Water Treatment Review – Desktop Study

July 10, 2020 | Revision 0

Submitted to: Qualicum Bay Horne Lake Waterworks District
Prepared by McElhanney Ltd.

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Project # 2231-34510-01

Your Challenge.
Our Passion.

File: [2231-34510-01]

July 10, 2020

Qualicum Bay - Horne Lake Waterworks District
234 Lions Way
Qualicum Beach, BC V9K 2E2

Attention: Leigh Campbell, Administrator

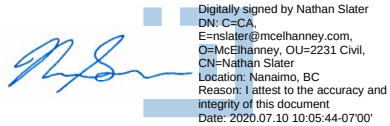
Re: Water Treatment Review – Desktop Study

Please find attached a conceptual water treatment review focusing on water quality and treatment options for the District's current supply system. The work was carried out in accordance with McElhanney's proposal dated August 20, 2019.

McElhanney would be happy to discuss the findings with the District and answer any questions at the next available board of Trustees meeting or another time convenient for both parties.

It should be noted that one of the key recommendations of this report is to obtain further water sampling and testing, with that in mind if future test results in 2020 bring forth new information that impacts the recommendations in this report; McElhanney would be happy to issue a revision as necessary.

Sincerely,
McElhanney Ltd.



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Executive summary

The Qualicum Bay Horne Lake Waterworks District (the District) retained McElhanney Ltd. (McElhanney) to conduct a conceptual water treatment review and this report presents a desktop overview of our findings. Specifically, this report provides background on the existing water supply, water quality criteria, historical and current water quality as well as a potential treatment options to remove the presence of Manganese from the District's water supply.

Currently, the District supplies drinking water from Quadra Sands aquifer via three ground water wells and two reservoirs located on Horne Lake Road. The reservoirs are connected to a distribution system which serves approximately 500 connections within the District.

Historically, the drinking water has consistently been within the Guidelines for Canadian Drinking Water Quality as set by Health Canada. Based on historical data the ground water is high in Manganese content. When Manganese is present in groundwater it is soluble meaning it is dissolved in the water and visually undetectable; however, when it reaches the surface and is exposed to oxygen, Manganese precipitates into a suspended solid form that discolours the water creating a blackish hue. This becomes a problem for the District as it builds up in the distribution system and the water becomes aesthetically undesirable to its users by appearing "dirty" and staining household items such as dishes and laundry. To combat the build up of precipitated Manganese the D istrict flushes the entire system 4 times a year; an intensive and cumbersome process.

Historically, Manganese has been an aesthetic nuisance for the District. Prior to 2019 the only guideline for Manganese was an aesthetic objective (AO) of equal or less than 0.05 milligrams per litre (mg/L); however, based on new research, the guideline was updated in 2019 to include a Maximum Allowable Content (MAC) of 0.12 milligrams per litre (mg/L). In the past 10 years the average Manganese content in the District has been approximately 0.12 mg/L; however, test results conducted in December 2019 showed well #1 (0.143 mg/L) and well #2 (0.135 mg/L) both exceed the MAC. McElhanney recommends the District complete at least 3 more water quality tests in 2020 to confirm exceedance of MAC.

Beyond the current guidelines and water quality this report focused on potential water treatment options for the District. It has been determined this system would be most suited for a chlorination and filtration process contained within a water treatment facility. One key advantage with this methodology is that it provides chlorination which serves two purposes; firstly, by acting as an oxidant, which will precipitate the Manganese and allow it to be filtered out of the water distribution; secondly, the chlorine will act as a disinfectant which protects against bacteriological outbreak and could become an eventual requirement for the District via the Island Health Authority. Another advantage to chlorination and filtration is that the technology is common and can be standardized from a wide range of vendors, and can be contained in a prefabricated water treatment plant which lowers capital cost, provides higher quality control during construction and provides easier maintenance verse conventional built onsite water treatment plants.

A summary of key recommendations in this report are as follows:

1. At minimum, McElhanney recommends completing at least 3 water quality tests in 2020 to confirm exceedance of maximum allowable manganese content. A recommended sampling schedule is as follows:

Proposed Testing Schedule
April 2020
June 2020
September 2020

2. McElhanney recommends continuing to test from all three well sites but also recommends adding a fourth testing location at the output of the reservoir to ensure a true representation of Manganese concentration in the distribution system is obtained.

3. Based on the summary of historical Manganese test results Well #3 has produced the lowest concentration and Well #1 the highest. McElhanney has been informed by the District that they are exploring the option of only pumping from Well #2 and #3 to possibly “blend” the concentration to a level lower than the MAC. McElhanney acknowledges that this approach could be beneficial as a temporary solution but recommends consulting with their groundwater resource consultant (Waterline) to ensure that these wells can handle the water demand without disturbing their recharge rates.

4. If further test results confirm that the Manganese concentration is above the MAC (maximum allowable content) McElhanney recommends discussing the results with Island Health to determine appropriate steps forward as per the water supply regulations. If treatment is determined to be a requirement McElhanney recommends the District retain a consultant to examine options and qualifications for provincial funding.

5. At a Class D level, we estimate capital for this project to be in the range of $1,141,000 and the 20- year life-cycle costs to be in the range of $2,837,000.

1. Introduction

The Qualicum Bay Horne Lake Waterworks District (the District) retained McElhanney Ltd. (McElhanney) to conduct a conceptual water treatment review and this report presents a desktop overview of our findings. The following information is discussed in this report:

- an overview of the existing water infrastructure and supply;
- water quality criteria;
- historical and current water quality;
- an overview of water treatment options;
- capital and operating expenditure estimates; and
- conclusions and recommendations

1.1. BACKGROUND

Qualicum Bay is a seaside community located on the east coast of Vancouver Island approximately 60 km north of Nanaimo, BC and 50 km south of Courtenay, BC. This unincorporated community lies within the Regional District of Nanaimo and forms part of Electoral Area “H”.

The Qualicum Bay Horne Lake Waterworks District was incorporated by Letters Patent under the Water Act in 1968 as an Improvement District as defined under the Local Government Act. The District’s Letters Patent define a mandate to acquire, maintain, and operate works for water supply and distribution and all matters incidental.

The District borders the Bowser Waterworks District to the North and the Little Qualicum Waterworks District to the south. The water system serves approximately 500 customers.

Figure 1 District Boundaries

The District supplies water to its customers through three production wells. Groundwater is untreated; however, it is periodically sampled by the District and tested as a requirement of their operating permit regulated by the region's health authority (Island Health). Historically, water quality results have been of good quality and have met water quality standards set by Health Canada.

In 2019, Health Canada issued an update to their Guidelines for Canadian Drinking Water Quality. Of significant importance was Manganese, a parameter commonly seen in groundwater sources. Manganese was previously considered as an aesthetic nuisance, having typically resulted in discolouration of water and water fixtures. That has since changed to an allowable Maximum Acceptable Concentration, with studies suggesting it could lead to health effects in certain parts of the population, including infants.

1.2. SIGNIFICANCE OF MANGANESE

1.2.1. Origin and Occurrence

Manganese is an essential trace element originating within the earth's crust. While also found in industrial and consumer products, it is common to see this element within groundwater, and in some cases surface water sources. In humans, manganese is involved in the digestion and absorption of food as well as other metabolic activities

1.2.2. Ground Water

Manganese is found naturally in groundwater throughout British Columbia. It is common to see Manganese and Iron concentrations in groundwater, which typically fluctuates with the passing of each season. Manganese concentrations can also vary with the depth, location of the well and the geology of an area. Manganese naturally occurs in groundwater that has little or no oxygen, typically in deeper wells (but not always), in areas where groundwater flow is slow, and in areas where groundwater flows through soils rich in organic matter. In ground water wells, where oxygen content is low, manganese-bearing water is clear and colorless as the manganese is dissolved in the water. Once groundwater is exposed to oxygen, such as entering a water reservoir or exiting a tap, the Manganese oxidizes and can present a discolouration to the water.

2. Water Supply

2.1. GROUND WATER WELLS

Water supply is currently provided by three (3) water wells located on the west side of Horne Lake Road, 160 metres south of Olympic Road. These wells tap the Quadra Sands Aquifer and provide high yield and good quality water. Security fencing is installed around the reservoirs and well field. In addition, each well head is protected with an individual pump control building. Water from these wells is pumped to 3 storage facilities.

Figure 2 Plan and street view of the current well and reservoir infrastructure

All three wells are in general use, with any one well in operation at any given time. Pumps are controlled manually to alternate well operation. Water consumption is measured by flow meters at each well head and logged via SCADA (supervisory controlled and data acquisition). The system is also tracked by individual meters on each service connection. Further analysis of water usage is presented in the District's Water System Evaluation Report completed by McElhanney dated January 3, 2014. Based on analysis completed in that report a safe yield from all 3 water wells is assumed as 14 litres per second (L/s)[2] and a historical Maximum Day Demand 14.8 litres per second (L/s).

2.2. WATER STORAGE

The following three reservoirs are located at the well field:

- Two above ground bolted steel tanks with a volume of 500,000 litres (110,000 lgal) each; and,
- One ground level concrete tank with a volume of 230,000 litres (50,500 lgal).

[2] Pajak, Dalton. Well Field Capacity Assessment Qualicum Bay Horne Lake Waterworks. Waterline Resources Inc., 2020, pp. 1–56, Well Field Capacity Assessment Qualicum Bay Horne Lake Waterworks.

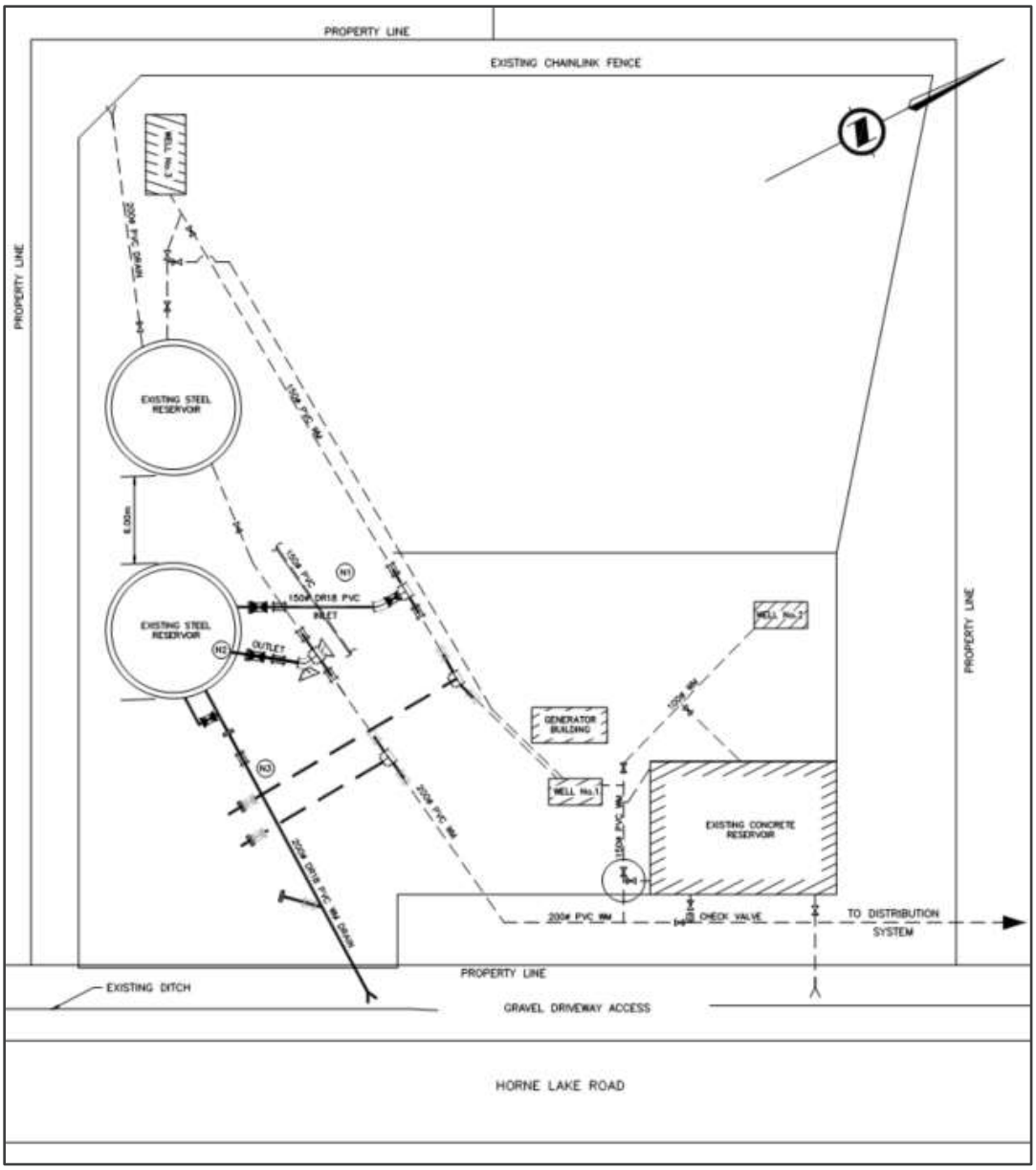


Figure 3 System overview showing wells, reservoirs, and buried piping

Both steel reservoirs are in regular use. The concrete reservoir is cycled regularly and kept for emergency storage only, as well as used by the Bow Horn Bay Volunteer Fire Department to fill their trucks. The concrete reservoir predates the steel tanks and the steel tanks were built 8 metres higher to provide an additional 75 kPa (11 psi) of system pressure. Based on the McElhanney Water System Evaluation Report there is assumed an effective, operational storage capacity of 1,000,000 litres (220,000 lgal).

3. Standards

3.1. GUIDELINES FOR CANADIAN DRINKING WATER QUALITY

The 2019 Guidelines for Canadian Drinking Water Quality are established by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and other federal government departments. They are published by Health Canada and available on their website[3].

Each guideline was established based on current, published scientific research related to health effects, aesthetic effects, and operational considerations. Guidelines (maximum acceptable concentrations or treatment goals) are based on a comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies. Aesthetic objectives (e.g., for taste or odour) are provided when they play a role in determining whether consumers will consider the water drinkable. Operational guidance values are provided when a substance may interfere with or impair a treatment process or technology (e.g., turbidity interfering with chlorination or UV disinfection) or adversely affect drinking water infrastructure (e.g., corrosion of pipes).

A key parameter under the guidelines is the maximum allowable content (MAC). This parameter set by Health Canada determines the safe level of concentration of a specific substance (metal, nutrient, anion, etc) for human consumption. This parameter is usually given in milligrams per liter and is only present in the guidelines when too much of a substance is a health risk for humans. Another parameter is the aesthetic objective (AO) which is determined by the physical characteristics of the water; aspects like the taste, colour, smell, etc are characteristics of the aesthetic objective. This parameter is usually given in milligrams per liter and is based solely on aesthetics and not the safe consumption level for humans.

3.1.1. Manganese Guideline

Based on the Guidelines for Canadian Drinking Water Quality when analysing the parameters of Manganese, prior to 2019 it did not have a maximum allowable content (MAC). Prior to 2019 the only guideline for manganese was an aesthetic object (AO) of equal or less than 0.05 milligrams per litre (mg/L). Based on new research, the guideline was updated in 2019 to include a Maximum Allowable Content (MAC) of 0.12 milligrams per litre (mg/L) as shown below in table 1.

[3] https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html

Table 1 Guideline for Canadian Drinking Water Quality - Manganese Guideline[4]

Type'	Parameter (Published, reaffirmed)	MAC (mg/L)	Other value (mg/L)	Common sources of parameter in water	Health Considerations	Applying the Guideline/Comments
I	Manganese (2019)	0.12	AO:≤ 0.02	Dissolution of naturally occurring minerals commonly found in soil and rock. Other sources include industrial discharge, mining activities and leaching from landfills.	Health Basis of MAC: Effects on neurological development and behaviour; deficits in memory, attention, and motor skills. Other: Formula-fed infants (where water containing manganese at levels above the MAC is used to prepare formula) may be especially at risk.	AO based on minimizing the occurrence of discoloured water, consumer complaints and staining of laundry.

The Maximum Allowable Content was set by Health Canada as while a small amount of manganese is essential for human health, new research shows drinking water with too much manganese can be health risk. Particularly drinking water with high levels of manganese may harm brain development in infants and young children. According to Health Canada, manganese is most easily absorbed in the body through drinking water.

Health Canada established the MAC using a precautionary approach, assuming the most vulnerable people would be constantly exposed to high levels of manganese for long periods of time. Therefore, there are built-in additional safety factors. Drinking water with manganese levels above the MAC for short periods of time is unlikely to cause any health issues.

3.2. DRINKING WATER PROTECTION ACT & DRINKING WATER PROTECTION REGULATION

In addition to adhering to the Guidelines for Drinking Water Quality; water suppliers are also responsible to provide safe drinking water that meets the requirements of the Drinking Water Protection Act and Drinking Water Protection Regulation, as well as the conditions set forth on their operating permits. These requirements include treating the water, if necessary, and ensuring water quality through monitoring. Water suppliers must notify the public when there is a potential or actual problem.

In the case of the District the regional health authority Island Health is responsible for providing the oversight to ensure compliance and drinking water safety through their drinking water officers. Environmental health officers, public health engineers and medical health officers are also involved in this work.

Drinking water officers are mandated to apply and enforce the Drinking Water Protection Act and Drinking Water Protection Regulation. They monitor the operations of drinking water systems and act on any notices of threats

[4] 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.

to drinking water quality. Drinking water officers are responsible for issuing operating permits and will work with water suppliers to help them achieve compliance with the legislation and the conditions on their permits.

3.3. OPERATING PERMIT

The District operates their potable water supply system under a Permit to Operate issued by Island Health (previously Vancouver Island Health Authority) as shown in Appendix A. The permit is validated annually and outlines 4 operating conditions to be followed by the District. Condition 1 states “Conduct a chemical analysis of raw water in accordance with the list of parameters specified in the VIHA Guidelines for Approval of a Waterworks System at a frequency of no less that once every 5 years”. A copy of the Island Health Guidelines for Approval of a Waterworks System is shown in Appendix B. The District follows these Guidelines by sampling and analyzing source water quality parameters in approximately 3-year intervals.

4. Water Quality

4.1. BACKGROUND

In the past no treatment was incorporated into the District’s water system. Aside from the Manganese aesthetic, three production water wells have overall met the water quality guidelines, up until the 2019 update to Health Canada’s water quality guidelines. Water is sampled and tested at an approved laboratory per Island Health, and in accordance with the Operating Permit. The tested water is then compared against several parameters outlined in the Guidelines for Canadian Drinking Water Quality as well as the District’s Operating permit.

4.1.1. Bacteriological Indicators

The District samples for Bacteriological Indicators once every two weeks at various locations throughout the distribution system. Indicators include *E.coli, Coliforms, etc.* Based on results, water consistently meets the water quality criteria and Operating Permit, without the use of water treatment.

4.1.2. Chemical and Physical Indicators

Results for Chemical and Physical Indicators were provided by the District. Since 2010, the District has sampled each of the three wells a total three times (or once every 3 years). A summary of notable indicators is shown in table 2 below.

Table 2 Physical Test Results Summary

				Physical Tests								
	Units of Measure	MAC	AO	2019 Well #1	2019 Well #2	2019 Well #3	2016 Well #1	2016 Well #2	2016 Well #3	2014 Well#2	2011 Well #3	2010 Well #1
Colour, True	CU			5	5	5	5	5	5		5	5
Total Dissolved Solids	mg/L		500	128	120	102	110	102	108		96	118
*Turbidity	NTU	1		0.3	0.3	0.4	0.1	0.11	0.1			

Table 3 Anions and Nutrients Test Results Summary

	Anions and Nutrients											
	Units of Measure	MAC	AO	2019 Well #1	2019 Well #2	2019 Well #3	2016 Well #1	2016 Well #2	2016 Well #3	2014 Well#2	2011 Well #3	2010 Well #1
Bicarbonate (HCO3)	mg/L						91.6	89.3	86.2			
Conductivity (EC)	uS/cm										146.3	152.7
Fluoride (F)	mg/L	1.5		3	3	3	0.05	0.052	0.05		1	0.06
Hardness (as CaCO3)	mg/L		500	72	74	70	66.4	65	64.1	72		
pH	pH	6.5-8.5	7-10.5	7.92	8.01	7.97	8.11	8.07	8.02		8.1	8.56

Table 4 Total Metals Test Results Summary

	Total Metals											
	Units of Measure	MAC	AO	2019 Well #1	2019 Well #2	2019 Well #3	2016 Well #1	2016 Well #2	2016 Well #3	2014 Well#2	2011 Well #3	2010 Well #1
Aluminum (Al)-Total	mg/L		0.1	0.0050	0.0050	0.0050	0.0030	0.0030	0.0030	0.0005	0.0050	0.0050
Antimony (Sb)-Total	mg/L	0.006		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0002	0.0002
Arsenic (As)-Total	mg/L	0.01		0.0018	0.0019	0.0016	0.0018	0.0019	0.0017		0.0014	0.0016
Barium (Ba)-Total	mg/L	1		0.0037	0.0038	0.0026	0.0036	0.0039	0.0025	0.0047	0.0020	0.0040
Boron (B)-Total	mg/L	5		0.0130	0.0140	0.0013	0.0500	0.0500	0.0500	0.1500	0.0130	0.0150
Cadmium (Cd)-Total	mg/L	0.005		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Calcium (Ca)-Total	mg/L			19.900	20.500	20.000	18.300	18.000	18.300	20.600	19.800	19.500
Chromium (Cr)-Total	mg/L	0.05		0.0005	0.0005	0.0005	0.0010	0.0010	0.0010	0.0050	0.0040	0.0004
Copper (Cu)-Total	mg/L	2	1.0	0.0023	0.0009	0.0015	0.0027	0.0050	0.0005	0.0029	0.0010	0.0010
Iron (Fe)-Total	mg/L		0.3	0.0200	0.0200	0.0200	0.0100	0.0100	0.0100	0.0990	0.0140	0.0110
Lead (Pb)-Total	mg/L	0.005		0.0003	0.0009	0.0005	0.0002	0.0002	0.0002	0.0006	0.0001	0.0002
Magnesium (Mg)-Total	mg/L			5.320	5.420	4.940	5.010	4.890	4.460	5.100	4.690	4.890
Manganese (Mn)-Total	mg/L	0.12	0.02	**0.1430**	**0.1350**	0.1020	**0.1300**	0.1150	0.9800	0.1060	0.9500	**0.1400**
Mercury (Hg)-Total	mg/L	0.001		<0.01	<0.01	<0.01					0.0000	0.0000
Molybdenum (Mo)-Total	mg/L			0.0003	0.0002	0.0002	0.0010	0.0010	0.0001		0.0003	0.0003
Potassium (K)-Total	mg/L			1.300	1.300	1.300	1.150	1.140	1.270	1.400	1.100	1.600
Selenium (Se)-Total	mg/L	0.01		0.0005	0.0005	0.0005	0.0001	0.0001	0.0001	0.0001	0.0006	0.0006
Silver (Ag)-Total	mg/L			0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Sodium (Na)-Total	mg/L		200	4.100	4.100	4.100	3.780	3.720	3.900	10.600	4.230	4.630
Uranium (U)-Total	mg/L	0.02		0.0000	0.0000	0.0000	0.0001	0.0001	0.0001		0.0004	0.0004
Zinc (Zn)-Total	mg/L		5.0	0.0070	0.0060	0.0070	0.0083	0.0050	0.0050	0.0559	0.0070	0.0060

The water has shown to generally meet the guidelines; however, those test results did determine the source water has been consistently high in Manganese content. As mentioned under Manganese parameters, as of 2019 there is now a Maximum Allowable Content (MAC) of 0.12 milligrams per litre (mg/L). The test results of Manganese content are summarized in table 5 below. The cells highlighted in grey represent results that are over the maximum allowable content as per the 2019 Guidelines for Canadian Drinking Water Quality.

Table 5 Manganese Test Results Summary

Year	Manganese Content mg/L		
	Well #1	Well #2	Well #3
2010	0.140		
2011			0.095
2014		0.106	
2016	0.130	0.115	0.098
2019	0.143	0.135	0.120

Before confirming this parameter is a concern, we would recommend further testing are outlined in the recommendation section of this report.

4.1.3. Aesthetics

Historically, Manganese in high concentrations can cause aesthetic concerns, mostly a nuisance for consumers. The primary problem with manganese is discolouration. A high content of manganese in water can have a brownish-black discolouration, Once oxidized it can physically build up in the distribution system and appear as “dirty” water when washing dishes or laundry. It can physically leave a brownish-black stain on dishes, porcelain, utensils and cloths, etc. It is also important to note that detergents and soaps do not remove these stains and the use of chlorine bleach and alkaline builders may intensify the stains. Boiling the water may also increase oxidation and intensify discolouration.

Manganese may affect the taste of water. Some research suggests that it can be unpleasant and affect the flavour and colour of food and water. McElhanney would recommend the District conduct a survey with customers of the water system to understand whether users notice an odour or taste in the water. This can also be confirmed if the District maintains a record of complaints from customers.

The aesthetic affects have been noted in the community of Qualicum Bay Horne Lake Waterworks District and exploring treatment options for manganese removal has been supported. To combat the build up of Manganese, the District currently flushes the entire distribution system 4 times per year. This is a cumbersome, intensive and time-consuming process. The process also provides valuable insight into the displeasing aesthetic visual of the water. The below photos (figure 4) were taken during a flushing event; the first photo shows the initial release from a hydrant where there is a distinct discoloration and the second shows a black stream of water that was released from the distribution system.

Figure 4 Distribution System Flushing

5. Treatment Components

5.1. TREATMENT PROFILE - PHYSICAL PARAMETERS

Prior to developing treatment options, an accurate profile of the District's existing site and infrastructure was established by posing and answering a series of questions to help define the parameters of a potential treatment system.

Table 6 The District's existing site profile

Site Information	Comment	Source
Population Served?	Approximately 900	Based on McElhanney Report 2014
Number of Connections?	Approximately 500	Based on McElhanney Report 2014
Future Forecasted Population Served?	1888 (Max Build Out 2059)	Based on McElhanney Report 2014
Number of Ground Water Wells:	Three	
Max Well Output (L/s):	14.0	Based on Waterline Report 2020
Historical Max Day Demand (L/s):	14.8	Based on McElhanney Report 2014
Proposed MDD (L/s)	14.0	Based on Waterline Report 2020
Max Litres per Day:	1,279,000	Based on McElhanney Report 2014
Operating Pressure (kPa):	69-83 kPa @ reservoir outflow	
Is Backwash Discharge Available at Site:	Yes, but needs to be constructed	
Is System Redundancy Required?	Yes, 100%	
Is There Any Existing Treatment or Disinfection?	No Existing Treatment	
Is a Reservoir Present?	2 tanks - 28'x28'	

5.2. TREATMENT PROFILE - CHEMCIAL PARAMETERS

Based on water quality parameters, Manganese is the only parameter that exceeds Health Canada's guidelines. Treatment for Manganese is recommended; however, there are potential challenges depending on treatment options proposed. For example, filtration will require an oxidant be added to the system, commonly in the form

of sodium hypochlorite (chlorine). This addition may have a potential influence on other parameters such as water hardness, and other metal parameters. It is recommended that any potential influences be examined during a detailed design phase.

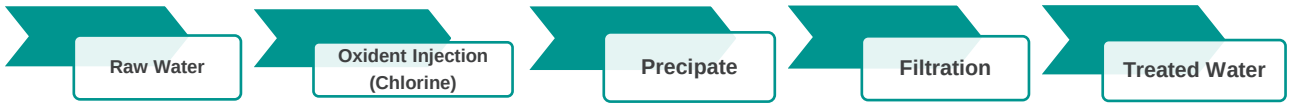
There are benefits to adding treatment, beyond removal of Manganese. Treatment may also result in reduced Iron and Arsenic concentrations; however, in this instance, both parameters already meet the guidelines.

5.3. COMMON TREATMENT METHODOLOGY

Several designs and flow schematics are available for the removal of manganese from raw water. The following are common systems that are currently used in the industry:

- Aeration, settling, and filtration
- Manganese-zeolite filter system
- Chlorination and filtration

The common theory is to add oxygen to the water, to help precipitate Manganese, and then filter the solid out from the water. The following diagram presents a general overview of how treatment of Manganese might work.



After consultation with industry suppliers and experts this report will focus on providing chlorination and filtration as the preferred treatment option. This option allows for chlorination of the water which is added protection against bacteriological viruses. Currently Island Health does not mandate the District's water be chlorinated; however, it is a possibility in the future.

5.4. OXIDANT

Chlorine is a very common and accessible oxidant which would enter the system prior to filtration. It is usually dosed in one of two ways as a solution pumped into water by a chemical pump. The common chlorine solution options include:

- Calcium hypochlorite which is shipped as granular or in pellet form and is mixed with water prior to dosing. The granules or pellets contain 65 percent available chlorine. This option can be challenging as the solution may not always provide the exact chlorine levels expected.
- Sodium hypochlorite is an option which is shipped as a liquid and contains 12 percent available chlorine; it is dosed either directly from the shipping barrel full strength or after dilution with water in a batch mix

tank and then pumped into system via a chemical pump. For this application sodium hypochlorite is the recommended option.

Potassium Permanganate could be used as an alternate to chlorine; however, it will not result in a system chlorine residual. This option may be considered if the community wishes to avoid the use of chlorine.

5.5. FILTRATION

Two common types of filters in use today are open top, high-rate gravity filters and enclosed steel pressure filters. Due to size and containment restrictions of an open top gravity system; enclosed steel pressure filters would be preferred for this application (typical steel vessel shown if figure 5). Vessels are sized depending on input and output requirements. The filtration process involves each vessel containing filter media, a very common media type for this application is called Manganese Greensand, it is an American product that gets is name from the colour and shape as it green in colour and the consistency of sand particles. After investigation it has been found that there are many proprietary products on the market and are all similar in nature. Most all rely on particle size distribution, shape, and Manganese Dioxide at the surface to accomplish oxidation/coagulation, absorption and filtration.

5.5.1.MEDIA

There are proprietary media's out there that provide similar filtration benefits to Manganese Greensand. An example of a proprietary media product is called MangOx™ refer to appendix C for a full product sheet. This media is very dense and helps stop already precipitated forms of manganese from passing through but also acts to accelerate the oxidation to maximize capture of precipitates.

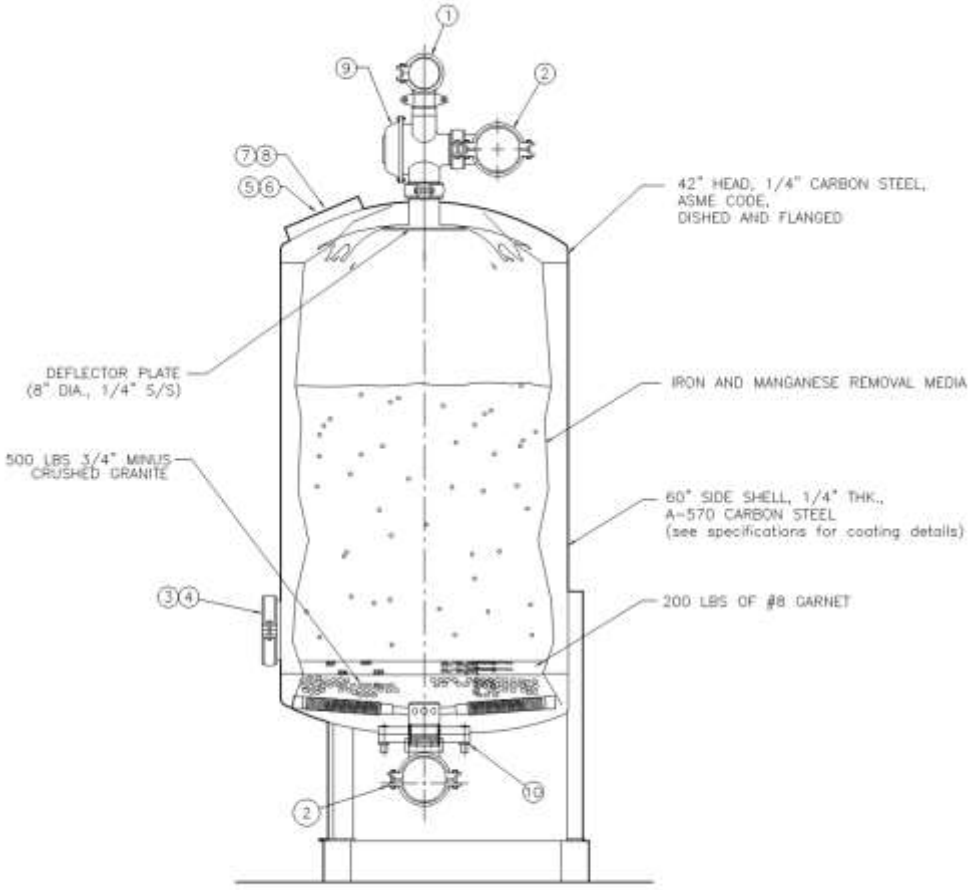


Figure 5 Typical steel vessel with media

5.6. BACK WASH

Backwash is a necessary process of reversing flow in the filters to flush out and remove the precipitates that have collected in the media. Back washing in a manganese removal system is required after a certain operational period (can range from once per day to once per week) to help regenerate the media. Backwash frequency may range from once a day up to once a week. A small excavated space near the treatment facility will need to be designated as a drying bed for backwash. The backwash will be a build up of manganese in a solid form and will likely be required to be removed and disposed of in a waste facility on a semi-annual basis or as required.

5.7. WATER TREATMENT PLANT

Combining the elements of chlorination and filtration to remove manganese requires the process to be contained within a water treatment plant as shown in the conceptual schematic design figure 6. For this report the common options on the market involved a range of 2 to 6 steel pressure vessels ranging from 96 inches in diameter to 48 inches in diameter. The systems are skid mounted and manufactured in an offsite fabrication facility. This allows

the water treatment plant to be fabricated in a controlled environment and shipped to site as one unit which is likely to permit higher quality control and cost efficiency.

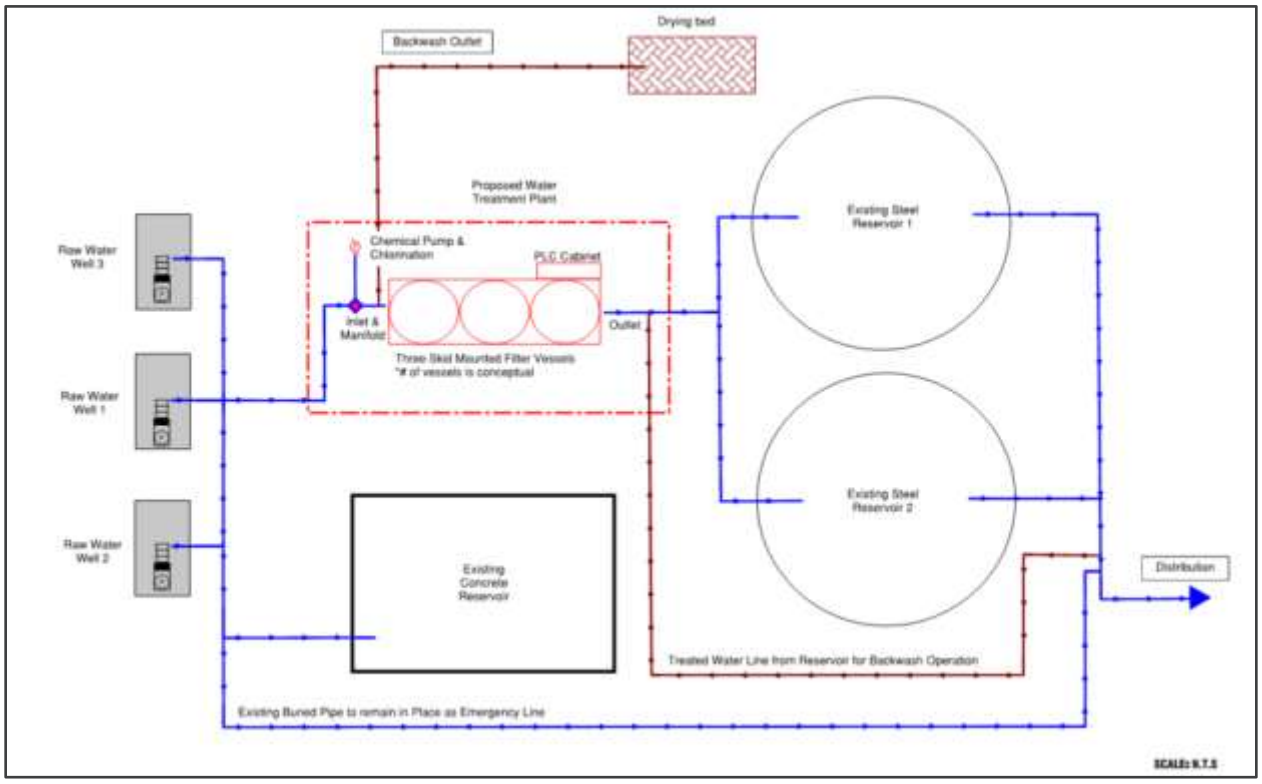


Figure 6 Initial schematic design

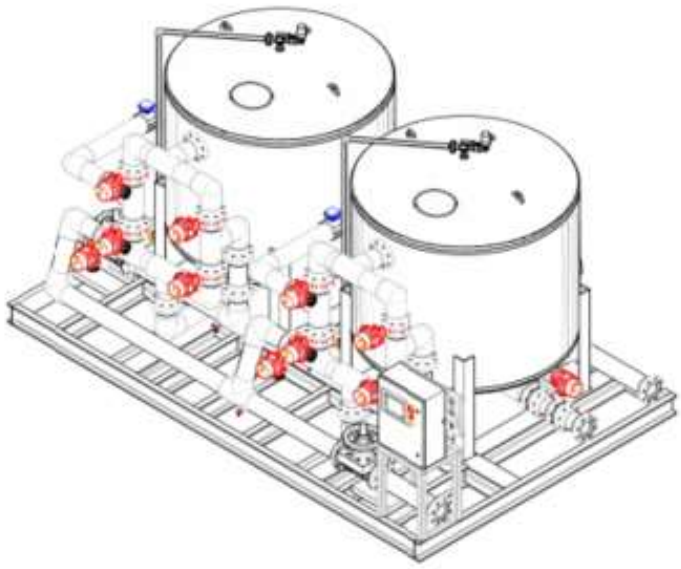


Figure 7 Typical skid mounted steel pressure vessel filtration system

In addition to a skid mounted system, modularized systems are also available to completely contain the water treatment plant as shown below in figure 8. This allows all the components of the treatment plant such as the chemical feed, PVC (programmable logic controller), pressure vessels, etc. to be housed in one building unit. Fabricating the unit offsite and shipping to site is likely to permit higher quality and cost efficiency.

Figure 8 Modularized water treatment plant example from AdEdge water technologies[5]

An alternative treatment approach includes an option where filtration is eliminated from the process and treatment is contained in the existing reservoirs. This method is a quiescent settling approach where an oxidant such as chlorine is added to the top of the reservoir which suspends the Manganese into solution where a solid is formed and settles to the bottom of the reservoir tank. This method is dependent on having enough resident time in the reservoirs meaning a long enough period from water entering to exiting the tanks to allow the Manganese solids to settle out of the water. The major draw back of this method is that the Manganese will collect at the bottom of the reservoirs and would require the tanks to periodically be drained and the Manganese to be removed via a vacuum truck. The viability of the method would need further investigation but due to the maintenance requirements would not be recommended.

6. Project Cost & Schedule

6.1. CONCEPTUAL DESIGN AND CONSTRUCTION SCHEDULE

From initial concept to a completed project is estimated to take approximately 30 months including warranty period and would be split into three phases. The first would be a design stage where a consulting engineer is

[5] https://www.adedgetech.com/waterpod-containerized-treatment

selected along with a water treatment supplier to complete initial and detailed designs along with permitting and completion of a test pilot program to confirm design viability. The second phase would include a procurement stage to select an appropriate general contractor to organize and complete construction works. The third phase would include fabrication of a water treatment plant offsite, contractors to mobilize and complete civil, mechanical piping and electrical works. This would allow the treatment plant to be installed, star up and commissioning to take place and would eventually allow turnover to operations, a warranty period and project close out.

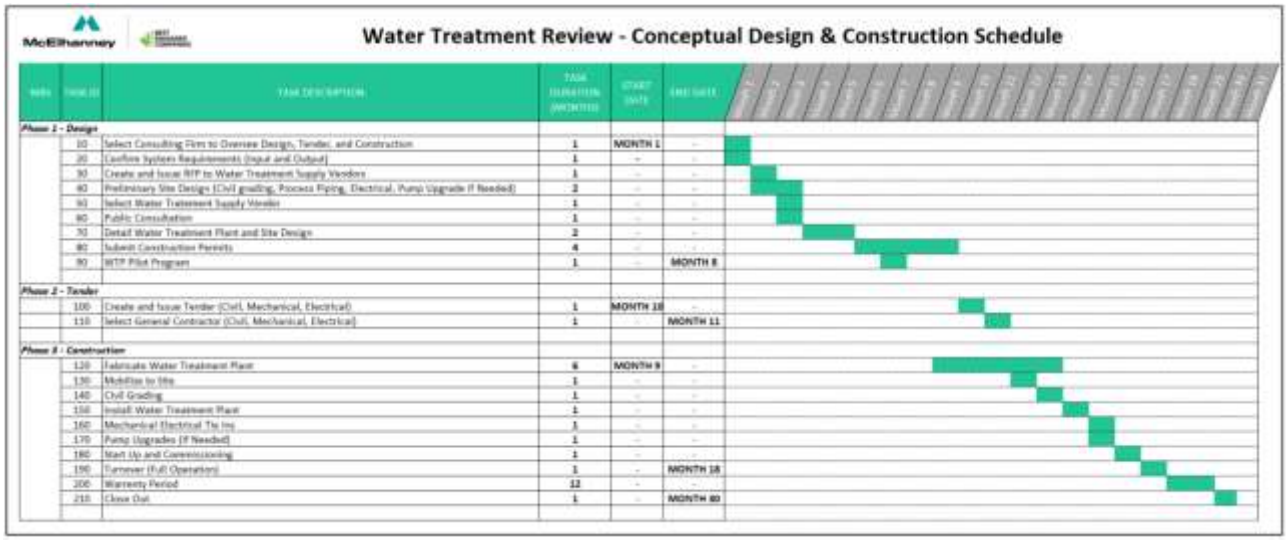


Figure 9 Conceptual Design and Construction Schedule

6.2. INITIAL CAPITAL COST

Initial capital cost for this type of project can be split into three components. The first component is construction cost which includes all materials, fabrication and equipment needed to construct the civil, mechanical, and electrical components of the project. The second component is the engineering fees, which at this stage of budgeting are based on 15% of the total construction cost. The third component is contingency, which is included as 30% of the engineering and construction cost combined. The contingency is added at 30% as there is little to no cost certainty in the conceptual stage. The estimated cost is derived from a combination of initial quotes from water treatment vendors along with recent experience from McElhanney completed projects on Vancouver Island. A summary of the cost is shown below in table 7 and a further breakdown is shown in Appendix E. McElhanney has analyzed cost options for a skid mounted water treatment plant from 3 vendors and has provided an average cost of $605,667 as shown in table 7.

Table 7 Conceptual capital cost

Initial Capital Cost (Class D Estimate)		
		Average Cost
SECTION 1	GENERAL CONDITIONS	$20,000
SECTION 2	WATER TREATMENT PLANT	$605,667
SECTION 3	CIVIL	$77,200
SECTION 4	WATER DISTRIBUTION	$60,100
TOTAL CONSTRUCTED WORKS		$762,967
CONTINGENCY (30%)		$228,890
ENGINEERING (15%)		$148,779
TOTAL PROJECT (LESS GST)		$1,140,635

6.3. OPERATIONS AND MAINTENANCE COST

Operations and maintenance are split into two components. The first component is operator time to supervise the production of water treatment, conduct water quality testing and carry out routine maintenance. Based on discussion with operators at similar size water treatment plants in the local area, operation would be a part time job requiring an operator about twenty (20) hours per week or on average two (2) to three (3) hours per day. The second component of operations and maintenance cost is the water treatment facility, this includes power, material and supplies, equipment maintenance, as well as building and facility maintenance. A summary of the cost by month, year and a twenty (20)-year period is shown below in table 8 and a further breakdown is shown in Appendix F.

Table 8 Conceptual operations and maintenance cost

Operations & Maintenance Estimate				
		Monthly	**Yearly with 2.5% Inflation**	**20-year Period with 2.5% Inflation**
SECTION 1	OPERATOR	$5,509	$67,761	$1,730,924
SECTION 2	WATER TREATMENT FACILITY	$2,440	$30,012	$848,577
TOTAL O&M WORKS		$7,949	$97,773	$2,579,501
CONTINGENCY (10%)		$795	$9,777	$257,950
TOTAL O&M (LESS GST)		$8,744	$107,550	$2,837,451

7. Conclusions & Recommendations

7.1. UNDERSTANDING THE WATER SYSTEM

Manganese is found naturally in groundwater and concentrations that exceed the drinking water guideline can occur locally in all regions of British Columbia. Water supply for this community is provided through 3 groundwater wells, tapped into the Quadra Sands Aquifer.

Water is primarily pumped into two 2 steel bolted reservoir tanks with an effective system storage of 1,000,000 litres. We understand the well has a safe yield of 33 litres per second (L/s) and a historical Maximum Day Demand is 14.8 litres per second (L/s), suggesting wells are within its available capacity.

7.2. WHY TREAT WATER?

The Guidelines for Canadian Drinking Water Quality are established by Health Canada and regulated by the provincial health authority, 'Island Health'. Of particular importance to this report is Manganese, which is regulated to a Maximum Allowable Concentration (MAC) is 0.12 milligram per litre (mg/L). Water quality results indicate this value has been exceeded, with the latest test results in December 2019 showing that well #1 and #2 are slightly over the MAC and well #3 is slightly under.

Manganese is also a nuisance element, which can cause discolouration of water and to fixtures. For this reason, the District has an interest in determining the needs for Manganese treatment. A suggested treatment option to remove manganese from the District's water supply is to install water treatment plant using the base methodology of chlorination and filtration.

We estimate an average capital cost ($2020 CAD) of $1,141,000. Over a 20-year life, we estimate a water treatment plant would result in an overall life-cycle cost of $2,837,000.

8. Recommendations

8.1. ACTION ITEMS

Based on the information provided and our review McElhanney recommends the following action items in order of priority.

1. At minimum, McElhanney recommends completing at least 3 water quality tests in 2020 to confirm exceedance of maximum allowable manganese content. A recommended sampling schedule is as follows:

Proposed Testing Schedule
April 2020
June 2020
September 2020

2. McElhanney recommends continuing to test from all three well sites but also recommends adding a fourth testing location at the output of the reservoir to ensure a true representation of Manganese concentration in the distribution system is obtained.

3. Based on the summary of historical Manganese test results Well #3 has produced the lowest concentration and Well #1 the highest. McElhanney has been informed by the District that they are exploring the option of only pumping from Well #2 and #3 to possibly "blend" the concentration to a level

lower than the MAC. McElhanney acknowledges that this approach could be beneficial as a temporary solution if the but recommends consulting with their groundwater resource consultant (Waterline) to ensure that the wells can handle the water demand without disturbing their recharge rates.

4. If further test results confirm that the Manganese concentration is above the MAC (maximum allowable content) McElhanney recommends discussing the results with Island Health to determine appropriate steps forward as per the water supply regulations. If treatment is determined to be a requirement McElhanney recommends the District retain a consultant to examine options and qualifications for government funding.

5. Depending on the outcome of action items 1,3 and 4 and if budgeting permits McElhanney recommends the District consider chlorination and filtration contained within a prefabricated water treatment facility as the preferred treatment option. One key advantage with this methodology is that it provides chlorination which serves two purposes; firstly, by acting as an oxidant, which will precipitate the Manganese and allow it to be filtered out of the water distribution; secondly, the chlorine will act as a disinfectant which is protects against bacteriological outbreaks and could become an eventual requirement of the District by Island Health.

9. Closure

It has been a pleasure to work with the Qualicum Bay Horne Lake Water District. We trust this document meets your requirements. If you have any further inquiries, please do not hesitate to contact the undersigned at your earliest convenience.

Yours very truly,

McElhanney Ltd.

Written By,

Digitally signed by Nathan Slater
DN: C=CA, E=nslater@mcelhanney.com, O=McElhanney, OU=2231 Civil, CN=Nathan Slater
Location: Nanaimo, BC
Reason: I attest to the accuracy and integrity of this document
Date: 2020.07.10 10:07:05-07'00'

Nathan Slater, E.I.T., Project Engineer

nslater@mcelhanney.com | 778 762 0658

Reviewed By,

Chris Pogson, P.Eng. Project Manager

cpogson@mcelhanney.com | 778 762 0667

10. Sources

Canada, Health. “Government of Canada.” *Canada.ca*, Government of Canada, 1 Feb. 2017, www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html.

Ministry of Health. “Drinking Water Quality.” *Province of British Columbia*, Province of British Columbia, 29 June 2016, www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality.

Oram, Brian. “Mr. Brian Oram, PG.” *Water Research Center - Get Rid of Iron and Manganese Red Black Staining Dishwasher*, water-research.net/index.php/water-treatment/water-staining.

“How Do You Regenerate Manganese Greensand Filter Media Just Purchased Prior to Placing It into Service?” *Water Quality Information - How Do You Regenerate Manganese Greensand Filter Media Just Purchased Prior to Placing It into Service? | APEC Water*, www.freedrinkingwater.com/water_quality/quality1/49-08-regenerate-manganese-greensand-filters.htm.

“USE OF ANTHRACITE IN WATER TREATMENT AND PURIFICATION.” *Keiken Engineering*, 15 Feb. 2019, www.keiken-engineering.com/en/use-of-anthracite-in-water-treatment-and-purification/.

Tunnicliffe, Darryl. *QUALICUM BAY HORNE LAKE WATERWORKS DISTRICT WATER SYSTEM EVALUATION*. McElhanney Ltd., 2014, pp. 1–68, *QUALICUM BAY HORNE LAKE WATERWORKS DISTRICT WATER SYSTEM EVALUATION*.

Nagpal, N. K. *Ambient Water Quality Guidelines for Manganese: Overview: Prepared Pursuant to Section 2(e) of the Environment Management Act, 1981*. Water Management Branch, 2001.

Pajak, Dalton. Well Field Capacity Assessment Qualicum Bay Horne Lake Waterworks. Waterline Resources Inc., 2020, pp. 1–56, Well Field Capacity Assessment Qualicum Bay Horne Lake Waterworks.

APPENDIX A - OPERATING PERMIT

VANCOUVER ISLAND health authority

HEALTH PROTECTION

PERMIT

to OPERATE

A WATER SUPPLY SYSTEM

Water System Name:	**QUALICUM BAY/HORNE LAKE WWS**
Premises Number:	1310853
Premises Address:	240 Lions Way Qualicum Beach, BC V9K 2E2
Water System Owner:	Qualicum Bay/Horne Lake Water Board

Qualicum Bay/Horne Lake Water Board is hereby permitted to operate the above potable water supply system and is required to operate this system in accordance with the Drinking Water Protection Act and in accordance with the conditions set out in this operating permit and conditions established as part of any construction permit.

The water supply system for which this operating permit applies is generally described as:

Service Delivery Area:	Qualicum Bay
Source Water:	3 deep wells, Well plate ID# 13744, 13745, 13746
Water Treatment methods are:	None
Water Disinfection methods are:	None
Number of Connections	301-10,000 Connections - DWT

Operating conditions specific to this water supply system are in Appendix A.

Date: July 1, 1992

Issued By: J Preston
Environmental Health Officer

IN A

APPENDIX A

WATER SYSTEM OPERATING CONDITIONS FOR

QUALICUM BAY/HORNE LAKE WWS

240 Lions Way

Qualicum Beach, BC, V9K 2E2

Condition 1.

Conduct a chemical analysis of raw water in accordance with the list of parameters specified in the VIHA Guidelines for Approval of a Waterworks System at a frequency of no less than once every 5 **years.**

Condition2.

The water system owner must ensure the person operating the water system is certified to operate, maintain or repair your system.

Condition 3.

Develop and implement a Cross-connection Control Program. The details of the cross-connection program and timing of implementation of the program shall be established in consultation with the local Environmental Health Officer.

Condition 4.

Develop and implement a wellhead protection plan to ensure that the drinking water source is protected in to the future. The wellhead protection plan should establish management strategies to avoid contamination of, or activities, which may degrade the quality of the drinking water source. The details of the wellhead protection plan and timing of the implementation of the program shall be established in consultation with the local Environmental Health Officer.

The Wellhead protection plan should be based on the publication "Well Protection Tool Kit", Ministry of Environment, Lands and Parks, Ministry of Health and Ministry of Municipal Affairs; Issued by: Water Stewardship Division. ISBN 0-7726-5566-9
http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/wellprotect.html

Date: Aug 8, 2011

Environmental Health Officer

APPENDIX B - GUIDELINES FOR THE APPROVAL OF WATER SUPPLY SYSTEMS

GUIDELINES FOR THE APPROVAL OF WATER SUPPLY SYSTEMS

Vancouver Island Health Authority

GUIDELINES FOR THE APPROVAL OF WATER SUPPLY SYSTEMS

Vancouver Island Health Authority

1. INTRODUCTION

To improve public health protection in British Columbia, the Ministry of Health Service's **Drinking Water Protection Act**, Section 7 and Section 6 of the ***Drinking Water Protection Regulation***, requires that a **Construction Permit** is obtained from a Drinking Water Officer before construction, installation, alteration or extension of a water supply system is commenced. New sources of water require both a **Construction Permit** before construction of works and an **Operating Permit** before the source can be used. The Construction Permit is issued by the Public Health Engineer (or the Drinking Water Officer) and the Operating Permit is issued by the local Environmental Health Officer (or the Drinking Water Officer).

Applications may be made by water system staff, consultants or owner, should be of professional quality, and must be prepared by a professional engineer registered to practice in British Columbia.

Applications for a Construction Permit should be made in writing at least 60 working days before approval is needed. For water systems on Vancouver Island, the Gulf Islands and the mainland coast (Brettell Point to Cape Caution), submit applications to:

Vancouver Island Health Authority
Public Health Engineering, **Telephone: (250) 755-6299**
3rd Floor 6475 Metral Drive, Nanaimo, BC V9T 2L9 **Fax: (250) 755-3372**

Include a completed "Application for Water Supply Systems Construction Permit" (see attached), plus other information as applicable (see section 2. "SUBMISSION REQUIREMENTS"). If the proposed water system involves more extensive works, include an explanatory letter which provides the name of the water system that the proposed works is part of, the name and current address of the water purveyor (owner/representative) that the Construction Permit is to be sent to, and other information as noted in the applicable portions of the following sections.

The overall objective is water quality that consistently meets the **Drinking Water Protection Act,** the ***Drinking Water Protection Regulation*** and the Guidelines for Canadian Drinking Water Quality, Health Canada and adequate quantity to meet reasonable peak demands without development of low pressures, which could result in health hazards.

2. SUBMISSION REQUIREMENTS

2.1 General

Submit ONE complete set of plans for watermain extensions or replacements. Submit THREE complete sets of construction plans (and specifications where needed) for new sources. All plans submitted by a professional engineer must be signed and sealed.

Include a key plan/map to show where the water system is located. Include all supply, transmission, storage, pumping, treatment and distribution works. Include a plan and profile to show high and low spots in the water system and any sanitary and storm sewers that are crossed or are nearby.

Where watermains are nearer than 3 m horizontally or have less than 45 cm clearance vertically (with watermain above, where possible) from any sanitary or storm sewer, detail safeguards that are proposed to protect the watermain.

…/2

For new groundwater sources, submit to the Public Health Engineer, with a copy to the local Environmental Health Officer, data on chemical and bacteriological water quality (see attached parameters list) and, as applicable: well log, pump test, hydrogeologist's report, mechanical and instrumentation/control facilities at wellhead, or pumphouse, proposed treatment and confirmation that the water will have acceptable taste (caution: do not taste undisinfected water), colour and odour. The hydrogeological report should include an assessment and recommendations on: water quality protection including a description of any risks, confining/protective layers, time of travel radius for existing/suspected point sources of potential well contamination, non-point sources, maximum discharge rates, wellhead protection, and quality and quantity monitoring including parameters and frequency, etc. The report should include information on historical use of groundwater in the area and area recharge.

For new surface water sources, submit to the Public Health Engineer, with a copy to the local Environmental Health Officer, data on chemical and bacteriological water quality (see attached parameters list) and as applicable: water license, mechanical and instrumentation/control facilities at the intake or pumphouse, method of disinfection, proposed treatment and confirmation that the water will have acceptable taste (caution: do not taste undisinfected water), colour and odour, description of the watershed, noting any existing or potential sources of contamination, which may affect water quality, flood level, safe yield, hydrological data, etc. The level of treatment and disinfection for surface supplies should ensure a minimum level of inactivation of 99.99% for viruses and bacteria, 99.9% for *Giardia lamblia* cysts and 99% for cryptosporidium oocysts. Higher levels of treatment and disinfection may be required based on pollution sources in the watershed or poor water quality.

Additional testing or pilot scale studies of treatment processes may be required. Disinfection must not create unacceptable levels of disinfection by-products (trihalomethanes, haloacetic acids, chlorite or bromate).

Where the proposed water system involves new lots or strata with on-site sewage disposal systems under the *Sewerage System Regulation*, state clearly the number of lots/units that are to be served by the new water system.

Where new servicing and an existing water system are involved, confirm that both water quality and capacity of the existing or proposed expanded or improved waterworks, as applicable, are, or will be, adequate to accommodate existing, already committed and proposed new servicing.

Where applicable provide an equipment maintenance manual, operating guidelines and a written Emergency Response Plan (per **Drinking Water Protection Act**, Section 10; ***Drinking Water Protection Regulation***, Section 13) to the local Environmental Health Officer. The submission may be in draft form for review and comment before finalizing.

Where applicable, provide a description of the planned physical, chemical and bacteriological water quality monitoring program including parameters, frequency and duration, and provide a commitment to carry out the program.

2.2 **Other Agencies**

Where applicable, confirm that the water system meets all local government bylaws.

Where a water utility is involved, confirm that the design incorporates the wishes of the Comptroller of Water Rights, via the Utility Regulation Section, Land and Water Management Division, Land and Water British Columbia, Inc., in Victoria.

Where water systems are to be installed on road easements under the jurisdiction of the Ministry of Transportation, confirm that an approval has been received for the specific proposal and state any conditions specified.

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2.3 **Construction**

Specify who will be responsible for construction inspections and post construction certification of the waterworks to ensure that materials and construction standards meet current engineering standards such as American Water Works Association (AWWA).

3. SMALL SYSTEMS AND RURAL RESIDENTIAL COMMUNITY SYSTEMS

In cases where an application for approval is made for a Construction Permit for a small water system serving less than 50 people (or the equivalent 15 service connections), and is needed to resolve existing water problems, to minimize approval costs the procedures outlined above will generally apply, but the submission may be modified, at the discretion of the Drinking Water Officer or Public Health Engineer, as follows:

a) It should be of reasonable quality, with an explanatory letter and plans preferably prepared by a Professional Engineer.

b) It should include the name and address of the water supplier or person responsible for the water system operation and include documentation outlining the legal basis for operation - Municipality, Regional District, Improvement District, Water Utility under the Water Utility Act, Water Users Community under the Water Act, Strata Corporation, Privately Owned (mobile home parks, campsites), etc.

c) It should contain sufficient general information to assess the proposal.

d) It should include recent bacteriological and chemical analysis of the proposed source and, if warranted, contamination protection plans.

e) It should include, where applicable, in recognition of the nature and often remote location of these small/rural systems, written operating and maintenance instructions, a written Emergency Response Plan and a written sampling/water quality-monitoring plan. A draft copy may be submitted to the local Environmental Health Officer before finalizing.

NOTE: An **Operating Permit** must be obtained from the local Environmental Health Officer before a new source is used.

The publication Design Guidelines for Rural Residential Community Water Systems is available from the Utility Regulation Section, Land and water Management Division, Land and Water British Columbia, Inc., in Victoria, and can be used as a reference document.

4. WATER QUALITY

Water supplies for drinking, culinary, and other domestic uses must be free of pathogenic organisms and their indicators and deleterious chemical substances including radioactive materials. In addition, the water should have acceptable colour, odour and taste.

The **Drinking Water Protection Act**, the ***Drinking Water Protection Regulation*** and the current edition of Guidelines for Canadian Drinking Water Quality should be used as a guideline for evaluation of water sources.

The raw water must be sampled and analyzed for the parameters shown on the attached lists. Initial samples from groundwater sources should be taken near the conclusion of the pump test, when the water is visually clear of sediment.

.../4

5. SOURCE AND PROTECTION

The water supply should be obtained from a source that is most likely to produce drinking water of a quality meeting the **Drinking Water Protection Act,** the ***Drinking Water Protection Regulation*** and the Guidelines for Canadian Drinking Water Quality. The source chosen should be one, which is least subject to municipal and industrial contamination, or other types of contamination, resulting from human, or animal activities within the watershed or within the aquifer recharge zone. Every effort should be made to prevent contamination of the source. The water source should be protected against access by unauthorized persons.

The water supplier shall conduct routine quality monitoring of the water source. The monitoring program should attempt to recognize all potential sources of contamination and assess their present and future importance. The monitoring program and any remedial action should be determined in consultation with the local Environmental Health Officer.

6. DISINFECTION AND TREATMENT REQUIREMENTS

Some natural purification occurs in surface waters because of dilution, storage, sunlight and associated physical and biological processes. With groundwater, natural purification may occur by filtration of the water through soil. However, effective treatment should be provided whenever necessary to ensure safety and consistency in the quality of all finished waters.

Water sources for new water systems or new sources for existing systems using surface water or shallow groundwater must be disinfected. If necessary, treatment such as coagulation-flocculation, adsorption, sedimentation and filtration may be needed. Deep well sources must be disinfected if deemed necessary by the Medical Health Officer for reasons of either bacteriological quality or nuisance biological growths and may require other treatment to meet the quality guidelines.

The applicant must demonstrate that the source is adequately protected from contamination and that the bacteriological and/or physical and chemical water quality of the source consistently meets the **Drinking Water Protection Act,** the ***Drinking Water Protection Regulation*** and the Guidelines for Canadian Drinking Water Quality. Provisions should be made for the installation and operation of disinfection and/or other treatment facilities should they be required at a later date.

7. HEALTH RELATED DESIGN CONSIDERATIONS

7.1 Quantities

Water supplied must be of sufficient quantity for sanitary purposes and 225 L (50 Imperial gallons) per person per day (680 L or 150 Imperial gallons per household based on triple occupancy) may be adequate. Water for fire fighting, irrigation, or other purposes, is additional to that required for sanitary purposes. The supply must be adequate to meet reasonable peak demands without development of low pressures that could result in health hazards. For details regarding fire protection requirements, the designer should refer to the must current Fire Underwriters Survey publication entitled Water Supply for Public Fire Protection available from the Insurance Advisory Organization (604) 681-3113.

7.2 Wells

Wells must be located to conform to the requirements of the ***Sanitary Regulations*** (30.5 m from any probable source of contamination, 6 m from any dwelling house and 122 m from a cemetery) pursuant to the **Health Act**. Wells should, in general, follow the "AWWA Standard for Water Wells" (A100-97) and the publication "Guidelines for Minimum Standards in Water Well Construction" available from the Groundwater Section, Water Protection Branch, Ministry of Environment and the ***Groundwater Protection Regulation*** pursuant to the Water Act to ensure contamination does not enter the well.

.../5

7.3 **Pumping Stations**

Pumping facilities must be designed to maintain the sanitary quality of the pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided. No pumping station should be subject to flooding. A standby pump should normally be provided. Standby power should be provided in situations where a power failure could produce complete pressure loss in high areas of the distribution system.

7.4 **Impounding Reservoirs**

Any earth storage facility for raw water should be designed to minimize contact between the water and organic materials such as grass, peat, trees, etc.

7.5 **Finished Water Storage**

Finished water storage must be adequately protected from contamination. Storage structures must have a cover that is watertight, opaque and vermin proof. No drains or overflows shall be directly connected to a sewer or storm drain. Venting of these structures must not be by open construction between the sidewall and the roof, but by special vent structures, which will exclude birds, vermin, and dust. Manholes to these structures must be framed at least 10 cm (4 inches) above the surface of the roof at the opening and the cover must be watertight and extend down around the frame at least 5 cm (2 inches).

It is recommended that 455 L (100 gallons)/dwelling unit be provided for emergency standby storage. Additional storage may be required for pressure regulation and for fire protection.

Steel storage tanks, and paintings and coatings for steel storage tanks, shall comply with the AWWA standards for steel tanks (D100, D102, D103 or D104). Hydropneumatic tanks should be constructed to comply with the B. C. Boiler and Pressure Vessels Code.

7.6 **Transmission and Distribution**

It is recommended that watermains normally be 15 cm (6 inches) in diameter or greater and be looped wherever economically feasible to minimize contamination risks and service disruption during repair of breaks or watermain flushing.

Flushouts or hydrants should be provided for flushing purposes on dead-ends and low points. Air relief valves should be provided at high points.

Wherever possible, watermains should be laid at least 3 meters (10 feet) horizontally from any manhole, oil-water separator, vertical seepage pit etc, or sanitary or storm sewer. Where this horizontal separation is not possible, (where watermains and sewers must cross or share the same trench) the watermain should be at least 0.45 m (1.5 feet) above the sewer (measured between the bottom of the watermain and top of the sewer) and sufficiently to one side of the sewer to allow for sewer repairs without disturbing the watermain.

If neither the horizontal or vertical separation are possible then the sewers should be of the same service capability as the watermain, and should be designed to withstand high groundwater table conditions without damage to joint seals. (This also applies to watermains when depressurized). The bottom portion of manholes, manhole connections to sewers, service connections to sewers and joints in service connections should all be designed to not leak where the normal separation distances are not possible. At crossings, the watermain joints should be as far as possible from the sewers.

Where new and existing works are involved, these construction practices should be applied to the new works and, with possible exceptions, the existing works may remain as is.

.../6

Where watermains must cross under sewers, at least 0.45 m clear vertical separation should be provided. Protection should be detailed wherever crossings have inadequate structural separation. Wherever possible these separation practices should also be applied to water service connections.

Watermain valves should be provided to isolate reasonably sized sections of the system for repair or maintenance. It is recommended that they be placed on property line projections if possible, to make them easier to locate.

Cross connections with any sanitary or storm sewer or other source of non-potable water is prohibited. Measures should be taken to prevent freezing of watermains and services. The system should be pressure tested before use.

7.7 **Disinfection**

The water purveyor is responsible to ensure that all new and repaired tanks, watermains, wells, etc. are disinfected before use according to the AWWA Standards or an equivalent provided for such disinfection.

Disinfecting agents commonly used in water treatment are chlorine, chlorine compounds, ultraviolet light and ozone. Other methods of disinfection will be considered if an application provides sufficient evidence to support their use.

Free residual chlorination is the method of disinfection most commonly practised. A minimum contact time (T) and minimum level of free chlorine residual (C) is required to produce a CT (product of C and T) of 12 min•mg/L. This level of CT will ensure adequate destruction of viruses and bacteria. If inactivation of *Giardia lamblia* cysts are required, higher levels of CT are required. Consideration must be given to pH, ammonia, taste producing substances, temperature, bacteriological quality and other pertinent factors when determining CT. At pH levels above 9, CT has to be increased substantially and this office should be contacted for appropriate levels. Where other methods of disinfection are employed, contact time and residual concentrations must be sufficient to provide adequate disinfection.

The water quality following any treatment and disinfection should normally produce a minimum chlorine residual of 0.2 mg/L or a chloramine residual of 1 mg/L (maximum 3.0 mg/L) throughout the distribution system.

The capacity of chlorination equipment must be such that an adequate residual can be maintained when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment must be of such design that it will operate accurately over the entire anticipated flow, including low chlorine demand and low flows.

If gas chlorine is used, a separate room and operator protection must be provided including fan ventilation from floor level to an approved area, viewing window, exterior light and fan switches, chain storage for cylinders, chlorine container repair kit, breathing apparatus, emergency eye wash facilities, chlorine leak monitoring and alarm equipment. Additional guidelines for gas chlorine are available from this office and the Workers' Compensation Board.

If powdered chlorine is used, storage facilities should preclude contact with moisture or organic materials and should be mechanically vented to an approved area.

If needed, to ensure reliable, effective and continuous disinfection, additional facilities such as standby equipment, flow pacing, residual monitoring, automated recording and controlling equipment and alarms should be provided.

A chlorine test kit (DPD) suitable for measuring both free and total chlorine residual over a range of 0 to 2.0 mg/L, should be provided when chlorine is used. Test kits with either a scale or digital readout are far better than those, which rely on visual colour comparison, particularly for measurements below 0.5 mg/L, and should be provided.

.../7

7.8 **Fluoridation**

If water is to be fluoridated as a means of reducing tooth decay, the control objective is 1.0 mg/L. Where flow is variable, automatic proportioning equipment must be used.

If fluoride is used in acid form, facilities for operator safety must be provided including pumps for transferring acid, suitable acid storage, fan ventilation to an approved area, protective clothing and emergency eye wash units. Facilities for spill containment must also be provided. If powdered fluoride is used, storage facilities should be mechanically vented to an approved area and should preclude contact with moisture or other foreign materials. A suitably accurate fluoride test kit should be provided. In larger installations, fluoride monitoring, automated recording and controlling equipment and alarms should be provided.

8. OPERATING PERMIT

New sources of water require an **Operating Permit** from the local Environmental Health Officer, to confirm that the quality is satisfactory before the source is used. The Environmental Health Officer may require additional pumping and analysis before issuing the Operating Permit.

9. COMMENTS AND QUESTIONS

Suggestions for improving public health protection of water systems and for improving these guidelines and any questions concerning these guidelines would be welcomed.

Provincial legislation is available from the Queen's Printer, 563 Superior Street, P.O. Box 9452, Stn. Prov. Govt., Victoria, B. C., V8W 9V7, tel. (250)-387-6409. The **Drinking Water Protection Act,** the ***Drinking Water Protection Regulation*** can be viewed at the www.qp.gov.bc.ca. The Guidelines for Canadian Drinking Water Quality are available from Health Canada and can be viewed at www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/dwguide.htm.

WATER SOURCE MONITORING – APPROVAL OF NEW SOURCES

MINIMUM UNTREATED WATER SOURCE QUALITY PARAMETERS TO BE ANALYZED

SOURCE TYPE: SURFACE WATER

MICROBIOLOGICAL(1)

Total Coliform
Non-coliform (background) bacteria
Escherichia coli
Heterotrophic Plate Count

PHYSICAL/CHEMICAL

Alkalinity
Ammonia
Arsenic
Chloride
Colour
Conductivity (2)
Corrosiveness (3)
Fluoride
Hardness
Metals Scan (4)
Nitrate
Nitrite
Organic Nitrogen
pH
Selenium
Sulphate
Total Dissolved Solids
Total Organic Carbon (5) (6)
Turbidity

Notes:

(1) Bacterial analysis must be conducted at an approved laboratory (see attached list).
(2) Conductance/Specific Conductance.
(3) Calcium Carbonate saturation/Langelier's index.
(4) At least: aluminum, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, phosphorous, potassium, silver, sodium, zinc (expand if mineralized to include mercury).
(5) If Turbidity less than 1.0 mg/L Dissolved Organic Carbon may be used as an alternative to Total Organic Carbon.
(6) If Total Organic Carbon greater than 2.5 mg/L analyze for Tannins and Lignin and perform a trihalomethane formation potential test (if chlorine is being used as the method of disinfection).

1. Analysis of additional parameters may be required based on the results of initial analysis and on potential impact by nearby sources of contamination or polluting sources. If industrial, agricultural or pesticide pollution is suspected, identify what chemicals may have been used and analyse for most likely indicator parameters. If petroleum pollution is suspected (underground fuel storage) analyse for alkyl benzene compounds. If parasitic pollution suspected, *Giardia lamblia* and/or *cryptosporidium* analysis may be required.

2. Analyses must be sufficiently accurate so that the minimum detectable concentration is less than 10% of **Drinking Water Protection Act,** the ***Drinking Water Protection Regulation*** or the Guidelines for Canadian Drinking Water Quality where applicable. Other analysis must provide sufficient information to reasonably assess the water suitability for drinking purposes and to determine what, if any, treatment might be needed. Analyses must be conducted in accordance with methods prescribed in "Standard Methods for the Examination of Water and Wastewater" (latest edition) or other acceptable procedures.

WATER SOURCE MONITORING – APPROVAL OF NEW SOURCES

MINIMUM UNTREATED WATER SOURCE QUALITY PARAMETERS TO BE ANALYZED

SOURCE TYPE: SHALLOW WELLS, DEEP WELLS, and SPRINGS

MICROBIOLOGICAL(1)

Total Coliform
Non-coliform bacteria
Heterotrophic Plate Counts
Escherichia coli
Iron and Sulphur Bacteria (deep wells)

PHYSICAL/CHEMICAL

Alkalinity
Ammonia
Arsenic
Chloride
Colour
Conductivity (2)
Corrosiveness (3)
Fluoride
Hardness
Metals Scan (4)
Nitrate
Nitrite
Organic Nitrogen
pH
Selenium
Sulphate
Sulphide (as hydrogen sulphide) (5)
Total Dissolved Solids
Total Organic Carbon (6) (7)
Turbidity

Notes:
1. Bacterial analysis must be conducted at an approved laboratory (see attached list).
2. Conductance/Specific Conductance.
3. Calcium Carbonate saturation/Langelier's index.
4. At least: aluminum, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, phosphorous, potassium, silver, sodium, zinc (expand if mineralized to include mercury).
5. For deep wells: On site or preserve sample, or use alternative method of confirming that water has satisfactory odour.
6. If Turbidity less than 1.0 mg/L Dissolved Organic Carbon may be used as an alternative to Total Organic Carbon.
7. If Total Organic Carbon greater than 2.5 mg/L analyze for Tannins and Lignin and perform a trihalomethane formation potential test (if chlorine is being used as the method of disinfection).

1. Analysis of additional parameters may be required based on the results of initial analysis and on potential impact by nearby sources of contamination or polluting sources. If industrial, agricultural or pesticide pollution is suspected, identify what chemicals may have been used and analyse for most likely indicator parameters. If petroleum pollution is suspected (underground fuel storage) analyse for alkyl benzene compounds. If parasitic pollution suspected, *Giardia lamblia* and/or *cryptosporidium* analysis may be required.

2. Analyses must be sufficiently accurate so that the minimum detectable concentration is less than 10% of Guidelines for Canadian Drinking Water Quality, the **Drinking Water Protection Act** or the ***Drinking Water Protection Regulation*** where applicable. Other analysis must provide sufficient information to reasonably assess the water suitability for drinking purposes and to determine what, if any, treatment might be needed. Analyses must be conducted in accordance with methods prescribed in "Standard Methods for the Examination of Water and Wastewater" (latest edition) or other acceptable procedure.

LABORATORIES APPROVED BY THE PROVINCIAL HEALTH OFFICER FOR WATER MICROBIOLOGY TESTING

(For updates to the approved laboratories check: http://www.pathology.ubc.ca/education/Certificate_Programs/Enhanced_Water_Quality_Assurance/PHO_-_Approved_Laboratory_List.htm)

AT April 6, 2006

NAME	ADDRESS	PHONE	FAX	APPROVED FOR	Approval Period
ALS ENVIRONMENTAL - CALGARY, ALBERTA	#2-21 HIGHFIELD CIRCLE SE, CALGARY, AB CANADA T2G 5N6	403-214-5431	403-214-5430	TOTAL COLIFORM AND *E. coli.*	To May 31, 2007
ALS ENVIRONMENTAL - FORT St. JOHN, BRITISH COLUMBIA	#2-8820 100TH STREET, FORT St. JOHN, BC V1J 3W9	250-785-8281	250-785-8286	TOTAL COLIFORM AND *E. coli.*	To June 16, 2007
ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA	1988 TRIUMPH STREET, VANCOUVER BC V5L 1K5	(604) 253-4188	(604) 253-6700	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To June 8, 2006
BCCDC ENVIRONMENTAL MICROBIOLOGY LABORATORY	655 WEST 12TH AVENUE, VANCOUVER BC V5Z 4R4	(604) 660-1753	(604) 660-6073	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To December 31, 2007
CANTEST LTD - BURNABY, BRITISH COLUMBIA	4606 CANADA WAY, BURNABY BC V5G 1K5 (	604) 734-7276	(604) 731-2386	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To November 25, 2007
CANTEST LTD - VICTORIA, BRITISH COLUMBIA	1104 – 4464 MARKHAM STREET, VICTORIA BC V8Z 7X8	(250) 385-6112	(250) 382-6364	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To September 15, 2007
CARO ENVIRONMENTAL SERVICES	102 – 3677 HIGHWAY 97N, KELOWNA BC V1X 5C3	(250) 765-9646	(250) 765-3893	TOTAL COLIFORM, FECAL COLIFORM AND *E.coli*	To December 31, 2007
C R D WATER SERVICES LABORATORY*	479 ISLAND HIGHWAY, VICTORIA BC V9B 1H7	(250) 474-9680	(250) 474-9691	TOTAL COLIFORM, FECAL COLIFORM AND *E.coli*	To December 31, 2007
ECO TECH LABORATORY LTD.	10041 DALLAS DRIVE, KAMLOOPS BC V2C 6T4	(250) 573-5700	(250) 573-4557	TOTAL COLIFORM, FECAL COLIFORM AND *E.coli*	To February 28, 2007
G V R D WATER LABORATORY	4330 KINGSWAY, VANCOUVER BC V5G 4G8	(604) 451-6001	(604) 451-6019	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To December 31, 2007
IG MICROMED ENVIRONMENTAL INC	190 - 12860 CLARKE PLACE, RICHMOND BC V6V 2H1	(604) 279-0666	(604) 279-0663	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To June 6, 2006
MB LABORATORIES LTD	2062 HENRY AVENUE WEST, SIDNEY BC V8L 5Y1	(250) 656-1334	(250) 656-0443	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To January 14, 2008
NORTH ISLAND LABORATORIES Nanaimo - Drop Off	2755 B MORAY AVE, COURTENAY BC V9N 8M9 532 – B COMOX ROAD, NANAIMO BC V9R 3J1	(250) 338-7786 (250) 716-8731	(250) 338-7553	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To December 9, 2007
NORTHERN LABORATORIES LTD	251 KAIEN ROAD, PRINCE RUPERT BC V8J 4B7	(250) 627-1906	(250) 627-8214	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To December 31, 2007
NORWEST LABS	104 - 19575 - 55A AVENUE, SURREY BC V3S 8P8	(604) 514-3322	(604) 514-3323	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To June 15, 2006
MAXXAM ANALYTICS INC.	8577 COMMERCE COURT, BURNABY BC V5A 4N5	(604) 444-4808	(604) 444-4511	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To August 24, 2006
PROVINCIAL LABORATORY FOR PUBLIC HEALTH - CALGARY (MICROBIOLOGY)	3030 HOSPITAL DRIVE NW,CALGARY, AB T2N 4W4	(403) 944-4563	(403) 270-2216	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To June 1, 2006
PROVINCIAL LABORATORY FOR PUBLIC HEALTH - EDMONTON (MICROBIOLOGY)	8440 – 112 STREET, EDMONTON, AB T6G 2J2	(780) 407-2699	(780) 407-8984	TOTAL COLIFORM, FECAL COLIFORM AND *E. coli.*	To June 1, 2006

*CRD Water Services Laboratory does not accept any external water samples for testing

Revised: 2006-04-45
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APPLICATION FOR WATERWORKS CONSTRUCTION PERMIT
Vancouver Island Health Authority

Water System Name: _____ **Date:** _____

Owner/Representative: _____

Address: _____ **Telephone:** _____
(if new)

_____ **Postal Code:** _____

DESCRIPTION OF PROPOSED WATERMAIN EXTENSION/REPLACEMENT:
(e.g. 200m of 150mm Class 150 PVC)

LENGTH (m)	SIZE (mm)	PRESSURE RATING (Class)	TYPE

Description of related works - source, treatment, reservoir, etc.

Does the submission include a new source(s)? _____

Does the water quality of the existing waterworks and/or new source(s) meet the *Drinking Water Protection Regulation* and the *Guidelines for Canadian Drinking Water Quality*? _____

Will all watermains have 3 meters clear horizontal separation from sanitary and storm sewers? _____

At all crossings and wherever the normal horizontal separation is not possible are the watermains at least 45 cm (18 inches) above and clear of the sanitary or storm sewer? _____

Do all service connections meet the above separation guidelines? _____

Have blow-offs or hydrants been provided for flushing purposes on all dead-ends and low points? _____

Have air relief valves, hydrants or services designed to provide air relief been provided at all high points? _____

Will watermains/reservoirs be disinfected per current AWWA standards? _____

Are all works on public right-of-ways or registered easements? _____

Are all plans, reports, specifications, etc., sealed and signed by a Professional Engineer? _____

How many new lots/connections will be serviced? _____

Is the capacity of the existing waterworks adequate (including existing and committed servicing)? _____

Are the lots serviced by septic tank _____ **or sewer** _____ **systems?**

Submitted by: _____
Signature: _____

Send to: Public Health Engineering
Vancouver Island Health Authority
3RD Floor 6475 Metral Drive, Nanaimo BC V9T 2L9

APPENDIX C - MANG OX PRODUCT INFORMATION

Noble House Group

Mang-Ox™

Product Information

Mang-Ox™ is a high rate, granular filter media used for removing hydrogen sulfide, iron and manganese compounds from water supplies.

Mang-Ox™ operates both as a classical filter working with an oxidant and as a catalytic media due to its ability to accelerate the reaction between the oxidizing agent and any prevalent dissolved oxygen with sulfide, iron and manganese present.

Dissolved iron, manganese and hydrogen sulfide will stay in solution unless the equilibrium is changed. Iron and manganese that is not oxidized become catalytically precipitated and then adsorbed directly on the media. **Mang-Ox™** is a very dense media that stops oxidized (precipitated) forms of iron, manganese and hydrogen sulfide from passing through the bed.

Most of the manganous manganese is rapidly removed in the first few inches of the media where it is further oxidized to manganese dioxide.

The adsorbed manganese, iron and precipitated sulphur are expelled during backwash. Any insoluble ferric hydroxide particulate growths are also expelled during backwash. The media must be properly backwashed to break loose and remove the filtered contaminants and precipitated iron, manganese and hydrogen sulfide. System sizing of the control valve and tank are necessary to sustain media performance.

A continuous reaction occurs with the addition of an oxidant, regenerating the media surface and replenishing the **Mang-Ox™**. For difficult applications, **Mang-Ox™** filters can be enhanced with aeration, chlorination, and ozone.

Because of **Mang-Ox™** naturally high manganese dioxide content, it provides a higher adsorption capacity than other media.

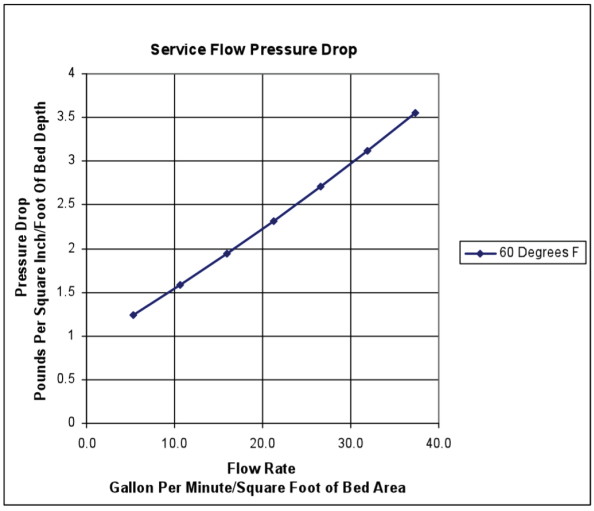
A **Mang-Ox™** filter is recommended before softeners to protect the ion exchange resin from fouling.

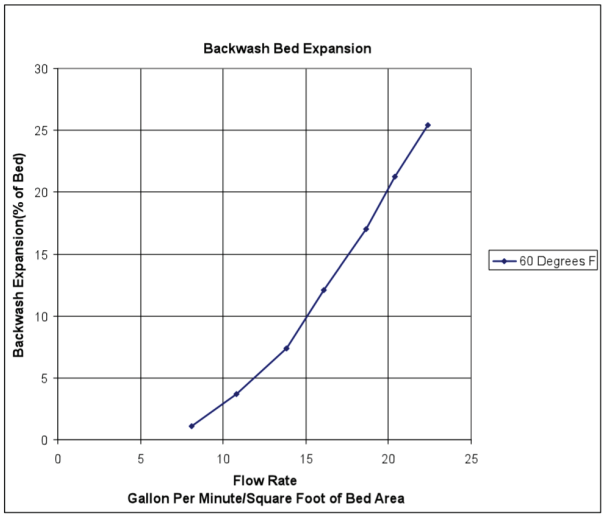
Mang-Ox™ Applications

- Removal of Iron up to 10 ppm.
- Removal of Manganese up to 5 ppm.
- Removal of Hydrogen Sulfide (rotten egg smell) up to 3 ppm.
- Not recommended for Iron Bacteria and Manganese bacteria removal.
- Not recommended for tannin and organics removal.

Mang-Ox™ Advantages

- Efficient reduction of manganese, iron and hydrogen sulfide - Long service life.
- Ease of placing into service since the product is triple-washed, minimizing fines and dust.
- Only regular backwashing is necessary.
- Ability to process high flow rates with low pressure drop.
- 10 to 30 second reaction time with oxidant additive.
- Ability to be utilized with common oxidants including:
    1. CL^2 (gas)
    2. Sodium hypochlorite
    3. Potassium permanganate
- Continuous regeneration.
- Converts ferrous iron to ferric iron.
- Converts H^2S to sulphur.
- Converts manganese to MnO^2.
- No chemical regeneration is required but may reduce service life.
- Allows for adequate reaction time to permit for the formation of ferric hydroxide.
- Allows for physical straining of the ferric hydroxide floc and sulphur until media.
- Allows for adsorption of MnO^2.
- NSF/ANSI Standard 61-2002 Certified.





Specifications	Physical Properties
Colour	Black
Mesh Size	20 x 40
Granule Size	.35 mm - .85mm
Uniformity Coefficient	1.45
Pinball Hardness	97%
Bulk Density	1.90 g/ml or 120 lbs. per cubic ft.
Packaging	½ cubic foot or 55 lb bags; 2,205 lb or 1 metric ton super sacks

NSF

Certified to NSF/ANSI Standard 61

Noble House Group

981 HWY. 98 E., SUITE 3280 - DESTIN, FLORIDA 32541
PHONE: (850) 837-2619 EMAIL: INFO@NOBLEHG.COM
www.noblehg.com

APPENDIX D - CONCEPTUAL SCHEMATIC DESIGN

Drying bed

Backwash Outlet

Proposed Water
Treatment Plant

Existing Steel
Reservoir 1

Raw Water
Well 3

Chemical Pump &
Chlorination

PLC Cabinet

Inlet &
Manifold

Outlet

Three Skid Mounted Filter Vessels
*# of vessels is conceptual

Raw Water
Well 1

Existing Steel
Reservoir 2

Raw Water
Well 2

Existing
Concrete
Reservoir

Distribution

Treated Water Line from Reservoir for Backwash Operation

Existing Buried Pipe to remain in Place as Emergency Line

SCALE: N.T.S

No.	Date	Revision	Dr.
1	Jan 09, 2020	Initial Schematic	NS

McElhanney
Suite 1
1351 Estevan Road
Nanaimo BC
Canada V9S 3Y3
Tel 250 716 3336

Designed:	Checked:	Date: Jan 09, 2020
Drawn: NS	Surveyed:	

Approved Sealed

QUALICUM BAY HORNE LAKE WATERWORKS DISTRICT

Inital WTP Schematic

Client Project No

Client Drawing No

MCSL Project No. 2231-34510-01

Drawing No. Rev.

Destroy all prints bearing previous number ▲

Plotted: January 09, 2020 , 16:36:05 Filename: Z:\Proj-Active\34510-01 QBHLWD - Water Treatment System Review\10.0 Drawings\1 - Active\Project Data\Initial Schematic.dwg

APPENDIX E - CONCEPTUAL CLASS D CAPITAL COST ESTIMATE

Conceptual Initial Capital Cost Estimate for Design And Construction of a Water Treatment Plant

General Note:
Note, this is considered a Class "D" Estimate. This is a preliminary estimate which due to little or no design information indicates the approximate magnitude of cost of the proposed project, based on QBHLWD requirements.

McElhanney Ltd. (2020 dollars)

QBHLWD - WATER TREATMENT PLANT

ITEM NO.	DESCRIPTION	UNIT	UNIT PRICE	QUANTITY	AMOUNT
1.0	**GENERAL CONDITIONS:**				
1.1	Mobilization and Demobilization	Lump Sum	$15,000.00	1.00	$15,000.00
1.2	Environmental and Sediment Management	Lump Sum	$5,000.00	1.00	$5,000.00
	GENERAL CONDITIONS SUBTOTAL				**$20,000.00**
2.0	**WATER TREATMENT FACILITY:**				
2.1	Pilot Program	Each	$10,000.00	1.00	$10,000.00
2.2	Skid mounted filtration system	Each	Varies	1.00	$409,000.00
2.3	Building	Each	$75,000.00	1.00	$100,000.00
2.4	Mechanical Piping Misc.	Each	$35,000.00	1.00	$55,000.00
2.5	Electrical Misc.	Each	$25,000.00	1.00	$31,666.67
	CIVIL SUBTOTAL				**$605,666.67**
3.0	**Civil Works:**				
3.0	Adjust existing electrical service boxes	Each	$800.00	1.00	$800.00
3.1	Clearing and grubbing	Square metre	$20.00	1500.00	$30,000.00
3.2	Common excavation (stripping) , off-site disposal	Cubic metre	$40.00	150.00	$6,000.00
3.3	Subgrade preparation	Square metre	$4.00	100.00	$400.00
3.4	Granular base - 150 mm thickness	Square metre	$50.00	200.00	$10,000.00
3.5	Granular sub-base - 250 mm thickness	Square metre	$50.00	200.00	$10,000.00
3.6	Asphaltic concrete paving 100mm thickness	Square metre	$100.00	120.00	$12,000.00
3.7	Landscaping	Square metre	$100.00	80	$8,000.00
	CIVIL SUBTOTAL				**$77,200.00**
4.0	**Water Distribution (At Facility)**				
4.1	Pump Upgrades	Each	$50,000.00	1.00	$50,000.00
4.2	Pipe - 200mm diam. PVC CL 150 C900, imported backfill. Includes joint wrapping where required.	Lineal Metre	$180.00	20.0	$3,600.00
4.3	Tee - 150F x 150F x 150H	Each	$800.00	3.0000000	$2,400.00
4.4	Gate Valve - 150 HxF	Each	$1,200.00	3.000000	$3,600.00
4.5	Coupler - 200mm diam. Robar	Each	$500.00	1.000000	$500.00
	WATER DISTIBUTION SUBTOTAL				**$60,100.00**

Notes:

1) Estimated costs are derived from recent experience on Vancouver Island, but there is no warranty that actual cost will not vary. McElhanney Ltd. accepts no liability for actual cost which may vary from the estimated construction costs provided herein.

2) Cost estimate based on conceptual design

SECTION 1	**GENERAL CONDITIONS**	**$20,000.0**
SECTION 2	**WTP**	**$605,666.7**
SECTION 3	**CIVIL**	**$77,200.0**
SECTION 5	**WATER DISTRIBUTION**	**$60,100.0**
TOTAL CONSTRUCTED WORKS		**$762,966.7**
CONTINGENCY (30%)		**$228,890.0**
ENGINEERING (15%)		**$148,778.5**
TOTAL PROJECT (LESS GST)		**$1,140,635.2**

Conceptual Initial Capital Cost Estimate for Design And Construction of a Water Treatment Plant

General Note:
Note, this is considered a Class "D" Estimate. This is a preliminary estimate which due to little or no design information indicates the approximate magnitude of cost of the proposed project, based on QBHLWD requirements.

				McElhanney Ltd. (2020 dollars)					
				QBHLWD - WATER TREATMENT PLANT					
				Concept 1		Concept 2		Concept 3	
ITEM NO.	DESCRIPTION	UNIT	UNIT PRICE	QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
1.0	**GENERAL CONDITIONS:**								
1.1	Mobilization and Demobilization	Lump Sum	$15,000.00	1.00	$15,000	1.00	$15,000	1.00	$15,000
1.2	Environmental and Sediment Management	Lump Sum	$5,000.00	1.00	$5,000	1.00	$5,000	1.00	$5,000
	GENERAL CONDITIONS SUBTOTAL				**$20,000**		**$20,000**		**$20,000**
2.0	**WATER TREATMENT FACILITY:**								
2.1	Pilot Program	Each	$10,000.00	1.00	$10,000	1.00	$10,000	1.00	$10,000
2.2	Skid mounted filtration system	Each	$350,000.00	1.00	$350,000	1.00	$720,000	1.00	$157,000
2.3	Building	Each	$75,000.00	1.00	$200,000	1.00		1.00	$200,000
2.4	Mechanical Piping Misc.	Each	$35,000.00	1.00	$65,000	1.00	$35,000	1.00	$65,000
2.5	Electrical Misc.	Each	$25,000.00	1.00	$35,000	1.00	$25,000	1.00	$35,000
	CIVIL SUBTOTAL				**$660,000**		**$790,000**		**$467,000**
3.0	**Civil Works:**								
3.0	Adjust existing electrical service boxes	Each	$800.00	1.00	$800	1.00	$800	1.00	$800
3.1	Clearing and grubbing	Square metre	$20.00	1500.00	$30,000	1500.00	$30,000	1500.00	$30,000
3.2	Common excavation (stripping) , off-site disposal	Cubic metre	$40.00	150.00	$6,000	150.00	$6,000	150.00	$6,000
3.3	Subgrade preparation	Square metre	$4.00	100.00	$400	100.00	$400	100.00	$400
3.4	Granular base - 150 mm thickness	Square metre	$25.00	200.00	$5,000	200.00	$5,000	200.00	$5,000
3.5	Granular sub-base - 250 mm thickness	Square metre	$30.00	200.00	$6,000	200.00	$6,000	200.00	$6,000
3.6	Asphaltic concrete paving 100mm thickness	Square metre	$95.00	120.00	$11,400	120.00	$11,400	120.00	$11,400
3.7	Landscaping	Square metre	$100.00	80	$8,000	80	$8,000	80	$8,000
	CIVIL SUBTOTAL				**$59,600**		**$59,600**		**$59,600**
4.0	**Water Distribution (At Facility)**								
4.1	Pump Upgrades	Each	$100,000.00	1	$100,000	1	$100,000	1	$100,000
4.2	Pipe - 200mm diam. PVC CL 150 C900, imported backfill. Includes joint wrapping where required.	Lineal Metre	$180.00	20	$3,600	20	$3,600	20	$3,600
4.3	Tee - 150F x 150F x 150H	Each	$800.00	3	$2,400	3	$2,400	3	$2,400
4.4	Gate Valve - 150 HxF	Each	$1,200.00	3	$3,600	3	$3,600	3	$3,600
4.5	Coupler - 200mm diam. Robar	Each	$200.00	1	$200	1	$200	1	$200
	WATER DISTIBUTION SUBTOTAL				**$109,800**		**$109,800**		**$109,800**

Notes:

1) Estimated costs are derived from recent experience on Vancouver Island, but there is no warranty that actual cost will not vary. McElhanney Ltd. accepts no liability for actual cost which may vary from the estimated construction costs provided herein.

2) Cost estimate based on concept drawings

3) No allowance has been made for land acquisition costs, property negotiations or environmental compensation.

SECTION 1	**GENERAL CONDITIONS**	**$20,000**	**$20,000**	**$20,000**
SECTION 2	**WTP**	**$660,000**	**$790,000**	**$467,000**
SECTION 3	**CIVIL**	**$59,600**	**$59,600**	**$59,600**
SECTION 5	**WATER DISTRIBUTION**	**$109,800**	**$109,800**	**$109,800**
TOTAL CONSTRUCTED WORKS		**$849,400**	**$979,400**	**$656,400**
CONTINGENCY (50%)		**$424,700**	**$489,700**	**$328,200**
ENGINEERING (15%)		**$191,115**	**$220,365**	**$147,690**
TOTAL PROJECT (LESS GST)		**$1,465,215**	**$1,689,465**	**$1,132,290**

APPENDIX F - CONCEPTUAL OPERATIONS AND MAINTENANCE ESTIMATE

Conceptual Operations and Maintenance Estimate

General Note:
Note, this is considered a Class "D" Estimate. This is a preliminary estimate which due to little or no design information indicates the approximate magnitude of cost of the proposed project, based on QBHLWD requirements.

				McElhanney Ltd. (2020 dollars)					
				QBHLWD - WATER TREATMENT PLANT					
				Monthly		Yearly (with 2.5% Inflation)		20 Year Period (with 2.5% Inflation)	
ITEM NO.	DESCRIPTION	UNIT	UNIT PRICE	QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
1.0	**OPERATOR**								
1.1	Regular Operations (SCADA Review, Backwash, Testing, Etc)	Hours	$57.00	87.00	$4,959	1040.00	$60,996	20800.00	$1,558,114
1.2	Unforeseen Maintence & Repair (Operator Only)	Hours	$55.00	10.00	$550	120.00	$6,765	2400.00	$172,810
	OPERATOR SUBTOTAL				**$5,509**		**$67,761**		**$1,730,924**
2.0	**WATER TREATMENT FACILITY:**								
2.1	Power	kW/hr	$0.15	3500.00	$525	60000.00	$6,458	1200000.00	$164,955
2.2	Material Supplies (Chroline, Media, etc)	Weekly	$350.00	1.00	$1,500	52.00	$18,450	1040.00	$471,299
2.3	Building and Facility Maintenance	Lump Sum	$200.00	1.00	$200	52.00	$2,460	1040.00	$62,840
2.4	Equipment Maintenance (Hardware, Software)	Weekly	$50.00	1.00	$215	52.00	$2,645	1040.00	$67,553
2.5	1 Complete Media Replacement	Lump Sum	$50,000.00					1.00	$81,931
	WATER TREATMENT FACILITY SUBTOTAL				**$2,440**		**$30,012**		**$848,577**
3.0	**MISCELLANEOUS**								
	MISCELLANEOUS SUBTOTAL								

Notes:

1) Estimated costs are derived from recent experience on Vancouver Island, but there is no warranty that actual cost will not vary. McElhanney Ltd. accepts no liability for actual cost which may vary from the estimated construction costs provided herein.

2) Cost estimate based on concept drawings

SECTION 1	**OPERATOR**	**$5,509**	**$67,761**	**$1,730,924**
SECTION 2	**WATER TREATMENT FACILITY:**	**$2,440**	**$30,012**	**$848,577**
SECTION 3	**MISCELLANEOUS**			
TOTAL O&M WORKS		**$7,949**	**$97,773**	**$2,579,501**
CONTINGENCY (10%)		**$795**	**$9,777**	**$257,950**
TOTAL O&M (LESS GST)		**$8,744**	**$107,550**	**$2,837,451**

APPENDIX G - CONCEPTUAL DESIGN AND CONSTRUCTION SCHEDULE

McElhanney | BEST MANAGED COMPANIES

Water Treatment Review - Conceptual Design & Construction Schedule

WBS	TASK ID	TASK DESCRIPTION	TASK DURATION (MONTHS)	START DATE	END DATE
Phase 1 - Design					
	10	Select Consulting Firm to Oversee Design, Tender, and Construction	**1**	**MONTH 1**	-
	20	Confirm System Requirements (Input and Output)	**1**	**-**	-
	30	Create and Issue RFP to Water Treatment Supply Vendors	**1**	-	-
	40	Preliminary Site Design (Civil grading, Process Piping, Electrical, Pump Upgrade if Needed)	**2**	-	-
	50	Select Water Tratement Supply Vendor	**1**	-	-
	60	Public Consultation	**1**	-	-
	70	Detail Water Treatment Plant and Site Design	**2**	-	-
	80	Submit Construction Permits	**4**	-	-
	90	WTP Pilot Program	**1**	-	**MONTH 8**
Phase 2 - Tender					
	100	Create and Issue Tender (Civil, Mechanical, Electrical)	**1**	**MONTH 10**	-
	110	Select General Contractor (Civil, Mechanical, Electrical)	**1**	-	**MONTH 11**
Phase 3 - Construction					
	120	Fabricate Water Treatment Plant	**6**	**MONTH 9**	-
	130	Mobilize to Site	**1**	-	-
	140	Civil Grading	**1**	-	-
	150	Install Water Treatment Plant	**1**	-	-
	160	Mechanical Electrical Tie ins	**1**	-	-
	170	Pump Upgrades (If Needed)	**1**	-	-
	180	Start Up and Commissioning	**1**	-	-
	190	Turnover (Full Operation)	**1**	-	**MONTH 18**
	200	Warrenty Period	**12**	-	-
	210	Close Out	**1**	-	**MONTH 30**