guideline
Well ID		Community Hall Well	Lake Well	
Field Parameters	**Units**			**GCDWQ**
pH (field)	pH units	8.20	8.38	AO = 6.5 - 8.5
General Parameters and Nutrients				
Total Dissolved Solids	mg/L	459	463	AO ≤ 500
Hardness	mg/L	330	274	
Fluoride	mg/L	0.04	0.097	MAC = 1.5
Nitrate/Nitrite	mg/L	1.07	<0.02	Nitrate MAC = 45 Nitrite MAC = 3
Chloride	mg/L	-	-	AO ≤ 250
Sulfate	mg/L	65	154	AO ≤ 500
Selected Total Ions and Metals				
Aluminum	mg/L	0.01	0.023	OG < 0.1
Antimony	mg/L	<0.0005	<0.0005	MAC =0.006
Arsenic	mg/L	0.0042	0.0034	MAC = 0.01
Barium	mg/L	0.01	0.0186	MAC = 1
Chromium	mg/L	0.001	<0.001	MAC = 0.05
Copper	mg/L	0.0023	<0.0002	MAC =2 AO ≤ 1
Iron	mg/L	0.13	0.045	AO ≤ 0.30
Lead	mg/L	0.0035	<.0002	MAC = 0.01
Manganese	mg/L	0.01	0.045	MAC = 0.12 AO < 0.02
Selenium	mg/L	0.0034	<0.0001	MAC = 0.05
Sodium	mg/L	41	63	AO ≤ 200
Uranium	mg/L	0.017	0.0013	MAC = 0.02
Zinc	mg/L	0.01	<0.005	AO ≤ 5

Parameter	Units	Average Results 1996 - 2018	Average Results 2010 - 2017	Guideline
Bacteriological Parameters				
Total Coliforms	MPN/100mL	<1	<1; (2 in July 2016)	MAC < 1
E. coli	MPN/100mL	<1	<1	MAC < 1
		Dec 18, 2019		
Hydrocarbons				
MTBE	mg/L	<0.001	-	AO ≤ 0.015
Benzene	mg/L	<0.0005	-	MAC = 0.005
Toluene	mg/L	<0.0005	-	MAC = 0.06 AO < 0.024
Ethylbenzene	mg/L	<0.0005	-	MAC = 0.14 AO < 0.0016
Total Xylenes	mg/L	<0.001	-	MAC = 0.09 AO < 0.02

The above water quality summary table shows the that the Community Hall Well meets all the maximum acceptable concentration and aesthetic objects set out in the GCDWQ, and the Lake Well has elevated levels of manganese, and total coliforms were present in 2016.

2.3 Water Supply and Treatment Options

The LWS primary water source is a groundwater well located behind the Community Hall at 3997 Cariboo Highway South. The high quality and volume of water available makes it a viable option for continued use, however; the Community Hall Well is 39 years old and is currently the only water source capable of providing high quality safe drinking water. The backup well, the Lake Well, is capable of providing sufficient quantity of water to the community in the case of emergency. However, the water quality is undesirable. The Lake Well has elevated levels of manganese and in 2016 tested positive for total coliforms. In addition, the Lake Well is reported to have elevated water temperature in the summer months, odour similar to the adjacent lake and sulfur, and causes staining due to the elevated level so manganese. The Community Hall Well water on the other hand meets all the maximum acceptable concentration, and aesthetic objectives of the GCDWQ, and the water Operators have received no complaints from the system users.

Two water supply options were considered to improve redundancy and treatment of the LWS. Option 1 was to construct a new well adjacent to the Community Hall Well, and Option 2 was to provided treatment to the existing Lake Well. It was quickly determined that Option 1 was the preferred option. Option 1 was preferred over Option 2 because it is very likely that a new well constructed adjacent to the existing Community Hall Well would produce the same high quality water as the Community Hall Well. The water quality in the Community Hall Well aquifer requires no water treatment other than the addition of chlorine to provide residual disinfection of the water distribution system. Also, having the two supply well located adjacent to each other would allow each well to share a common pumphouse and chlorination building.

The water quality in the Lake Well is less desirable and would require filtration treatment for manganese reduction, primary and secondary treatment for virus and pathogen removal, and potentially scrubbing and/or aeration for gas removal. The elevated water temperature during the summer months is also a concern, and there are no cost effective methods of reducing the Lake Well water temperatures. In addition, the Lake Well and Community Well are located approximately 300m apart from each other and separated by Highway 97. If the Lake Well were to be used as a supply well, the LWS would require a treatment system at both well sites, or a dedicated supply main from one well to the other well would be required. Both of those options are not economical, or necessary.

2.4 Proposed Improvements

The proposed LWS system improvements associated with the preferred Option 1 water supply and treatment consist of constructing a new groundwater well adjacent to the existing Community Hall Well. Both wells would share a new pumphouse and water treatment building. The Lake Well and existing infrastructure would remain in place and continue to be used as an emergency backup water source.

A description and rational of each proposed work item identified in the project cost estimate is provided following:

1. **Construct new 200mm diameter well**

Construct a new 200mm diameter well approximately 30m Northwest of the existing Community Hall Well. Construction will consist of hydrogeological study and analysis, drilling of the well, and pump testing including well development and water quality analysis. It is proposed to construct the new well 30m Northwest of the existing well because the private property neighboring to the East is a known former gas station and contaminated site.

The neighbouring contaminated site does not appear to be a concern; however, locating the well approximately 30m away from the contaminated site decreases the likelihood of it ever becoming an issue. Water samples from the existing Community Hall Well were collected and tested for hydrocarbons in December 2019. All hydrocarbons tested for were found to be below detectable

limits which indicates contamination has not reached the aquifer. The Community Hall Well log indicates a well confined aquifer with blue – grey silt above and below the aquifer. This silt layer may act as an impermeable lay to contamination flow and/or contamination may not be sufficient to migrate into the aquifer. Western Water Associates report provides further detail regarding the adjacent registered contaminated sites.

2. Complete new and existing wells

The new well and the existing Community Hall Well will require the installation of well pitless adaptors. Pitiless adaptors are required to protect infrastructure against freezing while still providing easy access for maintenance and repair. Both wells will require the installation of variable frequency drive pumps and motors as well as the associated piping and electrical. The well will also be equipped with monitoring equipment to assist the water Operators in the operation of the LWS as well as provide additional data which can be used in the distance future should the requirements of the LWS change.

3. Remove and dispose of existing pumphouse building

The existing pumphouse building is a small wood framed building that was constructed in 1982. The building is approximately 38 years old and the existing Community Hall Well is located inside the building. The existing building is nearing the end of its expected useful life and is not large enough accommodate the proposed electrical and chlorination equipment. The existing build should be removed to allow for the construction of the proposed pitiless adaptor.

The existing build could remain in place; however it is not recommended. The building is old, undersized, and is not built to the current post disaster requirements of a water utility building. If the existing building were left in place the only purpose it would serve is to heat the existing community well. Leaving the building in place would create unnecessary operation and maintenance work and cost, all of which will be negated with the installation of a pitless adaptor.

4. Construct new pumphouse/treatment building

The new pumphouse/treatment building would be similar the CRD's Lexington water system building that was constructed in 2019. The building would be approximately 4m x 4m and constructed of insulated concrete forms and cast-in-place concrete. The CRD has used this method of construction for all of their smaller utilty buildings in the last 12 years. The CRD has found that insulated concrete form and cast-in-place concrete construction are energy efficient, easy to heat, require no maintenance, vandal resistant, and retain heat very well in the event of power outages.

The pumphouse/treatment building would contain all of the necessary equipment and controls to operate the LWS. These include but are not limited to electrical, mechanical, communication, controls, treatment, and process.

5. Connect wells to new pumphouse

The two wells would both need to be connected mechanically and electrically to the new pumphouse/treatment building and mechanically to the existing water distribution network. This would be achieved by constructing water pipe from each well to the new building and constructing one watermain back to the existing distribution system. The existing electrical service would be relocated to the new pumphouse/treatment building, and power and controls constructed between the new building and each well.

6. Backup power generator

The LWS has an existing 533 cubic metre cast-in-place concrete reservoir which is used to store water for use during peak water demand period. A rural community water reservoir is typically sized to accommodate Balancing Storage, Fire Storage, and Emergency Storage. For the LWS, the 20 year design volume of a water reservoir is 625 cu.m. (141 cu.m. + 360 cu.m. + 125 cu.m.). Although the existing water reservoir volume is slightly below the 20 year future design volume, it is considered acceptable and fire suppression from the wells and therefore backup power system is not required.

The backup power system would only be required to provide treated water at the system design flow rate of 90 US GPM. The backup power generator would be fuled by a natural gas service connection, and sized to ensure the water system is operational during a power outage or emergency event.

7. Rehabilitate existing Community Hall Well

The existing Community Hall Well was constructed in 1981 and is 39 years old. Although the well has passed its theoretical useful life expectancy, the well is still productive. During installation of the proposed pitless adaptor, the existing well should undergo some basic well rehabilitation. This work would include brushing of the screen and casing, and surge and bail redevelopment of the well. This minor rehabilitation work would extend the life of the well and ensure the LWS has two reliable water sources for years to come.

8. Close existing well on neighbouring property

The property located to the east of the existing well is an old gas station site and registered contaminated site. Review of the well logs, and lab analysis of the groundwater well quality have determined that hydrocarbons are not present in the aquifer. However, there is an old private groundwater well on the neighbouring property that poses a significant risk to the aquifer. This existing private well is a potential pathway for contamination to the aquifer and should be closed by a hydrologist.

The CRD should approach the property owner and request the well be closed, or request permission to close the well. If the property owner is not cooperative, the CRD should involve the

Ministry of Environment as the well is currently in defiance of the BC Groundwater Protection Regulation.

9. Obtain utility easement or right of way

The proposed new well would be located approximately 30m Northeast of the existing Community Hall Well. The Lac La Hache Community Hall is located on the parcel of land, and the CRD should approach the landowner and request a utility easement for the new well and associated infrastructure. The utility easement is for the benefit of the community and if the property is owned by the community, there should be no cost associated with the purchase of the property. The schedule of quantity's shows a cost allowance of $3,000 to cover the legal land surveyor fees associated with registration of the utility easement.

3.0 Cost Estimates

Section 3.0 of this feasibility study provides a Class 'D' construction cost estimates for the infrastructure required to construct the Option 1 improvements as described in section 2.4 of this report.

Item	Description	Quantity	Price
1	Construct new 200mm diameter well	Lump Sum	$75,000
2	Complete new and existing wells	Lump Sum	$80,000
3	Remove and dispose of existing pumphouse	Lump Sum	$12,000
4	Construct new pumphouse/treatment building	Lump Sum	$225,000
5	Connect wells to new pumphouse	Lump Sum	$90,000
6	Backup power generator	Lump Sum	$40,000
7	Rehabilitate existing Community Hall Well	Lump Sum	$25,000
8	Close existing well on neighbouring property	Lump Sum	$10,000
9	Obtain utility easement or right of way	Lump Sum	$3,000
		Subtotal	**$560,000**
	Engineering and Contingency (30%)		$170,000
	TOTAL (Excluding GST)		**$730,000**

The proposed Lac La Hache water system improvements have an estimated total cost of $730,000. The Lac La Hache water system has a total of 216 water service connections (193 residential and 23 commercial) and an estimated residential user base of 483 people (2.5 people per residential service). Based on the above, the total project cost per service connection is $3,380 or total project cost per resident is $1,510.

4.0 Conclusions and Recommendations

4.1 Summary

The Lac La Hache water system is owned and operated by the Cariboo Regional District and was constructed in 1982. It services approximately 483 residential user on 193 residential properties and 23 commercial properties. The system currently operates with one reliable groundwater well known as the Community Hall Well and has a second unused groundwater well known as the Lake Well. The Lake Well is no longer used due to its poor water quality.

TRUE Consulting along with Western Water Associates Ltd. prepared this feasibility study to determine the feasibility of providing the Lac La Hache Water System with a second reliable water source. Two options for providing a second reliable water source were considered as part of this Feasibility Study. The first option was to construct a new well near the existing Community Hall Well and have the new and existing well both operate from a new pumphouse building. The second options was to provide treatment of the existing Lake Well and treatment of the existing Community Hall Well. Options 1 was chosen because it is the least expensive option and provides the most long term sustainable benefit to the community water system.

The estimated project cost of constructing a second well adjacent to the Community Hall Well, and having both wells share a new common pumphouse/treatment building is $730,000, or $3,380 per water service connection.

4.2 Recommendations and Next Steps

The one potential risk associated with this project and the existing community water source is the registered contaminated site located East of the existing Community Hall Well. Although the risk is low due to the known silt lay which confines and protects the aquifer, it is recommended that two additional samples for hydrocarbons be collected from the Community Hall Well in 2020 following snow melt. No hydrocarbons were detected during the December 2019 analysis, and the 2020 spring freshet samples should confirm the absence of hydrocarbons.

The property to the East also has an old unused groundwater well. This well is a potential conduit to the groundwater aquifer and should be closed as soon as possible. The Cariboo Regional District should contact the property owner and have the well closed by a hydrogeologist as soon as possible.

Based on the finding of this feasibility study, it is recommended that the Cariboo Regional District move forward with the design phase of the new well and pumphouse/treatment build as described in section 2 of this report.

4.3 Closure

We trust this study provides the information required to proceed with subsequent steps for improvements to the Lac La Hache Water System. If you have any questions or would like to discuss these findings further, do not hesitate to contact the undersigned.

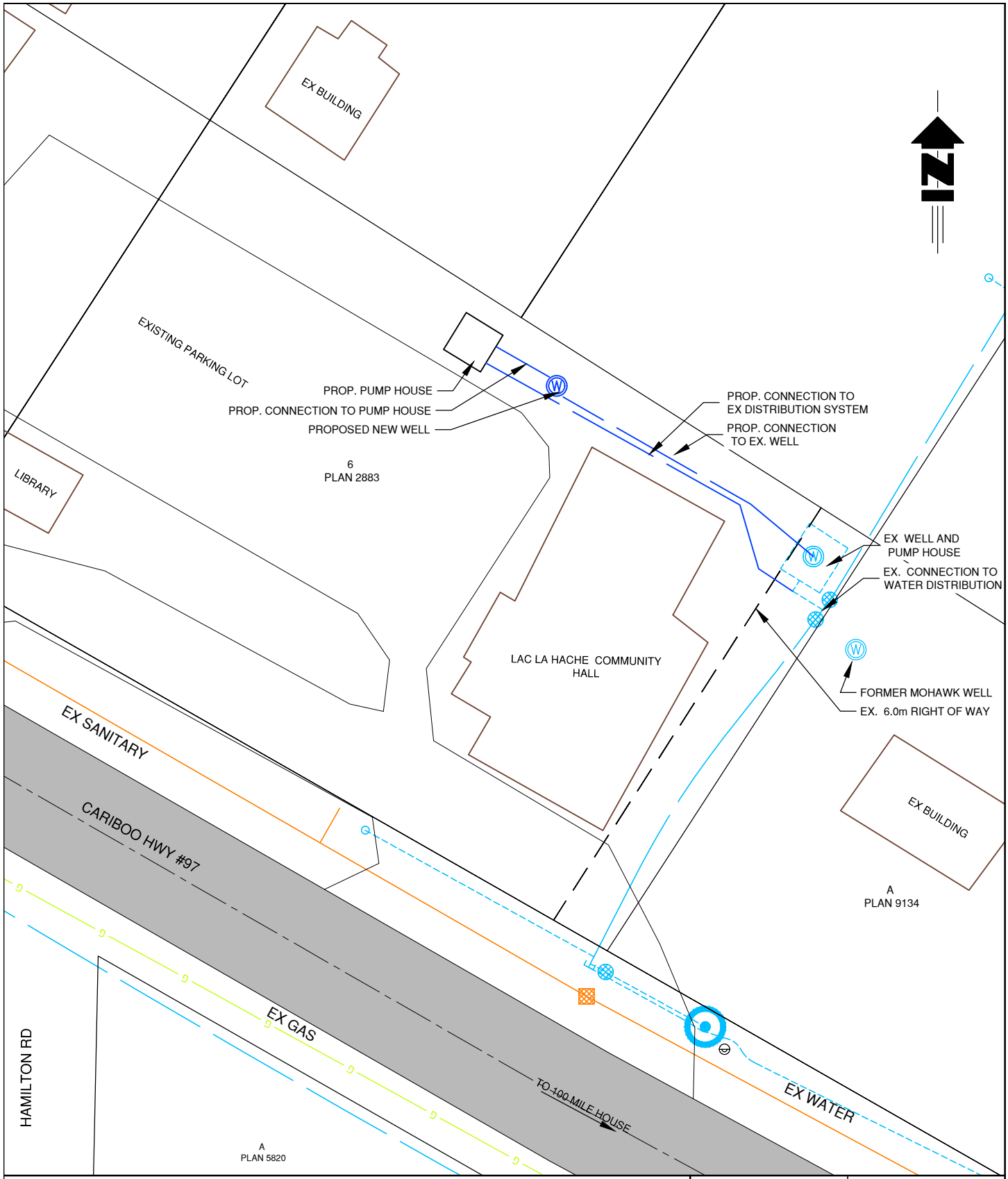
2020-02-05

Graham McCoubrey, AScT.
Project Technologist

Will Bamsey, P.Eng, PMP
Project Engineer

APPENDIX A

Site Plan



CARIBOO REGIONAL DISTRICT

SITE PLAN

TRUE CONSULTING

DSGN. BY:	
SCALE:	NTS
DWG. NO.:	FIG 1
REV.:	1
DWN. BY:	GMC
DATE:	02/04/2020

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APPENDIX B

Groundwater Feasibility Assessment – Western Water Associates

western water
ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

January 31, 2020 FILE: 19-123-01VR

Cariboo Regional District
c/o TRUE Consulting
#106-197 Second Avenue North,
Williams Lake, B.C.
V2G 1Z5

Attn: Will Bamsey, P.Eng.

Re: Groundwater Feasibility Assessment for the Cariboo Regional District Lac La Hache Community Water System

Western Water Associates Ltd. (WWAL) is pleased to provide this hydrogeological assessment of groundwater supply potential for the community of Lac La Hache B.C., located in the Cariboo Regional District (CRD). The feasibility assessment was completed in support of a planned CRD grant application, the goal of which is to provide redundancy to the community water supply.

1. PROJECT BACKGROUND

CRD operates a water system supplying water to the community of Lac La Hache B.C. that is fed by two drilled water supply wells. The wells are situated about 250 m apart on separate parcels, and are referred to as the "Community Hall Well" (WPID15894) and the "Lake Well" (WPID15893) – See Figure 1. WWAL submitted an existing use groundwater licence application on behalf of CRD in February 2019 for the Lac La Hache wells. The annual volume on the licence would be 80,000 m^3/year with a November 1981 date of precedence.

Raw water quality from the Community Hall Well is excellent with no reported aesthetic concerns. The deeper Lake Well has a history of water quality concerns. These include a noted increase in water temperature in the summer months, and a noticeable odour issue (variously described as sulfur or "like lake water" (R. Peddie, pers. comm 2020) When used, the Lake Well is disinfected with chlorine whereas the community hall well water source is delivered to customers without treatment or disinfection. Samples collected from the Lake Well showed detectable total coliforms in the summer of 2016, after which, use of the well was curtailed. Since existing information suggests the shallower Community Hall Well has better water quality, this feasibility study focuses on adding a second well in the same aquifer as the Community Hall well, and preferably, on the same property.

WWAL was retained by the Cariboo Regional District to determine the feasibility of a second supply well with similar water quality and quantity as the District's Community Hall Well. The study was largely a desktop review of available information supplemented by a site visit completed in December 2019.

2. SITE DESCRIPTION, PHYSIOGRAPHY AND GEOLOGY

The Community Hall site covers an area of approximately 0.95 acres, is relatively flat with a slight northeast slope and elevations ranging from approximately 817 m above sea level (masl) in the southwest to approximately 814 masl in the northeast. Highway 97 runs along the southwest property boundary, a former gas station site was reportedly located to the southeast, and residential housing currently bound the site to its north (Figure 1). The Lac La Hache Community Hall, community well, library and thrift store are located on the site. The community hall is near the east property boundary, the Community Well in a pump house in the northeast corner of the site, the thrift store in the site's north, and the library in the northwest of the property.

Bedrock geology beneath the site is mapped as basaltic volcanic rocks of the Chilcotin Group (ENV, 2020). The bedrock in this area is from the Miocene to Pleistocene, 23.3 to 0.01 million years before present. The depth to bedrock in Lac La Hache is variable based on well driller logs. The log for one well (WTN40500) located in close proximity to the Community Well indicated basalt bedrock at 22 m, while bedrock was encountered at 130 m in well WTN1641. Surficial geology at and around the site reflect the influence of glacial advances and retreats, including materials deposited in both sub-glacial and ice-margin environments. Thick till units blanket the majority of the area, deposited during the most recent glacial advance. During the retreat of the regional ice sheet multiple deposits formed in the area, including thin to thick lacustrine (silts) along the shore of Lac La Hache. Adjacent the lacustrine units, to the northeast, are esker deposits (elongated gravel units formed in subglacial meltwater channels), ice contact sand and gravel units formed along ice margins, and an aeolian deposit (sand dune) east of site (Plouffe, 2009).

3. HYDROLOGY, HYDROGEOLOGIC SETTING AND NEARBY WELLS

Lac La Hache is the main surface water body in the area, and at its closest point is about 200 m south of the Community Hall Well. 117 Mile Creek flows past the northeast property boundary at a distance of approximately 300 m and discharges into Lac La Hache 600 m south of the site (Figure 3).

The Community Hall site and much of the Lac La Hache area is underlain by provincially mapped aquifer 423 IIB, mapped as extending approximately 18 km along the north shore of Lac La Hache. The aquifer is classified as a sand and gravel aquifer confined by till with moderate productivity and moderate vulnerability (ENV, 2020). Figure 2 depicts the mapped aquifers in the area.

The other two mapped aquifers in the area include basalt bedrock Aquifer 124, mapped as being present to north, west and east of the subject site and limestone Aquifer 126, mapped the east of the subject site (Figure 2). Some well logs in the Lac La Hache area indicate basalt bedrock was intercepted at varying depths.

Select well construction details for the Community Hall and Lake Wells are included for reference in Table 1. While there are no available well driller's logs, well construction details were obtained from original well construction reports (Kala Groundwater Consulting Ltd., 2003) (Pacific Hydrology Consultants, 1981).

Table 1. Lac La Hache Supply Well Construction Summary

	Community Well (WPID15894)	Lake Well (WPID15893)
Depth (m)	31.4	101.1
Nominal Casing Diameter (mm)	200	150
Static Water Level (m)	5.5 m (1981)	10.2 (2003)
Well Yield (L/s)	12.6	12.6
Screen Details	200 slot (26.9-29.9 mbgs) 150 slot (29.9-31.4 mbgs)	60 slot (96.6-97.8 mbgs) 80 slot (97.8-99.1 mbgs) 120 slot (99.1-100.3 mbgs)
Pump Depth (m)	-	60.0

- Community Well construction details obtained from (Pacific Hydrology Consultants, 1981)
- Lake Well construction details obtained from (Kala Groundwater Consulting Ltd., 2003)

Lithology reported on the log for the Community Hall Well indicates a well confined aquifer (at least locally), with blue – grey silt above and below the aquifer. Lithology for the Lake Well also indicates that the well is completed in a confined aquifer system, with around 70 m of silt and clay overlying the aquifer, which begins at 96 m depth.

The Lake Well is significantly deeper than the Community Hall Well, and Kala Groundwater Consulting hypothesized a lack of hydrologic connection between the aquifers sourced by the Community and Lake Wells based on topography and depths (Kala Groundwater Consulting Ltd., 2003). However, CRD operators reportedly observe water level drawdown in the Community Well during pumping in the Lake Well (Peddie, 2020) suggesting that there is interconnection.

The BC Ministry of Environment Water Resources Atlas (WRA) shows 25 wells within approximately 500 metres of the subject property, select information on these wells is included in Table 2 and Figure 3 (attached) depicts the location of the wells as reported in the WRA. The majority of these wells are within the area serviced by the Lac La Hache water system and are likely no longer in use. It is unknown whether private wells were properly decommissioned following construction of the community water system, but we expect that few if any were. The *BC Groundwater Protection Regulation* requires that owners of wells not in use for 5 years decommission their wells if there is no plan for future use, but this requirement is rarely enforced unless driven by complaints.

Reported driller estimated water yields of wells in proximity to the subject property are on the order of 0.4 L/s to 3.8 L/s (6 to 60 US GPM) with WTN16141 reported as dry and installed in bedrock. The two community supply wells stand out as the most productive reported wells in the area (See Section 4).

Table 2. Selected information for wells near the subject property (See Figure 3)

Well Tag Number	Finished Well Depth (ft)	Diameter (in)	Depth to Water (ft)	Depth to Bedrock (ft)	Reported Well Yield (US GPM)
474	80	6.5	4	-	-
24334	72	-	-	-	-
45695	244	-	40	-	25
14333	86	5	36	-	6
5916	92	-	54	-	-
15621	136.5	-	15	-	35
5920	22	-	-	-	-
20345	36	-	-	-	
13920	130	5	0	-	-
14328	15	-	13	-	-
24267	83	-	-	-	10
24331	327	-	-	-	-
16798	160	-	20	-	-
21845	200	6.5	30	30	22
14330	45	5	12	-	6
17289	42	-	30	-	-
16198	140	-		-	-
19699	50	-	14	-	-
31837	130	6	50	-	5
16141	428	-		422	dry
40500	100	-	16	-	45
20343	60	-	2	-	-
24336	210	-	21	-	-
13728	90	-	30	-	60
5912	81	-	16	-	0

4. SUMMARY OF PREVIOUS PUMPING TEST RESULTS

Community Hall Well (WPID15894)

The Community Hall Well was drilled in 1981 and tested under the supervision of Pacific Hydrology Consultants Ltd. in March 1981. The well was pumped at a rate of 25.2 L/s (400 USgpm) for 30.5 hours after which time 73% of the available drawdown was used. Water level stabilization did not occur during the test. Based on the results of the pumping test Pacific Hydrology Consultants concluded that the well was capable of sustainably producing at least 200 US GPM (12.6 L/s), which was the community's anticipated demand at that time (Pacific Hydrology Consultants, 1981).

Lake Well (WPID15893)

The Lake Well was drilled in 2002 under the supervision of Kala Groundwater Consulting and well yield testing was conducted August 24, 2002. A static water level of 11.3 mbtoc was observed and a variable rate test was completed at rates of 6.3 (100 USgpm) and 12.6 L/s (200 USgpm). The variable rate test was followed by a 1,256 min (20.9 hours) constant rate pumping at a rate of 19 L/s, after which, a maximum water level drawdown of 21.8 mbtoc was observed. Water level drawdown neared but did reach stabilization and 12% of the available drawdown was utilized (Kala Groundwater Consulting Ltd., 2003).

Seasonal Water Level Variations

There are no provincial observation wells installed near Lac La Hache from which seasonal groundwater level variations could be inferred. We would expect that seasonal and multi-year water level fluctuations in the aquifer could be 1-3 m in magnitude, with lower water levels occurring during late fall and winter and higher water levels occurring in spring and early summer. There are no reports of water levels in the Community Hall Well fluctuating significantly enough to raise concerns regarding availability of water. We do not believe that seasonal water level variations will limit availability of water in a similarly constructed well near the community well.

Potential for Well Interference

Well interference, where significant enough, can be a limiting factor to well yield. The potential for well interference at this site is considered to be low as the wells reported near the property are likely no longer in use as the surrounding area is connected to the Lac La Hache water system. Well interference between the Lake Well land the Community Well has reportedly been observed by the water system operators, the magnitude of which was not considered significant (Peddie, 2020). Considering the observed productivity of the aquifer and the available drawdown, well interference is not considered a concern with expected pumping rates.

5. WATER DEMAND

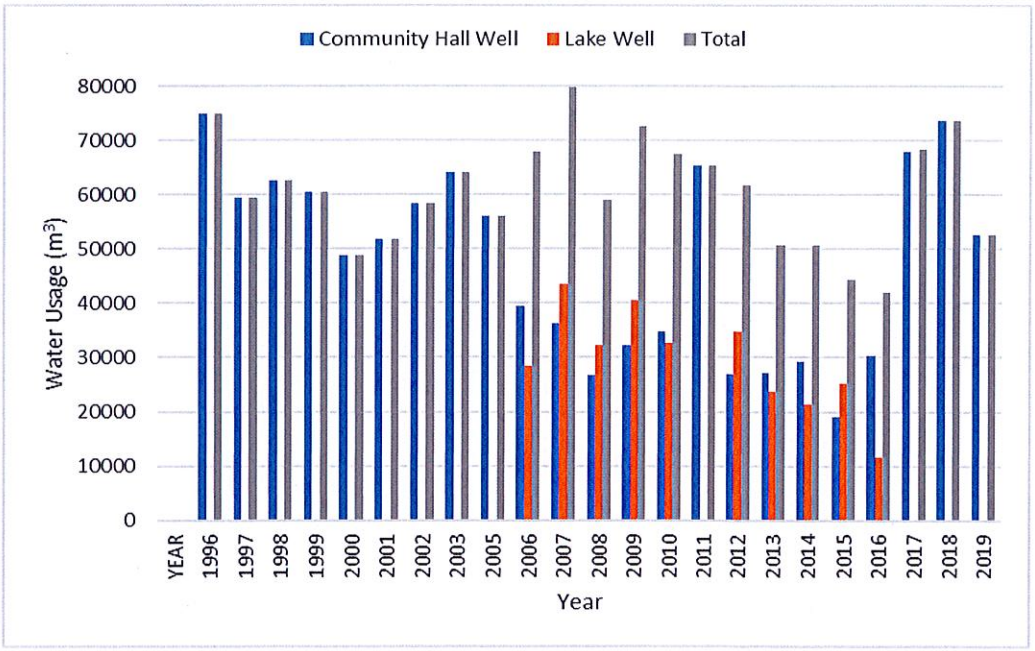
Annual water usage data for Lac La Hache from 1996 to 2019 are summarized in Table 3 and depicted in Figure A. Annual water usage recorded between 1996 and 2018 ranges from approximately 42,000 m^3/year to 80,000 m^3/year, equivalent to continuous pumping rates of roughly 21 to 38 US GPM.

Water usage appeared on the decline from 2007 to 2016 followed by an increase in usage in 2017/2018 to near 2007 totals. Years 2017 and 2018 were notably hot, dry summers and may have contributed to the increase in usage. Most notable is the decrease in usage of water from the Lake Well starting in 2016. CRD operators reported poor aesthetic water quality from the Lake Well which also had detectable Total Coliforms in 2016 (Peddie, 2020). The CRD also indicated that the current pumping rate of 200 USgpm had been more than adequate at maintaining reservoir levels during peak demand (Peddie, 2020).

Table 3. Lac La Hache Water System Annual Water Usage

Year	Annual Water Usage (m^3)		
	Community Hall Well	Lake Well	Total
1996	74,899.10	-	74,899.10
1997	59,362.5	-	59,362.5
1998	62,594.46	-	62,594.46
1999	60,418.87	-	60,418.87
2000	48,839.17	-	48,839.17
2001	51,865.89	-	51,865.89
2002	58,292.19	-	58,292.19
2003	64,067.26	-	64,067.26
2005	56,104.57	-	56,104.57
2006	39,499	28,344	67,843
2007	36,250.59	43,448	79,698.59
2008	26,675.23	32,272	58,947.23
2009	32,247.12	40,407	72,654.12
2010	34,826.75	32,691	67,517.75
2011	65,286.95	0	65,286.95
2012	26,928.38	34,802	61,730.38
2013	27,088.49	23,648.70	50,737.13
2014	29,327.27	21,463.36	50,790.63
2015	19,143	25,194.32	44,337.32
2016	30,354.31	11,538	41,892.31
2017	67,993.00	238	67,993.00
2018	73,713.00	0	73,713.00
2019	52,603.50	0	52,603.50

Figure A: Lac La Hache Water System Annual Water Usage



6. B.C. SITE REGISTRY SEARCH

A search of the iMap B.C. Environmental Remediation Sites layer, which includes all sites recorded in the B.C. Site Registry Database was completed on December 16, 2019. Detailed reports were requested for Site ID 5526. Based on our search of available records the status of the sites, in terms of remediation, are relatively unknown (BC Online: Site Registry, 2019). Table 4 summarizes provincially registered sites identified during the search, and the locations of these sites are shown on Figure 1.

Table 4: Summary of Provincially Registered Sites (Contaminated Sites Regulation).

Site ID Number	Civic Address	Location Relative to Community Well	Location Relevant to Inferred Groundwater Flow Direction	Site Details (if known)
455	4842 Hamilton Road, Lac La Hache	120 m Southwest	Down/cross gradient	Former Gas Station
728	3989 Highway 97, Lac La Hache	190 m Northwest	Cross gradient	Husky Foodmart
981	4017 Highway 97, Lac La Hache	275 m Southeast	Down/cross gradient	Former Shell Station
5526	3999 Highway 97, Lac La Hache	Adjacent property to the southeast.	Cross gradient	Former Mohawk Gas Station

Site 455

The detailed report for Site ID 455 indicated that gasoline odour was encountered during the excavation of the water line to the Lac La Hache library in 1986 (80 m west of Site). The contamination source was suspected to be a leaking underground fuel storage tank (UST) at a former service station across the highway from the community hall (BC Online: Site Registry, 2019). No additional information was included in the detailed report indicating further investigation. However, CRD operators believed the source of the contamination was later found to have been a truck spill in the ditch (Peddie, 2020). A surficial spill is more likely to have impacted the library property soils than Site 455 as a ditch line separates the sites (ultimately draining to the lake) and impacted soils were above the groundwater table.

Site 5526

Site ID 5526 adjoins the site to its southeast and a gas station (Mohawk) was formerly located on the now vacant property (BC Online: Site Registry, 2019). A Phase 1 and 2 Environmental Site Investigation were conducted by Marlim Ecological Consulting Ltd (Marlim Ecological Consulting Ltd. , 2004). and underwent a third-party review requested by the B.C. Ministry of Environment conducted by Keystone Environmental (Keystone Environmental, 2004). WWAL reviewed the Phase 1 and 2 report, and the third-party review.

Three groundwater monitoring wells were installed and sampled at the property in 2004. Impacts to groundwater were observed exceeding standards at the time. Soils were described as having very little moisture content above 4.6 mbgs overlying "very dry" till (Marlim Ecological Consulting Ltd. , 2004). No well construction details were included in the report and maximum depths described in soil logs were (12.2 mbgs). As such, there is no

information to infer the vertical location of any potential soil/groundwater impacts. In addition, there is a high likelihood that large screens were installed to attempt to obtain a groundwater sample from dry soils. The large screens would be a potential vertical pathway for contaminants to migrate through a portion of the aquitard protecting the Community Hall Well.

Two water wells (WTNs 40500 and 24267) are reported on the former Mohawk property in the BC Water Resources Atlas (MFLNRORD 2019), at least one of which is still present on the site. The existing well is located 6 m from the community hall well and formerly used to supply domestic water to the Mohawk station. Based on notes on the onsite well logs, the well is believed to be WTN 40500, which indicates that the well was located in the northwest corner of the property. The well is reportedly located in a 2.5 m deep pit and was capped with a welded steel plate by the CRD (Peddie, 2020). The presence of this well represents a significant concern as it penetrates the aquitard capping Aquifer 423 providing a preferential pathway for shallow contamination.

Based on our review of the Phase 1 and 2 report and subsequent third-party review, it appears hydrocarbon contamination in soil and shallow groundwater at the site existed in 2004. It is our understanding that no remedial actions were completed at the site since 2004.

7. WATER QUALITY ASSESSMENT

Table 4 shows a summary of the average water quality results from samples collected by the CRD from the Community Hall Well between 1996 and 2018 (14 samples) and from the Lake Well between 2010 and 2017 (7 samples). The water quality results were compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) criteria for the parameters analyzed (Health Canada, 2019). A complete summary of water quality results is included as an attachment to this report. When CRD operates the Lake Well, water quality issues such as orange staining in fixtures and a sulfur like odour were noted by residents (Peddie, 2020). Although there have been suggestions of possible surface water (lake water) influence, there is insufficient information to determine if this could be the case. Given the relatively deep well completion, a direct influence from the lake seems unlikely.

In general, water from the two supply wells meet all health-based Maximum Allowable Concentrations (MAC) and Aesthetic Objectives (AO) of the GCDWQ with a few exceptions.

- Exceedances of the AO for iron and manganese were noted in a 2002 sample collected from the Community Hall Well. This appears to be an anomalous result, as concentrations of these parameters are typically very low or below detection limits.
- Samples for uranium exceeded the MAC in the Community Hall Well between 1997 and 2001. These results are also suspect, as in the nine samples collected since 2002, uranium has consistently been in the 0.002 mg/L range, 10x below the MAC.
- Total coliform bacteria were detected in one sample collected from the Lake Well in July 2016 and manganese concentrations in this well are consistently above the new AO of 0.02 mg/L introduced in 2018 Aesthetically, residents and operators report excellent water quality from the Community Well and poor quality from the lake well (Peddie, 2020).

Some additional general observations on water quality from the wells include:

- Since 2010, iron and manganese concentrations have been consistently below their respective detection limits at the Community Hall Well. In contrast, manganese in the Lake Well is consistently in the 0.04 to 0.5 mg/L range, which is above the manganese AO of 0.02 mg/L.
- During the original testing of the Community Hall Well in 1981, nitrate was measured at 3.7 mg/L. Since 2010, nitrate concentrations have fluctuated in the 0.6 to 1.5 mg/L range. It appears that nitrate concentrations in the aquifer have declined since a community wastewater collection system was constructed in Lac La Hache.
- All water quality parameters reviewed for the Community Hall Well appear stable, with no obvious increasing or decreasing trends in concentration.
- Routine bacteriological results collected from the distribution system dating back to 2006 indicate very few occurrences of total coliform bacteria. *E.Coli* has never been detected.
- Although there is some evidence of shallow soil and groundwater contamination by hydrocarbons, there has been no testing of the deeper CRD wells for hydrocarbon-related contaminants.

The CRD does an excellent job at collecting comprehensive potability samples from the supply wells on a frequent basis, but as we note above, hydrocarbons have not been a part of this routine analysis. Accordingly, WWAL collected a water sample for hydrocarbon analysis from the Community Hall Well during a site visit on December 18, 2019, as several gas stations, the majority of which are no longer operational, were identified during the site registry search. Analytical results for hydrocarbon sampling are included in Table 5 and the complete laboratory report is provided as an attachment. Water samples collected for hydrocarbon analysis were analyzed for BTEX, VPH, EPH and PAH. All analyzed hydrocarbon parameters were below laboratory method detection limit, suggesting that water quality within the aquifer at the time of samples showed no signs of impact from hydrocarbon contamination. The Community Hall Well was noted to have been actively pumping within a 24 hour period prior to sampling.

Table 5. Groundwater Quality Summary – Lac La Hache Community Hall Well and Lake Well

Parameter	Units	Average Results 1996 - 2018	Average Results 2010 - 2017	Guideline
Well ID		Community Hall Well	Lake Well	
Field Parameters	**Units**			**GCDWQ**
pH (field)	pH units	8.20	8.38	AO = 6.5 - 8.5
General Parameters and Nutrients				
Total Dissolved Solids	mg/L	459	463	AO ≤ 500
Hardness	mg/L	330	274	
Fluoride	mg/L	0.04	0.097	MAC = 1.5
Nitrate/Nitrite	mg/L	1.07	<0.02	Nitrate MAC = 45 Nitrite MAC = 3
Chloride	mg/L	-	-	AO ≤ 250
Sulfate	mg/L	65	154	AO ≤ 500
Selected Total Ions and Metals				
Aluminum	mg/L	0.01	0.023	OG < 0.1
Antimony	mg/L	<0.0005	<0.0005	MAC =0.006
Arsenic	mg/L	0.0042	0.0034	MAC = 0.01
Barium	mg/L	0.01	0.0186	MAC = 2
Chromium	mg/L	0.001	<0.001	MAC = 0.05
Copper	mg/L	0.0023	<0.0002	MAC =2 AO ≤ 1
Iron	mg/L	0.13	0.045	AO ≤ 0.30
Lead	mg/L	0.0035	<.0002	MAC = 0.01
Manganese	mg/L	0.01	**0.045**	MAC = 0.12 AO < 0.02
Selenium	mg/L	0.0034	<0.0001	MAC = 0.05
Sodium	mg/L	41	63	AO ≤ 200
Uranium	mg/L	0.017	0.0013	MAC = 0.02
Zinc	mg/L	0.01	<0.005	AO ≤ 5
Bacteriological Parameters				
Total Coliforms	MPN/100mL	<1	<1; (2 TC in July 2016)	MAC < 1
E. coli	MPN/100mL	<1	<1	MAC < 1
		Dec 18, 2019		
Hydrocarbons				
MTBE	mg/L	<0.001	-	AO ≤ 0.015
Benzene	mg/L	<0.0005	-	MAC = 0.005
Toluene	mg/L	<0.0005	-	MAC = 0.06 AO < 0.024
Ethylbenzene	mg/L	<0.0005	-	MAC = 0.14 AO < 0.0016
Total Xylenes	mg/L	<0.001	-	MAC = 0.09 AO < 0.02

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

8. CONCLUSIONS AND RECOMMENDATIONS

C1 Based on our review of the information available, we are of the opinion that there is a good probability of constructing a back-up well similar to the existing Community Hall Well on the same property. A suitable location with enough room to construct a new well exists between the community hall and the northeast property boundary (Figure 4).

C2 A review of historical water quality data from the Community Hall Well indicates good water quality, both in terms of health-based and aesthetic parameters. A sample for hydrocarbon parameters was collected in December 2019, and all parameters were below detection limits.

C3 Anecdotally, CRD water system operators report aesthetic water quality issues with the Lake Well, to the point where the well has been phased out of use since 2016. The anecdotal reports indicate changes in water temperature, odours and staining results when the Lake Well is used. A review of historical water quality results for the Lake Well suggests that water quality from that source is also fairly good, albeit with detectable iron and manganese.

C4 Several registered contaminated sites exist in proximity to the community hall property, representing a risk of subsurface contamination. All sites are associated with historical or current service and gas stations. Water quality in the Community Hall Well does not appear to be currently impacted by hydrocarbons, based on sampling conducted in December 2019.

C5 One of the reported contaminated sites, a former Mohawk gas station, is located directly east and adjacent to the Community Hall Well site. A review of historical reports indicates that soil and groundwater contamination were present at the site circa 2004, and we are not aware that any remediation occurred at the site since that time. Of import is the presence of the former domestic well for the Mohawk station which is located ~6 m from the community hall well. While this well was capped by the CRD, proper decommissioning of that well is a high priority.

Based on the above conclusions, the following recommendations are made:

R1 A new nominal 200 mm supply well is recommended for installation approximately 20 to 30 m from the Community Hall Well as shown on Figure 4. The new well is expected to be of similar construction to the existing well (WPID15894). We would suggest incorporating a slightly longer than typical surface seal into this well design to ensure the surface seal seats firmly into the silt confining unit overlying the aquifer. Once commissioned, the new well will likely be appropriate for use as the community's primary well, while WPID15894 can be maintained as a backup source.

R2 Following up on the December 2019 sampling, we recommend that two additional samples for hydrocarbons be collected from the Community Hall Well in 2020 following snow melt to confirm hydrocarbon absence. In addition, if a new well is to be constructed and chlorination included as part

of a water system upgrade, the Community Hall Well should be sampled for total organic carbon and disinfection by-product formation potential at one those times.

R3 The formerly-used water supply well located on the property to the southeast of the subject site (former Mohawk station) should be decommissioned in accordance with the *B.C. Groundwater Protection Regulation* to minimize the risk of contaminants being introduced into the aquifer. Specifications for decommissioning should be prepared by a hydrogeologist with experience in contaminated sites and completed by a licensed well driller. Proper decommissioning of the former Mohawk domestic supply well is identified as a high priority item. The well will need to camera surveyed first to verify its integrity and completion inform the closure design.

Several monitoring wells are also reportedly present on the Mohawk property, installed as part of a contaminated sites investigation in 2004. These wells may still be of minor use in assessing impacts at the Mohawk property, but are a potential aquifer contamination pathway. There is little information on the completion of these wells or lithology observed in the contaminated sites reports reviewed by WWAL, so their usefulness is limited.

Closure of the Mohawk domestic well and monitoring wells would require the consent of the property owner. In the case of the former domestic well, a strong case can be made that this well poses a risk to the Community Hall Well, and the help of the Ministry of Environment can likely be enlisted to issue an order for closure of that well, should it be needed.

R4 Consider establishing a Source Protection Area around the Community Hall property and wells and use this designation to advocate (e.g. through the Ministry of Environment) for further remedial works that may be necessary at nearby contaminated sites such as the former Mohawk station. Although the water supply aquifer at the site appears to be protected by a confining layer, the aquifer is relatively shallow and other wells may fully or partially penetrate the confining layer. Eliminating the source(s) of contamination as well as potential contaminant migration pathways such as abandoned or unused wells will be in the best interests of the community drinking water system.

R5 To the best of our knowledge, no remedial activities at the former Mohawk station have occurred since 2004. As that site is privately owned, it is difficult to force that to occur, but the CRD should consider contacting the owner of that property and requesting an update on his plans for the property. As a due diligence measure, and a lower priority/optional recommendation, we recommend consideration be given to installing three monitoring wells at the community hall property and sampling soil and groundwater for hydrocarbons. The approximate location of these wells are shown on Figure 4. These wells would be completed above the aquifer in which the community hall well is completed, and would be aimed at identifying if shallow soil and groundwater contamination have migrated onto the community hall property from offsite sources. Confirming offsite migration of contamination is a strong tool that could be used to help force remediation of the adjacent property, if other attempts to have contamination on the site addressed are unsuccessful.

R6 While no operational issues are reported with the current Community Hall Well, the well is 39 years old and we understand that no well rehabilitation works have been completed. We also understand that as part of water system upgrade project, the Community Hall Well would be retrofitted to include

a pitless adaptor. While the permanent pump is out of the well for pitless installation, we recommend that a camera survey on the well be completed, and some basic well rehabilitation (brush screen and casing, surge and bail development) on the well be completed.

9. COST ESTIMATES

WWAL has prepared a high-level cost estimate to complete the above recommended tasks. Table 6 below summarized the estimates by task.

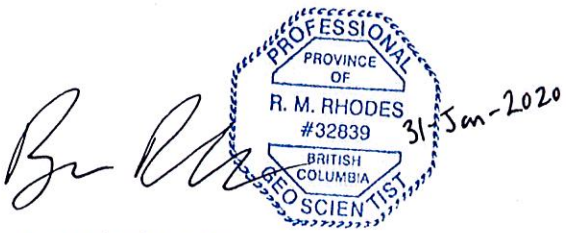
Table 6: High level cost estimates to complete recommended tasks.

Task	Contractor	Cost Estimate
Installation of new 200 mm supply well at Community Hall site	Hydrogeology	$17,000
	Drilling Contractor	$40,000
	Pumping Test Contractor	$18,000
	Sub-Total	**$75,000**
Camera survey and well decommissioning on adjacent property (former domestic well only)	Hydrogeology	$2,500
	Drilling Contractor	$6,000
	Sub-Total	**$8,500**
Well Rehabilitation Works on Existing Community Hall Well as Part of Upgrades	Hydrogeology	$5,000
	Well Rehabilitation Contractor	$20,000
	Sub-Total	**$25,000**
	Total	**$108,500**
Lower Priority / Optional		
Installation/Sampling of 3 monitoring wells	Hydrogeology; soil and water testing	$10,000
	Environmental Drilling Contractor	$15,000
	Sub-Total	**$25,000**

10. CLOSURE

We trust this letter provides the information you require. If you have any questions or would like to discuss these findings further, do not hesitate to contact the undersigned.

Western Water Associates Ltd.



Warren Grafton, P.Geo.
Hydrogeologist

Ryan Rhodes, P.Geo
Hydrogeologist

Attachments:

Figure 1: Site Location and Registered Sites Location
Figure 2: Regional Aquifer Map
Figure 3: Area Wells Map
Figure 4: Recommended Well Locations

11. REFERENCES

BC Online: Site Registry. (2019, December 15). Area Search. Williams Lake, BC.

ENV. (2020). *Water Resource Atlas*. Retrieved from http://www.env.gov.bc.ca/wsd/data_searches/wrbc/

Health Canada. (2019). Guidelines for Canadian Drinking Water Quality - Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada. Ottawa, Ontario.

Kala Groundwater Consulting Ltd. (2003). *Cariboo Regional Distric Lac La Hache Community Groundwater Supply Investigation.* Kamloops.

Keystone Environmental. (2004). *Opinion Regarding Adequacy of Phase 1 and 2 (Under Order).* Burnaby.

Marlim Ecological Consulting Ltd. . (2004). *Phase 1 and 2 Environmental Site Investigation Report 3999 Hwy 97 Lac La Hache, British Columbia.* Surrey.

Pacific Hydrology Consultants. (1981). *Well Construction and Testing.* Vancouver.

Peddie, R. (2020, January 21). Lac La Hach Communitee Well. (W. Grafton, Interviewer)

Plouffe, A. (2009). Lac La Hache Open File 6193. *Surficial Geology of British Columbia*. Geological Survey of Canada.

Province of British Columbia. (2016, February 29). *Groundwater Protection Regulation.* Retrieved from http://www.bclaws.ca/civix/document/id/complete/statreg/39_2016

Figure 1: Site Location Map and Registered Site Locations

Date: January 2020	Image Source: CRD Maps		WWAL Project: 19-123-01
Drawn by: WG	Checked by: RR	Client: Cariboo Regional District	Client Project: N/A

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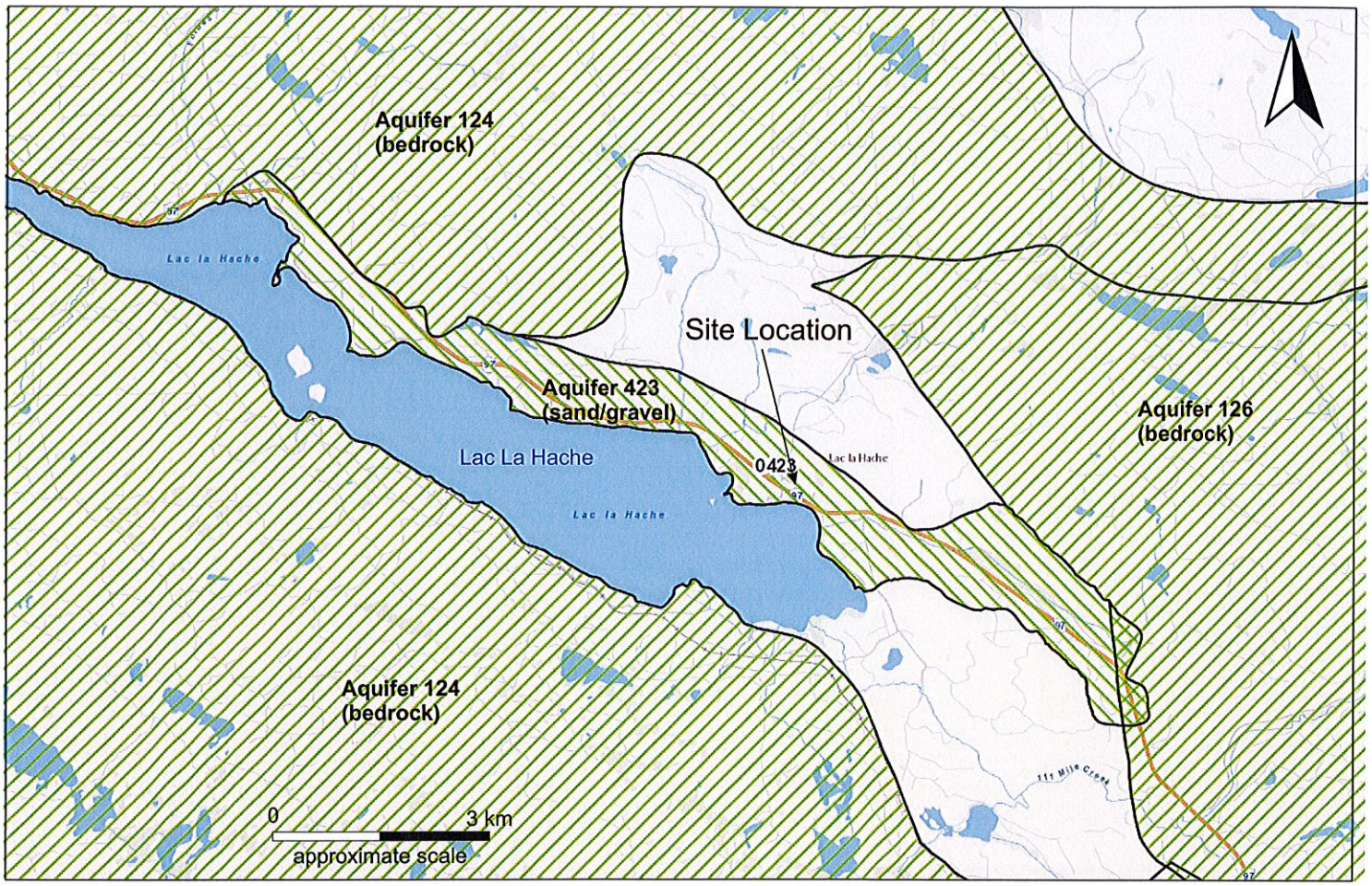

Figure 2: Regional Aquifer Map

Date: January 2020	Image Source: BC Water Resources Atlas		WWAL Project: 19-123-01
Drawn by: WG	Checked by: DG	Client: Cariboo Regional District	Client Project: N/A

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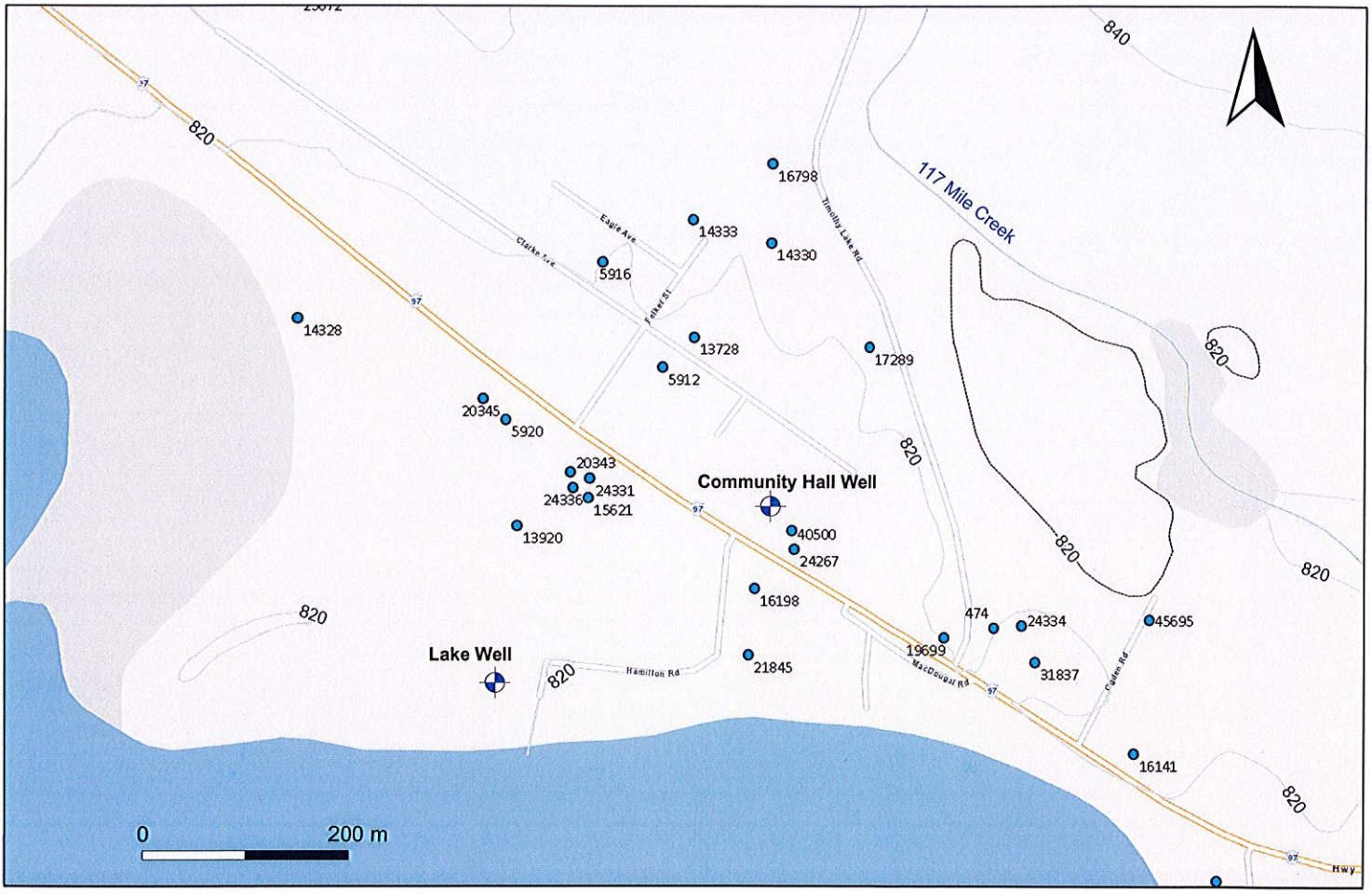

Figure 3: Area Well Location Map

Date: January 2020	Image Source: BC Water Resources Atlas		WWAL Project: 19-123-01
Drawn by: WG	Checked by: RR	Client: Cariboo Regional District	Client Project: N/A

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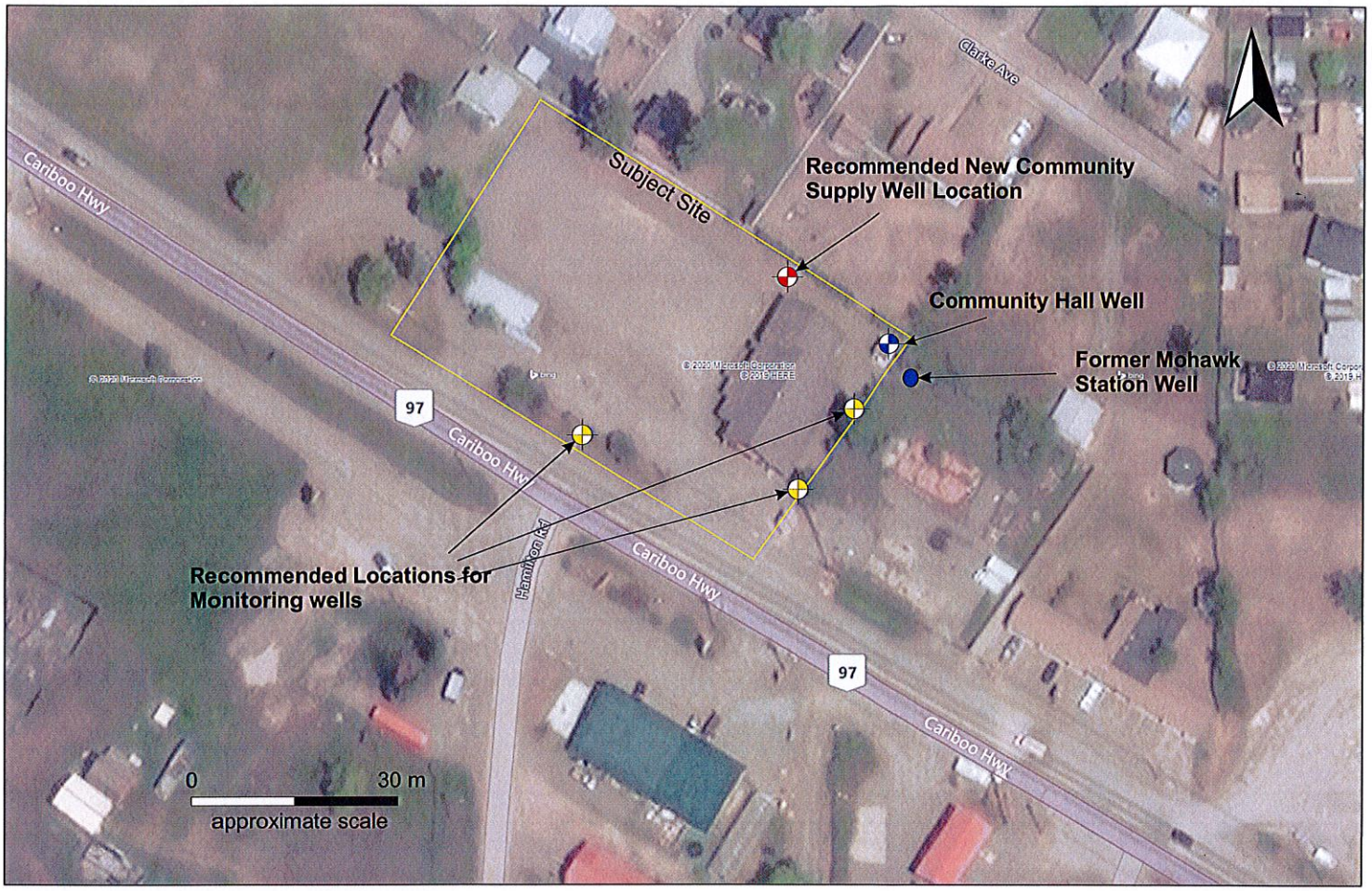

Figure 4: Well Installation Recommendations

Date: January 2020	Image Source: CRD Maps		WWAL Project: 19-123-01
Drawn by: WG	Checked by: RR	Client: Cariboo Regional District	Client Project: N/A

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